

IFIC Basic Concepts of Infection Control

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Editors

Candace Friedman

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IFIC Basic Concepts of Infection Control

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Foreword

The International Federation of Infection Control (IFIC) continues with its aim to provide up-to-date, scientifically sound tools and educational materials that can be used by professionals the world over.

This new edition of IFIC Basic Concepts of Infection Control builds on its predecessors, enhancing and updating in a scientific way the knowledge required as a foundation on which local policies and procedures can be developed.

Most chapters have been reviewed and brought up-to-date by an international panel of experts, and new ones have been added to ensure this new edition provides a sound comprehensive knowledge base.

As before, we hope the infection prevention and control principles set out in this book are applicable to all health care settings, especially in these days of global limitation of resources, but particularly to areas where infection prevention and control is still in its infancy.

The IFIC Board of Trustees, on behalf of the authors and our corporate sponsor, hope that you will find this book a helpful tool in your daily practice.

October 2011

Judith Richards
IFIC Chair

Chapter 1

Patient Safety

Barbara M Soule

Key points

- Safe patient care, including infection prevention, is a priority in all health care settings.
- A patient safety culture guides the attitudes, norms and behaviours of individuals and organisations.
- In a safe culture of care, all staff and leaders assume responsibility for the well-being of patients.
- Patient safety requires teamwork and collaboration, communication, measurement, and techniques such as human factors engineering.

Introduction

Patient safety remains a global health care challenge. Early pioneers in infection prevention and control (IPC) promoted safe patient care through their work. Ignaz Semmelweis reduced maternal mortality through hand hygiene, and Florence Nightingale minimised infections in wards during the Crimean war by rigorous environmental cleanliness. Joseph Lister insisted on antiseptics in surgery and reduced surgical site infections. Present-day IPC experts regard healthcare-associated infections (HAI) as a critical patient safety issue.^{1,2}

Recognizing HAIs as a serious problem, the World Health Organization (WHO) Assembly voted in 2004 to create a World Alliance for Patient Safety to coordinate, spread, and accelerate improvements in patient safety worldwide. The first challenge, launched in 2005, was “Clean Care is Safer Care”, which addresses HAIs and improved hand hygiene throughout the world.³

Why is there a patient safety problem in health care?

There is a paradox in patient safety. Caregivers continually strive to protect patients and “do no harm”, yet the complexity of human illness and frailties of human behaviour often result in errors or adverse events.⁴ Even with the most conscientious application of IPC principles and practices, HAIs may still occur from:

1. *Commission* (doing something wrong that leads to infection), e.g., not providing timely preoperative antibiotics for appropriate patients, or from
2. *Omission* (failure to do something right,) e.g., using poor aseptic technique when inserting a catheter.

Errors may be prevented by leadership providing resources, such as education for staff, and hand washing facilities. Infections formerly thought to be inevitable, such as ventilator-associated pneumonia, central-line-associated bloodstream infections, and catheter-associated urinary tract infections (CA-UTI), can be prevented when evidence-based safety practices are applied consistently.⁵

A Culture of Patient Safety

A culture of patient safety can greatly enhance IPC. Culture has been defined as the deeply rooted assumptions, values, and norms of an organisation that guide the interactions of the members through attitudes, customs, and behaviours.⁶⁻⁷

A culture of safety (See Figure 1.1) exists when there is a focused organisational effort with commitment from all staff and leaders to keep patients safe from harm. Everyone involved feels responsible for the safety of the patients and their families, and health care personnel feel safe in speaking out when care is compromised or when reporting adverse events. To work effectively, IPC professionals must understand their organisation's culture. It is a powerful force that must be addressed when trying to implement or change practices to reduce risk of infection.

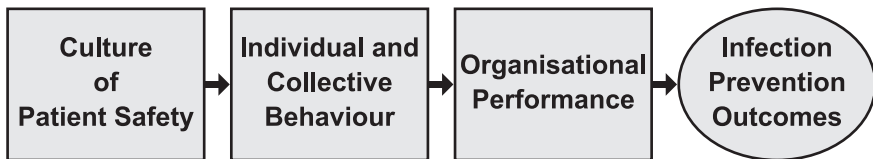


Figure 1.1 Culture of safety and infection prevention

A culture of patient safety involves: leadership, teamwork and collaboration, evidence-based practices, effective communication, learning, measurement, a just culture, systems-thinking, human factors, and zero tolerance.¹ Each can be applied to IPC practice and make an important contribution to reducing infection risk.

Leadership

Senior leaders are responsible for establishing safety as an organisational priority. They must engage other leaders and staff in the discussion, design, implementation, and sustainability of safety issues. Leaders set the tone by naming safety as a priority, supporting approved behaviours, and motivating staff to achieve the safest care. They must lay down best practices, such as excellent hand hygiene or use of isolation precautions. Leadership is critical to the success of a culture of safety and requires commitment from administrators, physicians, nurses, and others.¹³⁻¹⁴

Strategies for IPC professionals

- Engage leaders throughout the organisation in support of IPC; assist them in increasing the visibility and importance of infection prevention.
- Seek commitment from senior executives, boards of governance, clinical and support department leaders, and key staff to IPC principles and practices.
- Present a compelling case to leaders that emphasises the decreased morbidity, mortality, and cost when infections are avoided.⁷
- Provide leaders with valid information to help them make decisions about infection prevention.

Teamwork and Collaboration

Teamwork and collaboration combine the talents and skills of each member of a team and serve as a check and balance method. By encouraging the best thinking and evaluating the decisions and actions of each team member, it can avoid the top-down approach that often interferes with making the best decisions for the patient. Staff members from various disciplines are involved in the care of a single patient. This can lead to breaches or gaps in care. Strong collaboration and teamwork help minimise these errors.

Strategies for IPC professionals

- Foster collaboration and teamwork by engaging staff as partners in developing IPC policies and procedures.
- Encourage a multidisciplinary approach to IPC.
- Participate with teams of caregivers to address infection prevention issues.
- Maintain open communication about infection prevention to include staff and leaders across the organisation.

Effective Communication

Communication is a vital aspect of patient safety. Open communication encourages the sharing of patient, technological, and environmental information. In organisations with a strong patient safety culture, communication is based on mutual trust during the planning and delivery of care, and setting goals to achieve best outcomes for patients.

Communication strategies include use of written, verbal, or electronic methods for staff education, for sharing IPC data from surveillance, new

policies, procedures, and literature studies. Communication on patient safety should include a reporting system that allows staff to raise practice concerns or errors in care without fear of retribution.

Strategies for IPC professionals

- Make routine rounds and discuss patients with infections or those at risk of infection with the direct care providers and listen to staff concerns.
- Share surveillance data and new information.
- Develop a secure system for staff to report infection risks.

Evidence-based Practices

A basic element of a safe patient culture is use of evidence-based strategies for care delivery. This requires translating science into practice and standardising practices to achieve the best outcomes. Unfortunately, best practices to prevent infections are not always used. For example, the risk of developing a CA-UTI increases with duration of urinary catheter placement. Yet many practitioners fail to remove catheters when they are no longer needed; some physicians even forget that their patient has a urinary catheter.⁸ Evidence-based guidelines for patient care are available from the WHO, the US Centers for Disease Control and Prevention (CDC), the Institute for Healthcare Improvement (IHI), and Evidence-based Practice in Infection Control (EPIC).

Adoption of best practices sometimes meets with resistance. This may be due to lack of awareness, lack of desire or incentives to change practice, the culture in the organisation, or cumbersome methods required to implement new guidelines. Skilled IPC professionals must address these issues to assure that evidence-based practices are used to prevent infections.

Strategies for IPC professionals

- Learn about the incentives and barriers to adopting and implementing preferred practices in the organisation.
- Address incentives and barriers in the planning of new and existing policies and procedures for infection prevention.

Organisational Learning

A learning organisation must support its members so they can learn together, improve their ability to create desired results, embrace new ways

of thinking, and transform their environment for better care.⁹ An example of learning to think in new ways is the adoption of infection prevention “bundles” to prevent HAIs due to devices and procedures. Bundles are groups of practices that reduce infections and are carried out by teams of caregivers using the whole bundle for every patient all the time.

Strategies for IPC professionals

- Share infection information with all staff.
- Encourage staff to participate in formulating policies and procedures to reduce infection risk.
- Use adult learning principles to educate staff.

Measuring Care: Processes and Outcomes

To monitor compliance with patient care practices, to identify gaps in care, and to understand adverse events experienced by patients, IPC staff must collect and report reliable data.¹⁰⁻¹¹ In a patient safety culture, IPC professionals use surveillance to monitor infection risks, prevention strategies, and infections. Clinical staff must feel comfortable reporting infections to the IPC team. Many organisations and agencies (CDC, WHO, Health Ministries) throughout the world have promoted or required the reporting of infections.

Strategies for IPC Professionals

- Emphasise the importance of analysing and reporting infections to staff and leaders.
- Educate staff about their role for reporting infections in order to identify gaps in care that can be corrected.
- Be clear about the purpose and use for data that are collected. This involves precise definitions of colonisation vs. infection, consistent data collection processes, accurate capture of data, and validation of infection rates.
- Stratify data whenever possible for more precise analysis, for example, surgical site infections and infections in the newborn population.
- Determine when to maintain or to eliminate surveillance so that measurement is focused and useful.

“Systems” Thinking

Virtually all processes in health care organisations are systems which contain interconnected components, including people, processes, equipment, the

environment, and information.¹² In health care organisations, care delivery systems are often cumbersome and poorly designed; they may interfere with, rather than support, safe care.

An example of a system relevant to IPC is giving prophylactic antibiotics for surgery. This seems straightforward, however it is really complex. It involves the pharmacy, patient's families, and anaesthesiologists, together with provision, storage, and transport of the drug, responsibility for dosage, and documentation. Late or failed administration of the prophylaxis presents an infection risk.

Strategies for IPC professionals

- Consider the entire system, i.e., how the individual parts interact and how the system should work, when designing even simple IPC processes.
- Ensure that the system provides for supplies, that staff can successfully perform the assigned task(s), that the infrastructure supports the desired behaviours, and that coordinating departments support the infection prevention process.
- Work with others to design a system to achieve and sustain success.

Human Factors Theory

Human factors theory explores how to enhance performance by examining the interface between human behaviour and the elements of a work process (equipment and the work environment). The objective is to make the work easy and successful by removing barriers and using aids. The design of a care process, such as an operation or cleaning a wound, can benefit from using human factors engineering to reduce infection risk. For example, checklists are used to assure that approved procedures are used for surgeries or insertion of a central catheter.¹³ Volume-controlled alcohol gel dispensers and safety needles for injections reduce risks for patients and staff.

Human factors theory integrates several key principles into an overall philosophy. Table 1.1 describes several of these principles with application to IPC.

Table 1.1 Selected Human Factors Principles with Application to Designing Infection Prevention and Control Practices

Simplify the process:	minimise steps and make the process logical and easy to perform
Standardise the process:	standardise equipment and processes, e.g., standardising care of intravascular catheters to prevent bloodstream infections.
Reduce dependence on memory:	provide clear written direction, cues, visual aids, and reminders, for items such as preoperative preparation, hand hygiene, isolation precautions, or removal of indwelling devices.
Use forcing functions:	make it difficult to do it wrong by using equipment like safety needles and needle disposal devices.
Work toward reliability:	performing a task correctly and consistently, focusing on how to avoid failure, for example, using aseptic technique to insert a Foley catheter into the bladder.

Strategies for IPC professionals

- Integrate human factors engineering principles, such as standardisation, into patient care practices to promote success in reducing infection risk to patients or staff.
- Anticipate potential process failures in IPC strategies and incorporate methods to prevent them, such as visual cues for staff of expected behaviours (i.e., posters and checklists for surgical preparation) or supplies such as safety needles.
- Ensure that individuals performing the work are competent, there is clarity about the task being performed, that the tools and technologies involved work properly, and the environment supports the care process.¹⁴

No Blame – “Just” Culture

Since health care is delivered by humans, some will inevitably make errors. When potentially harmful events such as HAIs occur, an organisation

can either review the systems of care and learn from the errors, or blame personnel for making them. In a “just” culture (a key component of a patient safe environment) errors are addressed by providing feedback and encouraging productive conversations, and insisting on unbiased, critical analysis to prevent future errors.

Just cultures adopt a “no blame” approach that focuses on the “system” that led to the error rather than on the individual. Blaming staff for errors only creates anxiety and fear and does little to solve current problems or prevent them. Eliminating unwarranted blame is essential for excellence in patient care outcomes. However, a just culture does not allow purposeful disregard of the rules. Addressing these factors is part of a zero tolerance culture and is discussed below.

Strategies for IPC professionals

- Help maintain a “just”, no blame culture by continually focusing on evidence-based practices, epidemiology, and systems rather than “blaming” individuals.
- Use critical thinking to identify and analyse the causes of errors leading to infections so they can be prevented in the future.

Zero Tolerance Philosophy

Maintaining a “zero tolerance” approach to patient safety is crucial for safer care.¹⁵ To minimise infections (or errors), leaders must not tolerate non-adherence to proven prevention measures. When “best practices” are known, these should be expected of all staff. If staff disregards safety rules or best practices, such as failing to perform hand hygiene at the appropriate times, handling infectious waste inadequately, or skipping critical steps in cleaning, disinfection or sterilisation, these behaviours should be addressed and not ignored.¹⁶ The goal, as always, is to experience the fewest HAIs possible.

Strategies for IPC professionals

- Monitor evidence-based practices for infection prevention, e.g., isolation/precautions procedures, hand hygiene, sterile technique, and cleaning, disinfection and sterilisation.
- Work to improve “broken” or dysfunctional processes of care and defective systems, such as lack of soap and water or alcohol gel for hand hygiene, personal protective equipment for staff safety, or

- appropriate ventilation systems.
- Stay up-to-date on evidence-based guidelines and integrate them into the infection prevention program.
 - Focus less on simply achieving “benchmarks” for infections and work continually toward zero infections.
 - Do not accept the “status quo” as a long term goal; continually strive to reduce infection rates.
 - Other risks are described in Table 1.2 together with suggested preventive measures. IPC professionals should consider these measures as they review care processes and make their ward rounds.

What does the future hold for patient safety and infection prevention and control?

While contemporary IPC programs have only existed since the 1960s, ancient civilisations and health care leaders worldwide incorporated the principles into patient care for centuries. Today, the basic practices of IPC, including hand hygiene, aseptic technique, and cleaning, disinfection and sterilisation, remain critical to safe patient care. New technology will emerge, medications and therapies will become more sophisticated, and the body of science for IPC will continue to grow and help guide practitioners in their work. Consistent use of infection prevention principles and incorporation of new evidence-based care into the culture of patient safety will help to achieve better quality of care for patients and reduce infection risks.

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Table 1.2. Examples of Patient Safety Issues for Infection Prevention and Control

Patient Safety Issue	Infection Prevention and Control Example	Potential Solutions
<p>Multiple transfers or patient “hand offs” between staff and services</p>	<p>A patient who is admitted and prepared for surgery is transferred or “handed off” from the admission unit to the nursing staff, the operating theatre staff, post anaesthesia staff, and back to the nursing unit. Inadequate skin preparation, lack of timely administration of prophylactic antibiotics, or poor care of the surgical wound may occur.</p>	<ul style="list-style-type: none"> • Education about each phase of the surgical process • Clear communication strategies • Monitoring of competence • Reminders, checklists, visual cues • Documentation and analysis of preoperative and postoperative processes of care with feedback to staff
<p>Multiple types of equipment used for patient care</p>	<p>Patients in intensive care, haemodialysis, and other high intensity units often have multiple “lines”, fluids, ventilators, dialysers, and other equipment that must all be managed to avoid infection risks. Indwelling urinary or intravascular catheters and ventilators should be removed when no longer needed. Utilities such as water and air can present a risk if malfunctioning.</p>	<ul style="list-style-type: none"> • Education and training of staff on use of equipment • Competency assessment before performing work • Human factors engineering • Equipment maintenance • Environmental assessments

Patient Safety Issue	Infection Prevention and Control Example	Potential Solutions
High-risk illness	Patients with immunosuppressive diseases, burns, trauma, and high-risk conditions related to age (neonates) are prone to infections. They must be carefully assessed and monitored to prevent infections.	<ul style="list-style-type: none"> ● Staff education: observation and reporting criteria ● Population-specific criteria ● Clear policies and procedures ● Careful documentation, monitoring, and feedback to staff about infections
Time pressure	High intensity environments commonly have large workloads and limited time to complete essential infection prevention tasks. For example, nurses often indicate that they are “too busy” to wash hands or perform hand hygiene when appropriate.	<ul style="list-style-type: none"> ● Time management support; evaluation of workload; staffing and assignments ● Work environment design, such as (for hand hygiene) availability and location of water, sink design and location, alcohol-based solutions to decrease hand hygiene time
High-risk procedures/medications	Patients are at increased risk of unsafe care and infection during some procedures and with some medications. For example, the lack of preoperative antibiotics at the correct time and with the correct dose or discontinuation at the recommended time can fail to reduce risk of surgical site infections.	<ul style="list-style-type: none"> ● Develop clear protocols and processes for administration of preoperative antibiotics ● Educate staff about the procedures ● Assign responsibilities ● Monitor compliance with processes and report outcomes ● Initiate performance improvement when appropriate

Patient Safety Issue	Infection Prevention and Control Example	Potential Solutions
Distractions and multitasking	Distractions during delivery of care or attempting to perform many tasks simultaneously can lead to errors. Staff may omit hand hygiene because of distractions during busy times. Staff using aseptic or sterile techniques may contaminate the area because of distractions.	<ul style="list-style-type: none"> ● Provide work environment with few distractions Initiate culture of quiet and lack of interruption ● Encourage one task at a time ● Include staff in making decisions about work flow and environment ● Provide cues to remind staff of steps in an activity
Inexperienced or incompetent care givers:	Inexperience or lack of competence in healthcare personnel may lead to bad practice. For example, personnel who insert intravascular catheters and do not feel competent to use the recommended sites, such as the subclavian vein, may choose the femoral vein for insertion with its associated higher infection risk.	<ul style="list-style-type: none"> ● Analyse why staff feel inexperienced ● Provide orientation / training for all staff who insert intravascular catheters, including rationale and supervised practice until competency is established ● Periodically monitor skills and provide feedback

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Chapter 2

Organizational Structure

Ossama Rasslan

Key points

- Risk prevention for patients and staff is a concern of everyone in the facility and must be supported at the level of senior administration.
- Infection Prevention and Control Programs require an appropriate, clear, and firm organisational structure.
- The Infection Prevention and Control Programs in most countries is delivered through an Infection Control Team.
- A healthcare-associated infection manual compiling recommended instructions and practices for patient care is an important tool.

Introduction

Infection prevention and control (IPC) is a quality standard, essential for the well-being and safety of patients, staff, and visitors. Provision of an effective IPC program is a key to quality and a reflection of the overall standard of care provided by a health care institution. Each institution is unique and its specific needs must be considered when developing or reorganizing an IPC program. Because of these differing needs, various groups, individuals, and functions within the organisation may be responsible for the IPC program.

National Program

The responsible National Health Authority should develop a national program to support health care facilities in reducing the risk of healthcare-associated infections (HAI). Such programs must:

- Set relevant objectives consistent with other national health care objectives.
- Develop and continually update guidelines for health care surveillance, prevention, and practice.
- Develop a national system to monitor selected infections and assess the effectiveness of interventions.
- Harmonise initial and continuing training programs for health care professionals.
- Facilitate access to products essential for hygiene and safety.
- Encourage health care establishments to monitor HAIs, with feedback to the professionals concerned.

The Health Authority should designate an agency to oversee the program (a ministerial department, institution, or other body) and plan national activities with the help of an expert committee. Professionals and academic organisations must be involved.¹

Health Care Programs

The major preventive effort related to HAIs should be focused on hospitals and other health care facilities.²⁻⁴ Risk prevention for patients and staff is a concern of everyone in the facility and must be supported by the senior administration. A yearly work plan to assess and promote good health care, appropriate isolation precautions, sterilisation and other practices,

staff training, and epidemiological surveillance should be developed.

The manager or medical director is ultimately responsible for safety and quality. He or she must ensure that appropriate arrangements are in place for effective IPC practices and that there is an Infection Control Committee (ICC) and an Infection Control Team (ICT). If the health care setting is too small for such an organisation, experts in IPC should be available for consultation at regular intervals and in an acute situation. Providers of home care should also ensure that expertise in IPC is available for their staff.

Infection Control Committee

An ICC provides a forum for multidisciplinary input, cooperation, and information sharing. The ICC is responsible for the planning, implementation, prioritisation, and resource allocation of all matters relating to IPC. The ICC must report directly to either administration or the medical staff to promote program visibility and effectiveness. The committee should act as a liaison between departments responsible for patient care and support services (e.g., pharmacy, maintenance).

The ICC membership should reflect the spectrum of clinical services and administrative arrangements. It should include:

- Chief Executive/Administrator or his/her nominated representative.
- Infection Control Doctor/Microbiologist who may act as a chairperson.
- Infection Control Nurse (ICN).
- Infectious Disease Physician (if available).
- Director of Nursing or his/her representative.
- Occupational Health Physician (if available).
- Representatives from the major clinical specialties.
- Representatives of other departments (pharmacy, central supply, maintenance, housekeeping, training services, etc.) may be invited as necessary.

The committee should hold regular meetings with minutes. Minutes should be sent to the Medical Director and the facility's Management Board as well as to departments directly involved in the subjects discussed during the meeting. It should produce an annual report and an annual business plan for IPC. The ICC has the following tasks:

- To review and approve the annual plan for IPC.
- To review and approve IPC policies.
- To support the ICT and direct resources to address problems as identified.
- To ensure availability of appropriate supplies needed for IPC.
- To review epidemiological surveillance data and identify areas for intervention.
- To assess and promote improved practice at all levels of the facility.
- To ensure staff training in IPC and safety.
- To review infectious risks associated with new technologies and monitor risks of new devices and products, prior to their approval for use.
- To review and provide input into an outbreak investigation.
- To review and approve construction/renovation projects regarding infection prevention.
- To communicate and cooperate with other committees with common interests, such as the Antibiotic Committee, Occupational Health Committee, etc.

Infection Control Team

The ICT should have a range of expertise covering IPC, medical microbiology, infectious diseases, and nursing procedures. The team should have a close liaison with the microbiology laboratory and ideally a microbiologist should be a member. The team should consist of at least one physician, the Infection Control Officer (ICO), and at least one nurse, the ICN.

The ICT is responsible for the day-to-day running of IPC programs. All health care organisations should have an ICT. If this is not practical, arrangements for IPC services should be made with a nearby hospital. The optimal structure will vary with the type, needs, and resources of the facility. The ICT must have appropriate authority; in large facilities, this usually means a direct reporting relationship with senior administration.

The ICT must ensure that an effective IPC program has been planned, coordinate its implementation, and evaluate its impact. Twenty-four hour access to the ICT for advice (both medical and nursing) on IPC is essential.

The team should meet regularly (several times a week or, preferably, daily) to discuss relevant issues. A standing agenda may include updates on surveillance, observations of IPC practice, policy review, revision of education and training, and follow-up of identified problems. Minutes should be prepared for all meetings. Any regulations, rules, or recommendations should be widely distributed throughout the facility. Feedback from the ward staff should be encouraged.

The role of the ICT can be summarised as follows:

- To develop an annual IPC plan with clearly defined objectives.
- To develop written policies and procedures, including regular evaluation and updates.
- To prepare an action plan for implementation of the IPC program with approval from the ICC.
- To monitor and evaluate daily practices of patient care designed to prevent infection.
- To identify problems in the implementation of IPC activities which need to be solved or addressed by the ICC.
- To organise epidemiological surveillance for HAIs (particularly in high risk areas to detect outbreaks early).
- To investigate outbreaks and provide data (and expert advice) that should be evaluated to allow for any change in practice or allocation of resources.
- To educate all grades of staff in IPC policy, practice, and procedures relevant to their own areas.
- To provide advice to all grades of staff on all aspects of IPC on a day-to-day basis.
- To develop an annual training plan for healthcare workers and implement IPC training activities.
- To ensure availability of supplies and equipment needed for IPC.
- To have a scientific and technical support role in purchasing and monitoring of equipment and supplies, and in evaluation and checking the efficacy of sterilisation and disinfection measures.
- To collaborate with the pharmacy and antibiotic committees in developing a program for supervising antibiotic use.
- To support and participate in research and assessment programs.
- To participate in audit activities.
- To obtain program approval from the ICC.
- To submit monthly reports on activities to the ICC.

Infection Control Officer: Duties and Responsibilities

The ICO should be a medically qualified senior staff member who is interested in and who spends most of his/her time involved in IPC. The ICO could be a medical microbiologist, an epidemiologist, or an infectious diseases physician. If none of these are available, then a surgeon, a paediatrician, or another appropriate physician with a special interest in the field should be appointed. Irrespective of professional background, the ICO should have interest, knowledge, and experience in different aspects of IPC.

The role and responsibilities of the ICO are summarised as follows:

- Serves as a specialist advisor and takes a leading role in the effective functioning of the ICT.
- Should be an active member of the ICC and may act as its Chair.
- Assists the ICC in reviewing annual plans, policies, and long-term programs for the prevention and control of infection.
- Advises the Chief Executive/Administrator directly on all aspects of IPC and on the implementation of policies and procedures.
- Participates in the preparation of tender documents for support services and advises on IPC aspects.
- Must be involved in setting quality standards, surveillance, and audit with regard to infection prevention.

Infection Control Nurse: Duties and Responsibilities

An ICN or Practitioner is a registered nurse with an academic education (perhaps with a qualification, such as specialised training) and practical training which enables him or her to act as a specialist advisor in all aspects relating to IPC. The ICN is usually the only full-time practitioner on the ICT and therefore takes the key role in day-to-day IPC activities, with the ICO providing the leading role.

One ICN for 250 acute beds on a full-time basis was recommended in the United States during the 1980s. However, since then, the expansion in job responsibilities necessitates that staffing requirements reflect the scope of the program, rather than bed number.⁵

The role and responsibilities of the ICN are summarised as follows:

- Contributes to the development and implementation of policies and procedures, participates in audits, and monitors tools related to IPC and infectious diseases.

- Provides specialist-nursing input in the identification, prevention, monitoring, and control of infection.
- Participates in surveillance and outbreak investigation activities.
- Identifies, investigates and monitors infections, hazardous practices and procedures.
- Participates in preparing documents relating to service specifications and quality standards.
- Participates in training and educational programs and in membership on relevant committees where IPC input is required.

Infection Control Link Nurse

An effective way to develop IPC education and operational support can be through a link system. In a large facility the ICN can train link nurses. These individuals have special responsibility for maintaining good IPC practices and education within their departments. The Infection Control Link Nurse (ICLN) is the “link” between the ICN and the ward and helps identify problems, implements solutions, and maintains communications. A competent ICLN can motivate ward staff by enabling more effective practice. Sustained, consistent senior management backing and interest are effective in supporting such link programs and essential in ensuring their success.

The ICLN is responsible for:

- Monitoring hygiene, consistent with policies and good nursing practices.
- Monitoring aseptic techniques, including hand hygiene and use of isolation precautions.
- Reporting promptly to the attending physician any evidence of infection in patients.
- Initiating patient isolation/precautions and ordering culture specimens from any patient.
- Identifying signs of a communicable disease when the physician is not available.
- Limiting patient exposure to infections from visitors, staff, other patients, or equipment used for diagnosis or treatment.
- Maintaining a safe and adequate supply of ward equipment, drugs, and patient care supplies.

Infection Control Manual

An HAI manual, containing recommended instructions and practices for patient care, is an important tool. The manual should be developed and updated by the ICT, with review and approval by the committee. It must be made readily available for patient care staff and updated regularly.

Topics of importance for a procedure manual include:

Patient care

- Hand hygiene
- Isolation precautions practices
- Invasive procedures (intravascular and urinary catheterisation, mechanical ventilation, tracheostomy care, and wound management)
- Oral alimentation

Area specific procedures

- Isolation precautions procedures for infectious patients
- Surgical and operating theatre techniques
- Obstetrical, neonatal, and intensive care techniques

Processing of items of critical importance

- Cleaning, sterilisation, and disinfection
- Medication and preparation of infusions (including blood products)

Staff health

- Immunisation
- Post-exposure management for employees, patients, and others exposed to infectious diseases within the facility

Investigation and management of patients with specific infections

- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Diarrhoea
- Human immunodeficiency virus
- Tuberculosis
- Multi-resistant Gram-negative bacteria

Minimal Requirements

The IPC program must include:

- A physician and a nurse with responsibilities for IPC.
- A manual of critical IPC policies.
- An educational program for staff.
- A clear line of responsibility to senior management.

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Chapter 3

Epidemiology of Health care-Associated Infections

Akeau Unahalekhaka

Key points

- Patients are exposed to infectious risks when they receive care in health care facilities, especially when they undergo invasive treatments and procedures.
- Healthcare-associated infections impact patients, their family members, health care personnel, and health care facilities.
- Epidemiology can help health care personnel understand the occurrence, magnitude, distribution, and severity of healthcare-associated infections in their settings.
- Understanding the epidemiology of healthcare-associated infections can help prioritise problems and effectively determine prevention and control strategies.
- Understanding the chain of infection, especially the modes of transmission, can greatly help health care personnel prevent healthcare-associated infections.
- Information on the occurrence of healthcare-associated infections by host, agent and environment, and their distribution by time and place is very useful for planning prevention strategies and evaluating the success of preventive interventions.

Background

Healthcare-associated infections (HAI) are a significant cause of patient morbidity and mortality. Healthcare personnel should be actively involved in the diagnosis, surveillance, and early management of HAIs with the goal of reducing the risk of preventable complications associated with health care.

Epidemiology¹⁻²

Epidemiology is the study of the dynamic occurrence, distribution, and determinants of health-related events in specified populations. Epidemiology defines the relation of a disease to the population at risk and involves the determination, analysis, and interpretation of rates. The epidemiology of HAIs explains the occurrence of HAIs among patients cared for in a health care facility and the magnitude of the problem in these settings. It includes the distribution of HAIs by patient type, causative pathogen, unit of treatment, and period of time. This information can help healthcare personnel understand HAI problems in their facility and is very useful for determining preventive strategies.

Healthcare-associated Infections

HAI (previously called nosocomial infection) refers to infections associated with health care delivery in any setting (e.g., hospitals, long-term care facilities, community/ambulatory settings, and home/community care). An HAI is defined as a localised or systemic infection that results from an adverse reaction to the presence of an infectious agent(s) or its toxin(s), for which there is no evidence of infection on admission to a health care facility. An infection is frequently considered an HAI if it appears ≥ 48 hours after admission.

Magnitude and Impact²⁻⁶

HAIs occur in both developed and developing countries; approximately 1.4 million patients acquire HAIs each day. In the United States, the Centers for Disease Control and Prevention (CDC) estimated that 1.7 million HAIs contribute to 99,000 deaths each year; they are among the top ten leading causes of death. The highest morbidity was among patients in intensive care units (ICU). The number of deaths associated with HAIs was greatest for pneumonia and bloodstream infections. The infection rate per 1,000 patient-days was highest in ICUs, followed by high-risk nurseries, and well-baby nurseries.

The prevalence of HAIs among patients in France was 5.0% in 2006. The most common HAIs were urinary tract infections (30.3%) followed by pneumonia (14.7%), surgical site infection (14.2%), and infections of the skin and mucous membrane (10.2%). HAIs caused patients to stay in the hospital 4-5 additional days. During 2004-2005, about 9,000 patients died each year with an HAI.

In Italy, 6.7% of patients developed HAIs, between 450,000 and 700,000 patients since the year 2000. Approximately 4,500 - 7,000 patients with HAIs died.

In 2006 in the United Kingdom, the estimated HAI rate was 8.2%. In Switzerland, a national survey showed an infection rate of 7.2% in 2004. In Finland, 8.5% of patients developed HAIs in 2005.

A surveillance study of HAIs in developing countries was conducted in 173 ICUs in Latin America, Asia, Africa, and Europe from January 2003 through December 2008 by the International Nosocomial Infection Control Consortium. There were a total of 155,358 hospitalised patients in the study. The pooled rate of central venous catheter (CVC) - associated bloodstream infections (BSI) was 7.6 CVC-BSIs per 1,000 CVC-days. This rate is nearly 3 times higher than comparable U.S. ICUs. The overall rate of ventilator-associated pneumonia (VAP) was also far higher; 13.6 VAPs versus 3.3 per 1,000 ventilator-days, respectively. The rates of catheter-associated urinary tract infections (CA-UTI) were 6.3 versus 3.3 per 1,000 catheter-days, respectively. The crude unadjusted excess mortalities of device-related infections ranged from 23.6% (CVC-BSIs) to 29.3% (VAP).

Major types of HAI

There are four major types of HAIs, all related to invasive or surgical procedures. They include:

1. Catheter-associated urinary tract infection
2. Ventilator-associated pneumonia
3. Surgical site infection (SSI)
4. Catheter related bloodstream infection (CR-BSI)

Epidemiologic Factors related to HAI

There are three main risk factor groups for HAIs: host factors, agent factors and environmental factors. The detail of each risk factor is as follows:

Host factors

Host factors affect a person's risk of exposure and resistance to infection. Patients admitted to health care facilities are usually in a poor state of health, with weakened defences against bacteria and other infectious agents. Advanced age or premature birth and immunodeficiency (due to drugs, illness, or irradiation) present a general risk, while some diseases present specific risks. For instance, chronic obstructive pulmonary disease increases the chances of respiratory tract infection.

Additional host factors associated with an increased risk of HAIs include malignancies, infection with human immunodeficiency virus, severe burns and certain skin diseases, severe malnutrition, coma, diabetes mellitus, bronchopulmonary disease, circulatory impairment, open wound, and trauma.

Agent factors

An infectious agent can be a bacterium, virus, fungus, or parasite. The majority of HAIs are caused by bacteria and viruses; fungi occasionally and parasites rarely cause HAIs. There are 2 major types of bacteria that cause HAIs, Gram positive cocci (e.g., staphylococci and streptococci) and Gram negative bacilli (e.g., *Acinetobacter*, *Pseudomonas*, *Enterobacter*, *Klebsiella*)

Environmental factors

Environmental factors are extrinsic factors that affect either the infectious agent or a person's risk of exposure to that agent. Environmental factors related to HAIs include both the animate and inanimate environment of patients. The animate environment refers to health care personnel, other patients in the same unit, families, and visitors. The inanimate environment refers to medical instruments and equipment and environmental surfaces. Other risk factors associated with the health care environment include sanitation, cleanliness of the unit, temperature and humidity, and diagnostic and therapeutic manoeuvres.

Diagnostic and therapeutic procedures can increase the risk of acquiring HAIs, particularly

1. those transecting contaminated/infected tissues or involving insertion of a foreign body;
2. indwelling catheters, especially intravenous and urinary catheters;
3. tracheostomy or tracheal intubation, assisted respiratory ventilation, anaesthesia;

4. dialysis;
5. transfusion;
6. immunosuppressive drugs, antimicrobials, hyperalimentation; and
7. radiation therapy. Invasive devices, for instance intubation tubes, catheters, surgical drains, and tracheostomy tubes, all by-pass the patient's natural defence mechanisms and provide an easy route for infection. The longer a device is left in place, the greater the risk of infection.

A patient's treatment can also leave them vulnerable to infection – immunosuppression and antacid treatment undermine the body's

Table 3.1 Risk factors of important healthcare-associated infections

Site of infection	Risk factors
Urinary tract infection	Female sex Severity of illness Urinary tract catheterisation Breaks in closed system Advanced age
Pneumonia	Underlying disease (altered mental status, diabetes, alcoholism) Malnutrition Severity of illness Histamine II blockers, antacid Intubation, mechanical ventilation, respiratory therapy equipment, tracheostomy
Primary bloodstream	Extremes of age Severity of illness Underlying disease, immunosuppression, burns Intravascular devices
Surgical site	Advanced age Malnutrition Severity of illness Preoperative shaving Wound classification Type of procedure Prosthesis

defences, while antimicrobial therapy (removing competitive flora and only leaving resistant microorganisms) and recurrent blood transfusions have also been identified as risk factors. Table 3.1 outlines risk factors for some specific HAIs.

Chain of Infection

Infection results from an interaction between an infectious agent and susceptible host. This interaction occurs by means of contact between the agent and the host and is affected by the environment. Breaking the chain of infection by interrupting transmission is generally the best way to prevent HAIs. The chain of infection consists of the following components: infectious agent, reservoir, portal of exit, mode of transmission, portal of entry and susceptible host. (See Figure 3.1)

The infectious agent is a pathogen that causes an HAI. The ability of a pathogen to cause an infection depends on its virulence, pathogenicity, infectious dose, and infectivity. Reservoir is a place in which an infectious agent can survive but may or may not multiply. Common reservoirs in health care facilities are persons with infectious diseases and contaminated medical devices or equipment (usually called vehicles). There are three types of human reservoirs:

1. persons who are ill (have signs and symptoms of disease)
2. colonised persons (harbour an infectious agent but do not have an infection)
3. carriers (are infected but do not show any signs or symptoms; they can transmit the infection to others).

Portal of exit is the path by which an infectious agent leaves the reservoir. Portal of exit can be the respiratory tract, genitourinary tract, gastrointestinal tract, skin/mucous membrane, blood, or transmission of disease from a mother to her child during pregnancy (transplacental).

Mode of transmission is the movement of pathogens from the reservoir to the host.

Portal of entry is the path by which an infectious agent enters the host. The portal of entry can be via the respiratory tract, genitourinary tract, gastrointestinal tract, skin/mucous membrane, parenteral, or transplacental.

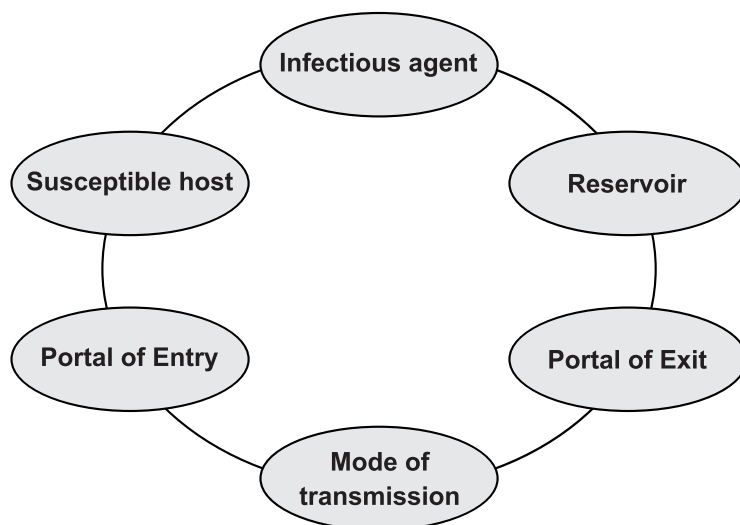


Figure 3.1 Chain of Infection

Susceptible host is a person lacking effective resistance to a particular pathogen. In health care facilities, many patients are susceptible to infections since they are seriously ill.

Modes of transmission of HAI

A pathogen may be transmitted by a single route or it can be transmitted in several ways. The modes of transmission of HAIs are as follows:

Contact Transmission

Contact is the most important and frequent mode of HAI transmission; it is divided into three subgroups: direct-contact, indirect-contact, and droplet transmission.

Direct-contact transmission involves a direct body surface-to-body surface contact and physical transfer of microorganisms between a susceptible host and an infected or colonised person. For instance, direct contact occurs when a nurse turns a patient, gives a patient a bath, or performs other patient-care activities that require direct personal contact. Direct-contact transmission also can occur between two patients.

Indirect-contact transmission involves contact of a susceptible host with an intermediate object, usually inanimate, such as contaminated instruments, needles, or dressings, or contaminated gloves that are not changed between patients.

Droplet transmission occurs when droplets are generated from a human reservoir, mainly during coughing, sneezing, or talking, and during the performance of certain procedures such as bronchoscopy. Transmission occurs when droplets containing pathogens from the infected person are propelled a short distance (< 1 meter) through the air and deposited on the host's body.

Airborne Transmission

Airborne transmission occurs by dissemination of either airborne droplet nuclei (small-particles, <5 µm in size) of evaporated droplets containing microorganisms that remain suspended in the air for long periods of time or dust particles containing the infectious agent. Droplet nuclei, dust particles, or skin squames containing microorganisms are transmitted by air currents and may become inhaled by a susceptible patient within the same room or over a longer distance from the source patient, depending on environmental factors. Special ventilation is required to prevent airborne transmission. Microorganisms transmitted in this manner include *Mycobacterium tuberculosis*, rubeola (measles), and varicella (chickenpox) viruses.

Vehicle Transmission

Vehicle transmission applies to microorganisms transmitted through contaminated items such as food, water, medications, medical devices and equipment, toys, and biological products, such as blood, tissues or organs.

Vector Transmission

Vector-borne transmission occurs when vectors such as mosquitoes, flies, rats, and other vermin transmit microorganisms. Transmission occurs through simple contamination by animal or arthropod vectors or their actual penetration of the skin or mucous membranes. This mode of transmission plays a minor role in transmission of HAIs.

Basic principles of epidemiology

Use of surveillance data to make improvements⁸⁻⁹

One of the most useful epidemiological methods is surveillance. The results from the CDC's Study on the Efficacy of Nosocomial Infection Control (SENIC Study)⁷ supported four important recommendations for effective

prevention of HAIs: surveillance, control measures, an infection control professional/nurse, and a hospital epidemiologist.

HAI surveillance is the systematic, active, ongoing observation of the occurrence and distribution of HAIs and of the events or conditions that increase the risk of HAI occurrence. The information allows health care organisations to direct their efforts toward the most serious HAI problems and risks, to obtain support of personnel, and to provide feedback on the results of preventive changes.

Surveillance data can be used to provide baseline endemic infection rates, identify epidemics, provide information on the occurrence of HAIs, evaluate efficacy of control measures, reinforce appropriate infection prevention and patient-care practices, defend against malpractice suits, provide data for comparisons, problem solving and/or research, and plan and measure the impact of implementing recommendations.

Surveillance data can enhance a health care organisation's performance and reduce the risk of adverse outcomes. These data can be combined with process indicators to improve practices. Process indicators are activities that affect the development of HAIs.

Table 3.2 Type of epidemiological studies

Type of study	Alternative name	Unit of study
Observational studies		
Descriptive studies		
Analytical studies		
Ecological	Correlational	Population
Cross-sectional	Prevalence	Individuals
Case-control	Case-reference	Individuals
Cohort	Follow-up	Individuals
Experimental studies	Intervention studies	Patients
Randomised controlled trials	Clinical trials	Patients
Field trials		Healthy people
Community trials	Community intervention studies	Communities

Care bundles are groupings of these best practice process indicators with respect to a disease process that individually improve care. However, when applied together they result in substantially greater improvement. The Institute for Health Care Improvement outlines care bundles for the most common HAIs.

Types of epidemiological studies¹⁰

Epidemiological studies can be classified as either observational or experimental. The most commonly used types of epidemiological studies are listed in Table 3.2 together with their focus of study and their alternative names.

Observational studies include descriptive or analytical studies. A descriptive study describes the occurrence of a disease in a population and is often the first step in an epidemiological investigation.

A cross-sectional study, often called a prevalence study, measures the prevalence of disease. The measurements of exposure and effect are made at the same time. Data from cross-sectional studies are helpful in assessing the health care needs of populations.

An analytical study analyses and tests relationships between a disease and its causes. Case-control studies are used to investigate causes of disease, especially rare diseases. The possible cause is compared between cases (people with a disease) and controls (people without a disease). This is a *retrospective study*, since the design looks backward from outcome to possible exposure or causative factors. Case-control studies often are performed when investigating an outbreak.

In a cohort study, a group of people (a cohort) is evaluated, none of whom has experienced the outcome of interest. On entry to the study, people in the cohort are classified according to characteristics or exposures that might be related to the outcome. Groups with and without certain exposures or characteristics are then observed over time to compare the outcome.

An experimental or intervention study involves an active attempt to change a disease determinant, such as an exposure or behaviour, or the progress of a disease, through treatment, usually involving a randomised controlled trial (RCT) with patients as subjects. Field trials and community

trials are other experimental designs, in which the participants are healthy people and communities, respectively. The effects of an intervention are measured by comparing the outcome in the experimental group with that in a control group. Since the interventions are strictly determined by the protocol, ethical considerations are of paramount importance in the design of these studies.

Statistics

Some basic use of statistics is helpful in infection prevention and control activities. Proper statistical methods must be used if correct interpretation of the data is expected.

Mean - Measure of Central Tendency

The most commonly used parameter is the arithmetic mean. The formula to calculate the sample mean is: $\bar{x} = \frac{\sum x}{n}$ - where \sum (sigma) is the symbol for "the sum of," x is the value of each observation, and n is the number of observations.

Standard Deviation - Measure of Variability

Standard deviation is a measure of dispersion that reflects the variability in values around the mean. The standard deviation (σ) of a distribution is defined as the square root of the variance, $\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$

Pictures

Pictorial statistics present the numerical data that have been collected in graphs or charts, creating a picture of the data. Types include bar and line graphs and pie charts.

Summary

Healthcare-associated infections are those that occur among patients who receive care in hospitals or other health care facilities. HAIs can cause serious complications and greatly impact patients, their families, and health care personnel. Health care personnel need to understand the epidemiology of HAIs to prevent them in their own settings. Understanding the chain of infection and epidemiology of HAIs can lead to effective prevention and control intervention.

The epidemiology of HAIs can explain what happens to whom, and where and when it happens, (i.e., the occurrence and distribution of HAIs). Using evidence-based recommendations can reduce infection rates. This information supports effective planning and implementation of programs to prevent HAIs.

Acknowledgement

This chapter is an update of the earlier one by Grace Emori.

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Key Web Links

The Association for Professionals in Infection Control and Epidemiology (APIC) www.apic.org

U.S. Centers for Disease Control and Prevention (CDC)
www.cdc.gov

Institute for Health care Improvement (IHI)
www.ihl.org

U. K. National Patient Safety Agency (NPSA)
www.npsa.nhs.uk

The Society for Health care Epidemiology of America (SHEA)
www.shea-online.org

World Health Organization (WHO)
www.who.int

Statistics

<http://easycalculation.com/statistics/standard-deviation.php>

Web Resource

Centers for Disease Control and Prevention Self-Study Course: Principles of Epidemiology in Public Health Practice, Third Edition

The introductory self-study course, Principles of Epidemiology in Public Health Practice, Third Edition, is available online. The course provides an introduction to applied epidemiology and biostatistics; it consists of six lessons: Introduction to Epidemiology, Summarizing Data, Measures of Risk, Displaying Public Health Data, Public Health Surveillance, and Investigating an Outbreak. Continuing education credits are offered to physicians, nurses, veterinarians, pharmacists, certified public health educators, and other professionals. The textbook is available at no charge at <http://www.cdc.gov/training/products/ss1000/ss1000-ol.pdf> and the self-study course (SS1000) is available at no charge at http://www2a.cdc.gov/tceonline/registration/detailpage.asp?res_id=1394. [Accessed July 8, 2011]

Chapter 4

Surveillance

Mary-Louise McLaws

Key points

Surveillance:

- should detect changes in patterns of healthcare-associated infections and/or infection prevention and control processes that indicate an infection problem.
- includes data collection to assist in detecting infection patterns (such as infection site, pathogen, and ward) and/or important infection prevention and control processes (hand hygiene, antibiotic use and resistance, and antibiotic prophylaxis).
- is used to assess the performance of healthcare providers.
- is not research, therefore data should be limited to what will be immediately helpful in deciding where to focus infection prevention and control resources.
- is only useful if data are provided in a timely manner to those who need to know so they can improve their quality of care.

What is Surveillance?

An early example of surveillance is the investigation of a cholera outbreak in London in 1854 by John Snow. With the ‘germ theory of disease’ still to be postulated, he used rudimentary microbiology, chemistry, epidemiologic, and statistical analysis to identify the Broad Street water pump as the cause. He recommended removing the pump handle, thereby preventing further consumption of the contaminated water and stopping the outbreak.

Surveillance is often defined as: the systematic observation of the occurrence and distribution of disease within a population and of the events that increase or decrease the risk of the disease occurrence. The reference to “population” is a key distinction between surveillance as used in public health and healthcare-associated infections (HAI).

Routine auditing for HAIs is part of ongoing (*continuous*) surveillance of the incidence cases (i.e., new) of infection. Alternatively, *point prevalence* surveys (i.e., collecting data on existing HAIs and new cases of HAIs that manifest during the surveillance period) may be performed at various frequencies to estimate the magnitude of HAI during a specified period (usually a week or a month). Prevalence surveillance can be as effective as continuous surveillance; it is particularly useful in low-resource countries.

What Should a Surveillance Programme Include?

The aim of surveillance is to reduce the incidence of HAIs. If limited to collection and dissemination of data, the effect will be short lived; it must be followed by relevant interventions. Surveillance programmes should include timely feedback of results. Wider aims of surveillance include:

- identification of problem areas and prioritising infection prevention and control (IPC) activities;
- assisting the development of IPC policy and associated clinical practices;
- detecting changes in the endemicity of an HAI (e.g., methicillin-resistant *S. aureus* - MRSA) or an adverse event (e.g., needle stick injury in healthcare workers);
- detecting changes in compliance with IPC policies (e.g., hand hygiene, timely removal of peripheral intravascular lines);

- detecting outbreaks of adverse events (e.g., food-borne illness);
- establishing the effectiveness of an IPC intervention;
- identifying whether the current programme meets benchmarks for IPC; and
- establishing data for an evidence-based plan to improve care and, if required, to meet accreditation or regulatory requirements.

The strength of surveillance is that it identifies a problem and enables focusing of scarce resources by providing information on the size of the problem and relevant risk factors.

Successful surveillance programs include the ground-breaking Study on the Efficacy of Nosocomial Infection Control (SENIC).¹ This study reported for the first time that hospitals with an effective surveillance program had lower infection rates. Repeated prevalence surveys² or point prevalence surveys³⁻⁵ of HAIs and predisposing factors for HAIs also provide improvement in rates.

Establishing a Framework for Surveillance

A sound infection surveillance framework⁶ includes:

1. Assessing the population
2. Selecting the outcome or process for surveillance
3. Using surveillance definitions
4. Collecting surveillance data
5. Calculating and analysing surveillance rates
6. Applying risk stratification
7. Reporting and using surveillance information

To assist with this framework, consider the following questions:

1. Is it necessary to survey the entire health care facility or only focus on high-risk patient groups/procedures or commonly performed procedures? Recent historical data or a rapid prevalence survey may help focus surveillance activities.
2. Have rates increased in certain groups/procedures/interventions? What is the most important IPC-related process that is likely to be associated with this rate? Should it also be measured?
3. How will a standard, validated, and reproducible definition of infection be applied?

4. Should continuous surveillance or point prevalence surveys be used?
5. Before embarking on continuous surveillance, is there access to historical data? If not, then consider a one-off point prevalence survey as a basis for surveillance activities.
6. How will the data be collected, stored, retrieved, summarised, and interpreted? How will results to clinicians be provided in a timely manner?
7. How will the information be used to continue to lower infection rates?

Types of Surveillance

Continuous surveillance or periodic prevalence surveys

Continuous surveillance is typically undertaken prospectively; it is the best way to establish trends and distribution of disease incidence. Intrinsic risk factors or proxies should also be collected to ensure that rates of HAI have not changed because of these factors rather than clinical practice.⁷ Intrinsic risk factors include age, gender, blood loss, smoking behaviour, immune status, or underlying diseases/conditions that may increase the risk of infection. Simple measures of age and average length of stay (as a measure of severity of illness) may be useful proxy risk factors. Extrinsic risk factors are easier to control; these include hand hygiene, pre-operative length of stay, duration of surgical procedures, surgical teams that include trainees, and pre-operative skin preparation.

Sometimes both intrinsic and extrinsic risk factors can change HAI rates (e.g., increased colonisation with community-acquired *Staphylococcus aureus* in patients combined with poor hand hygiene by healthcare workers). Relevant risk factors should be measured to identify any significant changes; these factors may explain a changed HAI rate and require refocusing of IPC efforts.

Continuous surveillance can be active, passive, or a combination of both. Active surveillance involves daily visits to patient wards/care units to assess patients at-risk of HAI, e.g., surgical site infection (SSI) or central line – associated bloodstream infection (CLABSI). It is expensive because it requires trained staff; therefore it is often performed passively using laboratory reports or reports from ward staff, who can enter data on cards for the IPC practitioner. Positive laboratory reports do not always indicate infection, and negative ones do not always mean infection is absent.

Case finding using active and passive surveillance by an IPC practitioner increases correct detection of HAIs from approximately 25% to >85%.

Whichever method is used, it is important to use the same definitions and data collection method over time so that any change in the rates is not due to changes in methodology. In continuous surveillance, only incidence cases of HAI should be reported.

Prevalence surveys are a good substitute for continuous surveillance, performed ideally on a single day or week. They can show the magnitude of HAI within a health care facility or region, highlight problems requiring more investigation, and identify changing patterns of HAIs. They can be used to target areas or services where infection rates are suspected to be high.

Figure 4.1 illustrates an example of a blank line-list. It is completed during a prevalence survey to collect a minimum amount of data to establish a prevalence rate stratified by type of HAI.

Figure 4.1 Prevalence Survey: Line listing of all patients to be surveyed [modified from http://www.mi-marr.org/LTC_toolkit.html]

Area: _____					
Month / Quarter: _____ Year _____					
Resident/patient Identifiers		HAI (No=0 / Yes=1)	HAI		
Name	Bed Number		Type of HAI	Micro-organism	Antibiotic Treatment

Point prevalence studies have shown that the prevalence of HAIs is approximately 5%-16% depending on the resourcing of the health care setting.³⁻⁵ These surveys can supplement continuous surveillance by focusing on IPC processes (e.g., hand hygiene, prophylaxis, etc.) or be used instead of continuous surveillance where HAIs are rare. For example, data from the laboratory and intensive care unit staff may indicate that an HAI rate is low. Performing a point prevalence survey of processes biannually of all patients with a central line to establish whether clinicians are practicing aseptic insertion techniques may be appropriate.

Prevalence rates differ from those produced by continuous surveillance. The difference depends on the type of HAI. If prevalence and incidence audits were taken simultaneously, the prevalence rate would be higher than the incidence rate for common infections and similar to it for rare infections.

Alert-based surveillance

Alert-based surveillance means monitoring specific clinical conditions, such as infectious diarrhoea, tuberculosis, surgical site infections caused by Group A Streptococcus, or meningococcal meningitis. This is part of the daily work of the IPC team and aims to warn of early outbreaks and allow rapid control procedures. Because this activity is not systematic and relies on data from the laboratory or alerts from ward staff, it does not measure true incidence.

Alert organism surveillance is the continuous monitoring of specific microorganisms (e.g., MRSA, glycopeptide-resistant enterococci, gentamicin-resistant coliforms, *Clostridium difficile* toxin) identified by the microbiology laboratory. Isolation of a microorganism is not necessarily indicative of infection; failure to isolate a microorganism does not prove the absence of infection. Multiple cultures from the same patient must be ignored. Alert organism surveillance is simple and cheap, and, in computerised laboratories, can be automated. It can show trends of specific microorganisms in different wards over time, allowing the IPC team to formulate preventive actions, such as review of antibiotic prescribing.

Post-discharge surveillance

A common question of surveillance programmes is: *Do you need to include post-discharge surveillance in the surveillance plan?* Surveillance for SSIs in

inpatients will underestimate the true rate because around 70% of SSIs manifest after discharge from hospital. This is especially true for countries with short post-operative hospital stays. This bias (i.e., only including current inpatients) is called selection bias.

However, the method chosen to survey discharged patients depends on the patient population (such as their likelihood of returning to their surgeon for follow-up).⁸ All methods will be time-consuming; however, post-discharge surveillance is helpful and provides information about who is more likely to become infected.


A post-discharge surveillance letter is one method used. It is sent home with the patient who is instructed to complete the questionnaire and return it to IPC. An alternative is to send a questionnaire to the patients' medical practitioners; however this can pose logistic problems and may be costly. Regardless, it will be important to highlight outcome data from inpatient or readmission versus that from post-discharge surveillance.

A comprehensive surveillance program, including post-discharge surveillance, will identify more infections and therefore yield a higher SSI rate. Where post-discharge surveillance is inconsistently employed across facilities that routinely make inter-facility comparisons, post-discharge data should be excluded from rates made public. Post-discharge data are most useful for analysis of trends in rates over time.

Important surveillance methodology considerations

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

However, systematic errors can be reduced by using standardised methods. This means the application of valid definitions is reliably performed in the same way every time. Reliability and validity of the definitions of HAIs are two important concepts of surveillance.

This target  illustrates both high validity and reliability – the arrows that hit the true mark illustrate validity and arrows that hit the same spot

on the target each time illustrate repeatability or reliability. If the arrows hit to the side of the target each time then the results would be reliable but not valid.

Definitions for HAI

Definitions should distinguish between HAI and community-acquired infection (CAI). HAIs can be defined generally as *“An infection occurring in a patient during the process of care in a hospital or other health-care facility which was not present or incubating at the time of admission. This includes infections acquired in the health-care facility but appearing after discharge and also occupational infections among health-care workers of the facility”*.⁹ A cut-off point 48 hours after admission is typically used to distinguish between HAI and CAI.

Well-established criteria for HAIs have been developed by the U.S. Centers for Disease Control and Prevention (CDC).¹⁰ These can be modified for settings without pathology services, however all modifications should be documented; modification may alter the comparability between results of surveillance. A set of definitions for HAIs that are less dependent on laboratory testing has been used for residents in long term care facilities.¹¹ The World Health Organization has also developed symptomatic criteria.⁹

What are standards or thresholds for HAI rates?

While the CDC definitions of HAI are commonly accepted, there is no universal definition. Infection rates will vary according to the definition used and comparisons should only be made if the same set of definitions is used and applied in exactly the same manner. Hence, it is often more meaningful to use surveillance data from your own institution to measure trends over time, either to alert staff of increasing problems or to monitor the effectiveness of interventions.

The threshold rate for a specific HAI may be set by previous surveys, followed by discussions with clinicians (e.g., surgical teams) about what target they believe they can achieve. Alternatively, you might identify a threshold from the scientific literature. Published rates largely come from high resource health care systems¹² and may not be appropriate for others.

However, rates for comparison in lower or mixed resourced health care facilities are available from the International Nosocomial Infection Control Consortium.¹³

Surveillance Statistics

Rates

Regardless of whether prevalence or incidence data are collected, the data will form a numerator and denominator used to calculate a rate or provide a measure of important risk factors for each surveillance reporting period. Rates are always calculated with the numerator (number of persons with the infection or condition) divided by the denominator (number of persons at risk for the infection). The more precisely the denominator captures the potentially preventable risk elements the better. Type of HAI (e.g., alert microorganisms and antibiogram) is typically used as numerator. Denominator data should reflect the patient population at-risk in the numerator (e.g., type of HAI). These data are collated separately (stratified) for different sites of infection.

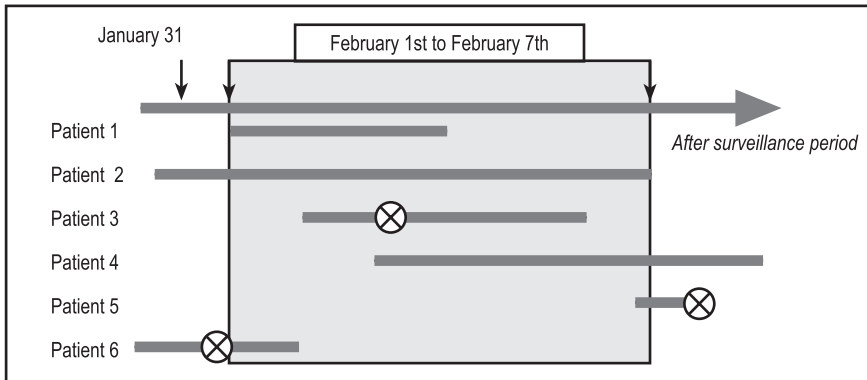
A prevalence measure of HAI is the number of cases of active HAI in a defined patient population during the point prevalence survey. These may be new cases or ones that developed before the survey. The prevalence rate is the proportion of patients in the population who have an active infection at the time of the survey.

Figure 4.2 depicts a short prevalence survey of seven days. Six patients were surveyed, and two had an active infection: Patient-3 developed a new infection during the surveillance period and Patient-6 had an existing infection. Therefore, the number of infections (numerator) would be two for six (denominator) patients. Patient-5 acquired an infection which is not included because it appeared after the last day of the survey.

A prevalence rate can be displayed in the following manner:

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

An incidence measure of HAI is the number of new cases of disease occurring in the defined patient population during the surveillance period.

Figure 4.2 Illustration of new and existing infections

Continuous surveillance measures the cumulative incidence of cases in the population at-risk. In strict epidemiological terms, the denominator for a cumulative incidence rate would be the *number of patients at-risk for the specific HAI at the beginning of the surveillance reporting period*. However, we typically use the *number of patients at risk of the specific HAI during the surveillance reporting period*. An incidence rate can be displayed in the following manner:

Incidence rate (%) = Number of patients diagnosed with new specific HAI during the surveillance reporting period / Number of patients at-risk of the specific HAI during the surveillance reporting period (× 100)

Remember, rates established from prevalence data include new and existing infections and cannot be compared with rates established from continuous surveillance of incidence data which collects only new infections.

Incidence density is a measure of cumulative incidence divided by a unit of risk exposure that is in common for all at-risk patients but that will differ for each patient. For example, the unit of risk may be 24 hours of exposure to an intravascular device; so each patient will have a different number of risk units, i.e., catheter-days. A unit of risk exposure is referred to as person-time. All person-time units are summed for the patients who are reviewed for HAI.

For example, in intensive care units, central catheters generally remain in situ for 4 days but many remain longer. Therefore, a day has been chosen

as the person-time unit. Because incidence density rates are based on an accumulation of person-time units with a statistically rare numerator (e.g., CLABSI) the convention is to multiply the proportion by 1,000 to be expressed as *per 1,000 patient days*.

An incidence density can be displayed in the following manner (using ‘catheter-days’ or ‘patient days’):

$$\text{Incidence density} = \frac{\text{number of new specific HAI during the surveillance reporting period}}{\text{Person-time of susceptible patients at risk during the surveillance reporting period}} \times 1,000$$

Sometimes the person-time denominator can be difficult to collect and may be approximated the same way for each surveillance reporting period. This is an epidemiologic method which ‘averages’ person at-risk time. For example, if you do not have the resources to identify accurately the true number of catheter-days or patient days, you might use an estimate:

$$\text{Incidence density} = \frac{\text{number of new specific HAI during the surveillance reporting period}}{(\text{number of patient-days for first day of the surveillance reporting period} + \text{number of patient-days for the final day of surveillance}) / 2} \times 1,000$$

Note: The term incidence rate usually refers only to cumulative incidence not incidence density.

Sample rates:

$$\text{Rate of catheter-associated urinary tract infection (CAUTI)} = \frac{\text{Number of CAUTI}}{\text{Sum of urinary catheter-days}} \times 1,000$$

$$\text{Rate of CLABSI} = \frac{\text{Number of central line -associated bacteraemia infections}}{\text{Sum of central catheter days}} \times 1,000$$

Utilisation ratio is the number of devices per number of patient-days. This is a measure of the total patient-days in which a high-risk device was used, and can be used as a marker for risk of infection. Remember, calculate the utilisation ratios for each unit with a denominator that should reflect only those patients at-risk.

Examples:

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

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

Frequency of analysis

Incidence data are usually analysed periodically to establish rates, usually calculated as rates at the end of every month or quarter. Prevalence data collected using point prevalence surveys is analysed immediately at the end of the survey to establish a rate that reflects that survey period.

What Happens When the Current Estimate of HAI is Higher than the Threshold?

Rates for a current surveillance period may appear to be higher than the accepted threshold; however, this may be because the sample size does not include every patient (i.e., full population). If every patient is surveyed, the rate reflects a population. If not all patients are evaluated during a survey period (this is most common because patients move beds, are transferred, discharged, or die before being surveyed), then a sample statistic is calculated that reflects the reliability of an 'estimate' of the true rate.

A simple statistic, the 95% Confidence Interval, provides boundaries around the sample rate. Each surveillance period is based on different sample sizes. If the 95% confidence interval includes the threshold rate, then the rate is within acceptable limits.

95% confidence intervals can be calculated from the numerator (number of infections during the surveillance period) and the denominator (infected and non-infected patients who were at risk of the infection during the surveillance period). Software is available to help with calculations – see web resources at the end of the chapter.

Reporting Rates to Clinicians

Surveillance reports should include:

- surveillance reporting period or point prevalence period;

- whether the data are prevalence or incidence measures;
- rationale for surveillance being focused on particular at-risk patients;
- rates calculated separately for specific HAIs;
- threshold rate and source of the threshold; and
- control and prevention action required.

Surveillance results must be provided regularly and in a timely manner to the front-line clinical staff in order to help them choose actions to reduce infection rates.¹⁴ Provide basic descriptive data on the total number of cases (i.e., the numerator), the total number of patients, device-days, etc., (i.e., the denominator) for each rate. Keep records of rates for the previous surveillance period in order to outline if any change was statistically significant.

Summary

There should be a written surveillance plan for the health care facility. It should include definitions used, which HAIs are followed, how data are collected, and the frequency of data collection. It should also outline who is responsible for surveillance activities.

Acknowledgement

This chapter is an update of the earlier one by Dr. Gary French.

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Further Reading

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Web Resources

Epi Info, a free software package can be downloaded from the Centers for Diseases Control and Prevention, <http://wwwn.cdc.gov/epiinfo/html/downloads.htm>, with a desktop calculator version (Epi Info version 6.04) accessed from <http://wwwn.cdc.gov/epiinfo/html/prevVersion.htm>

Alternatively, a free calculator written in Excel is available at www.pedro.org.au/wp-content/uploads/Cicalculator.xls. [Accessed June 20, 2011]

Chapter 5

Outbreak Management

Ossama Raslan

Key points

- Outbreaks of infection should be clearly defined, identified, and promptly investigated because of their importance in terms of morbidity, cost, improvement of patient care, and institutional image.
- Proper steps and effective techniques should be used to investigate a suspected outbreak.
- Clear recommendations should be formulated to prevent further transmission and/or outbreaks.

Introduction

Communicable disease outbreak investigation outlines what an epidemiologist does when investigating disease patterns. Analysis of these patterns leads to an understanding of their spread and control.¹ Outbreaks should be identified and investigated promptly because of morbidity, cost, and institutional image.² Outbreak investigations may lead to improved patient care.

Early identification of an outbreak is also important to limit spread by healthcare workers or contaminated materials. A potential problem may be initially identified by nurses, physicians, microbiologists, or other health care workers, or through an infection surveillance program. Appropriate investigations are required to identify the source of the outbreak and justify control measures.

Definitions

Outbreak or epidemic: An excess over the expected (usual) level of a disease within a geographic area; however, one case of an unusual disease (e.g., postsurgical group A streptococcus infection) may constitute an epidemic.³

Pandemic: An epidemic that spreads in several countries, usually affecting many people.

Endemic: The usual level of a disease within a geographic area (e.g., a hospital); these 'sporadic' infections ("baseline incidence") represent most preventable healthcare-associated infections.

Relative risk: The relative risk (RR) is a measure of association between a disease or condition and a factor under study. It is calculated by dividing the incidence rate of those exposed to the factor by the incidence rate of those not exposed. If the $RR = 1$, the incidence in the exposed group is the same as in the non-exposed; thus there is no association between exposure and disease. $RR > 1$ denotes a larger incidence in the exposed than in the non-exposed; thus exposure seems to increase the probability of developing the disease. $RR < 1$ denotes a smaller incidence in the exposed than in the non-exposed; thus exposure seems to decrease the probability of developing the disease.¹

Case Definition

A case definition should be developed; it must include a unit of time and place and specific biological and/or clinical criteria. The inclusion and exclusion criteria for cases must be precisely identified. A graded definition (definite, probable, or possible) often helps. The definition should differentiate between infection and colonisation.

Example of case definition: A definite case patient will be defined as a patient hospitalised in the geriatric ward during January, with diarrhoea, cramps, and vomiting and in whom routine culture of faeces identifies *Salmonella* species.

Why Epidemics Occur

There are many causes of outbreaks, four common ones are:

1. When susceptible individuals travel into an area where the infectious disease is endemic.
2. When humans or animals travel from an endemic area into a susceptible human population in whom the disease is not endemic, or when food, water, or other vehicles become contaminated by an infectious agent not normally present (e.g., anthrax spores placed into mail as a terrorist act).
3. When a pre-existing infection occurs in an area of low endemicity and reaches susceptible persons as a result of new or unusual social, behavioural, sexual, or cultural practices. Examples include migration of refugees during war time and pilgrimages to religious places.
4. When host susceptibility and response are modified by natural or drug-induced immunosuppression (e.g., cancer treatment, malnutrition, or diseases such as acquired immunodeficiency syndrome).

In health care settings, outbreaks are typically related to hand or environmental contamination, invasive devices, and procedures.

Types of Outbreaks

1. Community-acquired: e.g., food-borne infections, measles.
2. Healthcare-associated: when two or more cases of infection appear to be epidemiologically related.⁴

Investigating an Outbreak

Purpose and objectives of an outbreak investigation

The purpose of an epidemic or outbreak investigation is to prevent further transmission or outbreaks of the disease. The three main objectives are:

1. Identify the causal agent;
2. Find the source of infection by studying the occurrence of the disease among persons, place, or time, as well as determining specific attack rates; and
3. Formulate recommendations to prevent further transmission.

Outbreak investigation tasks

The Infection Control Committee should take the following steps to investigate a suspected outbreak of a communicable disease. These steps provide a guideline and may not proceed in sequence.

Verify if an outbreak really exists

Compare the number of current cases with the usual baseline incidence (from previous months or years). If local data are not available, compare to information from national surveillance systems or the literature (however, these data may not be applicable to the local situation).

Determine if there were changes in case finding or diagnostics

New techniques or laboratory tests may increase identification when historically cases would not have been identified, providing a new 'baseline' of disease.

Establish diagnosis of reported cases (identify agent)

Define cases based on the following common factors:

1. Population risk factors: e.g., age, race, sex, socioeconomic status.
2. Clinical data: e.g., onset of signs and symptoms, frequency and duration of clinical features associated with the outbreak, treatments, and devices.
3. Laboratory results.

Search for other cases that may have occurred retrospectively or concurrently

Collect critical data and specimen information from:

1. Laboratory reports
2. Medical records
3. Patient charts
4. Physicians and nursing staff
5. Public health data

Characterise cases

1. Assemble and organise available information (in terms of time, place, and person) for analysis.
 - a. Time
 - 1) The exact period of the outbreak.
 - 2) The probable period of exposure.
 - 3) Date of onset of illness for cases; draw an epidemic curve.
 - 4) Is the outbreak common source (single point source) or propagated (on-going transmission)?
 - b. Place
 - 1) Service, ward, operating room.
 - 2) Clustering of cases.
 - c. Person
 - 1) Patient characteristics (age, sex, underlying disease).
 - 2) Possible exposures (surgery, nursing and medical staff, infected patients).
 - 3) Therapy (invasive procedures, medications, antibiotics).

From this information, the population at risk can be accurately described.

2. Calculate rates

- a. Incidence rate: The number of new cases occurring in the population during a specified time / number of persons exposed to the risk of developing the disease during that time.¹
- b. Attack rate: The cumulative incidence rate of infection in a

group over a period of an epidemic. The attack rate = Number of people at risk who are infected / Total number of people at risk.

- c. The attack rate can also be stratified by relevant characteristics, such as sex, age, location, or specific exposure (e.g., ventilation, catheterisation, operating rooms, and occupational exposure).²

Formulate a hypothesis about the cause of the outbreak from epidemiological and clinical data

Make a best guess to explain the observations. The hypothesis should explain most cases.

Test the hypothesis

This may require a special study.

1. Many investigations do not reach this stage; investigation may end with descriptive epidemiology and then the problem goes away without intervention or does not require a special study. Whether or not an investigation is carried out, the hypothesis testing phase is a function of available personnel, severity of the problem, and resource allocation.
2. Examples of situations that should be studied:
 - a. Infection associated with a commercial product.
 - b. Infection associated with considerable morbidity (e.g., bacteraemia) and/or mortality.
 - c. Infections associated with multiple services.
For example:
during an outbreak of food poisoning the rate of disease in young adults was 40% and in older individuals was 2%. It was 65% for those who ate in a popular cafeteria and only 3% for those who ate in other places. Therefore younger individuals eating in the popular cafeteria are the ones who should be investigated regarding specific foods eaten.
3. Analyse data derived from case investigation. Determine sources of transmission and risk factors associated with disease.
4. Refine hypothesis and carry out additional studies if necessary.

Institute control measures and follow up

The aims are:

1. To control the current outbreak by interrupting the chain of transmission.
2. To prevent similar outbreaks. Control measures are determined by the results of the initial analysis in consultation with appropriate professionals (i.e., infection prevention and control staff, epidemiologist, clinicians, microbiologists, nurses, and technicians). They will vary depending on the agent, the mode of transmission, and observations.³ (See Table 5.1)

Table 5.1 Immediate control measures for outbreak management

Type of transmission suspected	Suggested action
Contact-Cross-transmission (transmission between individuals)	Patient isolation and barrier precautions
Contact-Hand transmission	Improvements in hand hygiene (e.g., washing, disinfection, glove use)
Airborne agent	Patient isolation with appropriate ventilation
Waterborne agent	Checking of water supply and all liquid containers
Foodborne agent	Elimination of the at-risk food

Evaluate efficacy of control measures

1. Cases cease to occur or return to endemic level.
2. No change (re-evaluate cases).
3. Use the opportunity of an outbreak to review and correct other health care practices which could contribute to future outbreaks.

Communicate and write a final report

During the investigation of an outbreak, timely, up-to-date information must be communicated to administration and public health authorities. In some cases, information may be provided to the public and the media with agreement of the outbreak team, administration, and local authorities.

A final report should be prepared describing the outbreak, interventions, and effectiveness, and summarising the contribution of each team member participating in the investigation. It should include recommendations to prevent any future occurrence.

Determining the Source of Infection

The source of infection may be:

1. Common source (single-point source): Same origin (i.e., the same person or vehicle is identified as the primary reservoir or means of transmission).
2. Propagated or continuing source (ongoing transmission): Infections are transmitted from person to person in such a way that cases identified cannot be attributed to agent(s) transmitted from a single source.
3. Both common and propagated source (intermittent source): Intermittent exposure to a common source produces an epidemic curve with irregularly spaced peaks.

Epidemic curve

The character of an epidemic is determined by an epidemic curve. This is a graph in which cases are plotted according to the time of onset of illness.³

The reasons for constructing an epidemic curve include:

1. To determine whether the source of infection was common, propagated, or both; the shape of the curve is determined by the epidemic pattern.
2. To identify the probable time of exposure of the cases to the source(s) of infection.
3. To identify the probable incubation period.
4. To determine if the problem is ongoing.

Characteristics of an epidemic curve

1. An epidemic curve is a histogram.
2. Cases are plotted by date of onset of illness.
3. Time intervals (on the X axis) must be based on the incubation or latency period of the disease and the length of the period over which cases are distributed.³

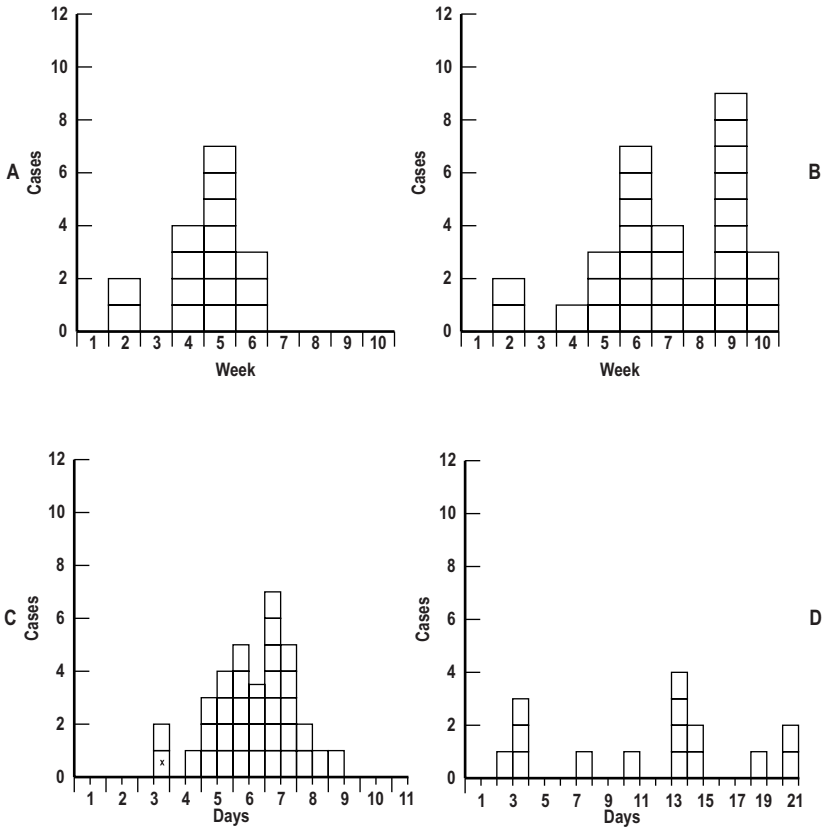


Figure 5.1 Epidemic curves: common vs. propagated source outbreak. [Reproduced with permission from Checko PJ. Outbreak Investigation IN: APIC Text of Infection Control and Epidemiology. 2nd Ed. Association for Professionals in Infection Control and Epidemiology, Washington, DC. 2005; 4: 1-10]

- A. Propagated source: single exposure, no secondary cases (e.g., measles).
- B. Propagated source: secondary and tertiary cases (e.g., hepatitis A).
- C. Common source: point exposure (e.g., Salmonellosis following a company picnic) (food handler = x).
- D. Common source: Intermittent exposure (e.g., bacteraemia associated with contaminated blood product).

Characteristics of common vs. propagated sources

In practice, other information gathered in the course of investigation is used to interpret epidemic curves. (See Figure 5.1) Information required includes the specific disease involved, either mean or median, or minimum and maximum, incubation period(s) for the specific disease, and dates of onset of cases.

Draw epidemic curve and calculate by either of the following methods

1. Using the mean or median incubation period: identify the peak of the epidemic or the date of onset of the median case; count back into one incubation period.
2. Using minimum and maximum incubation periods: start with the first case identified and count back in time the minimum incubation period; then using the last case, count back in time the maximum incubation period.

Common source

1. Curve approximates to a normal distribution curve if there are enough cases and if they are limited to a short exposure with maximum incubation of a few days (common source).
2. Exposure may be continuous or intermittent; intermittent exposure to a common source produces a curve with irregularly spaced peaks.
3. Determination of the probable period of exposure of cases in a common-source outbreak (See Figure 5.2)

Propagated source

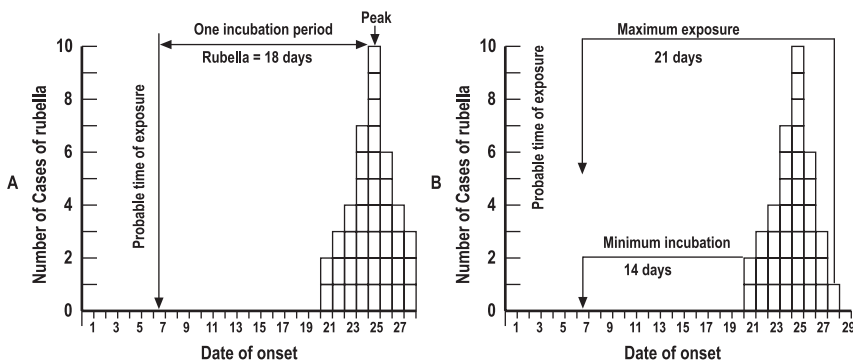


Figure 5.2 Determining the probable period of exposure in common source outbreaks using mean or median incubation period (A) or minimum and maximum incubation periods (B). [Reproduced with permission from Checko PJ. Outbreak Investigation IN: APIC Text of Infection Control and Epidemiology. 2nd Ed. Association for Professionals in Infection Control and Epidemiology, Washington, DC. 2005; 4: 1-10]

1. Cases occur over a long period.
2. Explosive epidemics due to person-to-person transmission may occur (e.g., chickenpox).
3. If secondary and tertiary cases occur, intervals between peaks usually approximate to the average incubation period.

Control Measures and Follow-up

Interventions commonly used to control an outbreak are as follows:

- o Control the source of the pathogen. Remove the source of contamination, e.g., discard contaminated food.
- o Remove persons from exposure, e.g., keep people from being exposed to mosquito bites to prevent West Nile virus encephalitis.
- o Inactivate or neutralise pathogen, e.g., disinfect and filter contaminated water.
- o Treat infected persons.
- o Interrupt transmission.
 1. Patient isolation and barrier precautions determined by infectious agent.
 2. Disinfect environmental sources of transmission, e.g., milk, water, air.
 3. Control mosquito or vector transmission using skin repellents, improve personal sanitation (e.g., washing hands).
- o Control or modify the host response to exposure. Immunise susceptible hosts, use prophylactic chemotherapy, modify behaviour, or use a barrier.

Why Some Outbreaks End

Outbreaks may end for the following reasons:

1. No more susceptible individuals. Everybody who was susceptible got the disease.
2. No more exposure to the source. The individuals move away from the source of infection.
3. No more source of contamination. The source of contamination ends (e.g., all the contaminated food is consumed).
4. Individuals decrease their susceptibility. People get naturally

immunised, are vaccinated, or use preventive measures to avoid disease.

5. The pathogen becomes less pathogenic. Sometimes when microorganisms pass from one individual to another they change or mutate, becoming less pathogenic, or less capable of producing disease.

Conclusion

Performing surveillance, monitoring trends, and detecting outbreaks, investigating outbreaks and eliminating sources, providing technical assistance and education to the medical community, and designing and implementing special epidemiologic studies are important for controlling outbreaks of communicable diseases.

Acknowledgement

We thank Dr. Lamia Fouad, lecturer of Microbiology and Immunology, Ain Shams School of Medicine, Cairo, Egypt, for assistance in preparation of this chapter.

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Chapter 6

Audits in Infection Prevention and Control

Nagwa Khamis and
Gertie van Knippenberg-Gordebeke

Key points

- Audit means checking practice against a standard. It examines the actual situation and compares it to written policies or another benchmark.
- Audit can help to improve health care service by providing a blame-free mechanism for changes in practice. It can also be used for risk assessment, strategic planning, and root cause analysis.
- An audit team is essential to carry out a proper audit through good planning, performance, and feedback of results.
- Audit results may be provided to others through various types of reporting.

Introduction

Healthcare-associated infections are generally related to multiple factors. Prevention of these infections depends on daily vigilance and implementation of infection prevention and control (IPC) practices. These practices are outlined in written guidelines, policies, and procedures.

Audit means checking actual practice against a standard; it should permit reporting of noncompliance or issues of concern by either healthcare workers (HCW) or the Infection Control Team (ICT). Providing results of the audit to staff enables them to identify where improvement is needed.¹ Internal auditing involves monitoring and evaluating the effectiveness of the organisation's risk management process. Risk management involves setting objectives then identifying, analysing, and responding to those risks that could potentially impact the organisation's ability to realise its objectives. Internal auditors can offer advice and help identify emerging risks.²

Internal auditing standards require the development of a plan of audit engagement (project) based on an annually updated risk assessment using the concept: Plan, Do, Study, Act (PDSA). The PDSA cycle is shorthand for developing a plan to test a change (Plan), carrying out the plan (Do), observing and learning from the consequences (Study), and determining what modifications should be made (Act). (See Figure 6.1) Changes in processes often generate audit projects in addition to reviews of documents such as strategic plans.³

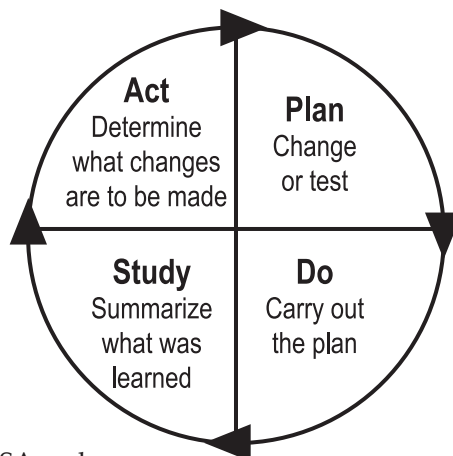


Figure 6.1 The PDSA cycle

There is enormous scope for an audit in IPC. The audit can lead to improvement of services because it provides a blame-free mechanism for changes in practice. The results of audit, when provided back to staff, can turn defects into improvements after appropriate changes are completed.⁴ (See Figure 6.2)

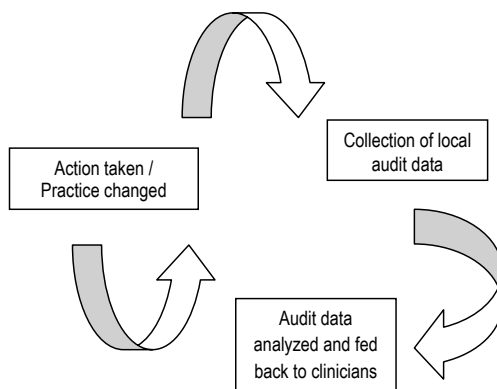


Figure 6.2 The PDSA cycle

Audit tools are commonly referred to as “quality improvement tools”.⁴ They are templates for ICTs to evaluate implementation of standard procedures, such as hand hygiene, isolation precautions, environmental cleaning, disinfection or sterilisation of equipment, handling linen/waste/sharps/supplies, etc., in their facility. In addition, specific practices may be monitored, e.g., use of personal protective equipment, insertion and care of intravascular, respiratory and urinary devices, and wound care. Operating room observations for practices such as patient preparation, hair removal, surgical team scrub, and prophylactic antibiotic use, may also be included. The audit can be performed by the ICT or other designated staff. The audit tool must match the recommended practices and resources of the health care setting.¹

Audit Method

Initially it is probably worth selecting a few areas to audit, preferably those that are most important to the organisation. These may include high-risk areas highlighted through surveillance results or occurrence of outbreaks. An effective audit should include a description of the physical layout; review of traffic flow, protocols and policies, supplies and equipment; and observation of appropriate IPC practice.

The audit should take place over a defined time.¹ A rapid audit cycle plan can be completed in a few days and the results provided very quickly.⁴ (See Table 6.1) In addition to the rapid cycle plan, an annual plan may be useful.⁴ (See Table 6.2) Link personnel and ward staff may assist with the process.¹

Table 6.1 Rapid Cycle Audit Plan

Day	1	2	3	4	5	6	7	8
Environment								
Hand hygiene								
Indwelling lines								
Urinary catheters								

Preparation of Audit Team

All HCWs and support staff must be included in preparing for an audit. They need to understand that its purpose is to improve IPC practice. It is in no way punitive or a search for weaknesses. Pre-audit meetings are essential to explain and discuss the goals and objectives of the audit, how it will be conducted, and how the results will be reported.

Staff should understand that an objective approach will be maintained, that the audit will be performed consistently across the facility, and anonymity will be protected. The audit team must identify the leaders in the area being audited and continue communication with them. Management and other key decision makers (e.g., educators) need to support the audit team in any changes required post-audit.

Knowledge Assessment

A questionnaire on employees’ knowledge of safe IPC practice should be developed and distributed prior to any audit.⁵ The questionnaire can assist in determining what areas of practice should be audited. Respondents should be identified only by job title (e.g., nurse, physician, radiographer, cleaner, etc.). The questionnaire can be modified to suit the department or area being audited. A deadline must be provided so that questionnaires are returned on time. One person in each survey area should be asked to

ensure that questionnaires are completed and kept securely for collection and tabulation by the audit team. The results will allow the ICT to determine where additional education is needed. Dissemination of results and discussion of the correct answers can be used as an educational tool.

Basic Principles

Bundles

A bundle is a multi-model structured way of improving processes of care and patient outcomes. A bundle is a collection of processes needed to effectively and safely care for patients undergoing particular treatments with inherent risks. Several interventions are “bundled” together and, when combined, significantly improve patient care outcomes. Bundles are helpful and have been developed for ventilator-associated pneumonia, catheter-associated urinary tract infection, and central line-associated bloodstream infection prevention.⁶ A bundle pack includes:

1. A statement of commitment for the clinical team to sign.
2. A cause-effect chart describing the evidence for optimal practice⁷ (See Figure 6.3) and used also for root cause analysis of non-conformities, in reference to the standards.
3. Standard operating procedures for the bundle including specific criteria.
4. A data collection sheet.
5. Explanation of the bundle to the clinical staff (e.g., group discussion, slide presentation)

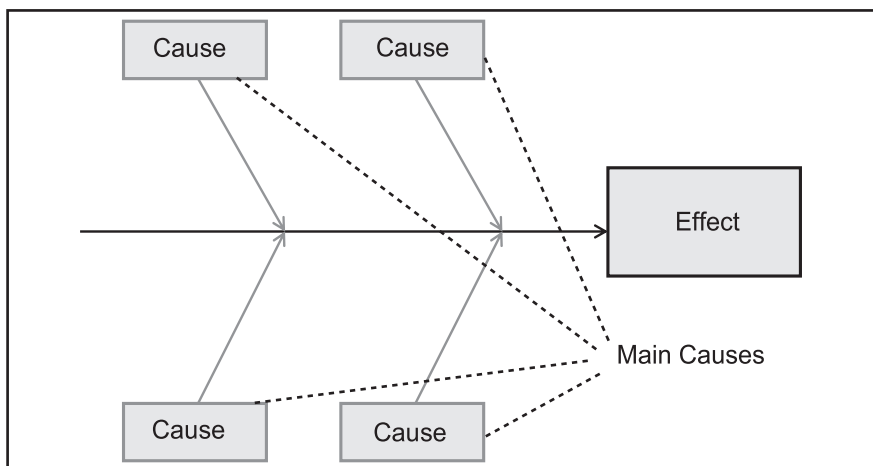


Figure 6.3 Fish-bone type of Cause and Effect diagram

The bundle typically consists of a small (usually three to five) critical set of procedures, all determined by robust evidence, which when taken together create improved outcomes. Successfully completing each step is a straightforward process and can be audited.⁸

Types of audits

Toolkits to carry out different types of audits in health care settings are available.

- The Community and Hospital Infection Control Association-Canada audit toolkit.⁹
- World Health Organization audit toolkits.¹⁰

They include, but are not limited to:

- Hand hygiene (readiness and practice; supplies such as soap, paper towel, alcohol-based products).
- Use of standard precautions/routine practices.
- Use of isolation/precautions.
- Use of personal protective equipment.
- Monitoring of sterilisation equipment.
- Cleaning, disinfection, and sterilisation of reusable equipment and devices, such as bronchoscopes and surgical instruments.
- Health care environment cleaning.
- Haemodialysis practices, equipment, facility.
- Operating room IPC practices, asepsis and preoperative antisepsis, traffic control, patient skin preparation, hair removal, surgical scrub, and prophylactic antibiotics.
- Practice and medical device reprocessing in clinics and physician offices.
- Occupational health issues, such as, sharps injuries/needle sticks, vaccination rates.
- Outbreak management.
- Self-audit tool for ICT.

The data derived from audits can be used to direct the IPC program's annual goals and objectives. It also assists in meeting the needs of the health care setting in relation to IPC standards and safer health care practices.

Reports

Once the audit is completed, a draft, detailed report must be written and

reviewed with management and key staff in the audit area before it is finalised and distributed. The report should include information on why the audit was performed, method used, findings, and recommendations. Compliance data should be included as appropriate.¹ Reporting of audits could be in the form of:

Weekly reports: Providing rapid feedback on incidental issues while they are still fresh (e.g., during outbreaks or after occupational sharp injuries).

Monthly reports: A monthly report should include sections about surveillance, audit results, education, training, and consultations.

Quarterly reports: These are formal reports including recommendations and management of issues.

Annual reports: A summary of audits carried out during the year and the resulting improvement or changes during the rapid and annual audit plans, illustrated as appropriate with graphs.

Staff must learn to appreciate that the intent of audits is to promote good practice, improve patient care, and ensure safety. A key person must be identified in each area to help facilitate implementation of any recommendations within a specified time.⁴

Behavioural Change

Review of prevailing behavioural theories and their application to health professions is recommended in an attempt to understand how to target more successful interventions.¹¹ In hand hygiene, although behavioural theories and secondary interventions have primarily targeted individual workers, this might be insufficient to produce sustained change.¹² Interventions must account for different levels of behavioural interaction.¹³ Thus, the interdependence of individual factors, environmental constraints, and the institutional climate must be taken into account in the strategic planning and development of programs, e.g., hand hygiene campaigns.¹¹

Factors necessary for change include 1) dissatisfaction with the current situation, 2) perception of alternatives, and 3) recognition, both at the individual and institutional level, of the ability and potential to change.

Table 6.2 An Annual Audit Plan

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
MRSA admission screening												
Hand hygiene												
Antimicrobial policy												
Disposal of sharps												
Disinfection policy												
Central processing policy												
Aseptic techniques in operating room												
Surveillance												

Although the latter implies education and motivation, the former two necessitate a system-wide change.

Guidelines

IPC audits ensure that written guidelines are in place for each procedure. These guidelines must be current, acceptable and practical, and used in developing the IPC program’s policies and procedures.

An audit checks whether these guidelines are being followed in actual practice. This can be accomplished by auditing practices with “Staff Interviews” and “Observational Tours”. This latter form of auditing is relatively simple, albeit time-consuming. Developing an audit calendar for planning the audit cycle may be useful from a time management perspective.⁹ (See Tables 6.1 and 6.2)

Summary

Health care requires an increased emphasis on the use of audits to measure the implementation of policies and procedures relating to IPC practices. Development of audit plans based on a risk assessment strategy, preparation of the audit team, tailoring of the audit method, and audit assessment of knowledge are pillars of internal audits in health care organisations.

The data from audits can be used to direct the IPC program to target more successful interventions. Audit reporting includes recommendations and guidelines to create a safer environment and to minimise the risk of healthcare-associated infections.

Acknowledgement

This chapter is an update of the earlier one by Dr. E. Bryce, S. Sharf, G. van Knippenberg-Gordebeke and M. Walker.

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Chapter 7

The Role of the Microbiology Laboratory

Smilja Kalenic

Key points

- Microbes are infectious agents that are not visible to the naked eye; they are widespread in nature. Some cause human diseases. They are divided into bacteria, fungi, viruses, prions and protozoa. Macroscopic parasites are also included.
- Diagnosis of infection by the microbiology laboratory has two important functions: clinical and epidemiological.
- The microbiology laboratory should be able to determine the most frequent microbes causing healthcare-associated infections, and perform at least some basic typing.
- The microbiology laboratory should produce routine reports for infection prevention and control personnel to develop incidence graphs for specific pathogens, antibiotic resistance, wards, and groups of patients.
- Microbiologists, knowing the role of normal colonising flora of humans, the pathogenesis of infections, and the characteristics of specific pathogens can interpret microbiological findings for infection prevention and control personnel.

Basics of Microbiology¹⁻⁷

Microbes are infectious agents that are invisible to the naked eye. They are divided into bacteria, fungi, viruses, prions and protozoa. Microbes are ubiquitous, living as free organisms in the environment or on/in plants, animals and humans, either as normal flora (not harming them) or pathogens (causing disease). While some microbes are confined to one host, most can live on/in a wide array of hosts in nature. Plant microbes are harmless to humans, however some animal microbes can cause disease (zoonotic diseases).

When a microbe finds a new host and starts to multiply, this phenomenon is usually called colonisation. The microbe can remain in balance with the host and no disease will develop. However, if the microbe causes disease, this is called an infectious disease (infection).

Microbes that usually cause disease in a susceptible host are called primary pathogens. Microbes that live as normal flora of humans or live in the environment and do not harm a healthy host – but can cause disease in an immunocompromised host – are called opportunistic pathogens. When we encounter unusual microbes on skin and non-living surfaces/items, we call it contamination.

Infection can be asymptomatic or symptomatic. After infection, microbes can remain present for some time in the host and may be passed on to others, although the person is clinically completely healthy. This state is called a “carrier state” and such persons are called “carriers”.

If infection is caused by microbes that are part of one’s normal flora, we call it endogenous; an exogenous infection is caused by microbes that are not part of the normal flora.

Microbes are transmitted from one host to another by a number of pathways including: air, water, food, live vectors, indirect contact with contaminated items or surfaces, or direct contact with different hosts. To cause an infectious disease, a microbe must first enter the human body, either through the respiratory, gastrointestinal or genitourinary tract, or through damaged or even intact skin. Microbes usually multiply at the site of entry, then enter through mucous membranes to tissue and sometimes

to blood. When in blood, they can spread throughout the body and enter any organ.

After multiplication, microbes usually leave the body, either through respiratory, gastrointestinal or genitourinary discharges, and seek a new host. Some are transmitted by insect vectors that feed on human blood. Knowing how an infection develops is essential for clinical diagnosis and for timing and ordering the right specimen for microbiological diagnosis, as well as for taking proper measures to prevent its spread.

Bacteria

Bacteria are the smallest organisms with all the functions of life. They multiply by simple division from one mother cell to two daughter cells. When multiplying on a solid surface, they form “colonies” that are visible with the naked eye. The genetic material (DNA) is situated in one circular chromosome and several independent units called plasmids. The chromosome is haploid (only one DNA chain) so every variation can be easily expressed phenotypically.

Genetic material is transferred vertically by cell division, and also horizontally between different bacteria. The latter is especially important when antibiotic resistance genes are transferred. Most bacteria are readily adaptable to any kind of environment. All pathogenic and most opportunistic bacteria have constituents that act as virulence factors, which are important in the development of infectious diseases.

Some bacteria can become dormant by forming spores, which have a strong protective coat, and are the most resistant form of life we know – if the conditions for a vegetative form is unfavourable. When conditions are once again favourable, vegetative forms of the bacteria develop.

Table 7.1 outlines the main groups of pathogenic and opportunistic bacteria that can cause healthcare-associated infections (HAI). Included are their usual habitat, survival in the environment, mode of transmission, infections they cause, and main HAI prevention methods.

Table 7.1. The most widely used chemical disinfectants in healthcare

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection/ colonisation	Main preventive measures
<i>Acinetobacter baumannii</i>	MDR strains	Humans: moist parts of skin, gastrointestinal tract	3 days - 5 months	Air; indirect** and direct contact	UTI, sepsis, meningitis, pneumonia	Urine, blood, CSF, sputum, aspirates	Clean environment, clean instruments, clean hands
<i>Bordetella pertussis</i>		Humans: nasopharyngeal mucosa (patients)	3 - 5 days	Droplets	Pertussis	Nasopharyngeal swab	Source isolation
<i>Campylobacter jejuni, C. coli</i>		Humans, animals: gastrointestinal tract	Up to 6 days	Faecal-oral, water, food	Diarrhoea	Stool	Safe food and water, clean hands
<i>Clostridium difficile</i>		Humans: gastrointestinal tract	Highly resistant (spores – 5 months)	Faecal-oral; indirect and direct contact	<i>Clostridium difficile</i> infections (CDI)	Stool	Clean environment, clean hands of healthcare workers and patients; prudent use of antibiotics

Bacteria	Multi drug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare-associated infections	Specimens for diagnosis of infection/colonisation	Main preventive measures
<i>Clostridium tetani</i>		Environment: earth, dust	Highly resistant (spores)	Entering umbilical cord wound (on dirty instruments)	Tetanus		Sterilisation of instruments for umbilical cord
<i>Coagulase negative staphylococci</i> (CNS)	Methicillin-resistant <i>S. epidermidis</i>	Humans: skin, mucous membranes	ND	Contact (direct, indirect); endogenous	Different infections in immunocompromised host	Different specimens depending on infection	Clean hands, clean environment, clean equipment
<i>Corynebacterium diphtheriae</i>		Humans: nasopharyngeal mucosa (patients, carriers)	7 days – 6 months	Droplets, contact (direct, indirect)		Nasopharyngeal swab	Source isolation (vaccination)
<i>Enterococcus</i> species	Glycopeptide-resistant Enterococcus	Humans: gastrointestinal tract, genitourinary tract	5 days – 4 months	Indirect and direct contact; endogenous	UTI, sepsis	Urine, blood	Clean environment, clean hands; avoid the use of cephalosporins

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection/ colonisation	Main preventive measures
<i>Enterobacter species</i>	Extended spectrum beta lactamase, MDR	Environment, human gastrointestinal tract	5-49 days	Contact, food	UTI, sepsis, wound infection	Urine, blood, wound exudate	Clean hands, clean environment, clean equipment
<i>Escherichia coli</i>	Extended spectrum beta lactamase- strains	Humans: gastrointestinal and genitourinary tract	1.5 hours – 16 months	Faecal-oral, indirect and direct contact, food, water, endogenous	UTI, sepsis, pneumonia, peritonitis, neonatal meningitis	Urine, blood, sputum, aspirates, CSF, wound exudate	Clean hands, safe food and water; prudent use of antibiotics (avoiding the use of 3rd generation cephalosporins)
<i>Helicobacter pylori</i>		Gastric mucosa of humans	Less than 90 minutes	Contaminated gastrointestinal endoscopes	Acute and chronic gastritis	Biopsy material; urea breath test; stool for antigen detection	Properly disinfected gastrointestinal endoscopes
<i>Klebsiella pneumoniae</i>	ESBL strains Carbapenem resistant strains	Humans: gastrointestinal tract; humid environment	2 hours – more than 30 months	Indirect and direct contact, endogenous	UTI, sepsis (neonatal units), pneumonia	Urine, blood, sputum, aspirates	Clean hands; prudent use of antibiotics (avoiding the use of 3rd generation cephalosporins)

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare-associated infections	Specimens for diagnosis of infection/colonisation	Main preventive measures
<i>Legionella pneumophila</i>		Water (natural water, tap water, shower heads, cooling towers, hot water tanks, humidifiers, respiratory therapy equipment)	NA	Aerosols from environmental water sources (usually warm water in hospitals) no person-to-person transmission	Legionnaire's disease	Sputum, blood for serology	No patient isolation needed; hyperchlorination of water or heating to at least 55°C
<i>Listeria monocytogenes</i>		Soil, vegetables, human gastrointestinal tract (rarely); human birth canal	1 day - months	Contaminated food; perinatal transmission; contact with contaminated equipment in nurseries	Meningitis, bacteremia	Blood, CSF	Safe food, clean equipment in nurseries
<i>Mycobacterium tuberculosis</i>	MDR strains, Extremely drug resistant strains (XDR)	Respiratory tract of patients	1 day - 4 months	Airborne, droplets	Tuberculosis	Sputum	Source isolation (Vaccination)

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection/ colonisation	Main preventive measures
<i>Neisseria meningitidis</i>		Nasopharyngeal mucosa of humans	ND	Droplets	Acute meningitis	CSF	Source isolation, Chemoprophylaxis (Vaccination against groups A,C, Y, W135)
<i>Proteus species</i>	ESBL	Gastrointestinal flora of humans	1 - 2 days	Endogenous, contact (direct and indirect)	UTI, sepsis	Urine, blood	Clean hands, clean environment, clean equipment
<i>Pseudomonas aeruginosa</i>	MDR and poly-drug resistant (PDR) strains	Humans: gastrointestinal tract, humid skin regions; ubiquitous in humid environment, (water, soil, plants)	6 hours to 16 months	Direct and indirect contact (humid items: poorly disinfected items, ventilator circuits)	Different, usually severe infections in hospitalised, especially immunocompromised patients	Different specimens depending on infection	Clean, dry environment, disinfected/sterilised instrument and equipment; clean hands, prudent use of antibiotics

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection/ colonisation	Main preventive measures
<i>Salmonella</i> species		Gastrointestinal tract of humans and animals	1 day	Faecal-oral, water, food	Diarrhoea, sepsis	Stool, blood	Safe food and water, clean hands
<i>Salmonella typhi</i>		Gastrointestinal tract of humans	6 hours – 4 weeks	Faecal-oral, water, food	Typhoid fever	Stool, blood	Safe food and water, clean hands
<i>Salmonella typhimurium</i>		Gastrointestinal tract of humans and animals	10 months – 4.2 years	Faecal-oral, water, food	Diarrhoea, sepsis	Stool, blood	Safe food and water, clean hands
<i>Serratia marcescens</i>		Humans: gastrointestinal tract; humid environment	3 days – 2 months; on dry floors 5 weeks	Indirect and direct contact, contaminated intravenous fluids (especially heparin solutions)	Sepsis, wound infection	Blood, wound exudate	Clean hands, clean environment, clean equipment
<i>Shigella</i> species		Gastrointestinal tract of humans	2 days – 5 months	Faecal-oral, water, food	Diarrhoea	Stool	Safe food and water, clean hands

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection/ colonisation	Main preventive measures
<i>Staphylococcus aureus</i>	MRSA	Humans: skin, mucous membranes	7 days - 7 months	Droplets, direct and indirect contact, medical equipment, endogenous	Skin infections, pneumonia, sepsis, osteomyelitis	Swabs, sputum, blood, aspirates, biopsy, wound exudate	Clean hands, clean environment; prudent use of antibiotics (ciprofloxacin)
<i>Streptococcus agalactiae</i> (Group B streptococcus)		Humans: birth canal	ND	Intrapartum; direct and indirect contact in delivery room and nurseries	Sepsis and meningitis of newborn	Blood, CSF	Antibiotic prophylaxis during delivery when indicated; clean hands
<i>Streptococcus pyogenes</i> (Group A streptococcus)		Humans: oropharyngeal mucosa	3 days - 6.5 months	Droplets, contact, endogenous	Pharyngitis ("strep throat"), surgical wound infection	Oropharyngeal swab, wound exudate	Surgical masks in the operating room

Bacteria	Multidrug resistant strains (MDR)	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare-associated infections	Specimens for diagnosis of infection/colonisation	Main preventive measures
<i>Vibrio cholerae</i>		Gastrointestinal tract of humans; water	1 – 7 days	Faecal-oral, water, raw seafood	Cholera	Stool	Safe water and food
<i>Yersinia enterocolitica</i>		Gastrointestinal flora of many animals, causes diarrhoea in young animals; rarely - humans as carriers	ND	Blood transfusion in hospitals; faecal-oral in the community	Bacteremia connected to blood transfusion; (diarrhoea in the community)	Blood, stool	Safe blood products

* Survival is better if conditions are humid for most organisms (exception being *Staphylococcus aureus*), if microorganism is in biological material (blood, faeces, wound exudate), if the temperature is lower, and if bacteria are in higher numbers

** whenever indirect contact is involved, it is most frequently by hands of healthcare workers

ND = not done

NA = not applicable

UTI = urinary tract infection

CSF = cerebrospinal fluid

Fungi

Fungi are unicellular (yeasts) or multicellular (moulds) microorganisms that are widespread in nature. Their cell is so-called “eukaryotic” that means they have DNA packed in the nucleus, like plants and animals. Their chromosome is diploid, so the variations in genome are not as easily expressed phenotypically as in bacteria. Some yeast is part of the normal flora in humans, while moulds are usually living free in nature.

Yeasts multiply by budding a new cell from the mother cell (blast conidia), while moulds multiply both asexually (conidia) and sexually (spores). It is important to remember that fungal spores are not as resistant as bacterial spores. Growth on a solid surface will lead to the formation of colonies. Some pathogenic fungi can live as a yeast (in the host) and as a mould (in the environment); they are called dimorphic fungi.

Table 7.2 outlines the main groups of fungi that can cause HAIs with their usual habitat, survival in the environment, mode of transmission, infections they cause, and main HAI prevention methods.

Viruses

Viruses are the smallest infectious agents, however they require living cells (bacterial, plant, or animal) for reproduction. Outside a living cell, viruses can survive, but not multiply. They consist of either DNA or RNA, protected by a protein coat; some viruses also have a lipid envelope outside the protein coat.

When a virus enters a host cell, viral nucleic acid (NA) makes the cell synthesise viral proteins and NA. It then assembles and exits the host cell to enter other host cells. During this process, host cells are damaged or destroyed and signs and symptoms of infectious disease appear. Infection can also be asymptomatic. Some viruses can incorporate their DNA into the host DNA, or can live in host cells causing no harm – these latent infections sometimes become re-activated.

Table 7.3 outlines the main groups of viruses that can cause HAIs with their usual habitat, survival in the environment, mode of transmission, infections they cause, and main HAI prevention methods.

Prions

Prions are protein particles; they do not contain any NA. They are known to be connected with some neurological diseases (Creutzfeldt-Jakob disease – familial spongiform encephalopathy; variant Creutzfeldt-Jakob disease – bovine spongiform encephalopathy, and some other diseases). Prions are highly resistant to the usual methods of disinfection and even sterilisation. There is a possibility of iatrogenic transmission of these diseases through transplantation, or contamination of instruments with brain tissue, dura mater, or cerebrospinal fluid of diseased persons.

Parasites

Parasites include protozoa, i.e., unicellular microorganisms with a eukaryotic diploid nucleus that can live free in nature, and/or in animal hosts including humans. Some of them cause infections. There are also helminths (worms) that cause infections – known as infestations. Although many parasites are widespread in the world and cause some of the most important community-acquired infections (malaria, ascariidosis, etc.), not many cause HAIs.

Table 7.4 outlines the main groups of parasites that can cause HAIs with their usual habitat, survival in the environment, mode of transmission, infections they cause, and main HAI prevention methods. There is a group of animals – insects and arthropods – that transmit microbes (viruses, bacteria, parasites) between humans or between animals and humans. Some of them can also cause disease in humans. One such arthropod is *Sarcoptes scabiei* causing scabies in humans. Scabies is a highly contagious skin disease that can be spread rapidly in a health care institution unless very vigorous containment measures are instituted.

Role of the Microbiology Laboratory

The diagnosis of infections performed by the microbiology laboratory has two important functions. The first is clinical - everyday management of infections. The second is epidemiological - knowledge of an infective microbe in a patient can lead to finding its source and route of transmission. This allows staff to stop infections from spreading. Furthermore, the microbiology laboratory interprets microbiology data for clinicians and for infection prevention and control (IPC) professionals, thus participating in healthcare worker (HCW) education and the facility's antibiotic policy.

Table 7.2. Characteristics of main groups of fungi potentially causing healthcare-associated infections

Fungi	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare-associated infections	Specimens for diagnosis of infection / colonisation	Main preventive measures
<i>Candida albicans</i> (yeast)	Soil, animals, humans, inanimate objects	1 - 120 days	Direct and indirect contact, endogenous	Different opportunistic infections	Different specimens depending on infection	Clean hands, clean equipment
<i>Candida glabrata</i> (yeast)	Soil, animals, humans, inanimate objects	120 - 150 days	Direct and indirect contact, endogenous	Different opportunistic infections	Different specimens depending on infection	Clean hands, clean equipment
<i>Candida parapsilosis</i> (yeast)	Soil, animals, humans, inanimate objects	14 days	Direct and indirect contact, endogenous	Different opportunistic infections	Different specimens depending on infection	Clean hands, clean equipment

Fungi	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection / colonisation	Main preventive measures
<i>Aspergillus</i> species (mold)	Ubiquitous in soil, water, food, decaying material, outdoor and indoor air	Conidia and spores are resistant forms	Inhalation, (contact)	Pneumonia, disseminated infections in severely immunocompromised patients	Sputum, different other specimens depending on infection	Reverse/protective isolation of susceptible patients
<i>Mucor</i> (mold)	Soil, plants, fruits, animal excreta, food	Conidia and spores are resistant forms	Inhalation	Different opportunistic infections in immunocompromised patients (zygomycosis)	Different specimens depending on infection	Reverse/protective isolation of susceptible patients; safe food and drinks
<i>Rhizopus</i> (mold)	Soil, plants, fruits, animal excreta, food	Conidia and spores are resistant forms	Inhalation	Different opportunistic infections in immunocompromised patients (zygomycosis)	Different specimens depending on infection	Reverse/protective isolation of susceptible patient; safe food and drinks

* Survival is better at low temperature, high humidity, and presence of serum or albumin

Table 7.3. Characteristics of main groups of viruses potentially causing healthcare-associated infections

Virus	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection **	Main preventive measures
Adenovirus Several types	Humans, water, fomites (e.g. ophthalmological equipment and solutions), environment	7 days – 3 months	Direct and indirect contact	Eye infections, respiratory infections	Serum sample	Individual eye drops
Coronavirus, including severe acute respiratory syndrome (SARS) virus	Humans	3 hours SARS virus: 72-96 hours	Droplets	Respiratory infections	Serum sample	Source isolation, clean environment, clean hands
Coxsackie B virus	Humans	>2 weeks	Faecal-oral; direct and indirect contact	Generalised disease of newborn	Serum sample	Clean hands, clean environment
Cytomegalovirus	Humans	8 hours	Blood products, tissue and organs for transplantation; mucosal contact with secretions and excretions	Huge range of different diseases	Serum sample	Safe blood products and tissues/organs for transplantation

Virus	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection **	Main preventive measures
Hepatitis A virus	Humans	2 hours – 60 days	Faecal-oral	Hepatitis A	Serum sample	Clean hands, clean environment, safe food and water
Hepatitis B virus	Humans	>1 week	Blood, bodily fluids, tissue and organs for transplantation	Hepatitis B	Serum sample	Safe blood products and tissues/organs for transplantation
Hepatitis C virus	Humans	NA	Blood, bodily fluids, tissue and organs for transplantation	Hepatitis C	Serum sample	Safe blood products and tissues/organs for transplantation
Herpes simplex virus	Humans	4.5 hours – 8 weeks	Droplets, close contact	Different mucosal and skin infections	Serum sample	If infected, HCW should not care for susceptible persons (newborn, immunocompromised)
Human immunodeficiency virus	Humans	>7 days	Blood, bodily fluids, tissue and organs for transplantation	Acquired immune deficiency syndrome	Serum sample	Safe blood products and tissues/organs for transplantation

Virus	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection **	Main preventive measures
Influenza virus	Humans	1-2 days	Droplets, direct and indirect contact, HCW as symptomatic or asymptomatic	Influenza	Serum sample	Source isolation; HCW vaccination
Norovirus	Humans	8 hours – 7 days	Faecal-oral, direct and indirect contact, aerosols from vomitus	Diarrhoea	Stool	Clean hands, clean environment, safe food
Respiratory syncytial virus	Humans	Up to 6 hours	Droplets, direct and indirect contact	Acute respiratory infections in young children	Nasopharyngeal exudate	Source isolation, clean hands, clean environment
Rotavirus		6-60 days	Faecal-oral, direct and indirect contact	Diarrhoea	Stool	Clean hands, clean environment
Rubula virus (mumps)	Humans	ND	Droplets	Mumps (parotitis)	Serum sample	Source isolation, vaccination

Virus	Habitat	Survival in the environment (dry surfaces)*	Transmission in healthcare	Healthcare - associated infections	Specimens for diagnosis of infection **	Main preventive measures
Rubivirus (rubella)	Humans	ND	Droplets	Rubella (German measles)	Serum sample	Source isolation, vaccination
Morbillivirus (measles)	Humans	ND	Droplets	Measles	Serum sample	Source isolation, vaccination
Varicella-zoster virus	Humans	ND	Droplets, close contact	Varicella	Serum sample	Source isolation, HCW vaccination

* Survival is better at low temperature, presence of biological material and if viruses are in higher numbers

** Diagnosis is mostly done by serology. If laboratory can perform direct diagnostics, it will be by antigen detection or nucleic acid detection in the sample from infectious site

NA = not applicable

ND = not done

HCW = healthcare worker

Clinical role

Some infections must be diagnosed clinically and treated empirically (acute meningitis, sepsis, or severe pneumonia), without previous isolation of causative microorganisms or determination of antibiotic susceptibility. However, if there is a clinical suspicion of infection, laboratory tests may confirm the diagnosis and suggest the correct treatment (especially as most HAIs are caused by bacteria and fungi that are more antibiotic resistant than community-acquired pathogens). Targeted antimicrobial therapy leads to better patient outcomes, and as eradication of a pathogen is achieved earlier, the danger of transmission to other patients will be decreased.

Microbiology is becoming more important in clinical medicine and in the prevention of HAIs, especially as new or antibiotic-resistant pathogens emerge, and new diagnostic technologies are developed. The microbiology laboratory should be able to diagnose the commonest infectious agents, especially those causing HAIs, and determine susceptibility to antibiotics for bacteria and fungi (See Tables 7.1 and 7.2).

The right specimens from appropriate sites must be taken using proper techniques (See Tables 7.1-7.4). Specimens should be sent to the laboratory as quickly as possible. Microbiology laboratory staff can assist in ensuring good specimens by educating other staff. Identification of the microorganism and its antibiotic susceptibility should be as precise as possible (identification to the species level).

Microbiological diagnostic methods can be divided into direct methods (smear from specimens, isolation of infectious agents on culture media, or evaluation of microbial antigens or NAs in a specimen) and indirect methods – evaluation of an immune response by the patient to the infectious agent (serology). The latter is usually used for diagnosis of difficult to isolate bacteria and most viruses; however antibodies take at least 10-14 days to develop. Therefore, serology is mostly an epidemiological method, with the clear exception for some viral diseases where a diagnosis of acute infection can be based on immunoglobulin class M, or avidity of class G, or a combination of antibodies to different viral antigens.

An important new technology in microbiology is molecular diagnostics. Diagnosis can be rapid because it does not require microbial growth in

cultures. It is sensitive, as it can detect a small number of microorganisms. It is specific, as it detects microbe-specific genes. However expensive machines and reagents are required – beyond the reach of many laboratories.

Infection prevention and control role⁸⁻¹²

The microbiology laboratory has many roles in the control of HAIs: outbreak management, performing additional epidemiological tests, bacterial and fungal typing, HAI surveillance, and reports about new alert microbes or unusual resistance to antimicrobials. In some countries, the microbiology laboratory is responsible for reporting infections to public health departments.

The laboratory can educate both clinical and IPC personnel about microorganisms and their role in infections, especially in HAIs. Furthermore, daily communication of laboratory staff with the Infection Control Team (ICT) is vital, allowing for timely and rapid information transmission about causative agents of HAIs. The clinical microbiologist should ideally be a member of the Infection Control and Antibiotic Committees and a member of the ICT.

Outbreak investigation

Sometimes the ICT requires additional data to clarify endemic or epidemic situations. Microbiological tests of blood products, environmental surfaces, disinfectants and antiseptics, air, water, hands of personnel, anterior nares of personnel, etc., may be necessary. During an outbreak or in endemic situations when the causative agent is known, the microbiology laboratory can use selective media for the agent in question to minimise expense. To determine the cause of a single-source outbreak, the causative microorganism must be defined.

Typing of bacteria and fungi

Microorganism typing determines whether two epidemiologically connected strains are really related or differ from strains that are not epidemiologically connected. If strains are unrelated, the patients do not belong to the same outbreak. If strains are related it is impossible to say that the patients are involved in an outbreak without epidemiological analysis. So, epidemiology and typing are complementary.

Typing methods differ in several important points:

1. Typability, i.e., the method can type most or even all strains of the same species;
2. Discriminatory power, i.e., the method can differentiate well between different types;
3. Inter-laboratory and intra-laboratory reproducibility, i.e., the method can provide the same typing results in repeated testing on different sites or in different times; and
4. The method should be simple, unambiguous to interpret, and inexpensive.

There are two groups of typing methods: phenotyping and genotyping.

Phenotyping

Phenotyping methods can determine characteristics that differ between different strains of the same species. These methods may be based on antigenic structure (serotyping), physiologic properties/metabolic reactions (biotyping), susceptibility to antimicrobial agents (resistotyping), colicines (colicinotyping), or bacteriophages (phage typing).

Phenotyping methods are well standardised with high reproducibility. Discriminatory power is not always high (if only a few types exist), but can be very high (if many types exist). They are simple and unambiguous to interpret. Many are cheap enough to be performed in every microbiology laboratory.

The main objection to phenotyping is that bacterial genes are not always expressed. Two phenotypically different strains can actually have the same genetic background or two phenotypically identical strains can actually differ genetically. Sometimes the emergence of a particular phenotype is specific enough to explain an outbreak. However, if a phenotype is widespread and frequent, genotyping will be required for outbreak management.

Genotyping

Molecular techniques have revolutionised the potential of the microbiology laboratory because they have very high typability and discriminatory power. Genotyping can demonstrate definitively the relatedness or difference between two isolates of the same species. However, genotyping

methods require sophisticated and expensive equipment and materials and trained staff. Furthermore, some tests have a low reproducibility, especially in inter-laboratory comparisons. Result interpretation is neither always simple nor unambiguous.

Role in the surveillance of HAIs

The microbiology laboratory should produce routine reports of bacterial isolates to allow the ICT to make incidence graphs for specific pathogens, wards, and groups of patients. These data can be made available immediately if the laboratory is computerised. A 'baseline incidence' can be established and any new isolates can then be compared to it. Graphs enable the ICT to discover the beginning of an outbreak earlier than it can be discovered clinically. Periodic reports are also important because they demonstrate trends of specific pathogens, and can be very useful in planning preventive measures.

Alert organism reports

The early isolation of a new or unusual microorganism, without any further typing, enables the ICT to take appropriate measures to stop it from spreading. The ICT should identify, together with laboratory personnel, possible 'alert' microorganisms, such as multiresistant or highly pathogenic microorganisms (methicillin-resistant *S. aureus*, vancomycin-resistant *S. aureus*, vancomycin-resistant Enterococcus, multidrug-resistant [MDR] *P.aeruginosa*, MDR *A.baumannii*, MDR *M.tuberculosis*, *C.difficile*, etc.). Any new isolates should be reported immediately to the wards and the ICT. Alert organism surveillance may be all that can be performed if the facility is understaffed. In addition, laboratory staff may report clustering of infections (two related isolates in different patients in the same time frame).

Interpreting microbiology data

Microbiologists must interpret microbiological data (results of isolation, identification, susceptibility tests, serology, typing). To interpret microbiological data for an individual patient, one should first make sure the specimen was correct. Is the microorganism concerned a primary or opportunistic pathogen? What is the clinical diagnosis? And lastly, what was the immune state of the patient at the time of specimen collection?

It is relatively easy to interpret the results of specimens from normally sterile sites (blood, cerebrospinal fluid, biopsy materials, and urine); however it is

harder to interpret results from non-sterile samples (respiratory specimens, wound exudates, etc.). As the result comes often after antibiotic treatment has already begun, has the patient reacted or not reacted to the antibiotic? Do other laboratory and/or imaging results affect the diagnosis?

To interpret microbiological data for IPC purposes, the relevant specimens are needed, either from the patient, healthy contacts, or the environment. A microbiologist who knows the normal colonising flora of humans, pathogenesis of infections (incubation period, inoculum size, kind of vehicle), and the characteristics of specific pathogens (natural habitat, resistance to drying, to disinfectants, and to antibiotics) – can then interpret laboratory data for the ICT. In a more complicated outbreak or endemic situation, besides good microbiology (especially typing), there is a clear need for an epidemiologist to interpret microbiological data.

Ideally the microbiologist should be a medical doctor specialising in clinical microbiology. If this is not possible, then a properly educated scientist is required.

Antibiotic policy

Determining antibiotic susceptibility patterns for microorganisms causing HAIs is vital for individual patient care. It can also help in planning antibiotic policy and designing the local antibiotic formulary. The microbiology laboratory should only report antibiotics contained in the formulary. Periodic resistance reports should be provided for specific wards and for the whole institution broken down by pathogen species and infection site. These reports should be available for every physician who prescribes antibiotics. These reports are very important for the design of empirical therapy.

Infection Prevention and Control in the Laboratory

All laboratory staff may be exposed to viruses that are spread through blood and bodily fluids (human immunodeficiency virus [HIV], hepatitis B virus [HBV], hepatitis C virus [HCV]). Laboratory workers must take preventive measures against those viruses.

The clinical microbiology laboratory is usually at biosafety level 2. This means that staff work with well-characterised agents that only pose a

moderate potential hazard to personnel and the environment. Laboratory access should be limited to the people working in it; staff should take precautions for handling biological specimens and microbial cultures (hand hygiene, disinfection of the environment, specific precautions with sharps, and use of biological safety cabinets if aerosols are a risk).

If *Mycobacterium tuberculosis* or *Legionella pneumophila* are expected, diagnostic tests should be performed in a biosafety level 3 facilities (for agents which may cause serious or potentially lethal disease in healthy adults after inhalation, but for which vaccine or other treatment exists). If this is not possible, and a level 2 laboratory is used, it should be secured; the room should have negative air pressure and the exhaust air should be filtered and discharged outdoors. The laboratory workers should be properly educated and follow all recommended practices for biosafety level 3 rigorously.

Microbiology Diagnostics in Low Resource Settings

The main problem for microbiological diagnostics in low resource countries is the lack of microbiology laboratories; they are usually sited in major urban areas. Therefore, it is very important to have point-of-care microbiological tests that are sensitive and specific, rapid, easy for HCWs that have no specific education in laboratory procedures to perform without special equipment, unambiguous to interpret, and affordable. Several such tests are already in use (for malaria, HIV serology), however more are needed. Especially important tests from the point of view of HAI prevention and control would be tests for diagnosing tuberculosis and for identifying multidrug resistant strains to stop their spread.

Minimal Requirements for Microbiology Laboratories in the Control of HAIs

1. Should be sited inside the health care facility; if this is not possible, then negotiate a contract for diagnostic microbiology with the nearest laboratory.
2. Should be available every day, including Sundays and holidays, ideally on a 24-hour basis. Gram stain should be available on a 24-hour basis.
3. Should be able to examine blood, cerebrospinal fluid, urine, stool, wound exudates or swab, respiratory secretions, and perform serological tests (HIV, HBV, HCV).

4. Should be able to identify common bacteria and fungi that can cause HAI to species level (*Staphylococcus aureus*, *Escherichia coli*, *Salmonella*, *Shigella*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Streptococcus pyogenes* [Group A streptococci], *Streptococcus agalactiae* [Group B streptococci], enterococci, *Campylobacter jejuni/coli*, other enterobacteria, *Neisseria meningitidis*, *Candida albicans*, aspergilli, etc.), besides other common microorganisms that cause severe community-acquired infections (*Streptococcus pneumoniae*, *Neisseria gonorrhoeae*, *Vibrio cholerae*, *Corynebacterium diphtheriae*).
5. Should be able to perform susceptibility testing to relevant antibiotics using disc-diffusion methodology.
6. Should be able to perform basic typing - serotyping (for salmonella, shigella, *P. aeruginosa*, *N. meningitidis*) and biotyping (e.g., for *S. typhi*).
7. Should have quality assurance procedures (both internal quality control and external quality control [national or international]).
8. Should have a clinical microbiologist (if possible a medical doctor) who has good skills of communication with clinical and ICT staff.
9. May have the ability to perform simpler genotyping methods or access to genotyping methods centrally at state or regional laboratories. The central laboratory can then assist with epidemiological investigations of HAIs.

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Chapter 8

Pathogens Important to Infection Prevention and Control

Zahir Hirji and Vydia Nankoosingh

Key points

- Infection prevention and control practitioners routinely address issues related to tuberculosis and multi-drug resistant organisms.
- Tuberculosis control involves engineering controls, administrative controls, and personal protective equipment.
- Many microorganisms have developed resistance to antimicrobials, making them less effective. Control measures vary by microbe.
- Infection prevention and control management of these various pathogens differs depending on the institutional setting and the resources available.

Introduction

Every-day problem microorganisms for infection prevention and control (IPC) practitioners include *Mycobacterium tuberculosis* and antibiotic-resistant microorganisms, namely methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococci* (VRE), *Clostridium difficile*, and multi-drug resistant Gram-negative bacilli. Section A focuses on TB and Section B on antibiotic-resistant microorganisms.

SECTION A: Tuberculosis¹⁻⁴

Tuberculosis (TB) affects one third of the world's population; in 2008 there were 9.4 million new cases and 1.8 million deaths, mostly in developing countries. It is the leading cause of death in individuals with human immunodeficiency virus (HIV). TB is caused by *Mycobacterium tuberculosis*.

Pathogenesis and transmission

Tuberculosis is spread by droplet nuclei travelling through the air when someone with active disease coughs, talks, sneezes, or spits. The bacteria are inhaled into the lungs and multiply in the alveoli; only a small number are needed to cause infection. Once in the body *M. tuberculosis* can travel to any location.

People infected with TB bacilli do not necessarily develop disease; the bacilli may be contained by the body's host defences but remain alive-so-called latent TB. Approximately 10% of people with latent TB develop active TB when the bacteria subsequently grow and cause symptoms. The lungs are the most commonly infected organ. An untreated person with active pulmonary TB can infect 10-15 people a year. Other common sites of infection include the pleura, central nervous system, lymphatic system, genitourinary system, bones, and joints. TB outside the lungs is referred to as extrapulmonary TB and is not contagious.

Symptoms of pulmonary TB include a cough that brings up thick, cloudy, and, sometimes, bloody sputum, tiredness, appetite loss/unexplained weight loss, night sweats, fever/chills, and shortness of breath. In people with extrapulmonary TB, signs and symptoms vary with the site of infection.

Risk factors for TB include 1) illnesses that weaken the immune system, such as cancer and HIV; 2) close contact with someone with active TB; 3) caring for a patient with active TB; 4) living or working in crowded places like prisons, nursing homes, and homeless shelters where there are other people with active TB; 5) poor access to health care; 6) alcohol or drug abuse; 7) travel to places where TB is endemic; 8) being born in country where TB is endemic, and 9) some treatment medications for rheumatoid arthritis. Age too is important, the very young and the very old have naturally weaker immune systems.

Diagnosis

The tuberculin skin test (TST) can be used to determine infection with TB. It can take up to three months for a newly exposed individual to develop a positive TST. TB blood tests (also called interferon-gamma release assays or IGRAs) may be used to measure how the immune system reacts to the bacteria that cause TB. These tests cannot determine if a person has latent TB infection or active TB disease.

Bacille Calmette-Guérin (BCG) is a vaccine for TB. BCG vaccination may cause a positive reaction to the TST, which may complicate decisions about prescribing treatment. TB blood tests, unlike the TST, are not affected by prior BCG vaccination and are not expected to give a false-positive result in persons who have received prior BCG vaccination.

The management of patients with a positive test should occur in two steps: confirmation of a positive TST then referral for medical evaluation. This includes checking their medical history for potential exposures, demographic risk factors, and medical conditions that increase the risk of TB. Physical examination can be helpful, and a chest radiograph, although suggestive, is not confirmatory.

The standard method of diagnosis is microscopy of stained smears (e.g., sputum, cerebrospinal fluid, pus). Tubercle bacilli may be cultured; however, cultures may take up to six weeks. Cultures will allow performing tests for antibiotic susceptibility.

Treatment

Treatment for latent TB is generally nine months of isoniazid. Treatment for active TB should be consistent with the World Health Organization DOTS protocol.⁵ Incomplete treatment can lead to *M. tuberculosis* becoming resistant, therefore adherence to therapy is important to prevent treatment failures.

Infection prevention and control measures

IPC measures include; engineering controls, administrative controls, and personal protective equipment. Engineering controls involve negative pressure isolation rooms, enhanced ventilation, ultraviolet irradiation, or high efficiency particulate air filtration systems. Sunlight is a good source of ultraviolet rays; if no other measures are available – open the windows. This also provides room ventilation; diluting out bacteria in the air.

Administrative controls include identifying patients with signs and symptoms of TB, isolation of suspected cases, and prompt treatment of active cases. Personal protective equipment that can be used to limit transmission includes the use of a surgical mask for symptomatic patients, especially if they leave their room, and the use of N-95/FFP masks for healthcare workers. If these masks are not available, then surgical masks should be used.

Conclusion

Despite the immense global impact of TB, it is treatable and preventable. Occupational exposure remains a significant risk to healthcare workers everywhere. IPC measures are important to lessen exposure of staff and patients.

SECTION B: Antibiotic Resistant Microorganisms

Introduction

Antimicrobial agents have been used since the 1940s, greatly reducing illness and death from infectious diseases. However, many microorganisms have developed resistance to antimicrobials, making them less effective. People infected with resistant microorganisms have longer and more expensive health care stays and are more likely to die from infection. Resistant microorganisms have a world-wide distribution and are a cause of major concern.

Methicillin-resistant *Staphylococcus aureus* (MRSA)⁶⁻¹⁰

Background

Staphylococcus aureus is a Gram-positive coccus and a leading cause of infection. Up to 30% of people are colonised in the nose, pharynx or perineum, and may become transiently colonised on the hands. Colonisation, especially of intact skin, is harmless, however it can increase the risk of infection, and carriers may transmit infection to others.

Mechanisms of resistance

S. aureus can become resistant to antibiotics, especially penicillins and cephalosporins. Methicillin, although no longer used for treating infections, is used to test for this resistance; therefore the strains are called 'methicillin-resistant' (MRSA). The resistance is due to an altered bacterial cell wall, which has lost the ability to bind to the antibiotics, therefore MRSA bacteria are resistant to virtually all penicillins and cephalosporins.

Epidemiology

MRSA first became a problem in the 1960s; today it has reached epidemic proportions. Globally, the burden of disease caused by healthcare-associated and, more recently, community-associated MRSA, is rising. This has resulted in considerable health care pressures due to increased lengths of stay, costs, morbidity, and mortality. Although rates vary from country to country, and even from hospital to hospital, MRSA is the commonest antibiotic-resistant pathogen in hospitals.

Community-associated MRSA

Until recently, MRSA was considered to be primarily healthcare-associated (HA-MRSA), affecting older adults with co-morbidities. Recently, community-associated MRSA (CA-MRSA) has emerged in many parts of the world. In contrast to HA-MRSA, CA-MRSA occurs in healthy individuals. Acquisition of CA-MRSA is associated with crowding, compromised skin integrity, contaminated items or surfaces, and lack of cleanliness. The introduction of CA-MRSA strains into health care settings is a major concern.

Control measures

See Table 8.1-Major Pathogens of Concern in Healthcare Facilities for MRSA control measures.

Vancomycin-Resistant *Staphylococcus aureus* (VRSA)

Vancomycin is the drug of choice for treatment of MRSA infections. Of concern is the appearance of *S. aureus* with a reduced susceptibility to vancomycin (called VRSA), which is MRSA containing the resistance genes Van-A or Van-B. Spread of these strains has a potential for major public health consequences. VRSA appeared in Japan in 1996, then in the United Kingdom, Asia, Brazil, US and France. Strict adherence to Contact Precautions and additional precautions are required for patients carrying these microorganisms.

Vancomycin Resistant *Enterococcus* (VRE) ¹¹⁻¹³

Background

Enterococci are facultative anaerobic Gram-positive cocci that are part of the normal gut flora but may be present in the oropharynx, vagina, or skin. Enterococci can also be found on environmental surfaces. These bacteria can cause serious infections, such as septicemia, endocarditis, urinary tract infections, and wound infections, especially in immunocompromised patients.

Infections with enterococci are treated with glycopeptides, for example vancomycin, which block the synthesis of the microbial cell wall. VRE is an *Enterococcus* that is resistant to vancomycin. There are two types of resistance. Intrinsic resistance, demonstrated by *E. gallinarum* and *E. casseliflavus*, is a naturally occurring low-level resistance. These microorganisms are less commonly associated with serious infections and are not associated with outbreaks. The second type is acquired resistance which occurs in *E. faecium* and *E. faecalis*. These are the commonest cause of serious VRE infections and carry resistance genes, with Van-A and Van-B being the most clinically relevant.

Epidemiology

VRE was first isolated in Europe in the 1980's. Since then, reports of VRE colonisation and infection have rapidly increased and outbreaks have occurred globally. According to European Antimicrobial Resistance Surveillance System (EARSS) data from 2008, in some European countries VRE are found in almost 30% of invasive *Enterococcus* infections. However, Denmark and the Netherlands have managed to keep rates at or close to zero by enforcing stringent IPC policies.

Clinical significance

Infection with VRE is hard to treat and is associated with high patient mortality rates, prolonged hospital stay, and increased cost of care. Recent reports of transfer of the Van-A gene from vancomycin-resistant *E. faecalis* to MRSA (leading to VRSA), raise concerns that the spread of VRE is creating a reservoir for mobile resistance genes. There is now the threat of large scale emergence of VRSA to add to the global crisis of antimicrobial resistance.

Acquisition and transmission

Patients who are colonised carry VRE as part of their gut flora and demonstrate no symptoms. However, they may act as a reservoir for spread. The length of time a patient remains colonised is variable. VRE is spread by direct contact via the hands of healthcare workers or indirectly through contaminated materials or equipment. The environment plays a large role in its spread because VRE can survive on inanimate objects for weeks. Proper cleaning and disinfection of surfaces and shared equipment is extremely important in preventing transmission. Equipment that may normally be shared between patients, such as thermometers and blood pressure cuffs, should be dedicated to individual VRE positive patients, if possible.

Laboratory testing methods

Accurate and early detection of colonisation or infection is important to initiate precautions and prevent the spread of VRE. Diagnosis is usually made by microbial culture or by molecular methods, such as polymerase chain reaction (PCR) assays.

Control measures

See Table 8.1 for Management of Major Pathogens of Concern in Healthcare Facilities for control measures.

***Clostridium difficile* infection¹⁴**

Background

The prevalence of *Clostridium difficile* infection (CDI) and number of outbreaks has been increasing globally for the past 10 years. CDI primarily occurs in patients who are exposed to antibiotics in health care facilities. It may cause uncomplicated diarrhoea, pseudomembranous colitis, and, on rare occasions, ileus or toxic megacolon.

Pathology

Clostridium difficile is a Gram-positive spore-forming anaerobic bacillus; it is widely distributed in the environment. The vegetative form is the active state when the microorganism produces toxins and can be killed by antibiotics. The spore form is the dormant state and does not produce toxins. Spores are resistant to many types of disinfectants, heat, and dryness and can persist in the environment for months on bed rails, commodes, electronic thermometers, stethoscopes, and skin folds.

Some strains of CDI produce two cytotoxins (Toxin A, Toxin B) which bind to receptors on intestinal epithelial cells causing inflammation and diarrhoea. Both toxins appear to be cytotoxic and enteropathic. Exposure to antibiotics, such as clindamycin, penicillins, cephalosporins, and fluoroquinolones, alters the gut flora and seems to be an important risk factor for CDI. Mild disease is characterised by non-bloody diarrhoea that is often mucoid and foul smelling, cramping, nausea, dehydration, low grade fever, and leukocytosis. Severe disease can include colitis, watery diarrhoea, abdominal pain, fever, nausea, abdominal distension, and pseudomembranes in the gut.

New strain

Since 2000 there has been an increase in the incidence of the BI/NAP1/027 strain of *C. difficile*. This strain causes a severe illness, and is more resistant to standard therapy, more likely to relapse, and associated with higher mortality. The strain produces approximately 16 times the amount of toxin A and 23 times the amount of toxin B than normal strains because of the partial deletion of a gene.

Colonisation

Approximately 3-5% of healthy adults and 20-40% of hospitalised patients may be colonised with inactive spores of *C. difficile*. Colonised patients are generally not symptomatic; however they may be a potential reservoir for transmission. Evidence suggests that spores on the skin of asymptomatic patients can contaminate the hands of healthcare workers. There are no recommendations to treat carriers.

Control measures

Many measures have been used to prevent spread of *C. difficile* (See Table 8.1). Other measures include the discontinuation of all antibiotics upon

suspicion of CDI and facility-wide antibiotic control policies. Prompt notification of patients with diarrhoea to the IPC personnel can assist in focusing interventions.

Although effective against vegetative bacteria, alcohol-based hand hygiene products may be less effective against the *C. difficile* spore than soap and water. Environmental audits can assist in identifying sources, such as multiuse patient care equipment, that can be targeted for cleaning. Strict adherence to cleaning the environment is important. Sporicidal agents should be used for cleaning, especially during outbreaks; these include various formulations of hydrogen peroxide and chlorine-based products like bleach. Routine identification of asymptomatic carriers or repeat testing after treatment is not recommended.

Multi-drug resistant Gram-negative microorganisms¹⁵⁻²⁰

Microorganisms of concern

Enterobacteriaceae (Escherichia coli and Klebsiella pneumoniae)

Enterobacteriaceae are a large group of fermentative bacilli that are a normal part of the gastrointestinal flora. They are among the most common isolates from inpatients. The common cause of resistance is the production of beta-lactamases, enzymes which destroy some of the penicillin and cephalosporin antibiotics. *Serratia* and *Enterobacter* species may also be multi-drug resistant.

Acinetobacter species

Acinetobacter is a non-fermenting bacterium that is present in aquatic environments in nature. It is an opportunistic pathogen for humans and may cause healthcare-associated infections (HAI), especially ventilator-associated pneumonia (VAP), bacteraemia, and urinary tract infections (UTI).

Pseudomonas aeruginosa

P. aeruginosa is a non-fermenting bacterium that is ubiquitously present in aquatic environments in nature; it is resistant to many antibiotics. It can be an opportunistic pathogen for humans and a major cause of HAIs. *P. aeruginosa* is responsible for a wide range of severe infections including VAP, bacteraemia, and UTI.

Mechanisms of resistance and epidemiology

There are many mechanisms of resistance associated with Gram-negative bacteria and these microorganisms often use multiple mechanisms against the same antibiotic. Gram-negative bacteria are efficient at acquiring genes that code for antibiotic resistance, especially in the presence of antibiotic pressure.

E. coli and *Klebsiella* species can have extended spectrum beta-lactamase (ESBL) enzymes that are plasmid-mediated (plasmids are small pieces of genetic material that are independent and can be transferred between bacteria) so the genes encoding these enzymes are easily transferable among different bacteria. ESBL enzymes cause resistance to most beta-lactam antibiotics, penicillins, cephalosporins, cephamycins, carbapenems, and monobactams. ESBLs are often located on large plasmids that harbour resistance genes for other antimicrobial classes such as aminoglycosides and fluoroquinolones.

ESBLs were first detected in Europe in 1983. There are several types of ESBLs, including TEM, SHV, and CTX-M. ESBLs had originally mainly been of the TEM and SHV types, mostly found in *K. pneumoniae*, and at times associated with institutional outbreaks. More recently, *E. coli*-producing CTX-M enzymes have emerged worldwide as a cause of community-onset UTI and bloodstream infections.

The prevalence of ESBL-producing strains varies by geography, type of facility, and patient age. SENTRY Antimicrobial Surveillance data showed that the rate of ESBL-producing strains of *Klebsiella* species in bloodstream infections between 1997 and 2002 was 43.7% in Latin America, 21.7% in Europe, and 5.8% in North America. The SMART Program (Study for Monitoring Antimicrobial Resistance Trends) reported high rates of ESBL-producing *E. coli* in China (55%) and India (79%) of *E. coli* isolates in 2007.

Carbapenem antibiotics are the treatment of choice for serious infections due to ESBL-producing microorganisms; however, unfortunately, carbapenem resistant isolates have also been reported. Carbapenem-resistant Enterobacteriaceae (CRE) have been identified in many parts of the world; outbreaks have also been documented. *Klebsiella pneumoniae* carbapenemase (KPC) producers are a major problem in the United States, Greece, and Israel. VIM metallo-carbapenemases have also been identified

in *K. pneumoniae* in Greece. Recently, a new carbapenemase, New Delhi metallo-beta-lactamase 1 (NDM-1), has been discovered in patients in India and Pakistan.

Clinical significance

Patients with Gram-negative multi-drug resistant infections have increased length of stay and increased infection-related health care costs. Initial antimicrobial therapy is often less successful, leading to greater morbidity and mortality.

Control measures

See Table 8.1 Major Pathogens of Concern in Healthcare Facilities for control measures.

Management of Pathogens in Low Resource Countries

IPC management of these various pathogens differs depending on the institutional setting and the resources available. At a minimum, hand hygiene should be a focus in all health care institutions. Healthcare workers should clean their hands before and after contact with patients or the patients' environment. This is the single most important control measure. Transmission-based precautions depend on the particular pathogen, especially in an acute care setting or during an outbreak. Patients colonised or infected with a particular pathogen may be placed in a single room or cohorted (roomed in) with other positive patients.

Conclusion

Antimicrobial resistance is a world-wide public-health problem whose solution is multifaceted. Improving the behaviours of prescribers, dispensers, and consumers is essential. Global awareness of the issue of resistance and surveillance for significant pathogens in the parts of the world where these pathogens are prevalent are primary considerations. Integration of antimicrobial stewardship processes may be beneficial. Implementation of appropriate IPC practices will help to reduce the spread of these microorganisms.

Table 8.1. Management of Major Pathogens of Concern in Healthcare Facilities

	MRSA*	VRE*	MDRGN*	CDI*
Patients at Risk	<p>Previous antibiotic use Severe underlying illness Prolonged hospital stay Previous contact with medical facility Use of invasive procedures Close proximity to a patient that is colonised or infected with MRSA</p>	<p>Previous antibiotic use Severe underlying illness Prolonged hospital stay Previous contact with medical facility Use of invasive devices Close proximity to a patient that is colonised or infected with VRE</p>	<p>Previous antibiotic use Severe underlying illness Prolonged hospital stay Previous contact with medical facility Contact with a facility with known outbreaks with MDRGN microorganisms</p>	<p>Previous antibiotic use Severe underlying illness Prolonged hospital stay Advanced age Gastrointestinal surgery/manipulation History of irritable bowel disease Patients on proton pump inhibitors</p>
Admission Screening Sites	<p>Yes, based on patient risk factors Swab of nares, rectal, wounds, exit sites</p>	<p>Yes, based on patient risk factors Rectal swab</p>	<p>Based on local epidemiology and patient risk factors Rectal swab</p>	<p>No</p>
Route of Transmission	<p>Contact (plus droplet for symptomatic patients with pneumonia)</p>	<p>Contact</p>	<p>Contact (plus droplet for symptomatic patients with pneumonia)</p>	<p>Contact</p>
Isolation Precautions?	<p>Yes</p>	<p>Yes</p>	<p>Yes</p>	<p>Yes</p>

	MRSA*	VRE*	MDRGN*	CDI*
Documentation (flagging of patients)	It may be of benefit to implement a system to designate patients known to be colonised or infected with antibiotic resistant microorganisms for early notification on readmission			
Environmental Cleaning	Routine cleaning with attention to high touch surfaces	Routine cleaning with attention to high touch surfaces Consider double cleaning in outbreak situations	Routine cleaning with attention to high touch surfaces	Routine cleaning with attention to high touch surfaces and the use of a sporicidal agent Consider double cleaning for outbreak situations
Discontinuation of Precautions	<p>This is an unresolved issue</p> <p>Some institutions use the following criteria: Negative results from all colonised/infected body sites - 3 consecutive negative cultures taken at least one week apart in the absence of antibiotic therapy</p> <p>Note:</p> <ul style="list-style-type: none"> ● Recolonisation is known to occur, on-going monitoring is recommended ● Consider maintaining isolation precautions in an outbreak setting <p>No diarrhoea for at least 48 hours</p>			
Follow-up of Contacts	Two sets of specimens taken on different days, with one taken a minimum of 7 days after last exposure, especially in an outbreak setting		Based on local epidemiology and patient risk factors	No

	MRSA*	VRE*	MDRGN*	CDI*
<p>Point Prevalence</p>	<p>In an outbreak setting: Conduct serial (e.g., weekly) unit-specific point prevalence culture surveys of the target antibiotic-resistant microorganism to determine if transmission has decreased or ceased</p>			
<p>Environmental Cleaning</p>	<p>Routine cleaning with attention to high touch surfaces</p>	<p>Routine cleaning with attention to high touch surfaces Consider double cleaning in outbreak situations</p>	<p>Routine cleaning with attention to high touch surfaces</p>	<p>Routine cleaning with attention to high touch surfaces and the use of a sporicidal agent Consider double cleaning for outbreak situations</p>
<p>Additional Outbreak Measures</p>	<p>Strict cleaning of multi-use patient equipment in between patients Dedicated patient equipment to positive cases Education of staff, patients, and visitors Auditing of outbreak unit/area including hand hygiene, isolation precautions practices, and environmental cleaning</p>			

*MRSA = methicillin-resistant *S. aureus*;

MDRGN = Multi-drug resistant Gram-negative microorganisms;

VRE = vancomycin-resistant *Enterococcus*;

CDI = *C. difficile* infection

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Chapter 9

Principles of Antibiotic Policies

Judith Richards

Key points

- Resistant bacterial strains are selected in health care settings because of the large usage of antibiotics.
- To postpone development of resistance, antibiotics should be used carefully and rationally.
- Good antibiotic prescribing should be encouraged in hospitals and health care facilities.
- The microbiology laboratory service can guide clinicians to use targeted antibiotic treatment.
- Antibiotic stewardship programmes are important for reducing the risks of resistance.

Introduction [H1]

Background to resistance¹⁻⁶

The discovery of antibiotics was a revolutionary event that has saved millions of lives; however, their effectiveness has lessened because microorganisms have developed resistance. The emergence of bacteria resistant to many antibiotics (such as multidrug-resistant tuberculosis [TB], beta-lactamase-producing Gram-negative bacteria, carbapenemase producers, and methicillin-resistant *Staphylococcus aureus*) has created a vicious cycle, requiring new antibiotics which are invariably more expensive. Many medical services cannot afford such expensive agents, and so patients, especially in developing countries, will be denied appropriate treatment.

To preserve susceptibility, or at least postpone development of resistance, antibiotics should be used rationally. This is of prime interest to everyone – government, physicians and the public. Resistance can be delayed by better prescribing, this includes: 1) education, 2) antibiotic policies, and 3) surveillance of antibiotic usage and bacterial resistance with regular feedback to physicians. Effective infection prevention and control (IPC) activities are also required.

Antibiotic resistance develops through the natural process of mutation. As bacteria multiply rapidly (sometimes once every 20 minutes), mutations can be expressed very quickly. Resistance can be transferred not only to their offspring, but sometimes to totally different bacteria. The acquisition of resistance through plasmids, transposons, or direct genetic mutations can result in their progeny (daughter cells) exhibiting changes in the antibiotic target sites, in the production of detoxifying enzymes, or in decreased uptake of antibiotic. (See Figure 9.1)

If this happens in an environment where the antibiotic is commonly used, resistant strains of bacteria will be selected. In a health care facility with an inadequate IPC programme, they may spread and cause outbreaks.

Antibiotics affect normal human bacterial flora, which can become resistant and act as a reservoir of resistance genes. This poses a unique problem, as treatment of one patient's infection may then affect other patients. Therefore, narrow spectrum antibiotics should be used whenever possible.

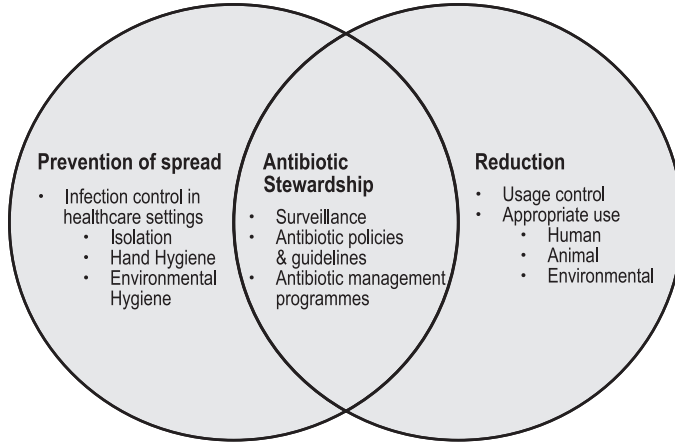


Figure 9.1 Methods to manage resistance

Antibiotics are also used extensively in veterinary medicine (for infections and as growth promoters) and agriculture, creating additional reservoirs of antibiotic-resistant microbes that may infect humans.

Excessive antimicrobial use is directly responsible for development of resistance; therefore good antibiotic prescribing practices should be encouraged. Effective IPC interventions should also be used, although mathematical models suggest that in situations where there is both a high level of antibiotic resistance and high antimicrobial consumption, control of antibiotic use provides the best solution.

The clinical impact of antibiotic resistance is huge, with increased morbidity and mortality. Patients with resistant microorganisms have extended hospital stays, leading to increased costs and loss of bed days. In the community, the treatment of diseases such as TB, especially autoimmune deficiency syndrome (AIDS)-related TB, is hampered by the emergence of multidrug-resistant strains (MDR-TB).

Antimicrobial uses

Empirical therapy

Empirical therapy is treatment for a possible or likely infection before laboratory results become available, or when they are impossible to obtain. Empirical choices may have to be made on the basis of microscopy, without the benefits of culture and sensitivity data; however, this information must be reviewed when available.

Pathogen-directed therapy

Pathogen-directed therapy is antibiotic treatment guided by the results of microbiological investigations, with choices determined by specific sensitivity/resistance data.

Prophylaxis

Prophylaxis is use of antibiotics to prevent infection. Generally used just prior to surgery, it must target the microorganisms most likely to cause infections following a procedure. It can also be applied to prevent infections in immunocompromised patients (e.g., AIDS, cancer patients, transplants) and contacts of known infected cases (e.g., meningococcal meningitis, TB). Prophylaxis must be used for the shortest possible time, and given when antibiotics are most effective.

Early review of prescribed antibiotics is essential for prudent therapy, especially for switching from intravenous (IV) to oral therapy. Suitable choices should be provided in local guidelines and formularies.

Antibiotic Stewardship⁷

Antibiotic stewardship programmes are seen as a key to modify prescribing practices of physicians, and decrease antibiotic use. Antibiotic guidelines or policies, which can be national, or local/health care facility-specific, demonstrate a commitment to the prudent use of antibiotics. Their use

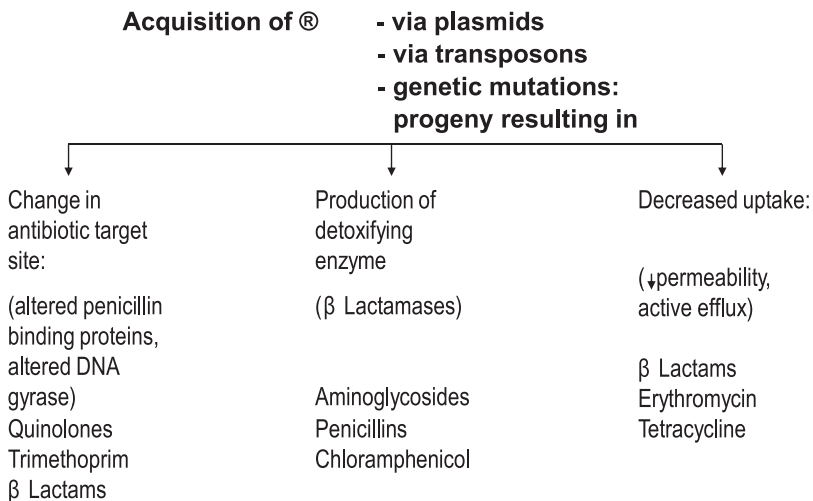


Figure 9.2 Bacterial responses

Table 9.1 Stewardship programme key points

- National policies
- Local hospital/health care facility policies
- Formularies and guidelines appropriate to local needs
- Effective infection control teams (ICT)
- Effective microbiology laboratory support
- Education and audit

shows that government, medical societies, and the public are aware of the problem and committed to solving it. Local policies should focus on using antibiotics with the narrowest spectrum, least expensive, minimal toxicity, and the least impact on development of resistance.

Health care programmes which require the co-operation and interaction of multiple teams are shown in Figure 9.2. Key points are outlined in Table 9.1. Any programme should be well designed, and implemented through a mixture of voluntary, persuasive, or restrictive means. Education is important, as is the production and dissemination of guidelines. The programme should be audited regularly and feedback provided both to users and programme directors. If an audit indicates that voluntary methods are not working, restriction of certain classes of antibiotics may be necessary.

National Antibiotic Policies

Initiatives should start at the national level with regulation of production and import of antibiotics, as well as control of local production. Legislation aimed at reducing the use of over-the-counter (OTC) antibiotics, imposing limitations on veterinary uses, and educating the public, is an important role for governments. The government must ensure enough essential antibiotics are available for local needs; and that every health care facility has access to effective microbiology and IPC services. The national policy should include education on antibiotic use and misuse at both graduate and postgraduate levels. There should be written guidelines for the treatment of important community-acquired infections. The general population should be educated about the consequences of antibiotic misuse.

Antibiotics for humans should be prescribed only by medical doctors or appropriately trained healthcare workers using carefully supervised

protocols. OTC medications should be avoided. Antibiotic use in veterinary practice should be confined to disease treatment, and not for normal husbandry (growth) or welfare (group/herd prophylaxis).

Management of Antibiotics in Health Care Facilities⁸⁻¹¹

Improper antibiotic prescribing has been described as “too many patients receiving unnecessary broad spectrum antibiotics by the wrong route, in the wrong dose, and for too long.” This often results from resistance by prescribers who believe that personal experience is more relevant than evidence-based recommendations, or who view initiatives as excuses to cut costs. Physicians often question why they should not use any available antibiotic. The answer is simple: antibiotics do not act on the patients; they act on their microorganisms. Individual treatments can and do impact other patients through spread of resistance. In addition, infections happen in patients under the care of many different medical specialists, most of whom are not specially educated in infectious diseases.

Careful management of antibiotics in health care settings requires a holistic approach including prioritisation by administrators and involvement of multiple stakeholders, as well as dedicating sufficient manpower and financial resources.

Important elements of a comprehensive stewardship programme include the following elements.

The antibiotic committee

This committee can be either stand-alone or part of the Drug and Therapeutics Committee. Antibiotic Committees must prepare local guidelines / protocols for antibiotic use. The members should be:

- doctors who prescribe antibiotics (specialists in infectious diseases, intensive medicine, internal medicine, paediatrics, clinical pharmacology, surgery);
- nurses, especially in countries where they prescribe antibiotics;
- specialist pharmacists (will provide data about antibiotic use);
- microbiologists (will provide data about bacterial resistance, as well as mechanisms and development of resistance);
- members of management;
- members of the Infection Control Committee (often, especially in small facilities, this is the microbiologist);

- Others may be co-opted as needed.

The antibiotic management team

Larger hospitals and other health care facilities should have a team to advise on antibiotic use and audit prescribing. It could include infectious disease physicians, clinical pharmacologists, pharmacists (ideally with specialist training), clinical microbiologists, and any doctors authorised to use reserve antibiotics. An antibiotic pharmacist (at least part-time) with the support of the Infection Control Doctor (ICD) is a minimum requirement for smaller institutions.

Guidelines and protocols

Health care facilities should have antibiotic policies containing guidelines and protocols for antibiotic use. Protocols may be ward specific, especially if there are special problems due to bacterial resistance – for example in oncology or intensive care wards.

The areas most often covered by an antibiotic policy are:

- o List of antibiotics in the formulary - no antibiotic outside the list should be used.
- o Guidelines for empiric and targeted treatment of common infections, including dosage and duration of treatment, first and second line therapy, and what to use for allergic patients.
- o Protocols for surgical prophylaxis (including stop-orders after 24 hours).
- o Protocols for de-escalation of parenteral use of antibiotics, including stop-orders after 3-5 days (depending on severity of infection) and recommendations for sequential treatment such as IV to oral switch protocols.
- o Protocols for a reserve antibiotic, to include how to order and who can authorise its use (usually the microbiologist, ICD or infectious disease physician).

The guidelines and protocols should be developed after discussions with all physicians, and take into consideration their views on type of antibiotic, route of administration, dosing, and duration of therapy. They will then be owned by everyone and easier to implement.

Antibiotics for surgical prophylaxis should vary with the type of operation and epidemiological situation. Prophylactic antimicrobials should be different from those normally used to treat surgical infections.

The list of antibiotics available depends on a country's politics and funding of the health care system. The World Health Organisation recommends a list of essential antibiotics in the Model List for Essential Drugs¹⁰ which is updated every two years. The most recent list (2009) includes 30 antibacterial antibiotics: 23 on the basic list, 2 for sexually transmitted diseases, and 5 on the complementary list for exceptionally severe healthcare-associated infections caused by resistant pathogens (ceftazidime, cefotaxime, imipenem+cilastatin, clindamycin and vancomycin), as well as listing 5 drugs for use as a reserve list for MDR-TB.

Antibiotics recommended in local guidelines/protocols should be chosen according to local bacterial resistance patterns. If a health care facility does not have a microbiological service, regional or national resistance data can be used. If such data do not exist, then guidelines/protocols could be based on international resistance data, although this is least appropriate.

Education

Correct use of guidelines/protocols requires education, especially of younger physicians. This includes formal meetings, clinical rounds with antibiotic committee members or antibiotic management team, and formal lectures. Education must focus on new antibiotics, new methods of administration, and the influence on bacterial ecology. Education has to be provided by employees or an independent professional. It must NOT be provided by individuals from the pharmaceutical industry. Drug company presentations require the endorsement of the Antibiotic Committee and should not be provided unless a committee member is present.

Role of the microbiology laboratory

The microbiology laboratory plays a crucial role in helping to manage the use of antibiotics in health care settings. The routine application of sensitivity tests (antibiograms) helps to identify individual levels of sensitivity and resistance to specific antibiotics, and helps clinicians choose appropriate therapy.

Microbiology laboratories should only test the antibiotics recommended

in local guidelines. They should report first-line antibiotics if an isolate is sensitive; and only add the second line antibiotic if resistant. This makes it less likely that second line antibiotics (usually broader spectrum, more toxic, more expensive) will be prescribed.

Additional information from the microbiology laboratory which can offer general guidance in the choice of antibiotics and reduce unnecessary use includes:

- Surveillance of bacterial resistance with regular feedback to prescribers.
- Screening for carriage of resistant microorganisms and molecular detection and typing.
- Restricted reporting of antibiotic sensitivities to narrow spectrum agents, only reporting second and third line antimicrobials when first-line will not work.
- Regular reporting of changing resistance patterns to users, via newsletters, etc.

A number of strategies for testing and reporting of antibiotic sensitivities have been recommended, all aimed at reducing the risks of resistance development. They include selective reporting; active surveillance for resistance; antibiotic cycling policies (e.g., the regular changing of antibiotics reported); and molecular detection and surveillance for resistance of key microorganisms.

Important roles for the microbiology laboratory include early and regular notifications of resistant bacterial isolates to the infection control team (ICT) (to help control their spread); and feedback to clinicians on antibiotic use and cost, as well as resistance on their wards (often the best way to change prescribing habits).

Audit of compliance

Compliance with all the policies/guidelines needs to be audited. (See Table 9.2) Feedback of audit data reinforces the educational messages, and helps to highlight areas where further work is required. Audits usually require a multidisciplinary team, generally lead by a clinical microbiologist or an infectious disease physician, as clinical notes have to be reviewed and interpreted correctly. If performed as part of teaching ward rounds, they can be a very powerful tool to develop sensible prescribing.

Table 9.2 Minimal requirements for an effective local antibiotic programme

1. Antibiotic Committee producing a formulary and guidelines for empiric and targeted therapy for infection in the particular setting.
2. Microbiology service - in the health care facility or contracted out.
3. Surveillance of antibiotic consumption and antimicrobial resistance; regular feedback to prescribers.
4. Effective Infection Control Programme.
5. Education on antibiotic use and consequences of antibiotic misuse.
6. Regular, comprehensive audits, with feedback to prescribers.

Key areas for audits are

- Adherence to agreed protocols and guidelines: are drugs being used in accordance with protocols?
 - o Are empirical vs. targeted treatments clearly specified?
 - o Are drugs stopped at the correct time?
 - o Is there appropriate use according to clinical need and microbiology results?
 - o Is there correct and appropriate use and application of surgical prophylaxis guidelines?
- Effectiveness: are policies and guidelines being followed?
 - o Consumption data: based on stock controls.
 - o Signed prescriptions.
 - o Usage data: Defined Daily Doses based on patient bed days/length of stay.
- Appropriateness: Are the policies being used effectively?
 - o Dosage: too much - too little?
 - o Timeliness: start - stop dates?
 - o Appropriateness: compliant with local policies?

Audit questions can also be used to build a bundle. The development and use of audit bundles are based on an “all or nothing” approach, where each element of the bundle is as important as the others. Together they reflect the strategy for a comprehensive policy for antibiotic management.

Control of Healthcare-Associated Infections

Resistant bacterial strains are selected by excessive antibiotic use, but may also enter a facility when patients come from another hospital, nursing home, or even the community. If IPC is effective, there is an equilibrium between introduced, selected, and 'discharged' resistant strains and containment of resistance will be possible.

Effective IPC should decrease healthcare-associated infections, stopping outbreaks and decreasing transmission of pathogens. This will decrease antibiotic usage and reduce antibiotic pressure; hence, there will be less selection of resistant strains. However, it cannot stop the emergence of new resistance patterns, and so will only be successful in combination with effective antibiotic policies. Of course, poor IPC leads to more infections, more antibiotic usage, more resistance, etc., and so a vicious cycle occurs. The ICT should work in close collaboration with the local microbiology department, and receive regular early reports of patients who are detected as carrying a resistant strain. Local policies should identify actions to be taken for the effective isolation of these patients, and appropriate environmental cleaning measures once they have been discharged.

Acknowledgement

This chapter is an update of the earlier one by Drs. Smilja Kalenic and Michael Borg.

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Chapter 10

Hand Hygiene

Benedetta Allegranzi, Claire Kilpatrick
and Didier Pittet

Key points

- Hand hygiene is the most effective single measure to prevent transmission of healthcare-associated pathogens.
- Compliance with hand hygiene recommendations is often sub-optimal and is influenced by many factors, including equipment/supplies, time constraints, and behavioural factors.
- Hand hygiene can be performed either by washing with soap and water or by rubbing with an alcohol-based hand rub. The World Health Organization recommends the preferred use of alcohol-based hand rub for routine hand hygiene in health care, if available.
- Hand hygiene promotion and multimodal improvement strategies have a great impact on healthcare worker practices and can reduce healthcare-associated infections and the spread of resistant microorganisms.
- Effective strategies include: provision of alcohol-based hand rubs and clean water, soap, and disposable towels; staff education; monitoring of hand hygiene practices and performance feedback; reminders in the work place; and promotion of a patient safety climate.

Background

Hand washing with soap and water has been considered a measure of personal hygiene for centuries. In the mid-1800s, studies by Ignaz P. Semmelweis in Vienna, Austria, and Oliver Wendell Holmes in Boston, US, established that hospital-acquired infections were transmitted via the hands of healthcare workers (HCW).¹ Following the observation of high maternal mortality rates due to puerperal fever, Semmelweis made physicians wash their hands in a chlorinated lime solution before every patient contact. Now our knowledge of the transmission of pathogens through hands and of infection prevention has greatly evolved, and the first international guidelines on hand hygiene published in 2009 recommend a range of evidence-based actions.¹

Resident or transient microbial flora is present on normal human skin. The resident flora is protective and less likely to be associated with healthcare-associated infections (HAI), but can cause contamination of sterile body cavities, eyes, or non-intact skin. The transient flora colonise the superficial layers of the skin and frequently cause HAIs as they are acquired and passed on by HCWs during direct contact with patients or contaminated environmental surfaces. Contaminated HCWs' hands are the commonest route of transmission of HAIs. Hand hygiene is therefore the most effective measure to prevent HAIs.¹

Hand Contamination

HCWs can contaminate their hands or medical gloves with pathogens, such as *Staphylococcus aureus*, *enterococci*, *Clostridium difficile*, Gram-negative bacilli, and some viruses (e.g., respiratory syncytial virus and rhinovirus), by touching infected sites and draining wounds, as well as patient skin or contaminated surfaces within the health care environment, especially surrounding the patient.¹ Some activities (e.g., direct patient contact, contact with body fluid or waste, diaper change, and respiratory care) lead to heavier hand contamination. In addition, HCWs with dermatitis or skin lesions on their hands may remain colonised with acquired microorganisms for a long time.¹

Subungual (beneath the nails) areas of the hand carry high concentrations of bacteria and yeasts. Artificial nails may also contribute to the transmission

of pathogens as wearers are more likely to harbour Gram-negative pathogens on their fingertips than those with natural nails, despite hand washing or rubbing with an alcohol-based product. Diseased fingernails reduce the efficacy of hand hygiene.¹ The skin underneath rings (including wedding rings) is more heavily colonised than that on other fingers. Rings with sharp and voluminous surfaces and long, sharp fingernails, either natural or artificial, can puncture gloves and limit HCWs' hand hygiene performance.¹

Compliance Among Healthcare Workers

Without adequate hand hygiene, hand contamination increases and contaminated HCWs' hands have been associated with endemic HAIs.¹ Therefore, hand hygiene is the primary measure to prevent HAIs and will help decrease the spread of antimicrobial resistance. However, many determinants, such as lack of time, lack of equipment/supplies, and behavioural factors, often result in HCWs neglecting hand hygiene. Although many HCWs perceive their performance as high,^{2,4} their hand hygiene compliance is usually < 40% in the absence of interventions.^{1,5}

Hand hygiene performance varies according to work intensity, type of ward, professional category, and time of day/week. Compliance is usually lower in settings with high care intensity (e.g., intensive care units), among physicians, and before rather than after touching a patient.^{1,5} Indeed, HCWs tend to comply more frequently with indications that protect themselves (e.g., after exposure to body fluids, after glove use, after contact with the patient or the patient's environment).^{1,6}

Products and Techniques

Hand hygiene can be performed either by rubbing with an alcohol-based formulation or by washing with soap and water. Soaps are available as bar, leaf, powder, and liquid, but must be placed alongside running water, and re-stocked when needed to achieve compliance. Plain soap has minimal antimicrobial activity, however it can be used for hand washing because mechanical friction removes many transient microorganisms. (See Table 10.1)^{1,7}

The commonest antimicrobials in hand hygiene products are: alcohols, chlorhexidine, chloroxylenol, hexachlorophene, iodine and iodophors, quaternary ammonium compounds, and triclosan. All are effective against Gram-positive and Gram-negative bacteria with maximal efficacy demonstrated by alcohols and iodophors.¹ Mycobacteria and fungi are most effectively eliminated by alcohols, and less so by chlorhexidine, chloroxylenol, and hexachlorophene.

Enveloped viruses (e.g., herpes simplex virus, human immunodeficiency virus, influenza virus, respiratory syncytial virus) are highly susceptible to alcohols;^{1,8} hepatitis B and C viruses require high concentrations (70-80% [volume/volume(v/v)]).¹ Alcohols have also shown *in vivo* activity against some non-enveloped viruses (rotavirus, adenovirus, rhinovirus, hepatitis A virus, and enteroviruses).¹ *In vitro* virucidal activity against surrogate strains of norovirus was demonstrated by 70% alcohol-based formulations and several norovirus outbreaks were controlled with preventive measures, including alcohol-based hand rubs.^{1, 9-10} In general, ethanol has a greater activity against viruses than isopropanol.

Iodophors and chlorhexidine have some activity against enveloped and some non-enveloped viruses.¹ None of these antiseptics has activity against bacterial spores or protozoan oocysts although the mechanical effect of washing with soap and water allows their partial removal.^{1,7,11}

According to WHO, alcohol-based hand rubs should be the preferred method for hand hygiene (See Table 10.1)^{1, 7} as they have the broadest antimicrobial spectrum, require a short time (20-30sec) for effective antimicrobial decontamination (See Figure 10.1), have better skin tolerance, and are readily available at the point of care (i.e., where care is provided).¹

¹²

The efficacy of an alcohol-based hand rub depends on its quality, the amount used, the time spent rubbing, and complete coverage of the hands' surfaces (See Figure 10.2). These parameters also apply to washing with soap and water (See Figure 10.3). Hand rubs containing 60-80% alcohol are satisfactory, provided that they meet recommended standards (European Norms [EN] or American Society for Testing and Materials [ASTM] standards).^{1, 13} 75-87% ethanol, isopropanol, or n-propanol, or a combination of these products guarantee the optimal antimicrobial

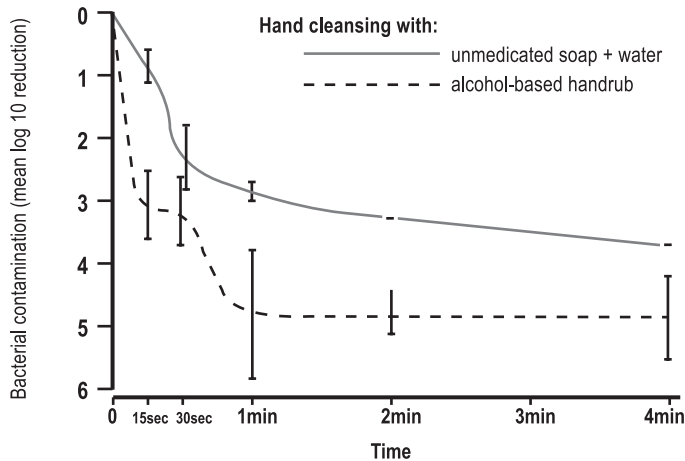


Figure 10.1 Time-course of efficacy of unmedicated soap and water and alcohol-based hand rub in reducing the release of test bacteria from artificially-contaminated hands.

(Reprinted from *The Lancet Infectious Diseases*, vol 1, Pittet D, Boyce J, Hand hygiene and patient care: pursuing the Semmelweis legacy, page 14, 2001, with permission from Elsevier)


efficacy. The WHO-recommended formulations contain either 75% v/v isopropanol, or 80% v/v ethanol.^{1,14}

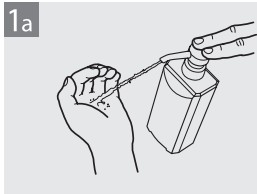
Alcohol-based hand rubs are available as rinses (with low viscosity), gels, foams, and impregnated wipes. However, wipes and foams have little supporting evidence.¹⁵ Gels were considered to have a low microbicidal efficacy; however newer formulations are more bactericidal.

Points to consider when selecting a product include:^{1,14}

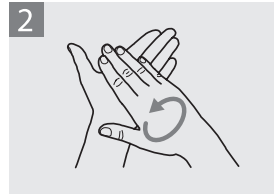
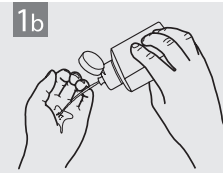
1. demonstrated antimicrobial efficacy according to ASTM or EN standards for hygienic hand antisepsis and/or surgical hand preparation;
2. proven good dermal tolerance and minimal skin reactions;
3. minimum drying time (products that require longer drying times may affect hand hygiene best practice);
4. cost;
5. aesthetic preferences of HCWs and patients, such as fragrance, colour, texture, "stickiness", and ease of use; and

Hand Hygiene Technique with Alcohol-Based Formulation

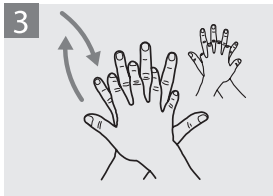
 Duration of the entire procedure: 20-30 seconds



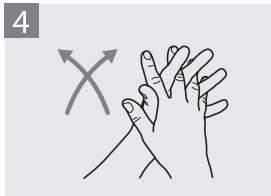
Apply a palmful of the product in a cupped hand, covering all surfaces;



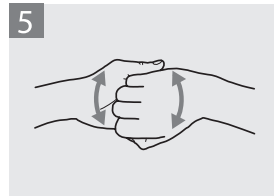
Rub hands palm to palm;



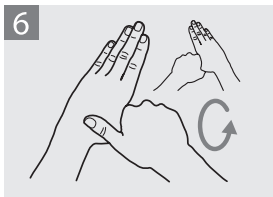
Right palm over left dorsum with interlaced fingers and vice versa;



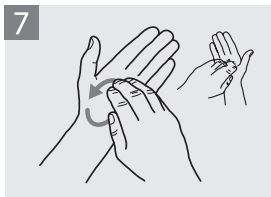
Palm to palm with fingers interlaced;



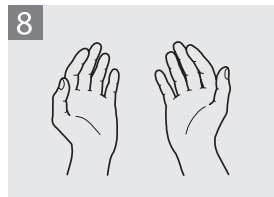
Backs of fingers to opposing palms with fingers interlocked;



Rotational rubbing of left thumb clasped in right palm and vice versa;




Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;

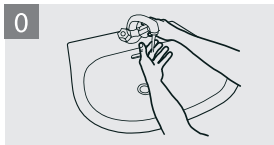


Once dry, your hands are safe.

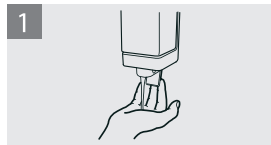
Figure 10.2 Hand hygiene technique with an alcohol-based formulation (Based on the hand hygiene technique with an alcohol-based formulation, URL: http://www.who.int/gpsc/5may/tools/system_change/en/index.html © World Health Organization 2009. All rights reserved.)

Hand Hygiene Technique with Soap and Water

 Duration of the entire procedure: 40-60 seconds



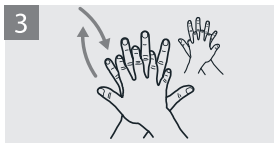
0 Wet hands with water;



1 Apply enough soap to cover all hand surfaces;



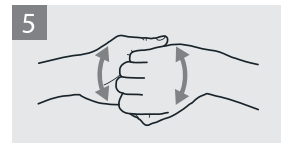
2 Rub hands palm to palm;



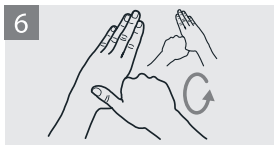
3 Right palm over left dorsum with interlaced fingers and vice versa;



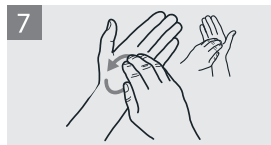
4 Palm to palm with fingers interlaced;



5 Backs of fingers to opposing palms with fingers interlocked;



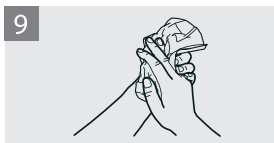
6 Rotational rubbing of left thumb clasped in right palm and vice versa;



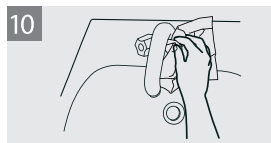
7 Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;



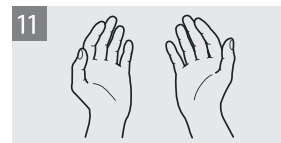
8 Rinse hands with water;



9 Dry hands thoroughly with a single use towel;



10 Use towel to turn off faucet;



11 Your hands are now safe.

Figure 10.3 Hand washing technique with soap and water (Based on the hand washing technique with soap and water, URL: http://www.who.int/gpsc/5may/tools/system_change/en/index.html © World Health Organization 2009. All rights reserved.)

6. availability, convenience, and functioning of dispensers, and ability to prevent contamination.¹²

A rational location of facilities (sinks, soap, and hand rub dispensers), as well as good maintenance and user-friendliness, are essential. Ideally, different alcohol-based hand rub dispensers, e.g., pocket bottles, wall-mounted, or those placed on carts/trolleys, night stand/bedside table, or affixed to the bed rail, should be used.

When to Perform Hand Hygiene

The “My five moments for hand hygiene” approach^{1, 16-17} (See Figure 10.4) merges the hand hygiene indications recommended by the WHO Guidelines¹ into five moments when hand hygiene is required. These are: 1) before touching a patient, 2) before clean/aseptic procedures, 3) after body fluid exposure/risk, 4) after touching a patient, and 5) after touching patient surroundings. This approach proposes a unified vision for HCWs, trainers, and observers to minimise inter-individual variation.

Glove Use

Gloves prevent contamination of HCWs’ hands, reduce transmission of pathogens, and help control outbreaks. However, gloves do not prevent microorganism transmission and HAI unless rigorously accompanied by other measures, including hand hygiene.¹ Gloves must be used according to established indications for donning and removal.

Use of the same gloves for several hours, while providing care to different patients and touching multiple surfaces, is a very frequent malpractice. Several studies have established an association between inappropriate glove use and low compliance with hand hygiene. Others have found that HCWs wearing gloves were significantly more likely to cleanse their hands following patient care.¹

Understanding that glove use does not replace hand hygiene is of utmost importance. When there is a need for performing hand hygiene (opportunity) before a care act which also requires glove use, hand washing or hand rubbing must be performed before donning gloves, as well as immediately after glove removal. In addition, gloves must be removed to

My five moments for hand hygiene

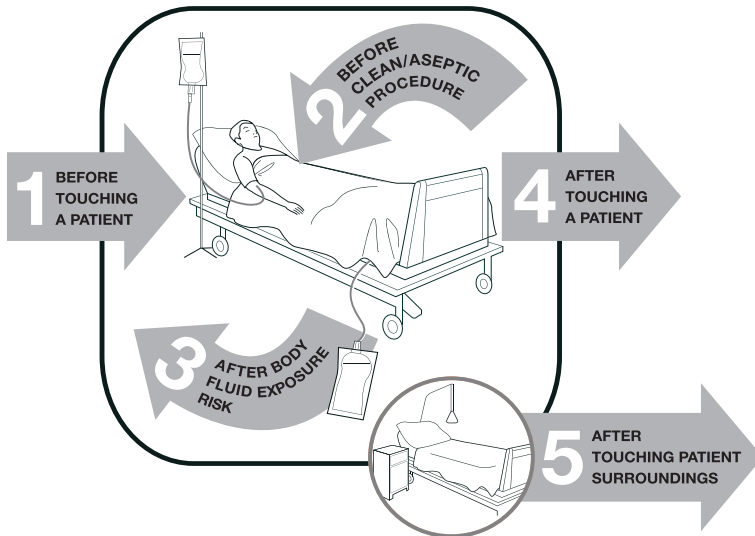


Figure 10.4 “My five moments for hand hygiene” (reproduced with permission from reference 12)

perform hand washing or hand rubbing to protect a body site from the flora of another body site or skin area previously touched within the same patient.¹

Improvement Strategies

Key components of successful strategies are ¹:

1. System change

Ensure that the necessary infrastructure is in place to allow HCWs to practice hand hygiene at the point of care. This includes two essential elements:

- access to a safe, continuous water supply, soap, and disposable towels; and
- provision of alcohol-based hand rub at the point of care.

2. Training/education

Provide regular training on microbial transmission through HCWs’ hands and the importance of hand hygiene based on the “My five moments for

hand hygiene” approach. Also include the correct procedures for hand rubbing and hand washing by using presentations, e-learning modules, posters, focus groups, reflective discussion, videos, self-learning modules, practical demonstrations, feedback from assessment, buddy systems, or combinations of these methods. Assess the impact of training on HCWs’ knowledge to identify areas for further education.

3. Evaluation and feedback

Monitor hand hygiene practices and knowledge among HCWs and feedback of results to staff. The gold standard for measuring hand hygiene compliance is direct observation; electronic monitoring of hand hygiene actions and evaluation of alcohol-based hand rub consumption can be used as indirect methods and surrogate markers.

4. Reminders in the workplace

Remind HCWs about the importance of hand hygiene and the indications and procedures for performing it.

5. Institutional safety climate

Create an environment and perceptions that raise awareness about patient safety while making hand hygiene a high priority at all levels, including:

- active participation at institutional and individual levels;
- awareness of individual and institutional capacity to change and improve (self-efficacy); and
- partnership with patients and patient organisations (depending on cultural issues and resources available).

These elements were included either as a single intervention (mostly staff education and the introduction of an alcohol-based hand rub) or in an integrated approach in studies demonstrating that improved hand hygiene significantly reduces HAI and cross-transmission rates of potential pathogens.^{1, 18} Multimodal interventions are considered the most effective.

Applicable Guidelines

The WHO Multimodal Hand Hygiene Improvement Strategy and the WHO Implementation Toolkit¹⁹ have been developed to assist health care facilities to implement improvements in hand hygiene in accordance with

the WHO Guidelines on Hand Hygiene in Health Care. They have been pilot tested by the WHO in settings with different levels of resources and in a multicultural environment and produced significant improvement of practices, as well as HCWs' perception of HAI and its prevention, and their knowledge about hand transmission and hand hygiene. Furthermore, a substantial improvement was achieved in the facilities and equipment available for hand hygiene, including the low-cost provision of alcohol-based hand rubs through local production of the WHO-recommended formulations¹⁴ where these were not available commercially.

Summary

Healthcare workers' hands play a crucial role in the transmission of microorganisms during the sequence of care and contact with environmental surfaces and patients' skin. Hand hygiene is the single most effective measure to prevent healthcare-associated infection. However, hand hygiene practice at the right moment with proper technique is usually sub-optimal among HCWs due to many constraints and behavioural factors. Improvement of practices can be achieved and lead to substantial reduction of transmission by multimodal strategies aimed at strengthening infrastructure, knowledge, and the institutional patient safety culture. The preferred use of alcohol-based hand rubbing as the gold standard for hand hygiene and the identification of the right moments for hand hygiene during patient care are essential elements for success. The World Health Organization has promoted innovative concepts and strategies to achieve hand hygiene improvement worldwide in close collaboration with other key players and stakeholders in the field of infection prevention and control, such as the International Federation of Infection Control.

Acknowledgement

This chapter is an update of the earlier one by Gertie van Knippenberg-Gordebeke, Pola Brenner, and Dr. Peter Heeg.

Table 10.1 World Health Organization Consensus Recommendations Hand Hygiene in Health Care, 2009

Recommendation by topic and grade according to the HICPAC ranking system*	
1.	Indications for hand hygiene
A.	Wash hands with soap and water when visibly dirty or visibly soiled with blood or other body fluids (IB) or after using the toilet (II).
B.	If exposure to potential spore-forming pathogens is strongly suspected or proven, including outbreaks of <i>C. difficile</i> , hand washing with soap and water is the preferred means (IB).
C.	Use an alcohol-based handrub as the preferred means for routine hand antisepsis in all other clinical situations described in items D(a) to D(f) listed below if hands are not visibly soiled (IA). If alcohol-based handrub is not obtainable, wash hands with soap and water (IB).
D.	Perform hand hygiene: <ul style="list-style-type: none"> a. before and after touching the patient (IB); b. before handling an invasive device for patient care, regardless of whether or not gloves are used (IB); c. after contact with body fluids or excretions, mucous membranes, non-intact skin, or wound dressings (IA); d. if moving from a contaminated body site to another body site during care of the same patient (IB); e. after contact with inanimate surfaces and objects (including medical equipment) in the immediate vicinity of the patient (IB); f. after removing sterile (II) or non-sterile gloves (IB).
E.	Before handling medication or preparing food perform hand hygiene using an alcohol-based handrub or wash hands with either plain or antimicrobial soap or water (IB).
F.	Soap and alcohol-based handrub should not be used concomitantly (II).

2. Hand hygiene technique

- A. Apply a palmful of alcohol-based handrub and cover all surfaces of the hands. Rub hands until dry (IB).
- B. When washing hands with soap and water, wet hands with water and apply the amount of product necessary to cover all surfaces. Rinse hands with water and dry thoroughly with a single-use towel. Use clean, running water whenever possible. Avoid using hot water, as repeated exposure to hot water may increase the risk of dermatitis (IB). Use a towel to turn off tap/faucet (IB). Dry hands thoroughly using a method that does not recontaminate hands. Make sure towels are not used multiple times or by multiple people (IB).
- C. Liquid, bar, leaf or powdered forms of soap are acceptable. When bar soap is used, small bars of soap in racks that facilitate drainage should be used to allow the bars to dry (II).

3. Recommendations for surgical hand preparation

- A. Remove rings, wrist-watch, and bracelets before beginning surgical hand preparation (II). Artificial nails are prohibited (IB).
- B. Sinks should be designed to reduce the risk of splashes (II).
- C. If hands are visibly soiled, wash hands with plain soap before surgical hand preparation (II). Remove debris from underneath fingernails using a nail cleaner, preferably under running water (II).
- D. Brushes are not recommended for surgical hand preparation (IB).
- E. Surgical hand antisepsis should be performed using either a suitable antimicrobial soap or suitable alcohol-based handrub, preferably with a product ensuring sustained activity, before donning sterile gloves (IB).
- F. If quality of water is not assured (as described in Table I.11.3) in the operating theatre, surgical hand antisepsis using an alcohol-based handrub is recommended before donning sterile gloves when performing surgical procedures (II).
- G. When performing surgical hand antisepsis using an antimicrobial soap, scrub hands and forearms for the length of time recommended by the manufacturer, typically 2–5 minutes. Long scrub times (e.g. 10 minutes) are not necessary (IB).
- H. When using an alcohol-based surgical handrub product with sustained activity, follow the manufacturer's instructions for application times. Apply the product to dry hands only (IB). Do not combine surgical hand scrub and surgical handrub with alcohol-based products sequentially (II).
- I. When using an alcohol-based handrub, use sufficient product to keep hands and forearms wet with the handrub throughout the surgical hand preparation procedure (IB).
- J. After application of the alcohol-based handrub as recommended, allow hands and forearms to dry thoroughly before donning sterile gloves (IB).

4. Selection and handling of hand hygiene agents

- A. Provide HCWs with efficacious hand hygiene products that have low irritancy potential (IB).
- B. To maximize acceptance of hand hygiene products by HCWs, solicit their input regarding the skin tolerance, feel, and fragrance of any products under consideration (IB). Comparative evaluations may greatly help in this process.
- C. When selecting hand hygiene products:
 - a. determine any known interaction between products used to clean hands, skin care products and the types of glove used in the institution (II);
 - b. solicit information from manufacturers about the risk of product contamination (IB);
 - c. ensure that dispensers are accessible at the point of care (see Part I.1 of the Guidelines for the definition) (IB);
 - d. ensure that dispensers function adequately and reliably and deliver an appropriate volume of the product (II);
 - e. ensure that the dispenser system for alcohol-based handrubs is approved for flammable materials (IC);
 - f. solicit and evaluate information from manufacturers regarding any effect that hand lotions, creams or alcohol-based handrubs may have on the effects of antimicrobial soaps being used in the institution (IB);
 - g. cost comparisons should only be made for products that meet requirements for efficacy, skin tolerance, and acceptability (II).
- D. Do not add soap (IA) or alcohol-based formulations (II) to a partially empty soap dispenser. If soap dispensers are reused, follow recommended procedures for cleansing.

5. Skin care

- A. Include information regarding hand-care practices designed to reduce the risk of irritant contact dermatitis and other skin damage in education programmes for HCWs (IB).
- B. Provide alternative hand hygiene products for HCWs with confirmed allergies or adverse reactions to standard products used in the healthcare setting (II).
- C. Provide HCWs with hand lotions or creams to minimize the occurrence of irritant contact dermatitis associated with hand antisepsis or handwashing (IA).
- D. When alcohol-based handrub is available in the healthcare facility for hygienic hand antisepsis, the use of antimicrobial soap is not recommended (II).
- E. Soap and alcohol-based handrub should not be used concomitantly (II).

6. Use of gloves

- A. The use of gloves does not replace the need for hand hygiene by either handrubbing or handwashing (IB).
- B. Wear gloves when it can be reasonably anticipated that contact with blood or other potentially infectious materials, mucous membranes or non-intact skin will occur (IC).
- C. Remove gloves after caring for a patient. Do not wear the same pair of gloves for the care of more than one patient (IB).
- D. When wearing gloves, change or remove gloves during patient care if moving from a contaminated body site to either another body site (including non-intact skin, mucous membrane or medical device) within the same patient or the environment (II).
- E. The reuse of gloves is not recommended (IB). In the case of glove reuse, implement the safest reprocessing method (II).

7. Other aspects of hand hygiene

- A. Do not wear artificial fingernails or extenders when having direct contact with patients (IA).
- B. Keep natural nails short (tips less than 0.5 cm long or approximately ¼ inch) (II).

8. Educational and motivational programmes for healthcare workers

- A. In hand hygiene promotion programmes for HCWs, focus specifically on factors currently found to have a significant influence on behaviour and not solely on the type of hand hygiene products. The strategy should be multifaceted and multimodal and include education and senior executive support for implementation. (IA).
- B. Educate HCWs about the type of patient-care activities that can result in hand contamination and about the advantages and disadvantages of various methods used to clean their hands (II).
- C. Monitor HCWs' adherence to recommended hand hygiene practices and provide them with performance feedback (IA).
- D. Encourage partnerships between patients, their families and HCWs to promote hand hygiene in health care settings (II).

9. Governmental and institutional responsibilities

9.1 For healthcare administrators

- A. It is essential that administrators ensure that conditions are conducive to the promotion of a multifaceted, multimodal hand hygiene strategy and an approach that promotes a patient safety culture by implementation of points B–I below.
- B. Provide HCWs with access to a safe, continuous water supply at all outlets and access to the necessary facilities to perform handwashing (IB).
- C. Provide HCWs with a readily accessible alcohol-based handrub at the point of patient care (IA).
- D. Make improved hand hygiene adherence (compliance) an institutional priority and provide appropriate leadership, administrative support, financial resources and support for hand hygiene and other infection prevention and control activities (IB).
- E. Ensure that HCWs have dedicated time for infection control training, including sessions on hand hygiene (II).
- F. Implement a multidisciplinary, multifaceted and multimodal programme designed to improve adherence of HCWs to recommended hand hygiene practices (IB).
- G. With regard to hand hygiene, ensure that the water supply is physically separated from drainage and sewerage within the healthcare setting and provide routine system monitoring and management (IB).
- H. Provide strong leadership and support for hand hygiene and other infection prevention and control activities (II).
- I. Alcohol-based handrub production and storage must adhere to the national safety guidelines and local legal requirements (II).

9.2 For national governments

- A. Make improved hand hygiene adherence a national priority and consider provision of a funded, coordinated implementation programme while ensuring monitoring and long-term sustainability (II).
- B. Support strengthening of infection control capacities within healthcare settings (II).
- C. Promote hand hygiene at the community level to strengthen both self-protection and the protection of others (II).
- D. Encourage healthcare settings to use hand hygiene as a quality indicator (II).

***Ranking system used to grade the recommendations** (Healthcare Infection Control Practices Advisory Committee [HICPAC] of the US Centers for Disease Control and Prevention [CDC]): IA= Strongly recommended for implementation and strongly supported by well-designed experimental, clinical or epidemiological studies. IB=Strongly recommended for implementation and supported by some experimental, clinical or epidemiological studies and a strong theoretical rationale. IC= Required for implementation as mandated by federal and/or state regulation or standard. II=Suggested for implementation and supported by suggestive clinical or epidemiological studies or a theoretical rationale or the consensus of a panel of experts

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Key Web Sites

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Chapter 11

Isolation Precautions

Gayle Gilmore

Key points

- Microorganisms causing healthcare-associated infections can be spread from infected or colonised patients to other patients and to staff. Appropriate isolation/precautions can reduce transmission if they are applied properly.
- The isolation/precautions policy aims to decrease the spread of infectious agents between staff and patients to such a level that infection or colonisation does not occur.
- Isolation/precautions policies have several parts: hand hygiene, protective clothing, single rooms with more or less sophisticated ventilation, and restrictions for movement of patients and staff.
- Apply isolation/precautions according to signs and symptoms of the patient; in general, do not wait for laboratory results.

Introduction ¹⁻³

With the constant emergence of new pathogens, the management of infected patients in the health care setting becomes extremely important.

The fundamental principles of managing patients with a transmissible infection are:

1. What is to be achieved by using isolation/precautions (IP)
2. Knowledge of the route of transmission of an infectious agent
3. How to reduce risks between patients, and between patients and healthcare workers (HCW)

Since hospitals began to segregate patients with potentially transmitted pathogens, different types of IP have been recommended. Before 1900, infected patients were segregated in separate wards depending on their diseases. After 1900, the emphasis was on the use of protective barriers for HCWs treating patients with specific diseases.

Universal Precautions

In 1985, the concept of Universal Precautions (UP) was created, primarily due to the acquired immune deficiency syndrome (AIDS) epidemic. The objective was to prevent infections transmitted by blood and body fluids between patients and HCWs. These recommendations had a great impact because they were the first directed toward HCW protection. For the first time, emphasis was placed on precautions for all persons, regardless of their presumed infection status.

Body Substance Isolation

The idea underlying Body Substance Isolation (BSI) was published in 1987; it is similar to UP. All fluids coming from patients must be handled with gloves. It doesn't consider other barriers or additional practices to prevent sharps injuries. The main problem with BSI is overuse of gloves or performing patient care without changing gloves when needed. There is also less hand washing due to the perceived security of gloving, together with an increase in latex dermatitis due to glove use.

Transmission of Infection

The routes for transmission of microorganisms are:

Contact spread

Direct contact occurs when microorganisms are transferred from one person to another. It can involve contact with blood, body fluids, excretions, or secretions:

1. During patient care by the HCW or a visitor or family member.
2. During interactive activities in playrooms or lounges between patients.

Indirect contact involves the transfer of a microorganism through a contaminated intermediate object, substance, or person, e.g., contaminated equipment, food, water, or supplies, when:

1. Inadequate handwashing is performed by a care provider.
2. Equipment is not cleaned, disinfected, or sterilised adequately between patients.
3. Bloodborne pathogens are transferred by sharps or needle-stick injuries, transfusion, or injection.

Droplet spread

Infectious droplets that are expelled, e.g., when sneezing or coughing, are too heavy to float in air and are transferred less than 2m from the source of the droplets. Spread may be direct or indirect.

1. Direct droplet transmission. Droplets reach mucous membranes or are inhaled.
2. Indirect droplet transmission. Droplets fall on to surfaces or hands and are transmitted to mucous membranes or food. Indirect droplet transmission is often more efficient than direct transmission. Infections spread this way include the common cold, influenza, and respiratory syncytial viruses.

Airborne spread

Small particles ($\leq 5\mu\text{m}$ in size) carrying microbes can remain airborne; they may be transferred via air currents for more than 2m from the source as droplet nuclei or on skin scales. These particles are then inhaled. Examples of microbes spread in this manner are varicella zoster, measles, and pulmonary tuberculosis.

Prevention of Transmission

Standard precautions

Basic hygienic precautions are recommended for all patient encounters. These precautions are often called Standard Precautions or Routine Practices. Because unsuspected infectious agents may be present in blood and most body fluids and on nonintact skin and mucous membranes of all patients, hand hygiene and personal protective equipment (PPE) (e.g., gloves, gown, mask, and eye/face protection) should be used if contact with those substances is likely. This concept is an extension of UP.

The precautions include:

- hand disinfection with alcohol-based hand rubs or soap and water
- disposable gloves on contact with secretions, excretions, or blood/body fluids
- protective apron or gown for body contact with patient or patient's bed
- appropriate handling of patient care equipment and soiled linen
- environmental cleaning and spills-management
- no cap, mask, or shoe covers are needed

These precautions will block both contact and droplet transmission.

Space between beds has been shown to be important in transmission of microorganisms. Beds should be at least far enough apart that a nurse cannot touch both beds at the same time. Increasing the distance decreases the risk of transfer of pathogens, which may be directly related to overcrowding.

Sinks are needed for good hand hygiene; hands should be washed when visibly dirty. However, hand hygiene has not been improved by installing more than one sink per six patient beds. Dispensers for alcohol-based hand rub must be available and placed within easy reach.

A separate gowning area may be useful.

Additional transmission-based precautions

Transmission-based precautions are used for containing highly transmissible and/or epidemiologically important pathogens.

They include:

1. Contact precautions. Includes use of PPE when a caregiver is likely to be in contact with an environment contaminated with microbes such as vancomycin-resistant *Enterococcus* (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), or *Clostridium difficile*. Place patient in a single room (or in a room with another patient infected by the same pathogen). Wear clean gloves when entering the room and a clean gown/apron if substantial contact with the patient, environmental surfaces, or items in the patient's room is anticipated.
2. Droplet precautions. Place patient in a single room (or in a room with another patient infected by the same pathogen). Wear face protection when working within 1-2 metres of the patient. Place a mask on the patient if transport is necessary.
3. Airborne Isolation/Precautions. Simply placing the patient in a single room (including bathroom facilities) reduces the risk of transmission. However, an isolation room with negative air pressure relative to corridors, air exhausted directly to the outside or recirculated through high efficiency particulate air (HEPA) filtration with 6 - 12 air changes per hour is recommended.
4. Protective Isolation. Positive room air pressure is required, relative to corridors, along with HEPA filtration of incoming air at ≥ 12 air changes per hour. Protective Isolation is recommended only for allogeneic hematopoietic stem cell transplant patients; it requires appropriate engineering controls to prevent exposure to environmental fungal spores.

Single rooms with negative or positive air pressure are very difficult to maintain. In single rooms with ventilated anterooms (airlocks), the risk of air movement between room and corridor is minimised. This system is easier to maintain; however it is costly to build.

Isolation of Patients

In most cases, use of Standard Precautions is sufficient. IP should primarily be based on clinical signs and symptoms. When IP is needed, the following practices should be considered:

- Single room (including bathroom) when gross contamination of the environment is likely (e.g., large wounds with heavy discharge, massive uncontrolled bleeding, diarrhoea)
- Single room, door closed when contact transfer is likely (e.g., injured skin with Gram positive infection)
- Single room ventilated to the outside when airborne transfer is likely (e.g., tuberculosis)
- Single room with airlock when massive airborne transfer is likely (e.g., varicella)

Use of a single room is not the whole solution to preventing spread of infections. Barrier practices must be adhered to as well.

Staff, equipment, and surfaces

Cleanliness is one of the main objectives of infection prevention and control. Handle patient care equipment soiled with blood, body fluids, secretions or excretions with care to prevent exposure to skin and mucous membranes, clothing, or the environment. Ensure all reusable equipment is cleaned and reprocessed appropriately before being used on another patient.

Hand hygiene

Good hand hygiene reduces the number of microorganisms found on the hands during daily duties and is especially important after contact with blood, body fluids, secretions, excretions, and contaminated equipment or surfaces.

Personal protective equipment

Using PPE provides a physical barrier between microorganisms and the wearer. It offers protection by preventing microorganisms from contaminating hands, eyes, or clothing and then being spread to other patients and staff.

Gloves

Wear clean gloves when touching blood, body fluids, secretions, excretions, or mucous membranes. Change gloves between patients and different tasks/procedures on the same patient to prevent cross-contamination between body sites. Remove gloves immediately after use. Disposable gloves should not be reused.

Clothes

Contamination of work clothes can be considerable (from splashes or spills of body fluids) and is reduced by a protective gown or apron. Wearing a plastic apron during nursing procedures reduces the risk of transmission. Remove a soiled or wet gown as soon as possible. If it is necessary to use the gown/apron later again on the same patient, remove it without touching the outer side.

Masks

Mask, goggles, and/or visors protect mucous membranes against blood/body fluid splashes. A respirator may provide useful protection against tuberculosis. Disinfect items as needed.

Linen

Handle, transport, and process linen that is soiled with blood, body fluids, secretions, or excretions with care to ensure that there is no leaking of fluid.

Family members providing care to patients

Family members providing care to patients **MUST** be educated by the staff to use good hygiene and appropriate precautions to prevent spread of infections to themselves and to other patients. The precautions for the family members should be the same as those used by the staff.

In General

- IP is associated with adverse psychological effects as well as decreased physician contact and other adverse effects, so it should be discontinued as soon as possible.
- Regard all patient blood/body fluids, excretions, and secretions as potentially infectious and institute appropriate precautions to minimise risks of transmission of infection.
- Decontaminate hands between each patient contact.
- Wash hands promptly after touching potentially infective material (blood, body fluids, secretions, or excretions).
- Use a no-touch technique when possible to avoid touching infective material.
- Wear gloves, if available, when in contact with blood, body fluids, secretions, excretions, and contaminated items. Disinfect hands immediately after removing gloves. (If gloves **MUST** be re-used, dip the gloved hand into dilute bleach [1:100]. If soiled, wash with soap and water first.)
- Dispose of faeces, urine, and other patient secretions via designated sinks, and clean and disinfect bedpans, urinals, and other containers appropriately.
- Clean up spills of infective material promptly. General disinfection of floors and walls is then not necessary.
- Ensure that patient-care equipment, supplies, and linen contaminated with infective material is cleaned and/or disinfected between each patient use.
- For tuberculosis patients – develop a protocol outlining methods for separation of patients, type of ventilation (e.g., natural or negative pressure), and use of masks.

Acknowledgement

This chapter is an update of the earlier one by Pola Brenner and Dr. Ulrika Ransjo.

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Chapter 12

Cleaning, Disinfection, and Sterilisation

Syed Sattar

Key points

- Cleaning, disinfection, and sterilisation are the backbone of infection prevention and control.
- Proper cleaning is essential before any disinfection or sterilisation process.
- Failure to sterilise or disinfect reusable medical devices properly may spread infections.
- The type and level of device decontamination depends upon the nature of the item and its intended use.
- Thermal decontamination is safer and more effective than chemical decontamination.
- Steam sterilisation is effective only when preceded by thorough pre-cleaning, proper packaging/loading, and careful monitoring of autoclaves.
- Chemical disinfectants must be selected, used, and discarded so as to minimise harm to humans and the environment.
- All those responsible for processing contaminated items must be fully trained and wear protective clothing when necessary.
- Clearly written policies and procedures must be available on-site for training personnel and for monitoring their performance.

Introduction

Cleaning, disinfection, and sterilisation are the backbone for preventing the spread of infections. In spite of this, many health care facilities either lack these basic facilities for infection prevention and control (IPC) or their personnel receive insufficient training. The following is a critical overview of the fundamentals for cleaning, disinfection, and sterilisation with particular emphasis on reprocessing reusable medical devices. See references for more detailed advice.¹⁻⁶

Cleaning and Pre-cleaning

Everyone responsible for handling and reprocessing contaminated items must:

- Receive adequate training and periodic retraining.
- Wear appropriate personal protective equipment (PPE).
- Receive adequate prophylactic vaccinations.

While 'cleaning' means to get rid of visible dirt, 'pre-cleaning' refers to the removal of body fluids and other contamination before disinfection or sterilisation. Proper pre-cleaning can substantially reduce the pathogen load while removing organic and inorganic residues to facilitate reprocessing. *Thorough pre-cleaning is vital for successful disinfection and sterilisation.*

Effective cleaning and pre-cleaning of devices often requires chemicals, combined with mechanical action and heat. It can be performed manually and/or with machines. Equipment must be regularly checked and maintained.

Reusable items must be disassembled safely and cleaned as soon as possible after use to prevent any contaminants from drying. Manual pre-cleaning requires detergents or enzymes with friction (rubbing, brushing, flushing) to remove soil from the outside and inside of the items being reprocessed. After cleaning or disinfection, items must be rinsed and flushed thoroughly to remove any chemical residues and then dried. *All reprocessed items must be stored properly to prevent damage or recontamination.*

The Spaulding Classification

In 1968, Spaulding classified medical/surgical devices as: critical, semi-critical and non-critical based on their potential to spread infections.

Critical items enter normally sterile tissues, the vascular system, or equipment through which blood flows for example: surgical instruments and vascular catheters. *These items must be properly and safely pre-cleaned and sterilised before use.*

Semi-critical items come into contact with intact mucous membranes or non-intact skin; flexible fiberoptic endoscopes, vaginal probes, and respiratory therapy equipment are examples. *These items require proper pre-cleaning and, at a minimum, high-level disinfection before use.*

Non-critical items (such as blood pressure cuffs, stethoscopes) which only contact intact skin have a low risk for spreading infections, except by transferring pathogens to the hands of healthcare personnel. *Periodic cleaning and wipe-down of such items with a neutral detergent or 70% (volume/volume) ethanol in water is usually adequate.* (Reusable bedpans, also non-critical items, require more rigorous cleaning, washing, and disinfection, especially when suspected of contamination with, for example, vancomycin-resistant Enterococcus or *Clostridium difficile*.⁷)

Most environmental surfaces in patient rooms and throughout a health care facility are non-critical and do not require routine disinfection. However, high-touch surfaces, particularly those in a patient's immediate surroundings, need regular decontamination to prevent the transfer of pathogens to hands. *Currently, there are no generally accepted guidelines regarding: if, when, how, and how often such surfaces are to be decontaminated.*⁸

While the Spaulding classification system remains useful, it needs adjusting to suit current requirements. Prions with their unusual resistance to many physical and chemical agents and the emergence of the spore-former *Clostridium difficile* as a healthcare-associated pathogen, are forcing a re-examination of medical device reprocessing. Prion-contaminated devices require sterilisation protocols well beyond those in normal use.⁹ Some disinfectants (e.g., glutaraldehyde) normally used to reprocess gastrointestinal endoscopes need prolonged contact times to kill *C. difficile*

spores. Heat-sensitive devices such as flexible fibreoptic endoscopes are increasingly being used for operations in which the integrity of a mucous membrane is deliberately breached, thus blurring the line between 'critical' and 'semi-critical'.

Reprocessing Medical Devices

Disinfection

'Disinfection' means to reduce the number of pathogens on an inanimate surface or object using heat, chemicals, or both. Most disinfection procedures have little activity against bacterial spores; any reduction in the spore load is mainly achieved by mechanical action and flushing.

Pasteurisation and boiling

Semi-critical items, such as respiratory therapy and anaesthesia equipment, can be pasteurised by heating in water. All their parts must remain well-immersed throughout; holding the heat at about 65-77°C for 30 minutes is sufficient. Locations at higher elevations require a longer time because the boiling point of water gets lower the higher one gets from sea-level.¹⁰ Immersion of heat-resistant items in boiling water for about 10 minutes can substantially reduce the pathogen load, but must never be regarded as 'sterilisation'. Pasteurisation and boiling are thus low-tech and chemical-free methods (as long as the water is pure); treated items must be retrieved carefully for safe transport and storage.

Chemical disinfection

Common chemical disinfectants include alcohols, chlorine and chlorine compounds, glutaraldehyde, *ortho*-phthalaldehyde, hydrogen peroxide, peracetic acid, phenolics, biguanides, and quaternary ammonium compounds (QAC). Such chemicals can be used alone or in combination. They must be used in accordance with the manufacturer's instructions and only on surfaces with which they are compatible. Table 12.1 lists chemical disinfectants common in health care facilities.

Ideally, commercial products should pass standard tests to support label claims before being sold for use in health care settings. However, requirements for product registration and allowable label claims vary widely from region to region. This not only interferes with global harmonisation, it also makes testing products prohibitively expensive.

There are often serious disparities between what is claimed on the product label and its actual use. For example, the recommended contact time for environmental surface disinfectants is usually much too long for practical use. While wiping is the norm in the disinfection of non-porous inanimate surfaces, label claims of a product's microbicidal activity almost never support this. Chemical disinfectants vary widely in the harm they can cause to humans and the environment, so must be used carefully, and only when no suitable alternatives are available.

Disinfectants are placed into three categories depending on microbicidal activity:

High-level disinfectants

High-level disinfectants (HLD) are active against vegetative bacteria, viruses (including the non-enveloped ones), fungi, and mycobacteria. They may also have some activity against bacterial spores with extended contact times. HLDs are used to disinfect heat-sensitive and semi-critical devices such as flexible fiberoptic endoscopes.

Aldehydes (glutaraldehyde and *ortho*-phthalaldehyde) and oxidisers (e.g., hydrogen peroxide and peracetic acid) are HLDs. The aldehydes are non-corrosive and safe for use on most devices. However, they can fix organic materials, therefore it is particularly important to remove any embedded microbes prior to disinfection. Unless properly formulated and carefully used, oxidisers can be corrosive. However, they can be faster-acting, non-fixative and safer for the environment than aldehydes.

HLDs typically require 10-45 minutes contact time for disinfection, depending on the temperature. After disinfection, items require thorough rinsing with sterile or filtered water to remove any chemical residues; they must then be dried with an alcohol rinse or by blowing clean and filtered air through the device's channels prior to safe storage.

Intermediate-level disinfectants

Disinfectant active against vegetative bacteria, mycobacteria, fungi and most viruses. They may fail to kill spores, even after prolonged exposure.

Low-level disinfectants

Low-level disinfectants (LLD) are active against vegetative bacteria (except mycobacteria), some fungi, and only enveloped viruses. In many cases, washing with unmedicated soap and water would be sufficient in place of LLD.

Sterilisation

Sterilisation is any process that can inactivate all microorganisms in or on an object; routine sterilisation procedures may require modification to address prions. Heat is the most reliable sterilant; most surgical instruments are heat-resistant. Moist heat, when used as steam under pressure in an autoclave, kills microbes by denaturing their proteins. Dry heat in an oven kills by oxidation, which is a much slower process. Dry heat is used to sterilise moisture-sensitive materials (powders) or items which steam cannot penetrate (oils and waxes). Heat-sensitive items require low-temperature sterilisation; ethylene oxide (EO) gas, hydrogen peroxide gas-plasma, and steam-formaldehyde are often used for this purpose.¹¹

Sterilised items must be stored in a clean, dust-free, and dry place and the integrity of the wrapping must be protected. Packages containing sterile supplies should be inspected before use to verify barrier integrity and dryness. If packaging is compromised, the items should not be used and instead cleaned, wrapped, and resterilised.

Steam sterilisation

Steam is the most reliable means of sterilisation. It is non-toxic (when generated from water free of volatile chemicals), has broad-spectrum microbicidal activity, and good penetrating ability, while being cheap and easy to monitor for efficacy. Sterilisation requires direct contact of an item with steam at a required temperature and pressure for a specified time. Autoclaves are specially designed chambers in which steam under pressure produces high temperatures. They are based on the same principle as pressure-cookers. There are two main types of steam sterilisers:

- In gravity (downward) displacement autoclaves, steam is introduced at the top of the chamber to purge out the cooler and denser air-steam mixture from the bottom of the chamber. The exhaust valve closes when all the air has been removed, thus allowing the pressure to build and temperature to rise. Such autoclaves are used for sterilising

Table 12.1. The most widely used chemical disinfectants in health care

Agents	Spectrum	Uses	Advantages	Disadvantages
<p>Alcohols (60-90%) including ethanol and isopropanol</p>	<p>Low- to intermediate-level disinfectant.</p>	<p>Used for decontaminating the outside of some semi-critical and noncritical items, e.g., oral and rectal thermometers and stethoscopes. Also to disinfect small surfaces such as rubber stoppers of multi-dose vials. Alcohols with detergent are safe and effective for spot disinfection of countertops, floors, and other surfaces. Also common in handrubs.</p>	<p>Fast acting. No residue. Non-staining. Low cost. Widely available in many countries for medicinal and research purposes.</p>	<p>Volatile, flammable, and an irritant to mucous membranes. Inactivated by organic matter. May harden rubber, cause glue to deteriorate, or crack acrylate plastic.</p>
<p>Chlorine and chlorine compounds: the most widely used is an aqueous solution of sodium hypochlorite 5.25-6.15% (domestic bleach) at a concentration of 100-5000 ppm free chlorine</p>	<p>Low- to high-level disinfectant.</p>	<p>Used for disinfecting tonometers and for spot disinfection of countertops and floors. Can be used for decontaminating blood spills. Concentrated hypochlorite or chlorine gas is used for disinfection of large and small water distribution systems, such as dental appliances, hydrotherapy tanks, and water distribution systems in haemodialysis centres.</p>	<p>Low cost, fast acting. Readily available in most settings. Available as liquid, tablets or powders.</p>	<p>Corrosive to metals in high concentration (>500 ppm). Inactivated by organic material. Decolourises or bleaches fabrics. Releases toxic chlorine gas when mixed with ammonia. Irritant to skin and mucous membranes. Unstable if left uncovered, exposed to light, or diluted; store in opaque container.</p>

Agents	Spectrum	Uses	Advantages	Disadvantages
<p>Aldehydes</p> <p>Glutaraldehyde: ≥2% alkaline or acidic solutions. Also formulated with phenol-sodium-phenate and alcohol.</p>	<p>High-level disinfectant.</p>	<p>Widely used as high-level disinfectant for heat-sensitive semi-critical items such as endoscopes.</p>	<p>Good material compatibility.</p>	<p>Allergenic and irritating to skin and respiratory tract. Must be monitored for continuing efficacy levels when reused.</p>
<p>Ortho-phthalaldehyde (OPA) 0.55%</p>	<p>High-level disinfectant.</p>	<p>High-level disinfectant for endoscopes.</p>	<p>Excellent stability over wide pH range. Superior mycobactericidal activity compared to glutaraldehyde. Does not require activation.</p>	<p>Expensive. Stains skin and mucous membranes; may stain items not thoroughly cleaned. Eye irritation. Poor sporicide. Must be monitored for efficacy during reuse. Contraindicated for reprocessing certain urological instruments.</p>
<p>Peracetic acid 0.2-0.35% and other stabilised organic acids.</p>	<p>High-level disinfectant/sterilant.</p>	<p>Used in automated endoscope reprocessors. Can be used for cold sterilisation of heat-sensitive critical items, e.g., haemodialysers. Also suitable for manual instrument processing when properly formulated.</p>	<p>Rapid sterilisation cycle time at low temperature (30-45 min. at 50-55°C). Active in presence of organic matter. Environmentally-friendly by-products (oxygen, water, acetic acid).</p>	<p>Corrosive to some metals. Unstable when activated. May be irritating to skin, conjunctivae and mucous membranes.</p>

Agents	Spectrum	Uses	Advantages	Disadvantages
Hydrogen peroxide 7.5%.	High-level disinfectant/sterilant.	Can be used for cold sterilisation of heat-sensitive critical items. Requires 30 minutes at 20°C.	No activation. No odour. Environmentally-friendly by-products (oxygen, water).	Not compatible with brass, copper, zinc, nickel/silver plating.
Hydrogen peroxide 7.5% and peracetic acid 0.23%	High-level disinfectant/sterilant.	For disinfecting haemodialysers.	Fast-acting (high-level disinfection in 15 min.). No activation required. No odour.	Not compatible with brass, copper, zinc, and lead. Potential for eye and skin damage.
Phenolics	Low- to intermediate-level disinfectant.	Has been used for decontaminating environmental surfaces and non-critical items. Concerns with toxicity and narrow spectrum of microbicidal activity.	Not inactivated by organic matter.	Leaves residual film on surfaces. Harmful to the environment. No activity against viruses. Not recommended for use in nurseries and food contact surfaces.
Iodophores (30-50 ppm free iodine)	Low-level disinfectant.	Used on some non-critical items, e.g., hydrotherapy tanks; however, main use is as an antiseptic.	Relatively free of toxicity or irritancy.	Inactivated by organic matter. Adversely affects silicone tubing. May stain some fabrics.
Quaternary ammonium compounds	Low-level disinfectant unless combined with other agents.	Used mainly on environmental surfaces. Can be used on skin.	Stable with good detergent properties (cationic detergent). Usually non-irritating.	Relatively narrow microbicidal spectrum, but range of activity can be expanded when combined with other agents, e.g., alcohols.

ppm = parts per million

liquids and items in wraps that steam can penetrate. The sterilisation step itself normally lasts about 15 minutes at 121°C at 103.4 kilopascal (15 pounds/square inch).

- In high-vacuum autoclaves, the air from the steriliser chamber is first vacuumed out and then steam is introduced allowing faster and better penetration throughout the entire load. The pressure and temperature rise quickly allowing process times of three minutes at 134°C at about 206.8 kilopascal (30 pounds/square inch).

Instruments to be autoclaved must be wrapped in materials that allow steam penetration while keeping the processed item sterile during storage. Over-loading of autoclaves must be avoided to permit free access of steam throughout a load. Packages must be marked to identify their contents and date of sterilisation along with steriliser and load number to facilitate any recall and to aid in rotation of supplies.

All steam sterilisers must be tested upon installation and regularly thereafter; written records of routine operation and maintenance must be kept. *All staff must be thoroughly trained in autoclave operation and safety.*

Monitors

Biological and chemical indicators are available and must be used for routine monitoring of autoclaves.

Biological indicators (BI) contain the spores of the bacterium *Geobacillus stearothermophilus*. Commercially-available spore strips or vials containing the spores are strategically placed in the load to be sterilised. After a cycle, the BI are cultured or evaluated for growth and they must all indicate no growth to declare the sterilisation process a success.

Chemical indicators (CI) are used to assess if the required time and temperature were attained during the sterilisation process. One type of CI is an autoclave tape that can be affixed to the outside of a package; it shows a colour change if the package was exposed to heat. Though CIs are not meant to indicate that a product has been sterilised, they can help to detect equipment malfunctions and identify procedural errors.

For the high vacuum process, steam penetration of the load depends on adequate air removal. This can be monitored in two ways – firstly by a

'leak test' - can the vacuum be maintained or will air leak in (often around the door) - and secondly by the ability of steam to penetrate a small pack of towels used in the 'Bowie Dick' test. If these tests are satisfactory then an alternative monitoring approach is 'parametric release'. This system relies on ensuring that the autoclave cycle has fulfilled all specifications with regard to temperature, pressure and time using calibrated instruments in addition to, or in place of, BIs. Since this approach is based on measurable data and calibrated equipment, the results tend to be more reliable and much more rapid than the use of BIs.

Other Sterilisers

Steam is also used in two other types of sterilisers. In the low-temperature steam-formaldehyde (LTSF) process, steam (50-80°C) is used with vapourised formaldehyde to sterilise heat-sensitive medical devices (even those with narrow lumens). As usual, devices are cleaned and then processed. First, a vacuum is created; steam is introduced in several pulses followed by vapourisation of formaldehyde. At the end of the cycle, the formaldehyde is evacuated and completely purged out with several pulses of steam and high vacuum. Chemical and biological indicators are used to monitor the steriliser performance. It cannot be used with liquids and the potential toxicity of formaldehyde remains a concern.

In a Flash steriliser, steam is used to process surgical items for use when a critical item has become accidentally contaminated during an operation or when no other means of sterilisation are available. It should never be used for implantable items or to compensate for a shortage of essential instruments. Either a gravity-displacement or pre-vacuum autoclave can be used for flash sterilisation of porous or non-porous items without wrapping or with a single wrap. Waiting to read any included BIs is not possible due to the rapid turn-around needed for flash-sterilised items. *Unless suitable containers are used, there is a high risk of recontamination of the processed items and also thermal injury to personnel during transportation to the point-of-use.*

Microwaves

Exposure of water-containing items to microwaves generates heat due to friction from rapid rotation of water molecules. Thus far this process has only been used for disinfecting soft contact lenses and urinary catheters for intermittent self-catheterisation. However, small volumes of water could possibly be made safe for drinking by microwaving in a glass or plastic container. Similarly, small glass or plastic objects could be immersed in water and 'disinfected' in a microwave oven.

Dry-heat sterilisation

Hot-air ovens are used for dry-heat sterilisation. They can reach high temperatures and should be equipped with a fan for even distribution of heat. Preheating is essential before starting the sterilisation cycle. Hot-air ovens are simpler in design and safer for use than autoclaves and are suitable for sterilisation of glassware, metallic items, powders, and anhydrous materials (oil and grease). Sterilisation takes two hours at 160°C, or one hour at 180°C. Plastics, rubber, paper, and cloth must not be placed in them to avoid the risk of fires.

Ethylene oxide

Ethylene oxide (EO) is used to sterilise items that are sensitive to heat, pressure, or moisture. EO is a colourless gas that is flammable, explosive, and toxic to humans. Two EO gas mixtures are available, one with hydrochlorofluorocarbons (HCFC) the other a mixture of 8.5% EO and 91.5% carbon dioxide; the latter mixture is less expensive.

EO concentration, temperature, relative humidity (RH), and exposure time must all be maintained at the right levels during the process to ensure sterilisation. Gas concentration should be 450 to 1200 mg/l, temperature ranges from 37 to 63°C, RH from 40% to 80%, and exposure times from one to six hours.

Parametric release is not possible since gas concentrations and RH cannot readily be measured; a BI should be included with each load. The recommended BI is *Bacillus atrophaeus*; loads should be quarantined until the incubation time of the BI is complete. The main disadvantages of EO sterilisation are the long cycle times and high cost. Sterilised items must be aerated well after processing to remove all residues of EO.

Hydrogen peroxide gas plasma

Gas plasmas are generated in an enclosed chamber under deep vacuum using radio frequency or microwave energy to excite hydrogen peroxide gas molecules and produce charged particles, many of which are highly reactive free radicals. Gas-plasma can be used to sterilise heat- and moisture-sensitive items, such as some plastics, electrical/electronic devices, and corrosion-susceptible metal alloys. The spores of *G. stearothermophilus* are used as BIs.

This is a safe process, and, as no aeration is needed, sterilised items are available for immediate use or storage. However, it is not suitable for devices with dead-end lumens, powders, or liquids. Other disadvantages include the high cost and need for special packaging material since paper or linen cannot be used. In addition, any liquid or organic residues present interfere with the process.

Fumigation

Recently, there has been much interest in using fumigants to deal with healthcare-associated pathogens such as methicillin-resistant *S. aureus* and *C. difficile* in the environment. Several devices are now available which vary in cost, the process used, and the degree of field testing they have undergone.

A common process is to vaporise a solution of hydrogen peroxide into a sealed room, such as a patient room, for surface decontamination. No post-treatment aeration is necessary because hydrogen peroxide readily breaks down into oxygen and water. Spore strips are strategically placed throughout the room and retrieved later to monitor the effectiveness of the process. Disadvantages include incompatibility with cellulosic materials and potential corrosion of electronic devices.

Chlorine dioxide generated on-site may be released as a gas for room decontamination. The rooms must not only be sealed but also darkened to prevent daylight accelerating the breakdown of the gas. Like hydrogen peroxide, chlorine dioxide naturally breaks down into innocuous by-products.

Ozone can decontaminate surfaces in enclosed spaces, however it is highly unstable and potentially damaging to a variety of the materials common in health care facilities. However, an ozone-based medical device steriliser is now available. It generates the gas from oxygen and at the end of the cycle converts it to oxygen and water by catalysis. The machine claims wide materials compatibility and the ability to handle narrow-lumened devices.

Filtration

A simple means of removing microbes from air or heat-sensitive liquids is by passage through membrane or cartridge filters. This process retains physical microorganisms based on their size, without killing them unless the filter matrix is impregnated with or exposed to a microbicidal agent.

High efficiency particulate air (HEPA) filters are frequently used to remove microbial contamination from air in surgical theatres, microbiology laboratories, and for sterile manufacturing of pharmaceuticals. Their use in hospital wards and waiting rooms is also increasing to reduce the risk of spread of airborne pathogens. HEPA filters must be checked for integrity after installation and have a scheduled maintenance programme. Cartridge filters may be used on air-supply lines to remove microbial contamination.

Membrane and cartridge filters with a nominal pore diameter of 0.2 μm are quite commonly used in the manufacture of a variety of heat-sensitive biologicals and injectables. Such filters cannot remove viruses due to their much smaller size. Cartridge filters are also common on taps for potable water and inside automatic endoscope reprocessors to protect processed devices from recontamination with bacteria in rinse water. Liquids passed through such filters are often referred to as 'sterile', although this is not strictly true.

Automatic Endoscope Reprocessors

Medical devices are frequently manually disinfected. However, such an approach is operator-sensitive and exposes staff to infectious agents and potentially toxic chemicals. Automated endoscope reprocessors (AER) are a safer alternative, resources permitting. They require reliable

supplies of electricity and water, and require expensive maintenance and consumables (disinfectants, filters, etc.). The water quality is especially important to forestall premature clogging of filters and prevent the growth of opportunistic pathogens, such as environmental mycobacteria and pseudomonads.

Ultraviolet Radiation

Recent advances in ultraviolet (UV) lamp technology make the microbicidal potential of short-wave UV radiation viable for a variety of uses. UV lamps are increasing popular for disinfection of water and wastewater. UV-based devices are also being marketed for the disinfection of air in hospitals and clinics to reduce the spread of airborne pathogens. Devices are now being marketed for the disinfection of environmental surfaces in hospitals as well.

UV radiation does not add any chemicals to the water and air being treated, except for the generation of low levels of ozone. However, it cannot penetrate through dirt, and items require direct exposure to the radiation. Such lamps require regular cleaning and periodic replacement; they can still emit visible light even after the UV radiation has diminished.

Single-use Items

Single-use items are not designed for reprocessing; manufacturers will not guarantee safety and performance after reprocessing these items. If reprocessing is contemplated, satisfactory answers are required for the following questions.

1. Is the device undamaged and functional?
2. Can the device be disassembled for cleaning, decontamination, and further processing?
3. Can its sterility be validated, if needed?
4. Is the reprocessing cost-effective?
5. Is a person of authority at the site available and willing to take responsibility for any negative consequences from the use of the reprocessed item?

General Points

The main IPC priorities (regardless of resources) are:

1. Development of reprocessing protocols for instruments and equipment based on generally recognised standards and manufacturer's recommendations.
2. Use of clean water for cleaning items thoroughly.
3. Maintenance, use, and monitoring of equipment, e.g., autoclaves.
4. Discarding items that cannot be cleaned or reprocessed adequately.
5. Storing reprocessed items away from potential sources of contamination.

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Chapter 13

Special Populations

Candace Friedman

Key points

- Basic healthcare-associated infection prevention strategies apply, regardless of patient type or setting.
- Additional strategies may be required for special populations.
- Strategies designed for hospitals may need adapting for other health care settings which lack guidelines or evidence-based information.

Introduction

Basic healthcare-associated infection (HAI) prevention strategies apply, regardless of the patient type or setting. These strategies are presented in other chapters and include hand hygiene, standard precautions, isolation/precautions, staff education, aseptic techniques, and vaccination. However, additional practices are required for some patients or settings and are discussed in this chapter.

Geriatrics

Background

The number of people older than 65 years of age is increasing globally.¹ The elderly are susceptible to infection as a result of underlying illness, multiple medications, and alterations in immune function. Residents of nursing homes (NH) or long-term care facilities (LTCF) are particularly at risk.^{2,3}

Risk factors

Respiratory tract infections, urinary tract infections (UTI), gastrointestinal infections, and skin and soft tissue infections are the most frequent problems in this population.⁴ The incidence of UTIs increases with age, becoming nearly equal in women and men > 65 years old.

Both bronchitis and pneumonia occur in the elderly. Special risk factors include swallowing disorders or poor gag reflex with aspiration, impaired mucociliary clearance, increased esophageal reflux, immobility, and dehydration. Tuberculosis may occur in the elderly; often due to reactivation of old disease.

Cellulitis of the skin is also seen in the elderly. Predisposing factors include chronic oedema, venous insufficiency, unrecognised trauma, diabetes mellitus, and dry skin.

Diarrhoea is a significant cause of morbidity, particularly in institutionalised older persons.⁵ Pathogens may be spread by ingestion of microorganisms or toxins from (1) an infected person, (2) contaminated food or water, (3) contaminated objects in the environment, or (4) infected animals.

Prevention

See Table 13.1 for general prevention measures. Indwelling bladder catheters should be avoided whenever possible, and antimicrobials used only for symptomatic infections.

Prevention of bronchitis and pneumonia includes vaccination for patients and caregivers. In all settings there should be policies on distribution of pneumococcal and influenza vaccine for patients over 60 years of age. There should also be discussion of a policy on influenza vaccine for staff. Residents and staff of NHs/LTCFs should be screened for tuberculosis at a routine frequency, e.g., yearly.

Mobilisation of residents in NHs/LTCFs is important; it results in improved respiratory effort and reduced incidence of atelectasis and secondary bacterial pneumonia. Adequate hydration is also important to prevent formation of thick, tenacious pulmonary secretions.

Table 13.1. Preventing infections in the elderly

Infection	Prevention
Urinary tract infection	Adequate hydration Good personal hygiene Mobilisation
Bronchitis and pneumonia	Vaccination Cohorting patients with respiratory illness Limiting group activities and communal dining
Pressure ulcers	Mobilisation Keeping the patient dry Providing nutritional support
Diarrhoeal illnesses	Early implementation of cohorting or room closure Reinforcement of environmental disinfection Hand hygiene Isolation precautions

Endoscopy

Background

Endoscopy involves risks due to the complexity of the instruments. The patient's own microorganisms may be spread by the endoscope (rare) or microorganisms colonising the equipment may be introduced into the patient.⁶

Risk factors

Many outbreaks have been caused by defective equipment or inadequate cleaning and disinfection of endoscopes or accessories between patients (due to contaminated water rinses or contaminated automatic endoscope reprocessors⁷). To minimise the risk of infection, equipment must be maintained properly and reprocessing guidelines strictly followed.

Prevention

In addition to the external surface of endoscopes, the internal channels for air, water, aspiration, and accessories are exposed to body fluids and other contaminants. Cleaning is therefore critical. Most guidelines prescribe the following six steps for re-processing: cleaning, rinsing, disinfection, rinsing, drying, and storage. Whenever possible, sterilisation should replace disinfection.

Special infection prevention and control (IPC) principles for endoscopy:

1. To prevent cross-contamination in an endoscopic procedure room, most areas of the room should be designated as clean areas.
2. Contaminated areas where accessories and specimens are handled should be separate from clean counter areas.
3. Manual cleaning is important, including brushing, using a medical grade, low-foaming, and neutral pH detergent formulated for endoscopes.
4. Automatic disinfection, rinsing, and drying of all exposed surfaces of the endoscope, when available. Water for automatic endoscope reprocessors should be free from particles and microorganisms.
5. Isopropyl alcohol is recommended for flushing endoscope channels as part of the drying process at the end of the working day prior to storage.
6. Single-use accessories should be used in preference to reusable accessories when possible.

7. Rubber valves covering the working channel must be discarded after all procedures involving the passage of biopsy forceps, guidewires, and/or other accessories through the endoscope.

Paediatrics

Background

IPC issues are generally similar for adults and children. However, youth and immature immune systems make children more susceptible to infections; the pathogens and most common HAI sites differ from those in adults.⁸ Close contact with patients, siblings and family, uncontrolled body fluids, and play areas create unique opportunities for the spread of infection.

Infection risks

Many of the HAIs that occur in adults also occur in children, e.g., bloodstream and surgical site infections. However, children are susceptible to other pathogens, such as respiratory syncytial virus (RSV) and rotavirus; their lack of immunity affects the likelihood and severity of infection. Children are also often admitted to hospital with respiratory and gastrointestinal viral infections; they may then serve as a source of infection for others. Children at higher risk for HAI include those in intensive care, patients with cancer, solid organ transplant and haematopoietic cell transplantation recipients, and neonates.⁸

Prevention

See Table 13.2 for general prevention measures. Prevention of HAIs in children includes measures taken for adults with a focus on invasive devices and procedures. Additional preventive activities centre on vaccination, care of human milk/formula and toys, patient placement, and family/visitors.

Staff may transmit infection to children and vice versa, so staff and patients should maintain up-to-date vaccinations.

Pumping, collection, and storage of breast milk create opportunities for bacterial contamination and cross-infection, if equipment is shared between mothers. Appropriate cleaning and use protocols should be developed. Proper preparation and storage practices for powdered infant formula decrease the risk of microbial growth.⁸

Children are often in close proximity to one another and spend time in common areas, such as playrooms, where sharing of toys, equipment, and secretions can occur. Toys that have become contaminated with secretions should be washed thoroughly; treat them with a nontoxic, low-level disinfectant (e.g., bleach 1:100) and air dry completely between patients. Alternatively, a combined detergent disinfectant may be used. Toys and playroom surfaces should be disinfected as often as possible. Clean toys should be clearly separated from dirty ones.⁸

In general, control of viral respiratory and gastrointestinal transmission should include placing infected children in a single-room or use of an appropriate cohort for room placement.¹¹ Ideally, all visitors would be screened for evidence of communicable disease, recent exposure to communicable disease, and, in some instances, immunisation history.

Table 13.2. Preventing infections in paediatrics

Infection	Prevention
Communicable diseases	Vaccinate according to national guidelines
Breast milk and infant formula	Mothers should be instructed on hygienic methods Proper cleaning and disinfection of breast pumps
Toys	Avoid high-risk toys, such as soft/stuffed toys, that are difficult to clean and dry.
Viral respiratory and gastrointestinal illnesses	Patients should be screened; isolation/precautions initiated while awaiting a diagnosis.

Burns

Background

Significant burns have a major impact on both cellular and humeral immune systems, therefore predisposing patients to infection. Burn injury causes mechanical disruption of the skin which allows skin and environmental microbes to invade deeper tissues.

Infection risks¹²⁻¹³

Many of the same HAIs that occur in other patients occur in burn patients.

The incidence of infection is higher, particularly in patients with larger burns. As burn size increases, or it is complicated by other injuries, the risk of infection increases.

Wound infection can occur in surgically created wounds, such as excised burns, donor sites, and grafted wounds, which have not epithelialised. Burn wound cellulitis occurs in uninjured skin surrounding the burn wound or donor site.

Most deaths after severe burns are due to wound sepsis or complications of inhalation injury. Burn patients are also at risk for developing sepsis secondary to pneumonia, device-related infections, and suppurative thrombophlebitis.

Prevention¹²⁻¹³

Preventive strategies include strict aseptic technique, use of sterile gloves and dressing materials, wearing masks for dressing changes, and spatial separation of patients, either using single rooms or cubicles. The following IPC strategies are recommended by burn treatment facilities:

1. Emphasise hand hygiene before and after patient contact.
2. Use standard precautions/routine practices.
3. Wear protective apparel, e.g., aprons or gowns, before each patient contact and discard after leaving the patient's room.
4. Change gloves when soiled and before continuing with care at another site on the same patient.
5. Ensure appropriate cleaning and disinfection of reusable equipment before use on another patient.
6. Restrict plants and flowers at the bedside of patients with burn injuries because they harbour Gram-negative microorganisms, such as *Pseudomonas* species, and fungi.
7. Restrict non-washable toys (stuffed animals, cloth objects) which can harbour bacteria and are difficult to clean.
8. Whenever possible, catheters should be placed through unburned skin, preferably at a sufficient distance from the wound to prevent contamination of the insertion site. Because this is not always feasible in patients with large burn injuries who require long-term vascular access, frequent change of the catheter may be attempted to decrease risk of infection.
9. Patients colonised with multiply resistant microorganisms need to be

isolated in single rooms or cubicles to ensure physical separation from other patients.

10. Hydrotherapy is used routinely in some facilities; however it has been associated with outbreaks, particularly among patients with large burns. Some prefer to use local wound care with sterile saline solution instead. If hydrotherapy is used, shower tables are less risky than immersion. Disinfection protocols generally describe rinsing the tanks or equipment with a solution of sodium hypochlorite after each use.

Behavioural Health

Background

Behavioural health care provides prevention, intervention, and treatment services in the areas of mental health, substance abuse, developmental disabilities, and sexuality.

Infection risks

Geriatric patients in behavioural health often acquire urinary tract and upper respiratory infections. Skin and soft tissues are also frequent sites of infection in this specific population.

Prevention

The following are examples of general IPC strategies in this setting:

1. Staff should be aware of their immune status and practice standard precautions/routine practices. Those who work with children should be vaccinated for typical childhood illnesses.
2. An inpatient influenza and pneumococcal immunisation program should be considered for adults. Children should be up-to-date on their immunisations.
3. Mixing of patient clothing should be prevented. Special consideration should be given to the clothing of patients with incontinence, wound infections, or lesions, and suspected or confirmed cases of scabies or lice (e.g., use bleach in wash water, dry clothing on hot setting, or decontaminate washer and dryer after each use).
4. Procedures with regard to lice and scabies should include identification of illness, monitoring for transmission, treatment (includes staff monitoring of the application of treatment) and follow-up, and housekeeping procedures.

5. Patients can be provided with a caddy or basket in which to keep personal toiletry items if they share a bathroom.
6. Disposable paper mats for individual shower use protect the patient from transmission of athlete's foot (*Tinea pedis*).
7. Disposable razors for shaving should be provided and discarded after use in an appropriate sharps container. If electric shavers are provided, a protocol for cleaning and disinfecting the shaver after each use is needed.
8. For electroconvulsive therapy, there should be procedures for hand hygiene, use of gloves, and the cleaning and disinfection of equipment. Reusable items such as bite blocks and laryngoscope blades require high-level disinfection.

Ambulatory/Community Care

Background

Ambulatory/community care settings provide health care to patients who do not remain overnight; examples include physician's surgeries, clinics, dental surgeries, diagnostic treatment centres, and physical and occupational therapy centres.

Specific IPC problems include determining which infections require surveillance, what definitions to use, who will conduct the surveillance, to whom the data will be reported, and who will be responsible for implementing any required changes. Implementing measurement and operational definitions for HAI can be challenging as no standards are available. Definitions used in hospitals, long term care facilities, or home care may be adapted.

Process surveillance or audit is an important aspect of IPC in these settings. Surveys/audits provide a way to introduce and track improvements. Audits consisting of a standard list of criteria that are checked at each site are commonly used.

Infection risks

The overall risk of HAIs is lower in ambulatory/community settings than in hospitals.¹⁴ The visits are brief, environmental contamination is lower, less invasive procedures are performed, and, in general, the population is healthier.

One risk factor is exposure to infection in waiting rooms. Many patients and visitors may be congregated in common waiting areas. The chief risk is spread of infection by an airborne or droplet route; outbreaks of respiratory viruses have been reported in these settings.

Infections may also occur after procedures performed in ambulatory settings. Several outbreaks have been attributed to re-use of single use items. *Burkholderia cepacia* bacteraemia and hepatitis B and C infections have been attributed to reuse of needles and syringes and use of multidose vials of medication.¹⁵

Prevention

See Table 13.3 for general prevention measures. Prevention of HAIs includes those measures taken in hospitals, i.e., standard precautions/routine practices, hand hygiene, safe medication and needle use, and aseptic practices. Additional activities in these settings focus on communicable diseases, respiratory hygiene, toys, and instruments/devices.

Patients should be assessed as soon as possible for signs and symptoms of potentially communicable illnesses, particularly productive cough, diarrhoea, undiagnosed rash, bleeding, and wound or eye drainage. Patients with these conditions should be placed in a separate room as soon as possible.

Respiratory hygiene / respiratory etiquette measures are designed to limit droplet spread. Patients presenting with cough or respiratory symptoms should be provided with tissues or surgical masks and instructed to cover coughs and sneezes with a tissue and where to safely dispose of tissues. Patients should be reminded to clean their hands after a cough or sneeze and a container of alcohol based hand rub should be available.

Patients with suspected or known tuberculosis, chickenpox, measles, mumps, rubella, or bacterial meningitis should wear a surgical mask and be placed in a separate room with the door closed and a sign placed on the door to inform staff of necessary precautions. After a patient with suspected tuberculosis leaves an examination room, close the door and allow the room to ventilate before using it again.

Sharing of toys should be limited to prevent cross transmission, although spread of infection by shared toys is rare. If toys are provided, they should be readily cleanable (no stuffed animal toys).

Instruments are re-processed in many ambulatory/community settings. All re-usable instruments and medical devices require written procedures for cleaning and disinfection or sterilisation. The use of safer medical devices designed to reduce the risk of needle-stick injuries should be evaluated.

Immunocompromised Populations

Background

The severe neutropenia of treatment regimens and certain underlying diseases, coupled with invasive devices and procedures which bypass the physical barriers to infection, result in a high frequency of infection in these patients. In addition, illnesses such as acquired immune deficiency syndrome, place the patient at risk for infection. Because of defects in immunity, environments and activities that would be safe for patients with intact immune systems present hazards for these patients.

Infection risks

There are four broad categories of risk factors that predispose the immune compromised host to infection: 1) granulocytopenia; 2) immune system defects; 3) destruction of protective barriers, e.g., skin and mucous membranes, and 4) environmental contamination/alteration of microbial flora.

Table 13.3. Preventing infections in ambulatory care

Infection	Prevention
Respiratory illness	Respiratory hygiene / respiratory etiquette
Communicable diseases	Wear a surgical mask and place in a separate room with the door closed
Toys	Limit sharing Easily cleanable
Instruments	Clean, disinfect/sterilise properly

Many infections in the immunocompromised individual are caused by the patient's own flora, especially during periods of severe neutropenia. Because of conditioning or other immunosuppressive therapy, patients undergoing chemotherapy and haematopoietic stem cell transplantation (HSCT) or solid organ transplantation are at increased risk of infection.

Prevention¹⁶⁻¹⁷

General concerns include ventilation, construction/renovation, equipment, plants, play areas and toys, health-care workers, visitors, skin and oral care, and general HAI prevention. See the guidelines section of this chapter for information on HSCT recipients.

Patient-focused

1. Good oral and dental hygiene are important. The oral cavity is a reservoir for microorganisms capable of causing life-threatening infection. Any severe mucositis experienced by patients predisposes the spread of these microorganisms into the bloodstream.
2. Patients and family members, as well as healthcare workers, should be taught the importance of hand hygiene.

Staff-visitor-focused

1. Screening programs for communicable infections in visitors and staff are essential, especially during the appropriate "seasons" for certain illnesses.
2. Every effort should be made to restrict from direct patient care activities all healthcare workers with infections that may be spread to immunocompromised patients.

Environment-focused

1. Various combinations of isolation/precautions techniques, including requirements for caregivers to wear masks and gowns to enter rooms, gloves for patient contact, and sterile water, food, and linens, are recommended in an attempt to protect neutropenic patients from HAIs. However, there are insufficient data to provide recommendations regarding the use of these additional protective precautions.
2. Dust accumulation should be prevented with daily cleaning of frequently touched horizontal surfaces. However, cleaning methods that generate dust, such as dry dusting and mopping, should be avoided.

3. Doors to patient rooms should remain closed while any vacuuming takes place nearby.
4. Exclude plants and flowers from units housing immunocompromised patients.
5. Showers for immunocompromised patients have been controversial. Several studies have suggested an association between aerosols from showerheads and aerators and outbreaks of *Legionella*, *Acinetobacter*, and even *Aspergillus* sp.
6. All toys are to be cleaned and disinfected regularly and when visibly soiled or mouthed. Toys that cannot be washed or disinfected after use should be avoided.
7. Construction and renovation may result in an increased risk for healthcare-associated invasive mould infection, particularly aspergillosis. Whenever possible, immunocompromised patients should avoid construction or renovation areas.
8. Containment measures necessary to protect at-risk populations from dust include adequate barriers with air-tight seals and negative pressure inside a construction site.

International Perspectives

The epidemiology of infectious diseases and antibiotic resistance varies by geographical area. Endemic diseases and microbial flora of patients can impact the practice of IPC. Despite these differences, the principles should basically remain the same; that is, recognise that the patient is at increased risk for certain types of infection and minimise that risk to the extent possible.

Summary

Some patients have specific risk factors or require interventions that place them at increased risk of HAIs; general IPC practices are applicable, regardless of health care setting. However, thoughtful adaptation of these practices may be necessary in certain types of settings or with certain groups of patients.

Applicable Guidelines/Resources

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Immunocompromised

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Chapter 14

Maternal - Child Health

Sandra Callery

Key points

- Infection prevention and control strategies for mother and child are based on the principle of combined care. In many birthing centres, the mother often labours, delivers, and recovers in the same room. Wherever possible the mother and child are cared for together.
- For neonates requiring intensive care, the newborn's environment must be clearly delineated, with spatial separation between incubators.
- The sharing of equipment and supplies must be preceded by thorough cleaning, and appropriate disinfection/sterilisation.
- The blood and body fluids of mother and child are assumed to be potentially infectious and standard precautions should be applied for all patient care.
- Prevention strategies include hand hygiene, patient hygiene, environmental cleaning and immunisation.

Background

The World Health Organization (WHO) estimates that approximately 210 million women become pregnant each year and that 529,000 die from complications. In the immediate post-partum period, sepsis and haemorrhage are the commonest causes of maternal death. 99% of these maternal deaths occur in developing countries.

Similarly, 99% of the estimated 4 million annual neonatal deaths occur in developing countries. Severe infections cause more than one-third of deaths; these are not always carefully recorded, however the commonest are likely to be sepsis, pneumonia, tetanus, and diarrhoea.¹

Neonatal Risks and Infections

Neonatal infections occur in the first 28 days of life.² These infections may be contracted:

- In utero, by the transplacental route.
- Intrapartum, when in contact with the maternal genital tract, blood, or stool.
- Postpartum, when in contact with the mother, family, and visitors, other neonates in the nursery, healthcare workers, or contaminated equipment.

Risk factors for neonatal infections include:

- Maternal infections
- Foetal gestational age at the time of the infection
- Complications of delivery
 - o Invasive procedures and interventions, such as foetal monitoring devices
 - o Premature rupture of membranes > 24 hours.
 - o Caesarean section delivery (associated with respiratory distress syndrome and possible infection).

Premature infants are at increased risk for infection due to:

- The absence of normal microbial flora which increases the risk of colonisation with pathogens.
- The colonisation of gastrointestinal flora (this risk differs between breast-fed babies versus formula-fed babies).

- Abnormal colonisation that occurs most often in newborns in neonatal intensive care units (NICU).
- Fragile, underdeveloped organs that normally provide a barrier to infectious pathogens, such as the skin and lining of the lung.
- A poor immune (antibody) response.

Common infections for full-term newborns are superficial infections of the skin, eye, and mucous membranes. Additional infections occur in intensive care, such as bacteraemia associated with central lines, pneumonia, and gastrointestinal infections. Microorganisms associated with neonatal infections include *Staphylococcus aureus*, coagulase negative staphylococci, Group B streptococci, *Escherichia coli*, and *Candida*. Other pathogens often associated with outbreaks in the nursery include *Klebsiella*, *Serratia*, *Enterobacter*, *Citrobacter*, and *Pseudomonas* species.²

Maternal Risks and Infections

Healthcare-associated maternal infections are acquired in hospital and did not exist before admission. These infections are typically attributable to the health care setting up to 10 days post-partum. Most surgical site infections are considered healthcare-associated up to 30 days post procedure.³

Maternal risk factors for infection include: 1) prolonged rupture of membranes (>24 hours), 2) obesity (interferes with wound healing), 3) diabetes mellitus, and 4) invasive tests and procedures.

Common infections include:

- Endometritis – infection of the lining and wall of the uterus (endometrium and myometrium).
- Mastitis – inflammation and infection of the breast.
- Caesarean surgical site infections.
- Episiotomy site infections – infection at the site of the incision of the perineum.
- Sepsis - bloodstream infection which causes a systemic inflammatory response.

Endometritis is often polymicrobial with both anaerobic and aerobic bacteria (e.g., Group A streptococcus, Group B streptococcus, *Staphylococcus* sp., *Escherichia coli*, *Bacteroides*, and *Clostridium* sp.). *Staphylococcus aureus* is the

pathogen most often associated with mastitis. The pathogens associated with surgical site infections are typically endogenous to the patient, most often skin flora or bacterial flora of the lower genital tract.⁴

Prevention Strategies

As with all patients, use standard precautions/routine practices. Specific practices focused on the mother and child include:

1. Gloves are worn for all contact with mucous membranes, non-intact skin, and moist body substances.
 - a. Gloves are changed after each infant and/or procedure
 - b. Gloves are not necessary for contact with the intact skin of an infant
 - c. Gloves are worn for all diaper changes
 - d. Gloves are worn when handling the infant after delivery prior to bath or adequate removal of mother's body fluid
 - e. Sterile gloves are worn for the delivery
 - f. Clean gloves are worn when handling soiled linen and waste
2. Gowns and/or plastic aprons are worn for holding infant to a uniform.
3. Cohorting of infants with the same infection helps prevent spread of infections in the nursery.
4. Parent/infant contact is encouraged, except for the occasional case when there is a risk of transmitting infection. Labouring mothers may shower or bathe. Post-partum, instruct patient on daily perineal care after toileting. Reviewing good hygienic policies with parents is vital to protect both mother and infant from acquiring or spreading infections.
5. Additional precautions may be indicated for infants colonised or infected with microorganism(s) epidemiologically significant to the facility.
6. Suspected or confirmed infections should be handled according to the guidelines in Table 14.1.

Mothers and infants with the following infections/microorganisms are managed using standard precautions/routine practices; mothers and infants may have contact; and breast feeding is allowed: amnionitis, Chlamydia, bacterial conjunctivitis, cytomegalovirus, endometritis (unless

group A streptococcus), gonococcal infections, hepatitis B and C, herpes simplex, listeria, *Staphylococcus epidermidis* and other coagulase negative staphylococcal infections, group B streptococci infection/colonisation, toxoplasmosis, urinary tract infection, West Nile virus, wound infection, and yeast. Also included in this group:

- tuberculosis in mother (pulmonary or laryngeal on effective treatment, extrapulmonary, or positive skin test)
- mastitis/abscess due to *S. aureus* (for premature infants it may be prudent to withhold milk from a breast with mastitis/for breast abscess, recommended to refrain from breast feeding from affected breast until treated and abscess drained)
- *S. aureus* pneumonia/skin lesions in infant (during outbreak situations, additional precautions and cohorting of infants may be required)

Patients with acquired immune deficiency syndrome, HIV or Human T-Cell Lymphotropic Virus I/II (HTLV I/II) are cared for using standard precautions, contact is permitted; however mothers are not allowed to breast feed their child.

7. Infants and/or mothers with diagnosed or suspected infections transmitted by the airborne route must be placed in a single room with negative pressure and the door closed. Masks or respirators should be worn according to policy.
8. Priority for single room accommodation should be given to mothers who soil articles in the environment with body substances and those colonised or infected with microorganism(s) epidemiologically significant to the facility.
9. Environmental cleaning – For labour and delivery suites, post-delivery remove soiled linens using gloved hands. The delivery table/bed and the immediate patient environment should be cleaned after each use.
10. Use non-toxic disinfectants for cleaning neonatal equipment and incubators. Avoid phenolic disinfectants.
11. Breast milk is protective as it provides specific IgA antibody and helps establish normal flora in the neonate. See Table 14.1 for maternal/newborn infections and recommendations for breastfeeding.
12. Provide post-partum hygiene for the mother and infant immunisations as required.
13. For facilities with little room and overcrowding, consider kangaroo mother care. This includes skin to skin positioning of the baby on the mother's chest. Antepartum, intrapartum, and postpartum: Maintain

standard precautions with designated areas for bathing, toilet, and hand washing facilities for patients. Refrain from communal use of ointments and lotions; mother should bring in her own lotions and creams. Post-partum – Encourage mothers to perform hand hygiene before breast feeding.

Prenatal assessment

This is used to identify risk factors for maternal / newborn infection and focus prevention strategies.

Screen women for Group B streptococcus (GBS) at 35-37 weeks gestation. GBS-positive mothers should receive treatment if they are symptomatic. Colonised mothers should receive prophylactic penicillin at the time of delivery (ante-partum).

Screen for human immunodeficiency virus (HIV) and Hepatitis B virus. If a mother is Hepatitis B surface antigen positive, the infant should receive hepatitis B immune globulin and the first dose of Hepatitis B vaccine within the first 12 hours of life. HIV positive mothers should refrain from breastfeeding unless alternatives are not available.

Antepartum - Screen mothers upon admission for symptoms of infection, such as new onset of fever and other respiratory symptoms, e.g., new onset of cough, rash, or diarrhoea. If the patient responds “yes” to the any of these conditions, initiate the appropriate additional precautions and spatial separation from other patients (> 2 metres). If airborne infections are suspected, e.g., pulmonary *Mycobacterium tuberculosis* or varicella, then place patient in single room with the door closed and initiate airborne precautions.

Table 14.1. Maternal/Child Infectious Diseases and Infection Prevention and Control Management (Table adapted from Sunnybrook Health Sciences Centre, Toronto, Ontario, 2010).^{5,6}

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Antibiotic Resistant Microorganisms - Mother	Vancomycin-resistant Enterococcus (VRE) or methicillin-resistant <i>S. aureus</i> (MRSA): Contact Precautions	Standard Precautions	Permitted	Permitted	MRSA - Infant to room with woman
Antibiotic Resistant Microorganisms - Infant	Standard Precautions	VRE or MRSA: Contact Precautions	Permitted	Permitted	MRSA - Single room preferred. If open concept nursery, then spatial separation from other infants required (>2 metres)
Chickenpox Mother ill – healthy term infant	Airborne Precautions	Infant room in with mother	Permitted	Permitted	Provide varicella zoster immune globulin (Varig) to infants where onset of maternal disease is <5 days prior to delivery or within 48 hours after delivery ⁵
Chickenpox Mother ill – Infant in NICU	Airborne Precautions Mother may not visit the NICU	Standard Precautions until day 10. As of day 10 through day 28 start Airborne Precautions	Not permitted	Permitted (as expressed breast milk)	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Chickenpox Infant in NICU	Only parents and visitors who are immune may visit	Airborne Precautions	Permitted if woman is immune	Permitted	Provide varicella zoster immune globulin (Varig) to infants where onset of maternal disease is <5 days prior to delivery or within 48 hours after delivery ⁵
Conjunctivitis Adenovirus - Mother	Contact Precautions No sharing of towels, face cloths, pillows, linens	Standard Precautions	Healthy term infant: Room in No sharing of towels, linens	Permitted	Check for Chlamydia, viral, and bacterial pathogens.
	Standard Precautions	Contact Precautions No sharing of patient care items	Infant in NICU: Mother NOT to go to NICU	Permitted as expressed breast milk	
Conjunctivitis Adenovirus - Infant	Standard Precautions	Contact Precautions No sharing of patient care items			

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Diarrhoea Mother - Bacterial (suspected or confirmed)	Standard Precautions Single room with toilet	Standard Precautions	Healthy term infant: Permitted with Standard Precautions	Permitted	
Diarrhoea Mother - C. difficile	Contact Precautions Single room with toilet	Standard Precautions	Infant in NICU: Not permitted until asymptomatic for 48 hours	Permitted as expressed breast milk	
Diarrhoea Mother - Viral (e.g., norovirus)	Contact Precautions Single room with toilet	Contact Precautions Single room with toilet	Healthy term infant: Permitted with Standard Precautions	Permitted	
			Infant in NICU: Woman is not permitted in the NICU until asymptomatic for 48 hours	Permitted as expressed breast milk	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Diarrhoea Infant - Bacterial (suspected or confirmed)	Standard Precautions	Contact Precautions	Permitted	Permitted	Diapered infants require Contact precautions for the duration of illness
Diarrhoea Infant - Viral (e.g., norovirus)	Standard Precautions	Contact Precautions	Permitted	Permitted	Diapered infants require Contact Precautions for the duration of illness
Enterovirus Mother	Contact Precautions	Contact Precautions	Healthy term infant: Permitted with Standard Precautions	Permitted	
	Single room	Single room	Infant in NICU: Woman is not permitted in the NICU until asymptomatic	Permitted as expressed breast milk	
Enterovirus Infant	Standard Precautions	Contact Precautions	Permitted	Permitted	
Hepatitis, type A Mother	Standard Precautions	Standard Precautions	After prophylaxis of infant	After prophylaxis of infant	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Herpes simplex Mother - Oral or mucocutaneous (i.e., cold sore)	Standard Precautions	See Infant - Asymptomatic	Permitted Total rooming-in preferred	Permitted if there are no herpetic lesions on the breast	Instruct the woman on hand hygiene, to wear a mask or cover lesion when around her infant, not kiss infant while lesion is present, and to avoid touching affected area
Herpes simplex Mother - Whitlow	Standard Precautions	See Infant – Asymptomatic	Direct/hands-on contact is NOT permitted	May pump and discard milk until lesions are gone or may nurse if the woman does not touch her infant (i.e., someone else holds and positions the infant)	
Herpes simplex Infant - Asymptomatic	Standard Precautions	Contact Precautions For duration of incubation period (up to 4 weeks)	Permitted	Permitted	
Herpes simplex Infant - Symptomatic	Standard Precautions	Contact Precautions	Permitted	Permitted	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
<p>Herpes zoster (shingles) Mother – localised</p>	<p>Standard Precautions in single room Only immune staff may care for patient</p>	<p>Standard Precautions</p>	<p>Permitted Total rooming-in preferred Mother may not go to nursery until lesions are crusted</p>	<p>Permitted if lesions are not on breast.</p>	<p>Only immune visitors/siblings to visit</p>
<p>Herpes zoster (shingles) Mother – disseminated</p>	<p>Airborne Precautions Immune staff only</p>	<p>Term infant rooming-in: Standard Precautions</p> <p>Infant in NICU: Airborne Precautions day 10 from 1st exposure to day 21 of last exposure (or day 28 if infant has been given VarG)</p>	<p>Permitted Total rooming-in preferred Mother may not go to nursery until lesions are crusted</p> <p>Infant in NICU: Woman may NOT go to the NICU until lesions are crusted.</p>	<p>Permitted if lesions are not on breast</p> <p>Infant in NICU: Provide expressed milk.</p>	<p>VarG is not indicated for infant if the mother has zoster;⁶ however, if infant is <32 weeks, VarG is to be given</p>

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Influenza Mother	Droplet and Contact Precautions Single room preferred	Standard Precautions	Healthy term infant: Permitted Woman must wear a surgical mask when within 2 metres of infant	Infant in NICU: Permitted as expressed breast milk	Consider acute respiratory illnesses to be influenza during influenza season
Influenza Infant	Standard Precautions	Droplet and Contact Precautions	Infant in NICU: Woman is not permitted to go to NICU	Permitted	During outbreak situations, additional precautions and cohorting of infants may be required
Measles (Rubeola) Mother ill – Term, healthy infant	Airborne Precautions Immune staff only Only immune family and visitors permitted	Standard Precautions	Room in with woman	Permitted if rooming in with woman May provide expressed breast milk if not rooming in	Infant should receive immune globulin (IG)

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Measles (rubeola) Mother ill – infant in NICU	Airborne Precautions Immune staff only Only immune family and visitors permitted	8 days from 1st exposure to 12 days from last exposure - Airborne Precautions	Woman not permitted in NICU until 4 days after the appearance of the rash	Permitted as expressed breast milk only until woman no longer infectious	Infant should receive immune globulin (IG). Families & Visitors: Immunity is defined as previous history of measles or having received measles vaccine
Measles (rubeola) Infant ill or exposed (i.e., exposed in NICU)	Standard Precautions	Airborne Precautions	Woman immune – permitted to see infant Woman susceptible – woman not permitted to see infant	Permitted Permitted as expressed breast milk only until infant no longer infectious	
Meningitis <i>Neisseria meningitidis</i>/ <i>Haemophilus influenzae</i>	Droplet Precautions until 24 hours after appropriate antimicrobial therapy				Consider infant a contact of the mother

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Mumps Mother	Droplet/Contact Precautions Immune staff only Only immune family and visitors permitted	Standard Precautions	Term infant: Permitted Infant in NICU: Woman is not to go in the NICU until 9 days after the onset of the parotid swelling	Term infant: Permitted Infant in NICU: Expressed breast milk until 9 days after the onset of the parotid swelling	Families & Visitors: Immunity is defined as a previous history of mumps or having received mumps vaccine
Mumps Infant in NICU Exposed or ill	Standard Precautions	Droplet/Contact Precautions starting 10 days from 1st exposure to 26 days from last exposure Single room Immune staff only Only immune family and visitors permitted	Woman immune – permitted to see infant Woman susceptible – woman not permitted to see infant	Permitted Permitted as expressed breast milk	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Pediculosis (Head Lice)	Contact Precautions Precautions remain in place until after woman has been appropriately treated	Standard Precautions	Healthy term infant: Permitted Infant in NICU: Permitted once woman has been appropriately treated	Permitted Infant in NICU: Permitted as expressed breast milk until woman has been appropriately treated	
Pertussis Mother	Droplet Precautions Single room	Standard Precautions	Healthy term infant: Permitted Reinforce hand hygiene and wear a surgical mask when within 2 metres of infant Infant in NICU: Not permitted until 5 days of appropriate antibiotic treatment completed	Permitted	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Pertussis Infant	Standard Precautions	Contact Precautions Consider cohorting Precautions remain in place until 5 days of appropriate antibiotic treatment has been completed	Permitted	Permitted	
Respiratory Virus Infections Mother ill	Droplet/Contact Precautions Single room	Standard Precautions	Healthy term infant: Permitted Reinforce hand hygiene and wear a surgical mask when within 2 metres of infant	Infant rooming-in: Permitted	
Respiratory Virus Infections Infant ill	Standard Precautions	Droplet/Contact Precautions	Infant in NICU: Not permitted	Infant in NICU: Permitted as expressed breast milk	During outbreak situations, additional precautions and cohorting of infants may be required.

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Rubella Mother	Droplet precautions Immune staff only	Droplet precautions Immune staff only	Healthy term infant: Permitted Infant in NICU: Woman cannot go into the NICU until 7 days after the onset of the rash	Healthy term infant: Permitted Infant in NICU: Expressed breast milk as the woman cannot go into the NICU until 7 days after the onset of the rash	Families and visitors: Immunity is defined as having received rubella vaccine or laboratory evidence of immunity
Rubella Infant (Congenital)	Standard Precautions	Droplet Precautions	Permitted	Permitted	Congenitally infected infants may shed virus for up to 2 years.
Scabies	Contact Precautions Precautions remain in place until woman has been appropriately treated	Standard Precautions	Healthy term infant: Permitted once woman has been appropriately treated Infant in NICU: Permitted once woman has been appropriately treated	Permitted once woman has been appropriately treated or may provide expressed breast milk Infant in NICU: Permitted once woman has been appropriately treated or may provide expressed breast milk	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
<i>Staphylococcus aureus</i> Mother - Major Wound (not contained)	Contact Precautions	Standard Precautions	Permitted if draining can be adequately contained – see comments	Permitted	Change dressing and woman's gown, and have woman perform hand hygiene prior to contact with infant
Streptococcal Disease (Group A) Mother - Minor Wound Infection (contained)	Single room until 24 hours after effective treatment	Standard Precautions	Permitted	Permitted	
Streptococcal Disease (Group A) Mother - Major wound infection or endometritis	Single room until 24 hours after effective treatment	Standard Precautions	Permitted	Permitted	It may be advisable to withhold milk from breast with mastitis until 24 hours of effective treatment
Streptococcal Disease (Group A) Mother - Invasive Disease	Single room until 24 hours after effective treatment.	Standard Precautions	Permitted after 24 hours of effective treatment	Permitted after 24 hours of effective treatment	

Infection/ Microorganism	Maternal Precautions	Newborn Precautions	Mother/Infant Contact	Breast Feeding	Comments
Streptococcal Disease (Group A) Mother - Pharyngitis (strep throat)	Droplet Precautions Single room	Standard Precautions	Permitted after 24 hours of effective treatment	Permitted after 24 hours of effective treatment	It may be advisable to withhold milk from breast with mastitis until 24 hours of effective treatment
Streptococcal Disease (Group A) Infant	Standard Precautions	Contact Precautions	Permitted	Permitted	
Syphilis Mother - Mucocutaneous	Contact Precautions	Standard Precautions	Permitted after 24 hours effective treatment	Permitted after 24 hours effective treatment	
Syphilis Infant - Congenital	Standard Precautions	Contact Precautions	Permitted	Permitted	
Tuberculosis Mother - Pulmonary or laryngeal – newly diagnosed, on inadequate treatment or noncompliant	Airborne Precautions	Standard Precautions	Not permitted until woman is no longer infectious	Mother may provide expressed breast milk	Continue Airborne Precautions until the mother no longer considered infectious

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Chapter 15

Prevention of Surgical Site Infections

Pola Brenner and Patricio Nercelles

Key points

- Surgical site infections are one of the most common healthcare-associated infections.
- Evidence-based measures exist that are effective in reducing surgical site infections.
- Although sterilisation of instruments, aseptic technique, clean air, and antimicrobial prophylaxis have been shown to reduce the incidence of surgical site infections, it remains an important cause of morbidity and mortality worldwide.
- Risk factors involve the patient, the operation itself, and the environment.

Introduction

Surgical site infections (SSI) are one of the most important healthcare-associated infections (HAI). In many countries, SSIs account for up to 25% of HAIs. It is estimated that 40% to 60% of SSIs are preventable. SSIs may prolong hospital stay from 6-30 days, increase antimicrobial and laboratory costs, and require added health care interventions.¹

Despite an understanding of infection prevention and control (IPC) measures and, although sterilisation of instruments, aseptic technique, clean air, and antimicrobial prophylaxis have reduced the incidence of SSI, the rate remains unacceptably high. It is an important cause of morbidity and mortality. This is due to breaches in good IPC practices, host risk factors, and/or the complexity of the procedure. The development of a SSI is multi-factorial; in general, it is impossible to determine an exact cause.

Risk Factors

Patient risk factors, types of surgical procedures, and the operating room environment have been associated with an increased risk of SSI. These risk factors are outlined in Tables 15.1 – 15.3.²⁻¹¹

Surveillance^{3, 12-15}

Surveillance for SSIs with appropriate feedback to surgeons has been shown to reduce SSI risk. Many SSIs are detected after the patient leaves hospital. Therefore, post-discharge surveillance is essential (particularly for day cases). However, this activity is resource intensive, requiring direct examination of patients, review of medical records, or patient surveys by mail/telephone.

A surveillance system should include use of standard definitions and risk stratification. A frequent criterion used to identify a SSI is purulent drainage from the incision or from the site of a drain with either a positive or negative culture. An infection occurring within 30 days of an operation or within 1 year of an implant procedure is classified as a SSI. Definitions from the US Centers for Disease Control and Prevention are often used.³

Table 15.1.1. Patient risk factors for surgical site infection (SSI)

Risk Factor	Comments
Nutritional status	In theory, malnutrition increases the risk of SSI; however, this is difficult to demonstrate. Some studies of malnutrition predict mortality but not SSI. The benefits of preoperative total parenteral nutrition in reducing the SSI risk are not proven.
Diabetes	There is a significant relationship between increased glucose levels (>200 mg/dL) in the peri-operative period and the risk of SSI. Good glycaemia control and stable serum glucose concentration is essential.
Smoking	Nicotine delays wound healing. Studies have associated cigarette smoking with an increase in SSI, however they are controversial.
Obesity	Obesity (Body Mass Index >40) has been associated with SSI, especially after cardiac and orthopaedic implant surgery.
Coexisting remote infection	Active infection, especially of the skin and respiratory tract, increases SSI risk in all types of surgery.
Colonisation with microorganisms	Nasal carriage of <i>S. aureus</i> is a risk factor for SSI. Some studies support pre-operative nasal mupirocin. However its use needs further evaluation, and there is concern about mupirocin resistance.
Length of preoperative stay	Prolonged preoperative hospitalisation has been associated with increased SSI risk, probably because it may indicate severe illness.
Perioperative transfusion	SSI has been associated with perioperative transfusion. However interpretation of data is difficult due to methodological problems.

Table 15.2. Operative risk factors for surgical site infection (SSI)

Risk Factor	Comments
Colonisation of the operative site - Antiseptic bath	A preoperative antiseptic shower or bath decreases skin microbial colony counts; however it has not definitively been shown to reduce SSI rates.
Colonisation of the operative site - Skin antiseptics	Antiseptics decrease skin colonisation of microorganisms. Preoperative skin preparation with an antiseptic solution is recommended for all operations. Iodophors, alcohols, and chlorhexidine are the most commonly used. Current data suggest that chlorhexidine is better than other products in prevention of SSI. More studies are needed.
Colonisation of the surgical team - Surgical scrub	The aim of a surgical scrub/rub is to reduce colonisation of the surgical team's hands. Various antiseptics have been used, e.g., alcohols, chlorhexidine, iodine/iodophors, parachloro-meta-xyleneol, and triclosan. Isopropyl alcohol is considered the gold standard due to its rapid effect; chlorhexidine is used for its persistent action. Artificial nails increase bacterial and fungal colonisation of the hands despite adequate hand scrubs. No clinical trials have evaluated the effectiveness of surgical scrubs on SSI.
Preoperative shaving	Preoperative shaving of the surgical site is associated with a significantly higher SSI risk than using depilatory agents or no hair removal. Clipping hair immediately before an operation lessens the risk. However, the risk from either shaving or clipping increases when it is performed the night before surgery. Use of depilatories is better; however, it sometimes causes hypersensitivity. Some studies demonstrate that any hair removal is associated with increased SSI rates and suggest that no hair should be removed unless essential.
Infected or colonised surgical personnel	Personnel with skin diseases, such as psoriasis, active infections, or who are colonised with microorganisms, such as staphylococci, have been linked to outbreaks of SSIs. Health care organisations should exclude infected individuals from surgical activities.

Risk Factor	Comments
Duration of operation	Lengthy operations are associated with an increased risk of SSI. Operation time should be kept to a minimum.
Contamination of the operative site - Antimicrobial prophylaxis	Antimicrobial prophylaxis reduces SSI and is recommended when a SSI would represent a catastrophe, e.g., in orthopaedic and other high-risk procedures. A single dose is usually sufficient (maximum of 3); timed to have a bactericidal concentration of the drug in the tissues at the time of the incision. Usually it is given at the induction of anaesthesia or, in any case, not more than 30 minutes before the skin is incised. The prophylactic agent should be safe, inexpensive, and have a spectrum that covers likely intraoperative contaminants. First and second generation cephalosporins are often used, e.g., cefazolin or cefuroxime. A second dose is recommended if the operation lasts >3 hours or involves rapid blood loss.
Foreign material in the surgical site (sutures and drains)	A foreign body may promote inflammation and act as a point of entry for microorganisms. Drains used to evacuate postoperative haematomas or serous fluids in the post-operative period increase incisional SSI risk. Drains should be passed through a separate incision away from the operative wound and removed as soon as possible; use closed suction. Monofilament suture material is the least irritating.
Hypothermia	Hypothermia causes vasoconstriction, decreased delivery of oxygen to the wound space, and impairment of leukocyte function.
Surgical technique	Breaks in aseptic technique, such as use of communal syringes or contamination of intravenous fluids or equipment, have been associated with SSI. Good surgical technique (effective homeostasis, gentle handling of tissues, and removal of devitalized tissues) reduces the risk. The risk of SSI is strongly associated with the experience of surgical teams. Institutions should select experienced surgeons for complex interventions and monitor surgical technique.

Table 15.3. Environmental risk factors for surgical site infection (SSI)

Risk Factor	Comments
Operating room ventilation	An operating room should be at positive pressure relative to adjacent areas and supplied with enough filtered air to provide at least 20 air changes per hour. Use of ultra-clean air in the prevention of SSI in implant surgery is well established. Use of ultraviolet radiation has not been shown to decrease SSI. The microbial count in operating room air is directly proportional to the number of people and their movement; movement must be controlled and numbers kept to a minimum.
Inanimate surfaces	Environmental surfaces, i.e., floor, walls, or tables, have not been associated with SSIs. There are no data to support the use of environmental disinfectants. Tacky mats placed outside the theatre entrance and use of overshoes is unnecessary.
Inadequate sterilisation of instruments	Sterilisation of instruments is an essential part of aseptic technique and must be performed using validated methods. Inadequate sterilisation has been associated with increased SSI rates and outbreaks. Flash sterilisation should only be performed in an emergency. There are issues with absence of protective packaging, possibility for contamination of processed items during transportation, and difficulty in monitoring cycle parameters (time, temperature, and pressure). Flash sterilisation should be never be used for implants or invasive devices.
Contamination from the surgical team - Surgical clothes and gloves	Barrier clothing and gloves are necessary to minimise exposure of a patient's wound to the skin, mucous membranes, and hair of the surgical team. It also protects the team from exposure to a patient's blood. Masks can prevent contamination of patients with respiratory pathogens. Surgical caps reduce contamination of the surgical field by microbes from the hair and scalp. Footwear should be enclosed and protect the team from accidentally dropped sharps and other contaminated items. Open footwear must never be worn. If there is a risk of spillage of blood or other high-risk body fluids, surgical waterproof boots should be worn. Sterile gloves minimise transmission of microbes from the hands of the surgical team to patients and prevent contamination of team members from blood and body fluids. Wearing two pairs of gloves may provide added protection.

Some countries recommend SSI surveillance based on a specific surgery (e.g., cholecystectomy, hernia repair, Caesarean section, hip replacement). This approach assumes that patients having similar operations have similar risk factors.

The rates of SSIs must be calculated based on the specific risk of the patients. Risk stratification or standardisation is necessary because not all the operations or patients have the same risk of infection.¹⁵ There are several methods to classify SSI in relation to risk. The first method is by type of surgery: clean, clean-contaminated, contaminated, or dirty. The main predictor of SSI for this method is regarded as the intrinsic degree of wound contamination.

Another approach is to compare the clean wound SSI rates from different surgeons. This strategy has been shown to decrease SSIs in some studies. However, it may be unpopular and unfair if the data are not adjusted for patient's risk factors.

The former NNIS (National Nosocomial Infection Surveillance – now the National Healthcare Safety Network) system in the US developed a method that used the type of surgery classification, the duration of an operation, and the ASA (American Society of Anesthesiologists) score as its SSI risk stratification system. This method demonstrated that the degree of contamination is not the only predictor of SSI.

Standardised infection ratios (SIR) for SSI data may also be used. The SSI SIR is the result of logistic regression modelling that considers all procedure-level data in order to provide better risk adjustment than afforded by the NHSN risk index.

Basic Recommendations for Prevention^{2-11, 16}

Preoperative

- Identify and treat all infections before elective operations.
- Maintain good control of diabetes.
- Keep preoperative hospital stay to a minimum.
- Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation. If considered essential, remove hair immediately before the operation with a non-invasive procedure, e.g., clipper.

- Use an antiseptic for skin preparation.
- Perform a preoperative surgical scrub for 2-4 minutes using an appropriate antiseptic. A surgical scrub can be performed using water-less products (e.g., alcohol-based hand rubs) in the absence of visibly dirty hands. Do not use a brush. Remove debris underneath the fingernails using a nail cleaner before the first procedure in the morning.
- Exclude personnel who have signs and symptoms of a transmissible infection from surgical activities. Personnel with draining skin lesions must be excluded until the infection is fully resolved.
- Administer prophylactic antibiotics according to local policy.
- Determine the level of experience required for surgeons in complex surgeries.

Intraoperative

- Use a surgical checklist.
- Limit the duration of the procedure as much as possible.
- Sterilise all surgical instruments with validated methods. Do not use flash sterilisation routinely.
- Wear sterile gloves. Put gloves on after donning a sterile gown. Use water-repellent surgical gowns and drapes. Wear a surgical mask and a cap or hood to fully cover hair.
- Maintain positive pressure ventilation in the operating room with respect to the corridors and adjacent areas. Twenty air changes per hour are recommended. Filter all air, recirculated and fresh.
- Keep operating room doors closed except as needed for passage of equipment, personnel, and the patient.
- Restrict entrance to the operating room to necessary personnel only and restrict their movement as much as possible.
- Adhere to principles of asepsis when performing interventions and invasive procedures in the operating room, e.g., when placing central venous, spinal, or epidural anaesthesia catheters or when dispensing and administering intravenous drugs.
- Handle tissue gently, maintain effective homeostasis, minimise devitalized tissue and foreign bodies (e.g., sutures, charred tissues, necrotic debris), and eliminate dead space at the surgical site.
- Use drains only if is necessary due to the patient's condition; then use closed suction drains. Place a drain through a separate incision distant from the operative incision. Remove it as soon as possible.

- Keep the body temperature of the patient between 36.5 and 37°C during the operation (normothermia).
- Keep the glycaemia level to <200 mg/dL during the operation (normoglycaemia).
- Avoid use of artificial nails among the surgical team.
- Consider screening and decolonisation of carriers of *S. aureus* in high-risk patients if the SSI rates for this microbe are high and is not controlled by routine infection prevention measures.
- Do not perform special cleaning or closing of operating rooms after contaminated or dirty operations.
- Do not use over-shoes and tacky mats at the entrance to the operating room suite.

Post-operative

- Don't touch the wound unless it is necessary.
- Review daily the necessity of continuing use of drains and take out when no longer necessary.
- Have an on-going surveillance system for SSI using standard definitions and risk classifications. Perform post-discharge surveillance for ambulatory surgery or short hospital stay patients.

Low Resource Issues

Surgical site infections are typically higher in developing nations than in high-resource countries.¹⁷ Minimal requirements for the prevention of SSIs include:

- Do not remove hair preoperatively unless hair at or around the incision site will interfere with the operation.
- Perform glycaemia control in cardiac and vascular surgery.
- Use an antiseptic agent for skin preparation immediately prior to the operation.
- Perform a preoperative surgical scrub using an antiseptic product.
- Administer a prophylactic antimicrobial agent when indicated according to established criteria.
- Sterilise all surgical instruments with validated methods.
- Adhere to principles of asepsis when performing interventions or invasive procedures in the operating room.
- Have an on-going surveillance system for SSI using standard definitions and risk classifications.

Summary

Research has shown that surgical techniques, skin preparation, and the timing and method of wound closure influence the incidence of subsequent infection. Antibiotic prophylaxis has also had a positive impact after certain types of surgery.

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Chapter 16

Prevention of Lower Respiratory Tract Infections

Emese Szilágyi

Key points

- Healthcare-associated pneumonia causes significant patient morbidity and mortality and increased utilisation of costly health care resources; prevention is therefore vital.
- Prevention measures include hand hygiene, use of gloves when handling respiratory secretions, daily assessment of readiness to wean from a ventilator, elevation of the bed head (unless contraindicated), use of orotracheal intubation, regular oral care with an antiseptic solution, and proper use, cleaning, and disinfection of respiratory equipment.

Introduction¹⁻⁴

The cough reflex, together with a healthy respiratory mucosa, antimicrobial secretions, and immunity mechanisms, effectively prevent microorganisms from reaching the lower respiratory tract (LRT). As a result, in the healthy individual the LRT is sterile.

Factors that predispose to infection include alteration in level of consciousness, aspiration, endotracheal tubes, respiratory therapy devices, enteral feeding, severe underlying illness, extremes of age, malnutrition, immunosuppression, mechanical obstruction, viral infection, cigarette smoke, and alcohol intake. The LRT may become contaminated by aspiration of secretions, colonisation of the aerodigestive tract, or use of contaminated equipment/medication.

Pneumonia accounts for 11% - 15% of healthcare-associated infections (HAI) and for 25% of infections acquired in an intensive care unit (ICU). It has the highest mortality among HAIs; prevention is therefore vital. Postoperative pneumonia is a common complication of surgery, often because the patient fails to cough or breathe deeply because of pain. In these patients infections are usually caused by common respiratory pathogens. Ventilator-associated pneumonia (VAP) is a more serious condition seen in mechanically ventilated patients in ICUs. It occurs in 8-28% of patients undergoing mechanical ventilation. In these patients, mechanical or chemical injury to the ciliated epithelium impairs the normal removal of mucus and microorganisms from the lower airway. In addition, reduction of gastric pH by H₂ blocking agents is associated with colonisation of the upper gastrointestinal tract and oropharynx by aerobic Gram-negative bacilli derived from the patient's own bowel. These microorganisms may then pass to the LRT and cause infection.

These patients have usually had prolonged hospitalisation and antibiotics (sometimes several courses). Because of this, the microorganisms involved are often multidrug-resistant. Microorganisms may also be introduced into the respiratory tract via contaminated equipment or staff hands. Risk factors for healthcare-associated pneumonia can be related to the condition of the patient and/or the therapy received. (See Table 16.1)

Table 16.1. Risk factors for healthcare-associated pneumonia

Condition of patient	Severely ill, e.g., septic shock Age (elderly and neonates) Surgical operation (chest/abdomen) Major injuries Chronic obstructive lung disease Existing cardiopulmonary disease Cerebrovascular accidents Coma Heavy smoker
Therapy	Sedation General anaesthesia Tracheal intubation Tracheostomy Prolonged mechanical ventilation Enteral feeding Broad spectrum antibiotic therapy H2 blockers Immunosuppressive and cytotoxic drugs

Definitions and Diagnosis⁵

Healthcare-associated pneumonia is a LRT infection that appears during hospitalisation in a patient who was not incubating the infection at admission. It is diagnosed by the following:

- rales or bronchial breath sounds;
- fever;
- purulent sputum, cough, dyspnea, or tachypnea;
- relevant radiologic changes; and
- preferably, microbiological diagnosis from bronchial lavage, transtracheal aspirate, or protected brush culture.

Infection prevention and control (IPC) professionals must distinguish between clinical and surveillance definitions. For surveillance purposes, most IPC practitioners use the pneumonia definition published by the U.S. Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN) - see <http://www.cdc.gov/nhsn/PDFs/pscManual/6pscVAPcurrent.pdf>

There are three pneumonia categories:

- PNU1 - X-ray changes and clinical signs and symptoms are present; pneumonia with specific laboratory findings
- PNU2 - X-ray changes, clinical signs and symptoms are present as well as microbiological laboratory results from bronchoalveolar lavage, protected specimen brushing, blood culture, pleural fluid, or histopathologic exam; or
- PNU3 - pneumonia in immunocompromised patients.

Etiological Agents⁶⁻⁸

Healthcare-associated pneumonia is divided into early- and late-onset disease. Early-onset pneumonia occurs within four days of admission and is usually caused by *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis*, or methicillin-sensitive *Staphylococcus aureus* (MSSA). It may occur in ICUs or after surgery, particularly in patients with existing pulmonary disease.

Late-onset healthcare-associated pneumonia occurs more than 4 days after admission and is usually caused by Gram-negative bacilli, e.g., *Pseudomonas aeruginosa*, *Acinetobacter*, or *Enterobacter* spp, or methicillin-resistant *Staphylococcus aureus* (MRSA). Many late-onset VAPs are caused by microorganisms that are resistant to multiple antibiotics.

Viruses (e.g., influenza, respiratory syncytial, or other respiratory viruses) may also cause early- and late-onset pneumonia. They easily spread in health care environments and can cause severe pneumonia in immunocompromised patients and young children. Fungi, e.g., *Candida* spp. and rarely *Aspergillus* spp., typically cause late-onset pneumonia. *Legionella* infection may be acquired from the air conditioning system or from water supplies, particularly by immunocompromised patients. *Aspergillus* and *Legionella* infections do not spread from person to person.

Pneumocystis carinii causes pneumonia in immunosuppressed patients, particularly those with acquired immune deficiency syndrome. Opportunistic pulmonary diseases caused by mycobacteria, including *Mycobacterium tuberculosis*, can cause pneumonia and can be spread by airborne transmission.

A NHSN survey of causes of VAP in the United States identified the following isolates: *Staphylococcus aureus* (24.4%), *Pseudomonas aeruginosa* (16.3%), *Enterobacter* spp. (8.4%), *Acinetobacter baumannii* (8.4%), *Klebsiella pneumoniae* (7.5%), *Escherichia coli* (4.6%), *Candida* spp. (2.7%), *Klebsiella oxytoca* (2.2%), coagulase-negative *Staphylococcus* (1.3%), unspecified (23.1%).

A European Centre for Disease Prevention and Control (ECDC) survey involving 12 countries in 2008 found ICU-acquired pneumonia was associated with: *Pseudomonas aeruginosa* (18.2%), *Staphylococcus aureus* (16.3%), *Escherichia coli* (9.3%), *Klebsiella* spp. (8.1%), *Candida* spp. (7.9%), *Enterobacter* spp. (7.1%), *Acinetobacter* spp. 3.7%), *Haemophilus* spp. (3.7%), *Stenotrophomonas* spp. (3.5%), *Enterococcus* spp. (3.2%), *Serratia* spp. (2.8), *Proteus* spp. (2.7%), coagulase-negative *Staphylococcus* (2.4%), *Streptococcus* spp. (2.4%), and *Citrobacter* spp. (1.8%).

Etiological agents of early- and late-onset pneumonia and VAP are summarised in Table 16.2.

Prevention^{1-4, 9-11}

The core recommendations for prevention of healthcare-associated pneumonia are designed to avoid the three commonest mechanisms by which pneumonia develops: 1) aspiration, 2) contamination of the aerodigestive tract, and 3) contaminated equipment.

Basic measures for prevention of postoperative pneumonia include:

- Treat lung disease prior to surgery.
- Elevate the head of the bed, if not contraindicated.
- Avoid unnecessary suctioning of airways.
- Provide regular oral cavity care.
- Encourage deep breathing and coughing before and after operation.
- Provide appropriate pain therapy to avoid failing to cough or breathe deeply because of pain.
- Use non-sedative pain therapy.
- Use percussion and postural drainage to stimulate coughing.
- Encourage early mobilisation.

Table 16.2. Etiological agents of early- and late-onset and ventilator-associated pneumonia

Early-onset pneumonia	Late-onset pneumonia	VAP United States	VAP Europe
<i>Streptococcus pneumoniae</i>	<i>Pseudomonas aeruginosa</i>	<i>Staphylococcus aureus</i>	<i>Pseudomonas aeruginosa</i>
<i>Haemophilus influenzae</i>	<i>Acinetobacter</i> spp.	<i>Pseudomonas aeruginosa</i>	<i>Staphylococcus aureus</i>
<i>Moraxella catarrhalis</i>	<i>Enterobacter</i> spp.	<i>Enterobacter</i> spp.	<i>Escherichia coli</i>
Methicillin-sensitive <i>Staphylococcus aureus</i>	Methicillin-resistant <i>Staphylococcus aureus</i>	<i>Acinetobacter baumannii</i>	<i>Klebsiella</i> spp.
Influenza	Multidrug - resistant organisms	<i>Klebsiella pneumoniae</i>	<i>Candida</i> spp.
Respiratory syncytial or other respiratory viruses	<i>Candida</i> spp.	<i>Escherichia coli</i>	<i>Enterobacter</i> spp.
	<i>Aspergillus</i> spp.	<i>Candida</i> spp.	<i>Acinetobacter</i> spp.
		<i>Klebsiella oxytoca</i>	<i>Haemophilus</i> spp.
		Coagulase-negative <i>Staphylococcus</i>	<i>Stenotrophomonas</i> spp.

Basic measures for prevention of VAP include:

- Use hand hygiene before and after contact with patient, respiratory secretions, or objects contaminated with respiratory secretions, whether or not gloves are worn.
- Use single use or reprocessed gloves when handling respiratory secretions.
- Use sterile disposable or reprocessed gloves and sterile suction catheter for tracheal aspiration and tracheostomy care.
- Perform daily assessments of readiness to wean.
- Minimise the duration of ventilation and use noninvasive ventilation whenever possible.
- Elevate the head of the bed, if not contraindicated.

- Avoid gastric over-distension.
- Avoid unplanned extubation and reintubation.
- Use orotracheal intubation preferably vs. nasotracheal intubation.
- Avoid H2 blocking agents and proton pump inhibitors for patients who are not at risk for developing stress ulcer or stress gastritis.
- Perform regular oral care with an antiseptic solution.
- Use sterile water to rinse reusable respiratory equipment.
- Remove condensate from respiratory circuits. Keep the circuit closed during condensate removal.
- Change the ventilator circuit only when visibly soiled or malfunctioning.
- Store and disinfect respiratory therapy equipment properly. (See Table 16.3).
- Perform surveillance for VAP in units known or suspected to be at high risk for VAP.
- Perform direct observation of compliance with VAP-specific process measures (hand hygiene, bed position, daily assessment of readiness to wean, and regular oral care)
- Educate healthcare personnel who care for patients undergoing ventilation about VAP local epidemiology, risk factors, and patient outcomes.
- Establish antibiotic regimens in accordance with the local situation.

Acknowledgement

This chapter is an update of the earlier one by Drs. Gary French and Ulrika Ransjö.

Table 16.3. Prevention of ventilator-associated pneumonia

General measures	
1.	Thoroughly clean all respiratory equipment to be sterilised or disinfected.
2.	Whenever possible, use steam sterilisation or high-level disinfection by pasteurisation for reprocessing semi-critical equipment or devices (items that come into direct or indirect contact with mucous membranes of the lower respiratory tract). Use low-temperature sterilisation methods for equipment or devices that are heat or moisture sensitive. Take care not to contaminate the disinfected items during rinsing, drying, or packaging.
3.	Use sterile water to rinse reusable semi-critical respiratory equipment and devices after chemical disinfection. If this is not feasible, rinse the device with filtered water (0.2 µm filter) or tap water, and then rinse with isopropyl alcohol and dry with forced air or in a drying cabinet.
Mechanical ventilators	
1.	Do not routinely sterilise or disinfect the internal machinery of mechanical ventilators.
Breathing circuits, humidifiers, and heat-moisture exchangers	
1.	Do not routinely change the breathing circuit (ventilator tubing, exhalation valve, and attached humidifier) used by an individual patient. Change the circuit only when it is visible soiled or mechanically malfunctioning.
2.	Periodically drain and discard any condensate that collects in the tubing of a mechanical ventilator, taking precautions not to allow condensate to drain toward the patient.
3.	Wear gloves to perform the above procedures or when handling fluid.
4.	Decontaminate hands with soap and water (if hands are visibly soiled) or with an alcohol-based hand rub, after performing a procedure or handling fluid.
5.	Use sterile (not distilled, non-sterile) water to fill bubbling humidifiers.
6.	Change a heat-moisture exchanger when it malfunctions mechanically or becomes visibly soiled. Do not change it routinely at less than 48 hours.

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Chapter 17

Prevention of Intravascular Device-Associated Infections

Peter Heeg

Key points

- Thorough hand disinfection by operator before insertion of catheter and during maintenance procedures.
- Thorough disinfection of skin at insertion site.
- No touch technique or gloved hands during insertion, maintenance, and removal of catheter.
- Secure the IV line to prevent movement of the catheter.
- Maintain a closed system.
- Protect the insertion site with a sterile dressing.
- Inspect insertion site daily.
- Remove the catheter as early as possible and immediately if any signs of infection are present.
- Do not reuse catheters which are intended for single use.

Introduction

Intravenous (IV) infusions are among the commonest invasive procedures performed in health care; and are administered either by peripheral or central routes. Infections are common; IV catheters are the main source of central line-associated bloodstream infection (CLABSI). Infections associated with peripheral catheters may occur, however with a much lower incidence. The principles used for preventing infection are similar for both central and peripheral catheters.

An IV catheter is a foreign body that produces a reaction in the host resulting in a biofilm or layer of fibrinous material on the catheter's inner and outer surfaces. This biofilm may become colonised by microorganisms which are then protected from host defence mechanisms and the effect of antimicrobials. Both local and systemic infection may result from contamination or colonisation of intravascular devices. Cellulitis, abscess formation, septic thrombophlebitis, bacteraemia, or endocarditis may occur as complications of intravascular therapy and monitoring.¹

Infection prevention and control measures are designed to prevent contamination of intravascular devices from microorganisms entering equipment, catheter insertion sites, or the bloodstream (See Figure 17.1). Because of the risk of bloodborne pathogen transmission to patients and staff, do *not* reuse intravascular devices; they are intended for single use only.

Healthcare personnel should be educated about insertion, care, and maintenance of intravascular devices.^{2,3} Their knowledge of and adherence to preventive measures should be assessed periodically.

Because of the high risk of infection, IV catheters should not be inserted unnecessarily and used only for strict medical indications (e.g., severe dehydration, blood transfusion, parenteral feeding). Whenever possible, use alternative routes for hydration or parenteral therapy. Once catheters have been inserted, the need for them should be assessed daily. Catheters not required for patient care should be removed as soon as possible.⁴

Strict asepsis is required for insertion of the catheter and maintenance of the insertion site. The site should be kept dry, free from contamination,

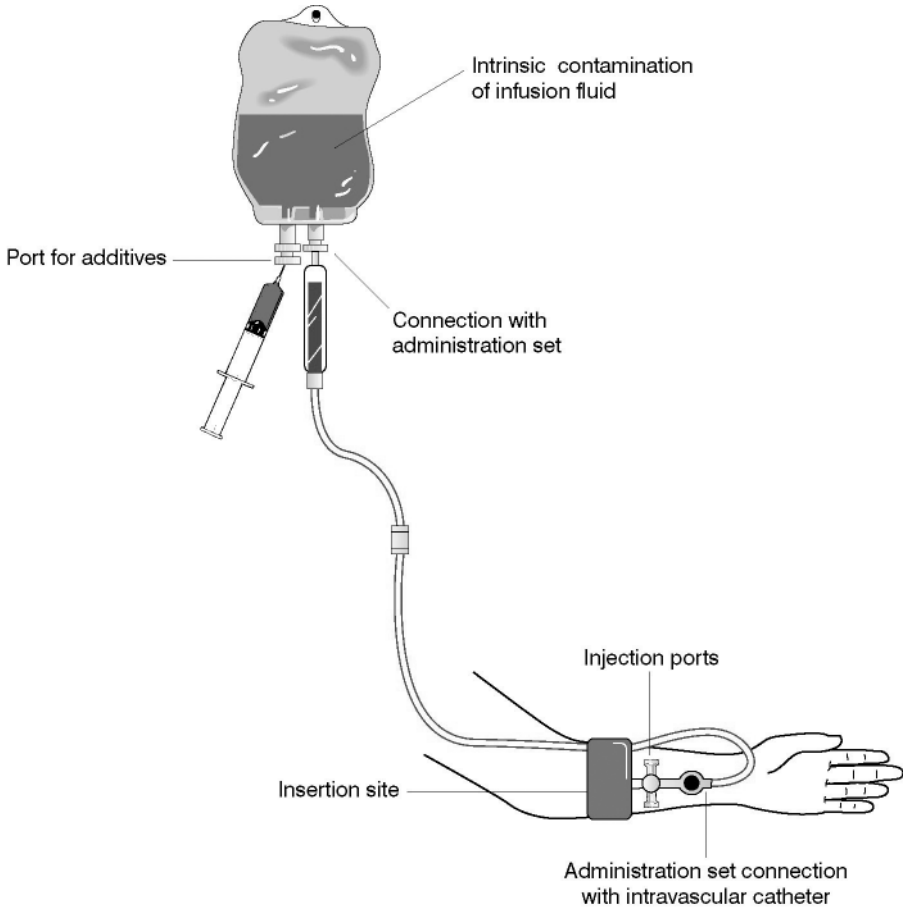


Figure 17.1 Sites of possible contamination of intravascular infusions [Reproduced with permission from Damani NN and Keyes JK. *Craigavon Infection Control Manual*, 2004]

secured, and dressed in a position which is as comfortable as possible for the patient.

Sources and Routes of Transmission

Sources of contamination of the device as well as the infusate are either intrinsic (contamination before use) or extrinsic (contamination introduced during therapy). Most of the microorganisms that cause intravascular device-related infections are from the patient's own skin flora, however, contamination of a device hub is also a major source of infection.⁵⁻⁶ Gram-

positive bacteria (methicillin-resistant and sensitive *S. aureus*, coagulase-negative staphylococci) account for 60 to 90% of infections.⁷⁻⁸ Less frequently, Gram-negative bacilli (including multiresistant *Acinetobacter baumannii*) or *Candida albicans* may cause infection.⁹

Skin microorganisms may enter the catheter insertion site along the outside of the catheter. Microorganisms from the hands of staff or the patient's skin may enter through the hub when the catheter is disconnected or through injection ports. In particular, coagulase-negative staphylococci can adhere to polymer device surfaces more effectively than other microorganisms. The microbes grow in the biofilm created, usually on the catheter's outer surface, and may be released into the bloodstream.

Less frequently, CLABSIs have been caused by microorganisms growing in inadequately sterilised, commercially prepared infusions or medications.¹⁰ Infections originating from contaminated infusates may appear as clusters of bloodstream infections. Finally, colonisation of the catheter tip may occur, seeded from a distant site of infection (e.g., wound, lung, or kidney).

Source of Infection and Prevention

Table 17.1 outlines the major sources of contamination related to intravascular catheters.

General Comments

Unless signs of infection or irritation occur, peripheral IV catheters do not require routine changes,¹¹ although some guidelines recommend changing peripheral venous catheters every 72-96 hours in adults to reduce the risk of phlebitis.¹² Peripheral catheters should not be replaced routinely in children, unless phlebitis or infiltration occurs.¹¹⁻¹²

Routine replacement of central catheters is not necessary and exposes the patient to additional infectious and mechanical complications. Central catheters should be used only when medically indicated.¹²

For peripheral and central IV catheters, the risk of infection increases with length of time of catheterisation. Non-essential catheters should be removed promptly.¹³

Table 17.1. Major sources of contamination related to intravascular catheters

Main source of infection	Prevention
Infusion fluid	If produced in house: <ul style="list-style-type: none"> • Monitor sterilisation process. • Ensure fluid is pyrogen free. Avoid damage to container during storage. Inspect container for cracks, leaks, cloudiness, and particulate matter.
Addition of medications	Use aseptic technique (hand disinfection, no touch technique). Use sterile medications only. Carry out procedure preferably in the pharmacy. Use a sterile device for accessing the system. Use single-dose vials whenever possible. If multidose vials have to be used: <ul style="list-style-type: none"> • Refrigerate after opening (if not otherwise recommended by manufacturer). • Wipe diaphragm with 70% isopropanol before inserting a cannula/needle.
Warming-container	Ensure no contamination from warming fluid. Dry warming systems are preferred.
Insertion of catheter	Thorough hand disinfection and use of sterile gloves by operator. Thoroughly disinfect the skin insertion site.
Catheter site	Cover with sterile dressing as soon as possible. Remove catheter if signs of infection occur. Inspect site every 24 hours. Change dressing only when soiled, loosened or wet/damp, using good aseptic technique. Do not use antimicrobial ointments.
Injection ports	Clean with 70% isopropanol and allow to dry before use. Close ports that are not needed with sterile stopcocks.
Changing of infusion set	Replace no more frequently than 72 hours (blood and lipids every 24 hours*). Thorough hand disinfection by operator. Use good aseptic technique.

* In some countries, national guidelines or recommendations exist for infusion of blood or blood products, including infusion times of <24 hours. Certain lipid products may also require more frequent replacement.⁵

Teflon[®] or polyurethane catheters have been associated with fewer infectious complications than catheters made of polyvinyl chloride or polyethylene. Steel needles used as an alternative to catheters for peripheral venous access have the same rate of infectious complications as Teflon[®] catheters. However, the use of steel needles frequently is complicated by infiltration of IV fluids into the subcutaneous tissues.¹⁴

Well-trained staff should set up and maintain infusions. Masks, caps, and gowns are not necessary for insertion of peripheral IV lines. The use of non-sterile gloves and an apron or gown will protect the operator if blood exposure is likely (e.g., profuse bleeding).

Protocol for peripheral infusions

- Place arm on a clean sheet or towel.
- Operator should use an alcohol-based hand rub or antiseptic soap to disinfect hands. If these are not available, wash hands thoroughly with plain soap for at least 20 seconds.
- Dry hands thoroughly on a paper or freshly washed, unused linen towel, unless alcohol-based hand rub is used.
- The use of gloves does not make hand hygiene redundant.
- If it is necessary to remove hair from the insertion site, clip the hair; avoid shaving.
- Disinfect skin site with 0.5% chlorhexidine-alcohol, 2% tincture of iodine, 10% alcoholic povidone-iodine, or 70% alcohol (isopropanol). Apply with rubbing for 30 seconds and allow drying before inserting the cannula. Chlorhexidine products should not be used in children younger than 2 months.¹
- Insert cannula into vein, preferably in an upper limb, using a no touch technique.
- Apply sterile dressing (gauze or equivalent or clear semi-permeable) and secure. Semi-permeable adhesive dressings are more expensive; however they allow inspection of the site without removal of the dressing.
- Secure cannula to avoid movement and label with insertion date.
- Assess the need for continuing catheterisation every 24 hours.
- Inspect catheter daily and remove at first sign of infection.
- Avoid cut downs, especially in the leg.
- Cannulae and administration sets must be sterilised before use. It is preferable to use single-use, disposable products.

- o If reuse is necessary, clean thoroughly and autoclave if possible.
- o If autoclaving is not possible, use boiling water for 15 minutes.
- o Chemical disinfection is undesirable. However, if reusable items are heat-labile, clean thoroughly then immerse in 0.5% sodium hypochlorite or other chlorine-releasing solution for 15 minutes (hypochlorites are neutralised by proteins such as blood). Flush the cannulae/catheter with a syringe and needle to clean the internal surface of the device. Ensure the disinfectant remains in contact with all surfaces of tubes and catheters. Hypochlorites are corrosive to metals and some plastics; thoroughly rinse the device with sterile water after disinfection.

Additional guidelines for central catheters

- Site selection may be an important risk factor for infection: higher infection rates have been observed for jugular and femoral than for subclavian catheters.¹²
- Use maximum barrier precautions: sterile gloves, gowns, cap, and mask for operator and a large sterile drape to cover the patient.¹⁵⁻¹⁶
- Preferably disinfect skin site with 2% chlorhexidine-alcohol. Allow drying before inserting the catheter.
- Change transparent dressings regularly, at least once a week or more frequently if the dressing is soiled, loose, or damp. Gauze dressings should be changed every two days. When changing the dressing, disinfect the site with chlorhexidine-alcohol.
- Replace administration sets not used for blood, blood products, or lipids at intervals no more frequently than 72 hours.¹²

Measures that should **not** be considered as part of a general prevention policy:¹

- Systemic antibiotic prophylaxis while the catheter is in situ.
- Topical use of antimicrobial ointments or creams at the insertion site.
- Routine replacement of central venous catheters.
- Routine use of antibiotic locks for central venous catheters.
- Routine use of in-line filters.

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Chapter 18

Prevention of Catheter-Associated Urinary Tract Infections

Nizam Damani

Key points

- Urinary catheterisation should be avoided if possible. Do not use urinary catheters for incontinence of urine.
- The catheter should be removed as soon as clinically possible, preferably within 5 days.
- Urinary catheterisation should be performed using sterile equipment.
- Aseptic technique should always be maintained during insertion and aftercare procedures.
- Catheters should not be changed routinely as this exposes the patient to increased risk of bladder and urethral trauma.
- Maintain a closed drainage system; open systems should be avoided if at all possible.
- Bladder irrigation or washout and instillation of antiseptics or antimicrobial agents does not prevent catheter-associated urinary tract infection and should not be used.
- The drainage bag should be emptied once per nursing session into a clean receptacle used only on one patient.

Introduction¹⁻⁴

Urinary tract infections (UTI) are the commonest healthcare-associated infections (HAI), accounting for up to 40% of all HAIs. Most involve urinary drainage devices, such as bladder catheters. The risk of a catheterised patient acquiring bacteriuria increases with the duration of catheterisation, rising from approximately 5% per day during the first week to almost 100% at 4 weeks. One to four percent of patients with bacteriuria will ultimately develop clinically significant infection, e.g., cystitis, pyelonephritis, and septicaemia.

Therefore, urinary catheters must only be inserted when there are clear medical indications, such as problems with emptying the bladder or measurement of urine production. They should be removed as soon as no longer needed. In suitable patients, clean intermittent urinary catheterisation should be considered, as it has a much lower risk of infection. Urinary incontinence is not an indication for urinary catheterisation; use napkins or absorbent pads instead.

Pathogenesis

Under normal circumstances urethral flora, which tends to migrate into the bladder, is constantly flushed out during urination. When a catheter is inserted this flushing mechanism is circumvented and perineal and urethral flora can pass up into the bladder in the fluid layer between the outside of the catheter and the urethral mucosa. Because of this, bladder colonisation is almost inevitable if catheters are left in place for prolonged periods.

In addition, bladder infection can be caused by bacterial reflux from contaminated urine in the drainage bag. Therefore, closed drainage systems should be used to reduce infection, when possible. Hands of personnel may also contaminate the urinary catheter system during insertion or management. [See Figure 18.1]

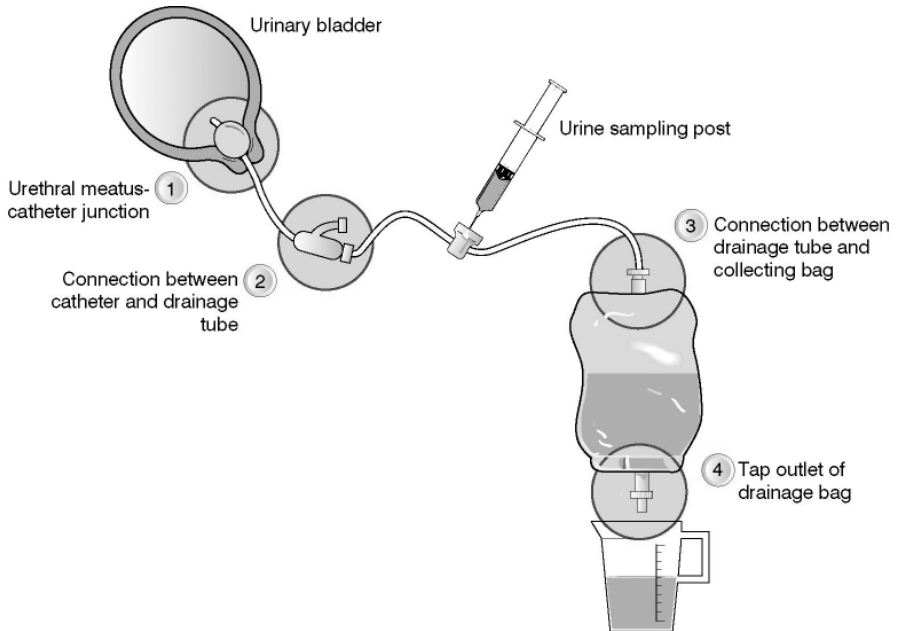


Figure 18.1 The four main sites through which bacteria may reach the bladder of a patient with an indwelling urethral catheter [With permission from Damani NN and Keyes J. *Craigavon Infection Control Manual*, 2004]

Microbiology

A UTI is usually caused by endogenous microorganisms from the patient's own bowel. In community-acquired infections, the commonest microorganisms are *E. coli* and *Proteus* spp. which are usually sensitive to most antibiotics and are relatively easy to treat.

However, healthcare-associated UTIs are more resistant to antibiotics. This is because hospitalised patients become colonised with resistant microorganisms, a process encouraged by an increased length of stay and exposure to antibiotics. In communities where indiscriminate antimicrobial use is common, multiresistant Gram-negative bacteria (e.g., extended spectrum beta-lactamase producers - ESBL) are also prevalent in the human bowel.

E. coli is the commonest cause of catheter-associated UTI (CA-UTI). However, increasingly, CA-UTIs are caused by more resistant Gram-negative species, such as *Klebsiella* and *Pseudomonas*. Similarly, ampicillin-sensitive *Enterococcus faecalis* is gradually being replaced by vancomycin-

resistant *E. faecium* (VRE). Then, with additional antibiotic exposure, infections occur with multiply drug resistant versions of these and other species (e.g., ESBL, VRE).

In addition, resistant microorganisms may be acquired by transfer from other patients, most commonly via contaminated staff hands, but sometimes from environmental sources. Urine and urinary catheter systems should be carefully disposed of, bottles and jugs cleaned and disinfected, and hands properly washed and decontaminated during insertion and management.

Definitions and Surveillance^{2,5}

Surveillance of CA-UTI can be performed in certain groups of patients, e.g., patients in intensive care units or specific types of surgical patients. The definition for CA-UTI may be obtained from the U.S. CDC/NHSN (Centers for Disease Control and Prevention/ National Healthcare Safety Network) or HELICS (Hospital in Europe for Link Infection Control through Surveillance).

Diagnosis

The diagnosis of UTI depends on laboratory support. Where a carefully collected midstream specimen is obtained, finding $\geq 10^5$ bacterial colony forming units (CFU)/ml in a patient without an indwelling catheter is diagnostic of UTI. Bacterial concentrations $>10^2$ CFU/ml suggest infection if the specimen is obtained aseptically by needle aspiration of the proximal drainage tubing in a patient with an indwelling catheter.

Although UTIs in non-catheterised patients are usually caused by a single microorganism, in catheterised patients infections can be polymicrobial. The presence of multiple microorganisms does not necessarily indicate contamination.

Urine must be processed promptly, since even with good technique urine samples may contain small numbers of contaminants. These can multiply at room temperature (especially in hot climates) and give falsely high colony counts. If delay is expected, the specimen should be transported in an ice box and refrigerated on arrival. Alternatively, boric acid (1% W/V or 1 g/10 ml of urine) should be added to the urine. Specimens containing boric acid need not be refrigerated.

Where microbiological support is poor or unavailable, clinical symptoms (e.g., fever, supra-pubic tenderness, frequency, and dysuria) may be useful in diagnosis, principally in non-catheterised patients. The presence of pyuria on either microscopic examination or by dip-stick (leukocyte esterase) is highly suggestive of UTI. If dip-sticks are available, a positive nitrite reaction in combination with a positive leukocyte esterase reaction is usually diagnostic. In catheterised patients, a positive urine culture or dip-stick is not sufficient for diagnosis of infection. In such patients, fever and leukocytosis or leucopenia are additional diagnostic criteria.

Strategies to Prevent Infection⁶⁻⁹

Also see Table 18.1.

Care bundle approach

A care bundle is a package of evidence-based interventions that, when implemented together for all patients with urinary catheters, has resulted in substantial and sustained reductions in CA-UTIs. Care bundle intervention plans for CA-UTIs have been developed by the US Institute for Healthcare Improvement and the UK Department of Health.

Staff training

Healthcare personnel performing urinary catheterisation should receive training on correct procedures for insertion and maintenance of urinary catheters based on local written protocols.

Catheter size

Catheters are available in different sizes. The smallest diameter catheter that allows free flow of urine should be used. Larger diameter catheters are more likely to cause unnecessary pressure on the urethral mucosa which may result in trauma and ischaemic necrosis. Urological patients and some other patient groups may require larger sized catheters; these should only be used on the advice of specialists.

Antimicrobial coated catheters

Several studies support the use of antimicrobial coated urinary catheters (latex-coated silver alloy) as an adjunct for the prevention of CA-UTI. These catheters significantly reduce the incidence of asymptomatic bacteriuria, however only for placement less than 1 week. There is no evidence that they decrease symptomatic infections and therefore they should not be

used routinely. However, their use should be considered in selected high-risk catheterised patients.

Catheter insertion

Urinary catheterisation should always be performed using sterile or high-level disinfected equipment and aseptic technique. To minimise trauma to the urethra and discomfort to the patient, a sterile lubricant or local anaesthetic gel should be used.

Meatal cleansing

Meatal cleansing should be performed regularly to ensure that the meatus is free from encrustations. Cleansing with soap and water is sufficient; application of antimicrobial ointment or disinfectant to the urethral meatus is harmful and should be avoided.

Drainage bag

To help prevent trauma to the urethra, the urinary drainage tubing should be secured to the patient's thigh with straps and adjusted to a comfortable fit. The catheter drainage bag must always be placed below the level of the bladder to promote good drainage. If a catheter stand is used, the drainage bag and drainage tap must not come in contact with the floor. During patient movement, the drainage tube should be temporarily clamped to prevent back-flow of urine. Do not disconnect the drainage bag unnecessarily to interrupt the closed drainage system.

Emptying the drainage bag

The drainage bag should be emptied regularly via the drainage tap at the bottom of the bag (i.e., when $\frac{3}{4}$ full or sooner if it fills rapidly). If the bag does not have a tap, it must be replaced when $\frac{3}{4}$ full using aseptic technique.

Extreme care must be taken when emptying a drainage bag to prevent cross-infection between patients. Hands must be washed or disinfected with an alcohol-based hand rub and non-sterile/clean disposable gloves should be worn when emptying the bag. Alcohol impregnated swabs should be used to decontaminate the outlet of the drainage tap (inside and outside). After emptying the bag, gloves must be removed and hands must be washed.

When emptying the drainage bag, use a separate container for each

patient's urine and avoid contact between the urinary drainage tap and the container. The urine container must be rinsed and heat disinfected after each use (preferably in a washer-disinfector unit), dried, and stored inverted in a clean place before further use.

Bladder irrigation

Bladder irrigation or washout and instillation of antiseptics or antimicrobial agents does not prevent CA-UTI and therefore should not be used for this purpose. The use of these agents may damage the bladder mucosa or catheter and promote the development of resistant bacteria which are difficult to treat.

Specimen collection

Samples of urine for bacteriological examination should be obtained from the sampling port or sleeve using aseptic technique. The sampling port should be disinfected by wiping with a 70% isopropyl alcohol impregnated swab. The sample may then be aspirated using a sterile needle and syringe and transferred into a sterile universal container. Never obtain a sample from the drainage bag. In asymptomatic patients, routine bacteriological testing is of no clinical benefit.

Use of antimicrobial agents

The routine administration of systemic antibiotics at the time of catheter insertion/removal is not recommended. The administration of a prophylactic antibiotic as a single dose at catheter change may be used in selected patients who either have clinical infection or a higher risk of developing UTIs. Routine use of prophylactic antibiotics while the catheter is in situ must not be used to prevent CA-UTI as it breeds resistant bacteria. For the same reason, the antibiotic treatment of CA-UTIs in the presence of long-term indwelling catheters may not be successful because the causative bacteria are often embedded in biofilm on the surface of the catheter and protected from the action of antibiotics.

Condom catheters

There may be a place for the use of condom catheters for short-term drainage in cooperative patients. Frequent changes, e.g., daily, may avoid complications, together with penile care. They should be removed at the first sign of penile irritation or skin breakdown. Condom use for 24 hour periods should also be avoided and other methods, such as napkins or absorbent pads, used at night.

Table 18.1. Prevention of bacterial colonisation/infection of the bladder in patients with indwelling urethral catheters

Summary of Prevention Strategies	
Entry points for bacteria	Preventive measures
1. External urethral meatus and urethra	
Bacteria carried into bladder during insertion of catheter	<ul style="list-style-type: none"> • Pass catheter when bladder full for wash-out effect. • Before catheterisation, prepare urinary meatus with an antiseptic (e.g., povidone iodine or 0.2% chlorhexidine aqueous solution). • Inject single-use sterile lubricant gel (e.g., 1–2%) lignocaine/lidocaine into urethra and hold there for 3 minutes before inserting catheter. • Use sterile catheter. • Use non-touch technique for insertion.
Ascending colonisation/ infection up urethra around outside of catheter	<ul style="list-style-type: none"> • Keep peri-urethral area clean and dry. • Secure catheter to prevent movement in urethra; bladder washes and ointments are of no value. • After faecal incontinence, clean area and change catheter.
2. Junction between catheter and drainage tube	
	<ul style="list-style-type: none"> • Do not disconnect catheter unless absolutely necessary. • Always use aseptic technique for irrigation. • For urine specimen collection, disinfect outside of catheter proximal to junction with drainage tube by applying alcoholic impregnated wipe and allow it to dry completely. Then aspirate urine with a sterile needle and syringe.

Summary of Prevention Strategies	
Entry points for bacteria	Preventive measures
3. Junction between drainage tube and collection bag	
Disconnection	<ul style="list-style-type: none"> • Drainage tube should be welded to inlet of bag during manufacture.
Reflux from bag into catheter	<ul style="list-style-type: none"> • Drip chamber or non-return valve at inlet to bag. • Keep bag below level of bladder. If it is necessary to raise collection bag above bladder level for a short period, drainage tube must be clamped temporarily. • Empty bag every 8 hours or earlier if full. • Do not hold bag upside down when emptying.
4. Tap at bottom of collection bag	
Emptying of bag	<ul style="list-style-type: none"> • Collection bag must never touch floor. • Always wash or disinfect hands (e.g., with 70% alcohol) before and after opening tap. • Use a separate disinfected jug to collect urine from each bag. • Routine instillation of disinfectant into bag after each emptying is of no value.

Guidelines

Catheter Care: RCN Guidance for nurses.

Royal College of Nursing (RCN).

http://www.rcn.org.uk/__data/assets/pdf_file/0018/157410/003237.pdf

[Accessed July 25, 2011]

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Chapter 19

Haemodialysis and Peritoneal Dialysis

Pat Piaskowski

Key points

- Dialysis patients are at high risk of infection because of underlying illness and numerous environmental and procedural factors.
- Establishing a comprehensive infection prevention and control program for dialysis settings will reduce the infection risks for both patients and healthcare providers.
- Patient education is essential to prevent infections associated with dialysis.

Background

Healthy kidneys clean the blood and remove bodily fluids by producing urine. Dialysis can remove metabolic toxins and fluids when the kidneys fail due to disease or damage. Patients who require dialysis have an increased risk of infection due to prolonged vascular access or methods used for dialysis, immunosuppression from end stage renal disease (ESRD), or co-morbid conditions such as diabetes.

There are two types of dialysis: peritoneal dialysis (PD) and haemodialysis (HD). PD involves instillation of dialysis fluids into the peritoneal space via a surgically inserted catheter. HD utilizes a dialysis machine and a dialyser to clean the blood.

Potential adverse events for PD include peritonitis (due to contamination at time of exchange or infection of the exit site), loss of access site, and death.¹⁻³ For HD, adverse events include bacteraemia, sepsis, and loss of vascular access.^{1-2,4} Another contributing factor for infection is failure to use aseptic technique during treatment. Infection prevention and control (IPC) measures (i.e., screening, surveillance, environmental cleaning, aseptic technique, Standard Precautions, and, where necessary, transmission-based precautions) are essential for preventing infections and transmission of microorganisms from patient to patient.

Transmission of infection can take place through contact with blood or body fluids, contaminated equipment, or surfaces. Blood can serve as an environmental source of contamination. Patients who are infected or colonised with microorganisms can also serve as sources for infection transmission. Staff may inadvertently spread infections from patient to patient via direct or indirect contact with contaminated surfaces/equipment or infected/colonised patients. Staff failure to perform hand hygiene, use Standard Precautions or, when required, transmission-based precautions, such as contact or droplet, places patients at risk of infection.

Definitions

Central catheter: Central venous catheters are only intended for short term access use for HD in an emergency, while awaiting a fistula to heal or in preparation for a graft. It carries the highest risk of infection.⁵

Standard central catheter care procedures must be followed to reduce the risk of infection.

Fistula: A connection that is surgically created between an artery and vein (usually in the arm). It is accessed via a needle for HD. It has the lowest risk of infection.⁵

Vascular graft: An artificial tube which is surgically placed between an artery and vein (usually in the arm). This graft is accessed via a needle for HD. It carries an intermediate risk of infection.⁵

Haemodialysis: HD utilises a dialysis machine and a special filter (dialyser) to clean the blood. The patient's blood enters the machine from the access point on the patient (e.g., a fistula, vascular graft, or a temporary central line), is filtered and then returned to the patient. Blood and dialysis fluids do not mix; the blood passes over a semi-permeable membrane which allows some molecules to pass through. This procedure can take up to 3-6 hours and usually takes place three times a week. It is typically carried out in an inpatient or outpatient HD area by trained staff. (See Figure 19.1)

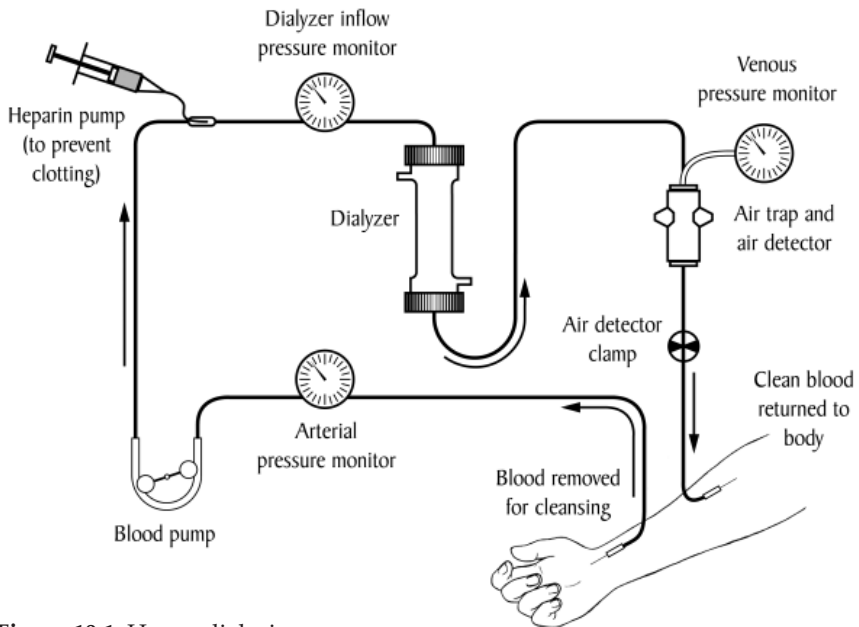


Figure 19.1 Haemodialysis

[Image courtesy of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health]

Dialysate: A balanced electrolyte solution which is introduced on one side of the semi-permeable dialyser membrane (opposite to the patient's blood) to exchange solutes with blood during haemodialysis.⁶

Dialysis water: Purified water that is used to mix the dialysate or to disinfect, rinse, or reprocess the dialyser.⁷

Dialyser: A part of the HD machine; it has two sections separated by a membrane. The patient's blood flows through one side and the dialysate flows through the other side. (See Figure 19.2)

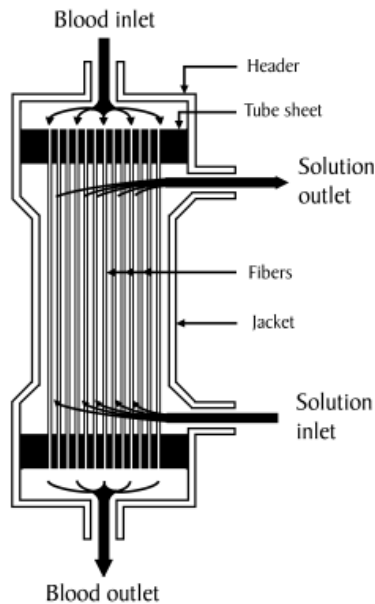


Figure 19.2 Dialyser

[Image courtesy of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health]

Reverse osmosis (RO): A process used to purify dialysis water by removing dissolved inorganic solutes as well as bacteria and their endotoxins.

Peritoneal dialysis: PD involves dialysis fluid instilled via a surgically inserted PD catheter into the peritoneal space of the abdomen. Most catheters are made from silicone. The fluid is removed, taking with it any toxins. Most common types of PD include chronic ambulatory PD, continuous cyclical PD, and chronic intermittent PD.⁶ (See Figure 19.3)

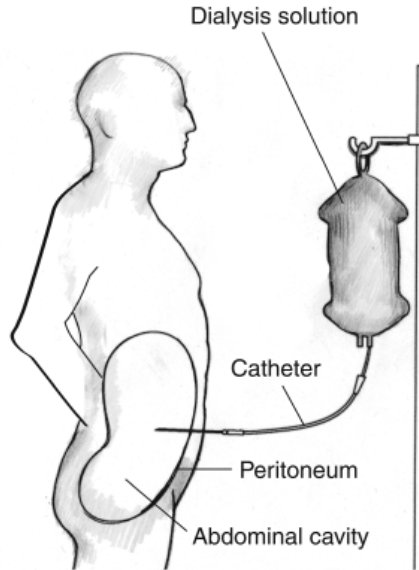


Figure 19.3 Peritoneal Dialysis

[Image courtesy of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health]

HBsAg: Hepatitis B surface antigen. All patients who are positive for HBsAg are infectious and may transmit Hepatitis B.⁵

Endotoxin concentration: It is measured in endotoxin units per millilitre (EU/ml), while the total viable microbial load is expressed as colony forming units per ml (CFU/ml).

Diagnosis

Diagnosis of infections related to HD or PD includes detection of the following signs and symptoms:

- Systemic infection: Fever, elevated white blood count (WBC), chills or rigors, and/or positive blood cultures.
- Peritonitis: abdominal pain, fever, elevated WBC, chills, or rigors. Culture specimens of exit site drainage and peritoneal fluid should be taken.
- Access site infections: redness or exudate at access site (vascular graft or PD catheter), nausea, vomiting, fatigue, and cloudy effluent.¹ Exudate should be cultured.

Infection-associated Risks

Hepatitis B

Hepatitis B virus (HBV) is transmitted through percutaneous or permucosal exposure to the blood of infected patients (HBsAg-positive or hepatitis B e antigen positive). Blood or body fluids from these positive patients can contaminate the environment which, even when not visibly soiled, can result in transmission of HBV.⁵

HBV remains viable at room temperature for at least seven days;⁵ it has been detected on clamps, scissors, and external surfaces and parts of dialysis machines. HBV can be transmitted to patients or staff on gloves or unwashed hands of care providers who touch contaminated surfaces or equipment.⁵

Hepatitis B vaccine for patients is an essential component of IPC measures.⁵ Although there is currently a low incidence of HBV infection in many HD patient populations, outbreaks do occur, usually because of failure to use recommended IPC measures.

Hepatitis C

Hepatitis C virus (HCV) is transmitted primarily by percutaneous exposure to infected blood. Factors that increase the likelihood of HCV infection in HD patients include a history of blood transfusions, volume of blood transfused, and years on HD. Like HBV, HCV transmission is often related to inadequate IPC practices.

Outbreaks of HCV have been associated with patients who received their HD treatment immediately after an infected patient. Transmission of HCV has been associated with shared equipment and supplies that were not disinfected between patients, use of common medication carts, shared multi-dose medication vials, contaminated HD machines and related equipment (priming buckets), and blood spills which were not cleaned.⁴⁻⁵

Acquired immune deficiency syndrome

Human immunodeficiency virus (HIV) is transmitted by blood or blood-containing body fluids. There have been very few reports of HIV transmission in dialysis and these resulted from inadequate disinfection of equipment, including access needles.⁴⁻⁵

Bacterial disease

Dialysis patients are at increased risk of infection and colonisation with multi-drug resistant organisms (MDRO), such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE). This is a result of frequent contact with health care facilities, frequent use of antibiotics, and use of invasive devices. VRE infection or colonisation has increased in some HD units. Vancomycin use is high in dialysis populations, contributing to this increase in resistance; this reduces the choice of antibiotics for treating enterococcal infections.⁸

Outbreaks of MRSA have occurred in some dialysis units where colonised \ infected patients served as a source for transmission. In addition there have been reports of vancomycin resistant *S. aureus* (VRSA) among HD patients.⁵

Multidrug-resistant Gram-negative infections in dialysis patients including *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, and *Acinetobacter* spp. have occurred. Some of these infections are resistant to all current antibiotics.⁶

Fungi

Dialysis patients are susceptible to fungal infections caused by microorganisms such as *Aspergillus* spp. Strict adherence to IPC precautions for construction and renovation activities is important. Prompt wiping up of water or other spills prevents mould contamination of the environment with subsequent fungal infections in susceptible populations such as dialysis patients.¹ In addition, there is a risk of *Candida* bacteraemia and peritonitis with the patient's skin as a source.

Mycobacteria

There have been reports of mycobacterial infections in dialysis patients from contaminated water used for dialysis.¹ Patients with ESRD are at high-risk for progression from latent tuberculosis (TB) infection to active TB disease. The frequent hospitalisation of dialysis patients increases the risk of transmission of TB to other patients or to healthcare providers.

Basic Principles

Surveillance

There are several components to a dialysis surveillance program:

1. Routine testing and documentation of all chronic dialysis patients for HBV and HCV. Routine testing for hepatitis D virus or HIV is not required.
2. Documentation of dialysis patient's vaccination status for vaccine-preventable illnesses.
3. On-going regular and documented surveillance of bacteraemia (microorganisms, treatment, date of onset, precautions used, and date resolved), access site infections, and peritonitis.
4. Records for each patient should include documentation of the location of the treatment station used and machine number, as well as names of staff connecting and disconnecting the patient. This information will be useful in any outbreak investigation.

Infection prevention and control measures

1. **Access site infection prevention and preventing bloodstream infections**
 - Proper hand hygiene must be carried out by all care providers following each of the World Health Organization's 5 moments.⁹
 - Staff must wear a mask and gloves and the patient must wear a mask while the site is being accessed.
 - Locate, inspect, and palpate the access site prior to skin preparation. Repeat skin preparation if the skin is touched by the patient or staff after it has been applied, if cannulation is not completed.
 - Wash the access site using an antibacterial soap/scrub and water. Cleanse the skin by applying 2% chlorhexidine gluconate/70% isopropyl alcohol, 70% alcohol, or 10% povidone iodine as per manufacturer's instructions for use.²
 - Access lines used for HD must not be used for other purposes.⁸
2. **Standard and transmission-based precautions**
 - All staff must use Standard Precautions, including hand hygiene, for dialysis patients.

- Staff must follow established procedures for Contact Precautions for antibiotic-resistant microorganisms, such as MRSA and VRE, and relevant antibiotic-resistant Gram-negative microbes.
- Staff should ensure segregation of HBsAg-positive patients and their equipment and supplies from those used for non-HBV-infected patients. Segregation of HBsAg-positive patients and their equipment can result in substantial reduction in the incidence of HBV transmission and infection amongst HD patients.⁵
- Isolation of patients with HCV infection is not recommended.

3. Environmental cleaning and disinfection

- Adequate environmental cleaning with a hospital grade disinfectant is required for all patient areas with special attention to high-touch items or surfaces likely to be contaminated with blood or body fluids.
- There should be procedures to ensure prompt containment and cleaning of spills of blood or body fluids.
- There should also be procedures to ensure prevention of mould contamination resulting from water damage or wetting of permeable walls, furniture, or other items.
- Used supplies and dialysers should be disposed of to prevent contamination of patients and environmental surfaces.

4. Equipment cleaning and disinfection

- Regularly maintained, cleaned, and disinfected dialysis equipment and machines, as well as reusable medical supplies, are essential for reducing the risk of infection.
- There must be policies and procedures for, as well as correct care and maintenance of, dialysis systems, including the water treatment system, distribution system, and dialysis machines.
- Manufacturer recommendations for equipment must be followed.⁸
- Reusable dialysers must be cleaned, receive high-level disinfection, and be thoroughly rinsed and dried prior to reuse. They must be stored to prevent contamination.⁷
- There must be adequate cleaning and disinfection of dialysis machines and equipment and reusable supplies between all patient uses.

5. Safe medication and injection practices

- Avoid contamination of multi-dose vials. The stopper should be disinfected with alcohol before accessing the vial. A single-use sterile needle and syringe should be used for each access. Single-use vials are preferable whenever possible.
- Needles should not be recapped.
- All used sharps should be discarded in designated sharps containers.
- Sharps containers should be available at the point of care to avoid carrying used needles.
- Safety engineered medical devices (e.g., self-retracting or self-sheathing needles) should be used when possible.

6. Patient immunisation, post-vaccination testing, and screening

- Screening programs for HBV and HCV are essential.⁵
- All dialysis patients must be screened for HBV prior to start of HD treatment.^{4,5}
- Immunise for HBV. Testing for HBV should take place one to two months after the primary vaccinations. The need for a booster dose of hepatitis B vaccine should be assessed through annual testing for antibody to HBsAg (anti-HBs). A booster dose should be administered when anti-HBs levels decline to <10 mIU/ml.
- Patients should be screened for HCV prior to receiving HD^{4,5} and at 6-month intervals.
- Dialysis patients younger than 65 years of age should receive a dose of pneumococcal vaccine followed by a dose every 5 years. If over 65 years, only one dose of vaccine is required.
- Screening of patients for MRSA or VRE is only necessary when there is an outbreak or suspected transmission in the dialysis unit.

7. Patient and healthcare provider education

- The staff should receive initial and on-going education on the basic principles and practices of dialysis, infectious risks and potential adverse events, and IPC practices.
- The patient should receive education on access site and dressing care, signs and symptoms of infection, and the importance of reporting potential infections.

8. Occupational safety considerations

- Staff who care for dialysis patients must follow Standard Precautions and, as necessary, transmission-based precautions, including use of appropriate personal protective equipment and hand hygiene to protect themselves from contact with and potential infection from blood or body fluids.
- Gloves, masks, and gowns must be used when connecting and disconnecting dialysis patients during the dialysis process.
- Routine testing of staff for HCV, HBV, or MDRO is not recommended.
- Staff should receive hepatitis B vaccination.

9. Water treatment and testing

- Testing of dialysis water and dialysate should be performed at least monthly per the US Association for the Advancement of Medical Instrumentation (AAMI) guidelines.⁷
- Water used to prepare dialysate or to process dialysers and dialysate should contain a total viable microbial count of no more than 200 CFU/ml and an endotoxin concentration lower than 2 EU/ml. If the total viable microbial count reaches 50 CFU/ml or the endotoxin concentration reaches 1 EU/ml, corrective measures should be taken promptly.⁷
- There should also be procedures and policies for testing and for follow-up when results are not within acceptable limits.

Low Resource Issues

In areas where access to resources is limited, the main IPC priorities are:

1. Safe reprocessing and reuse of dialysers.
2. Use, maintenance, and testing of safe, reliable water supply for dialysis.¹⁰
3. Spatial separation or segregation of patients infected with HBV or infected or colonised with MDRO, such as MRSA and VRE. Supplies should also be kept separate.
4. Access to reliable methods for regular cleaning and disinfection of surfaces and equipment in the dialysis area.
5. Access to lab testing for HBV/HCV status of patients and detection of other infections related to dialysis.
6. Access to HBV vaccine for patients and staff.

Relevant Guidelines

- Kidney Disease Outcomes Quality Initiative (KDOQI) <http://www.kidney.org/professionals/KDOQI/guidelines.cfm> [Accessed July 26, 2011]
- International Society for Peritoneal Dialysis (ISPD) Guidelines/Recommendations <http://www.ispd.org/lang-en/treatmentguidelines/guidelines> [Accessed July 26, 2011]

Summary

Dialysis (HD or PD) is a lifeline for patients with ESRD or renal failure and \ or awaiting kidney transplant. Patients receiving dialysis treatments are at increased risk of infection. The risk of infection or other adverse events can be reduced by prevention and control measures. Implementation of IPC procedures and a safe environment, including safe water, are all critical in eliminating or mitigating infection risk for this group of patients. The patient also has an important part to play in preventing infection and requires appropriate education.

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Chapter 20

Prevention of Blood-Borne Infections

Annette Jeanes and Martin Bruce

Key points

- Blood-borne transmission of viral infection is a recognised risk to both healthcare workers and the patients in their care.
- In health care, transmission of blood-borne viruses may occur by injection, infusion, transplantation, unsterile equipment, or other accidental injury/penetration.
- The risk of transmission of infections can be reduced by eliminating hazards, providing and using engineering controls, avoiding unsafe practices, using personal protective equipment, immunisation, and post-exposure prophylaxis.

Background

The main blood-borne viruses (BBV) transmitted in health care settings are;

- HIV (Human immunodeficiency virus)
- HCV (Hepatitis C virus)
- HBV (Hepatitis B virus)

Transmission of BBVs is an important risk for patients and healthcare personnel. Studies have shown that the risk of exposure of patients and staff to BBVs can be reduced significantly.¹

Healthcare workers (HCW) may acquire blood-borne infections from lacerations, punctures, and non-intact skin exposures to the blood or body fluids of infected patients. Exposures may occur during surgical or invasive medical/dental procedures.²

Patients may acquire blood-borne infections from improperly sterilised injection equipment, unsterile injection fluids, contaminated infusions, transplantation, or exposure to the blood of infected HCWs during invasive procedures.

Risk Reduction - Healthcare Workers

To prevent sharps injuries, clinical areas must be well lit and spacious; interruptions during procedures must be avoided. Sinks or alcohol-based hand rub should be readily available to promote good hand hygiene practice.

Unsafe injection practices can transmit blood-borne infections. NEVER re-sheath needles; always use any available safety devices. Containers for sharps disposal should be available within arm's length when sharp items are being used. The containers should be sealed with a tamper proof lid and safely discarded when three quarters full.

Standard Precautions³⁻⁴ must be adopted. Disposable gloves should be used by HCWs whenever exposure to blood or body fluids is likely; they act as a protective barrier and reduce exposure to BBVs if inoculation occurs.⁵ Appropriate staff should be offered immunisation against HBV before commencing work.⁵

Risk Reduction – Patients

Using needles and syringes which have been inadequately sterilised poses a risk of transmission of infection. Administration of medication by injection should be avoided if the oral route is possible. Inadequate supplies of equipment may lead to reuse of needles and syringes or to the multiple use of equipment without sterilisation between uses; both of which significantly increase the risk of transmission of BBVs.

If injections are essential, then HCWs should ensure that these do not expose a patient to a BBV.⁶ Needles and syringes should be single use. Single use vials of medications are preferable to multiple use vials as they increase the risk of BBV infection transmission due to contamination during use.

Equipment must be effectively cleaned and sterilised between patients to reduce the risk of BBV transmission. Single use disposable items should be used to avoid the need for sterilisation/disinfection; single use items must never be reused.

Blood and blood products being used for transfusion should be screened for BBVs prior to infusion, and for other microorganisms if required by local protocols.⁷ This may occur by testing the donor at the time of donation or testing the blood product itself.

Injection Safety

The World Health Organization proposes that “national strategies for the safe and appropriate use of injections address behaviour change among healthcare workers and patients, provision of equipment and supplies, and sharps waste management. Such initiatives should not constitute separate programs but should be integrated with other activities, including HIV prevention and care, essential medicines, immunisation, and health system management”.⁸

Outbreaks related to injections could have been prevented by the use of proper aseptic technique in conjunction with basic infection prevention practices for handling parenteral medications, administration of injections, and procurement and sampling of blood.⁹

The Safe Injection Global Network (SIGN)¹⁰ estimated that approximately ¹⁶ billion injections are performed annually, many of which are unnecessary. Reducing unnecessary injections may be accomplished by:

1. Developing national policies for health care facilities regarding appropriate medications and circumstances for injections. It is important to publicise the policy widely within the health care community and the country at large.
2. Educate HCWs, patients, and the public about injection risk by:
 - a. Developing teaching materials (posters, lectures) about injection risk and the importance of reducing injection frequency.
 - b. Enlisting influential institutions such as churches, mosques, universities, hospitals, and government agencies to campaign against unnecessary injections.
 - c. When available, teach how to properly use safety devices and proper disposal of all single use devices.
3. Eliminate use of unsterile needles, syringes, and solutions for injections.

Monitoring

A monitoring system to track occupational exposure to BBVs should be introduced. Surveillance for occupational blood exposures can provide useful data to focus local prevention efforts. An occupational health department can centrally collate trends of incidents and make recommendations for improving practice.

Routine accident reports may not provide adequate information; therefore focussed studies may be required.¹¹ Studies in departments where the risk for occupational blood exposures is high have shown that personnel could reduce the frequency of HCW exposure more than half by changing practices and increasing barrier precautions.¹²

Low Resource Issues

Many of the principles discussed in this chapter may be adopted in resource limited settings. Various sharps boxes are readily available. Health care facilities should ban reuse of single use items; inappropriate reuse increases the risk to both HCWs and patients. Education and training packages may

be initiated and should be encouraged as a strategy to prevent infection spread.

Summary

Whilst BBVs are a significant risk both in the community and health care settings, they can be prevented by strategies aimed at minimising risk to those giving and receiving care. If these strategies are universally adopted, a significant reduction in BBV transmission can be achieved.

Acknowledgement

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Chapter 21

Occupational Health Risks for Healthcare Workers

Walter Popp

Key points

- Healthcare workers are exposed to biological, chemical, physical, ergonomic, and psychosocial hazards.
- Hepatitis B, hepatitis C, human immunodeficiency virus, and tuberculosis pose the greatest risk of infection to healthcare workers.
- Infection with hepatitis B virus is preventable with immunisation; all healthcare workers should be vaccinated against hepatitis B.
- Written standard procedures on how to manage needlestick injuries should be available and known to all staff.
- Occupational medicine and infection prevention and control may be performed by the same person in low resource countries.

Background

Health care facilities around the world employ over 59 million workers¹ who are exposed to many health hazards including:

- Biological: tuberculosis (TB), Hepatitis B and C, human immunodeficiency virus (HIV)
- Chemical: disinfectants, ethylene oxide, antineoplastic agents, anaesthetic gases, latex (in gloves causing allergies)
- Physical: noise, radiation, falls
- Ergonomic: heavy lifting, musculoskeletal disorders
- Psychosocial: shift work, violence, stress, and burn-out.

Each year, 3 million healthcare workers (HCW) are exposed to bloodborne pathogens through a percutaneous route; 2 million are known to be exposed to hepatitis B, 900,000 to hepatitis C, and 170,000 to HIV. However underreporting of injuries can reach 40-75%, so there may be many more unreported. Known exposures result in 15,000, 70,000, and 1,000 infections, respectively, and > 90% of these infections occur in developing countries.² Needlestick injuries, which cause 95% of HIV seroconversions in HCWs, are preventable by practical and low-cost measures. Infection with hepatitis B virus is 95% preventable with immunisation, however less than 20% of HCWs in some regions of the world have received all three vaccine doses needed for immunity.¹

Prevention

Basic principles

Occupational medicine and infection prevention and control may be performed by the same person in low resource countries, although separate departments are preferred. To reduce occupational risks to healthcare staff:

- Conduct a written risk assessment for staff regarding physical, chemical, biological, ergonomic, and psychosocial hazards.
- Review the risk assessment annually to determine if the risks have changed or whether there are additional risks.
- Include an estimate of the degree of risk, e.g., low, medium and high (see Tables 21.1 and 21.2)

Table 21.1. Classification of biological agents into 4 groups according to their level of risk of infection*

Risk group	Description	Examples
1	Biological agent unlikely to cause human disease	Bacteria in yoghurt Yeast in beer
2	Biological agent that can cause human disease and might be a hazard to workers; it is unlikely to spread to the community; there is usually effective prophylaxis or treatment available	Most bacteria Nearly all moulds Most viruses
3	Biological agent that can cause severe human disease and present a serious hazard to workers; it may present a risk of spreading to the community, but there is usually effective prophylaxis or treatment available	Hepatitis B Hepatitis C Human immunodeficiency virus Tuberculosis
4	Biological agent that causes severe human disease and is a serious hazard to workers; it may present a high risk of spreading to the community; there is usually no effective prophylaxis or treatment available	Lassa virus Severe acute respiratory syndrome?

*According to Directive 2000/54/EC of the European Parliament and of the Council.³

Table 21.2. Risks for transmission of infectious agents in health care settings and risk reduction strategies for employee to patient and patient to employee transmission

Infection	Transmission in general	Risk of transmission evaluation		Risk classification of biological agents*	Main risk	Vaccine available	Post-exposure prophylaxis (PEP)
		Staff to patient	Patient to staff				
Cholera	Faecal-oral, contaminated water	Rare	Rare	2	Stool contact	Yes	
Conjunctivitis, viral (e.g., adenovirus)	Contact with eye secretions and contaminated objects	High	High	2	Hand contact and touching eye	No	No
Cytomegalovirus (CMV)	Contact with urine, saliva, breast milk, cervical secretions, and semen from infected person who is actively shedding virus	Rare	Rare	2	Contact with body fluids, especially saliva, blood, and urine	No	No
Diphtheria	By droplets, also by contact	No data	Rare	2	Close face to face exposure, cough	Yes	PEP with antibiotic should be discussed
Haemorrhagic fever (Ebola, Marburg, Lassa virus)	Bloodborne; some question of contact transmission	Negligible	Moderate	4	Blood splash on mucous membrane	No	Antivirals should be discussed
Hepatitis A	Person-to-person by faecal-oral route; infected food handlers with poor personal hygiene can contaminate food	Rare	Rare	2	Stool contact	Yes	Immune globulin

Infection	Transmission in general	Risk of transmission evaluation		Risk classification of biological agents*	Main risk	Vaccine available	Post-exposure prophylaxis (PEP)
		Staff to patient	Patient to staff				
Hepatitis B	Via percutaneous, mucosal, and nonintact skin contact with blood, semen, vaginal secretions, and bloody fluids	Low	Moderate	3	Needlestick injury	Yes	Hepatitis B immune globulin (HBIG)
Hepatitis C	Via percutaneous, mucosal, and nonintact skin contact with blood, semen, vaginal secretions, and bloody fluids	Low	Moderate	3	Needlestick injury	No	No
Herpes simplex	Contact with virus in saliva of carriers; contact with vesicle fluid	Rare	Low	2	Contact with infected site	No	No
Human immunodeficiency virus (HIV)	Primarily via percutaneous contact with blood; mucosal or nonintact skin contact with blood; semen, vaginal secretions, and bloody body fluids less likely to transmit	Rare	Low	3	Needlestick injury		Antivirals must be provided within hours!

Infection	Transmission in general	Risk of transmission evaluation		Risk classification of biological agents*	Main risk	Vaccine available	Post-exposure prophylaxis (PEP)
		Staff to patient	Patient to staff				
Influenza	Droplet spread; direct droplet transmission or droplet to contact transmission of respiratory secretions of infected patients	Moderate	Moderate	2	Close contact with patient (Within 3 feet from coughing/sneezing)	Yes	Antivirals normally not recommended
Measles	Airborne; direct airborne transmission or airborne to contact transmission of respiratory secretions of infected person	High	High	2	Inhaling or contact with the patient's respiratory secretions	Yes	Immune globulin
Meningococcal infection	Droplet spread; direct droplet transmission or droplet to contact transmission of respiratory secretions of infected patients		Rare	2	Close contact; face to face	Yes (tetravalent A, C, W135, and Y)	Antibiotic after close contact
Mumps	Droplet spread; direct droplet transmission or droplet to contact transmission of respiratory secretions of infected patients	Moderate	Moderate	2	Close contact with patient (Within 3 feet from coughing/sneezing)	Yes	

Infection	Transmission in general	Risk of transmission evaluation		Risk classification of biological agents*	Main risk	Vaccine available	Post-exposure prophylaxis (PEP)
		Staff to patient	Patient to staff				
Methicillin-resistant <i>S. aureus</i> (MRSA)	Direct and indirect contact	Rare	Rare	2	Skin contact	No	No
Norovirus	Faecal-oral (direct or indirect contact with patient's stool)	High	High	2	Stool contact	No	No
Pertussis	Droplet spread; direct droplet transmission or droplet to contact transmission of respiratory secretions of infected patients	Moderate	Moderate	2	Cough	Yes	Macrolides
Polio	Faecal-oral	Rare	Rare	2		Yes	
Rabies	Animal bite	Rare	Rare	3	Bites	Yes	Yes
Respiratory syncytial virus (RSV)	Droplet contact or direct contact with respiratory secretions	Moderate	Moderate				
Rotavirus	Person-to-person via faecal-oral route	Moderate	Moderate	2	Stool contact		

Infection	Transmission in general	Risk of transmission evaluation		Risk classification of biological agents*	Main risk	Vaccine available	Post-exposure prophylaxis (PEP)
		Staff to patient	Patient to staff				
Rubella	Droplet contact or direct contact with respiratory secretions; airborne transmission not demonstrated.	Moderate	Moderate	2	Yes		
Salmonella or Shigella	Person-to-person via faecal-oral route; via contaminated food or water; food handlers with poor personal hygiene can contaminate food	Low	Low	2	Stool contact		
Severe acute respiratory syndrome (SARS)	Droplets, contact	Medium	Medium	3	Cough	No	No
Scabies	Direct skin-to-skin contact with infested person	Low	Low		Skin contact		
Streptococcus, Group A	Droplet contact or direct contact with oral secretions or drainage from infected wounds	Rare	No data	2			
Syphilis	Direct contact with lesions of primary or secondary syphilis	No data	Rare	2	Direct contact with skin or mucous membrane lesions		Antibiotics possible

Infection	Transmission in general	Risk of transmission evaluation		Risk classification of biological agents*	Main risk	Vaccine available	Post-exposure prophylaxis (PEP)
		Staff to patient	Patient to staff				
Tetanus	Bites, skin wounds	No data	No data	2		Yes	Immune globulin
Tuberculosis (TB)	Airborne transmission from sources with active pulmonary or laryngeal tuberculosis; susceptible person must inhale airborne droplet nuclei to become infected	Low to high	Low to high	3	Cough	BCG - Bacille Calmette Guérin	Isoniazid (INH) for treatment of latent TB infection; 4 drug regimen for active TB
Typhus	Faecal-oral	Low	Low	3	Stool contact	Yes (IM, SC, oral)	
Varicella, Chickenpox, disseminated zoster Localised varicella-zoster (shingles)	Contact with vesicles; droplet or airborne spread from respiratory tract of acute cases and perhaps from disseminated zoster Contact with vesicles	High moderate	High moderate	2		Yes	Varicella-zoster immune globulin (VZIG)
Yellow fever	Mosquito bites	Negligible	Rare			Yes	No

* Risk classification according to Directive 2000/54/EG³

Try to reduce the risks to HCWs using the following order of activities:

1. Eliminate the hazard – for example:
 - Reduce the number of injections by providing more oral medication^{4,5}
 - Assign a central hospital for treating highly infective patients (e.g., tuberculosis) – for community.
2. Try to remove or isolate the hazard – for example:
 - Use safety needles (single-use needles designed to retract or cover the sharp end immediately after use).
 - Transport blood specimens in leak- and puncture-resistant boxes and use puncture-resistant waste boxes for discarding sharp items and needles.
3. Organisational measures - organise work so that the exposure is reduced - for example:
 - Reduce the number of staff members who care for a patient with TB or methicillin-resistant *S. aureus* (MRSA).
 - Train staff regularly in safe working condition practices.
 - Establish an occupational safety committee. In small hospitals this committee may be the infection prevention and control committee.
 - Consider every patient to be potentially infected with hepatitis B or C or HIV and be prepared – work with strict adherence to Standard Precautions/Routine Practices.
 - Audit compliance periodically focusing on prevention measures.
4. Evaluate use of personal protective equipment (PPE) – for example:
 - Gloves: Discard and change between patients. Use only once whenever possible or disinfect 2-3 times maximum.
 - Gowns: Use if spills/splashes are possible; change between patients. Single-use gowns are preferred. If gowns are used several times, e.g., during a shift time, put on the gown and remove it without touching the outer potentially contaminated side.
 - Eye goggles or face shields: Use if spills/splashes to the face are possible. Disinfect regularly and if visibly soiled.
 - Masks and respirators: N95/FFP respirators that have a tight face seal should be used if there is a risk of exposure to airborne pathogens. When these items are not available, surgical masks

are the best alternative, especially against droplet infection. Self-constructed, washable, and reusable textile masks provided some protection against severe acute respiratory syndrome, and may be a better than no protection.

- Develop written standard operating procedures for medium and high-risk activities. These may be identical to infection prevention and control procedures; however they should include staff protection and vaccination recommendations.

Provide a medical examination for all HCWs:

- The examination should include a physical examination and medical history for all new staff performed by an experienced physician.
- Results of the examination should be documented.
- HCW examination records and other health information should be kept confidential and stored in a secure place.
- Provide vaccinations for all staff. The following vaccinations are strongly recommended for all non-immune HCWs:
 - Hepatitis B
 - Influenza
 - Mumps/Measles/Rubella/Varicella/Pertussis (specially for staff working with children)
 - Poliovirus
 - Tetanus, Diphtheria (as a routine adult vaccination)
- All injuries should be documented in the respective staff member's medical record.
- Repeat the examination periodically, e.g., every 3 years.

Low Resource Issues

In low resource countries, special interest should be focused on preventing needlestick injuries. The two most important causes of these injuries are recapping of needles and unsafe handling of sharps waste. Other causes include:

- Overuse of injections
- Lack of supplies (disposable syringes, safer needle devices, sharps-disposal containers)
- Failure to place needles in sharps containers immediately after injection

- Passing instruments from hand to hand, e.g., in operating theatres
- Lack of awareness of the problem and lack of training for staff

Hepatitis B, hepatitis C, HIV, and TB pose the greatest risks of infection to HCWs in low resource countries. The risk of transmission from an infected patient to a HCW by a needlestick injury is around:⁵⁻⁸

- 30% for hepatitis B
- 3% for hepatitis C
- 0.3% for HIV

Surveillance of needlestick or sharp injuries may help identify problem areas/devices and be used in educating staff. After each needlestick or sharp injury:

- A co-worker should immediately be called to help.
- Ideally, any skin wound should be disinfected using alcohol or alcohol-based hand rub (use of alcohol will cause pain). If alcohol is not available, wash extensively with soap and water.
- For mucous membrane exposure, only water douching/washing may be realistic (alternatives: iodine, chlorhexidine, or octenidin preparations).
- After disinfection, the risk of transmission should be assessed. The risk may be increased with deep wounds, visible blood on the device, a blood-filled needle, and a high viral load status of the index/source patient (if known).

Specific prevention practices

Hepatitis B

The risk of infection with hepatitis B virus (HBV) can be avoided by decreasing exposure to blood and body fluids and through vaccination. Post-exposure prophylaxis (PEP) varies with the immune status of the HCW.

- An unvaccinated HCW should receive both hepatitis B immune globulin (HBIG) + HBV vaccination
- Previously vaccinated and known antibody responder HCW: no treatment
- Previously vaccinated, known non-responder HCW: should receive both HBIG + HBV vaccination (a second vaccine series)

or 2 doses of HBIG one month apart

- HCWs whose antibody response is unknown: test the HCW for antibody and administer HBIG + HBV vaccination if results are inadequate (<10mIU/ml).

Hepatitis C

There is currently no recommended PEP for hepatitis C virus (HCV). Perform baseline and follow-up testing for anti-HCV and alanine aminotransferase (ALT) up to six months after exposure. Perform HCV RNA testing at 4-6 weeks if an earlier diagnosis of HCV infection is desired. Staff members who develop hepatitis C should be treated after seroconversion.

Human immunodeficiency virus

PEP against HIV should be started as soon as possible, preferably within 2-24 hours, not after 72 hours. Problems with HIV PEP include:

- Proof of HIV transmission is only possible using PCR testing, which is only available in highly developed laboratories.
- PEP must be given within hours of exposure.
- Contraindications (e.g., pregnancy) should be considered.
- There is a high rate of side effects (and a high rate of dropouts in taking the drugs).
- Medication must be taken for at least 4 weeks.

HIV PEP may not be available in some countries; therefore, attention should be given to using PPE and safe practices to avoid injuries. Seek expert consultation if viral resistance is suspected. In case no PEP is available:

- Perform HIV antibody testing for at least six months post-exposure (e.g., at baseline, six weeks, three months, and six months).
- Perform HIV antibody testing if an illness compatible with an acute retroviral syndrome occurs.
- Advise exposed persons to use precautions to prevent secondary transmission during the follow-up period.

Tuberculosis

Some measures to control healthcare-associated TB transmission (ventilation systems, isolation rooms, personal protective equipment) may be beyond the resources of low-income countries.⁹ The following measures may reduce the risk of transmission:

- Establish a TB control committee.
- Increase awareness about TB among HIV-positive patients.
- Place patients with suspected TB or with an abnormal chest radiograph in an isolation room with door closed and a special ventilation system (natural or artificial).¹⁰
- Restrict sputum induction procedures and aerosolised pentamidine treatments to TB isolation rooms.
- Assign an adequate number of trained staff to perform routine and urgent acid-fast bacilli smears on a daily basis.
- Initial anti-TB treatment regimens should include four drugs.
- Patients in TB isolation rooms should only be allowed to leave their rooms when medically necessary and *must* always wear a surgical mask when outside the room.
- Place automatic closing devices on all TB isolation room doors.
- Continue isolation of TB patients until at least three negative acid-fast bacilli sputum smears are obtained.
- Forbid immunocompromised staff from contact with, or caring for, patients with TB.
- Ensure that all HCWs entering a TB isolation room wear a N95/FFP mask (or – if not available - at least a surgical mask).
- Perform routine tuberculin testing for tuberculin negative staff. In case of tuberculin conversion: Rule out active tuberculosis and treat HCW for latent TB infection.
- Each HCW has to inform a designated person on the TB control committee (or occupational health staff) if a cough for longer than 3 weeks has not responded to a course of antibiotics.
- Treat HCWs as soon as active TB is confirmed.

Acknowledgement

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Chapter 22

Housekeeping and Laundry

Ulrika Ransjö

Key points

- Neutral detergents are adequate for most cleaning purposes.
- Cleaning staff must be properly trained and supervised.
- An ongoing cleaning schedule must be established.
- All linen, whether visibly soiled or superficially clean, must be processed to the same high standard.

Housekeeping¹⁻³

The inanimate environment is rarely the source of infection outbreaks; however contaminated water and bedding may result in opportunistic infections. If the environment immediately around a patient becomes contaminated, either by direct patient shedding by healthcare workers touching instruments, door knobs, or other surfaces and equipment with contaminated hands, secondary transmission may occur.

Thus, it is necessary to clean the environment, especially around the area of recently discharged patients, to remove material that may harbour potential pathogens. A clean, well-maintained health care facility inspires confidence in patients, staff, and the public.

Disinfection

Surface disinfectants are hazardous and must be handled only by trained staff. Using disinfectants for general housekeeping is unsafe, as it poses risks to the environment as well as staff and there is no evidence that it prevents infection. Detergent/disinfectant products are available that clean well and are not readily affected by organic matter.

Housekeeping cleaning

Vigorous cleaning with water and neutral detergents reduces or eliminates reservoirs of potential pathogens and is adequate for most purposes. Cleaning personnel must be properly trained and supervised.

An ongoing cleaning schedule must be established, which should specify:

- Who is responsible for specific jobs
- Work procedures, including special equipment and supplies, e.g., cleaning and storage of equipment, mop head changing
- Use of protective clothing
- Accountability
- Frequency of floor cleaning
- Frequency of solution and mop change
- Frequency of furniture cleaning
- Frequency of toilet, commode, and fixture cleaning
- Frequency of cleaning fixtures such as ice machines
- Frequency of cleaning grilles and air-ducts

If a spill of moist body substances occurs, it should be spot disinfected with a detergent/disinfectant solution. This is particularly important above floor level where hands may come into direct contact with potential pathogens.

Walls rarely become contaminated and so do not need frequent cleaning. Horizontal surfaces, such as floors, and simple devices, such as intravenous therapy poles and bed frames, collect dust and can be maintained by cleaning with water and a detergent. However, areas that are repeatedly touched, for example, handrails/bedrails, door handles, and light switches, may need more frequent and intensive cleaning. Special cleaning procedures may be considered in certain circumstances, e.g., during an outbreak of *Clostridium difficile*-associated diarrhoea.

The manufacturers' instructions must be followed when preparing disinfectant and cleaning solutions. Some disinfectants, e.g., phenolics, must not be used in newborn nurseries or food preparation areas because of toxicity.

Laundry Services⁴⁻⁵

Careful handling and reprocessing of soiled linen prevents the spread of potential pathogens between patients and staff. Provision of fresh, clean linen enhances patient comfort. All linen, whether visibly soiled or superficially clean, must be processed to the same high standard. Gross soil (e.g., faeces) should be removed as close to the source as possible, preferably by dumping it into a sluice, clinical sink, or down a toilet.

All staff must be made aware of the risk to laundry workers from sharp objects left in soiled linen; laundry workers should be offered vaccination against hepatitis B virus. In addition, vaccination against hepatitis A virus is warranted in this group of workers. Special procedures need to be developed for linen contaminated with viral haemorrhagic fever viruses.

Sorting procedures

- Avoid contaminating hands with soil.
- Place soiled linen in a water-impermeable laundry bag.
- Secure bag when $\frac{3}{4}$ full - never over-fill it. If cloth bags are used, workers should wear gloves and handle bags with care. Bags of soiled

linen should be left in a secure place for pick-up and transport.

- Bags should be taken to an area in the laundry dedicated for pre-wash sorting.
- Laundry sorters must be educated on procedures and the proper use of barriers, and provided with puncture- and water-resistant gloves and plastic aprons or water-resistant gowns.
- Safely pre-sorting soiled linen into washer loads of sheets, pillow cases, towels, gowns, etc., facilitates laundry turn-around times.
- Minimise handling soiled linen as much as possible.

Washing processes

- A pre-wash rinse cycle of 15 minutes will remove gross soil.
- If using a cold water wash, chemicals such as bleach must be added (2 mL of household bleach for every litre of water) with detergent to facilitate disinfection.
- A high temperature wash must be performed (>71°C) if cold water detergents with bleach are not used.
- A souring agent should be added to the rinse cycle to reduce alkalinity and prevent yellowing. This decreases the likelihood of skin irritation and further reduces the number of bacteria present.
- Linen should be dried as soon as possible after washing to prevent regrowth of any bacteria not killed by the washing procedure.
- Hot air drying or drying on a clothes-line in sunlight will reduce the numbers of bacteria present.
- Ironing (especially using a steam iron) will destroy pathogens.

Clean linen must be stored and transported in such a manner that contamination is avoided. Storage must be at least 4-6 inches off the floor and linen must be covered during transport.

Linen to be sterilised must be appropriately wrapped before being sent to the sterile processing department.

Guidelines/Web Sites

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Chapter 23

Health Care Waste Management

Edward Krisiunas

Key points

- Sharps are the most likely health care waste to cause injury and/or exposure. Therefore, at a minimum, a waste management program must focus on sharps handling.
- Proper segregation using available means will reduce the risk of disease transmission and minimise the amount of potentially infectious health care waste generated.
- A range of treatment options for waste are available. Consideration should be given to those that reduce the opportunity for exposure and impact on the environment.
- Education and regular reinforcement of practices are the keys to success.

Introduction¹

Health care activities inevitably generate health care waste. The proper management of health care waste creates a safer environment for staff, solid waste workers, and the public. Health care waste management is dictated by professional standards, local laws and national legislation, and, most importantly, available resources.

Definitions

Health care waste can be considered any waste generated in a health care setting. Most concern is focused on the hazardous aspect of waste, i.e., infectious, chemical, radioactive, or other waste as listed in Table 23.1.

In addition to sharps and pathological waste, infectious waste includes:

1. Microbiological waste - culture plates, growth media, etc.
2. Swabs, dressings, bandages contaminated with potentially infectious fluids.
3. Blood – tubes of blood, units of blood, blood and blood products, and other containers used to collect blood.

Sources of Health Care Waste

Health care waste has many potential sources as outlined in Table 23.2.

Collection

Waste must be collected in containers that reduce the risk of exposure to users and meet the minimum specifications outlined in Table 23.3. They should be labelled with the international biohazard symbol, and not overfilled. The biohazard label can be painted on the containers or self-adhesive labels can be used.

Health care waste should be segregated from regular garbage at all facilities. It should be placed in special collection containers at the point of generation and kept separate from other waste. Labelled containers should be placed in areas where the specific waste is generated, along with containers for general garbage. Non-infectious and non-hazardous waste should be disposed of with regular garbage, recycled, or composted, as appropriate.

Table 23.1. Types of health care waste

Type of Waste	Definition	Examples
Sharps waste	Used or unused sharp items	Auto-disable syringes Broken glass Hypodermic, intravenous, or other needles Infusion sets Knives Pipettes Scalpels Syringes with attached needles
Infectious waste	Waste suspected to contain pathogens	Excreta Laboratory cultures Tissues (swabs), materials, or equipment that have been in contact with infected patients Waste contaminated with blood and other body fluids Waste from isolation wards
Pathological waste	Pathological waste	Body parts Fetuses Human tissues, organs or fluids
Pharmaceutical waste, including cytotoxic waste	Pharmaceuticals that are expired or no longer needed	Cytotoxic waste containing substances with genotoxic properties, e.g., waste containing cytostatic drugs (often used in cancer therapy) Genotoxic chemicals Items contaminated by or containing pharmaceuticals

Type of Waste	Definition	Examples
Chemical waste	Waste containing chemical substances	Broken thermometers and blood-pressure gauges Disinfectants that are expired or no longer needed Film developer Laboratory reagents Pressurised containers Solvents Waste with high content of heavy metals, e.g., batteries
Radioactive waste	Waste containing radioactive substances	Contaminated glassware, packages, or absorbent paper Sealed sources Unused liquids from radiotherapy departments or laboratory research Urine and excreta from patients treated or tested with unsealed radionuclides
Non-risk general waste	Waste that does not pose a biological, chemical, radioactive, or physical hazard	

Table 23.2. Examples of health-care waste from different sources

	Sharps	Infectious and pathological waste	Chemical, pharmaceutical and cytotoxic waste	General waste
Hospitals:				
Medical ward	Hypodermic needles, intravenous set needles; broken vials and ampoules	Dressings, bandages, gauze, and cotton contaminated with blood or body fluids; gloves and masks contaminated with blood or body fluids	Broken thermometers and blood pressure gauges; spill medicines; spent disinfectants	Packaging, food scraps, paper, flowers, empty saline bottles, non-bloody diapers; non-bloody intravenous tubing and bags
Operating theatre	Needles, intravenous sets, scalpels, blades, saws	Blood and other body fluids; suction canisters; gowns, gloves, masks, gauze, and other waste contaminated with blood and body fluids; tissues, organs, fetuses, body parts	Spent disinfectants	Packaging, uncontaminated gowns, gloves, masks, hats and shoe covers
Laboratory	Needles; broken glass, Petri dishes, slides and cover slips; broken pipettes	Blood and body fluids; microbiological cultures and stocks; tissue; infected animal carcasses; tubes and containers contaminated with blood or body fluid	Fixatives; formalin; xylene, toluene, methanol, methylene chloride, and other solvents; broken lab thermometers	Packaging; paper, plastic containers

	Sharps	Infectious and pathological waste	Chemical, pharmaceutical and cytotoxic waste	General waste
Pharmacy			Expired drugs; spilled drugs	Packaging, paper, empty containers
Radiology			Silver; fixing and developing solutions; acetic acid; glutaraldehyde	Packaging, paper
Chemotherapy	Needles and syringes		Bulk chemotherapeutic waste; vials, gloves and other material contaminated with cytotoxic agents; contaminated excreta and urine	Packaging, paper
Environmental Services	Broken glass		Disinfectants (glutaraldehyde, phenols, etc.); cleaners, spilled mercury, pesticides	Packaging, flowers, newspapers, magazines, cardboard, plastic and glass containers, yard waste
Engineering			Cleaning solvents, oils, lubricants, thinners, asbestos, broken mercury devices, batteries	Packaging, construction or demolition waste, wood, metal

	Sharps	Infectious and pathological waste	Chemical, pharmaceutical and cytotoxic waste	General waste
Food services				Food scraps; plastic, metal and glass containers; packaging
Minor sources:				
Physicians' offices	Needles and syringes, broken ampoules and vials	Cotton, gauze, dressing, gloves, masks and other materials contaminated with blood or other body fluids	Broken thermometers and blood pressure gauges; expired drugs; spent disinfectants	Packaging, office paper, newspapers, magazines, uncontaminated gloves and masks
Dental offices	Needles and syringes, broken ampoules	Cotton, gauze, gloves, masks and other materials contaminated with blood	Dental amalgam; spent disinfectants	Packaging, office paper, newspapers, magazines, uncontaminated gloves and masks
Home health care	Lancets and insulin injection needles	Bandages and other material contaminated with blood or other body fluids	Broken thermometers	Domestic waste

Table 23.3. Specifications for Collection Containers

Type of Waste	Specifications for Container or Bag	Examples
Sharps	<ul style="list-style-type: none"> • Container should be puncture-resistant, leak-proof on the sides and bottom, and durable. • Container should have the biohazard label. • Container should be closable for transport. 	<ul style="list-style-type: none"> • Empty bleach bottle with a biohazard label. • Thick, rigid, puncture-resistant cardboard box with a biohazard label. • Rigid plastic container with a biohazard label.
Non-sharps biomedical solid and semi-liquid waste	<ul style="list-style-type: none"> • Plastic bag that is leak-proof; designed to prevent ripping, tearing, or bursting under normal use. The plastic bag should be placed inside a rigid container. • Rigid container should be leak-proof, durable, labeled with the biohazard symbol, and red or yellow in colour. 	<ul style="list-style-type: none"> • Red or yellow plastic bags should be used. • When coloured bags are not available, plastic bag with the biohazard label can be placed in a red or yellow-painted garbage can or dust bin.
Non-sharps biomedical liquid waste	<ul style="list-style-type: none"> • Container should be leak-proof and durable. • Container should be marked with the biohazard label if it will be used to transport waste. • Container should be designed to be transported without spillage. 	<ul style="list-style-type: none"> • Bottles, vials, plastic containers, canisters, pails marked with biohazard labels.

In-House Transport

Waste transporters should wear gloves. Any cart for transporting health care waste within a facility should be fully enclosed. Health care waste carts should be used only for that purpose and not for regular garbage. They should be cleaned and disinfected regularly.

Storage

If storage of waste is necessary, the storage area (skip, shed, etc.) should meet the following parameters:

- Be protected from water, rain, or wind;
- Minimise the impact of odours, or putrescent waste (waste that can decompose and produce odours after several days). Do not store for more than 3 days; putrescent waste should be transported to the landfill immediately and buried in special trenches;
- Be accessible to authorised employees and lockable to prevent unauthorised access;
- Be protected from animals and not provide a breeding place or food source for insects and rodents; and
- Kept clean and free at all times of any loose debris and standing water. It should be disinfected weekly and whenever a spill occurs.

Treatment and Off-Site Transport

A variety of methods are available to treat health care waste. A number of variables will dictate the treatment method, the primary one being economic resources. On-going research by organisations, such as the United Nations Global Environment Fund (GEF), World Health Organization, and PATH, has provided a number of treatment technology options.

The World Health Organization does not recommend use of campfire-style open-pit burning, burning in a cement firebox, burning in drums, or open-burn cement-block incinerators, which should be discontinued. These methods are inefficient at destroying pathogens and release high levels of toxic pollutants. Use the low-cost interim options shown in Table 23.4. Small in-house incinerators, the local crematorium, and newer large-scale medical waste incinerator need to meet strict air pollution control requirements and, where possible, should be replaced by cleaner, state-of-

the-art non-burn treatment technologies.

These treatment methods can be used in combination. Health care waste from outlying areas could be transported to a centralised facility. The waste should be contained in sealed plastic bags and/or sharps containers and placed in hard corrugated cardboard boxes or reusable plastic bins for transport every few days (sooner for putrescent waste) or whenever sufficient waste has accumulated. The containers should have biohazard labels or be colour coded, e.g., red or yellow or as dictated by local legislation.

Health centres may decide to bury blood-soaked material, small tissues, and placentas in small burial pits and transport sharps for disposal in special landfill trenches. This reduces the amount of waste being transported to the landfill and avoids the problem of storing putrescent waste for extended periods. Another approach is to use sharps disposal burial pits for needles, syringes, and items that may injure waste pickers and transporters; other waste such as blood-soaked material, can be picked up and disposed in special landfill trenches.

Management

All health care facilities should have a person or group responsible for health care waste and waste management plans. Waste management should be incorporated into policies, procedures, and programmes to minimise the risk of spreading infection in and from the health care facility, thereby protecting patients, healthcare workers, and the public.

A number of resources are available for developing a waste management programme using a Rapid Assessment Tool available from the World Health Organization. This tool can provide an overview of the strengths and weaknesses of a waste management program and provide direction for further planning and implementation stages:

http://www.who.int/entity/injection_safety/toolbox/en/Healthcarewastemanagementtool.xls

Various programs from the Safe Injection Global Network (SIGN) offer useful guidance especially "Procuring Single-use Injection Equipment and Safety Boxes". See web sites at the end of the chapter.

Table 23.4. Waste Treatment and Disposal Options

Type of Waste	Methods	Notes
All infectious wastes <i>except</i> cultures and anatomical parts	Packaging, transport, and treatment by incineration or non-burn technology. When no technology is available, burial in special landfill trenches	This method should be used by large facilities (e.g., hospitals).
	Small on-site burial pits	This method could be used in health centres away from coastal areas and local wells, in areas that do not flood, and where the water table is at least 1.5 metres deeper than the bottom of the pit.
Cultures	Small on-site autoclaves or pressure cookers.	Preferably in the laboratory.
Anatomical parts	Interment at burial grounds or cemeteries.	This is the basic method for body parts.
	Cremation.	Perhaps use a local crematorium.
Placenta waste and small-tissue waste	Small on-site burial pits or interment at burial grounds or cemeteries.	These are acceptable methods.
	Composting method.	This is an acceptable method.
Free-flowing blood and body fluids	Sanitary sewer. When sanitary sewers are not available, known infectious blood and body fluids should be decontaminated with the addition of disinfectant such as sodium hypochlorite.	This method applies to all health facilities with sanitary sewers.

Training

A training programme should be used to present the elements of a plan and begin its implementation. Initial training could emphasize safe health care waste management practices and address issues related to the comprehensive, long-term plan. Practical training should be provided to all those involved in handling, packaging, transporting, and disposing of health care waste.

Summary

Health care waste is an inevitable part of health care. Infection prevention and control staff must use their experience and understanding of the chain of infection when developing a practical approach to waste management. If one focuses on the true risks of health care waste, a safe and effective program can be achieved, even where resources are limited.

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Chapter 24

Prevention of Healthcare-associated Gastrointestinal Infections

Michael Borg

Key points

- Noroviruses are the commonest cause of healthcare-associated gastroenteritis.
- Isolation of symptomatic patients, strict attention to Contact Precautions, and prompt decontamination of spillages of vomit are critical for prevention and control.
- Good antibiotic stewardship is essential to prevent *Clostridium difficile* infections.
- In outbreaks of gastroenteritis, hand hygiene should ideally be undertaken using soap and water because of the relatively limited effect of alcohol-based hand rubs on viruses and spores.
- Food-associated outbreaks of gastrointestinal infections continue to occur in health care settings, especially in developing countries.
- Control of microbiological hazards in food production is mainly undertaken through temperature control.
- Routine testing of food handler's faeces, blood, or rectal swabs is neither cost-effective nor normally indicated.
- Inspection and auditing often reveal deficiencies in catering practices and allow corrective action to be taken.

Introduction

A variety of microbes can cause infectious gastroenteritis; most outbreaks in the health care setting are caused by viruses. Bacterial gastroenteritis can be associated with contaminated food and/or water and may spread through common vehicles or by healthcare personnel. Another major cause of healthcare-associated gastroenteritis is infection by toxigenic strains of *Clostridium difficile*. Food-borne infections continue to occur in the community and in health care institutions, especially in low resource countries during warmer months.

Diarrhoea is defined as:

- 2 or more episodes of watery stools (Bristol Stool Type 71)
or
- 3 or more episodes of loose stools (Bristol Stool Type 6) over a period of 24 hours

It is important to exclude non-infectious causes of diarrhoea when investigating potential infections, such as:

- laxative use;
- allergic reactions, such as cases of lactose and coeliac diseases;
- chemical and physical agents;
- nasogastric feeding;
- inflammatory bowel disease;
- surgery on the gastrointestinal tract; and
- constipation associated with faecal impaction.

A food-borne outbreak should be considered when two or more persons develop gastroenteritis within 24 hours. Cases often occur in the same ward within a short time, or are linked by a common vehicle, such as contaminated food or water. Poor hygiene and non-compliance to infection prevention and control (IPC) practices can also be associated with transmission.

All cases of acute diarrhoea and/or vomiting in health care settings should be regarded as potentially infectious.

Viral Gastroenteritis²⁻³

Healthcare-associated gastroenteritis is most commonly caused by viruses, including norovirus, adenovirus, and rotavirus. Vomiting, often

sudden in onset and projectile in nature, is the major symptom. However, diarrhoea (mainly mild and short-term) can also be present, or occur on its own. Elderly patients are the most affected. Infections last 2 to 3 days and normally resolve spontaneously without the need for antibiotics. Immunosuppressed patients may shed viruses longer than others.

Outbreaks of viral gastroenteritis often have the following characteristics:

- Short incubation period (15 to 48 hours)
- Limited duration of illness (12 to 60 hours)
- Vomiting as the key symptom
- Affect both patients and staff

Noroviruses are highly infectious and can be transmitted between patients, healthcare workers, and the environment in two ways:

- Direct person to person contact (especially following hand contact)
- Indirect person-to-person spread following aerosol dispersion of viral particles during vomiting. This in turn contaminates the environment, which serves as the reservoir for subsequent contamination of hands.

Most health care outbreaks of gastroenteritis start following admission of an index symptomatic patient. For this reason, all patients admitted with gastrointestinal symptoms should be immediately isolated or cohorted.

Healthcare workers should wear gloves and an apron for all contact with these patients and their environment. Hands must be washed with soap and water after every such contact, including after removal of gloves. Alcohol-based hand rub should not be used, because the viruses that cause gastroenteritis tend to be of the non-enveloped variety and resistant to the effect of alcohol. There is no evidence to support the continuous wearing of masks when caring for patients with suspected viral gastroenteritis.

Bed linen and patient clothing should be changed daily. Removing and bagging linen should be performed in a way which minimises the dispersal of viruses from bed linen and clothes.

Environmental cleaning must be carried out to a high standard and cleanliness must be maintained. Patient rooms must be cleaned at least once a day and disinfected with an appropriate disinfectant (e.g., 1,000 ppm chlorine solution). Special attention should be given to toilets,

bathroom areas, commodes, and bedpans. Attention must also be given to horizontal and frequently touched surfaces, such as the nurses' station, nurse call system, telephones, door handles, sinks, and taps.

All spillages of vomit and faeces must be promptly decontaminated. Spillages must first be absorbed by paper towels; these should be discarded, wearing disposable gloves, apron, and a visor or mask. The contaminated area should then be washed with hot water and detergent and finally disinfected with a freshly-made chlorine solution at 10,000 ppm. All personal protective equipment should be discarded appropriately and hands then washed well with soap and water.

Cohorting of staff and patients can reduce the spread of viral gastroenteritis. Staff from wards with cases of gastroenteritis must not work in unaffected areas until 48 hours have elapsed. Affected staff should be excluded from the ward immediately; they should stay away from work until they have been symptom-free for 48 hours.

Monitor compliance with IPC practices during the outbreak. It is important to provide prompt feedback to reduce the risk of transmission. If these efforts fail, then it may be necessary to stop new admissions. Patients should not be transferred to unaffected wards or departments unless they need urgent specialist care.

In such situations, IPC staff must be consulted to assure proper precautions are in place to reduce the risk of exposure. If the agent is known, the IPC team and unit management should determine when the outbreak has stopped. Some experts believe that two complete incubation periods must go by without a new case prior to re-opening. For example, the ward could be re-opened 72 hours after the last case in a viral gastroenteritis situation with a short incubation period.

Terminal disinfection of the ward and changing of bed curtains should be performed before re-opening. The frequency of routine ward cleaning, especially bathrooms and toilets, should be increased and followed by disinfection using an appropriate disinfectant (e.g., freshly prepared 1,000 ppm chlorine solution).

Visitors should be restricted to individuals important for the well-being

of the patient. They may be asked to gown or wear an apron to reduce the risk of contamination. Visitors should be instructed in IPC practices, including hand hygiene while visiting and washing their hands on leaving the unit.

Antibiotic-associated Gastroenteritis⁴

Diarrhoea is a common complication of antibiotic treatment; it occurs due to disruption of the microbial flora in the large intestine. In some patients this microbial imbalance results in colonisation with *Clostridium difficile*. These anaerobic spore-forming bacteria can produce exotoxins that result in mucosal injury and inflammation of the large intestine. Symptoms ranging from mild diarrhoea to pseudomembranous colitis and even colonic perforation may occur. The risk of *C. difficile* infections (CDI) increases the longer the patient stays in hospital.

Antibiotic use is the major pre-disposing factor for CDI. Virtually all antibiotics, especially those with a wider spectrum, can predispose to the condition. Antibiotic stewardship initiatives that can reduce the volume of antibiotics prescribed – such as antibiotic restriction - are crucial for prevention of CDI.

If the infection does occur, effective IPC measures must be instituted promptly in order to minimise spread to other patients. Hygienic interventions, whether relating to hands or the environment, are important to achieve this goal. Hand hygiene should be undertaken using soap and water because of the lack of activity of alcohol-based hand rubs on *C. difficile* spores. Use of gloves and wearing of disposable gowns or aprons is also recommended for direct patient contact and contact with the patient's environment.

During outbreaks *C. difficile* has been cultured from numerous environmental sites, including toilets, commodes, bedding, and even cleaning equipment, such as mop heads. For this reason, a programme of thorough cleaning is critical to reduce environmental contamination with *C. difficile* spores. Chlorine-based compounds have long been the mainstay products for such applications. Recently, hydrogen peroxide mist has been used for terminal decontamination of rooms after discharge of CDI patients, with promising results.

Patients with CDI should be isolated as soon as possible in a single room with its own toilet facilities. If this is not achievable, cohorting is an acceptable alternative. Screening patients for asymptomatic carriage is not recommended. If, however, a patient's status is known, then patients with asymptomatic carriage of *C. difficile* should also be isolated, although decolonisation is not usually recommended.

It is important to ensure that equipment does not serve as a fomite to spread *C. difficile* spores. For this reason, single use items are preferred or thorough cleaning/disinfection must take place between patients. Use of rectal thermometers should be discouraged. Rectal thermometers must always be disposable and not used on another patient.

Prevention of Food-borne Gastroenteritis

The burden of food-borne illness in low resource countries is well documented. Intestinal diseases are prevalent in the community and transmission to health care facilities is common. The prevalence of healthcare-associated food-borne illness in developing countries varies; rates of healthcare-associated *Salmonella* and *Shigella* infections reaching 3% and 2.5% respectively have been reported. Fewer healthcare-associated food-borne illnesses occur in developed countries. Nevertheless, 247 outbreaks of *Salmonella* were documented in United Kingdom hospitals over a 10-year study period. Other microbes causing food-related illness include hepatitis A, *Campylobacter*, and *Yersinia*.

The role of IPC Teams (ICT) in promoting safe food hygiene practices depends on the type of catering used and the presence or absence of other stakeholders, such as catering managers and/or environmental health officers. Where the facility out-sources catering, the role of ICTs may be limited to contribution toward a due diligence approach through supervision of food distribution, as well as inspections and audits of the suppliers' kitchen premises. If food is prepared in the facility, the ICTs may need to provide a more significant contribution. Therefore, IPC personnel need to have a clear understanding of effective food hygiene.

Food Hygiene⁵⁻⁶

Food pathogens will survive and may multiply if food is left within the

temperature danger zone (6°C to 63°C). Control of microbiological hazards in food production is thus usually undertaken through temperature control.

Cold food must be served as soon as possible after removal from refrigeration. Heating food to achieve 75°C in its thickest part for 1-2 minutes will guarantee destruction of any biological hazards. When food is cooked and then cooled, cooling must be rapid; then the food should be held at temperatures that prevent microbial growth. Temperature control should be maintained until food is served.

Keeping hot food at an appropriate temperature is particularly important in systems where food is prepared in the kitchen and transported hot to be served without further re-heating. These systems are particularly risky and ICTs must pay special attention to ensuring that hot holding temperatures are maintained above 63°C.

The common causes of food-borne illness are:

- Preparing food more than a half day in advance of needs.
- Storage at room temperature.
- Inadequate cooling.
- Inadequate reheating.
- Undercooking.
- Cross contamination from raw to cooked food.
- Contamination from food handlers.

The concepts of food hygiene are similar to those used in other areas of IPC. IPC staff is therefore ideal candidates to spearhead food hygiene training. Numerous tools are available, both on the Internet and in print, to aid development of effective programs. The importance of preventing conditions for temperature and time to allow bacteria to reach infecting doses in food must be stressed. Effective personal and environmental hygiene and potential sources of contamination should also be part of any food hygiene training program.

Hazard Analysis Critical Control Points (HACCP) was pioneered in the 1960s within the United States' National Aeronautics and Space Administration program; it is incorporated into legislation of food safety both in the United States and the European Union. HACCP analyses the

food production process to determine possible microbiological, physical, or chemical hazards that may contaminate food as it is produced. Critical control points (steps in the process after which any contamination cannot be reversed) are identified. Preventive interventions are devised which are then monitored and corrected if any unacceptable deviation takes place. HACCP systems need to be recorded, audited, and verified routinely.

HACCP systems provide significant improvement in the quality and the safety of food. A successful HACCP system consists of a number of good hygiene practices, including regular equipment cleaning and maintenance, provision of effective hygiene facilities, systems to control insects and other pests, and regular training for staff on food hygiene. (See Table 24.1)

Testing of food, environment, and individuals

Food and environmental testing in the microbiology laboratory is expensive and labour intensive. It is not required to monitor food safety since a complete and functional HACCP system is more than satisfactory. Nevertheless, there are occasions when food and environmental testing is useful. It can provide confirmation of microbiological quality and safety. One useful spin-off is the impact such tests often have on food handlers, who can see visual evidence of the theoretical principles that they had been taught. A simple method of quality control that can be performed in all laboratories and is quite cost effective is semi-quantitative testing of environmental swabs taken from the production area. Routine testing for pathogens is of little benefit; it is more cost effective to count indicator microorganisms, especially *E. coli*, to identify poor hygienic food production practices.

Routine testing of food handler's faeces, blood, or rectal swabs is neither cost-effective nor generally indicated. An individual who screens negative may become a carrier; more worryingly, a negative screen may induce a false sense of security and result in negligence toward general and personal hygiene practices. It is much more cost-effective for any money set aside for food handler testing to be invested in better training of food handling personnel.

Ward kitchens

Ward kitchens should be kept clean. Refrigerators should be sited away from direct heat or sunlight and have a temperature monitoring device

Table 24.1. Adapting HACCP to health care food production

Step in Process	Foodborne Illness Concern	Prevention Methods
Receipt of food	Ready to eat foods contaminated with food poisoning bacteria or toxins.	Visual and temperature checks on food received. Accept frozen foods at $< -18^{\circ}\text{C}$ and chilled foods at $< 4^{\circ}\text{C}$.
Storage	Growth of food poisoning bacteria, toxins on high-risk (ready to eat) foods. Further contamination.	High-risk perishable foods stored covered and dated at safe temperatures. Rotate stock and use by recommended date. Ensure a pest free environment.
Preparation	Contamination of high-risk (ready to eat) foods. Growth of pathogenic bacteria.	Limit exposure to ambient temperatures during preparation. Prepare with clean equipment used for high-risk (ready to eat) foods only. Separate cooked and raw foods. Wash hands before handling food.
Cooking	Survival of pathogenic bacteria.	Thaw frozen items completely at temperatures $< 15^{\circ}\text{C}$. Cook food (especially chicken and minced meats) to $\geq 75^{\circ}\text{C}$ in thickest part for two minutes.
Cooling	Contamination. Growth of pathogens. Toxin production.	Cool foods as quickly as possible. Chill rapidly and refrigerate within 90 minutes. Do not leave out at room temperature to cool.
Chilled storage	Growth of pathogenic bacteria.	Temperature control. Date code high-risk (ready to eat) foods. Check on a periodic basis for expiration dates. Store food at least 6 inches above the floor and away from the wall. Use in rotation and always within shelf life. Consume within three days of cooking.
Hot holding/ Distribution	Growth of pathogenic bacteria. Toxin production.	Keep food hot at $> 63^{\circ}\text{C}$.
Reheating	Survival of pathogenic bacteria.	Avoid if possible. Reheat to $> 75^{\circ}\text{C}$.
Serving	Growth of pathogens. Toxin production. Contamination.	Serve cold high-risk foods as soon as possible after removing from refrigerated storage. Serve hot foods quickly. Ensure hands and equipment used to serve food are clean.

document the internal temperature at least once daily. If at any time the refrigerator temperatures fall out of appropriate range, the corrective action to fix the problem should be well documented and a decision as to whether the food should be discarded be made.

All items should be labelled, dated, and used within 72 hours. Any items that are not labelled, out-dated, or left exposed or unwrapped should be discarded. Attention should be given to separation between raw and cooked items; cooked items always being placed above the raw items if in the same refrigerator.

Kitchen Auditing

Food service practices should be established and include checklists for every day documentation of critical points. Additional inspection and auditing of kitchen practices can identify any deficiencies in catering practices and allow corrective action to be taken in a timely manner.

When undertaking an audit, particularly for the first time, the IPC professional should work with the food service team to develop critical checklists and use them to audit practice. The audit should include points related to common causes of foodborne illness. Particular attention should be given to evidence of prolonged exposure of food to warm temperatures. Other critical factors include: cross-contamination arising from lack of compliance with hygiene practices for hand or equipment cleaning; undercooking of high-risk meat products such as poultry; and cross-contamination between raw and cooked items.

If an audit is likely to be repeated regularly, an itemised audit sheet should be prepared including all the different areas in the kitchen being reviewed. In this way it is easier to achieve standardisation and reproducibility from one audit to the next and variations with time are more easily identified.

Summary

High standards of food hygiene must be maintained. A surveillance system must be able to identify potential food-borne outbreaks early and prompt outbreak investigation and control must be initiated if an outbreak is suspected.

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Chapter 25

Water Hygiene

Dorothea Hansen

Key points

- Everyone should have access to water free from pathogenic microbial and chemical contaminants.
- Water sources should be protected. The quality of piped water should be regularly verified according to a risk assessment and national regulations by water suppliers or public authorities. Analyses at point of use should be regularly performed (e.g., plate counts of *E. coli* or coliforms, *Pseudomonas aeruginosa*, *Legionella* species).
- Potable water can be rendered microbiologically safe by boiling, filtering, or chlorination.
- In health care settings, additional water treatment may be necessary (e.g., deionisation).
- Efforts are necessary to prevent infectious risks from bacterial contamination and formation of biofilms.

Background¹

Water is essential for human life; the minimum daily requirement is 7.5 litres per person per day. Diseases may be caused by ingestion, inhalation of droplets from, or contact with drinking water. Outbreaks of waterborne diseases may involve large numbers of individuals. Poor water quality may cause the spread of cholera, typhoid, dysentery, hepatitis, giardiasis, guinea worm, and schistosomiasis. 1.8 million people die every year from diarrhoeal diseases, most of them due to unsafe water. Waterborne outbreaks also occur in industrialised countries; for example, an outbreak of cryptosporidiosis in Milwaukee (US) affected 400,000 people.²

Chemical contamination of drinking water may also pose health risks. Chemical contamination tends to cause chronic long-term effects whereas microbiological contamination causes acute diseases and outbreaks.

Illness Related to Water

Domestic

Water-related infectious diseases are classified on the basis of transmission.

Water-borne

Diseases are due to microorganisms in water. Transmission can be caused by ingestion of contaminated water (e.g., diarrhoeal diseases, cholera, typhoid, hepatitis A, giardiasis, amoebiasis), inhalation of contaminated droplets or aerosols (e.g., legionellosis), or contact with contaminated water (e.g., skin diseases, otitis externa). Many pathogens are transmitted through contaminated drinking water, depending on their infectivity and their capability to persist in the environment or proliferate in water [See Table 25.1]. Microorganisms may be introduced into water by faecal contamination. Other pathogens may be naturally present in the environment or in source water.

Water-washed

Diseases caused by the lack of water and which are often associated with poor hygiene. Examples are diarrhoeal diseases, trachoma, conjunctivitis, and skin infection.

Water-based

Diseases which are caused by parasites that need an intermediate aquatic host for their life cycle. An example is schistosomiasis (bilharzia).

Water-related vector

Diseases which are transmitted by water-related insect vectors. Examples are malaria, dengue, and yellow fever.

Table 25.1. Microorganisms found in water

Microorganisms which may multiply in water supplies	Microorganisms which may persist in water supplies between 1 week and 1 month	Microorganism which may persist in water supplies for more than 1 month
Bacteria		
<i>Legionella</i> spp.	<i>Campylobacter jejuni</i> , <i>Campylobacter coli</i>	<i>Yersinia enterocolitica</i>
Non tuberculous mycobacteria	Pathogenic <i>E. coli</i> , enterohaemorrhagic <i>E. coli</i>	
<i>Pseudomonas aeruginosa</i>	<i>Salmonella typhi</i>	
Viruses		
		Adenoviruses
		Enteroviruses
		Hepatitis A virus
		Noroviruses
		Rotaviruses
Protozoa		
<i>Acanthamoeba</i> spp.	<i>Entamoeba histolytica</i>	<i>Cryptosporidium parvum</i>
<i>Naegleria fowleri</i>	<i>Giardia intestinalis</i>	<i>Cyclospora cayetanensis</i>
		<i>Toxoplasma gondii</i>

Health Care³⁻⁶

Hospitals often have complex plumbing and ambient-temperature water treatment systems. Both can be colonised by microorganisms (e.g., non pathogenic amoeba, *Pseudomonas* spp., *Legionella* spp. ubiquitous *Mycobacteria*, moulds) which may combine to form biofilms. Bacterial growth is promoted by stagnation of water. Because of their optimal growth temperature, *Legionella* spp. mainly colonise warm water distribution systems.

Biofilm formation increases with the age of the water distribution system. Biofilm particles can then become dislodged and aerosolised. The numbers of microbes are highest in the initial sample after opening the faucet. Inhalation of particles containing *Legionella* spp. can cause Legionnaire's disease even in the immunocompetent. Moulds can be resistant to the standard concentrations of free chlorine found in water.

Drains always harbour microorganisms, particularly *Pseudomonas aeruginosa*. If the water-jet from a sink impinges directly into the outlet, bacteria containing droplets can be aerosolised and pose infectious risks to the immunocompromised and patients with cystic fibrosis.

Uses of Water

Domestic

The World Health Organization (WHO) defines domestic water as being "water used for all usual domestic purposes, including consumption, bathing, and food preparation." When considering quantities required for domestic supply, subdividing uses of domestic water is proposed. In the "Drawers of Water" study⁶⁻⁷ four types of use were outlined:

- Consumption (drinking and cooking)
- Hygiene (personal and domestic cleanliness)
- Amenity use (car washing, lawn watering)
- Productive use (commercial activities)

Health care

In health care facilities, water is additionally used:

- to maintain autoclaves for sterilisation;
- during disinfection of medical devices, e.g., endoscopes;

- in dialysis units;
- in dental units; and
- in pharmacy.

Ambient-temperature water treatment systems are susceptible to microbiological contamination, particularly when there are periods of no or low demand for water. Stagnation promotes formation of biofilm and growth of water-borne microorganisms, e.g., *Pseudomonas aeruginosa*, *Aeromonas hydrophila*, non-tuberculosis mycobacteria and *Legionella* spp. Biofilms hinder disinfection.

Basic Principles⁸⁻⁹

Making water safe – boiling, chemicals, ozone, filtration

Water from non-piped supplies, such as roof catchments, surface water, water collected from wells or springs, or water from microbiologically unsafe piped water supplies, requires point-of-use treatment and protected storage. Technologies to improve the microbial quality of household water include a number of physical and chemical treatment methods. However, not all methods are equally effective in reducing pathogens or applicable in both domestic and health care settings.

Domestic water

Domestic water can be made safe by boiling, chlorination, or filtration.

Boiling

The recommended procedure is to raise the temperature so that a “rolling boil” (large bubbles continuously coming to the surface of the water) is achieved. “Rolling boil” must be maintained for 1 minute before removing the water from the heat source and allowing it to cool naturally in the same container. Water boils at lower temperatures as altitude increases. One minute of extra boiling time should be added for every 1000 m above sea level.

Water should be protected from post-treatment contamination during storage. Boiling inactivates vegetative cells of bacteria, viruses, and protozoa. Because spores are more resistant to thermal inactivation, treatment to reduce spores by boiling must ensure sufficient temperature and time.

Chlorination

Chlorination can be achieved by adding 2 drops of unscented liquid household chlorine (5-6%) bleach for each litre of clear water and 4 drops for each litre of cloudy water respectively. The mixture has to be stirred well and should stand at least 30 minutes before use. Because bleach solutions are unstable in sunlight and at warm temperatures, they should be stored in brown or green glass bottles or opaque plastic bottles in a cool, dark place.

Filtration

There are different types of simple household filters available, i.e., candle and stone filters. In a candle filter, water is allowed to filter slowly through a porous ceramic material. Large parasites (ova, cysts) and most bacteria are retained by the outer layer of the filter material. The filter can be periodically cleaned by gently scrubbing it under clean, running water. Viruses are not removed by candle filters.

Stone filters are carved from porous local stone. Their disadvantage is that they are difficult to clean.

Construction of the collecting vessel should prevent recontamination of filtered water.

Health care issues

In health care settings a continuous supply of a great quantity of safe water is essential. Depending on the kind of water supply, different approaches for safe water may be appropriate.

If there is a piped water supply, chlorination may be sufficient to make water safe. In addition to sodium hypochlorite, liquid bleach or sodium calcium hypochlorite, chlorination can be achieved by chlorine gas, liquefied under a pressure of 505 kPa. Chlorine gas is highly toxic and should be handled carefully by well-trained technical personnel.

Water from non-piped supplies may necessitate the use of drinking water treatment plants. Drinking water treatment plants combine coagulation and flocculation, filtration, and disinfection. They have to be regularly maintained according to manufacturer's instructions. Most technologies use free chlorine as a disinfectant. A minimum free chlorine residual of

0.5 mg/litre is recommended. The concentration of free chlorine should be monitored at least daily.

Ozone can be used for disinfection in water treatment. Because it is produced from oxygen in generators, a stable electricity supply is necessary. Ozone is toxic and has to be eliminated from water after treatment.

An evaluation of the outcome of water treatment should be regularly performed by plate count cultures and tests for total coliform bacteria. There should be less than 500 cfu (colony forming units) per ml and no coliform bacteria in 100 ml. (See Table 25.2)

Storage tanks

Storage tanks should be contaminant free and watertight. Storage tanks should be covered to prevent contamination. Tanks should be placed in shadow and be well insulated. Storage tanks for cold water should maintain temperatures at 20°C or lower. In storage tanks for hot water, the temperature should be maintained above 60°C. Construction of storage tanks should allow for adequate draining.

Because of the risk for formation of biofilms inside the tank, it should be inspected, emptied, cleaned, and disinfected at regular intervals. The frequency depends on the quality of water. The hot and cold pipes should be tagged if these are close together to avoid diffusion of heat and a possible increase in the cold water temperature.

Table 25.2. Requirements for water quality in healthcare

Plate counts at 22°C and 36°C	≤500 cfu/ ml
<i>E. coli</i>	0 in 100 ml
Coliform bacteria	0 in 100 ml
<i>Pseudomonas aeruginosa</i>	0 in 100 ml
Faecal streptococci	0 in 100 ml

cfu = colony forming units

Dialysis water – deionisation

Deionised water for dialysis is produced by reverse osmosis. Water entering the reverse osmosis machine must contain less than 0.5 ppm free chlorine or less than 0.1 ppm chloramines. If necessary, removal of chlorine or chloramines can be performed by filters containing granular activated carbon. Two carbon filters in series are recommended. Filters should be replaced rather than regenerated when exhausted. Whenever a carbon filter is replaced, the filter housing should be disinfected and rinsed before the new filter is installed.

Monthly bacteriologic assays of water should be performed immediately after the reverse osmosis process. If bacteria are not removed or destroyed by the deionisation unit, a submicron or endotoxin/ultrafilter will be needed downstream of the deionisation unit. If a storage tank is used in the water treatment system, bacterial levels should be evaluated directly from this tank.

Engineering

Domestic and health care

A well-trained team should be responsible for maintaining the water supply within both community and health care facilities. The quality of source water and possible sources of contamination should be known. Water sources should be protected and treatment processes controlled. Water and sewerage pipes should be well separated. Measures should be taken to prevent backflow. Pipes for hot water should be well insulated.

Health care

Construction of the plumbing system should avoid stagnation of piped water. Terminal lines should be as short as possible. Water pipes which are not used should be removed. Aerators should be decalcified if necessary. The temperature of both hot and cold water should be monitored at the faucets.

All water treatment equipment and storage tanks should be regularly cleaned and disinfected. The frequency should be determined according to a risk assessment.

Newly constructed plumbing systems should be filled with water just immediately before bringing them into service in order to prevent biofilm formation. Newly constructed plumbing systems need to be disinfected and rinsed prior to use.

To prevent formation of biofilm and microbial growth, a flow-through water treatment system should be maintained at all times. Water treatment components which can be thermally or chemically sanitised should be selected.

Role of the Infection Prevention and Control Team

The infection prevention and control team (ICT) should monitor patients for water-associated diseases, such as diarrhoeal illness or Legionnaire's disease. The ICT should assess the risks of the plumbing system of their health care facilities and of all equipment for water treatment. The ICT should know:

- Where drinking water comes from.
- How drinking water has been treated.
- Of which materials the plumbing system is constructed. Examples of plumbing materials are gray cast iron, lead, bitumen coated steel, copper, galvanized steel, polyethylene, or vinyl chloride.
- Chemicals that may contaminate the drinking water. There are chemicals which already contaminate ground water (e.g., arsenic, pesticides) and chemicals which can be released by plumbing material (e.g., copper, lead, cadmium, polycyclic aromatic hydrocarbons).
- The equipment for water treatment used in the facility.
- If there are persons at increased risk of Legionnaire's disease or if severely immunocompromised patients are present (e.g., transplant patients, patients with acquired immune deficiency syndrome).

According to the individual facility risk assessment and national regulations, the ICT should coordinate microbiological and chemical analyses of drinking water, deionised water, bathing water, etc. The frequency of analyses should be assessed according to the results.

In addition to the use of plate count cultures, tests for total coliform bacteria and nitrate should be analysed. Health care facilities which have patients at risk for Legionnaire's disease should regularly evaluate for *Legionella*

spp. in the hot water system. If there is ambient water treatment or storage of water, *Pseudomonas aeruginosa* should be part of the evaluation.

Establish a surveillance method for detecting healthcare-associated Legionnaires' disease. One way to do it is to perform appropriate laboratory tests for all healthcare-associated pneumonia. If there is evidence of healthcare-associated Legionnaire's disease, conduct an environmental assessment to determine the source of *Legionella* spp.

If disinfection of the hot water distribution system is necessary, high-temperature decontamination or chlorination can be performed.

- High-temperature decontamination: flush each outlet for ≥ 5 minutes with water at $71^{\circ}\text{C} - 77^{\circ}\text{C}$.
- Chlorination: Add enough chlorine (preferable sodium hypochlorite - bleach) to achieve a free chlorine residual of ≥ 2 mg/l (≥ 2 ppm). Flush each outlet until a chlorine odour is detected. Maintain the elevated chlorine concentration in the system for ≥ 2 but ≤ 24 hours.

Applicable Guidelines

There are international guidelines on water published by the World Health Organization:

- WHO Guidelines for the safe use of waste-water, excreta and grey water, 2006. http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html [Accessed July 26, 2011]
- Guidelines for safe recreational (bathing) waters, 2003. http://www.who.int/water_sanitation_health/bathing/en/ [Accessed July 26, 2011]

In countries of the EU or European Free Trade Association, the recommendations of the European Committee for Standardization should be applied <http://www.cen.eu/cen/pages/default.aspx>. [Accessed July 26, 2011]

If there are no national guidelines, the "Guidelines for Environmental Infection Control in Health-Care Facilities" of the US Centers for Disease Control and Prevention's Healthcare Infection Control Practices Advisory Committee (HICPAC)⁹ can be applied.

Low Resource Issues

Basic principles to follow are:

- Use alcohol-based hand rub to prevent the hand transfer of waterborne pathogens.
- Eliminate contaminated water or fluid environmental reservoirs. Prevent stagnation of piped water.
- Storage tanks should be regularly drained and disinfected.
- Establish precautions for microbial growth within the distribution system, e.g., maintain cold water temperature below 20°C and hot water temperature above 51°C.
- After significant water disruption or an emergency, run faucets and drinking fountains at full flow for ≥ 5 minutes, or use high-temperature water flushing or chlorination. In dialysis units change the pretreatment filter and disinfect the dialysis water system to prevent colonisation of the reverse osmosis membrane and downstream microbial contamination. If the facility has a water-holding reservoir or water-storage tank, verify if it has to be drained, disinfected, and refilled.
- Pharmaceuticals or medical solutions should not be stored on ice intended for consumption. Medical solutions should be kept cold only with sterile ice or with equipment specifically manufactured for this purpose.
- Ice storage chests should be regularly cleaned and disinfected according to manufacturer's instructions.
- Water which is used for routine dental treatment should contain less than 500 cfu/ml on heterotrophic plate count.
- Water used for rinsing disinfected endoscopes and bronchoscopes should have been boiled or filtered through 0.1-0.2 μm filters. Internal channels of the reprocessed endoscopes or bronchoscopes should be dried (e.g., using 70% alcohol followed by forced-air treatment).

Acknowledgement

This chapter is an update of the earlier one by Dr. Shaheen Mehtar.

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Web Sites

US Centers for Disease Control and Prevention: Healthy water. www.cdc.gov/healthywater/ [Accessed July 26, 2011]

WHO health topic: Water. www.who.int/topics/water/en [Accessed July 26, 2011]

Chapter 26

Health Care Facility Design, Construction, and Renovation

Ulrika Ransjö and Walter Popp

Key points

- Recommendations for construction of health care facilities must be based mainly on experience and assessment of infection risks, considering available local resources, as published evidence is scarce.
- Several factors might influence transmission of infection, some of which are listed below:
 - Numbers of patient and staff
 - Numbers and types of procedures and examinations
 - Available space
 - Numbers and types of rooms
 - Number of beds in a room
 - Floors and surfaces
 - Water, electricity, and sanitation
 - Ventilation and air quality
 - Handling of used and unused medical equipment
 - Handling of food, laundry, and waste

Background¹⁻³

The influence of design and construction on healthcare-associated infections (HAI) is difficult to evaluate. To identify environmental contributions to a risk-adjusted rate, such as surgical site infection (SSI), is even more challenging, since there are many patient-related and practice confounders. Secondary variables such as microbial counts in air or water are often used for bench-marking.

Infection Risks

Construction as an independent risk factor for HAIs is not clear. In order to identify the ideal design of operating theatres for decreasing the incidence of SSIs, a researcher will consider only clean surgeries, and any study will require impractically large numbers in order to show significant differences. Lidwell⁴ in the 1970s reviewed data for over 8,000 clean procedures. Even then his findings did not resolve some questions on the best design required to reduce SSIs.

Two well-designed recent studies demonstrated the impact of the environment involving respiratory pathogens and suggested practical design lessons. The severe acute respiratory syndrome (SARS) study, involving a virus primarily transmitted by droplet/contact, highlights the importance of short-range aerosols; the *M. tuberculosis* study considers alternate designs to control airborne transmission.

Yu, et al.⁵ conducted a case-control study in Guangzhou and Hong Kong, China, during the SARS epidemic of 2003 on 124 wards in 26 hospitals. Cases were on wards with super-spreading events of SARS; controls were on wards with SARS cases admitted but without HAI outbreaks. They found six significant risk factors, two of which were influenced by construction: distance between beds of <1 m (Odds Ratio 6.9) and availability of washing or changing facilities for staff (OR 0.12).

Escombe, et al.⁶ investigated the influence of natural and mechanical ventilation and found that in countries with limited resources, window ventilation may be effective to prevent the spread of tuberculosis. This was a modelling study using a surrogate for *M. tuberculosis*; however it helped define space requirements when considering natural ventilation in specific

climates. In countries where multi-resistant tuberculosis is common, planning should include ventilation.⁷⁻⁸

Prevention

Recommendations for health care design and construction must be based on experience and applicability, considering local resources and cultural conditions, together with a review of current scientific literature. Important factors include design, ventilation, patient placement or relocation, and effective construction barriers to protect susceptible patients from airborne pathogens.

Risks related to construction/renovation work are primarily associated with reduced air quality and environmental contamination from fungi (e.g., *Aspergillus* spp.) or with contaminated water (e.g., *Legionella* spp.). Newly constructed or renovated areas should be thoroughly cleaned before patients are allowed in them.

Design issues are outlined in Table 26.1. They include:

1. Air and water quality, e.g., heating, ventilating, and air-conditioning systems
2. Fixtures, e.g., sink numbers, placement of hand washing stations; dispensers for hand hygiene products and associated materials (soap, waterless alcohol-based hand rub, paper towels, lotion, and similar items)
3. Sharps and waste disposal placement
4. Surfaces, e.g., ceiling tiles, walls, counters, floor coverings, and furnishings
5. Utility rooms, e.g., soiled, clean, instrument processing
6. Storage areas, including patient care supplies and personal protective equipment
7. Patient placement and basic room design

Numbers and types of rooms^{9,10}

Patient care units or wards may be overcrowded. A maximum of 40 beds on a ward should not be exceeded because of very long distances for the staff to walk. There may be more than one baby/child in a cot/bed. Visitors often sleep with the patient. Therefore, during renovation the aim should be more rooms with fewer beds in each. Single rooms for isolating infectious

patients should be available, especially in countries where communicable diseases are endemic.

Laboratory space

Each hospital should have some laboratory capacity to support the diagnosis of infectious diseases. A side room with microscope, centrifuge, and dyes is the minimum.

Hand hygiene facilities

Alcohol-based hand rubs (ABHR) are critical, especially if wash basins are limited and water supply interrupted. There should be enough dispensers for ABHR, liquid soap, and paper towels for staff use. Reusable dispensers must be maintained, cleaned and then refilled.

Floors and surfaces

Surfaces and furniture need to be cleaned and disinfected to prevent indirect contact transmission. Surfaces should be smooth for ease in cleaning; this means no unlacquered wood and no carpets. The goal is to prevent collection of moisture, microorganisms from secretions and excretions, and chemicals.

Water, electricity and sanitation¹¹

Drinking water must be controlled and regularly checked for quality and safe levels of contaminants. Every ward should have enough toilets for both sexes. Toilets and washbasins must be maintained and cleaned daily. Showers should be available. Clean water supply and electricity should be available 24 hours a day.

Ventilation and air quality⁷⁻⁸

Natural ventilation is addressed in the World Health Organization's *Policy on TB infection control in health-care facilities, congregate settings and households 2009*. The choice of ventilation system should be based on facility assessment and informed by local climatic and socioeconomic conditions. Practical details for design are outlined in the WHO's monograph, *Natural ventilation for infection control in health-care settings*.

Handling of used and unused medical equipment

Proper handling of used and unused medical equipment requires separation of clean and dirty procedures. Designated areas are needed, as well as good cleaning and disinfection procedures.

Preparation of infusions and injections should take place in a separate clean room/area. Dirty procedures, such as cleaning of soiled bedpans, should be performed in another room.

Clean medical devices should be stored in a designated room or a defined place. Wrapped, sterile goods should be stored in closed lockers or cabinets and not on open shelves.

Handling of food, laundry, and waste

Food for patients should be prepared by trained staff in a kitchen where all the surfaces are smooth and easily cleaned. Hot food must be consumed immediately or chilled before storage.

Bed linen and working clothes of staff become contaminated and should be washed in the health care facility. Laundry facilities are needed, as well as storage for clean and dirty linen. Damp textiles must be aired and heat dried/ironed to prevent re-growth of microorganisms.

The WHO¹² has technical guidance for assessing waste production, creating national action plans, developing national healthcare waste management guidelines, and building capacity at a national level.

Resource Considerations

Medium to high resources

Factors /developments¹³ that should be considered for health care planning in medium and high income countries include:

- The number of day-care and out-patients will increase.
- Patients will stay in hospitals for shorter periods. On the other hand, patients in hospitals will be very sick and susceptible to infection and will need more care and more protection.
- The number of diagnostic procedures will increase. Therefore, at the end of the day, the patient may require more rest and privacy.
- People will get larger and more obese. Therefore, health care facilities need longer beds and stretchers, more square footage for rooms, doorways, and beds, and larger operating tables for heavy-weight persons.

Water purification plants for special units, such as haemodialysis and transplant wards, need careful maintenance to prevent growth of *Legionella*, *Pseudomonas*, moulds and other environmental microorganisms.

High-level resources

In high-income countries, health care facilities should be provided with a high percentage of single bed rooms. This allows for better sleep, more privacy, less noise, reduced bacterial transmission and capacity for isolation/precautions, fewer medication errors, and increased protection of patient-specific data.

Infection Control Team Involvement

Advice on construction must be a main focus for infection prevention and control (IPC) staff. They should have a broad understanding of disease transmission and experience related to construction and renovation. Most countries have little or no training for engineers and architects in prevention of infection, and health care staff has limited experience with construction planning. IPC staff can serve as a link between medical personnel, architects, and engineers.

Meetings for planning take up time, so IPC staff need to prioritise. Areas where IPC input is particularly important are those where many procedures are carried out and patients are prone to infection (operating and delivery rooms, intensive care units), and also those where many patients are congregated (emergency rooms).

Involvement with facility management staff during the initial design phase is the key to preventing and controlling airborne and waterborne contamination.

Design and Construction Activities by IFIC

In 2007, the IFIC Special Interest Group (SIG) “Design, construction and renovation” was founded. Its goal is to outline good practices for design, construction, and renovation. Another goal is to provide recommendations for low, medium, and high income countries.

- Basic: even with severely limited resources, “this is what you should do as a minimum”.

- Standard: “this is what you should aim for in less wealthy countries”.
- Ideal: “if you have the resources, this is what you could do”.
- Draft practice recommendations are sent to all SIG members and each member can take part in preparing and discussing drafts. The final version of the recommendation is reviewed by the IFIC board before publication.

Table 26.1 provides an example of recommendations from the SIG based on this approach. This table details the principles for a general ward. Additional recommendations may be found on the IFIC website: www.theific.org

Conclusion

Advice on building design, construction, and renovation is a critical task for IPC staff. Well-constructed localities are needed to enable staff to follow IPC guidelines. Essential requirements for a health care facility include constant, reliable supplies of clean water and electricity, adequate numbers of beds and space between beds, good ventilation, and sufficient sanitation for patients, visitors and staff, and surfaces that can be cleaned and if needed, disinfected.

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Table 26.1 Recommendations for design of a general hospital ward

Room	Basic	Standard	Ideal
<p>Patients' rooms/bays</p> <p>Each room must have a sink for hand washing and space for gloves and aprons.</p>	<p>If you must have wards with many beds, you should also have some bays or, ideally, single rooms to cohort or isolate infectious patients.</p> <p>Each room must be equipped with alcohol-based hand rub.</p>	<p>2 beds, maximum 4 beds.</p> <p>There should also be some single rooms for infectious patients.</p> <p>Each bed must be equipped with alcohol-based hand rub.</p>	<p>One bed per room.</p> <p>The room should be big enough to house 2 beds, for family member or another patient.</p>
Isolation rooms for infectious patients	Recommended, preferably with en-suite wash and separate toilet.	Some single rooms with en-suite wash/shower and toilet.	At least 2 of these rooms should have >12 air changes per hour and anterooms with negative pressure.
Distance between beds	Minimum 1 metre.	2 metres recommended.	More than 2 metres recommended.
Patients' toilets	Toilets on each ward.	Sex-specific toilets on each ward, at least en-suite toilets in single rooms.	En-suite toilets for each room.
<p>Wash/shower/bathroom</p> <p>One shower room per ward should be big enough for a shower bed or bathtub</p>	At least one wash/shower or bathroom on each ward in combination with toilet.	En-suite wash/shower for each patient room, recommended in combination with toilet.	En-suite wash/shower/toilet room for each patient room.
Other toilets	Separate toilets for both healthcare workers (HCW) and visitors.	Separate sex-specific toilets for both HCWs and visitors.	Separate sex-specific toilets for both HCWs and visitors.

Room	Basic	Standard	Ideal
<p>Nurses' workrooms (preparing care)</p> <p>Sharps must be collected in containers that close</p>	<p>At least one room for both clean and dirty work.</p> <p>Organise a maximum distance between clean and dirty work areas to ensure separation.</p>	<p>One room for clean work (preparing medications) and one room for dirty work (cleaning/ disinfection of medical products, bedpans and perhaps instruments).</p> <p>On large wards more rooms may be necessary to reduce walking distances.</p>	<p>One room for clean work (preparing medications) and one room for dirty work (cleaning/ disinfection of medical products, bedpans and perhaps instruments).</p> <p>On large wards more rooms recommended to reduce walking distances.</p>
<p>Nurses' rooms</p>	<p>One room for organising work and breaks.</p>	<p>One room for organising work and one for breaks.</p>	<p>One room for organising work and one for breaks.</p>
<p>Doctors' treatment/ examination rooms</p>	<p>One room desirable.</p>	<p>At least one room.</p>	<p>At least one room.</p>
<p>Waste room</p>	<p>There should be a specific area, preferably outside the ward, for the storage of waste awaiting collection.</p> <p>Waste sacks should be kept in large containers for collection.</p>	<p>May be combined with room for dirty work.</p>	<p>One special room for waste storage.</p>
<p>Kitchen</p>		<p>Small kitchen with sink and refrigerator.</p>	<p>Small kitchen with sink and refrigerator.</p>

Room	Basic	Standard	Ideal
Storage of clean equipment and products		At least one great storage room.	At least one great storage room.
Bed reprocessing (including cleaning of mattress and bedstead) Sheets, blankets, pillows sent to laundry	Bed reprocessing in patient room, not in corridor.	Bed reprocessing in patient room or in a reserved room on the floor.	Bed reprocessing in patient room or centralised.
Changing room for staff (if uniform is from the hospital)		Centralised or one room only for changing on the ward.	Centralised or one room only for changing on the ward.
Housekeeping and laundry room	Separate cleaning and disinfection agents in some area. Sacks for dirty laundry.	One room with sink, disinfectants, cleaning agents and cleaning cart. Sacks for dirty laundry.	One room with sink, disinfectants, cleaning agents and cleaning cart. Sacks for dirty laundry.

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Further Reading

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Chapter 27

Risk Management

Nizam Damani

Key points

- The Infection Control Team must identify infection prevention and control practices which are unsafe and hazardous.
- Unsafe practices must be assessed for their severity, frequency, and likelihood of recurrence.
- Priority must be given to hazardous practices that have high adverse effects, occur more frequently, and have lower cost to prevent.
- Effectiveness of these measures should be monitored by regular audits and/or outcome surveillance and the information must be provided to front-line clinical staff, relevant managers, and key decision makers.

Introduction¹⁻²

The delivery of an effective infection prevention and control (IPC) programme requires trained IPC practitioners whose job, amongst other things, is to identify unsafe and hazardous IPC practices, recommend cost-effective preventive measures, and help health care facilities set priorities both in high and low resource settings. These objectives can be achieved by applying the concepts of risk management. This skill is essential for IPC practitioners to perform their job effectively.

Risk Management

Risk is defined as the possibility of incurring misfortune and loss. Risk management is a *proactive approach* and its aim is to prevent or minimise harm. This process identifies potential problems and the potential for harm is assessed. Actions are then planned to reduce the likelihood of the problem arising or to limit the harm caused. In IPC the risks can be biological agents that have the potential to cause infection or a mechanism that allows the transmission of an infectious agent to occur. The risk management process can be divided into four key stages. (See Figure 27.1)

1. Risk identification
2. Risk analysis
3. Risk control
4. Risk monitoring

Risk Identification

The process of risk management starts with risk identification and involves:

- identifying the activities and tasks that put patients, healthcare workers, and visitors at risk;
- identifying the infectious agent involved; and
- Identifying the mode of transmission.

The aim is to identify common problems/practices that have impact on a large number of patients or rarer problems which can cause severe infection or death. Once a problem is identified, it is essential to obtain evidence through an investigation, which usually requires the expert knowledge of the IPC Team and can involve observational or experimental studies.

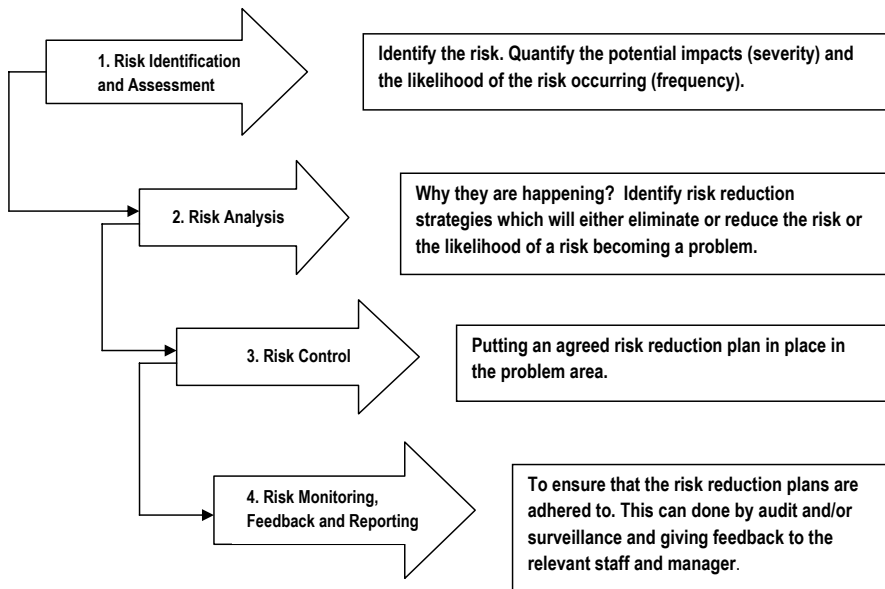


Figure 27.1 Risk management processes.

Risk Analysis

Once the risk has been identified, the likely consequences to patients must be estimated. This can be achieved by analysing four key questions:

- *Why* are infections happening?
- How *frequently* are they happening?
- What are the likely *consequences* if the appropriate action is not taken?
- How much is it going to *cost* to prevent it?

Why are infections happening?

A range of system failures can result in patients acquiring healthcare-associated infections and it is important to analyse these failures in detail.

Type I error

These occur due to an act of omission, e.g., failure to comply with current professionally accepted practice. The basic cause of a Type I error is lack of knowledge; it is typically common in health care institutions where there is inadequate provision of education, training, and supervision. In a low resource setting, a scarcity of goods can also contribute to this type of error. Regular education and competence-based training, good communication, and availability and regular supplies of goods are necessary to address this issue.

Type II error

These occur due to an act of commission, i.e., an act should not have been committed. These are due to lack of commitment or consideration for others. This type of error is more complex and amongst other things may also require management reinforcement.

Type III error

This mainly occurs due to a failure to understand the true nature of the problem. Real solutions are adopted to deal with the wrong problems, rather than incorrect solutions to real problems. This is often due to lack of communication, or misinterpretation of information as a result of inadequate research or information.

How frequently are they happening?

This information is quantitative and can be obtained by ongoing surveillance data (if available) or by performing a point prevalence study. The information can be gathered from other sources, e.g., as part of an outbreak investigation, local prevalence data, data published in the literature, or clinical evidence. Frequency can be measured as the percentage or rate of persons who developed infection following either a clinical procedure or exposure to a pathogen. If surveillance data are not available, probability can be used instead. See Table 27.1.

Table 27.1. Risk probability

Rating	Probability	Comments
4	1:10	Almost certain or very likely to occur.
3	1:100	Highly probably that they will occur.
2	1:1000	It is possible that they may occasionally occur.
1	$\geq 1:10000$	They are rare and do not believe/expect to occur.

What are the likely consequences?

Severity can be measured in terms of morbidity (disability or increased length of stay) or mortality experienced by persons who had the procedure or exposure. Severity of the adverse effects can be ranked as in Table 27.2 and Figures 27.2 and 27.3.

Table 27.2. Severity rating

Rating	Description		Comments
20-30	High or major	Major impact on patient which may lead to death or long term consequences	Urgent action is required
10-19	Moderate	Moderate impact which may lead to short term consequences	Action required
1-9	Low risk or minor	Minimum impact with no or minor consequences	Keep under review

High severity	2 - High severity Low frequency (bloodstream infections caused by contamination of intravenous feed/solution)	1 - High severity High frequency (blood-borne infections from re-use of syringes and needles)
Low Severity	4 - Low severity Low frequency (infections from hospital linen)	3 - Low severity High frequency (urinary tract infections)
	Low Frequency	High frequency

Figure 27.2. Severity and frequency of events.

How much is it going to cost to prevent it?

It is also important to estimate the cost of prevention of each risk. Estimated costs are acceptable, as the exact cost may be difficult to obtain. The cost of prevention of infections is important because it helps IPC practitioners target resources where they will deliver the greatest advantage in terms of preventing harm to patients.

LIKELIHOOD	IMPACT				
	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	MODERATE RISK	MODERATE RISK	HIGH RISK	CRITICAL RISK	CRITICAL RISK
Likely	LOW RISK	MODERATE RISK	HIGH RISK	CRITICAL RISK	CRITICAL RISK
Possible	LOW RISK	MODERATE RISK	MODERATE RISK	HIGH RISK	HIGH RISK
Unlikely	LOW RISK	LOW RISK	MODERATE RISK	MODERATE RISK	HIGH RISK
Rare	LOW RISK	LOW RISK	LOW RISK	MODERATE RISK	MODERATE RISK

Required action, level of involvement
and action timeline will be based
on the risk level

<p>Critical Risk: STOP ACTIVITY!</p> <ul style="list-style-type: none"> • Risk management must be informed to initiate senior administrative notification • Requires immediate written recommendations presented in person to Director and Manager • Written action plans with timelines must be set • ACTION TIMELINE: Immediate action required
<p>High Risk: STOP ACTIVITY!</p> <ul style="list-style-type: none"> • Risk management must be informed to initiate senior administrative notification as required Requires written recommendations, preferably presented in person to Director and Manager within 48 hours • Written action plans with timelines must be set • ACTION TIMELINE: 48 hours
<p>Moderate Risk:</p> <ul style="list-style-type: none"> • Written recommendations to Director and Manager • Written action plans with timelines set • ACTION TIMELINE: 3 months
<p>Low Risk:</p> <ul style="list-style-type: none"> • Written recommendations to Manager • Written action plans with timelines set • ACTION TIMELINE: 6 months or longer

Figure 27.3. Action planning risk level matrix. Adapted from Bialachowski A, et al ³

Risk Control

Once the risk analysis has been completed, review the possible solutions. Ideally, the risk should be completely eliminated; if this is impossible then it should be reduced to a minimum/acceptable level. In some situations, it may be more cost-effective to transfer the risk to a third party such as a private contractor. For example, if there is a problem with the supply of sterile goods it may be more cost-effective to purchase these items from another source.

If resources are severely constrained, then it may be possible to accept the risk in both the short and possibly long term. Willingness to tolerate known risks in a health care institution differs in various parts of the world and is based mainly on the availability of resources and the fear/level of litigation.

Monitoring and Feedback

Once appropriate measures are in place to reduce the risk, it is essential to monitor their effectiveness. Depending on resources available, this can be achieved by regular audit, process monitoring, and outcome surveillance of healthcare – associated infections. Timely feedback must be given to front line healthcare workers and senior management.

The Audit Process³

Identifying and analysing infection risks can be performed using an audit process. The process helps to identify new risks, analyse risks against evidence-based practices, and identify any gaps in practice so that appropriate action is taken. The key elements to the success of this process are communication, consultation, and timely feedback of information to all the key stake holders and making sure that the audit loop is closed. See Figure 27.4.

This can be achieved by:

1. Review of documentation to establish whether written guidance relating to certain procedures or practices exists. Are these guidelines in line with current evidence-based practice? This process may also involve review of documents of previous audits and other relevant reports, etc.

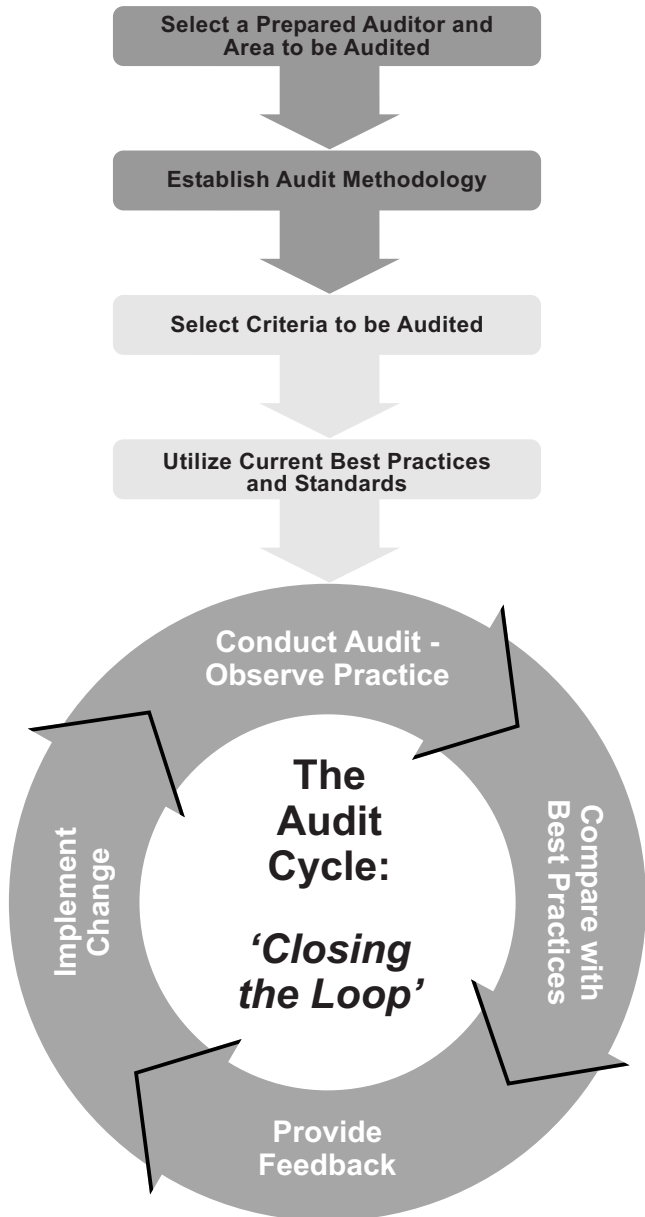


Figure 27.4 The Audit Cycle: 'Closing the Loop'. Adapted from Bialachowski A, et al³

2. Interviews with staff to assess their knowledge and practical application of IPC policies and procedures are also crucial. This is completed through questionnaires, face-to-face discussions, or group interviews.
3. Depending on the resources available, observational visits can be conducted to assess whether practice is actually followed or not. This can be achieved by using a validated audit tool.

Priorities for Action

Once all information is available on the severity, frequency of occurrence, and cost of prevention, priorities for action can be developed by calculating a risk rating as follows:

$$\text{Risk rating} = \text{Severity} \times \text{Frequency (probability) of disease} \times \text{Cost of prevention}$$

A risk rating with the highest score would merit immediate attention. Calculation of the risk rating helps to understand the true consequences of adverse incidents and helps the IPC Team set priorities in the most effective way.

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Chapter 28

The Costs of Healthcare-Associated Infections

Candace Friedman

Key points

- Healthcare-associated infections delay patient discharge and increase costs.
- Healthcare-associated infections are accompanied by increasing numbers of laboratory and diagnostic investigations.
- Healthcare-associated infections increase infection prevention and control costs, including epidemiological investigations and medical, nursing and management time.

Introduction

Healthcare-associated infections (HAI) are an important cause of morbidity and mortality and therefore should be rigorously controlled as part of the general duty of safe patient care. HAIs also have considerable economic impact on health care services and the cost of national health care. The members of the infection control team (ICT) need to understand the financial burden of HAIs and how to evaluate the cost savings of any infection prevention intervention.

Economic Consequences

Measuring the cost of HAIs is difficult and the financial impact varies between different health care systems. Nevertheless, HAIs can have the following economic results (See Table 28.1):

1. HAIs delay patient discharge, resulting in increased 'hotel' costs. In addition, the patient suffers additional costs due to absence from work, and relatives suffer costs of time and travel to visit the patient;
2. Infections require increased treatment costs (for example, drug therapy and procedures, including repeat surgery). The patient may be discharged from hospital while infected and these costs then fall on General Practice or Community Services;
3. HAIs involve increasing numbers of laboratory and diagnostic investigations;
4. HAIs increase infection prevention and control (IPC) costs, including epidemiological investigations and medical, nursing, and management time;
5. An HAI is often the subject of litigation.

There may also be costs associated with blocked beds and closed wards or operating theatres, resulting in increased unit costs for admissions and procedures, lengthening waiting lists, and failure to complete contracts. Patient morbidity resulting from an HAI generates community and society costs that are difficult to quantify but may have considerable impact. Also difficult to measure in economic terms is loss of reputation – either for the facility or for individual units – which can have a significant impact on contracts and patient referral.

Table 28.1. Economic consequences of healthcare-associated infections¹

Hospitalisation Costs	Use of antibiotics Increased length of hospitalisation Potential intensive care unit stay
Intervention Costs	Tests performed Barriers used (e.g., gown, gloves) Nurse/physician time Potential need for an isolation room
Outpatient/Community Care Costs	Physician visits Use of antibiotics Home health visits Rehabilitation center stay
Patient Costs/Outcomes	Mortality Morbidity Lost wages Travel expenses

Overall Cost Estimates

Many studies have focused on the severity of HAIs and their risk for patient safety, and have tried to analyse the economic impact of HAIs by different methods. These methods are often flawed by the failure to distinguish accurately between the type and amount of resources specifically associated with treating HAIs and those incurred by the original disease for which the patient was admitted.²

Although measuring the cost of HAIs is difficult, some studies have shown the probable magnitude of the problem. One study reviewed 4,000 adult patients in an English district general (community) hospital during 1994 - 1995.³ In this study, 7.8% of patients had an HAI identified in hospital. These patients remained in hospital about 2.5 times longer than uninfected patients, an average of 11 additional days. They had increased hospital costs 2.8 times greater than uninfected patients, averaging about £3,000 (US \$5,000) per case at that time. 13% of infected patients died compared

with 2% of those uninfected. Adjusted for age, sex, co-morbidity and other factors, the death rate was seven times higher for patients with an HAI. Estimated costs of HAIs to the hospital were £3.6m (US \$5.8m).

The extrapolated national annual cost burden of HAIs for English hospitals was about £1b (US \$1.6b), equivalent to about 1% of the total national hospital budget. The national annual post-discharge costs were estimated to be about £56m (US \$90m). This included General Practice costs of £8.4m, hospital out-patients, £27m, and community nursing services, £21m. It was estimated that HAI was the direct cause of about 5,000 deaths per annum in England (more than those caused by suicides or traffic accidents) and contributed to an additional 15,000 deaths.

One study in the United States noted that the direct hospital-related financial burden of HAIs was estimated to be between 25.0 and 31.5 billion dollars per year.⁵ Another US study found that each HAI adds \$12,197 in incremental costs to hospitals.⁵

In Mexico, Navarrete-Navarro and Armengol-Sanchez⁶ estimated costs associated with HAIs in paediatric intensive care. Infected children had an extra hospital stay of 9.6 days. This was the major factor contributing to an average cost per infection of nearly US \$12,000.

A study in Turkey suggested that a patient with an HAI spent an additional 23 days in the hospital compared with a patient not affected with an HAI. The extra cost for an infected patient was calculated as US \$2,026.⁷

Costs might be expected to be higher in tertiary referral hospitals. Costs will be different for various countries and will change with time; however the relative magnitudes will be similar.²

Types of Economic Evaluations

Several types of economic analyses can be employed, including: cost minimisation, cost effectiveness, cost benefit, and cost utility. The most preferred analyses are cost-effectiveness and cost utility.

A cost-effectiveness analysis compares interventions or products with different costs and different effectiveness. A cost utility analysis is similar,

except the benefits of a specific intervention are adjusted by health preference scores. Cost utility analyses are useful when there are no expected mortality differences between interventions, only differences in physical well-being which can be expressed as quality adjusted life years (QALY).¹

When data on costs used in analyses are from different years, they should be brought into current year values. A typical method is to inflate the amounts using a standard price index for the country.¹ The World Health Organization recommends that a threshold for calling an intervention cost-effective be three times the country's gross domestic product per capita.⁸

Costs that can be measured include the health care facility costs, health care facility charges, resources used, and actual reimbursed charges. Hospital costs are a useful measure; they best reflect the actual economic burden to the institution. If the only information available is charges, the data can be adjusted using cost-to-charge ratios.⁹

Costs of Outbreaks

Several investigators have attempted to measure the costs associated with outbreaks of infection. Again, the costs are tentative and must be considered in relation to the health care system studied and the year of study. Nevertheless, costs are considerable.

For example, a 4-month outbreak of *Klebsiella pneumoniae* infection in a neonatal intensive care unit was estimated to cost a hospital more than US \$300,000 in 2001.¹⁰ Kim et al¹¹ measured the costs of MRSA in their hospital and calculated that it cost all Canadian hospitals \$42m - \$59m annually.

Cost-benefit of Infection Prevention and Control

In the Study on the Efficacy of Nosocomial Infection Control (SENIC) of 1974-1983, US hospitals with one full-time infection control nurse (ICN) per 250 beds, an infection control doctor (ICD), moderately intense surveillance, and systems for reporting wound infection rates to surgeons reduced their HAI rates by 32%. In other hospitals the HAI rate increased by 18%.

The SENIC study estimated the annual cost of HAIs in US hospitals was \$1b (in 1975 dollars). The cost of IPC teams (0.2 ICD and 1 ICN per 250 beds) was \$72m per annum, only 7% of the infection costs. Therefore, if IPC programmes were effective in preventing only 7% of HAIs (normally distributed), the costs of the programmes would be covered. A 20% effectiveness would save \$200m and 50% would save \$0.5b (1975 US dollars).

The Association for Professionals in Infection Control & Epidemiology documented the business case for reducing HAIs from the perspective of the health care executive in 2007. Case studies of significant cost savings were presented along with a methodology for determining the cost of various categories of HAIs.¹²

Similarly, guidelines on how to develop a business case for infection prevention were developed by the Society for Healthcare Epidemiology of America. This publication also explains economic concepts.¹³

Decreasing organisational revenues and efforts to reduce overall operating costs have had a direct impact on IPC programmes. Senior managers in health care organisations are focusing on achieving and maintaining revenues while controlling costs. IPC professionals must align themselves and their programs with these organisational goals by: (1) identifying areas in which the IPC program can support and enhances revenues, (2) avoiding excess costs for care, especially those related to HAIs, (3) identifying opportunities for cost reduction through value analysis, and (4) participating in efforts to measure and prevent other adverse outcomes of care.¹⁴

Low Resource Issues

Improved data collection efforts would help estimate the burden of HAIs in low resource countries; drug resistance is a significant area where data are needed.⁹ Computer-assisted epidemiological surveillance may be an important aspect of monitoring IPC programmes.

Summary

The costs of HAIs are huge and include patient morbidity and mortality, hospital and community medical costs, the impact of blocked beds, and wider socio-economic costs. The costs of IPC programmes and staffing are relatively minor and with only a small degree of effectiveness they can pay for themselves. Investment in IPC is therefore highly cost-effective.

The constantly changing external environment, advancing technology, legislation, the introduction of government mandates, and a drive to maximise health care resources have made costing of IPC a management priority.¹⁵

Economic evaluations play an increasingly important role in IPC. It is important for IPC advocates to partner with individuals from many different fields to give decision-makers the information they need to make choices.

Acknowledgement

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