Chapter 12
Epidemiology of Methicillin Resistant Staphylococcus Aureus Bacteraemia Amongst Patients Receiving Dialysis for Established Renal Failure in England in 2008: a joint report from the UK Renal Registry and the Health Protection Agency

Richard Fluck[a], Jennie Wilson[b], Charles RV Tomson[c]

[a]Royal Derby Hospital, Derby, UK; [b]Health Protection Agency, London, UK; [c]UK Renal Registry, Bristol, UK

Key Words
Bacteraemia · Dialysis · Vascular access

Abstract
Background: From April 2007, all centres providing renal replacement therapy in England were asked to provide additional data on patients with Methicillin Resistant *Staphylococcus aureus* (MRSA) bacteraemia using a secure web based system established to capture data for the mandatory surveillance of MRSA bacteramia. ***Results:*** From April 2008 until March 2009 171 discrete episodes of MRSA bacteraemia were identified from the Health Protection Agency database as being potentially associated with patients in established renal failure (ERF) requiring dialysis. Of 171 records, 18 records were rejected by renal centres as not being associated with patients on dialysis or as being duplicates of other records. Following data validation by centres, 139 patients had vascular access documented (no episodes of bacteraemia were recorded amongst patients receiving peritoneal dialysis). Of these patients, 30.2% were utilising an arteriovenous fistula or graft and 69.8% were dialysing on a non-tunnelled or tunnelled venous catheter. Two of the patients on arteriovenous fistulae had used venous catheters in the prior 28 days. Eleven patients had more than one episode in the year and accounted for 30 (20%) of the episodes of MRSA bacteraemia. Overall there was a reduction of 22% in episodes from the previous year. The median centre-specific rate of MRSA bacteraemia was 0.64 (range 0–3.49) episodes per 100 haemodialysis

patients per year, and 0.55 (range 0–2.89) episodes per 100 dialysis (haemodialysis and peritoneal dialysis combined) patients per year. ***Conclusions:*** The rate of MRSA bacteraemia in patients requiring long term dialysis continues to fall within the prevalent dialysis population in England, but there is still marked variation in centre-specific rates.

Introduction

It is now well known that patients with ERF receiving renal replacement therapy (RRT) are at increased risk of bacteraemia [1, 2]. In particular, between 4 and 8% of all episodes of MSRA bacteraemia in the United Kingdom occur in patients with ERF on haemodialysis [1, 2, 3]. This is in part due to the use of venous catheters for access to the circulation [4, 5]. This increased risk of bacteraemia continues to be a major contributor to the high mortality associated with patients requiring RRT [3, 4, 5]. In the last Renal Registry report, the UK Renal Registry and the Health Protection Agency reported on data collected between April 2007 and March 2008 on patients receiving dialysis in England who had an episode of methicillin resistant Staphylococcus aureus (MRSA) [2]. These data were supplied by clinical staff and captured using a secure web-based system, the Health Care Associated Infection Data Collection System (HCAI-DCS). The dataset included the modality of treatment, the type of vascular access in use at the time of bacteraemia and the use of venous catheters in the prior 28 days. This analysis confirmed that the relative risk of MRSA bacteraemia was approximately 100 fold higher for dialysis patients than the general population and an additional 8 fold higher for a patient requiring a venous catheter compared to a fistula. There was also marked variation between renal centres, ranging between zero and 3.28 episodes per 100 patients per year, with a mean rate of 0.92 episodes per 100 prevalent dialysis patients per year [3]. This report contains the analysis of data collected in the second year of this surveillance system.

The term established renal failure (ERF) used within this chapter is synonymous with the terms end stage renal failure (ESRF) and end stage renal disease (ESRD) which are in more widespread international usage. Within the UK, patient groups have disliked the term 'end stage' which formerly reflected the inevitable outcome of this disease.

Methods

The renal component of the HCAI-DCS went live for all centres in England on 1st April 2007. Data are presented from the second year of collection, from 1st April 2008 until 31st March 2009.

The methodology has been described in the previous report [3]: in brief, three stages of data completion were required.

1 A MRSA bacteraemia was identified by the laboratory as possibly being associated with a patient in ERF, using the clinical details provided including the clinical setting in which the sample was taken.
2 This record was 'shared' with the parent renal centre; this required the laboratory staff to select the renal unit responsible for the dialysis of the patient, thus triggering an email alert to be sent to the identified contact within the parent renal centre.
3 The renal centre then completed the additional renal data on the case via the HCAI-DCS website.

An additional step of validation and data capture was introduced this year due to the low rate of both sharing and completion of records in the first year. Leads for infection in renal units and the clinical director were e-mailed with details of the cases at the end of the year, whether shared or unshared, to ensure that cases were completed and accepted as being related to patients in ERF requiring dialysis, or rejected as having occurred in a patient not in ERF, whether or not the patient was undergoing dialysis. The individual centres were then asked to complete and accept the record.

This data reporting mechanism applies only to centres in England and is not utilised in Northern Ireland, Scotland or Wales.

Results

Organisational results

From April 2008 until March 2009 a total of 171 records submitted to the Health Protection Agency database via the HCAI-DCS were identified by laboratory staff as being possibly associated with patients in ERF requiring dialysis. However, only 111/171 records were shared with the identified contact within the renal centre by laboratory staff (table 12.1); clinical details for the remaining 60 episodes were obtained by direct contact between the clinical lead for this joint analysis (RF) and the clinical director of the centre concerned. Of the 111 shared records, 42 had been completed, giving a completion rate via the web portal system of less than 40%. Of all 171 records, 18 episodes were rejected as not having occurred in patients in ERF by renal centres at the final step of validation; these episodes are not included in any further analyses. Of those, 8 had been shared and 6 had not been completed prior to that

Table 12.1. Breakdown of records by accepted/rejected, shared/unshared and completed/not completed status

		N	%
Rejected	Shared and completed	2	1.2
	Shared, not completed	6	3.5
	Not shared	10	5.8
	Total rejected	18	
Accepted	Shared and completed	40	23.4
	Shared, not completed	63	36.8
	Not shared	50	29.2
	Total accepted	153	
	Total	**171**	

point and 2 had been completed and rejected. Three centres (Coventry, Dudley, and Manchester Royal Infirmary) were unable to validate their records. All episodes of MRSA bacteraemia attributed to patients receiving dialysis in these three centres were included, resulting in a total of 153 episodes of MRSA bacteraemia in patients in ERF being included in this analysis.

Access and Modality

Table 12.2 gives a breakdown by modality and access. There were no patients reported to be on peritoneal dialysis at the time of the MRSA bacteraemia, although one patient had been on CAPD previously. For 9 patients both the modality and the access type were unrecorded. Four patients were on haemodialysis but with unknown access and one was reported as having 'other' access; 37 patients were reported as using an arteriovenous fistula, 5 an arteriovenous graft, 13 a non tunnelled catheter and 84 a tunnelled catheter. Of the patients using an AV fistula or an AV graft, 2 had had a venous catheter in-situ in the previous 28 days.

Table 12.2. Access and modality for 153 accepted episodes of MRSA bacteraemia

Modality	Access type	N	%	Access class %
Haemodialysis	AVF	37	26.6	
	AVG	5	3.6	
	AVF/AVG total	42		30.2
	NTC	13	9.4	
	TC	84	60.4	
	NTC/TC total	97		69.8
	Total known access	**139**		
	Other	1		
	Unknown	4		
Unknown		9		
	Total	**153**		

AVF = arteriovenous fistula
AVG = arteriovenous graft
NTC = non tunnelled catheter
TC = tunnelled catheter

Table 12.3. Episodes by recurrence

Episodes per patient	N	Total
1	123	123
2	5	10
3	4	12
4	2	8
Total	**134**	**153**

Assuming a 25% usage of venous catheters for the prevalent dialysis population [1, 2, 3], the relative risk of MRSA bacteraemia can be estimated to be 6.9 fold higher in comparison to a patient using a graft or fistula (calculation based on known access episodes divided by estimated prevalent population on this access: AVF/AVG 42/(16,227 × 0.75) vs. catheter 97/(16,227 × 0.25)).

Individual Episodes

Table 12.3 details repeat episodes in patients. Of the 134 patients, 123 had a single episode, 5 had 2 episodes, 4 had 3 episodes and 2 patients had 4 episodes.

Centre Level Data

Table 12.4 and figure 12.1 detail the absolute number of MRSA episodes by centre. The median absolute number of episodes per centre was 2 (range 0 to 18). Ten of the 52 English centres (Birmingham Heartlands, Bradford, Chelmsford, Exeter, Gloucester, Kent, London St Georges, Nottingham, Middlesbrough and Southend) recorded no episodes of MRSA bacteraemia from April 2008 to March 2009. Five centres recorded 10 or more episodes (Birmingham Queen Elizabeth Hospital, Leeds, Leicester, London Barts, and St Helier (Carshalton)). Figure 12.2 provides details on the access in use at the time of each episode of MRSA bacteraemia, by centre.

The normalised centre-specific rates are based on the number of patients receiving dialysis in each centre at the end of 2008, as reported to the UKRR (see chapter 4). Using the number of prevalent haemodialysis patients as the denominator, the median rate was 0.64 with a range from 0 to 3.49 episodes per 100 haemodialysis patients per year. Using the total number of prevalent

Table 12.4. Centre specific data for episodes of MRSA bacteraemia by access type

	Prevalent patients (31/12/2008)					Episodes (April 2008–March 2009)						Rates	
Centre	HD	PD	Dialysis	Tx	All	Total	AVF	AVG	NTC	TC	UK	HD	HD + PD
B Heart	411	33	444	150	594	0	0	0	0	0	0	0.00	0.00
B QEH	807	149	956	758	1,714	11	1	0	0	10	0	1.36	1.15
Basldn	139	34	173	44	217	1	0	0	0	1	0	0.72	0.58
Bradfd	194	33	227	187	414	0	0	0	0	0	0	0.00	0.00
Brightn	327	96	423	299	722	4	1	0	1	2	0	1.22	0.95
Bristol	453	88	541	706	1,247	5	2	1	0	1	1	1.10	0.92
Camb	358	45	403	524	927	1	0	0	0	0	1	0.28	0.25
Carlis	81	21	102	101	203	1	0	0	0	0	1	1.23	0.98
Carsh	630	128	758	491	1,249	11	5	0	2	3	1	1.75	1.45
Chelms	102	43	145	57	202	0	0	0	0	0	0	0.00	0.00
Colchr	118	0	118	0	118	3	1	0	0	2	0	2.54	2.54
Covnt	317	78	395	350	745	1	0	0	0	0	1	0.32	0.25
Derby	240	79	319	70	389	2	1	0	0	1	0	0.83	0.63
Donc	80	39	119	35	154	1	0	0	0	1	0	1.25	0.84
Dorset	211	55	266	247	513	1	0	0	0	1	0	0.47	0.38
Dudley	139	54	193	77	270	3	0	0	0	0	3	2.16	1.55
Exeter	319	83	402	306	708	0	0	0	0	0	0	0.00	0.00
Glouc	160	35	195	129	324	0	0	0	0	0	0	0.00	0.00
Hull	319	76	395	301	696	4	0	0	1	3	0	1.25	1.01
Ipswi	104	53	157	137	294	2	2	0	0	0	0	1.92	1.27
Kent	324	81	405	309	714	0	0	0	0	0	0	0.00	0.00
L Barts	633	230	863	663	1,526	10	2	2	0	5	1	1.58	1.16
L Guys	517	54	571	860	1,431	5	1	0	0	4	0	0.97	0.88
L Kings	415	82	497	287	784	2	1	0	0	1	0	0.48	0.40
L Rfree	646	91	737	773	1,510	4	1	0	1	2	0	0.62	0.54
L St. G	226	56	282	342	624	0	0	0	0	0	0	0.00	0.00
L West	1,236	44	1,280	1,290	2,570	5	0	0	0	5	0	0.40	0.39
Leeds	487	102	589	753	1,342	17	4	0	0	12	1	3.49	2.89
Leic	733	162	895	765	1,660	18	4	0	5	7	2	2.46	2.01
Liv Ain	127	3	130	0	130	1	0	0	0	1	0	0.79	0.77
Liv RI	403	106	509	691	1,200	4	2	1	0	1	0	0.99	0.79
M Hope	314	136	450	308	758	5	1	0	1	3	0	1.59	1.11
M RI	417	101	518	904	1,422	2	0	0	0	0	2	0.48	0.39
Middlbr	292	24	316	366	682	0	0	0	0	0	0	0.00	0.00
Newc	271	52	323	578	901	1	0	0	1	0	0	0.37	0.31
Norwch	303	64	367	200	567	1	0	0	0	1	0	0.33	0.27
Nottm	395	123	518	426	944	0	0	0	0	0	0	0.00	0.00
Oxford	358	122	480	826	1,306	2	1	1	0	0	0	0.56	0.42
Plymth	128	52	180	263	443	3	2	0	0	1	0	2.34	1.67
Ports	450	93	543	725	1,268	2	0	0	1	1	0	0.44	0.37
Prestn	443	63	506	367	873	1	0	0	0	1	0	0.23	0.20
Redng	260	80	340	238	578	1	0	0	0	1	0	0.38	0.29
Sheff	606	78	684	532	1,216	1	0	0	0	1	0	0.17	0.15
Shrew	184	37	221	104	325	1	0	0	0	1	0	0.54	0.45
Stevng	364	40	404	176	580	3	0	0	0	3	0	0.82	0.74
Sthend	131	16	147	57	204	0	0	0	0	0	0	0.00	0.00
Stoke	272	78	350	253	603	2	1	0	0	1	0	0.74	0.57
Sund	162	23	185	158	343	3	0	0	0	3	0	1.85	1.62
Truro	142	29	171	122	293	3	3	0	0	0	0	2.11	1.75
Wirral	179	37	216	0	216	1	0	0	0	1	0	0.56	0.46
Wolve	301	62	363	126	489	2	1	0	0	1	0	0.66	0.55
York	121	21	142	132	274	2	0	0	0	2	0	1.65	1.41
England	**17,349**	**3,564**	**20,913**	**18,563**	**39,476**	**153**	**37**	**5**	**13**	**84**	**14**	**0.88**	**0.73**

Total = total number of episodes
AVF = number of episodes associated with AVF
AVG = number of episodes associated with AVG
NTC = number of episodes associated with NTC
TC = number of episodes associated with TC
UK = number of episodes access or modality unknown
Rate HD = episodes per 100 HD patients
Rate HD + PD = episodes per 100 dialysis patients

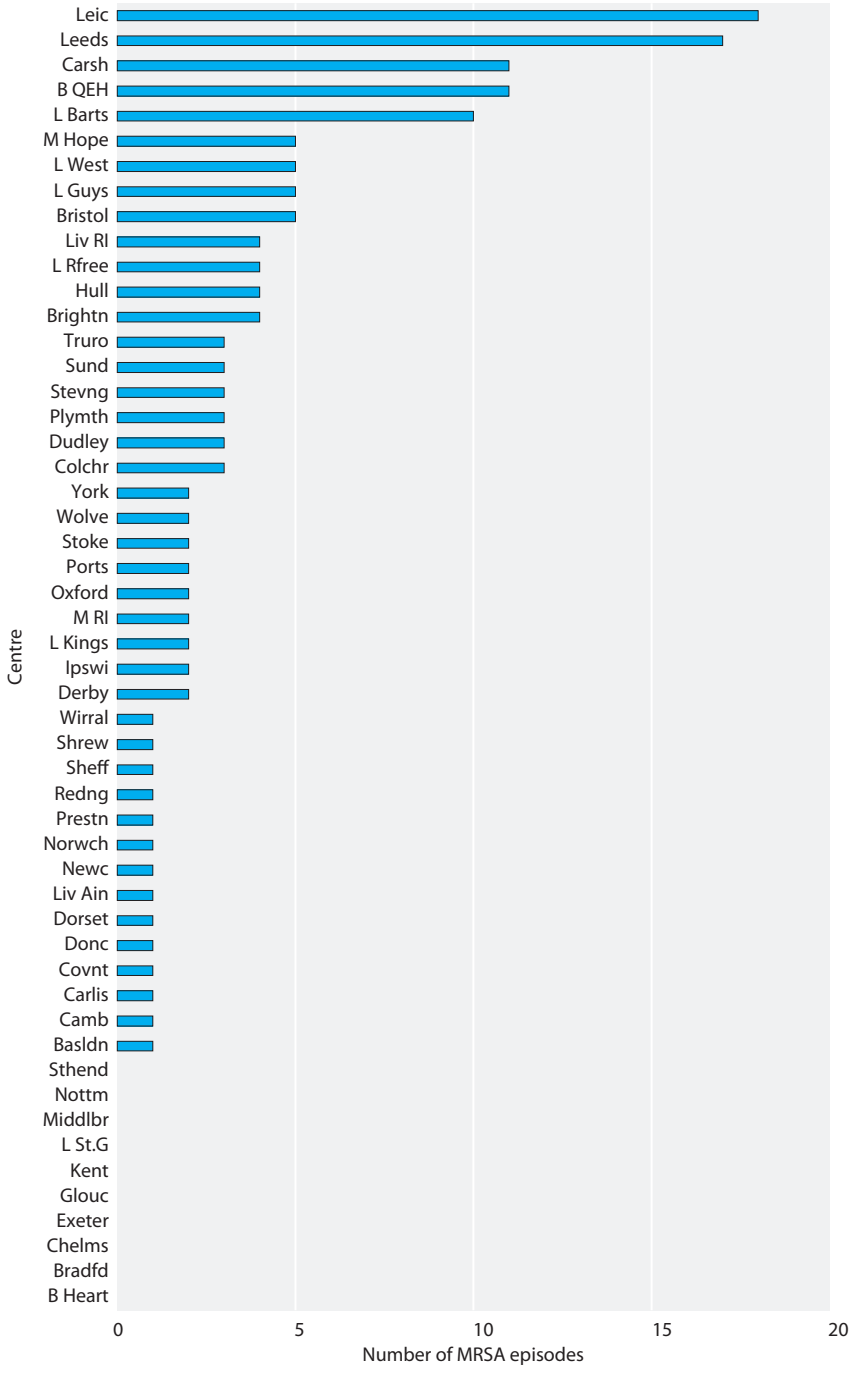

Fig 12.1. Number of MRSA bacteraemia episodes by centre (April 2008–March 2009)

dialysis patients (haemodialysis and peritoneal dialysis) as the denominator, the median rate was 0.55 with a range of 0 to 2.89 episodes per 100 patients per year. Figure 12.3 illustrates the MRSA rate per 100 haemodialysis patients for all centres, again demonstrating wide variation. Six centres had an overall rate of greater than 2 per 100 haemodialysis patients: Colchester, Dudley, Leeds, Leicester, Plymouth, and Truro.

Comparison with 2007 Report [3]

When these data were compared with the data in last year's report, the total number of episodes fell by 19%, from 188 in 2007/08 to 153 in 2008/09. The median centre-specific rate in England decreased from 0.86 to 0.64 episodes per 100 haemodialysis patients and, for haemodialysis and peritoneal dialysis combined, from 0.72 to 0.55 per 100 dialysis patients. The rate in England

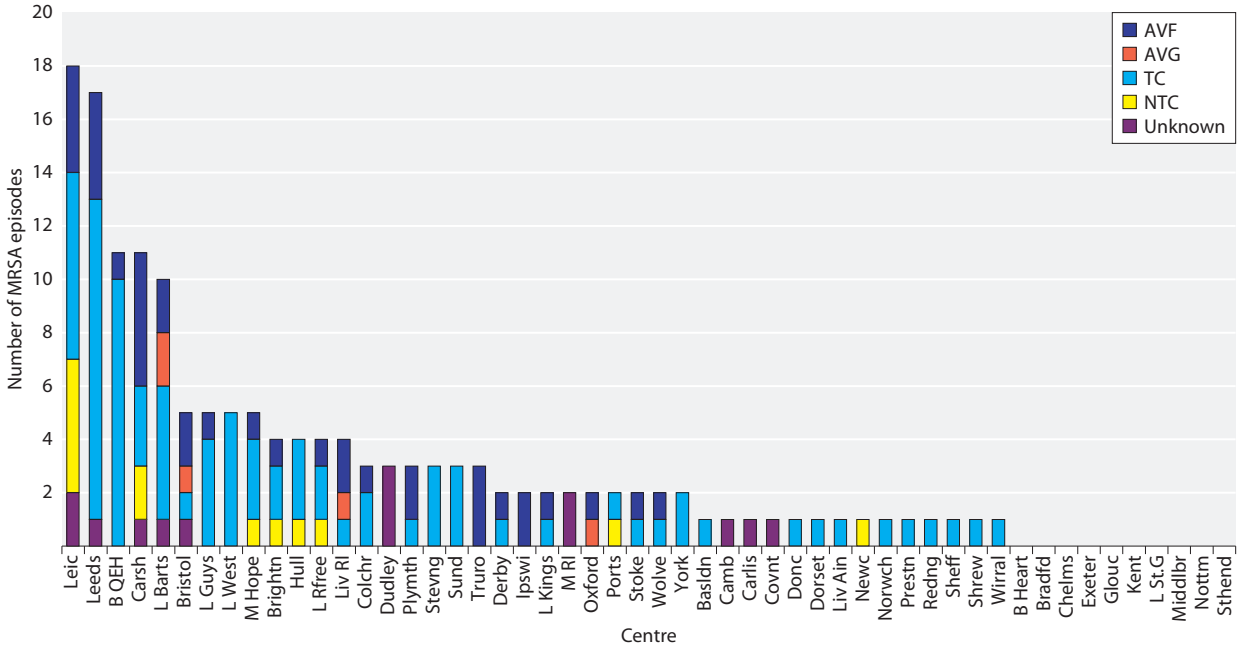

Fig 12.2. Number of MRSA bacteraemia episodes by access and renal centre (April 2008–March 2009)
Stacked bars, coded by access type for each English renal centre
AVF = arteriovenous fistula
AVG = arteriovenous graft
NTC = non tunnelled catheter
TC = tunnelled catheter

decreased from 1.14 to 0.88 episodes per 100 haemodialysis patients, and from 0.92 to 0.73 episodes per 100 dialysis patients (haemodialysis and peritoneal dialysis). Four centres showed an increase in absolute numbers of more than 2 bacteraemias reported. Seven centres that recorded no episodes last year have recorded episodes this year (Basildon, Derby, Doncaster, Reading, Sheffield, Wolverhampton and York), but none of these centres reported more than 2 episodes. Chelmsford and Exeter have recorded no episodes for the second year in succession. Bradford, Birmingham Heartlands, Gloucester, Kent and Canterbury, London St Georges, Middlesbrough, Nottingham, and Southend also all recorded no episodes for the 2008/09 reporting year.

Figure 12.4 shows the change in MRSA episodes by centre between 2007/8 and 2008/9.

Figure 12.5 demonstrates a box and whisker plot for the national data from 2007/08 and 2008/09. The reduction in median centre-specific rate does not reach statistical significance.

Finally, in order to adjust for variation in precision of the estimated rate, the rate of MRSA bacteraemia per 100 prevalent haemodialysis patients for each centre has been plotted against the centre size in a funnel plot (figure 12.6). The curved lines represent the 95% and 99.9% confidence limits. Two centres (Leeds and Leicester) lie between the upper 95% and 99.9% limits.

Discussion

Infection remains the second leading cause of death for patients requiring RRT in the form of dialysis [6], exceeded only by cardiovascular disease. The type of vascular access itself maybe a major factor, as both a primary source of bacteraemia [7–11] or as a potential influence on the outcome of another infective episode [4, 5, 12]. For example, a venous catheter may act as the portal for the direct entry of organisms into the circulation, via either the exit site on the skin or catheter lumen. Alternatively, a bacteraemia secondary to another infection (e.g. skin or soft tissue, pneumonia) may result in colonisation of the catheter biofilm. This may delay the effectiveness of therapy or increase the risk of relapse. These data from the Registry and HPA continue to demonstrate that dialysis patients are at an increased risk of MRSA bacteraemia.

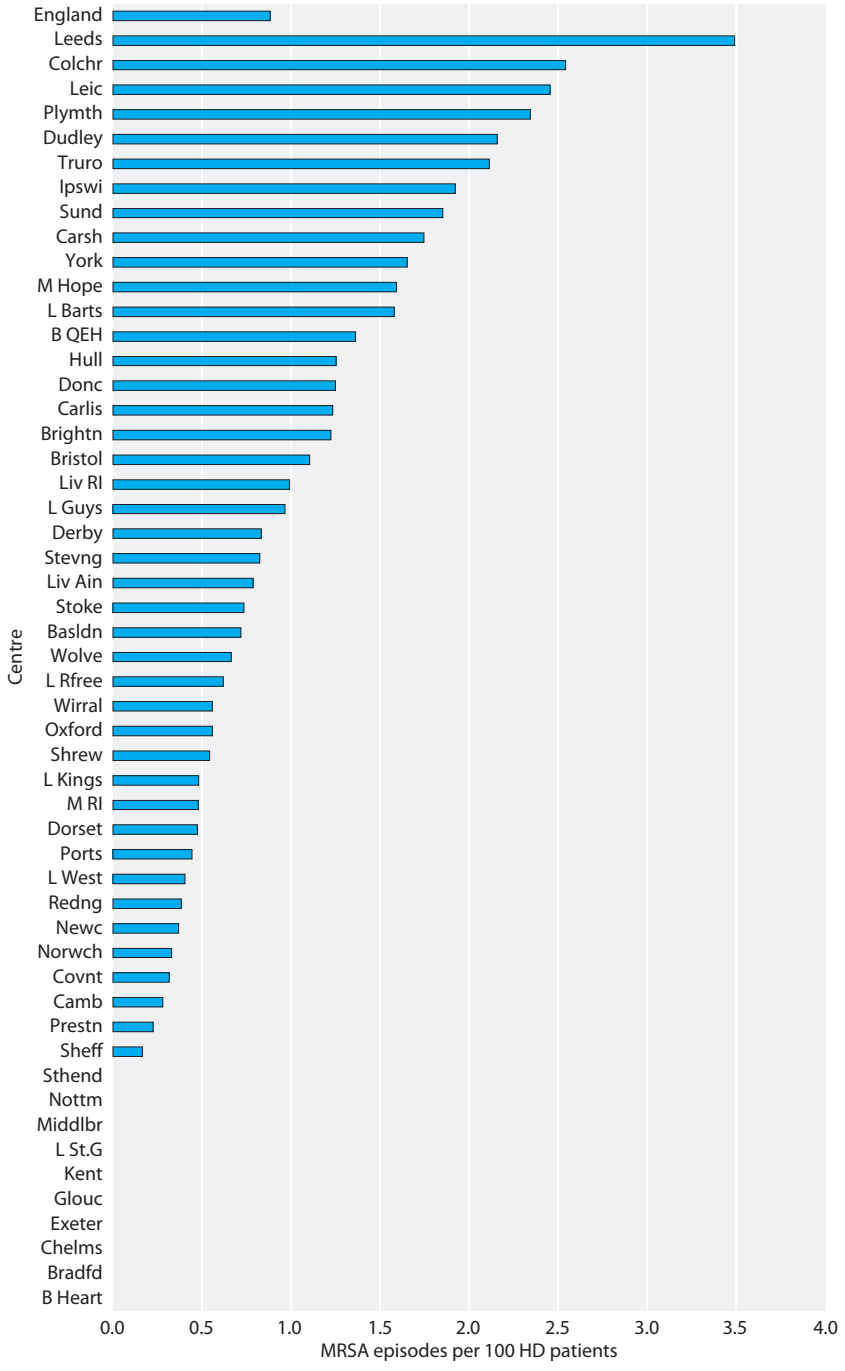

Fig 12.3. MRSA bacteraemia rate (April 2008–March 2009) per 100 prevalent HD patients by renal centre
For each centre the rate per 100 prevalent HD patients as reported 31/12/08 is provided. The overall rate for England is provided at the top of the graph

This is the second year of the full working of the reporting mechanism via the Health Protection Agency and has demonstrated continued decline in the risk of MRSA bacteraemia for patients requiring dialysis. The reasons for such improvement are not clear since the changes in practice that might be responsible are not analysed in this study. This may be related to the adoption of national policies (MRSA screening and general surveillance [13–15], reduction in the use of venous catheters or fundamental shifts in practice (for example antimicrobial lock solutions [16]).

Whatever the cause, there has been a continued reduction in the number of bacteraemia, with a further reduction of 22% from the previous year. There remains considerable variation in rates of MRSA blood related infections between centres in England. However many

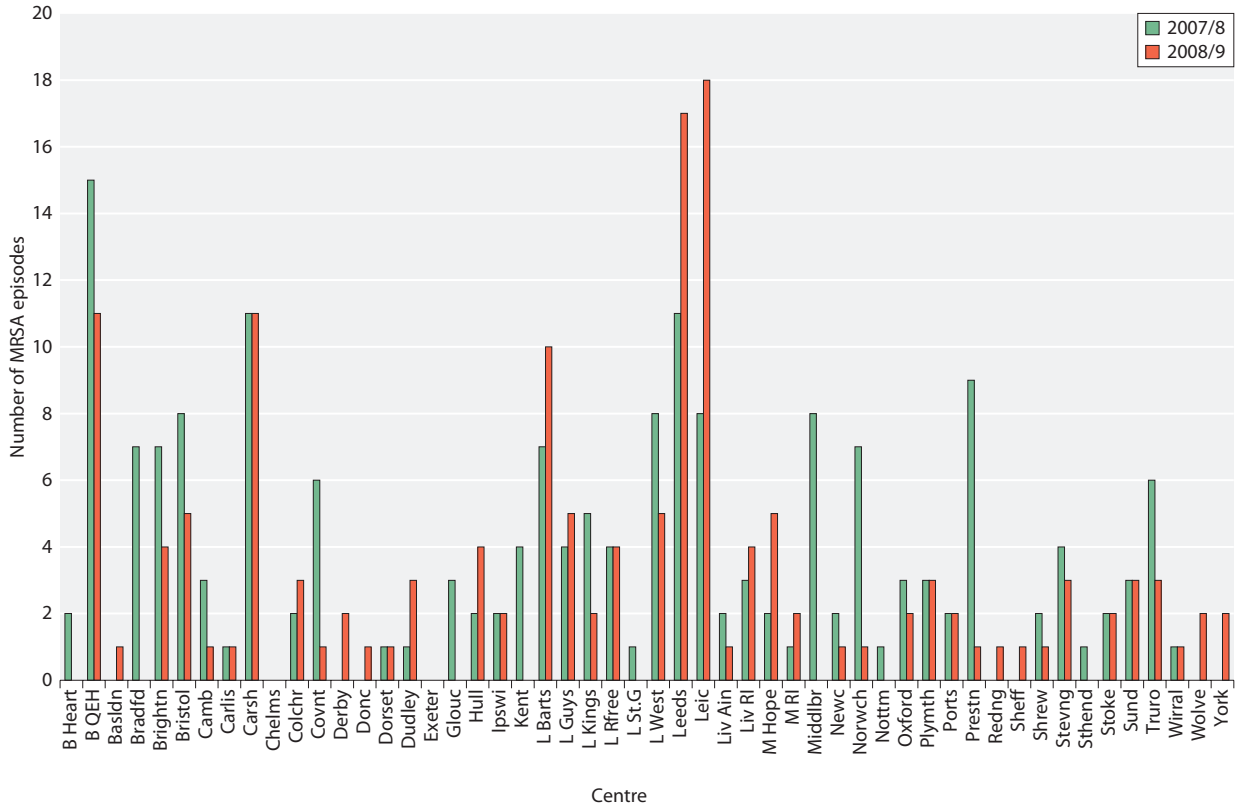

Fig 12.4. Change in MRSA bacteraemic episodes by centre for 2007/8 and 2008/9
2007/8 data Healthcare Associated Infection Data Capture System (HCAI-DCS) (previously called Mandatory Enhanced Surveillance System, MESS published 11th Annual UK Renal Report [2])
2008/9 data Healthcare Associated Infection Data Capture System (HCAI-DCS) (previously called Mandatory Enhanced Surveillance System, MESS)

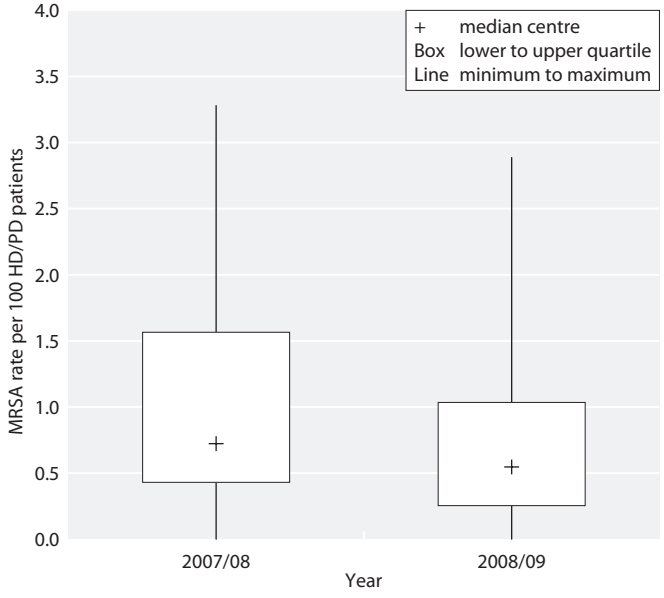

Fig 12.5. Box and whisker plot of MRSA rates by centre per 100 prevalent HD/PD patients for 2007/8 and 2008/9
Data source as per figure 12.4

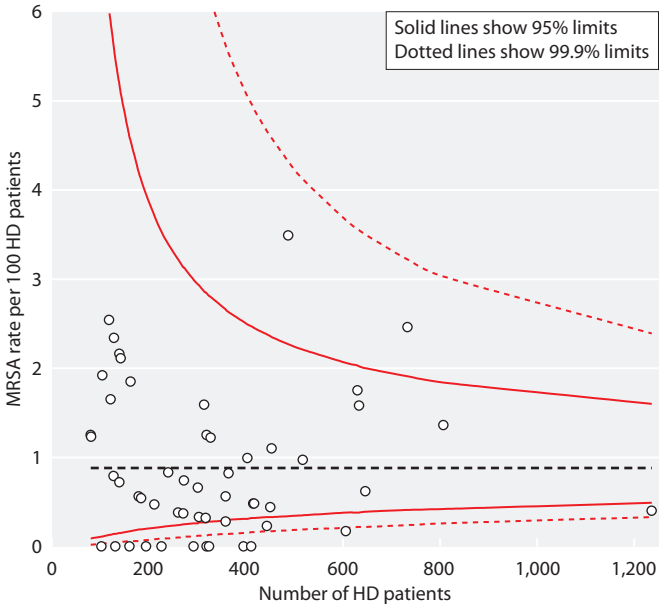

Fig 12.6. Funnel plot of MRSA rate (April 2008–March 2009) per 100 HD patients

centres have reported low or zero rates. Centres with low reporting rates last year have, in general, maintained such rates and many centres have continued to reduce the substantial burden of bacteraemia within their populations. This variation in outcome merits further study to address potential causes and refine therapy. A few centres continue to experience relatively high rates of MRSA bacteraemia. Often those centres have patients with recurrent episodes: 11 individual patients accounted for 20% of all MRSA bacteraemia in the English haemodialysis population. Clearly, chronically colonised patients represent a considerable challenge when access to the circulation is required but further research into the effective suppression or eradication of MRSA bacteraemia in the dialysis population is required. The place of MRSA screening and eradication or suppression therapy has only been documented in small studies and further work is required [17].

In the final round of data validation, many comments were made that the MRSA bacteraemia were not always associated with the type of vascular access but originated, for example, from other sites such as leg ulcers. This is a misconception of the purpose of these data. These data are not a measure of catheter related bacteraemia. Restricting analysis to catheter-related bacteraemia would mask many of the issues of infection burden in dialysis centres. Clearly, patients who have a bacteraemic episode whilst on dialysis but on a fistula, by definition, do not have a catheter related episode but none-the-less that episode is of significance to the individual. However, previous work has shown that the presence of a catheter is associated with a poorer outcome [4]. The Kidney Care National Audit will further examine the relationship between infection, access and hospital admission [18].

On an organisational basis, the current mechanism for sharing and completing records has continued to be problematic and has required an additional step of data validation this year. This was time consuming and required nearly two and a half months to complete. Whilst the quality of the data provided has improved substantially, it does slow down the process of reporting and feedback to centres. It remains a weakness of the current system, although it is hoped that changes made in May 2009 may improve the situation.

Conclusion

The second year of the reporting of the renal component of the mandatory MRSA bacteraemia surveillance scheme continues to show variability in performance between centres but an overall picture of improvement across England and a decline in episodes of about 20% from 2008. Once again, it has demonstrated the association of venous catheters with the risk of MRSA blood stream infection for patients requiring long term haemodialysis. Venous catheters continue to be the main risk factor associated with MRSA bacteraemia and the estimated relative risk compared to a fistula remains 7 fold higher.

Acknowledgements: The authors wish to thank Beverley Matthews, National Programme Director, NHS Kidney Care (England) and her team at NHS Kidney Care for their assistance in the final round of data validation. Thanks are due to Julie Gilg (UK Renal Registry) for preparation of figures 12.5 and 12.6.

Conflict of interest: none

References

1 UK Renal Registry. The National Dialysis Access Survey: preliminary results. Chapter 6, UK Renal Registry 8th Annual Report. Bristol: UK Renal Registry, 2005.
2 UK Renal Registry. The UK Vascular Access Survey – Follow-up Data & Repeat Survey. Chapter 5, UK Renal Registry 8th Annual Report. Bristol: UK Renal Registry, 2006.
3 Fluck R, Wilson J, Davies J, Blackburn R, O'Donoghue D, Tomson CR. UK Renal Registry 11th Annual Report (December 2008): Chapter 12 Epidemiology of Methicillin Resistant Staphylococcus aureus bacteraemia amongst patients receiving Renal Replacement Therapy in England in 2007. Nephron Clin Pract. 2009;111 Suppl 1:c247–56.
4 Inrig JK, Reed SD, Szczech LA, Engemann JJ, Friedman JY, Corey GR, *et al*. Relationship between clinical outcomes and vascular access type among hemodialysis patients with Staphylococcus aureus bacteremia. Clin J Am Soc Nephrol 2006;1(3):518–24.
5 Ansell D, Roderick P, Hodsman A, Ford D, Steenkamp R, Tomson C. UK Renal Registry 11th Annual Report (December 2008): Chapter 7 Survival and causes of death of UK adult patients on renal replacement therapy in 2007: national and centre-specific analyses. Nephron Clin Pract. 2009;111 Suppl 1:c113–39.
6 Moist LM, Trpeski L, Na Y, Lok CE. Increased hemodialyis catheter use in Canada and associated mortality risk: Data from the Canadian

Organ Replacement Registry 2001–2004. Clin J Am Soc Nephrol 2008; 3:1726–1732.
7 Walker TM, Bowler IC, Bejon P. Risk factors for recurrence after Staphylococcus aureus bacteraemia. A retrospective matched case-control study. J Infect. 2009 Jun;58(6):411–6.
8 Sarnak MJ, Jaber BL. Mortality caused by sepsis in patients with end-stage renal disease compared with the general population. Kidney Int 2000;58(4):1758–64.
9 Kuo CB, Lin JC, Peng MY, Wang NC, Chang FY. Endocarditis: impact of methicillin-resistant Staphylococcus aureus in hemodialysis patients and community-acquired infection. J Microbiol Immunol Infect 2007; 40(4):317–24.
10 Katneni R, Hedayati SS. Central venous catheter-related bacteremia in chronic hemodialysis patients: epidemiology and evidence-based management. Nat Clin Pract Nephrol 2007;3(5):256–66.
11 Ishani A, Collins AJ, Herzog CA, Foley RN. Septicemia, access and cardiovascular disease in dialysis patients: the USRDS Wave 2 study. Kidney Int 2005;68(1):311–8.
12 Chen CH, Hsu WH, Chen HJ, Chen W, Shih CM, Hsia TC, Tu CY. Different bacteriology and prognosis of thoracic empyemas between patients with chronic and end-stage renal disease. Chest. 2007 Aug;132(2):532–9.
13 Wyllie DH, Peto TE, Crook D. MRSA bacteraemia in patients on arrival in hospital: a cohort study in Oxfordshire 1997–2003. BMJ 2005; 331(7523):992.
14 Duckworth G, Charlett A. Improving surveillance of MRSA bacteraemia. BMJ 2005;331(7523):976–7.
15 Duerden B. Controlling healthcare-associated infections in the NHS. Clin Med 2008;8(2):140–142.
16 Jaffer Y, Selby NM, Taal MW, Fluck RJ, McIntyre CW. A meta-analysis of hemodialysis catheter locking solutions in the prevention of catheter related infection. Am J Kidney Dis. 2008 Feb;51(2):233–41.
17 Lederer SR, Riedelsdorf G, Schiffl H. Nasal carriage of methicillin resistant Staphylococcus aureus: the prevalence, patients at risk and the effect of elimination on outcomes among outclinic haemodialysis patients. Eur J Med Res. 2007 Jul 26;12(7):284–8.
18 The Information Centre. The National Kidney Care Audit. http://www.ic.nhs.uk/services/national-clinical-audit-support-programmencasp/kidney-care. Leeds, 2008.