Death certification following MRSA bacteraemia, England, 2004–05

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This study examined factors affecting whether or not meticillin resistant *Staphylococcus aureus* (MRSA) is recorded on the death certificate of individuals who died following a laboratory confirmed MRSA bacteraemia and compared this with another organism, *Streptococcus pneumoniae*. The study included all patients with a positive MRSA or *S. pneumoniae* bacteraemia reported to the Health Protection Agency between 1 January 2004 and 31 December 2005 and linked to a death registered up to 31 March 2006. It was an opportunistic analysis of infection surveillance records and death registrations that had been linked for other purposes. Certifiers are most likely to record MRSA on the death certificate if they believe that a large number of conditions contributed to the patient's death, and if the patient dies between 2 and 15 days following a positive blood culture. Certifiers do not appear to be deliberately omitting MRSA from death certificates; rather they report the clinical manifestation of infection or disease the patient died from, not the microbiological diagnosis. Certifiers were significantly less likely to mention *S. pneumoniae* than MRSA.

Introduction

Public, political and media interest in measuring the contribution of health care associated infections to mortality has grown and intensified over the past decade. There are no routine data which directly measure this. Death certificates very rarely state where or how any infection was acquired. Invasive infection with meticillin resistant *Staphylococcus aureus* (MRSA) is used as one of several indicators of incidence of health care associated infections.

The Office for National Statistics (ONS) has published figures on the numbers of death certificates in England and Wales on which MRSA infection of any body site is mentioned, and the number for which it is selected as the underlying cause of death, annually since 2004, following initial analysis by colleagues at the Health Protection Agency (HPA).¹ The published data series begins in 1993, because it is only from that year that the cause of death text from death certificates and International Classification of Diseases (ICD) codes for all the conditions on the certificate are stored electronically and available for analysis. MRSA infections may be coded to a range of ICD codes, depending on the body site or clinical disease (Boxes One and Two). Some of these codes are specific for *Staphylococcus aureus* infection (for example, A41.0 septicaemia due to *Staphylococcus aureus*), but others are not (for example, N39.0 urinary tract infection, site not specified). None of the codes used in mortality coding during the period of this study was specific for meticillin resistance. Identifying death certificates mentioning MRSA infection therefore involves a combination of searching ICD codes and text. MRSA is usually recorded as the underlying cause of death on between a quarter and a third of certificates that mention MRSA at all.^{2,3,4}

Box one

ICD-10 codes specifically relating to *Staphylococcus* infection

Code	Text
A05.0	Foodborne staphylococcal intoxication
A41.0–A41.2	Septicaemia due to <i>staphylococcus aureus</i> /other specified staphylococcus/unspecified staphylococcus
A49.0	Staphylococcal infection, unspecified
B95.6–B95.8	<i>Staphylococcus aureus</i> /other staphylococcus/unspecified staphylococcus as the cause of diseases classified to other chapters
G00.3	Staphylococcal meningitis
J15.2	Pneumonia due to staphylococcus
L00	Staphylococcal scalded skin syndrome
M00.0	Staphylococcal arthritis and polyarthritis
P23.2	Congenital pneumonia due to staphylococcus
P36.2	Sepsis of newborn due to staphylococcus aureus

Box two

ICD-10 codes related to infection, but not specifically *Staphylococcus*

Code	Text
A04.8	Other specified bacterial intestinal infections
A38	Scarlet fever
A48.3	Toxic shock syndrome
G06.1	Intraspinal abscess and granuloma
G04.2	Bacterial meningoencephalitis and meningomyelitis, not elsewhere classified
I30.1	Infective pericarditis
I38	Endocarditis, valve unspecified
J03.8	Acute tonsillitis due to other specified organisms
J86	Pyothorax
K12.2	Cellulitis and abscess of mouth
K14.0	Glossitis
L03	Cellulitis
L08.9	Local infection of skin and subcutaneous tissue, unspecified
M60.0	Infective myositis
M86	Osteomyelitis
M46.2	Osteomyelitis of vertebra
M71.1	Other infective bursitis
N39.0	Urinary tract infection, site not specified
T80.2	Infections following infusion, transfusion and therapeutic injection
T81.4	Infection following a procedure, not elsewhere classified
T82.6	Infection and inflammatory reaction due to cardiac valve prosthesis
T82.7	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts
T83.5	Infection and inflammatory reaction due to prosthetic device, implant and graft in urinary system
T83.6	Infection and inflammatory reaction due to prosthetic device, implant and graft in genital tract
T84.5	Infection and inflammatory reaction due to internal joint prosthesis
T84.6	Infection and inflammatory reaction due to internal fixation device [any site]
T84.7	Infection and inflammatory reaction due to other internal orthopaedic prosthetic devices, implants and grafts
T85.7	Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts
T87.4	Infection of amputation stump
T88.0	Infection following immunization

The number of death certificates in England and Wales mentioning MRSA showed a steady rise between 1993 and 2005, with a particularly large rise between 2004 and 2005 and a levelling off in 2006.^{2,3,4} It has been suggested that some of this rise may be due to increased awareness and reporting by certifying doctors and coroners, in response to increased professional and public concern and media attention.

Updated guidance on death certification from the ONS Death Certification Advisory Group (DCAG), including a section on health care associated infections, was published in *Association of Clinical Pathologists News* in May 2005⁵ and on the General Register Office website in June 2005.⁶ This was followed by a note from the Chief Medical Officer on certifying deaths involving MRSA in the *CMO Update* (number 42), which was sent to all registered doctors in July 2005, drawing their attention to the DCAG guidance.⁷

There is a popular perception that mortality statistics underestimate the contribution of MRSA to death and that doctors omit MRSA from death certificates because of its perceived links with standards of health care. There are other reasons why MRSA might not be on the death certificate. Certifiers should only mention those diseases and conditions that contributed to death.^{6,8,9} MRSA bacteraemia tends to occur in patients who are already seriously ill and have invasive treatment. The certifier may judge that the patient would have died from his underlying disease and/or other complications anyway and that the MRSA bacteraemia did not contribute significantly to the outcome. The certifier may include only the disease or manifestation of infection, for example septicaemia or pneumonia, and not the organism responsible. The certifier may not know the microbiological diagnosis or antibiotic resistance because the patient died before the laboratory report was available or the report was not forwarded on to the certifier when the patient did not die in the hospital where the test was done.

Until now, ONS has only had information from the death certificate, and so could only count deaths with MRSA mentioned. This article describes an analysis of data from national surveillance reports to the HPA of MRSA bacteraemia from laboratories in England which were linked to ONS data from death registrations by HPA as part of a study of mortality following MRSA bacteraemia. The proportion of deaths following laboratory-confirmed MRSA bacteraemia for which MRSA and/or septicaemia is mentioned on the death certificate were determined, and the determinants of whether or not the MRSA infection is mentioned on the certificate were explored.

To test whether doctors are less likely to mention MRSA than other micro-organisms because of its perceived links with health care, the likelihood of having MRSA reported was compared with the likelihood for *Streptococcus pneumoniae* infection. MRSA is largely hospital acquired, whereas *S. pneumoniae* is largely community acquired. Though both can give rise to serious disease, MRSA usually does so in patients who are already seriously ill with another condition, whereas *S. pneumoniae* can do so in previously healthy individuals.

Methods

Records of MRSA or *S. pneumoniae* positive blood cultures reported to the HPA by laboratories in England during the period 1 January 2004 to 31 December 2005 were linked by HPA to ONS data on deaths registered in the period 1 January 2004 to 31 March 2006 using a probabilistic record linkage method.¹⁰ Both MRSA and *S. pneumoniae* infection records were identified through routine laboratory reporting, although *S. pneumoniae* records were also supplemented with isolates referred to the national reference laboratory (HPA Streptococcal and Diphtheria Reference Unit). These voluntary laboratory data include individual identifiers, whereas the mandatory MRSA bacteraemia surveillance did not until October 2005.

Analyses were restricted to individuals who died after a single episode of bacteraemia during this time, to identify cases of acute rather than recurrent infection. ICD-10 codes and text for all of the conditions on the death certificate were searched to find any mention of MRSA, *Staphylococcus aureus*, *Streptococcus pneumoniae*/pneumococcus (including alternative terms and spellings), or septicaemia or pneumonia without specification of the micro-organism involved, using established methods.^{1,2,3} The codes used to identify various organisms are outlined in Boxes One to Five.

Box three

ICD-10 codes specifically related to *Streptococcus pneumoniae*

Code	Text
A40.3	Septicaemia due to <i>Streptococcus pneumoniae</i>
G00.1	Pneumococcal meningitis
J13	Pneumonia due to <i>Streptococcus pneumoniae</i>

Box four

ICD-10 codes related to streptococcal infection but not specifically related to *Streptococcus pneumoniae*

Code	Text
A49.1	Streptococcal infection, unspecified

Box five

ICD-10 codes for septicaemia (unspecified) and pneumonia (unspecified)

Code	Text
A41.9	Septicaemia, unspecified
J15.9	Bacterial pneumonia, unspecified
J18.0–J18.9	Pneumonia, organism unspecified
J90	Pleural effusion, not elsewhere specified
P23.6	Congenital pneumonia due to other bacterial agents

The relationships between the main explanatory variables and whether MRSA was recorded on the death certificate were examined using univariate analysis. Subsequently, a logistic regression model was developed including age and sex, and those variables with the strongest univariate relationships. A two-tailed t-test for comparing two independent proportions was used to compare the proportion of certificates mentioning MRSA with the proportion mentioning *S. pneumoniae*.

We analysed the effects of age, sex, days from specimen date to date of death, the number of conditions recorded on the death certificate, calendar period of death, certifier (doctor or coroner), whether or not a post mortem was carried out, and whether the death happened in hospital or not.

'Age in years' was split into the six age groups used in the ONS annual reports on deaths involving MRSA. Ages 0–44 are grouped together as there are very few deaths involving MRSA under age 45. Subsequent age groups are at ten-year intervals until the open ended '85 and over' group.

Time between the blood specimen and death ('lag in days') was split into six groups (categorised as 0–1, 2–15, 16–29, 30–43, 44–71 and 72+ days). This categorisation fits with the *a priori* assumption that no test results identifying the organism are likely to be available in the first 48 hours after a specimen was taken and that, additionally, MRSA was more likely to be recorded if death occurred during the phase of acute infection (that is, in the first two weeks). Subsequent categories are also at 14-day intervals until 44–71 days, which is a 28-day period to allow for a low number of cases in this category.

Changes in reporting over time were analysed by examining calendar month and year of death, as well as whether the death occurred before or after *CMO Update 42*.⁷ Date of death, not specimen date, was examined in order to look for changes in the practice of doctors and coroners completing certificates. After this univariate analysis, the same variables were assessed controlling for the lag between specimen and death, since deaths in the later part of the study period were likely to have occurred a longer time after the specimen than those at the beginning. The effect of limiting the analysis of changes in reporting over time to a lag period of 2 to 15 days, when certifiers would be likely to have the microbiological diagnosis and the MRSA infection would be at its most acute, was also assessed.

Results

MRSA

Of the 5,318 laboratory records of MRSA bacteraemia subsequently linked to a death in the two years of the study, MRSA infection at any body site was recorded as the underlying cause of death on 261 certificates (4.9 per cent), and was mentioned on the certificate though not as the underlying cause of death for 498 people (9.4 per cent). Overall, it was mentioned on 759 certificates (14.3 per cent). *Staphylococcus aureus* infection was mentioned on an additional 41 certificates (0.8 per cent) without mention of meticillin resistance. In total, 800 certificates (15.0 per cent) mentioned *Staphylococcus aureus*.

A total of 1,520 linked certificates (28.6 per cent) mentioned any type of septicaemia. Of these, 586 (38.6 per cent) mentioned MRSA, and a further 34 (2.2 per cent) mentioned *Staphylococcus aureus* without specifying meticillin resistance. Of all certificates mentioning septicaemia, 900 (59.2 per cent) did not specify the organism involved. Of all linked certificates, 3,798 (71.4 per cent) did not record any form of septicaemia.

Of all 759 linked certificates recording MRSA infection of any body site, 173 (22.8 per cent) did not have an ICD code for septicaemia. In addition, 7 of the 41 certificates (17.1 per cent) recording *Staphylococcus aureus* infection were not coded as a septicaemia. For patients dying in the first 15 days after a positive specimen, 23.5 per cent of certificates mentioned unspecified septicaemia, and 24.1 per cent mentioned MRSA. Overall, almost half (47.5 per cent) of certificates of patients dying within 15 days of a positive blood culture had either MRSA infection or unspecified septicaemia mentioned.

The proportion of all certificates with MRSA recorded was similar for males (13.9 per cent, 456 deaths) and females (14.9 per cent, 303 deaths). Sex was not related to whether MRSA was mentioned on the death certificate, either before ($p=0.274$) or after ($p=0.393$) controlling for other determinants (Table 1 and Table 2).

The percentage of death certificates mentioning MRSA increased with age from 10.2 per cent between ages 0 and 44 to 17.4 per cent at age 85 and over (Figure 1). Certificates mentioning septicaemia, but not specifying MRSA, increased from 15.5 per cent between ages 0 and 44 to 18.5 per cent in those aged 85 and over. Older age was associated with an increase in mention of MRSA both before and after adjustment for other factors. Taking a comparison group of

Table 1**Factors associated with recording of MRSA on death certificates – univariate logistic regression outcomes¹**

	Odds Ratio	P>z	Lower 95 per cent confidence interval	Upper 95 per cent confidence interval
Lag in days between specimen and death (continuous variable)	0.990	0.000	0.988	0.992
Days 0–1	1.707	0.041	1.023	2.848
Days 2–15	10.845	0.000	7.442	15.803
Days 16–29	6.621	0.000	4.364	10.047
Days 30–43	4.288	0.000	2.641	6.960
Days 44–71	3.290	0.000	2.010	5.384
Number of conditions	1.472	0.000	1.405	1.541
Ages 0–44	1.085	0.765	0.636	1.851
Ages 45–54	1.086	0.732	0.676	1.744
Ages 65–74	1.207	0.280	0.858	1.696
Ages 75–84	1.887	0.000	1.384	2.572
Ages 85+	2.018	0.000	1.463	2.783
Sex (male/female)	1.092	0.274	0.933	1.277
Hospital	3.828	0.000	2.702	5.425
Calendar month	0.995	0.359	0.984	1.006
Postmortem	0.906	0.405	0.717	1.144
Doctor/ Coroner	1.097	0.449	0.864	1.393
Year of death	1.022	0.787	0.874	1.195
Before/after CMO guidance	0.970	0.750	0.802	1.172

1 Univariate regression outcomes: lag between specimen and deaths starts at 0 days; categories of days all compared to a reference group of 72+ days since specimen; number of conditions compared to a reference group of 1 condition; age groups compared to a reference group of 55–64 years; sex – reference group males; hospital – whether death occurred in hospital or elsewhere, reference group 'elsewhere'; calendar month – continuous variable starting Jan 2004; postmortem – reference group 'no postmortem'; doctor/coroner – reference group doctor; year of death – reference group 2004; before/after CMO guidance – reference group 'before'.

Table 2**Final regression model – Factors associated with recording of MRSA on death certificates¹**

	Odds Ratio	P>z	Lower 95 per cent confidence interval	Upper 95 per cent confidence interval
Days 0–1	1.355	0.264	0.795	2.309
Days 2–15	8.751	0.000	5.862	13.065
Days 16–29	5.161	0.000	3.334	7.991
Days 30–43	3.766	0.000	2.280	6.220
Days 44–71	2.867	0.000	1.729	4.755
Number of conditions	1.429	0.000	1.360	1.501
Ages 0–44	1.069	0.814	0.611	1.872
Ages 45–54	1.112	0.680	0.672	1.838
Ages 65–74	1.062	0.744	0.741	1.522
Ages 75–84	1.673	0.002	1.204	2.324
Ages 85+	1.795	0.001	1.275	2.526
Sex	1.077	0.393	0.909	1.276
Hospital	1.423	0.069	0.973	2.082
Calendar	1.016	0.009	1.004	1.028

1 Logistic regression – outcome = whether MRSA was recorded on death certificate, explanatory variables = (a) lag in days since positive MRSA specimen (with a reference group of 72+ days since the specimen), (b) number of conditions recorded on the death certificate (reference group of 1 condition), (c) age group (with a reference group of 55–64), (d) sex (reference group is males), (e) whether the death occurred in hospital, and (f) calendar month of death (continuous variable starting January 2004).

ages 55–64, those aged 75–84 were 1.7 times as likely to have MRSA mentioned on their death certificate ($p=0.002$, $CI=1.2, 2.3$) and those aged 85 and over were 1.8 times as likely ($p=0.001$, $CI=1.3, 2.5$). The likelihood for younger age groups than this was no different to that for ages 55–64 (Table 2).

Figure 1**Percentage of death certificates mentioning MRSA after MRSA positive bacteraemia specimen, by age and sex**

Note: The numbers shown on this graph represent the number of death certificates in this study mentioning MRSA, for each sex by age group.

MRSA was recorded on 4.8 per cent of certificates for deaths occurring on the day of, or the day after, the blood specimen was taken. This proportion increased in the period between 2 and 15 days since the specimen to a high of 24.1 per cent, and then declined steadily (Figure 2). Levels of reporting of MRSA on days zero and one were not significantly different from those for day 72 onwards ($p=0.264$). In all other periods, the likelihood of MRSA being recorded was significantly higher than for day 72 onwards (Table 2). The odds ratio was highest in the 2–15 days category ($OR=8.75$, $CI=5.86, 13.07$). The pattern of recording of unspecified septicaemia, compared with MRSA, only differed in that on days zero and one, 20.9 per cent of certificates mentioned unspecified septicaemia, compared with 4.8 per cent for MRSA.

Figure 2**Percentage of death certificates mentioning MRSA and unspecified septicaemia after MRSA positive bacteraemia specimen, by days since specimen**

Note: The numbers shown on this graph represent the number of death certificates in each group of this study mentioning MRSA.

Only 3.6 per cent of death certificates recording only one condition mentioned MRSA infection. This rose to 34.5 per cent of certificates with six conditions recorded, and 46.2 per cent of certificates with nine conditions recorded (Figure 3). The likelihood of MRSA being mentioned rose with each additional condition recorded on the death certificate by 42.9 per cent ($p<0.0001$, $CI=36.0, 50.1$) after adjustment for other factors (Table 2).

The place where a death occurred (hospital compared with other places combined) was strongly related to whether MRSA was recorded on the death certificate before controlling for other determinants ($OR=3.83$,

Figure 3

Percentage of death certificates mentioning MRSA after MRSA positive bacteraemia specimen, by the number of conditions recorded on the death certificate

Note: The numbers shown on this graph represent the number of death certificates in each group of this study mentioning MRSA.

$p < 0.001$) (Table 1), but less strongly after controlling, when it was no longer statistically significant ($OR = 1.42$, $p = 0.069$) (Table 2).

There was no difference between the likelihood of doctors (14.4 per cent) and coroners (13.3 per cent) mentioning MRSA on the death certificate ($OR = 1.097$, $p = 0.449$). In addition, whether or not a post mortem was carried out made no difference to the likelihood of MRSA being mentioned. MRSA was mentioned on 14.4 per cent of certificates where no post mortem had been carried out compared with 13.2 per cent of certificates where a post mortem was done ($OR = 0.91$, $p = 0.405$).

Changes over time in proportion of linked certificates with MRSA reported

Before controlling for the effects of time between specimen and death, there was no clear increase in the percentage of linked certificates

mentioning MRSA over the period of the study (Figure 4). In January 2004, 14.2 per cent of certificates following a positive bacteraemia recorded MRSA. The highest recorded percentage was 19.1 per cent in June 2005; however, there is no consistent trend. In the month after *CMO Update 42* was published (August 2005), there was a slight increase in reporting to 18.6 per cent from 16.0 per cent in July. Immediately after this increase, there was a steep decline to 11.7 per cent in September 2005. Overall there was no persistent change in recording of MRSA on death certificates following the issue of new guidance to certifiers.

In logistic regression **without adjustment for time between specimen and death** (Table 3), there was no indication of a month to month increase in the recording of MRSA on certificates ($OR = 0.995$, $p = 0.359$). Similarly, there was no significant difference ($OR = 1.022$, $p = 0.787$) between the likelihood of MRSA being mentioned on a certificate in 2004 (14.5 per cent) and 2005 (14.8 per cent). Finally, there was no significant difference between reporting in the two periods before and after *CMO Update 42* ($OR = 0.865$, $p = 0.114$).

We subsequently re-examined the calendar month, year of death and before/after *CMO Update 42* variables, controlling for the effects of the time between specimen and death. This analysis showed a very small, but statistically significant, increase in the chance of MRSA being recorded month on month during the period of the study ($OR = 1.017$, $p = 0.005$) (Table 3). This increase of 1.7 per cent of the level of reporting at the start of the study period (14.2 per cent of linked certificates) per month, would result in 0.24 per cent more linked certificates mentioning MRSA in each succeeding month after January 2004. However, the proportion of certificates recording MRSA by month does not actually show a clear linear pattern upwards (Figure 4). There was no significant difference in the likelihood of MRSA being recorded in 2005 as a whole compared with 2004, even after controlling for the time between specimen and death ($OR = 1.165$, $p = 0.065$), nor was there a significant difference between the two periods before and after the *CMO Update 42* ($OR = 1.183$, $p = 0.083$).

Figure 4

Percentage of death certificates mentioning MRSA after MRSA positive bacteraemia specimen, by month of death and time between specimen and death

Table 3

Analysis of changes over time in certification of MRSA

	Odds Ratio	P>z	Lower 95 per cent confidence interval	Upper 95 per cent confidence interval
Unadjusted logistic regression				
Calendar month (continuous)	0.995	0.359	0.984	1.006
Year of death ¹	1.022	0.787	0.874	1.195
Before/after CMO guidance	0.865	0.114	0.722	1.036
Logistic regression adjusted for lag between specimen and death				
Calendar month (continuous)	1.017	0.005	1.005	1.029
Year of death ¹	1.165	0.065	0.991	1.371
Before/after CMO guidance	1.183	0.083	0.978	1.432
Logistic regression limited to deaths occurring 2–15 days after bacteraemia specimen				
Calendar month (continuous)	1.016	0.028	1.002	1.031
Year of death ¹	1.209	0.064	0.989	1.478
Before/after CMO guidance	1.185	0.185	0.922	1.522

¹ Data for 2004 and 2005 only.

Note: Calendar month starts in January 2004.

Limiting analysis to those deaths occurring between 2 and 15 days since the blood specimen showed similar results (Table 3). Logistic regression including only those deaths occurring between 2 and 15 days after a positive specimen shows a similar small yet statistically significant difference over time in the recording of MRSA when assessed by calendar month (OR=1.016, $p=0.028$), but no significant difference in reporting in 2005 as a whole compared with 2004 (OR=1.209, $p=0.064$) or before and after the CMO Update 42 (OR=1.185 $p=0.185$).

Univariate analysis of deaths between 2 and 15 days after the specimen again shows no overall pattern of increase in reporting by calendar month, with a great deal of variation between months (Figure 4). There was again an increase in reporting in the month immediately after CMO Update 42 was issued (August 2005). In July, MRSA was recorded on 25.6 per cent of certificates when death occurred between 2 and 15 days after a bacteraemia; in August this had increased to 41.1 per cent, only to fall as sharply the next month to 23.3 per cent in September.

Calendar month of death was included in the final model (Table 2), where it showed a very small but statistically significant upward drift in inclusion of MRSA on death certificates, after adjusting for other significant factors.

Streptococcus pneumoniae

Of the 3,141 people with a laboratory record of *S. pneumoniae* bacteraemia linked to a death, infection with *S. pneumoniae* was recorded as the underlying cause of death on 172 certificates (5.5 per cent), and mentioned – though not as the underlying cause – on a further 90 certificates (2.9 per cent); in all being mentioned on 262 certificates (8.3 per cent). A total of 1,453 death certificates (46.3 per cent) mentioned pneumonia but did not specify the organism involved and, similarly, 382 certificates (12.2 per cent) mentioned unspecified septicaemia. Certifiers were significantly less likely to mention *S. pneumoniae* (8.3 per cent) than MRSA (14.3 per cent) ($p<0.002$) after a positive bacteraemia specimen.

Comparison with number of deaths in ONS annual reports

ONS routine annual reporting identified a total of 2,605 death certificates with mention of MRSA infection of any body site in 2004 (1,069 deaths) and 2005 (1,536) in England. Only 28 per cent of these (729) could be linked to a positive bacteraemia reported in HPA voluntary surveillance data. This linkage study identified an additional ten deaths in these two years that had MRSA written on the certificate that had not been picked up by ONS standard search strategy using ICD codes then text on certificates.

Discussion

Main findings

In this dataset of over 5,000 MRSA bacteraemia laboratory reports linked to death registrations, more certifiers recorded unspecified septicaemia than the organism involved. Almost half of death certificates of patients who died in the first 15 days after their blood culture specimen had either MRSA infection or unspecified septicaemia mentioned. The proportion with mention of MRSA increased significantly with the number of conditions on the certificate and in the oldest age groups. Neither unspecified septicaemia nor MRSA septicaemia would be acceptable as the only cause on a certificate from a doctor without referral to the coroner (Box Six).

Box six

Death Certification and Registration in England and Wales and reporting deaths from septicaemia to the coroner

When someone dies, one of the doctors involved in their care is required under the 1953 *Registration of births and deaths Act* to complete a medical certificate of cause of death (MCCD), and ensure that it is delivered to the registrar of births and deaths for the area in which the death occurred.

The cause section of the MCCD is in the format internationally agreed through the World Health Assembly, and published by the World Health Organisation in the International Statistical Classification of Diseases, Tenth Revision (ICD–10) which also contains definitions and instructions about how the certificate should be completed. The certifier is asked to start with the immediate cause of death on line a in part I, and then to go back through the sequence of events or conditions that led directly to death on b and c, until s/he gets to the underlying cause of death (UCD). The UCD is defined by WHO as 'a) the disease or condition that initiated the morbid train of events leading directly to death, or b) the external circumstances that caused the fatal injury'. If the certificate has been correctly completed, the UCD should be the single condition written on the lowest used line of the MCCD, and should have caused the conditions written on the lines above it.

The certifying doctor usually gives the completed MCCD to a member of the deceased's family who takes it to the register office. Registrars have a statutory duty to report certain categories of death to the coroner before they can be registered. These include deaths for which the cause appears to be unknown and deaths which might be due to unnatural causes, including any form of accident or violence, injury or poisoning. Registrars have no clinical training. They use their judgement, and instructions provided by the General Register Office to identify deaths that must be referred. An MCCD on which the certifier had only written 'septicaemia' as the underlying cause would be referred to the coroner, because septicaemia could be the result of accidental or violent injury. An MCCD on which the certifier specified that the septicaemia was the result of a disease would not need to be referred, for example septicaemia due to a diverticular abscess due to diverticulitis, or septicaemia due to pneumonia.

There are a small number of organisms that are generally accepted as indicative of a natural illness. For example a death certified as due to meningococcal septicaemia on its own need not be reported to the coroner. However, merely specifying that the septicaemia involved MRSA would not make the certificate acceptable without referral, since this could still be the result of an injury. The certifier would still need to specify a disease that started the sequence leading to the septicaemia, or the death would have to be reported to the coroner.

Certifiers were significantly more likely to mention MRSA than *S. pneumoniae* in deaths following positive blood culture with one of these organisms.

When the proportion of linked certificates on which MRSA was mentioned in the two years overall was compared, the difference was not statistically significant, but there was a small statistically significant increase for calendar month. Applying the monthly odds ratio (1.017, Table 3) to the baseline MRSA reporting level in January 2004 (14.2 per cent of linked certificates) would indicate that, for each successive month during the study period, an additional 0.24 per cent of all linked certificates had MRSA mentioned. Assuming that this applied across a whole year, it would result in an annual increase of about 2.9 per cent of all linked certificates. This level of increased reporting of MRSA over time clearly cannot account for the 43.7 per cent increase in the overall number of death certificates in England with mention of MRSA, from 1,069 in 2004 to 1,536 in 2005.⁴ The new guidance issued to doctors does not appear to have caused a sustained large increase in the tendency of doctors to mention MRSA.

We did not find any difference in reporting of MRSA in relation to the patient's sex, place of death, certifier of the death, or whether or not a post mortem was carried out.

Comparison with other studies

Other studies have shown that the risk of invasive MRSA infection,¹¹ and population based mortality rates,^{3,12} rise with age. Mortality from hospital acquired infections also rises with severity of pre-existing disease.¹³ This study shows that the likelihood that MRSA will be mentioned on the death certificate when it has been grown from a blood culture also rises with age and with the total number of conditions the certifier thought contributed to death. Some doctors list more steps in the direct sequence leading to death than others, and/or more contributory conditions, given the same scenario, but their reasons for doing this are not known.^{14,15}

Studies linking hospital discharge records to death certificates have shown that some conditions are much more likely to be mentioned on the death certificate than others. Life threatening acute events such as stroke and myocardial infarction, as well as cancers of breast and lung, will nearly always be mentioned on the certificate if a patient dies within four weeks of admission for one of these, and will usually be the underlying cause. Acute conditions are more likely to be mentioned if death occurred soon after diagnosis or admission, whereas cancers are likely to be recorded whatever the interval.^{16,17} Our findings on the pattern of MRSA recording by time between specimen and death fit with the pattern seen for acute conditions.

Strengths

This study included all patients in England over a two year period with a first episode of MRSA bacteraemia reported to HPA that could be linked to a death registered in the same period or the subsequent three months. It was able to compare reporting of MRSA with *S. pneumoniae*, whose acquisition is less associated with health care, following positive blood cultures reported to HPA through a similar voluntary laboratory based system.

Limitations

Very little clinical information is available from the voluntary laboratory reports to HPA or from death certificates. It is not known where or how the infections were acquired, so it cannot be concluded that they were definitely the result of health care interventions or were hospital acquired. The linked dataset was based on voluntary laboratory reports of bacteraemias to HPA. This voluntary scheme is known to be less complete than the mandatory reporting of MRSA bacteraemia, but the latter did not have patient identifiers until near the end of the study period. Other research has shown that blood cultures are only a small proportion of all clinically significant MRSA infections confirmed by

microbiology laboratories in hospitals in Oxford.¹⁸ This may explain why only 28 per cent of the deaths could be linked back to a laboratory report.

There was no information on patients' main diagnoses or co-morbidity prior to their septicaemia or death, so reporting of MRSA could not be compared with other diseases, injuries or complications of treatment that the certifiers knew to be present. There was no way of measuring their prior risk of death, nor how much MRSA contributed to it, so it is not known how many deaths should have had MRSA recorded but did not.

Meaning of this study

This study shows that certifiers are most likely to report MRSA or septicaemia on death certificates when patients die during, or very soon after, acute bacteraemic illness, when it is most likely to contribute substantially to risk of death. They report septicaemia, but not MRSA, in the first two days, before laboratory results are available.

Our findings do not support the idea that doctors deliberately omit MRSA from death certificates because of its association with health care. On the contrary, they are more likely to mention MRSA than *S. pneumoniae*, which is almost always community acquired. Doctors are no less likely to mention MRSA than coroners when completing the death certificate. The study supports our hypothesis that certifiers more often specify the clinical diagnosis or body system infected, for example septicaemia or pneumonia, than the organism involved. This may be because medical certificates of cause of death (MCCDs) are completed by clinicians caring for patients, rather than microbiologists.

This study cannot tell whether MRSA is actually more likely to contribute to death when patients already have a large number of health problems, or whether it is simply more likely to be mentioned by certifiers who tend to include a large number of conditions.

The MCCD and associated instructions and guidance are designed to identify the underlying cause of death, which is defined by the World Health Organisation (WHO) as '(a) the disease or injury which initiated the morbid train of events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury'.⁸ By definition, infections acquired as a result of treatment for another serious disease or injury will not normally be the underlying cause, since they cannot be the start of this sequence. The instructions put much less emphasis on recording conditions other than the underlying cause, and the certifier is only supposed to record those which they believe contributed to the death. MRSA may be only one of many complications of a patient's pre-existing illnesses and the certifier may judge that it made little difference to the patient's risk of dying, given their prior health status, co-morbidity and/or other complications of their underlying condition.

There was a very small, but statistically significant, upward drift in the reporting of MRSA on death certificates following positive bacteraemia specimens during the period of the study. However, the level of upward drift identified here could not explain the level of increase (43.7 per cent) in all deaths involving MRSA as identified in ONS annual reporting between 2004 and 2005.

The analysis of changes in reporting following the new DCAG guidance and *CMO Update 42* showed that there was no sustained statistically significant difference in reporting before and after the guidance was issued. Any change in reporting immediately after the guidance was issued could just as likely be random variation as a true impact of the guidance.

Of all death certificates with MRSA mentioned in 2004 and 2005, only 28 per cent could be linked to a prior bacteraemia reported to the HPA. The majority of deaths to which certifiers believe MRSA infection made a significant contribution would not be identified from existing national

surveillance schemes based on bacteraemia alone. Other researchers have shown that bacteraemia specimens only make up a relatively small proportion of all clinically significant MRSA positive specimens identified in hospital laboratories.¹⁸ There was no information available about laboratory reports of specimens other than blood that might have identified MRSA infection of other body sites in these cases.

This study followed an opportunistic linkage of two existing data systems. Even in combination, these do not actually measure the contribution of MRSA infection to mortality. There is little to be gained from repeatedly linking bacteraemia reports to deaths, unless reports of other clinically significant MRSA infections are also linked and data on principle diagnoses and co-morbidities is collected. Only then would it be possible to estimate the contribution of MRSA infection to death, independent of the certifier's stated clinical opinion.

The laboratory reports available for this study did not include information about where or how the infections were acquired, and this information is very rarely recorded on death certificates. Unless this information is collected systematically, it will not be possible to measure the mortality burden from infections acquired through health care.

Key findings

- Certifiers are most likely to record MRSA on the death certificate if they believe that a large number of conditions contributed to the patient's death, if the patient was aged 75 or over, and if the patient died between 2 and 15 days following a positive blood culture
- More certificates mentioned unspecified septicaemia, the clinical diagnosis, than MRSA, the bacterium involved
- Almost half of certificates of patients dying within 15 days of a positive blood culture had either MRSA or unspecified septicaemia mentioned
- Certifiers were significantly less likely to mention *Streptococcus pneumoniae*, a largely community acquired infection, than they were to mention MRSA on the death certificates of patients with a laboratory confirmed bacteraemia
- There is evidence of a very small upward drift in recording of MRSA infection by certifiers following a positive blood culture

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References

1. Crowcroft N, Catchpole M (2002) 'Mortality from methicillin resistant *Staphylococcus aureus* in England and Wales: analysis of death certificates', *British Medical Journal* **325**, 1390–91.
2. Griffiths C, Lamagni T L, Crowcroft N S *et al* (2004) 'Trends in

MRSA in England and Wales: analysis of morbidity and mortality data for 1993–2002', *Health Statistics Quarterly* **21**, 15–22.

Available on the Office for National Statistics website at: www.statistics.gov.uk/statbase/Product.asp?vlnk=6725

3. Office for National Statistics (2007) Report: 'Deaths involving MRSA: England and Wales, 2001–05', *Health Statistics Quarterly* **33**, 76–81. Available on the Office for National Statistics website at: www.statistics.gov.uk/statbase/Product.asp?vlnk=6725
4. Office for National Statistics (2008) Report: 'Deaths involving MRSA: England and Wales, 1993–2006', *Health Statistics Quarterly* **37**, 57–62. Available on the Office for National Statistics website at: www.statistics.gov.uk/statbase/Product.asp?vlnk=6725
5. Rooney C (2005) 'Instructions for doctors certifying cause of death', *Association of Clinical Pathologists News*, Summer 2005, 25–29.
6. Office for National Statistics (2005) *Guidance for doctors certifying cause of death in England and Wales, from the Office for National Statistics Death Certification Advisory Group*, published on the General Register Office website, June 2005, accessed 30 January 2009, available at: www.gro.gov.uk/medcert
7. Department of Health (2005) *CMO Update*, Issue 42, Summer 2005, Department of Health: London.
8. World Health Organisation (1993) *International Statistical Classification of Diseases and related health problems, tenth revision; Vol. 2*, World Health Organisation: Geneva.
9. Office for National Statistics (1997) *Notes for doctors completing the medical certificate of cause of death*, (See books of certificates), Office for National Statistics: London.
10. Potz N, Powell D, Pebody R *et al* (2006) *Development of a method to link infection and mortality data*, poster presentation, Health Protection Agency Annual Conference, Sept 2006, Warwick, accessed 30 January 2009, available at: www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1200660056163
11. Health Protection Agency (2007) *Surveillance of Healthcare Associated Infections Report 2007*, accessed 30 January 2009, available at: www.hpa.org.uk/publications/PublicationDisplay.asp?PublicationID=108
12. Allard C, Carignan A, Bergevin M *et al* (2008) 'Secular changes in incidence and mortality associated with *Staphylococcus aureus* bacteraemia in Quebec, Canada, 1991–2005', *Clinical Microbiology and Infection*, May 2008, **14**(5), 421–28.
13. Salemi C, Morgan J, Padilla S and Morrissey R (1995) 'Association between severity of illness and mortality from nosocomial infection', *American Journal of Infection Control* **23**, 188–93.
14. Devis T and Rooney C (1999) 'Death certification and the epidemiologist', *Health Statistics Quarterly* **1**, 21–33. Available on the Office for National Statistics website at: www.statistics.gov.uk/statbase/Product.asp?vlnk=6725
15. Balkau B, Jouglu E, Papoz L and the Eurodiab subarea C study group (1993) 'European study of the certification and coding of causes of death of six clinical case histories of diabetic patients', *International Journal of Epidemiology* **22**, 116–26.
16. Goldacre M J, Roberts S E and Griffith M (2004) 'Place, time and certified cause of death in people who die after hospital admission for myocardial infarction or stroke', *European Journal of Public Health* **14**(4), 338–42.
17. Johansson L A and Westerling R (2002) 'Comparing Swedish hospital discharge records with death certificates: Can the differences be explained?' *Journal of Epidemiology and Community Health* **56**, 301–08.
18. Walker S, Peto T E A, O'Connor L *et al* (2008) 'Are there better methods of monitoring MRSA control than bacteraemia surveillance? An observational database study', *Public Library of Science Online*, **3**(6): e2378. doi:10.1371/journal.pone.0002378, accessed 30 January 2009, available at: www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0002378