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Bacteraemia

Voluntary surveillance of bacteraemia caused by *Pseudomonas* spp. and *Stenotrophomonas* spp. in England: 2008-2015

These analyses are based on data relating to diagnoses of bloodstream infections caused by *Pseudomonas* spp. and *Stenotrophomonas* spp. between 2008 and 2015 in England, extracted on 4 August 2016 from Public Health England's (PHE) voluntary surveillance database, Second Generation Surveillance System (SGSS). Data for Wales and Northern Ireland were extracted separately (DataStore on 20 July 2016 and CoSurv on 27 July 2016 respectively) and are included in the geographical and species analyses only.

SGSS comprises a communicable disease module that includes antimicrobial susceptibility data (CDR; formerly CoSurv/LabBase2) and a separate comprehensive antimicrobial resistance module (AMR; formerly AmSurv). Compared to CDR's antimicrobial susceptibility data, the AMR module captures more comprehensive antibiogram data (involving all antibiotics tested); however, until the launch of SGSS in 2014 fewer laboratories used the AMR module. Therefore, antimicrobial non-susceptibility trends cannot currently be undertaken using data from the AMR module, but data for 2015 were extracted to assess multidrug-resistance rates.

The data presented here may differ from data in previous publications due to inclusion of late reports.

Rates of laboratory reported bacteraemia were calculated using mid-year resident population estimates for the respective year and geography [1]. Geographical analyses were based on the residential postcode of the patient if known (otherwise the GP postcode if known or failing that the postcode of the laboratory) with cases in England being assigned to one of 15 local PHE centres (PHECs) formed from administrative local authority boundaries.

The report includes analyses on the trends, age and sex distribution, and antibiotic susceptibility of *Pseudomonas* and *Stenotrophomonas*. bacteraemia cases in England. In addition, analysis of resistance to more than one antibiotic is based on England's data reported to the AMR module (previously AmSurv) and extracted on 4 August 2016.

Key points

- in England, there was an overall 3.9% reduction in the rates of *Pseudomonas* bacteraemia between 2008 and 2015 (from 7.2 to 6.9 reports per 100,000 population); however, there was a year-on-year increase in rates between 2013 and 2015
- in England, the rates of reported *Stenotrophomonas* decreased by 25.8% (from 1.0 to 0.7 reports per 100,000 population, respectively) between 2008 and 2015
- the combined rate of *Pseudomonas* bacteraemia in England, Wales and Northern Ireland has increased by 4.4% from 6.6 to 6.9 reports per 100,000 population between 2008 and 2015, while the combined rate of *Stenotrophomonas* was relatively stable at 0.8 reports per 100,000 population within the same period
- in England, comparing 2011 and 2015, the highest increases in rates of *Pseudomonas* bacteraemia observed among PHE centres were in South Midlands and Hertfordshire (34.7%; from 4.7 to 6.4 reports per 100,000 population) and Avon Gloucestershire and Wiltshire (27.8%; from 5.0 to 6.4 reports per 100,000 population)
- within the same period (2011 and 2015), the highest increases in rates of *Stenotrophomonas* bacteraemia were observed in Kent, Surrey and Sussex (26.3%; from 0.6 to 0.7 reports per 100,000 population) and Cheshire and Merseyside (19.5%; from 0.8 to 0.9 reports per 100,000 population)
- in England, Wales, and Northern Ireland between 2011 and 2015, the most frequently identified *Pseudomonas* species causing bacteraemia was *Pseudomonas aeruginosa* (~80% in all years). Similarly, the percentages of the other named *Pseudomonas* species identified within the same period remained relatively stable
- in 2015, the highest rates of *Pseudomonas* bacteraemia in England was observed among the elderly (>74 years) at 54.7 and 21.9 reports per 100,000 population for males and females, respectively
- in the same year (2015), the highest rates of *Stenotrophomonas* bacteraemia reported among males were reported among infants (less than 1 year old; 2.6 reports per 100,000 population), while the highest rates among females were observed among older adults (65 to 74 years old) and young children (1 to 4 years old) at 1.1 reports per 100,000 population
- the percentage of *Pseudomonas* isolates non-susceptible to the antimicrobials included here (gentamicin, ciprofloxacin, ceftazidime, meropenem, imipenem, tobramycin, amikacin, piperacillin\tazobactam) reduced between 2011 and 2015 except for piperacillin\tazobactam, which increased from 6.8% to 10.1%. The highest reduction in non-susceptibility was observed for tobramycin, with a decrease from 5.7% to 3.4% within the same period (2011-2015)

- non-susceptibility of *Stenotrophomonas* to co-trimoxazole increased steadily between 2011 and 2014, reaching 7.6% before falling to its lowest percentage (3.2%) in 2015

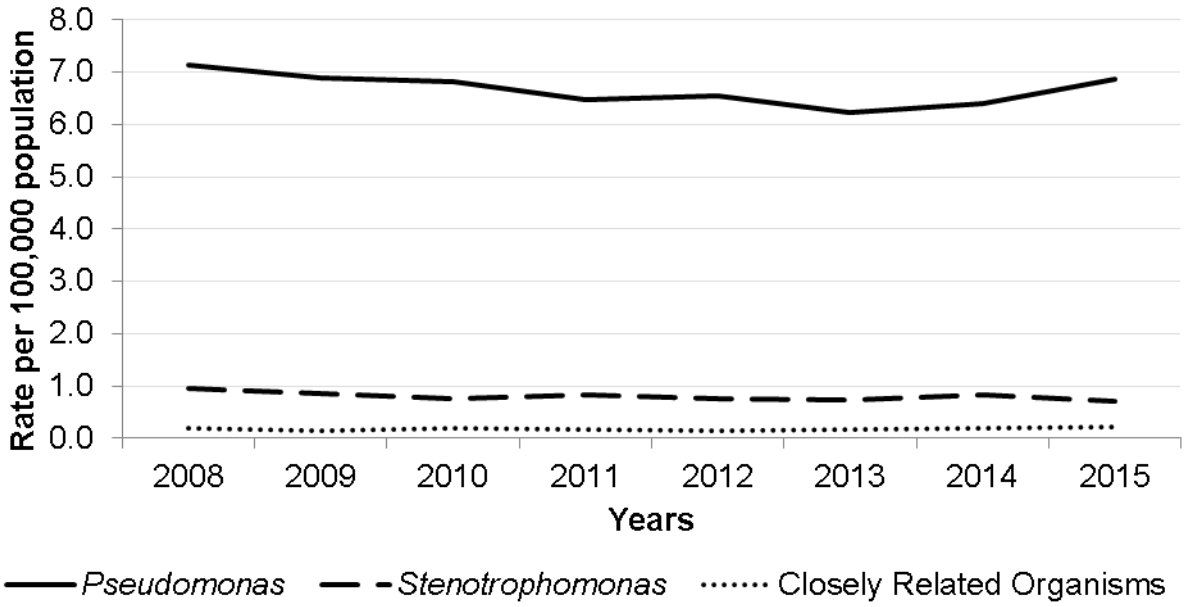
Trends: England

Overall, there was a 3.9% reduction in the rates of *Pseudomonas* bacteraemia (from 7.2 to 6.9 reports per 100,000 population) between 2008 and 2015 (figure 1); however, a year-on-year increase in rates was observed between 2013 and 2015, with a 7.4% increase between 2014 and 2015 in England alone (from 6.4 to 6.9 reports per 100,000 population) (figure 1).

There has been a decreasing trend in the rates of reported *Stenotrophomonas* bacteraemia with an overall reduction of 25.8% between 2008 and 2015 (from 1.0 to 0.7 reports per 100,000 population, respectively) (figure 1).

Between 2008 and 2015, the rates of closely related species[1] remained stable at 0.2 reports per 100,000 population.

Figure 1. *Pseudomonas, Stenotrophomonas* and closely related species bacteraemia rate per 100,000 population in England: 2008 to 2015



[1] Closely related organisms include genera where at least one species has previously been classified as *Pseudomonas* spp. or *Stenotrophomonas* spp.

Geographical distribution: *Pseudomonas* (England, Wales and Northern Ireland)

The combined rate of *Pseudomonas* bacteraemia in England, Wales and Northern Ireland increased overall by 4.4% from 6.5 to 6.8 reports per 100,000 population between 2011 and 2015. Similar to the trends observed in England alone, the aggregated rate for England, Wales and Northern Ireland decreased between 2011 and 2013, with annual increases observed between 2013 and 2015 (table 1a). However, while the rates in Northern Ireland and England both decreased from 2011 to 2013 and then increased each year thereafter, the rates of *Pseudomonas* bacteraemia in Wales have fluctuated more, with an overall decrease of 13.5% between 2011 and 2015 (from 7.8 to 6.7 reports per 100,000 population) (table 1a).

In addition, while an overall increase in rates was observed for England between 2011 and 2015, this increase in rates was not observed among all PHE centres. Between 2011 and 2015, 11 of the 15 PHE centres experienced this increase in rates of reported *Pseudomonas* bacteraemia, with the highest increases observed in South Midlands and Hertfordshire (34.7%; from 4.7 to 6.4 reports per 100,000 population) and Avon Gloucestershire and Wiltshire (27.8%; from 5.0 to 6.4 reports per 100,000 population) (table1a). Conversely within the same period (2011-2015), the highest reductions in rates were observed in North East (19.5%; from 7.5 to 6.0 reports per 100,000 population) and Greater Manchester (13.9%; from 5.4 to 4.7 reports per 100,000 population) (table1a).

Similarly, when comparing the most recent years (2014 versus 2015), increases in rates were observed in the majority of the PHE centres. The highest increases within this period (2014-2015) were observed in Yorkshire and Humber (27.7%; from 4.7 to 6.0 reports per 100,000 population) and Devon Cornwall and Somerset (22.3%; from 5.7 to 7.0 reports per 100,000 population) (table1a).

Figure 2a. Geographical distribution of *Pseudomonas* bacteraemia rates per 100,000 population (England, Wales and Northern Ireland): 2011 to 2015

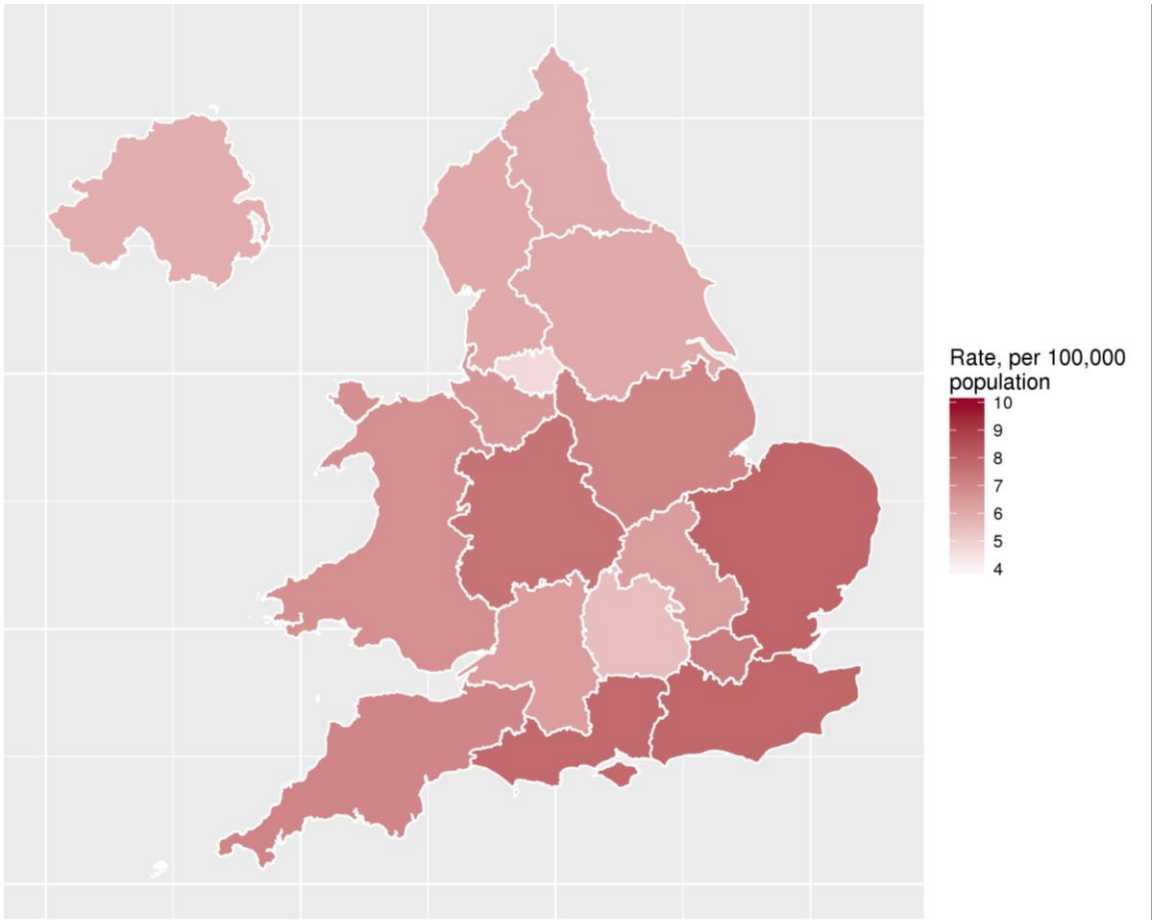


Table 1a. *Pseudomonas* bacteraemia rate per 100,000 population by region (England, Wales and Northern Ireland): 2011 to 2015

Region		2011	2012	2013	2014	2015
London	London	7.6	7.4	6.8	8.0	7.3
Midlands	Anglia and Essex	6.6	6.7	7.0	6.8	7.9
	East Midlands	7.1	8.1	6.1	6.7	7.1
	South Midlands and Hertfordshire	4.7	5.2	6.0	5.5	6.4
	West Midlands	6.6	6.3	6.8	6.9	7.5
Northern	Cheshire and Merseyside	6.0	7.0	7.0	5.5	6.5
	Cumbria and Lancashire	6.0	5.9	5.8	6.7	6.0
	Greater Manchester	5.4	5.8	4.5	4.4	4.7
	North East	7.4	6.1	5.4	5.4	6.0
	Yorkshire and Humber	5.9	5.2	4.9	4.7	6.0
Southern	Avon Gloucestershire and Wiltshire	5.0	6.0	5.4	6.5	6.4
	Devon Cornwall and Somerset	6.3	6.2	6.4	5.7	7.0
	Kent Surrey and Sussex	7.4	7.9	7.6	7.4	7.9
	Thames Valley	4.8	4.6	4.5	5.2	5.4
	Wessex	7.0	7.2	6.9	6.4	7.8
England*		**6.5**	**6.6**	**6.2**	**6.4**	**6.9**
Northern Ireland†		**6.1**	**4.9**	**4.8**	**5.3**	**5.9**
Wales¥		**7.8**	**7.1**	**7.4**	**6.8**	**6.7**
England, Wales and Northern Ireland		**6.5**	**6.5**	**6.3**	**6.4**	**6.8**

* Data extracted on 4 August 2016. † Data extracted on 27 July 2016. ¥ Data extracted on 20 July 2016

Geographical distribution: *Stenotrophomonas* (England, Wales and Northern Ireland)

Between 2011 and 2015, the combined rate of *Stenotrophomonas* bacteraemia in England, Wales and Northern Ireland was relatively stable at 0.8 reports per 100,000 population. However, there were variations observed among the individual countries within the same time period (2011-2015). In Northern and Wales Ireland, there was an increase in rates by 115.6% (from 0.6 to 1.2 reports per 100,000 population) and 36.4% (from 0.9 to 1.3 reports per 100,000 population), respectively within the same time period. However, in England within the same period, there was an overall reduction of 14.1% in the rates of reported *Stenotrophomonas* bacteraemia from 0.8 and 0.7 reports per 100,000 population (table1b). This reduction in rates of reported *Stenotrophomonas* bacteraemia was not observed among all English PHE centres. Between 2011 and 2015, six PHE centres observed an increase in their rates of reported *Stenotrophomonas* bacteraemia. The highest increases were observed in Kent, Surrey and Sussex (26.3%; from 0.6 to 0.7 reports per 100,000 population) and Cheshire and Merseyside (19.5%; from 0.8 to 0.9 reports per 100,000 population) (table1b). Conversely within the same period (2011-2015) the highest reductions in rates were observed in West Midlands (43.2%; from 0.9 to 0.5 reports per 100,000 population) and Greater Manchester (37.5%; from 1.5 to 0.9 reports per 100,000 population) (table1b). However, when comparing the most recent years (2014-2015), fewer (four) PHE centres observed an increase in their rates of reported *Stenotrophomonas* bacteraemia. The highest increase within that period (2014 and 2015) were observed in Thames Valley (61.2%; from 0.4 to 0.6 reports per 100,000 population), while the highest reduction in rates were observed in Cumbria and Lancashire (58.8%; from 1.5 to 0.6 reports per 100,000 population) (table1b).

Figure 2b. Geographical distribution of *Stenotrophomonas* bacteraemia rates per 100,000 population (England, Wales, and Northern Ireland): 2011 to 2015

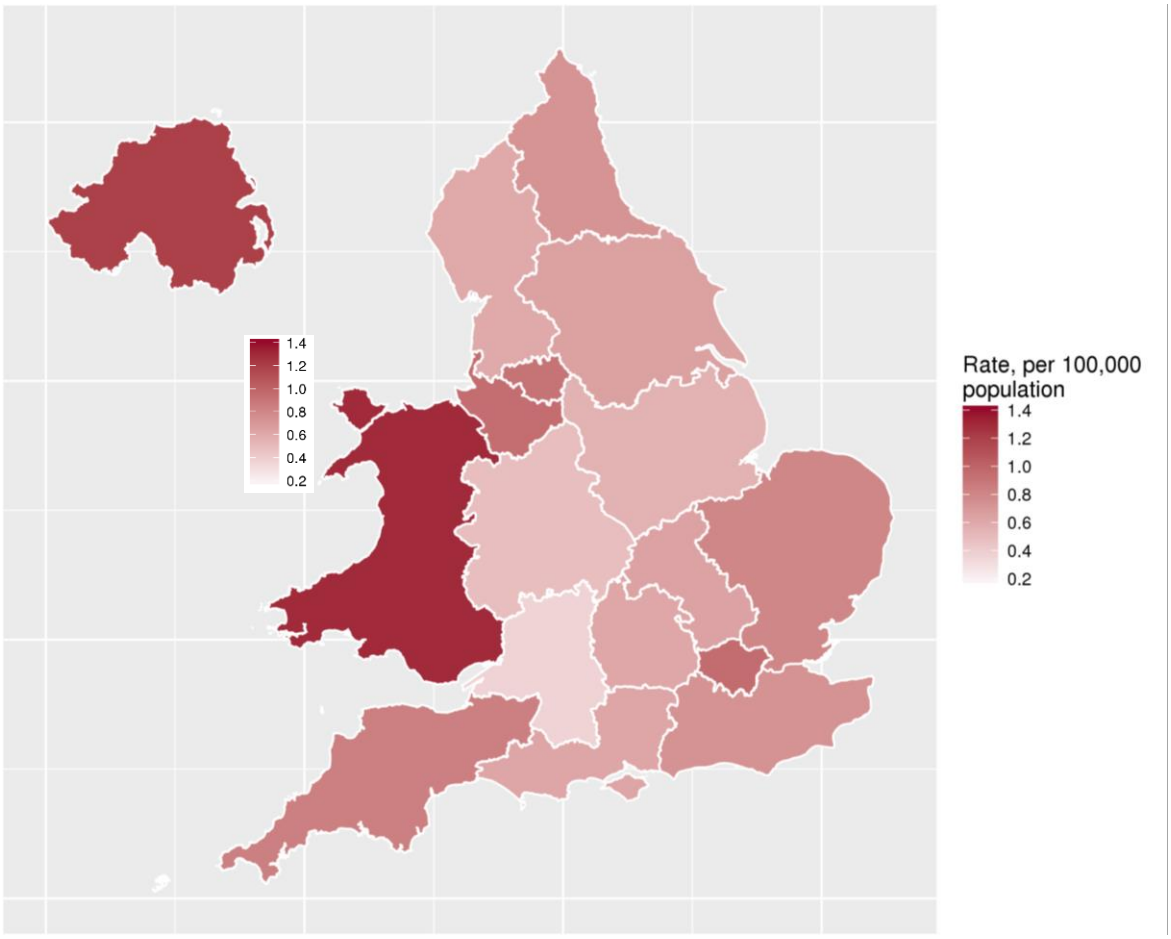


Table 1b. *Stenotrophomonas* bacteraemia rate per 100,000 population by region (England, Wales, and Northern Ireland): 2011 to 2015`

Region		2011	2012	2013	2014	2015
London	London	1.2	0.9	0.9	1.2	0.9
Midlands	Anglia and Essex	0.7	0.8	0.8	0.8	0.8
	East Midlands	0.7	0.7	0.8	0.9	0.6
	South Midlands and Hertfordshire	0.6	0.3	0.2	0.5	0.6
	West Midlands	0.9	1.0	0.7	0.6	0.5
Northern	Cheshire and Merseyside	0.8	0.4	0.4	0.9	0.9
	Cumbria and Lancashire	0.5	0.7	1.2	1.5	0.6
	Greater Manchester	1.5	1.4	1.5	1.2	0.9
	North East	0.8	0.9	0.9	1.0	0.7
	Yorkshire and Humber	0.7	0.6	0.5	0.6	0.6
Southern	Avon Gloucestershire and Wiltshire	0.3	0.7	0.6	0.4	0.4
	Devon Cornwall and Somerset	1.4	0.9	0.8	1.3	1.1
	Kent Surrey and Sussex	0.6	0.5	0.8	0.8	0.7
	Thames Valley	0.7	0.2	0.4	0.4	0.6
	Wessex	0.6	0.7	0.5	0.4	0.4
England*		**0.8**	**0.8**	**0.7**	**0.8**	**0.7**
Northern Ireland†		**0.6**	**0.5**	**1.5**	**1.1**	**1.2**
Wales¥		**0.9**	**1.2**	**0.7**	**0.9**	**1.3**
England, Wales and Northern Ireland		**0.8**	**0.8**	**0.8**	**0.8**	**0.8**

* Data extracted on 4 August 2016. † Data extracted on 27 July 2016. ¥ Data extracted on 20 July 2016

Species distribution

Between 2011 and 2015 in England, Wales and Northern Ireland, *Pseudomonas aeruginosa* has remained the most frequently identified *Pseudomonas* species causing bacteraemia. It accounted for 81-82% of all *Pseudomonas* species identified in blood isolates within this period. In 2015, it made up 81% (n = 3,297/4,077) (table 2a) of the reported *Pseudomonas* bacteraemia. In the same year (2015), 92% of all reported *Pseudomonas* bacteraemia isolates were identified to species level.

Within the same period (2011-2015) in England, Wales and Northern Ireland, 91% to 99% of isolates were identified as *Stenotrophomonas maltophilia* (table 2b). 2014 had the highest percentage (9%; n = 43/503) of *Stenotrophomonas* not identified at species level; however, this reduced to 2% (n = 7/452) in the following year 2015. As *S. maltophilia* is the only known opportunistic human pathogen in the *Stenotrophomonas* genus it is likely that further investigation will yield the incompletely identified isolates as *S. maltophilia* [2].

The most commonly reported closely related organisms[2] between 2011 and 2015 were *Burkholderia* and *Brevundimonas.* In 2015, there were 125 closely related organisms isolated from blood samples, 46% (n = 58) of these were identified as *Burkholderia,* while 35% (n = 44) were identified as *Brevundimonas*

[2]Closely related organisms include genera where at least one species has previously been classified as *Pseudomonas* spp. or *Stenotrophomonas* spp.

Table 2a. Distribution of *Pseudomonas* identified in blood specimens (England, Wales and Northern Ireland); 2011 to 2015

	2011		2012		2013		2014		2015	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
P. aeruginosa	3,071	81%	3,108	81%	3,031	82%	3,071	81%	3,297	81%
P. alcaligenes	4	0%	3	0%	2	0%	4	0%	7	0%
P. fluorescens	42	1%	61	2%	54	1%	55	1%	38	1%
P. mendocina	0	0%	0	0%	1	0%	7	0%	4	0%
P. oryzihabitans	6	0%	6	0%	2	0%	14	0%	21	1%
P. paucimobilis	64	2%	70	2%	65	2%	63	2%	56	1%
P. putida	68	2%	71	2%	58	2%	71	2%	63	2%
P. stutzeri	84	2%	99	3%	82	2%	94	2%	92	2%
Pseudomonas, other named	63	2%	60	2%	72	2%	82	2%	63	2%
Pseudomonas, sp. not recorded	389	10%	338	9%	307	8%	317	8%	428	10%
Genus Total	**3,791**	**100%**	**3,816**	**100%**	**3,675**	**100%**	**3,778**	**1,00%**	**4,077**	**100%**

Table 2b. Distribution of *Stenotrophomonas* identified in blood specimens (England, Wales and Northern Ireland); 2011 to 2015

	2011		2012		2013		2014		2015	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
S. maltophilia	474	99%	446	99%	435	97%	460	91%	445	98%
Stenotrophomonas, sp. not recorded	5	1%	3	1%	12	3%	43	9%	7	2%
Genus Total	**479**	**100%**	**449**	**100%**	**447**	**100%**	**503**	**100%**	**452**	**100%**

Table 2c. Distribution of the 'closely related organisms* identified in blood specimens (England, Wales and Northern Ireland); 2011 to 2015

	2011		2012		2013		2014		2015	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Brevundimonas	27	29%	27	32%	33	33%	43	44%	44	35%
Burkholderia	46	49%	40	48%	48	48%	31	32%	58	46%
Comamonas	16	17%	9	11%	8	8%	12	12%	16	13%
Ralstonia	2	2%	6	7%	8	8%	9	9%	4	3%
Shewanella	3	3%	2	2%	4	4%	3	3%	3	2%
Total	**94**	**100%**	**84**	**100%**	**101**	**100%**	**98**	**100%**	**125**	**100%**

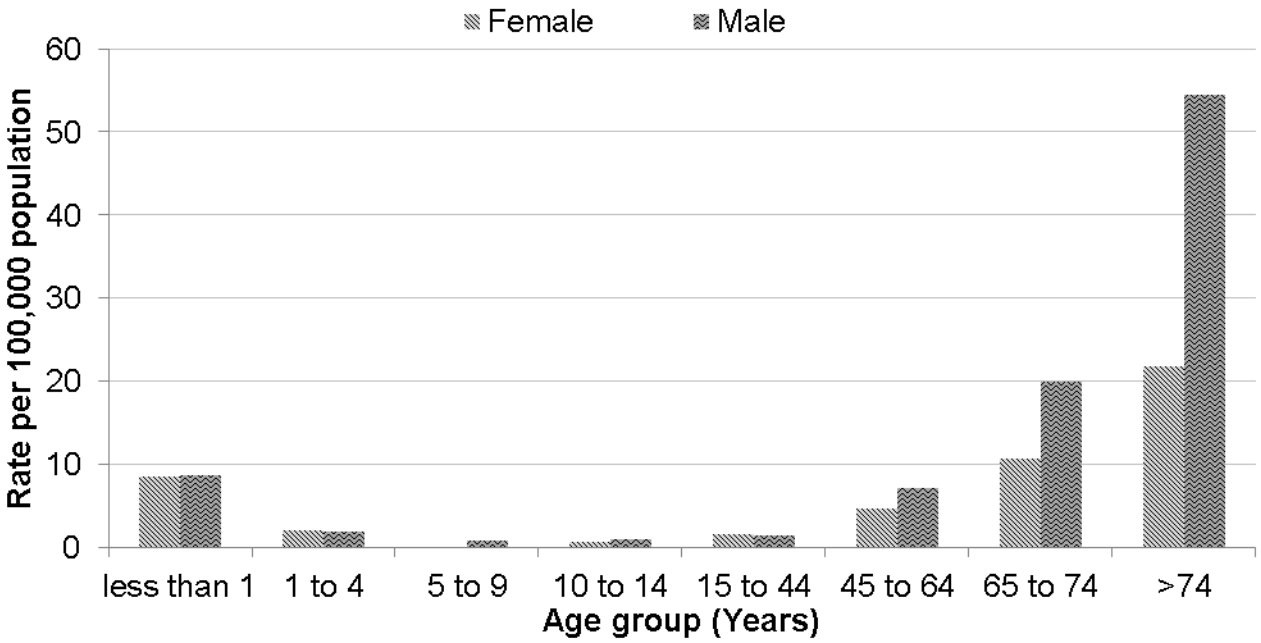
*Closely related organisms include genera where at least one species has previously been classified as *Pseudomonas* or *Stenotrophomonas*

Age and sex distribution: England

In England, the rates of *Pseudomonas* bacteraemia were generally higher among older age groups. A trend of increasing rates was observed with increasing age among those aged 5 years or older. This pattern was not observed in those less than 5 years old, where patients less than 1 year old had the third highest rate of reported *Pseudomonas* bacteraemia. Rates of *Pseudomonas* bacteraemia were higher among males in most age groups except 1 to 4 year olds and 15 to 44 year olds. The largest difference in rates between genders were observed in older age groups (i.e. 65 to 74 years and >74 years).This pattern was similar to what was observed in the previous year (2014) [3].

The highest rates of *Pseudomonas* bacteraemia in England were observed among the elderly (>74 years) at 54.7 and 21.9 reports per 100,000 population for males and females, respectively, followed by older adults (65-74 years) at 20.0 and 10.8 reports per 100,000 population for males and females, respectively. The rates observed among infants (less than 1 year old) were 8.8 and 8.7 reports per 100,000 population for males and females, respectively (figure 3a).

Figure 3a. *Pseudomonas* bacteraemia rates per 100,000 population by age and sex (England): 2015



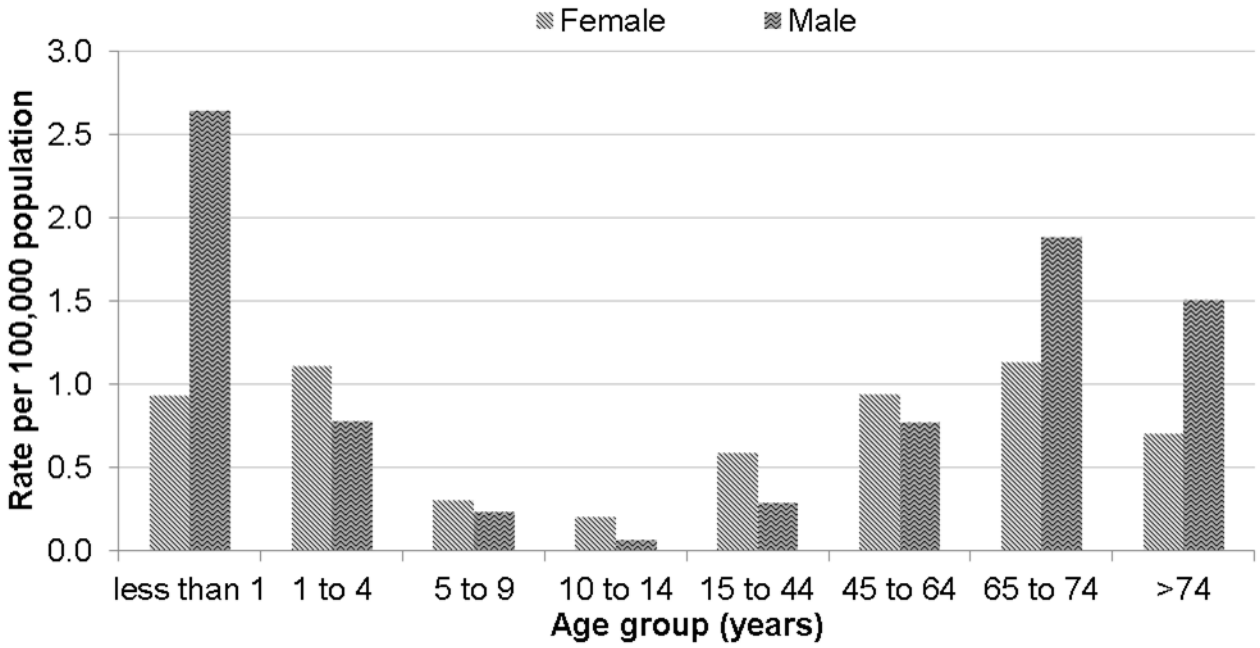
Unlike the age distribution of *Pseudomonas* bacteraemia, rates of reported *Stenotrophomonas* bacteraemia were generally higher in both youngest and oldest age groups (figure 3b). In addition, there was greater variation in the gender distribution of reported *Stenotrophomonas* bacteraemia. While the rates of reported *Stenotrophomonas* bacteraemia were higher among females compared to males in the majority of age groups (1 to 4 years, 5 to 9 years, 10 to 14 years, 15 to

44 years and 45 to 64 years), where the rates among males exceed that among females, the difference in the rates between genders was greater.

The highest rates of *Stenotrophomonas* reported among males were observed in both infants (less than 1 year old; 2.6 reports per 100,000 population) and older adults (65 to 74 years old; 1.9 reports per 100,000 population), while the highest rates among females were observed among older adults (65 to 74 years old) and young children (1 to 4 years old) at 1.1 reports per 100,000 population (figure 3b).

Further investigation would be required to determine the reasons for these differences across age groups and genders.

Figure 3b. *Stenotrophomonas* bacteraemia rates per 100,000 population by age and sex (England): 2015



Antimicrobial susceptibility: England

In England, between 2011 and 2015, the percentage of *Pseudomonas* isolates from blood with a susceptibility result reported for each of the key antimicrobials (table 3a) was at least 72% in each instance with exceptions for imipenem, tobramycin and amikacin. Imipenem was the least frequently tested antimicrobial that *Pseudomonas* isolates were tested against within the five year period (2011-2015), but had the highest observed non-susceptibility (table 3a). In general, the percentage of isolates non-susceptible to key antimicrobials fell between 2011 and 2015 for the majority of agents, with the exception of piperacillin\tazobactam, for which non-susceptibility

increased from 6.8% to 10.1%. The highest reduction in non-susceptibility was observed for tobramycin, which fell from 5.7% to 3.4% within the same period (2011-2015) (table 3a).

In 2015, the highest percentages of non-susceptibility to the antimicrobial agents were observed for imipenem (13.3%), piperacillin\tazobactam (10.1%), ciprofloxacin (9.4%) and meropenem (7.8%). These results are not surprising as *P. aeruginosa,* which accounts for the bulk of reported *Pseudomonas* bacteraemia, is often resistant to multiple antibiotics through intrinsic and adaptive mechanisms [4] to these agents. The relatively higher percentages of non-susceptibility to imipenem, meropenem and ciprofloxacin observed in this report is likely due to the pathogen's ability to develop antibiotic resistance through three main mechanisms - alteration in DNA gyrase by mutations in *gyrA* or *gyrB* genes, decreased drug accumulation by decreased permeability of the cell wall, and enhanced efflux [5]. *P. aeruginosa* cells possess low outer membrane permeability caused by reduced expression of OprD which will limit the penetration of imipenem into its cell [4,6]. On the other hand, non-susceptibility to meropenem is considered to be as a result of overexpression of multi-drug efflux pumps (*MexAB–OprM* and *MexCD–OprJ*) [4,6] which leads to the antibiotic's expulsion from its cells [7]. While the mechanism of the pathogen's resistance to ciprofloxacin involves mutations in *gyrA* or *gyrB* genes (gyrase), as well as *parC* and *parE* (topoisomerase IV) which reduces fluoroquinolones binding affinity [4,5].

Non-susceptibility of *P. aeruginosa* bacteraemia to the antibiotics was mostly similar to that of the other *Pseudomonas* species. However, small difference were observed in their susceptibility to imipenem and piperacillin\tazobactam (appendix 1 and 2)

There is a growing concern regarding the shift towards increased numbers of more drug-resistant organisms, this is a particular concern in *Pseudomonas* species, which are known to affect patients with weakened immune systems. This ongoing concern has led to *Pseudomonas* inclusion as one of the key groups of pathogens to monitor as part of the UK 5-year Antimicrobial Resistance Strategy, as well as the English surveillance programme for antimicrobial utilisation and resistance [8,9].

Analysis on *Stenotrophomonas* non-susceptibility to co-trimoxazole is presented here because it is the generally accepted drug of choice for treatment of *Stenotrophomonas maltophilia* [10,11]. Non-susceptibility of *Stenotrophomonas* to co-trimoxazole increased steadily between 2011 and 2014 before falling by more than 50% (7.6% to 3.2%) to its lowest percentage of non-susceptibility in the five year period presented in 2015 (table 3b). Interestingly, 2015 also had the highest percentage of *Stenotrophomonas* bacteraemia tested for co-trimoxazole. Further investigation would be required to understand the shift in non-susceptibility for the most recent year.

Analysis of resistance to more than one antibiotic (table 4) is based on data extracted from the AMR module of SGSS and is only presented for *Pseudomonas*. As a result, figures here may be different from those included in tables 3a (analysis of susceptibility to individual antibiotics extracted from the CDR module of SGSS). The data are also limited to isolates from England in 2015.

In 2015, 3,407 *Pseudomonas* isolates were tested against at least two of; carbapenems[3], ciprofloxacin, gentamicin and ceftazidime. More than 90% of *Pseudomonas* isolates (n=3,139) were tested against all four antibiotic classes of which only two (<0.1%) were resistant to all four antibiotics. The highest percentage of non-susceptibility (3.6%; n = 117) to pair-wise antimicrobial testing was observed for carbapenems and ciprofloxacin.

For advice on treatment of antibiotic-resistant infections due to these opportunistic pathogens or for reference services including species identification and confirmation of susceptibility testing results, laboratories should contact the Medical Microbiologists at PHE's Bacteriology Reference Department at Colindale on colindalemedmicro@phe.gov.uk and PHE's Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit on amrhai@phe.gov.uk [12].

[3] Meropenem and/or imipenem

Table 3a. Antibiotic susceptibility for *Pseudomonas* bacteraemia in England: 2011 to 2015

	2011		2012		2013		2014		2015	
Antimicrobial	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***
Gentamicin	3,081	5.9%	3,150	4.4%	3,006	3.8%	2,967	4.6%	3,322	3.8%
Ciprofloxacin	2,944	10.6%	2,995	9.7%	2,873	10.3%	2,837	10.9%	3,233	9.4%
Ceftazidime	2,753	9.3%	2,836	7.3%	2,668	7.2%	2,582	7.4%	2,968	7.1%
Meropenem	2,466	9.6%	2,568	8.9%	2,542	8.3%	2,621	9.8%	3,070	7.8%
Imipenem	890	13.8%	891	12.5%	793	14.6%	777	17.1%	903	13.3%
Tobramycin	1,098	5.7%	1,275	4.9%	1,199	4.3%	1,257	3.9%	1,465	3.4%
Amikacin	1,573	4.4%	1,736	3.6%	1,624	3.6%	1,651	3.0%	1,891	3.0%
Piperacillin\Tazobactam	2,854	6.8%	3,000	8.5%	2,906	8.8%	2,844	10.2%	3,189	10.1%
Genus total	**3,442**		**3,507**		**3,359**		**3,471**		**3,759**	

* Defined as reduced- or non-susceptible. Isolates can be tested against multiple antimicrobials.

Table 3b. Antibiotic susceptibility for *Stenotrophomonas* bacteraemia in England: 2011 to 2015

	2011		2012		2013		2014		2015	
Antimicrobial	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***
Co-trimoxazole	256	4.3%	256	3.9%	264	6.1%	277	7.6%	283	3.2%
Genus total	**440**		**404**		**398**		**456**		**390**	

* Defined as reduced- or non-susceptible. Isolates can be tested against multiple antimicrobials

Table 4. Pair-wise antimicrobial testing and resistance summary among *Pseudomonas* isolates causing bacteraemia in England: 2015

Antimicrobial	No. tested	% Resistant
Carbapenems* and ceftazidime	3,195	3.0
Carbapenems* and ciprofloxacin	3,247	3.6
Carbapenems* and gentamicin	3,269	2.0
Ceftazidime and ciprofloxacin	3,225	2.3
Ceftazidime and gentamicin	3,254	1.3
Ciprofloxacin and gentamicin	3,332	2.4

*Meropenem and/or imipenem

Appendix

Appendix 1. Antibiotic susceptibility† for *P. aeruginosa* bacteraemia in England: 2011 to 2015

	2011		2012		2013		2014		2015	
Antimicrobial	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***
Gentamicin	2,522	5%	2,585	4%	2,513	3%	2,450	4%	2,744	4%
Ciprofloxacin	2,431	10%	2,463	9%	2,403	10%	2,337	11%	2,668	9%
Ceftazidime	2,268	8%	2,333	6%	2,232	6%	2,125	7%	2,480	7%
Meropenem	2,036	9%	2,124	9%	2,145	8%	2,173	9%	2,553	8%
Imipenem	777	15%	786	13%	710	16%	683	19%	813	14%
Tobramycin	925	5%	1,091	4%	1,035	3%	1,075	3%	1,279	3%
Amikacin	1,329	4%	1,454	3%	1,382	3%	1,357	3%	1,619	3%
Piperacillin\Tazobactam	2,352	7%	2,467	9%	2,440	9%	2,369	11%	2,645	11%
Species total		**2,779**				**2,843**				**2,768**

† Defined as reduced- or non-susceptible

* Isolates can be tested against multiple antimicrobials

Appendix 2. Antibiotic susceptibility† for *Pseudomonas* bacteraemia (except *P. aeruginosa*) in England: 2011 to 2015

	2011		2012		2013		2014		2015	
Antimicrobial	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***	**No. tested**	**% Resistant***
Gentamicin	559	8%	565	5%	493	5%	516	5%	578	4%
Ciprofloxacin	513	13%	532	12%	470	12%	499	11%	565	11%
Ceftazidime	485	16%	503	13%	436	12%	457	9%	488	9%
Meropenem	430	12%	444	10%	397	10%	448	13%	517	9%
Imipenem	113	6%	105	6%	83	6%	94	6%	90	6%
Tobramycin	173	8%	184	10%	164	11%	182	9%	186	4%
Amikacin	244	6%	282	5%	242	4%	294	5%	272	3%
Piperacillin\Tazobactam	502	7%	533	8%	466	9%	474	6%	544	6%
Genus total		**663**				**664**				**591**

† Defined as reduced- or non-susceptible
* Isolates can be tested against multiple antimicrobials

References

1. Office for National Statistics. Mid-year population estimates for England, Wales and Northern Ireland. Available: http://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland
2. Ryan RP *et al.* The versatility and adaptation of bacteria from the genus *Stenotrophomonas*. *Nat Rev Microbiol*. 2009 Jul;7(7):514-25
3. PHE. Voluntary surveillance of bacteraemia caused by *Pseudomonas* , *Stenotrophomonas maltophilia* and closely related species, England, Wales and Northern Ireland: 2014. Health Protection Report [serial online] 2015; 9(25): Infection Report
4. Elena B.M. Breidenstein, César de la Fuente- Núñez and Robert E.W. Hancock. Pseudomonas aeruginosa: all roads lead to resistance. *Trends in Microbiology.* 2011 Aug;19(8):419-426.
5. Cambau E, Perani E, Dib C, Petinon C, Trias J, Jarlier V. Role of mutations in DNA gyrase genes in ciprofloxacin resistance of *Pseudomonas aeruginosa* susceptible or resistant to imipenem. *Antimicrob Agents Chemother.* 1995 Oct;39(10):2248-2252.
6. El Amin N., Giske C.G., Jalal S., Keijser B., Kronvall G., Wretlind B. Carbapenem resistance mechanisms in *Pseudomonas aeruginosa*: alterations of porin OprD and efflux proteins do not fully explain resistance patterns observed in clinical isolates. *APMIS.* 2005 Mar;113(3):187-196. DOI: 10.1111/j.1600-0463.2005.apm1130306.x
7. Jingjing S., Ziqing D., Aixin Y. Bacterial multidrug efflux pumps: Mechanisms, physiology and pharmacological exploitations. *Biochemical and Biophysical Research Communications.* 2014 Oct;453(2):254-267. DOI: 10.1111/j.1600-0463.2005.apm1130306.x
8. Department of Health. UK 5-year Antimicrobial Resistance (AMR) Strategy 2013-2018
9. PHE. English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) Report 2014.
10. Nicodemo, A.C. & Paez, J.I.G. Antimicrobial therapy for *Stenotrophomonas maltophilia* infections. *Eur J Clin Microbiol Infect Dis*. 2007 Apr;26(4):229-237. doi:10.1007/s10096-007-0279-3
11. David J. Farrell, Helio S. Sader and Ronald N. Jones. Antimicrobial Susceptibilities of a Worldwide Collection of *Stenotrophomonas maltophilia* Isolates Tested against Tigecycline and Agents Commonly Used for *S. maltophilia* Infections. *Antimicrob. Agents Chemother*. 2010 Jun;54(6): 2735-2737.
12. Antimicrobial Resistance and Healthcare Associated Infections Reference Unit (AMRHAI), https://www.gov.uk/amrhai-reference-unit-reference-and-diagnostic-services.

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