King's Fund

# Briefing

JULY 2008

# Healthcare-associated infections

## STEMMING THE RISE OF THE 'SUPERBUG'?

Healthcare-associated infections are a major concern to patients and the public as a result of both high rates of infection across the National Health Service (NHS), and media coverage of outbreaks at individual hospitals. The government has put in place a range of policies designed to reduce healthcare-associated infections in NHS organisations in England (with a similar priority being given in Scotland and Wales). This briefing provides some background on the infections that give most concern, their causes, prevalence and impact. It also summarises the policies and strategies being deployed in England to reduce infections, and offers some analysis of their likely effectiveness.

### What are healthcare-associated infections?

Healthcare-associated infections are infections that are acquired in a hospital or other health care setting, such as a hospice or care home, or as a result of a health care intervention or procedure. For an infection to be 'healthcare-acquired', the patient must neither have had the infection, nor have been incubating the infection, prior to attending the health care setting – something that is often difficult to determine.

There are many different types of healthcare-associated infections. These include infections caused by methicillin-resistant *Staphylococcus aureus* (S aureus, MRSA) and *Clostridium difficile* (*C difficile*), as well as other less well-known infective agents such as:

- glycopeptide-resistant enterococci, which can cause blood poisoning;
- norovirus, which causes a relatively mild, short-lived gastroenteritis but spreads easily in hospitals and other institutional environments sometimes leading to ward closures;
- the various *Pseudomonas* species, which can cause a range of illnesses in those who are already very ill, but are not as easily spread as MRSA or *C difficile* (see: www.hpa.org.uk).

This briefing will focus on MRSA and *C difficile* because they are both relatively common, have had a big impact on patients and the NHS, and receive a lot of attention from the government and the media.

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Although not all healthcare-associated infections can be prevented, many can be. In 1995, the Department of Health estimated that approximately 30 per cent of healthcare-associated infections were avoidable (National Audit Office 2000), but this is now thought to be a conservative estimate, and some of the targets for reducing infection are more ambitious than this. However, the extent to which infections are preventable at any one time depends on many factors. Different infections may require slightly different approaches: MRSA and *C difficile* are spread in different ways and cause different illnesses.

## What is MRSA?

*S aureus* is a common bacteria that can be carried harmlessly on human skin or mucosa (Health Protection Agency 2008b). MRSA is a variety of *S aureus* that is resistant to the antibiotic methicillin as well as some other antibiotics that are usually used to treat *S aureus*. This makes MRSA infections more difficult to treat, although they are not untreatable. Approximately 3 per cent of people are thought to be carriers of MRSA (10 per cent of those who carry *S aureus*) (Department of Health 2007a).

*S aureus*, including MRSA, will not normally cause infection unless it enters the body or bloodstream, for example via a cut or a catheter. People with weakened immune systems, the very old or young, and those who are ill are more susceptible to such infections.

MRSA can cause a range of infections including of the skin, lungs and bloodstream (this latter is also known as bacteraemia). In a health care setting, MRSA can enter the body or bloodstream in a variety of ways, such as:

- during surgery
- via wounds or ulcers
- via intravenous lines, catheters or breathing tubes.

MRSA bacteraemia can cause deep abscesses (when MRSA lodges in a particular part of the body, such as lungs or kidneys) or septicaemia, a serious and potentially fatal form of blood poisoning, although MRSA fatalities are 'the exception rather than the rule' (MRSA Working Group 2008). MRSA bacteraemias are much more likely to affect the elderly than younger, healthier individuals, and are usually associated with bloodstream infections.

## What is *C difficile*?

*C difficile* is a bacterium that is found naturally in the gut of 3 per cent of adults and up to two-thirds of babies (Health Protection Agency 2008a). It is usually harmless in healthy people. However, when the balance of bacteria in the gut has been affected by antibiotics, surgery, chemotherapy or other illnesses, *C difficile* bacteria can multiply, producing toxins that can cause symptoms such as diarrhoea and inflammation of the bowel. In its more severe form, *C difficile* can cause colitis (ulceration and bleeding of the colon) or, very rarely, perforation of the intestine, which can be fatal (Department of Health 2007b). As most *C difficile*-associated disease (the range of illnesses caused by *C difficile*) is strongly associated with the use of antibiotics, it tends to occur in health care settings. Older people and those with existing illnesses are most at risk of *C difficile*-associated disease.

*C difficile* is highly infectious. Bacteria can be transferred from person to person directly (such as from the patient to the health care professional), or indirectly via an environmental surface by spores shed in the faeces of those who are ill. These spores are very 'hardy' and can survive for long periods in the environment on surfaces such as toilets, sheets or floors. Infection can occur when these spores are ingested.

There has been a recent emergence of what is thought to be a 'hypervirulent' (highly infectious and capable of causing serious illness) strain of *C difficile* (type 027), with outbreaks occurring in Stoke Mandeville in 2003 and 2005.

## How are healthcare-associated infections measured?

There are two main sources of data that are readily available and, although not fully comprehensive, help provide a picture of the extent of healthcare-associated infections: surveillance data and data on deaths, collated by the Health Protection Agency and the Office for National Statistics, respectively.

### SURVEILLANCE DATA

Currently, surveillance data for healthcare-associated infections is based on information from NHS acute trusts in England on the number of laboratory confirmed cases of a particular infection in a given period of time. In each case, a clinician must have diagnosed or suspected an infection, taken a sample and had the diagnosis confirmed by a laboratory. Surveillance data is unlikely to be entirely complete because not every infection will be detected. In some cases a diagnosis may not take place, perhaps because the symptoms are not clear or the patient leaves hospital or dies before they emerge, and/or a sample might not have been taken. The level of detection will depend on many factors including professionals' knowledge of the infection and testing protocols and procedures, and may vary from individual trust to trust.

Although cases of healthcare-associated infections might be missed in hospital, they are probably more likely to be missed in the community where surveillance is less well established and there can be fewer opportunities to diagnose and confirm an infection. Indeed, although community-acquired infections are reported via laboratories, which tend to be housed in acute trusts, the attention to date has been very much on *hospital*-acquired infections. However, there has been a growing awareness of the importance of tackling community-acquired infections as many services are now delivered outside hospitals, and certain groups, particularly residents of care/nursing homes, are particularly vulnerable to such infections. In addition, the pressure put on acute trusts to reduce their infection rates means that they have an interest in differentiating between infections their patients arrive with and those they contract, or develop from previous carriage, in the hospital. Getting to grips with community-acquired infections will require better surveillance of infections acquired in non-hospital settings.

Despite some limitations, surveillance data is crucial to both the government and the NHS: it allows the success or failure of infection control policies to be determined, and at the individual trust level it provides information to help tackle the spread of infection (a good surveillance system is an essential component of any infection-control strategy). The government believes that its surveillance system for *hospital*-acquired infections in England and Wales is one of the best (ie, systematic, reliable and timely) in the world, particularly as reporting is mandatory (Department of Health 2008).

With respect to the two infections covered in this briefing, the Health Protection Agency publishes data from acute trusts on the number of cases of *C difficile*-associated disease among patients aged 65 years and over and, more recently, those aged 2 years and above, MRSA bloodstream infections (bacteraemia), and surgical site infections in orthopaedic

surgery. It is now mandatory for acute NHS trusts to report all laboratory-confirmed cases of these infections to the Health Protection Agency.

### DATA ON DEATHS

Information from death certificates is also useful for monitoring the impact of healthcare-associated infections. Death certificates can include a main cause of death as well as conditions or infections that have contributed to the death. As many people who die with a healthcare-associated infection are already ill, it is often their existing illness that is the underlying cause of death, but the healthcare-associated infection may be listed as a contributory cause.

However, data from death certificates may not reflect the true impact of these infections. Although it is likely that the detection and reporting of healthcare-associated infections has improved over time (as a result of increased awareness in trusts, better laboratory techniques, pressure from the public, and closer scrutiny of NHS organisations), it is widely believed that healthcare-associated infections are often omitted from death certificates. In 2005 and 2007, the Chief Medical Officer reminded doctors to record healthcare-associated infections on death certificates when appropriate (Chief Medical Officer 2005, 2007).

Poor recording was also highlighted in the recent investigation into the *C difficile* outbreaks at Maidstone and Tunbridge Wells NHS Trust, where the trust's own review of death certificates failed to identify any deaths due to the infection (Healthcare Commission 2007a).

In addition, a recent study of deaths following MRSA infection found that among cases identified on the basis of MRSA bloodstream infections, 'MRSA was not mentioned on less than half of the death certificates when it was considered to be the main or contributory cause of death' (Health Protection Agency 2007a).

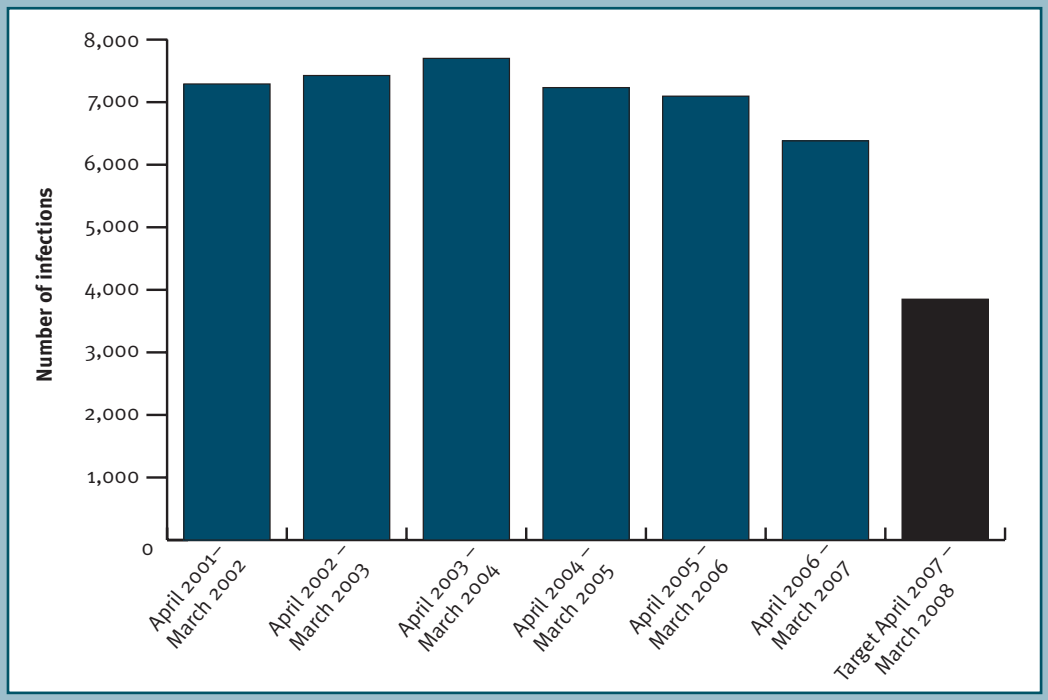
## What is the extent of MRSA?

### MRSA BLOODSTREAM INFECTIONS

Acute trusts have been reporting all *S aureus* (including MRSA) bloodstream infections (bacteraemia) on a voluntary basis to the Health Protection Agency since 1990. This data shows that, during the 1990s, while the number of *S aureus* infections in total rose, bloodstream infections caused specifically by MRSA increased dramatically: from fewer than 100 in 1990, to more than 5,000 in 2001 (Health Protection Agency, 2007c). The proportion of all *S aureus* bloodstream infections that were methicillin-resistant increased significantly, from fewer than 5 per cent in 1990 to more than 40 per cent in 2001. Although part of the increase was probably the result of better identification and reporting, it was clear that MRSA was becoming a significant problem in hospitals.

Concern about this rise led to the introduction of a mandatory system of reporting in 2001. Since then, more than 7,000 MRSA bloodstream infections have been reported annually until the most recent completed financial year, 2006/7, when 6,381 were recorded (Figure 1). This represented a fall of 10 per cent on the previous year, or 17 per cent from 2003/4 when MRSA numbers peaked at 7,700. Data for April 2007 to March 2008 is not yet available.

1 FIGURE 1: ANNUAL MRSA BLOODSTREAM INFECTIONS IN ENGLAND, 2001–08



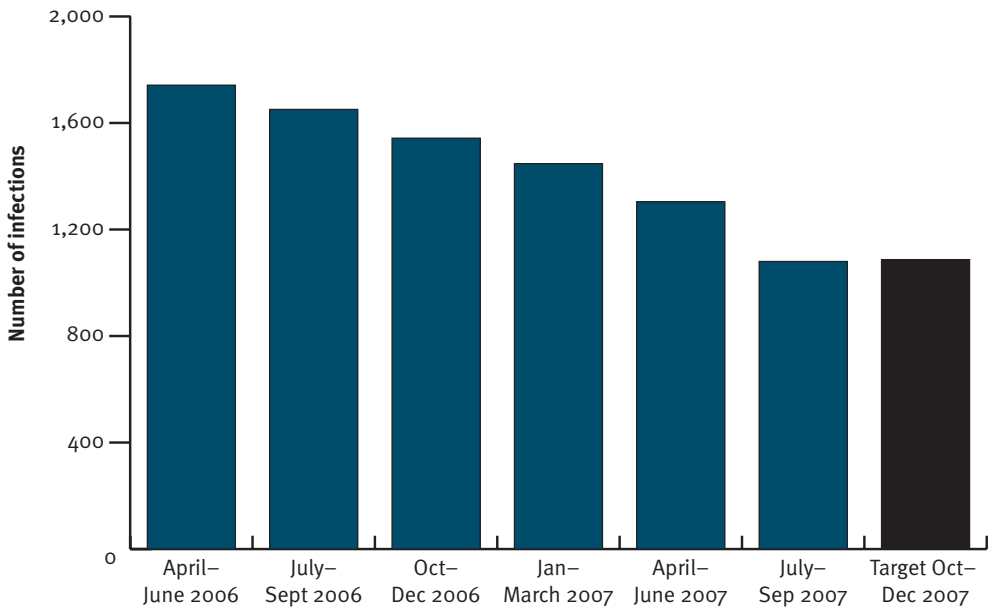

Source: King's Fund analysis of data from the Health Protection Agency (www.hpa.org.uk/web/HPAweb&Page&HPAwebAutoListName/Page/1191942126541)

In 2006, quarterly reporting of MRSA bloodstream infections began. Between April 2006 and September 2007, the data shows a continuous quarter-on-quarter decline (from 1,741 cases to 1,080) (Figure 2). The quarter-on-quarter reductions also appear to accelerate during this period: for example, infections fell 10 per cent between the last quarter of 2006/7 and the first quarter of 2007/8, then 18 per cent between the first and second quarters in 2007/8.

Progress was such that in its 2007 report on the surveillance of healthcare-associated infections, the Health Protection Agency concluded that MRSA bacteraemia was on 'a downward trend', heralding 'a real change' (Health Protection Agency 2007b).

However, data for the most recent quarter (October–December 2007) showed no decline – indeed an increase of 0.6 per cent – on the previous quarter. It is not possible to say whether this levelling off represents a new trend, or whether the steady decline seen earlier in 2007 will continue into 2008.

2 FIGURE 2: QUARTERLY MRSA BLOODSTREAM INFECTIONS IN ENGLAND, 2006–08




Source: King's Fund analysis of data from the Health Protection Agency (www.hpa.org.uk/web/HPAweb&Page&HPAwebAutoListName/Page/1191942126541)

## WILL THE GOVERNMENT MEET ITS MRSA BLOODSTREAM INFECTION TARGET?

In 2004, the government introduced a national target to halve the number of MRSA bloodstream infections by March 2008 from a 2003/4 baseline (Department of Health 2004a).

Although the details of how achievement against this target would be measured were not described at the time, it might reasonably have been concluded that the government would consider it had met its target if there were half the number of MRSA bacteraemia infections in 2007/8 compared with 2003/4. As there were 7,700 cases in 2003/4, a total of 3,850 or fewer cases of MRSA would need to be reported in 2007/8 to meet the target (as represented by the black bar in Figure 1). This, in turn, would require a 40 per cent reduction on the figure for 2006/7 – a significant challenge considering the level of annual reduction achieved so far. Furthermore, the data from the first nine months of 2007/8 suggests it will be near impossible to achieve a figure of 3,850 for the full year as 3,471 infections were recorded in the first three quarters.

However, although quarterly data was not available at the time the target was set, the government has since decided to define success in terms of *quarterly* rather than *annual* data. In essence, it decided to take the annual figure for 2003/4 (7,700), divide it by four to get a quarterly average (1,925) and then set the target at half this (963) for the selected quarter. This is represented by the black bar in Figure 2.

The Department of Health says the target will have been met if the figure for the April–June quarter of 2008 (ie, the first quarter of 2008/9) is 963 or lower (BBC 2008a). (Note, due to the time lag in the availability of data, it is likely that this information will not be available until

November 2008.) When calculated in this way, the target appears within reach if the levelling off seen in the most recent quarter proves to be an anomaly and the steady decline seen earlier continues. In October–December 2007, 1,087 cases were reported, so to achieve 963 would require an 11 per cent reduction over a six-month period.

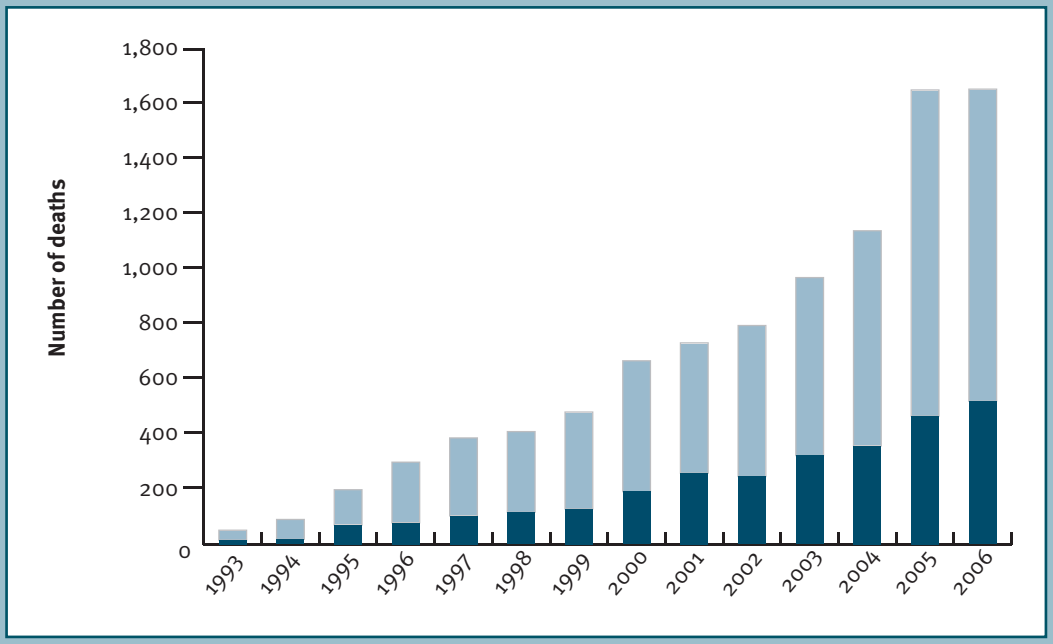
Clearly, as well as giving more time, this quarterly target allows the impact of policy initiatives introduced in 2007/8 to be felt (a number of policies was introduced during the past year, particularly since October 2007 when the outbreak of *C difficile* in Kent was reported, see below).

The issue of whether the statement 'by March 2008' implies that this should be achieved in the last quarter of 2007/8 or the first quarter of 2008/9 is debatable, although the government has interpreted it to be the latter. What is clear, however, is that halving the rate has been seen as an ambitious (and at times unrealistic) target, which, since it was announced, has maintained the pressure on the NHS, particularly on acute trusts, to deliver reductions in MRSA infections (*The Independent* 2007).

## DEATHS FROM MRSA

Data from the Office for National Statistics shows a dramatic rise in the number of deaths involving MRSA between 1993 and 2005 in England and Wales (Office for National Statistics 2008). In 1993, 51 death certificates mentioned MRSA, compared with 1,629 in 2005 (Figure 3). The number of deaths in which MRSA was a factor rose 39 per cent from 2004 to 2005. However, in 2006, deaths from MRSA stabilised at 1,652. MRSA was mentioned on 1 in every 500 death certificates over the period 2001–5.

3 FIGURE 3: MRSA DEATHS IN ENGLAND AND WALES, 1993–2006




Source: Office for National Statistics 2008 (www.statistics.gov.uk/StatBase/Product.asp?vlnk=13571)

As mentioned above, although it is likely that the identification of MRSA deaths has improved over time as awareness grew during the 1990s (ascertainment will account for some of the dramatic increase), the number of deaths in which MRSA is cited as a factor may still be an underestimate. This means that there may be a lag between infection rates going down, and deaths from MRSA declining. However, the number of deaths from MRSA will continue to be related to the type of patients contracting the infection – MRSA is more likely to kill the elderly and vulnerable and those with pre-existing conditions. Thus, if the 'case mix' changes, more deaths might occur, even if the rates of infection remain the same or fall.

## What is the extent of *C difficile*?

### *C DIFFICILE* INFECTIONS

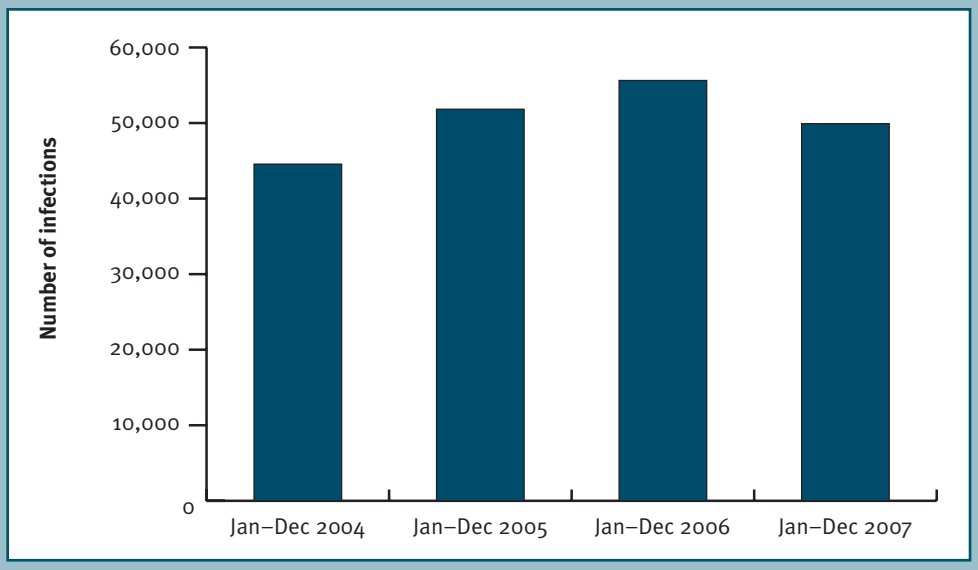
Mandatory reporting of *C difficile* by NHS acute trusts has been in place only since January 2004, despite a voluntary surveillance system showing annual increases in the infection since the 1990s. Initially, trusts were required to report cases of *C difficile* only in those aged 65 years and older (the population at most significant risk), but in April 2007 this was changed to include infections in all patients aged 2 years and older.

In addition, a number of other changes to the surveillance system were introduced, including allowing more than one instance of the infection to be recorded for a single patient in any one admission so long as the infections are more than 28 days apart (Chief Medical Officer 2008).

Trusts are currently in the process of validating their data from April 2007 against these new criteria, which means data should currently be interpreted with 'extreme caution' as it might be subject to change (Health Protection Agency 2008c).

In 2007, nearly 50,000 cases of *C difficile* were reported in acute trusts in patients aged 65 years and over – 11 times the number of MRSA bloodstream infections. Between 2004 and 2006, cases of *C difficile* rose steadily from 44,563 to 55,634 (Figure 4). Although the data for

4 FIGURE 4: ANNUAL *C DIFFICILE* INFECTIONS IN PATIENTS AGED 65+ IN ENGLAND, 2004–07

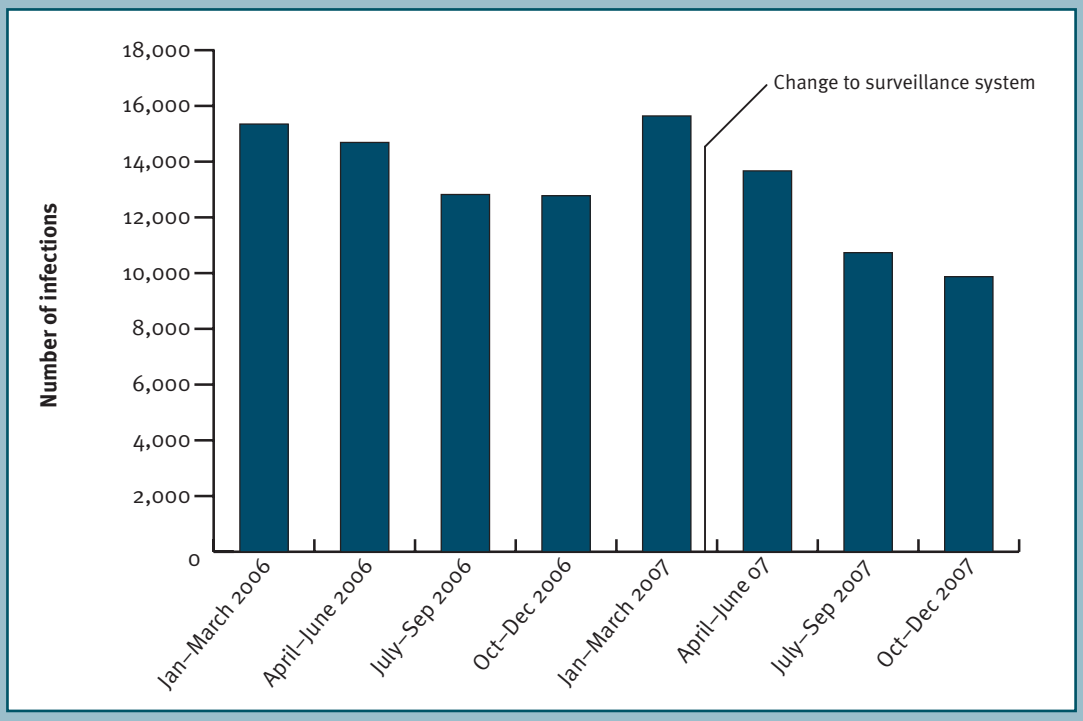



Source: King's Fund analysis of data from the Health Protection Agency (www.hpa.org.uk/web/HPAweb&Page&HPAwebAutoListName/Page/1191942126541)

2007 seems to suggest that *C difficile* infections might now be decreasing, the changes to the surveillance system mean that comparisons of figures pre- and post-2007 are problematic.

Since January 2006, trusts have been reporting *C difficile* on a quarterly basis. As *C difficile* infections show seasonal variations, it is not appropriate to compare consecutive quarters but rather equivalent quarters in different years. A comparison of the last three quarters in 2007 with the equivalent quarters in 2006 appears to show increasing reductions in *C difficile* infections. For example, the most recent quarterly data (October–December 2007) showed a 23 per cent decrease over the same period in 2006, compared with July–September 2007 versus July–September 2006, which saw a 16 per cent reduction (Figure 5). However, once again these comparisons are problematic because of the changes to the surveillance system. It is therefore hard to say at this point whether the tide has turned on *C difficile* infections.

5 FIGURE 5: QUARTERLY *C DIFFICILE* INFECTIONS IN PATIENTS AGED 65+ IN ENGLAND, 2006–07




Source: King's Fund analysis of data from Health Protection Agency (www.hpa.org.uk/web/HPAweb&Page&HPAwebAutoListName/Page/1191942126541)

In 2007, a target relating to *C difficile* was introduced to reduce the number of *C difficile* infections by 30 per cent by March 2011 from a baseline of 2007/8 (Department of Health 2007d). However, it is as yet unclear exactly how the target will be measured, for example, using quarterly or annual data.

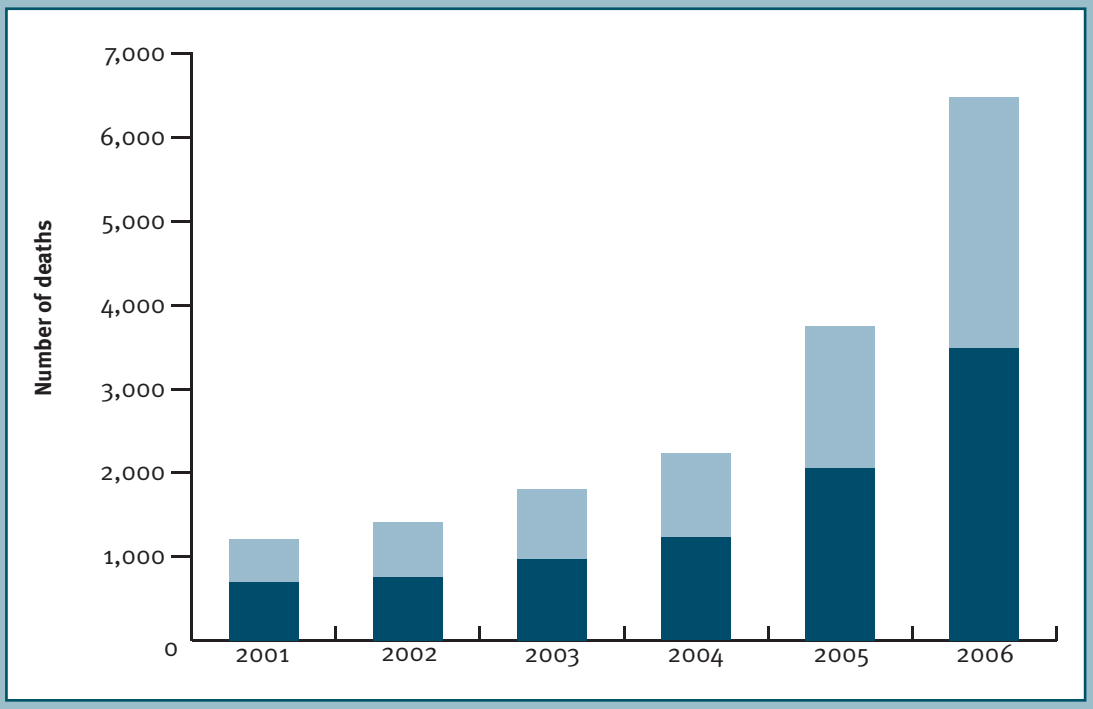
## DEATHS FROM *C DIFFICILE*

In England and Wales in 2006, 6,480 death certificates mentioned *C difficile*, an increase of 434 per cent from 2001 and a 72 per cent increase from 2005 (Figure 6, Office for National Statistics 2008). *C difficile* was mentioned on 1 in every 250 death certificates over the period

2001–5, twice as many as mentioned MRSA. The death rate from *C difficile* has been described as fast approaching that for road traffic accidents (Starr 2007).

As with MRSA, the number of deaths recorded as associated with *C difficile* may still be an underestimate given the evidence of poor recording of healthcare-associated infection on death certificates. However, the increase in deaths observed is likely to be the result of increased ascertainment (better recording) as well as increased infection rates. A change in the case mix (who gets the infection) can also affect death rates, as the more vulnerable and elderly are more likely to die from the infection.

6 FIGURE 6: DEATHS FROM *C DIFFICILE* IN ENGLAND AND WALES, 2001–06




Source: Office for National Statistics 2008 (www.statistics.gov.uk/StatBase/Product.asp?vlnk=14782)

## How does the United Kingdom compare with other European countries?

Although cross-national comparisons have to be treated with caution as different countries have different surveillance systems, it is still useful to get a sense of how the United Kingdom fares in terms of the burden of MRSA compared with other European countries.

Despite the fact that the MRSA rate appears to be declining nationally, data from the European Antimicrobial Resistance Surveillance System (EARSS) shows that the United Kingdom still has one of the highest recorded rates in Europe (EARSS 2007). According to the EARSS report, the burden of MRSA is highest in Portugal, Ireland, Italy and the United Kingdom (Table 1).

Countries with low rates of MRSA include the Scandinavian countries and The Netherlands. Germany also has a relatively low incidence of MRSA. Although the explanations for country

variations in MRSA rates are complex and partly historical, on the whole, those that tend to use 'aggressive search and destroy strategies', such as Sweden and The Netherlands, tend to have lower rates (Grundmann *et al* 2006). This approach involves systematically screening patients (and often staff) for MRSA, and isolating and decolonising those found to be infected or colonised – a strategy the Department of Health has now decided to adopt in the United Kingdom, although excluding staff screening (see below).

TABLE 1: INCIDENCE OF MRSA BACTERAEMIAS PER 10,000 PATIENT DAYS BY SELECTED COUNTRY 2006

| Higher rate countries | Rate/10,000 (95% confidence interval) | Lower rate countries | Rate/10,000 (95% confidence interval) |
|---|---|---|---|
| Portugal | 2.69 (2.54–2.84) | Denmark | 0.02 (0.01–0.05) |
| Ireland | 1.46 (1.37–1.55) | Sweden | 0.03 (0.02–0.05) |
| Italy | 1.41 (1.27–1.57) | Netherlands | 0.05 (0.03–0.08) |
| United Kingdom | 1.25 (1.16–1.34) | Germany | 0.11 (0.08–0.16) |

Source: EARSS 2007; data converted from rates per 100,000 to rates per 10,000 and some countries omitted (see p 43 of report, available at: www.rivm.nl/earss/Images/EARSS%202006%20Def_tcm61-44176.pdf)

Data for international comparisons of rates of *C difficile* are not readily available. However, *C difficile*-associated disease appears to be increasing in a number of Western countries, including the United States, and outbreaks of the more virulent strain (type 027) have affected the United States, Canada, The Netherlands, Belgium and France, as well as England (Kuijper *et al* 2007).

## What type of people get infected and where?

### MRSA

Although some patients enter hospital with MRSA ('community-acquired' cases), the majority (65 per cent) of bloodstream infections are detected two or more days after admission, suggesting they were acquired in hospital (Health Protection Agency 2007b). However, the likelihood that a patient will contract MRSA in any given hospital varies according to a range of characteristics relating to the types of patients the hospital sees, their illnesses, the type of hospital, and the way it is managed and delivers its services.

The 2007 Health Protection Agency report on the surveillance of healthcare-associated infection presents data on MRSA bloodstream infections by sex and age of patient, and region and type of trust, among other factors (Health Protection Agency 2007b). More men than women contract MRSA (it is not fully understood why), and most cases (69 per cent) occur among those aged 65 years or older (elderly patients tend to be sicker and more prone to infection).

Correspondingly, a Department of Health report that analyses variation in MRSA rates found that trusts with a higher share of male patients, and those with a higher average age of admission, have higher MRSA rates (Department of Health 2007c).

London has the largest number of MRSA cases (partly due to its size), but has also seen the largest reduction in cases recently (Health Protection Agency 2007b). The higher rate of MRSA in London could be due to the types of hospital in the capital (eg, more tertiary hospitals than elsewhere), the way they work (eg, higher levels of temporary nursing staff), or local population characteristics (Department of Health 2007c). However, the Department of Health found that even when these other factors are taken into account, trusts in London have historically relatively higher rates of MRSA.

Acute teaching trusts have tended to have higher rates of MRSA bacteraemia than small, medium or large non-teaching acute trusts (teaching hospitals see more complex patients), but have also seen the biggest decrease in infection rates (Health Protection Agency 2007b). The Department of Health analysis found that, other things being equal, specialist trusts had MRSA rates, on average, 28 per cent higher during the period 2001–4, and 12 per cent higher between 2005 and 2007 (Department of Health 2007c).

Single specialty trusts usually have low MRSA rates, probably because they see less complex cases (in terms of the patients not having a multiplicity of different problems), have fewer emergency admissions, and do less invasive procedures. This was also borne out in the Department of Health analysis.

### *C DIFFICILE*

The significant majority (84 per cent) of cases of *C difficile*-associated disease occur in patients aged 65 years and over (Health Protection Agency 2007b). Among the elderly, there are more cases of *C difficile* infection in women than in men, possibly reflecting the fact that there are more older women than men in the population. Small acute trusts had the highest rate of *C difficile*-associated disease and acute specialist trusts the lowest.

## INFECTIONS AT THE TRUST LEVEL

*C difficile*-associated disease and MRSA bloodstream infection figures are available only for individual NHS trusts (not individual hospitals). However, the Health Protection Agency warns against comparing infection rates by trust as a way of assessing the clinical service they provide for a number of reasons (Health Protection Agency 2007b).

First, different rates of infection may reflect differences in 'case mix', meaning the range of diagnostic and/or treatment categories dealt with by a trust. For example, if a trust tends to treat more complex cases (as teaching hospitals do), it will have a higher proportion of vulnerable and more seriously ill patients who are both more prone to infection and more likely to be receiving invasive and high risk care.

Second, certain clinical conditions make MRSA bloodstream infections or *C difficile*-associated disease difficult to treat, so a trust that has a case mix that includes many patients with such illnesses may have higher rates of infection.

Third, it is the trust laboratory in which positive specimens are processed that reports the cases, even though the infections might have been acquired elsewhere.

Since 2003, acute trusts have been required to achieve year-on-year reductions in MRSA rates. Specific targets have been dependent on the rate level at which they started, although most trusts have been required to aim higher than the national target and achieve a 60 per

cent reduction by 2008 (from a 2003/4 baseline). This is to compensate for the smaller reductions achievable by trusts that had low rates to start with. The majority of acute trusts – 107 out of 171 (63 per cent) – have managed to reduce or maintain their rate of MRSA bloodstream infection since 2003/4. Thus, in quite a substantial minority (37 per cent) of NHS acute trusts, MRSA rates have actually gone up since the target was set.

## What are the costs of healthcare-associated infections?

These infections impose costs not only on patients, their carers and relatives, but also on the health care system as a whole (primary and community services are often involved in treating former hospital inpatients with healthcare-associated infections) and the broader economy, as patients and carers are unable to return to work.

A study funded by the Department of Health estimated that healthcare-associated infections cost the health sector in England almost £1 billion a year, with patients remaining in hospital an extra 3.6 million days (Plowman *et al* 1999). According to this analysis, patients who contracts a healthcare-associated infection stay in hospital an average of 2.5 times longer than patients who do not, increasing their time in hospital by 11 days. The cost of treating a patient with a healthcare-associated infection is 2.8 times more than treating a patient without one, imposing an average additional cost of £3,154.

Patients with a healthcare-associated infection identified in hospital and post-discharge take an average of 17 extra days to return to normal daily activities. At the national level, this amounts to 8.7 million additional days. In addition, patients with a healthcare-associated infection identified in hospital and post-discharge take an average of six extra days to return to work, which constitutes an average cost of £800 per patient.

A more recent review concludes that the costs of healthcare-associated infections have been underestimated and that MRSA alone results in an annual loss to the UK economy of £3–11 billion (Gould 2006). Gould argues that there is a large body of evidence that suggests that controlling healthcare-associated infections is highly cost-effective. Although the Department of Health study was not directly concerned with estimating the benefits of prevention, it calculated that a 10 per cent reduction in the rate of healthcare-associated infections would result in savings of approximately £93 million, releasing 364,000 bed days, or the equivalent of nearly 48,000 finished consultant episodes (Plowman *et al* 1999).

## Media coverage and public concerns

There is extensive coverage of healthcare-associated infections in the media. Indeed, as one BBC reporter recently stated, 'There is probably no subject in health that has dominated the headlines as much as hospital infections' (BBC 2008b).

Evidence from public opinion polls and surveys also suggests that the public is worried about healthcare-associated infections or poor cleanliness, which are often equated. For example, almost 60 per cent of adults in an Ipsos MORI poll in 2005 cited 'cleanliness of hospitals/MRSA' as one of the most important health issues for the government (Ipsos MORI 2005).

## What is the government doing to tackle healthcare-associated infections?

The government has sought to encourage trusts to tackle infection control through a range of mechanisms, including providing advice and guidance, and introducing a legal framework, regular assessments and targets, as well as financial sanctions and incentives. The government also seeks to raise awareness and understanding of hospital infections among the public through a new national campaign (Department of Health 2008).

### POLICES, STRATEGIES AND GUIDELINES

In 2002, the Chief Medical Officer's report on infectious disease strategy, *Getting Ahead of the Curve* (Department of Health 2002), identified the need for better control measures for healthcare-associated infections. Since then, healthcare-associated infections have steadily moved up the government agenda until tackling MRSA and *C difficile* became one of the top priorities for the NHS in 2007/8, and then again in 2008/9 along with hospital cleanliness (Department of Health 2007d).

Since 2002, the Department of Health has published a swathe of policies, strategies and action plans designed to help trusts reduce rates of MRSA and other healthcare-associated infections, including:

- *Winning Ways*: *Working Together To Reduce Healthcare Associated Infection In England* (Department of Health 2003). This provided the initial direction for the NHS to reduce infection and antibiotic resistance.
- *Towards Cleaner Hospitals and Lower Rates of Infection: A Summary of Action* (Department of Health 2004b). This was an action plan for cleaner hospitals.
- *Saving Lives: A Delivery Programme to Reduce Healthcare Associated Infection Including MRSA* (Department of Health 2005), superseded by *Saving Lives: Reducing Infection, Delivering Clean and Safe Care* (2007e). This was a delivery programme to reduce healthcare-associated infection, including MRSA, that was supported by a range of learning resources, self-assessment tools and details of high impact interventions.
- *Essential Steps to Safe, Clean Care: Reducing Healthcare-Associated Infection* (Department of Health 2006a). This was a delivery programme to reduce healthcare-associated infection in health settings outside hospitals.
- *Clean, Safe Care: Reducing Infections and Saving Lives* (Department of Health 2008). The most recent infection control strategy, this outlines plans to introduce MRSA screening, deep cleaning and additional specialist staff to tackle infections.

National guidelines providing the evidence base for the prevention and control of healthcare-associated infections in general and MRSA in particular have also been produced (Coia *et al* 2006, Pratt *et al* 2007).

### REGULATION AND INSPECTION

In addition, in 2006, a Health Care Act required NHS trusts to follow recommendations and guidance relating to the prevention and control of healthcare-associated infections.

As part of its 'annual health check', the Healthcare Commission, the independent inspection

body for the NHS, assesses whether trusts are abiding by the2006 Act and protecting patients from healthcare-associated infections. A failure to follow the Act could result in an 'improvement notice' being issued or a trust being reported for significant failings and placed on 'special measures'.

The 2006/7 annual health check found the three standards relating to the hygiene code were included in the list of standards with the lowest compliance levels nationally across all NHS trusts (Healthcare Commission 2007b). In addition, the overall level of compliance for the three standards was lower in 2006/7 than in the previous year.

The Healthcare Commission also has responsibility for conducting investigations into serious NHS failures, and has completed two concerning infection control, both in relation to outbreaks of *C difficile*: one at Stoke Mandeville Hospital (Healthcare Commission 2006), the other at Maidstone and Tunbridge Wells NHS Trust (Healthcare Commission 2007a). The latter investigation estimated that 90 people had probably died as a result of the outbreaks, and highlighted significant failings in infection control as well as in patient care. However, despite the earlier failings identified, the trust had declared itself compliant on all standards relating to the hygiene code in its most recent annual health check. (This was qualified and down-rated by the Healthcare Commission.)

### TARGETS, FINANCIAL PENALTIES AND INCENTIVES

The government has also sought to control HCAIs by setting targets. On a national level, as mentioned above, in 2004 the government set a target to halve MRSA bacteraemia rates by March 2008 against a baseline of 2003/4. In 2007, the government announced a target relating to *C difficile*, which was to reduce the number of *C difficile* infections by 30 per cent by March 2011 from a baseline of 2007/8 (Department of Health 2007d).

The Healthcare Commission's annual health check assesses the extent to which individual trusts are meeting their MRSA targets. In 2006/7 the organisation found that trusts were making slower progress than planned: 44 per cent of acute and specialist trusts had achieved their planned reduction, compared with 53 per cent in 2005/6 (Healthcare Commission 2007b). In 2007/8 the annual health check will include surveillance of *C difficile* as well as MRSA.

The new *C difficile* target is backed up by a 'contract sanction' leading to a financial penalty, which can be imposed by a commissioner (eg, a primary care trust) if a trust breaches its target. Although other potential financial sanctions have been discussed, to date, beyond payouts in compensation claims (which are still relatively rare), this is the only financial sanction in place and it is yet to be used. Instead, the government has sought to highlight the gains trusts can make by reducing infection rates. For example, the Department of Health has provided trusts with a spreadsheet that allows gains to be calculated (Department of Health 2006b). In addition, foundation trust status is in part dependent on infection rates (Department of Health 2008).

## What evidence is there about which strategies are effective?

### HOSPITAL ENVIRONMENTAL HYGIENE/CLEANING

Despite the fact that research has found micro-organisms responsible for healthcare-associated infections such as MRSA in the hospital environment on, for example, taps and doors, the evidence that contamination of the environment is actually responsible for the transmission of healthcare-associated infections is not conclusive (Pratt *et al* 2007).

Recent analysis by the Department of Health of data for all acute trusts in England also failed to find a clear link between the hospital environment and healthcare-associated infection. Although

hospital cleanliness ratings (as measured by Patient Environmental Action Team [PEAT] scores) appeared to correlate with MRSA rates initially (data from 2001–4), the relationship was not evident when more recent years were analysed (2004–7) (Department of Health 2007c). It was hypothesised that this changing relationship might have been due to the introduction of new policies to combat healthcare-associated infections, particularly the 'clean**your**hands campaign', which might have lessoned the likelihood that micro-organisms could be transferred from the physical environment to patients. In addition, it may be that measures of environmental cleanliness – usually based on the visibility of dirt – might not reflect microbiological hygiene (Dancer 2008).

It is clear that the simple and direct association so often implied in the media between the physical, visible cleanliness of a hospital and its infection rates is not supported by the available research. That is not to say that hospital cleanliness has no bearing on healthcare-associated infection – clearly bacteria and viruses in the physical environment can in principle be transferred to patients – but other factors, such as effective hand hygiene, may be able to mitigate poorer standards in environmental cleanliness.

Also, as emphasised in the government's most recent strategy on healthcare-associated infection, hospital cleanliness is important in its own right, both as a 'backdrop' from which to tackle infections and in order to instil confidence in staff and the public (Department of Health 2008).

In addition, cleaning is thought to play a role in outbreak control, although different methods are recommended for different types of outbreak, eg, norovirus or *C difficile*. For these reasons, hospital cleanliness has been a central part of the guidance on reducing healthcare-associated infection as well as being a key criterion on which acute trusts are assessed by the Healthcare Commission.

The Department of Health's own analysis also appears to dispel the suggestion that MRSA rates are related to the contracting out of cleaning services (another theory that has also been widespread in the media) (Department of Health 2007c). Over the five-year analysis period, the relationship between contracting out and MRSA was initially negatively associated (trusts that contracted out had *lower* rates), and then not associated. Expenditure on cleaning also did not appear to be related to MRSA rates in more recent years.

Furthermore, there is little scientific evidence that 'deep cleaning' is an effective strategy for reducing healthcare-associated infection, despite the government's recent introduction of this policy (Dancer 2008). Although popular with the public, this initiative in itself seems unlikely to deliver reductions in infection rates (BBC 2008b). Questions also remain around how often a deep clean is required, as well as the practicalities around closing wards while such cleaning is conducted.

## HAND HYGIENE

The evidence suggests that 'hand-mediated cross-transmission is a major contributing factor in the current infection threats to hospital in-patients' (Pratt *et al* 2001, cited in Pratt *et al* 2007). Effective hand hygiene can reduce infection rates of most healthcare-associated infections in all health care settings, sometimes by 50 per cent or more (Larson and Kretzer 1995). Indeed, hand hygiene has been described as the 'single most important measure for controlling the transmission of infection in health care settings' (Pratt 2005).

Evidence-based guidance supports hand decontamination before and after any direct patient contact. The effectiveness of different methods of hand decontamination – alcohol gel or washing with soap and water – depends on the type of micro-organism and whether hands are visibly soiled. Alcohol gel is not effective against *C difficile* and will not remove dirt, and so it is recommended that hands be washed with soap and water in these circumstances (Pratt *et al* 2007).

The government introduced the 'clean**your**hands campaign' in September 2004, which promotes good hand hygiene in the NHS (www.npsa.nhs.uk/cleanyourhands). The campaign aims to be evidence-based, drawing on what is known about multifaceted approaches involving education, written materials and feedback, and ensuring alcohol gel is widely available close to patients (Naikoba and Hayward 2001). However, although the campaign has been found to be effective in changing many aspects of hand hygiene behaviour in acute settings, to date there is little direct evidence to show it has reduced healthcare-associated infection, although nationally MRSA rates have fallen since it was introduced (National Patient Safety Agency 2008).

## UNIFORMS AND WORKWEAR

Despite the fact that a Department of Health report found that 'there is no conclusive evidence that uniforms (or other work clothes) pose a significant hazard in terms of spreading infection' (Department of Health 2007g), the government recently implemented a 'bare-below-the-elbows' dress code for health care staff aimed at facilitating effective hand decontamination.

## SCREENING

Screening involves the identification of potential cases, or of key risk factors, in advance of the onset of symptoms. Screening is not effective for *C difficile* on the grounds that colonisation alone is not thought to increase the likelihood of spreading the infection and therefore there is little point in attempting to identify 'carriers' prior to the onset of symptoms, eg, diarrhoea. (A more effective marker for the potential for *C difficile* infection would be recent antibiotic treatment combined with exposure to other cases.)

However, there is evidence to support screening for MRSA colonisation in certain high-risk patients and certain high-risk units (Coia *et al* 2006). Examples of high-risk patients include those known to have been infected or colonised with MRSA in the past, patients who are often re-admitted to a health care facility, and patients transferred directly between hospitals. Examples of high-risk units (where the consequences of MRSA infection are severe and the opportunities for infection are high) include intensive care, neonatal intensive care, renal dialysis, burns, transplantation and trauma. It is thought that patients on elective surgical units, who tend to stay in hospital for less time, are at lower risk of MRSA infection than are patients on emergency or mixed units (Coia *et al* 2006).

As the evidence supports selective screening of high risk patients, the government has proposed that MRSA screening be introduced for all elective admissions in 2008 and all emergency admissions as soon as possible over the next three years (Darzi 2007; Department of Health 2008). Although screening for elective admissions can take place in the community prior to admission, screening patients in hospital is potentially logistically complicated and costly given that all patients found to be positive would need to be isolated or cohorted (treated together) and decolonised. Indeed, some have questioned how realistic it will be to screen every person and then ensure that those identified as carriers are kept separate from those who are MRSA-negative (MRSA Working Group 2008). This might present a challenge for hospitals with high bed-occupancy rates and few single rooms, and might conflict with other targets that require the speedy throughput of patients, eg, the 18-week referral-to-treatment-time target and the maximum four-hour wait in the accident and emergency unit target.

Other potential problems with MRSA screening that were identified by the MRSA Working Group include:

- no single test can rule out absolutely the possibility of MRSA colonisation;
- treatment to eliminate MRSA is only effective in 30–90 per cent of patients;
- conventional methods of screening take three to five days, and although new rapid screening methods are now available, they are relatively expensive, require skilled staff and are difficult to perform in large numbers (MRSA Working Group 2008).

In addition, focusing on MRSA alone will ignore other types of *S aureus* that result in hospital infections.

Although it is thought that MRSA screening in The Netherlands has helped to keep infection rates low, it is unclear whether screening in England, where rates are much higher, will be able to deliver much lower infection rates. That is, screening may be able to keep a low rate low, but turning a high rate into a low rate is much harder (MRSA Working Group 2008).

## MANAGEMENT OF INFECTED/COLONISED PATIENTS – ISOLATION AND BED OCCUPANCY

The 'saving lives' programme (Department of Health 2005, 2007e) recommends that infected or colonised patients be isolated in order to help control the spread and minimise the impact of MRSA, *C difficile* and other healthcare-associated infections. However, although isolation may be a beneficial strategy, it has been argued that the number of MRSA cases has the potential to overwhelm facilities, and if patients are moved from units where they receive specialist care, their health may be compromised (Coia *et al* 2006).

A hospital's capacity to isolate patients depends on the design of the building(s), particularly the number of single rooms, as well as an ability to move patients around, which could be affected by levels of bed occupancy (the proportion of beds in use at any one time).

The Department of Health investigated the relationship between the proportion of single rooms available in a hospital and MRSA rates (Department of Health 2007c). Initially (between 2001/2 to 2003/4), there appeared to be no association. However, an association was found when data from 2004/5 to 2006/7 was analysed, although the effect on MRSA rates was small.

The report makes the point that the existence of single rooms does not necessarily imply that they are being used to isolate infected patients (they could be being used for other purposes). Indeed, a recent study found that in one teaching hospital only 19 per cent of single rooms were being used for infection control reasons (Wigglesworth and Wilcox 2006). However, it has been suggested that perhaps more recently, particularly as healthcare-associated infections have moved up the agenda, single rooms might be being used more effectively for infection control purposes (Department of Health 2007c). In addition, a Healthcare Commission report found that trusts that had a higher proportion of single rooms were more likely to be reducing their MRSA rates, although this analysis did not control for other factors (Healthcare Commission 2007c).

However, although single rooms might be effective at reducing the rate of infection, the proportion of single rooms that NHS acute trusts have varies widely, and many will have insufficient levels to isolate all those with MRSA (MRSA Working Group 2008). The same study of hospital isolation room capacity cited above, found that 22 per cent of requests for isolation could not be met (Wigglesworth and Wilcox 2006).

High bed occupancy is thought to be associated with higher MRSA rates on the grounds that it increases patient-to-patient contact, reduces the time a bed is empty to allow cleaning, makes it more difficult to isolate patients, and increases patient movement (Department of Health 2007c). And indeed, when the Department of Health analysed data for a five-year-period from 2001/2, it found in the first three years that NHS acute trusts with bed-occupancy rates higher than 90 per cent had MRSA rates that were 10 per cent higher than those with bed-occupancy rates below 85 per cent. However, analysis of data from the following two years found no significant association (Department of Health 2007c). The report admits that this change might seem 'puzzling', but says that it is led to conclude that, although high bed occupancy might indeed make infection control more difficult, trusts, particularly those with high MRSA rates in 2001/2, have become better at meeting the challenges associated with such factors as a result of various policy initiatives and campaigns, as well as targeted support from the Department of Health.

However, compared with other countries, the United Kingdom has a relatively high bed-occupancy rate (84 per cent in 2005), and countries with low rates of MRSA tend to have low bed-occupancy rates: The Netherlands, for example, had a bed-occupancy rate of 64 per cent in 2005 (Organisation for Economic Co-operation and Development 2007).

## STAFFING

It has also been thought that higher levels of temporary staff might result in higher MRSA rates, on the grounds that temporary staff are less likely to be aware of infection control procedures, they may move around more (within and between hospitals), and they may increase patient–staff contacts as they tend to work shorter shifts (Department of Health 2007c). However, as with bed occupancy, although this association was in evidence between 2001/2 and 2003/4 (a 10 per cent higher than average temporary staff rate resulted in a 1 per cent higher MRSA rate), the relationship ceased to be significant in the last two years of the study (Department of Health 2007c). Again, the changing nature of the association between these variables was put down to policy changes resulting in reduced MRSA rates, particularly in hospitals that had previously had high rates.

Research suggests that higher nursing staff workloads are associated with higher rates of healthcare-associated infections (Coia *et al* 2006). It is suggested that when nurses are very busy, they have less time for routine infection-control procedures, including hand hygiene. Outbreaks themselves impose more work, but demand extra infection-control measures, stretching staff further. National guidelines require managers to consider nursing workload when planning their response to healthcare-associated infection.

## SAFE USE OF MEDICAL EQUIPMENT

Healthcare-associated infections can be transmitted through indwelling medical devices such as urethral catheters, intravenous feeding lines and central venous access devices. Government guidelines recommend that these devices be used only when entirely necessary, that they be used for the shortest time possible, and that they be maintained by appropriately trained staff (Department of Health 2003; Coia *et al* 2006).

## USE OF ANTIBIOTICS

The spread of many healthcare-associated infections, particularly *C difficile* and MRSA, is associated with the (over)use of antibiotics (Coia *et al* 2006; MRSA Working Group 2008). In addition, indiscriminate and inappropriate use of antibiotics can lead to the emergence of new antibiotic-resistant organisms (Department of Health 2003).

Antibiotics leave patients vulnerable to *C difficile* infection, and can promote the development of MRSA by failing to eradicate it, thus increasing the likelihood of infection in the patient and transmission to others. Evidence suggests that 'antibiotic stewardship programmes' (programmes that monitor antibiotic prescribing, resistance and use, and educate staff) can significantly reduce MRSA colonisation and rates (Coia *et al* 2006). Reducing the inappropriate use of antibiotics, particularly of broad-spectrum antibiotics, can also reduce infection rates from *C difficile* (Fowler *et al* 2007).

All trusts are required by the Health Act 2006 to have an antibiotic prescribing policy. A number of government documents, particularly the Department of Health's report *Winning Ways: Working Together to Reduce Healthcare Associated Infection in England* (Department of Health 2003), provides guidance on the prudent use of antibiotics.

## ORGANISATIONAL FACTORS: MANAGEMENT AND LEADERSHIP

Recent government documents have placed a great deal of emphasis on management structures, including senior management commitment and local infrastructure and systems, in the control of healthcare-associated infections. Indeed, trusts are required by the Health Act 2006 to have certain management systems in place – such as a director of infection prevention and control accountable to the board – which are designed to ensure infection control is a priority and there are clear lines of responsibility.

This is perhaps not surprising given that a report by the National Audit Office in 2000 painted a picture of ineffective, poorly funded and poorly resourced infection-control teams working with little support or input from senior management. Although the National Audit Office concluded in its progress report in 2004 that healthcare-associated infections had moved up the agenda and were being accorded a higher priority by trust boards, the NHS was still thought to have some way to go in changing staff behaviour and reducing infections (National Audit Office 2004).

While there appears to be little systematic evidence on the impact of management structures on the control of healthcare-associated infections (probably because quantifying this is problematic), examples have been cited of hospitals where management failures have resulted in outbreaks, and where successful management has led to reduced rates.

The Healthcare Commission's report into the major outbreak of *C difficile* at Maidstone and Tunbridge Wells NHS Trust in 2007, found that the board had been unaware of the high infection rates and had failed to address concerns about cleanliness and other problems consistently raised by patients and staff (Healthcare Commission 2007a). The outbreak was seen in part to be a failure of management and leadership at the board level.

In contrast, the Department of Health report *Going further faster: implementing the Saving Lives delivery programme* showcases four trusts that have successfully reduced their infection rates as a result of engaging and involving trust directors, ensuring commitment on the part

of senior managers and clinicians, and tackling the problem through high-level strategic planning (Department of Health 2006b).

The Healthcare Commission has published recommendations on how trusts can reduce their infection rates that focuses on organisational structures and systems including:

- developing an organisational culture
- corporate and clinical governance systems
- systems for reviewing performance
- integrated risk management and communication with patients and the public (Healthcare Commission 2007c).

## Conclusion

As has been seen, tackling healthcare-associated infections is a matter of priority for the government, the NHS and the public. Much progress has been made in terms of reducing MRSA bloodstream infections in the previous couple of years. However, a number of challenges still remain.

First, although progress has been made in terms of reducing MRSA infections, to reduce rates further and maintain the lower rate will require continued effort.

Second, although the focus over the past five years has been very much on MRSA, it is too early to say whether the interventions that have successfully appeared to reduce MRSA will have the same impact on *C difficile*. However, while the evidence is awaited on whether the government's new strategy on healthcare-associated infection is effective against *C difficile*, it is likely that, given the way infective agents change and gain resistance over time, new healthcare-associated infections will emerge to challenge the health service of the future.

Third, in policy terms, the NHS is starting to go the way of The Netherlands, with the introduction of mandatory screening (if not full 'search and destroy' tactics). However, to be effective this will require hospitals to have the staff, infrastructure and resources necessary to identify infected patients and then isolate and decontaminate them. However, such systems are expensive and could cause delays by preventing new admissions or surgery. Although healthcare-associated infections are high on the agenda and trusts will be judged on their success in tackling them, there are also other demands on trusts.

In addition, although many of the new initiatives and polices around infection control seem likely to be effective (on the grounds that they are evidence-based), others do not. The 'deep clean' programme might be reassuring for the public, but might not deliver value for money in terms of direct reductions in infection rates.

Finally, the focus so far has very much been on *hospital*-acquired infections. However, a reduction in healthcare-associated infections requires new policies to tackle infections in the community as well, particularly as more treatment is being planned for delivery in community settings in the future.

## References


BBC (2008a). 'MRSA Row as NHS Closes on Target'. BBC News website. Available at: http://news.bbc.co.uk/1/hi/health/7215551.stm (accessed on 12 May 2008).

BBC (2008b). 'The Politicisation of Hospital Bugs'. BBC News website. Available at: http://news.bbc.co.uk/1/hi/health/7177162.stm (accessed on 12 May 2008).

Chief Medical Officer (2008). *PL CMO (2008)1: Changes to the Mandatory Healthcare Associated Infection Surveillance System for Clostridium Difficile Infection (CDI) from 1 January 2008* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Lettersandcirculars/Professionalletters/Chiefmedicalofficerletters/DH_082107 (accessed 13 May 2008).

Chief Medical Officer (2007). PL CMO (2007)8: *Healthcare Associated Infections and Death Certification* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Lettersandcirculars/Professionalletters/Chiefmedicalofficerletters/DH_079104 (accessed on 13 May 2008).

Chief Medical Officer (2005). *CMO Update 42* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Lettersandcirculars/CMOupdate/DH_4115663 accessed on 13 May 2008).

Coia JE, Duckworth GJ, Edwards DI, Farrington M, Fry C, Humphreys H, Mallaghan C, Tucker DR, Joint Working Party of the British Society of Antimicrobial Chemotherapy, Hospital Infection Society, Infection Control Nurses Association (2006). 'Guidelines for the control and prevention of meticillin-resistant Staphylococcus aureus (MRSA) in healthcare facilities'. *Journal of Hospital Infection*, no 63, supp 1, pp S1–S44. Available at: www.his.org.uk/_db/_documents/MRSA_Guidelines_PDF.pdf (accessed on 11 May 2008).

Dancer SJ (2008). 'Importance of the environment in meticillin-resistant *Staphylococcus aureus* acquisition: the case for hospital cleaning', *The Lancet Infectious Diseases*, vol 8, pp 101–13. Available at: www.thelancet.com/journals/laninf/article/PIIS1473309907702414/fulltext (accessed on 13 May 2008).

Darzi (2007). *Our NHS Our Future: NHS Next Stage Review – Interim Report Summary*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/dh_079078 (accessed on 13 May 2008).

Department of Health (2008). *Clean, Safe Care: Reducing Infections and Saving Lives*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_081650 (accessed on 11 May 2008).

Department of Health (2007a). *A Simple Guide to MRSA* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4113886 (accessed on 13 May 2008).

Department of Health (2007b). *A Simple Guide to Clostridium Difficile* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4115883 (accessed on 13 May 2008).

Department of Health (2007c). *Hospital organisation, speciality mix and MRSA*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_081283 (accessed on 13 May 2008).

Department of Health (2007d). *The NHS In England: the Operating Framework for 2008/9*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_081094 (accessed on 11 May 2008).

Department of Health (2007e) *Saving Lives: Reducing Infection, Delivering Clean and Safe Care*. London: Department of Health. Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_078134 (accessed on 11 May 2008).

Department of Health (2007f). *Uniforms and Workwear: an Evidence Base for Developing Local Policy* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_078433 (accessed on 13 May 2008).

Department of Health (2006a). *Essential Steps to Safe, Clean Care: Reducing Healthcare-Associated Infection*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4136212 (accessed on 11 May 2008).

Department of Health (2006b). *HCAI Productivity Tool: An Excel Spreadsheet to Help Trusts Understand the Impact that Healthcare-Associated Infection Has on Trust Business* [online]. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4134551 (accessed 2 June 2008).

Department of Health (2006c). *Going Further Faster: Implementing the Saving Lives Delivery Programme – Sustainable Change for Cleaner, Safer Care*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4134547 (accessed on 12 May 2008).

Department of Health (2005). *Saving Lives: A Delivery Programme to Reduce Healthcare Associated Infection Including MRSA*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4113889 (accessed on 11 May 2008).

Department of Health (2004a). Press release: 'Bloodborne MRSA infection rates to be halved by 2008 – Reid'. Available at: www.gnn.gov.uk/environment/fullDetail.asp?ReleaseID=134568&NewsAreaID=2&NavigatedFromDepartment=False (accessed on 13 May 2008).

Department of Health (2004b). *Towards Cleaner Hospitals and Lower Rates of Infection: A Summary of Action*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/Browsable/DH_4096315 (accessed on 11 May 2008).

Department of Health (2003). *Winning Ways: Working Together to Reduce Healthcare Associated Infection in England*. London: Department of Health. Available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/Browsable/DH_4095070 (accessed on 11 May 2008).

Department of Health (2002). *Getting Ahead of the Curve. A strategy for combating infectious diseases (including other aspects of health protection)*. London: Department of Health. Available at: www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4060875.pdf (accessed 11 May 2008).

European Antimicrobial Resistance Surveillance System (2007). *EARSS Annual Report 2006*. Bilthoven: The Netherlands. Available at: www.rivm.nl/earss/Images/EARSS%202006%20Def_tcm61-44176.pdf (accessed 11 May 2008).

Fowler S, Webber A, Cooper BS, Phimister A, Price K, Carter Y, Kibbler CC, Simpson AJH, Stone SP (2007). 'Successful use of feedback to improve antibiotic prescribing and reduce *Clostridium difficile* infection: a controlled interrupted time series'. *Journal of Antimicrobial Chemotherapy*, vol 59, no 5, pp 990–5. Published online 26 March 2007. Available at: http://jac.oxfordjournals.org/cgi/content/abstract/dkm014v1 (accessed on 12 May 2008).

Gould IM (2006). 'Costs of hospital-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) and its control'. *International Journal of Antimicrobial Agents*, vol 28, no 5, pp 379–84.

Grundmann H, Aires-de-Sousa M, Boyce J, Tiemersma E (2006). Emergence and resurgence of meticillin-resistant *Staphylococcus aureus* as a public-health threat. *The Lancet*, vol 368, pp 874–85. Published online 21 June 2006. Available at: www.rivm.nl/earss/Images/sdarticle_tcm61-31185.pdf (accessed on 13 May 2008).

Healthcare Commission (2007a). *Investigation into Outbreaks of* Clostridium Difficile *at Maidstone and Tunbridge Wells NHS Trust*. London: Commission for Healthcare Audit and Inspection. Available at: www.healthcarecommission.org.uk/_db/_documents/Maidstone_and_Tunbridge_Wells_investigation_report_Oct_2007.pdf (accessed on 13 May 2008).

Healthcare Commission (2007b). *The Annual Health Check 2006/2007: A National Overview of the Performance of NHS Trusts in England*. London: Commission for Healthcare Audit and Inspection. Available at: www.healthcarecommission.org.uk/_db/_documents/Annual_health_check_national_overview_2006-2007.pdf (accessed on 13 May 2008).

Healthcare Commission (2007c). *Healthcare Associated Infection: What Else Can the NHS Do? Summary Report*. London: Commission for Healthcare Audit and Inspection. Available at: http://www.healthcarecommission.org.uk/_db/_documents/HCAI_Summary_200708205723.pdf (accessed on 13 May 2008).

Healthcare Commission (2006). *Investigation into Outbreaks of* Clostridium Difficile *at Stoke Mandeville Hospital, Buckinghamshire Hospitals NHS Trust*. London: Commission for Healthcare Audit and Inspection. Available at: www.healthcarecommission.org.uk/_db/_documents/Stoke_Mandeville.pdf (accessed on 13 May 2008).

Health Protection Agency (2008a). *Clostridium difficile*. London: Health Protection Agency. Available at: www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1179744911867 (accessed 21 May 2008).

Health Protection Agency (2008b). *Staphylococcus aureus*. London: Health Protection Agency. Available at:www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1191942169197 (accessed 21 May 2008).

Health Protection Agency (2008c). *Summary Points and Commentary on Quarterly (October to December 2007)* Clostridium Difficile *Data Derived from Mandatory Surveillance, April 2008*. London: Health Protection Agency. Available at: www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1209023432921 (accessed on 13 May 2008).

Health Protection Agency (2007a). *National Confidential Study of Deaths Following Meticillin-Resistant* Staphylococcus aureus *(MRSA) Infection*. London: Health Protection Agency. Available at: www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947311070 (accessed on 13 May 2008).

Health Protection Agency (2007b). *Surveillance of Healthcare Associated Infections Report 2007*. London: Health Protection Agency. Available at: www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1196942169446 (accessed on 13 May 2008).

Ipsos MORI 2005 "Healthcare Key For Older Voters". Available at: www.ipsos-mori.com/content/healthcare-key-for-older-voters.ashx (accessed on 21 May 2008).

Kuijper EJ, Coignard B, Brazier J, Suetens C, Drudy D, Wiuff C, Pituch H, Reichert P, Schneider F, Widmer AF, Olsen KE, Allerberger F, Notermans DW, Barbut F, Delmée M, Wilcox M, Pearson A, Patel BC, Brown DJ, Frei R, Åkerlund T, Poxton IR, Tüll P (2007). 'Update of *Clostridium difficile*-associated disease due to PCR ribotype 027 in Europe'. Eurosurveillance, vol 12, no 6. Available at: www.eurosurveillance.org/em/v12n06/1206-221.asp (accessed on 13 May 2008).

Larson E, Kretzer EK (1995). 'Compliance with handwashing and barrier precautions'. *Journal of Hospital Infection*, vol 30 (supp), pp 88–106.

MRSA Working Group (2008). *MRSA: Separating Fact from Fiction. The Role of Treatment within MRSA Management*. London: the MRSA Separating Fact from Fiction Working Group in collaboration with National Concern for Healthcare Infections. Available at: www.nc-hi.com/pdf%20files/pfizer/MRSA%20Separating%20fact%20from%20fiction%20report%20(2).pdf (accessed on 13 May 2008).

Naikoba S, Hayward A (2001). 'The effectiveness of interventions aimed at increasing handwashing in healthcare workers – a systematic review'. *Journal of Hospital Infection*, vol 47, no 3, pp 173–80.

National Audit Office (2004). *Improving Patient Care by Reducing the Risk of Hospital Acquired Infection: A Progress Report. Report By The Comptroller and Auditor General*. HC 876 (2003–2004). London: The Stationery Office. Available at: www.nao.org.uk/publications/nao_reports/03-04/0304876es.pdf (accessed on 13 May 2008).

National Audit Office (2000). *The Management and Control of Hospital Acquired Infection in Acute NHS Trusts in England. Report by the Comptroller and Auditor General*. HC 230 (1999–00). London: National Audit Office. Available at: www.nao.org.uk/publications/nao_reports/9900230.pdf (accessed on 13 May 2008).

National Patient Safety Agency (2008). *Latest Feedback from NOSEC Study – May 2008*. National Patient Safety Agency website. Available at: www.npsa.nhs.uk/cleanyourhands/in-hospitals/independent-evaluation/nosec/ (accessed on 13 May 2008).

Office for National Statistics (2008). 'Reported deaths involving *Clostridium difficile* rise by 72 per cent'. *Health Statistics Quarterly*, Spring. Office for National Statistics website. Available at: www.statistics.gov.uk/pdfdir/mrsa0208.pdf (accessed on 13 May 2008).

Organisation for Economic Co-operation and Development (2007). 'Health at a Glance 2007: OECD Indicators'. Organisation for Economic Co-operation and Development website. Available at: http://lysander.sourceoecd.org/vl=1436441/cl=21/ini=rcse/nw=1/rpsv/health2007/4-5.htm (accessed on 13 May 2008).

Plowman R, Graves N, Griffin M, Roberts JA, Swan AV, Cookson B, Taylor L (1999). *The Socio-economic Burden of Hospital Acquired Infection*. London: Public Health Laboratory Service. Available at: www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4089725.pdf (accessed on 11 May 2008).

Pratt, R J (2005). 'Preventing healthcare associated infections: an essential component of patient safety'. London: Patient Safety Agency, BMJ Publishing Group, and the Institute for Healthcare Improvements. Available at: www.richardwellsresearch.com/richardwells/pdfs%20and%20documents/Safer%20Healthcare%20What%20We%20Know.pdf (accessed 2 June 2008).

Pratt RJ, Pellowe CM, Wilson JA, Loveday HP, Harper PJ, Jones SR, McDougall C, Wilcox MH (2007). 'Epic 2: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England'. *Journal of Hospital Infection*, no 65, supp 1, S1–S64. Available at: www.epic.tvu.ac.uk/PDF%20Files/epic2/epic2-final.pdf (accessed on 11 May 2008).

Pratt RJ, Pellowe C, Loveday HP, Robinson N, Smith GW, Barrett S, Davey P, Harper P, Loveday C, McDougall C, Mulhall A, Privett S, Smales C, Taylor L, Weller B, Wilcox M (2001). 'The epic project: developing national evidence-based guidelines for preventing healthcare associated infections. Phase 1: Guidelines for preventing hospital-acquired infections'. *Journal of Hospital Infection*, no 47 (supplement), pp S3–S82.

Starr J (2007). 'Hospital acquired infection'. *British Medical Journal*, vol 334, no 7596, p 708.

*The Independent* (2007). 'Andreas Whittam Smith: The truth behind the missed MRSA targets'. *The Independent*. Available at: www.independent.co.uk/opinion/commentators/andreas-whittam-smith/andreas-whittam-smith-the-truth-behind-the-missed-mrsa-targets-432149.html (accessed on 13 May 2008).

Wigglesworth N, Wilcox MH (2006). 'Prospective evaluation of hospital isolation room capacity'. *Journal of Hospital Infection*, vol 63, no 2, pp 156–61.