

Nosocomial infections and infection control

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Abstract

Nosocomial infections are a leading cause of avoidable harm in hospital patients and a substantial, unnecessary drain on healthcare resources. They are frequently caused by bacteria that are resistant to multiple antibiotics, and the treatment of nosocomial infections contributes to the selection of resistant bacteria. Understanding the complex interplay of factors that contribute to nosocomial infection is a necessary first step to improving patient outcomes. This article highlights the role of pathogens, patients, practice and place in both aetiology and management of nosocomial infections, and references additional reading for more detailed information.

Keywords Antibacterial drug resistance; *Clostridium difficile*; disease outbreaks; infection control; methicillin-resistant *Staphylococcus aureus*; MRCP; nosocomial infections; patient care bundles; surgical wound infection

Defining nosocomial infections

Nosocomial (from the Latin *nosocomium* meaning hospital) infections are infections in hospital inpatients that were neither present nor incubating at the time of the patient's admission to hospital. Because of the difficulty of assessing the presence of an incubating infection, a practical approach is to define any bacterial infection as nosocomial if it becomes apparent >48–72 hours after admission. Viral infections with well-defined incubation periods can be more readily ascribed to community or nosocomial onset.

The epidemiology of nosocomial infections

Nosocomial infections occur frequently. A point prevalence survey of 231,459 patients from 947 acute care hospitals across 30 European countries in 2011/12 revealed that, at any given time, 5.7% of patients had at least one nosocomial infection.¹ Patients of all ages and clinical specialties are affected by nosocomial infections, as are all anatomical sites (Table 1).

The consequences of nosocomial infections

Nosocomial infections can be fatal or cause delayed recovery, functional impairment or aesthetic damage that can have lifelong consequences for patients. Management of these infections often requires prolonged inpatient stay, additional investigations,

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Key points

- Nosocomial infections are a major cause of harm for hospital patients
- Many infections can be prevented by good infection control practice
- Understanding the four main contributory factors – pathogen, patient, practice and place – helps with effective infection prevention

surgical intervention and antimicrobial treatment, all of which add to healthcare costs.

Across the world, healthcare payers are increasingly refusing to pay for the treatment costs of healthcare infections, claiming they could have been avoided. Hospitals in England are liable to lose the entire payment for an inpatient episode complicated by an avoidable nosocomial bloodstream infection with methicillin-resistant *Staphylococcus aureus* (MRSA). Healthcare regulators increasingly see nosocomial infections as preventable, and view rates of infection as a marker of the general quality of healthcare delivered by an organization.

Antimicrobial resistance

Nosocomial infections are an important factor in the emergence and spread of multidrug-resistant (MDR) bacteria. Broad-spectrum antibiotics, such as vancomycin, third-generation cephalosporins and carbapenems, are often used for empirical treatment of infected patients, thereby selecting for and favouring the persistence of MDR pathogens.

Defined terms are used to describe the extent of resistance. MDR organisms are resistant to at least one agent in three or more antimicrobial categories. Extensive drug resistance (XDR) is resistance to at least one agent in all but two or fewer antimicrobial categories. Pan-drug resistance (PDR) is resistance to all agents in all antimicrobial categories.

Important MDR causes of nosocomial infections include MRSA, vancomycin-resistant enterococci (VRE) and MDR Gram-negative bacilli, particularly *Escherichia coli* and *Klebsiella* species. The development of carbapenem resistance in Gram-negative bacteria, through the emergence of various carbapenemase genes, is increasing the prevalence of infections caused by XDR and PDR pathogens, and threatening the ability to deliver safe healthcare in many countries. Nosocomial infections caused by resistant fungi are also increasingly reported. The developing resistance crisis is worsened by a lack of new antibiotic classes entering clinical practice.

Infection prevention

The 'four Ps' of infection prevention – pathogens, patients, practice and place

Prevention is the best approach to management of nosocomial infections and can be addressed by considering the interaction of pathogens and patients within the context of clinical practice in the place where healthcare is delivered (Figure 1).

Relative frequency of nosocomial infections and causative organisms in a point-prevalence survey across Europe, 2011/12, in 13,829 infected patients

Infection type	Relative percentage of all nosocomial infections	Most frequent causative organisms (percentage of cases caused by identified pathogen)
Pneumonia	19.4	<i>Pseudomonas aeruginosa</i> : 17.4
Other lower respiratory tract infections	4.1	<i>Staphylococcus aureus</i> : 12.6 <i>Klebsiella</i> spp.: 11.4
Surgical site infections	19.6	<i>Staphylococcus aureus</i> : 17.9 <i>Enterococcus</i> spp.: 14.5 <i>Escherichia coli</i> : 14.0
Urinary tract infections	19.0	<i>Escherichia coli</i> : 36.2 <i>Enterococcus</i> spp.: 12.5 <i>Klebsiella</i> spp.: 12.0
Bloodstream infections	10.6	Coagulase-negative staphylococci: 18.5 ^a <i>Staphylococcus aureus</i> : 15.9 <i>Escherichia coli</i> : 11.0 <i>Klebsiella</i> spp.: 9.8
Catheter-related infections without bloodstream infection	1.6	
Cardiovascular system infections	1.4	
Gastrointestinal system infections	7.6	<i>Clostridium difficile</i> : 48
Skin and soft tissue infections	4.0	
Bone and joint infections	1.6	
Central nervous system infections	0.6	
Eye, ear, nose or mouth infection	3.0	
Reproductive tract infections	0.6	
Systemic infections	6.2	
Other/unknown	0.8	

^a Coagulase-negative staphylococci are a frequent contaminant of blood cultures, but are genuine pathogens in many device-related nosocomial bloodstream infections.

Data source: European Centre for Disease Prevention and Control. Point prevalence survey of healthcare-associated infections and antimicrobial use in European hospitals 2011–2012 (2013).

Table 1

Pathogens: the range of infecting microorganisms extends from prion proteins (Creutzfeldt–Jakob disease (CJD) and variant CJD), through viruses, bacteria and fungi to parasites and arthropods such as the scabies mite.

The most frequently isolated pathogens in the European survey are shown in Table 1. Many are normal members of the human microbiota – the thousands of microbial species found naturally on the epithelial surfaces of the skin, oropharynx and gastrointestinal and genitourinary tracts. These, along with less frequently isolated microorganisms such as *Acinetobacter baumannii*, *Serratia* species, *Stenotrophomonas maltophilia* and *Aspergillus* species, are important because of their propensity for cross-infection and their ready ability to acquire resistance to multiple antimicrobials.

Certain subspecies of bacteria, characterized by the possession of genes for virulence markers or antimicrobial resistance, have emerged as significant causes of nosocomial infection that can spread on an intercontinental scale. MRSA infections in England in the early 2000s were mostly caused by just two strains, epidemic MRSA 15 and 16. A global epidemic of *Clostridium*

difficile infection, peaking in England in 2007, was caused by a single strain, the 027 ribotype. Its spread was facilitated by antibiotic resistance, particularly to fluoroquinolones, and by a gene variant responsible for raised levels of toxin production. This modified gene led to severe diarrhoea and contamination of ward environments with high numbers of *C. difficile* spores, with increased numbers of secondary cases.

Patients: important patient determinants of infection risk include:

- extremes of age
- poor nutritional state
- obesity
- diabetes mellitus, lung, liver or renal disease, malignancy or immunodeficiency
- smoking
- coexisting infections.

Patients requiring emergency surgery are at increased risk of infection relative to elective patients undergoing the same procedure.

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