



A brief history of infection control – past and present

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However, the victory was short-lived. It was soon realised that infections occurred not only in obstetric and surgical patients, but in medical patients as well, and that air could also be a source of infection.

Streptococcal, staphylococcal and then Gram-negative bacilli as a cause of hospital infection became a focus of attention, as did antibiotic-resistant organisms.

This paper looks briefly at the establishment of the control of infection doctor, infection control committee and infection control nurse as well as summarising the changes, problems and advances in infection control up to the present time.

Sydney Selwyn in his 1990 epic opening lecture to the Second International Conference of the Hospital Infection Society traced the history of hospital infection over 2 500 years!¹ He reminded us of Florence Nightingale's favourite dictum: 'The first requirement of a hospital is that it should do the sick no harm'.

The scientific study of hospital or nosocomial cross-infection began during the first half of the 18th century, and from that time until the start of the 'Bacteriological Era', many of the most notable contributions originated in Scotland. Remarkable among these early pioneers was the physician Sir John Pringle, who strongly believed that overcrowding and poor ventilation added greatly to the problem of hospital infection. However, it was only 100 years later in 1858 that Florence Nightingale, following her experiences in military hospitals during the Crimean War, promoted the case for hospital reform, although

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she remained hostile to the 'germ theory' of disease for the remainder of her life.

Streptococcal and staphylococcal infections

The real understanding of hospital infection followed upon the discoveries of Pasteur, Koch and Lister, and the beginning of the 'Bacteriological Era'. The close of the 19th century saw triumphs of hospital reform and asepsis and seemed to herald the final victory over hospital cross-infection. However, the victory was short-lived. With the opening of numerous hospitals for infectious diseases in the 20th century, it was soon realised that infections occurred not only in obstetric and surgical patients (the emphasis in the late 19th century) but in medical patients as well. It was soon realised that air could be a source of such infection and that many viral, as well as bacterial, infections spread via this route.

In the early part of the 1900s streptococcal cross-infection became a focus of attention. The dissemination of *Streptococcus pyogenes* by scarlet fever patients was clearly documented in 1927, but it was not until the advent of serological typing of this bacterium that the high incidence of cross-infection in scarlet fever wards was confirmed by Gunn and Griffith.² The epidemiology of puerperal fever due to *S. pyogenes* was also further elucidated by means of serological typing. This work fully established the importance of nasal and throat carriers in the transmission of streptococcal disease. It also showed that streptococcal infection occurred in burns and maternity wards and implicated airborne dust in the spread of infection. The period from 1935 to 1950, which was marked by intensive enquiry into streptococcal cross-infection, also saw a great decline in the importance of this type of infection. While much of this decline was almost certainly due to the introduction of the sulphonamides and penicillin, and by improved methods in hospital hygiene, the streptococcus was probably also undergoing a spontaneous decrease in virulence.

Hospital cross-infection due to *Staphylococcus aureus*, although of some importance before the end of the period in which the streptococcus dominated, really came into its own in the late 1950s and early 1960s. Bacteriophage typing of this bacterium clearly revealed that evolutionary changes had occurred over the years with increasing virulence. This culminated in the appearance of the notorious 'phage 80/81 staphylococcus' in the 1960s, which resulted in epidemics of infection in many parts of the world. More recently, epidemic methicillin-resistant *S. aureus* (EMRSA) strains have emerged to produce clinical infections in many hospitals worldwide.³



The rise of Gram-negative infections

The importance of Gram-negative bacilli as a cause of hospital infection increased insidiously during the 1950s and had overtaken that of *S. aureus* by 1960. However, this event was not widely appreciated until comprehensive surveys had been conducted in the 1960s.⁴ *Escherichia*, *Klebsiella*, *Proteus* and *Pseudomonas* species and related genera, which possess very limited pathogenic abilities in the healthy host, were found to be well suited to their increasing role in hospital infection. Important factors were their considerable powers of resistance to antibiotics and disinfectants, and their ability to survive and even multiply under adverse environmental conditions. They were particularly suited to colonising and infecting debilitated patients, and the apparatus used on such patients. The introduction of broad-spectrum antibiotics hastened the emergence of highly resistant strains of *Pseudomonas* species, which rapidly became a major pathogen in the 1960s. This resistant organism was soon followed by resistant strains of *Serratia* and *Acinetobacter*. The age of opportunistic organisms had arrived.

Infection control doctors and nurses

It is interesting to note that the challenge of increasingly complex and expensive hospital infection problems over the past 60 years led to the development of a structured system of control. In the UK the first formal step was the recommendation in 1941 by the British Medical Research Council (MRC) that for the prevention of surgical sepsis, 'full-time special officers' should be appointed to supervise the control of infection.⁵ Thus was born the part-time control of infection officer (CIO), renamed in 1988 the infection control doctor (ICD). Then in 1944 the MRC advised that in every hospital an infection control committee be established with representative doctors, nurses and administrators. In the mid-1950s, Brendan Moore in Exeter developed the idea of an infection control nurse (ICN) (or sister) to assist the CIO.⁶ The first ICN in the UK was appointed in 1959. ICNs were appointed in South Africa at a much later stage.

It is now regular practice in most large hospitals worldwide to employ ICNs and to have established infection control committees with a mandate to monitor and prevent hospital-acquired infections. It is of interest to look back over the last 18 years to note what developments have taken place in the area of hospital-acquired infection.

Second International Conference on Nosocomial Infections – Atlanta, 1980

In August 1980, the Second International Conference on Nosocomial Infections was held in Atlanta, Georgia, USA. Richard Dixon, in his preface to the conference proceedings, drew attention to how the discovery of antimicrobial agents had made it seem likely in the late 1940s and early 1950s

that hospital-acquired infections would fade in importance.⁷ However, the surge of staphylococcal infections that occurred throughout the world in the next decade proved that these infections remained important, and their occurrence gave impetus to renewed epidemiological and clinical research. Thus was spawned the First International Conference on Nosocomial Infections, held in Atlanta in 1970.⁸ In closing this conference, Sir Robert E O Williams reflected that 'one of the principal reasons that we have so often failed to persuade our colleagues in hospitals to do the antiseptic things that we think they ought to do, is that we have so rarely provided them with convincing evidence that if they do, their patients will get better more quickly or survive in significantly greater numbers', and he challenged his audience to evaluate scientifically the control measures that had been recommended to date.⁹ The 10 years following that first meeting in Atlanta showed that infection control as a discipline had grown rapidly, and indeed three new journals devoted to infection control made their appearance, including the *Journal of Hospital Infection*. Theodore Eickhoff, in the keynote address given to the Atlanta meeting in 1980 entitled 'Nosocomial infections – a 1980 view: Progress, priorities and prognosis', noted that progress had been made in a few efficiency studies, emphasised the determinative role of the host in infections, stressed the concept of immunoincompetence, emerging pathogens such as *Legionella pneumophila*, the epidemiology of antimicrobial drug resistance and the concept of chemoprophylaxis. Major advances had also been made in preventing a few specific nosocomial infections such as hepatitis B. The evolving roles of ICDs, ICNs and hospital epidemiologists had been consolidated.¹⁰ Major failures of the preceding decade (1970 - 1980) had included the continuing absence of an acceptable scientific basis for infection control, the lack of standards for such control and the consequent inability to carry out effective education.

First International Conference of the Hospital Infection Society, 1987

Seven years later, this time in London, UK, the First International Conference of the Hospital Infection Society was inaugurated.¹¹ In his opening address, Ian Phillips noted that one of the strongest characteristics of hospital infection was its continued evolution. 'Not only does the procession of pathogens continue to recruit and regroup, but also fresh opportunities for invasion arise regularly as medicine tackles ever more complex problems, coincidentally lowering the patient's barriers to infection'. The evolution of organisms involved in hospital infection has been extensively documented over the past years and there seems little reason to suppose that the variety of species and their susceptibility to antibiotics will not continue to expand and that the importance of individual species will wax and wane. In addition to the familiar, it seems entirely possible that there will be new pathogens awaiting discovery. The task of detecting these



organisms will fall to the microbiologists in diagnostic laboratories of all types and it is essential that this major role should be recognised.¹²

Second International Conference of the Hospital Infection Society, 1990

September 1990 saw the Second International Conference of the Hospital Infection Society.¹³ There was an emphasis on the price of hospital infection, including new strategies for antimicrobial use, disinfection and sterilisation of instruments contaminated with viruses, and the impact of molecular biology on hospital infections.

Third International Conference on Hospital Infection, 1994

The Third International Conference of the Hospital Infection Society was held in September of 1994.¹⁴ Again there was a resurfacing of a number of older problems. Resource utilisation and infection control topped the list, followed by advances in preventing implant infections, the challenge of setting and achieving standards in hospital infection control, and risk factors in surgical infection; viral hazards to and from health care workers, multiresistant mycobacterial infections and ventilator-associated pneumonia were important additional topics.

More recently, antibiotic-resistant pathogens not seen previously have emerged, particularly in the immunocompromised host. Some of these more important emerging pathogens have included *Enterococcus* species (especially *E. faecium*), *S. viridans*, resistant Gram-negative organisms (*Klebsiella* spp., *Citrobacter* spp., *Enterobacter* spp.), and resistant *Candida* species.

Fourth International Conference of the Hospital Infection Society, 1998

The Fourth International Conference of the Hospital Infection Society was held in Edinburgh in 1998.¹⁵ It was clear from this meeting that old topics had surfaced again but now with greater insight and better methods of diagnosis and control. Antibiotic resistance in Gram-positive organisms was a main theme of the meeting, with vancomycin resistance and MRSA isolates causing concern.

The difficulty of inactivating prions by both physical and chemical methods was highlighted in an important paper by D M Taylor.¹⁶

Indwelling devices and prostheses again received attention and the question of *S. epidermidis* (coagulase-negative staphylococci) and biofilm formation was discussed. Infectious diseases and litigation was an important topic, as was a paper concerning nosocomial infections in HIV-infected/AIDS patients.

Because fever and infection are so common during periods of chemotherapy-induced neutropenia in cancer patients, antimicrobial prophylaxis has become a common practice. Currently oral quinolones are used in many centres for this purpose. However, there are two significant problems with quinolone prophylaxis; the first is the limitation of coverage of these agents that excludes most Gram-positive bacteria (some of the newer agents have better cover), and the second is the emergence of resistance in susceptible bacteria.

Viridans streptococci and resistance to quinolones

Among those bacteria that are not inhibited by quinolones are viridans streptococci. In the past these have seldom caused serious infections in neutropenic patients and have responded to a variety of antibacterial regimens, but in recent years they have emerged as a cause of significant infections. The routine administration of antacids or H₂-antagonists may be another important risk factor. Several studies have demonstrated that the concentration of organisms recovered from the stomach increases with increasing pH, and Gram-positive bacteria are predominant among them. These serious viridans streptococcal infections are of special concern because they may cause renal failure or acute respiratory distress syndrome resulting in the death of the patient, after the acute infection appears to have been controlled.

Although the majority of infections diagnosed are cases of bacteraemia, some patients develop serious infections such as pneumonia, skin, and urinary tract infections. Leukaemia patients appear to be at special risk of infection.

Emergence of 'new' Gram-positive bacteria

Over the past 14 years several Gram-positive bacteria have emerged as pathogens in immunocompromised hosts, and especially among neutropenic patients. Among these are *Corynebacterium jeikeium*, *Bacillus cereus*, *S. hemolyticus* and *Leuconostoc* sp. These organisms typically have two factors in common. Most of the infections are associated with indwelling intravascular catheters and the organisms are resistant to β -lactam antibiotics. In some series, fatality rates have approached 50%. In general, the only antimicrobial agent consistently effective in eradicating these infections is vancomycin.

Fungal pathogens

For many years the most common fungal pathogens among immunocompromised hosts were *Candida* spp. and *Aspergillus* spp. Although several fungi have emerged as important pathogens in recent years, the most disturbing of these are *Fusarium* spp.



Candida spp. have emerged as a significant cause of infection in a variety of immunocompromised hosts, but especially among HIV-infected patients, leukaemic patients and organ-transplant recipients. Whereas HIV-infected patients tend to have only superficial infections, such as oropharyngitis, oesophagitis and vaginitis, their frequent recurrence can represent a major cause of discomfort and a difficult management problem. Leukaemia and transplant patients are more likely to develop fungaemias, major organ and disseminated infection, but are less likely to experience frequent recurrence of infection. Resistance to antifungal therapy has not presented a significant problem until recently. Of great concern is the problem of emergence of resistance to fluconazole in *C. albicans* and other generally susceptible species among the AIDS population.

Tuberculosis

For a number of years a progressive decrease was observed in the incidence of tuberculosis in the Western world, but that trend has changed. This is partly caused by the frequency of infection among AIDS patients, but more alarmingly because of the increase in multiple-drug-resistant strains of *Mycobacterium tuberculosis*. There is great concern regarding the potential for spread of these resistant strains not only to other immunocompromised hosts but also to health care workers and the general population. Because of the increasing prevalence of multiple-drug-resistant strains and their role in immunocompromised hosts, there is a desperate need for new antituberculosis agents. The recent emergence of extremely drug-resistant tuberculosis (XDR-TB) is of great concern and highlights the problem of ineffective treatment.

The emergence of resistant organisms as a cause of serious infection in the immunocompromised host requires a re-examination of our infection control practices. Possibly air delivery systems must be installed to control spread of an airborne pathogen such as *M. tuberculosis*. Antibiotic practices need to be re-examined to avoid excessive and inappropriate use of drugs, such as vancomycin, before widespread epidemics of untreatable infections occur. Health care personnel need to become compulsive about careful hand-washing procedures. Recent studies continue to reinforce previous evidence that compliance with hand-washing procedures is suboptimal.

Clostridium difficile and enterococcal bacteraemia

Recent publications, international reports and supplements to journals covering hospital-acquired infections have discussed and commented upon *Clostridium difficile*,¹⁷ glycopeptide-resistant enterococcal bacteraemia,¹⁸ and more recently guidelines for preventing health care-associated infections in NHS hospitals in the UK.¹⁹ These guidelines are of special

interest, covering as they do standard principles for preventing health care-associated infections in hospitals and other acute care settings, guidelines for preventing infections associated with the use of short-term urethral catheters, and guidelines for preventing infections associated with the use of central venous access devices. There have also been evidence-based guidelines for preventing health care-associated infections in primary and community care in England.²⁰

Sixth International Conference of the Hospital Infection Society, 2006

The Sixth International Conference of the Hospital Infection Society was recently held in Amsterdam in October 2006,²¹ and again, MRSA and all its ramifications held centre-stage.

This brief overview of the history of infection control draws attention to the many challenges that lie ahead. Although hospital infection control has been accepted in theory as an important and necessary discipline in most hospitals in the world, the practical application of the principles involved in such control is often conspicuous by its absence. There is need to convince the health authorities that money and time spent on the implementation of effective and efficient infection control programmes is money and time well spent.

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