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Surveillance of *Proteus, Morganella* and *Providencia* species causing bacteraemia in England: 2015

These analyses are based on *Proteus* spp., *Morganella* spp. and *Providencia* spp. bloodstream infections in England during 2008 to 2015. The data were extracted on 23rd September 2016 from Public Health England's voluntary surveillance database, Secondary Generation Surveillance System (SGSS). SGSS comprises a communicable disease module (CDR; formerly CoSurv/LabBase2) and an antimicrobial resistance module (AMR; formerly AmSurv). Data for Wales and Northern Ireland were extracted separately (DataStore on 20 July and CoSurv on 27 July 2016, respectively) and are included in the geographical and species analyses only.

The analyses presented were based on data extracted from the CDR module of SGSS with the exception of analysis relating to multidrug resistance; this was extracted from the AMR module of SGSS, which captures more comprehensive data of multi-resistance rates than the CDR module. The AMR module is not suitable for trend analyses as it is comprised of recently collected data and has limited laboratory coverage in previous years.

Rates of bacteraemia were calculated using the relevant mid-year population estimates [1]. Geographical analyses for England were based on the 15 local PHE Centres, these were derived by using available postcode (in hierarchical order: patient, GP or laboratory).

This report includes analyses of the trends, age and sex distribution, geographical distribution and antimicrobial susceptibility data in cases of bacteraemia caused by *Proteus* spp., *Morganella* spp. and *Providencia* spp.

The data presented here may differ from previous reports due to inclusion of late reports and the exclusion of Wales and Northern Ireland from some analyses: eight-year trends, age and sex distribution and antimicrobial susceptibility.

Key points

- in England, the overall rate of *Proteus* spp. bacteraemia was 4.8 per 100,000 population (n=2,645) in 2015; this has increased from 4.3 per 100,000 population (n=2,285) in 2008
- in England, the overall rate of *Morganella* spp. bacteraemia was 0.7 per 100,000 population (n=385) in 2015; this has decreased from 0.8 per 100,000 population (n=404) in 2008
- in England, the overall rate of *Providencia* spp. bacteraemia was 0.2 per 100,000 population (n=97) in 2015; this has remained stable with 0.2 per 100,000 population (n=94) in 2008
- in England, the Devon, Cornwall and Somerset PHE Centre had the highest reported incidence rate of *Proteus* spp. in 2015: 6.1 per 100,000 population, followed by Cumbria and Lancashire (5.7 per 100,000 population). The lowest rate was seen in Thames Valley (3.5 per 100,000 population)
- in England, Kent Surrey and Sussex PHE Centre had the highest reported incidence rate of *Morganella* spp. in 2015: 1.1 per 100,000 population, followed by the East Midlands (0.9 per 100,000 population). The lowest rates were seen in South Midlands and Hertfordshire (0.3 per 100,000 population)
- in England, Thames Valley PHE Centre had the highest reported incidence rate of *Providencia* spp. in 2015: 0.4 per 100,000 population, followed by London (0.3 per 100,000 population). The lowest rate was seen in the West Midlands (<0.1 per 100,000 population)
- the majority of bloodstream infection isolates identified as *Proteus* spp. were *P. mirabilis* (87.4%) and *P. vulgaris* (3.4%)
- the majority of bloodstream infection isolates identified as *Providenca* spp. were *P. stuartii* (54.6%) and *P. rettgeri* (34.1%)
- those aged ≥75 had a higher rate of *Proteus* spp., *Morganella* spp. and *Providencia* spp. compared with other age groups
- males were more commonly infected by *Proteus* spp., *Morganella* spp. and *Providencia* spp. compared with females

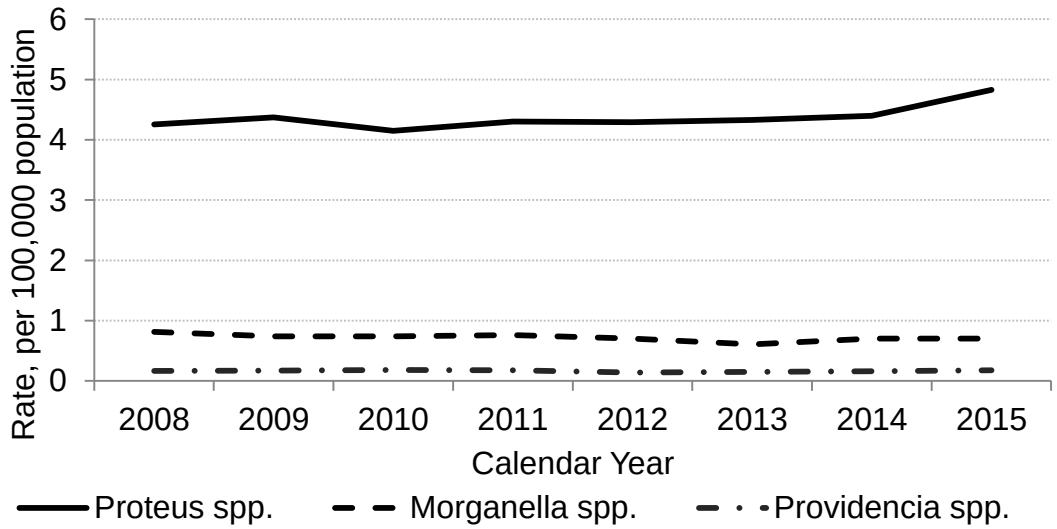
- the proportion of *Proteus mirabilis* and *Proteus vulgaris* bacteraemia reported with resistance to key antimicrobials in 2015 remained stable compared with 2011, emerging resistance to ertapenem has been observed in *P. vulgaris* since 2014
- the proportion of *Morganella morganii* bacteraemia reported with resistance to key antimicrobials in 2015 has observed increased resistance to gentamicin and ciprofloxacin, decreased resistance to ceftazidime and cefotaxime and no change in ampicillin/amoxicillin resistance since 2011
- the proportion of *Providencia stuartii* bacteraemia reported with resistance to key antimicrobials in 2015 increased compared with 2011 with 100% non-susceptibility to ampicillin/amoxicillin since 2014 and emerging resistance to ertapenem in 2015

Trends: England

The overall rate of *Proteus* spp. bacteraemia for England in 2015 was 4.8 per 100,000 population (n=2,645), 12% higher than 4.3 per 100,000 population in 2008 (n=2,285; Figure 1). The overall rate of *Morganella morganii* bacteraemia for England in 2015 was 0.7 per 100,000 population (n=385), representing an 8% decline- since 2008 (0.8 per 100,000 population; n=404; Figure 1). The overall rate of *Providencia* spp. bacteraemia for England in 2015 was 0.2 per 100,000 population (n=97), has remained stable since 2008 (0.2 per 100,000 population; n=94; Figure 1).

Proteus spp. accounted for 2.1% of monomicrobial bloodstream infections (BSI; all reported bacteraemia and/or fungaemia) in 2014; making them the ninth most commonly reported cause of monomicrobial BSI [2]. In contrast, *M. morganii* and *Providencia* spp. accounted for 0.3% (ranked 24th) and <0.1% (ranked 41st) of monomicrobial BSI, respectively in 2014 [2]. *Proteus* spp., *M. morganii* and *Providencia* spp. were identified in 7.2%, 1.5% and 0.4% of polymicrobial BSI, respectively in 2014 [2].

Figure 1. Eight-year trend in *Proteus* spp., *Morganella morganii* and *Providencia* spp. bacteraemia reports per 100,000 population (England); 2008 to 2015



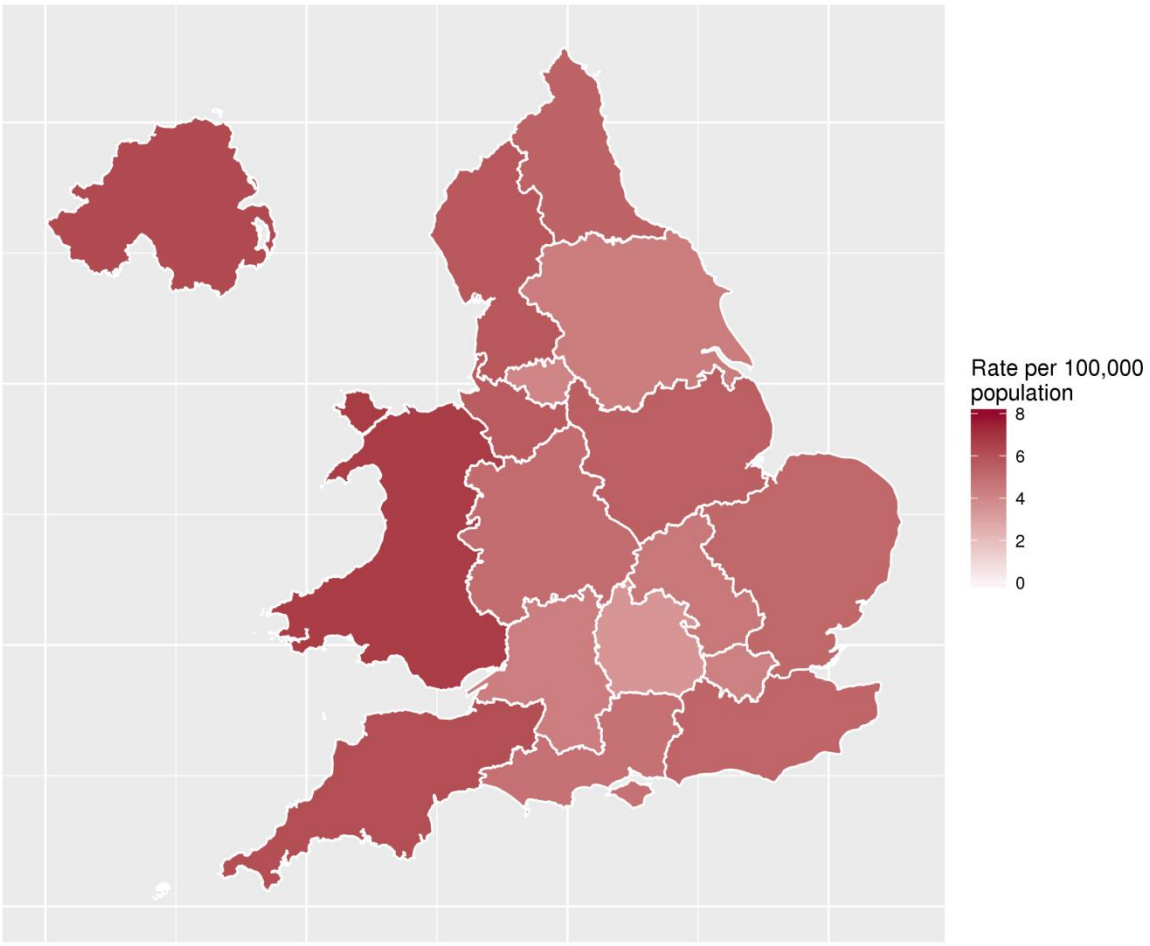
Geographic distribution: England, Wales and Northern Ireland

The Devon, Cornwall and Somerset PHE Centre, in the South of England PHE region, had the highest reported incidence rate of *Proteus* spp. bacteraemia in 2015, 6.1 per 100,000 population followed by the Cumbria and Lancashire PHE Centre with 5.7 per 100,000 population. Thames Valley in the South of England had the lowest reported incidence rate of *Proteus* spp. bacteraemia in 2015 (3.5 per 100,000 population). With the exception of London (6.7% decrease), all PHE Centres have seen increases in their rates of *Proteus* spp. bacteraemia since 2011. The largest increase in the rate of *Proteus* spp. bacteraemia has been observed in the South Midlands and Hertfordshire PHE Centre (59.6% between 2011 and 2015; Table 1a).

Table 1a. Five-year rates for *Proteus* spp. bacteraemia per 100,000 population, England by PHE Centre, Wales, Northern Ireland; 2011 to 2015

Region		Rate, per 100,000 population				
		2011	2012	2013	2014	2015
North of England	Cheshire and Merseyside	4.9	4.1	5.0	4.7	5.6
	Cumbria and Lancashire	4.0	3.7	4.4	4.3	5.7
	Greater Manchester	3.4	4.6	3.0	3.5	4.1
	North East	4.4	4.3	4.8	5.7	5.4
	Yorkshire and Humber	4.2	4.2	3.7	4.3	4.4
Midlands and East of England	South Midlands and Hertfordshire	2.8	3.9	3.8	4.1	4.5
	East Midlands	5.1	5.1	5.4	4.8	5.5
	Anglia and Essex	4.8	5.1	5.1	5.5	5.2
	West Midlands	4.7	4.9	4.7	4.5	5.0
London	London	4.5	4.2	4.3	4.3	4.2
South of England	Avon Gloucestershire and Wiltshire	4.3	4.1	3.9	3.4	4.3
	Devon Cornwall and Somerset	4.8	4.4	4.2	4.9	6.1
	Kent Surrey and Sussex	4.1	3.7	4.9	4.2	5.2
	Thames Valley	2.5	2.1	2.0	2.4	3.5
	Wessex	4.3	4.6	4.4	4.7	4.8
England		**4.3**	**4.3**	**4.3**	**4.4**	**4.8**
Northern Ireland		**5.3**	**6.2**	**6.4**	**6.0**	**6.3**
Wales		**5.6**	**5.0**	**5.6**	**6.2**	**6.7**
England, Wales and Northern Ireland		**4.3**	**4.3**	**4.4**	**4.5**	**5.0**

Figure 2a. Geographical distribution of *Proteus* spp. bacteraemia per 100,000 population in England, Wales, Northern Ireland, 2015

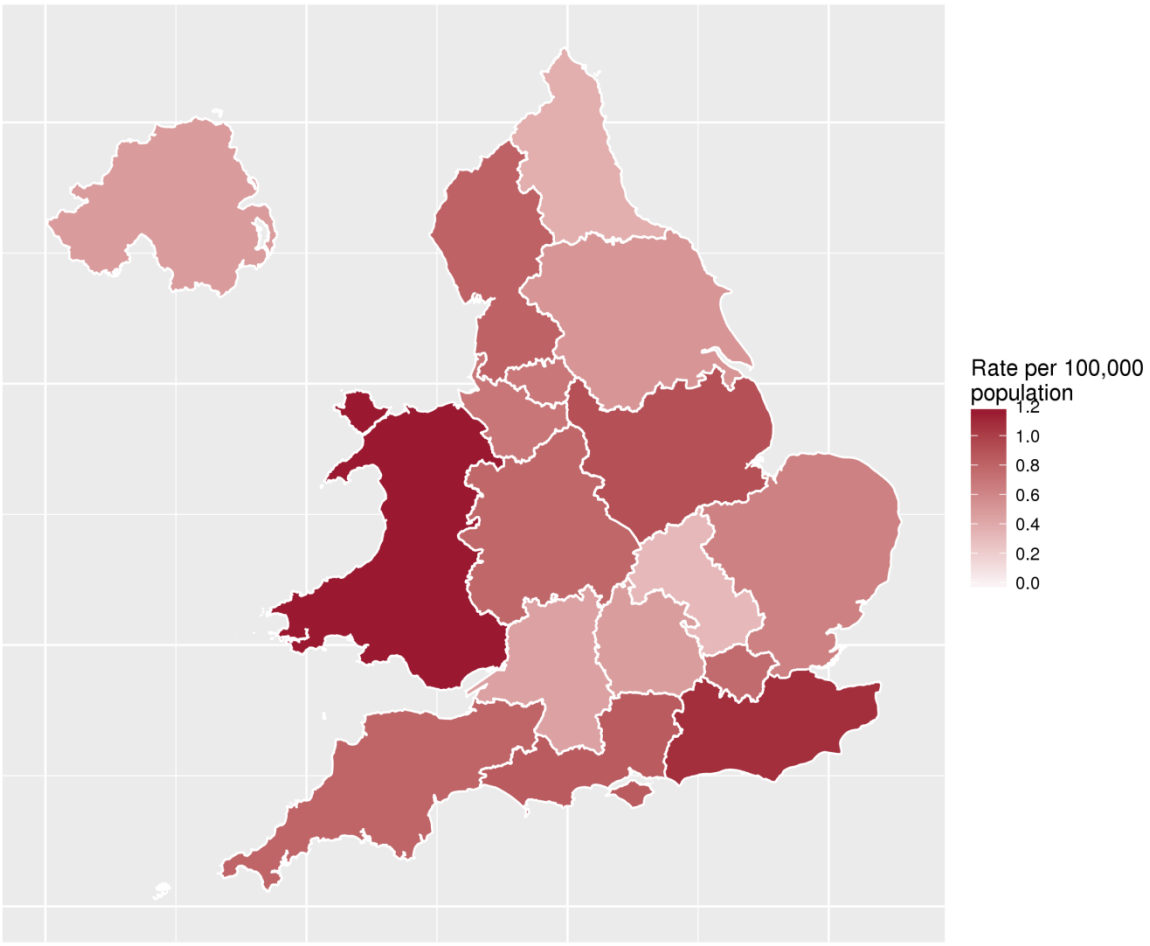


Kent, Surrey and Sussex PHE Centre, in the South of England PHE region, had the highest reported incidence rate of *Morganella* spp. bacteraemia in 2015, 1.1 per 100,000 population, followed by the East Midlands with 0.9 per 100,000 population. South Midlands and Hertfordshire had the lowest reported incidence rate of *Morganella* spp. in 2015, 0.3 per 100,000 population. There has been an overall decrease in England, Wales and Northern Ireland compared with 2011, however, there was variability in the trends across PHE Centres, with a 72% increase in rate, between 2011 and 2015, observed in the Wessex PHE Centre (Table 1b).

Table 1b. Five year rates for *Morganella* spp. bacteraemia per 100,000 population, England by PHE Centre, Wales, Northern Ireland; 2011 to 2015

Region		Rate, per 100,000 population				
		2011	2012	2013	2014	2015
North of England	Cheshire and Merseyside	0.5	0.7	0.5	0.9	0.7
	Cumbria and Lancashire	0.7	1.2	0.7	0.5	0.8
	Greater Manchester	0.9	0.7	0.4	0.7	0.7
	North East	0.5	0.6	0.4	0.7	0.4
	Yorkshire and Humber	0.9	0.7	0.4	0.4	0.5
Midlands and East of England	South Midlands and Hertfordshire	0.6	0.6	0.7	0.7	0.3
	East Midlands	1.0	0.6	0.6	0.7	0.9
	Anglia and Essex	0.8	0.6	0.8	0.7	0.6
	West Midlands	0.8	0.7	0.7	0.8	0.8
London	London	0.8	0.9	0.7	0.8	0.8
South of England	Avon Gloucestershire and Wiltshire	0.7	0.4	0.5	0.7	0.5
	Devon Cornwall and Somerset	0.6	0.5	0.9	0.8	0.8
	Kent Surrey and Sussex	0.9	0.8	0.7	0.9	1.1
	Thames Valley	0.5	0.3	0.3	0.4	0.5
	Wessex	0.5	0.5	0.5	0.5	0.8
England		**0.8**	**0.7**	**0.6**	**0.7**	**0.7**
Northern Ireland		**0.7**	**0.8**	**0.7**	**0.5**	**0.5**
Wales		**1.8**	**0.9**	**1.0**	**0.9**	**1.2**
England, Wales and Northern Ireland		**0.8**	**0.7**	**0.6**	**0.7**	**0.7**

Figure 2b. Geographical distribution of *Morganella* spp. bacteraemia per 100,000 population in England, Wales, Northern Ireland, 2015

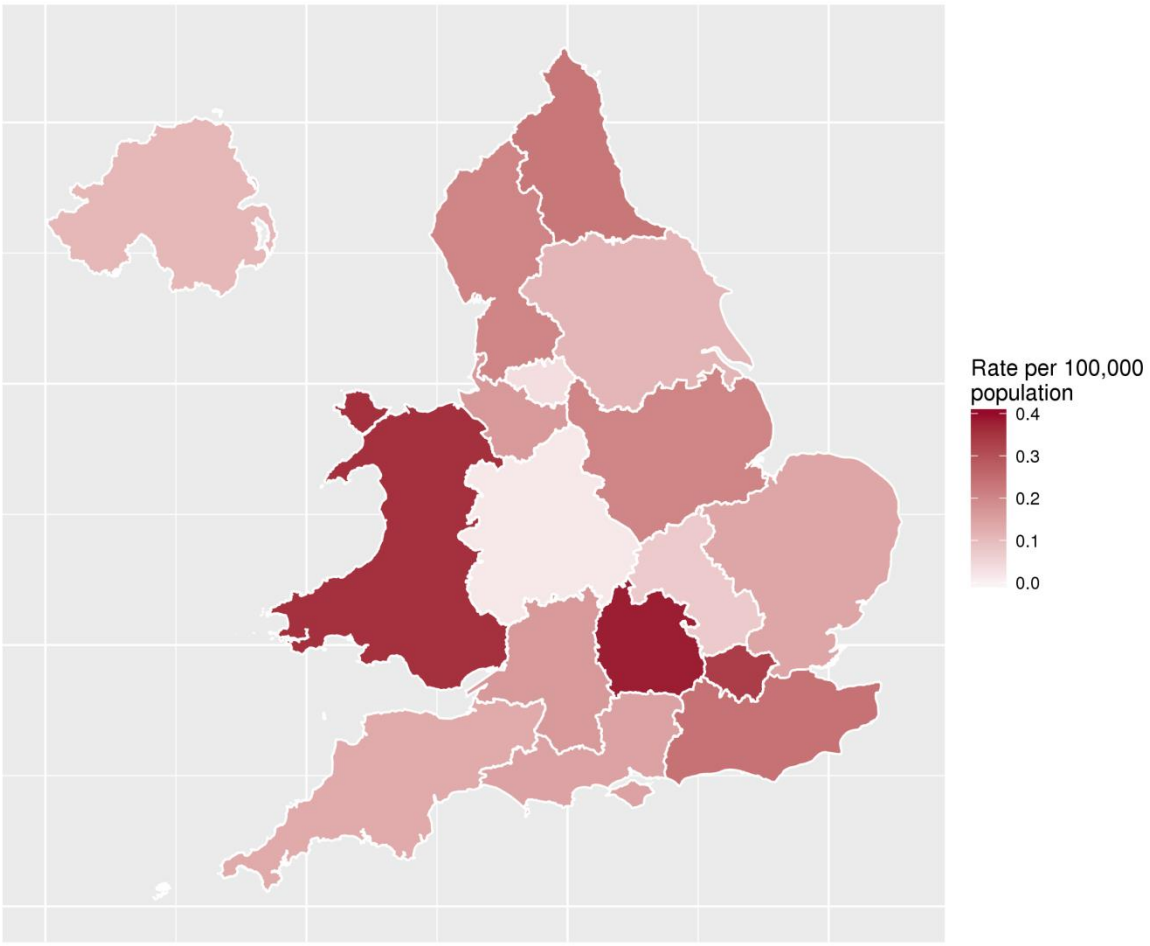


Thames Valley PHE Centre, in the South of England PHE region, had the highest reported incidence rate of *Providencia* spp. bacteraemia in 2015 (0.4 per 100,000 population) followed by London, with 0.3 per 100,000 population. Greater Manchester and the West Midlands had the lowest reported incidence rate of *Providencia* spp. bacteraemia in 2015, <0.1 per 100,000 population. There was variability in the trends across PHE Centres, however, there was an overall increase in the aggregated rate of England, Wales and Northern Ireland in 2015 compared to 2011.

Table 1c. Five-year rates for *Providencia* spp. bacteraemia per 100,000 population, England by PHE Centre, Wales, Northern Ireland; 2011 to 2015

Region		Rate, per 100,000 population				
		2011	**2012**	**2013**	**2014**	**2015**
North of England	Cheshire and Merseyside	0.1	0.1	0.1	0.1	0.2
	Cumbria and Lancashire	0.3	0.0	0.1	0.2	0.2
	Greater Manchester	0.1	0.3	0.1	0.1	<0.1
	North East	0.0	0.2	<0.1	0.1	0.2
	Yorkshire and Humber	0.3	0.2	0.1	0.1	0.1
Midlands and East of England	South Midlands and Hertfordshire	0.1	0.1	0.2	0.2	0.1
	East Midlands	0.2	0.2	0.1	0.2	0.2
	Anglia and Essex	0.1	0.1	0.2	0.1	0.1
	West Midlands	0.2	0.1	0.1	0.3	<0.1
London	London	0.2	0.2	0.3	0.2	0.3
South of England	Avon Gloucestershire and Wiltshire	0.1	<0.1	<0.1	0.0	0.2
	Devon Cornwall and Somerset	0.2	0.1	0.0	0.2	0.1
	Kent Surrey and Sussex	0.1	0.2	0.2	0.1	0.2
	Thames Valley	0.1	0.0	0.1	0.1	0.4
	Wessex	0.3	<0.1	0.2	0.1	0.1
England		**0.2**	**0.1**	**0.2**	**0.2**	**0.2**
Northern Ireland		**0.1**	**0.2**	**0.2**	**0.2**	**0.1**
Wales		**0.2**	**0.3**	**0.2**	**0.2**	**0.4**
England, Wales and Northern Ireland		**0.2**	**0.1**	**0.2**	**0.2**	**0.2**

Figure 2c. Geographical distribution of *Providencia* spp. bacteraemia per 100,000 population in England, Wales, Northern Ireland, 2015



Species distribution: England, Wales and Northern Ireland

In England, the majority of *Proteus* spp. bacteraemia isolates were identified to species level (91%), similar to previous years (Table 2a). In 2015, as in previous years, the predominant species was *P. mirabilis* accounting for 88% of bacteraemia, followed by *P. vulgaris* (3%). In Wales, the majority of *Proteus* spp. bacteraemia isolates were identified to species level (97%). In 2015, the predominant species was *P. mirabilis* (94%); the proportion of *P. vulgaris* has remained stable since 2013 at 3%. In Northern Ireland, the majority of *Proteus* spp. bacteraemia isolates were identified to species level (97%), and, in 2015, the predominant species was *P. mirabilis* (94%); the proportion of *P. vulgaris* has remained stable since 2011 at <3%.

Table 2a. Distribution of *Proteus* spp. identified in blood specimens, England, Wales, Northern Ireland 2011 to 2015

Species	2011		2012		2013		2014		2015	
	No.	%	No.	%	No.	%	No.	%	No.	%
England										
***Proteus* spp.**	**2,285**	**100**	**2,295**	**100**	**2,332**	**100**	**2,390**	**100**	**2,645**	**100**
P. mirabilis	1,976	86	2,001	87	2,070	89	2,139	89	2,335	88
P. penneri	4	<1	1	<1	4	<1	6	<1	3	<1
P. vulgaris	83	4	80	3	58	2	77	3	77	3
Proteus spp., other named	0	0	1	<1	0	0	1	<1	4	<1
Proteus spp., sp. not recorded	222	10	212	9	200	9	167	7	226	9
Wales										
***Proteus* spp.**	**172**	**100**	**153**	**100**	**173**	**100**	**192**	**100**	**208**	**100**
P. mirabilis	0	0	129	84	157	91	174	91	196	94
P. vulgaris	0	0	10	7	5	3	6	3	6	3
Proteus spp., not recorded	172	100	13	9	11	6	12	6	6	3
Proteus spp., other named	0	0	1	1	0	0	0	0	0	0
Northern Ireland										
***Proteus* spp.**	**96**	**100**	**113**	**100**	**118**	**100**	**111**	**100**	**116**	**100**
P. mirabilis	94	98	112	99	115	98	106	96	109	94
P. vulgaris	0	0	1	1	3	3	2	2	3	3
Proteus spp., not recorded	2	2	0	0	0	0	3	3	4	3
Proteus spp., other named	0	0	0	0	0	0	0	0	0	0

In England, trends for *Morganella morganii* have remained stable since 2011 (Table 2b). Reported cases have decreased in Wales (35% from 55 in 2011 to 36 in 2015) and in Northern Ireland (31% from 13 in 2011 to 9 in 2015) (Table 2b).

Table 2b. Distribution of *Morganella morganii* identified in blood specimens, England, Wales, Northern Ireland 2011 to 2015

Species	2011		2012		2013		2014		2015	
	No.	%	No.	%	No.	%	No.	%	No.	%
England										
***Morganella* spp.**	**404**	**100**	**377**	**100**	**326**	**100**	**383**	**100**	**385**	**100**
M. morganii	404	100	377	100	326	100	383	100	384	99
Morganella spp., sp. not recorded	0	0	0	0	0	0	0	0	1	<1
Wales										
Morganella morganii	**55**	**100**	**29**	**100**	**32**	**100**	**27**	**100**	**36**	**100**
Northern Ireland										
Morganella morganii	**13**	**100**	**14**	**100**	**13**	**100**	**10**	**100**	**9**	**100**

In England, all *Providencia* spp. were identified to species level in both 2014 and 2015. The most frequent species identified from blood isolates was *P. stuartii* (62%), followed by *P. rettgeri* (35%); of note, there has been a 47% increase in reported isolates of *P. rettgeri* since 2011. There has been an 8% increase overall in reported *Providencia* spp. isolates across England, Wales and Northern Ireland since 2011. In Wales and Northern Ireland, all *Providencia* spp. bacteraemia isolates were identified to species level since 2011. In Wales, the predominant species in 2015 was *P. rettgeri* (64%), whereas in previous years *P. stuartii* had been the dominant species. In Northern Ireland, there was an equal number of *P. stuartii & P. rettgeri* (50% each), the same as in the previous year.

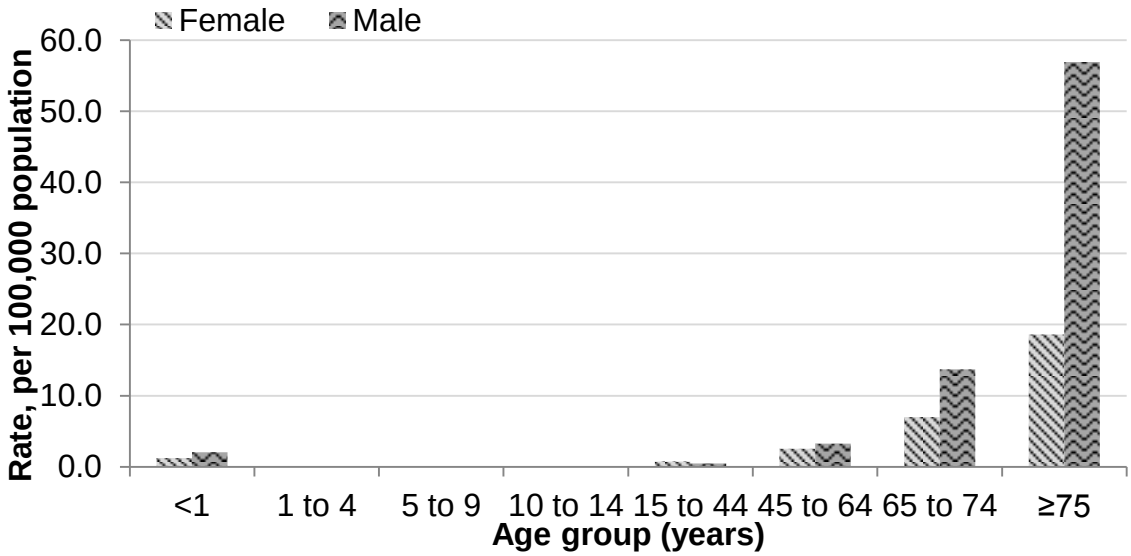
Table2c. Distribution of *Providencia* spp. identified in blood specimens, England, Wales, Northern Ireland 2011 to 2015

Species	2011		2012		2013		2014		2015	
	No.	%	No.	%	No.	%	No.	%	No.	%
England										
***Providencia* spp.**	**94**	**100**	**74**	**100**	**81**	**100**	**88**	**100**	**97**	**100**
P. alcalifaciens	10	11	6	8	4	5	0	0	3	3
P. rettgeri	23	24	31	42	29	36	41	47	34	35
P. stuartii	54	57	34	46	45	56	38	43	60	62
Providencia spp., other named	0	0	2	3	3	4	5	6	0	0
Providencia spp., sp. not recorded	7	7	1	1	0	0	4	5	0	0
Wales										
***Providencia* spp.**	**6**	**100**	**8**	**100**	**6**	**100**	**7**	**100**	**11**	**100**
P. rettgeri	3	50	3	38	1	17	2	29	7	64
P. stuartii	3	50	2	25	5	83	3	43	3	27
Providencia spp., other named	0	0	2	25	0	0	1	14	1	9
Providencia spp., sp. not recoded	0	0	1	13	0	0	1	14	0	0
Northern Ireland										
***Providencia* spp.**	**2**	**100**	**3**	**100**	**3**	**100**	**4**	**100**	**2**	**100**
P. rettgeri	1	50	0	0	1	33	2	50	1	50
P. stuartii	1	50	3	100	2	67	2	50	1	50
Providencia spp., other named	0	0	0	0	0	0	0	0	0	0
Providencia spp., sp. not recoded	0	0	0	0	0	0	0	0	0	0

Age and sex distribution: England

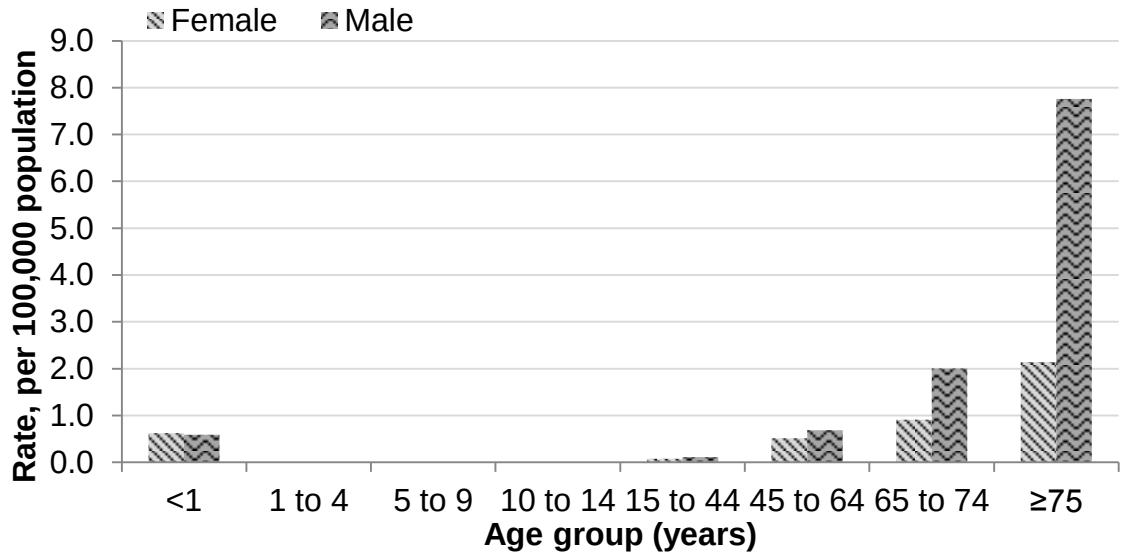
Age distribution of *Proteus* spp. bacteraemia for 2015 in England can be seen in Figure 3a. The highest rate of *Proteus* spp. bacteraemia was observed in those aged 75 years or older (34.7 per 100,000 population), followed by those aged 65 to 74 years (10.2 per 100,000 population). There were few cases reported in children aged one to 14. Males had higher rates of *Proteus* spp. bacteraemia than females in all age groups, except the 15 to 44 years age group, however incidence in this age band is low (<1 per 100,000 population).

Figure 3a. Rate per 100,000 population *Proteus* spp. by age and sex (England); 2015



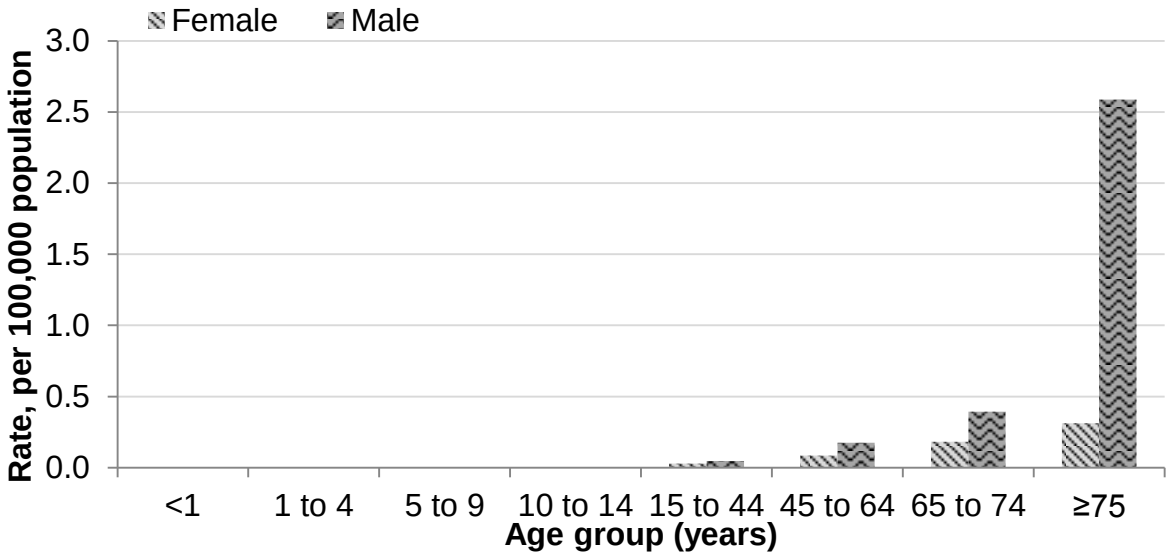
Age distribution of *Morganella* spp. bacteraemia for 2015 can be seen in Figure 3b. The highest rate of *Morganella* spp. bacteraemia was observed in those aged 75 years or older (4.5 per 100,000 population), followed by those aged 65 to 74 years (1.4 per 100,000 population). Males had higher rates of *Morganella* spp. bacteraemia than females in all age groups, except in those less than one year of age, where the rate was the same (0.6 per 100,000 population). The gender-disparity observed in those of at least one year of age was greatest in those aged 75 years or older, with over an 3-fold difference (7.8 versus 2.1 per 100,000 population). There were no *Morganella morganii* bacteraemias reported in persons aged 1 to 14 years.

Figure 3b. Population rate by age group for bacteraemia caused by *Morganella morganii* (England); 2015



Age distribution of *Providencia* spp. bacteraemia for 2015 can be seen in Figure 3c. The highest rate of *Providencia* spp. bacteraemia was observed in those aged 75 years or older (1.3 per 100,000 population), followed by those aged 65 to 74 years (0.3 per 100,000 population). Males had higher rates of *Providencia* spp. bacteraemia than females in all age groups. This gender-disparity was greatest in those aged 75 years or older, with over an 8-fold difference (2.6 versus 0.3 per 100,000 population in 2015). There were no *Providencia* spp. bacteraemias reported in persons less than 15 years of age.

Figure 3c. Population rate by age group for bacteraemia caused by *Providencia* spp. (England); 2015



Antimicrobial resistance: England

The proportion of *Proteus mirabilis* and *Proteus vulgaris* isolates with susceptibility test results reported in 2015 ranged from 50%-91% and 43%-78%, respectively, for key antimicrobials (Table 3a and 3b). The percentage of non-susceptible *P. mirabilis* bacteraemia isolates reported was ampicillin/amoxicillin (32%), gentamicin (6%), cefotaxime (2%), ceftazidime (<1%), ciprofloxacin (8%), ertapenem (<1%) and meropenem (0%); which have remained relatively constant since 2011 (Table 3a). The percentage of non-susceptible *P. vulgaris* bacteraemia isolates reported was ampicillin/amoxicillin (87%), gentamicin (8%), cefotaxime (6%), ceftazidime (4%), ciprofloxacin (5%), ertapenem (3%) and meropenem (0%), these have remained relatively stable since 2011; of note, ertapenem resistance emerged in 2014 (3%; Table 3b).

The proportion of *Morganella morganii* isolates with susceptibility test results reported in 2015 ranged from 47%-88% (Table 3c) for key antimicrobials. The percentage of non-susceptible *M. morganii* bacteraemia isolates reported was ampicillin/amoxicillin (98%), gentamicin (12%), cefotaxime (21%), ceftazidime (23%), ciprofloxacin (17%), ertapenem (<1%) and meropenem (<1%); increased resistance

to gentamicin (26%) and ciprofloxacin (55%), and decreased resistance to ceftazidime (9%) and cefotaxime (10%) has been observed since 2011 (Table 3c). Resistance to ampicillin/amoxicillin has remained stable since 2011.

The proportion of *Providencia stuartii* isolates with susceptibility test results reported in 2015 ranged from 47%-85% (Table 3d) for key antimicrobials. The percentage of non-susceptible *P. stuartii* bacteraemia isolates reported in 2015 was ampicillin/amoxicillin (100%), gentamicin (59%), cefotaxime (11%), ceftazidime (11%), ciprofloxacin (13%), ertapenem (6%) and meropenem (4%). All reported rates of *P. stuartii* resistance have increased to the reported antibiotics across the five year period with the largest increases seen in ceftazidime (99%) and ciprofloxacin (44%) observed since 2011 (Table 3d). One-hundred percent non-susceptibility to ampicillin/amoxicillin has been observed in *P. stuartii* since 2014; however, high non-susceptibility is expected due to the possession of chromosomal β-lactamases in *P. stuartii* [3].

EUCAST advises that due to the production of a chromosomal enzyme, *P. stuartii* should be considered to be resistant to clinically available aminoglycosides, except amikacin and streptomycin. Some isolates express the enzyme poorly and can appear to be susceptible to netilmicin *in vitro*, but should be reported as resistant, as mutation can result in overproduction of this enzyme [4].

Table 3a. Antimicrobial susceptibility for *Proteus mirabilis* bacteraemia (England); 2011 to 2015

Antimicrobial agent	2011 No. Tested	2011 %Resistant* (R)	2012 No. Tested	2012 % R*	2013 No. Tested	2013 % R*	2014 No. Tested	2014 % R*	2015 No. Tested	2015 % R*
Ampicillin/ Amoxicillin	1,644	34	1,743	33	1,738	33	1,707	34	1,959	33
Gentamicin	1,684	6	1,796	7	1,835	7	1,834	8	2,123	6
Ciprofloxacin	1,587	7	1,675	8	1,718	7	1,658	7	1,998	8
Ceftazidime	1,363	2	1,378	1	1,359	2	1,362	1	1,653	<1
Cefotaxime	936	2	1,044	1	1,087	2	1,018	1	1,178	2
Meropenem	1,260	<1	1,371	<1	1,501	0	1,505	<1	1,918	0
Ertapenem	467	<1	661	<1	849	<1	1,035	<1	1,633	<1
Total Reports	**1,976**		**2,001**		**2,070**		**2,140**		**2,335**	

* defined as reduced- or non-susceptible

Table 3b. Antimicrobial susceptibility for *Proteus vulgaris* bacteraemia (England); 2011 to 2015

Antimicrobial agent	2011 No. Tested	2011 %Resistant* (R)	2012 No. Tested	2012 % R*	2013 No. Tested	2013 % R*	2014 No. Tested	2014 % R*	2015 No. Tested	2015 % R*
Ampicillin/ Amoxicillin	71	87	68	94	52	94	60	93	55	87
Gentamicin	71	4	70	4	52	4	66	2	60	8
Ciprofloxacin	70	3	61	0	50	0	59	2	57	5
Ceftazidime	62	5	53	8	36	8	52	6	46	4
Cefotaxime	34	3	41	10	26	8	33	9	33	6
Meropenem	54	2	58	0	44	0	60	0	56	0
Ertapenem	16	0	24	0	23	0	32	3	40	3
Total Reports	**83**		**80**		**58**		**77**		**77**	

* defined as reduced- or non-susceptible

Table 3c. Antimicrobial susceptibility for *Morganella morganii* bacteraemia (England); 2011 to 2015

Antimicrobial agent	2011		2012		2013		2014		2015	
	No. Tested	%Resistant * (R)	No. Tested	% R*	No. Tested	% R*	No. Tested	% R*	No. Tested	% R*
Ampicillin/ Amoxicillin	328	96	315	98	265	96	296	98	315	98
Gentamicin	352	10	336	8	288	9	333	8	338	12
Ciprofloxacin	328	11	310	11	267	9	309	11	315	17
Ceftazidime	263	25	256	21	225	18	238	19	268	23
Cefotaxime	201	24	204	18	162	19	175	15	182	21
Meropenem	276	0	251	0	239	<1	280	0	308	<1
Ertapenem	97	0	120	0	135	<1	178	0	253	<1
Total Reports	**404**		**377**		**326**		**382**		**384**	

* defined as reduced- or non-susceptible

Table 3d. Antimicrobial susceptibility for *Providencia stuartii* bacteraemia (England); 2011 to 2015

Antimicrobial agent	2011		2012		2013		2014		2015	
	No. Tested	%Resistant* (R)	No. Tested	% R*	No. Tested	% R*	No. Tested	% R*	No. Tested	% R*
Ampicillin/ Amoxicillin	42	98	26	92	37	86	26	100	45	100
Gentamicin	43	49	27	59	41	54	31	61	51	59
Ciprofloxacin	46	9	28	0	38	11	30	10	48	13
Ceftazidime	35	6	27	7	32	6	25	8	44	11
Cefotaxime	24	8	17	0	28	4	22	5	28	11
Meropenem	33	0	22	0	36	0	24	0	48	4
Ertapenem	14	0	12	0	18	0	20	0	34	6
Total Reports	**54**		**34**		**45**		**38**		**60**	

* defined as reduced- or non-susceptible

Tables 4a-d show the dual resistance of *Proteus mirabilis, Proteus vulgaris, Morganella morganii* and *Providencia stuartii* respectively to third-generation cephalosporins, gentamicin or ciprofloxacin in a single year snapshot. Dual resistance is rare, seen for 0-3% of all bacteraemia isolates due to *Proteus* spp., 4-7% due to *M. morganii* and 0-7% of *Providencia* spp. Multi-drug resistance to meropenem in combination with gentamicin, ciprofloxacin and 3rd-generation cephalosporins (not shown) was detected in *P. stuartii* (4%). No meropenem multi-drug resistance was detected in *M. morganii*, *P. vulgaris* or *P. stuartii.*

A three-year susceptibility study in United States and European hospitals comparing ICU and non-ICUs in 2009-11 reported *P. mirabilis* non-susceptibility of 5%-10% to 3rd generation cephalosporins, 18%-27% to ciprofloxacin, and 17%-19% to gentamicin in their European isolates [5]. A similar study in 2003 reported individual resistance of *M. morganii* to ciprofloxacin (9-20%), gentamicin (6-16%) and 3rd generation cephalosporins (3-30% depending on the individual antimicrobial) [6].

Table 4a. Pair-Wise antimicrobial testing and non-susceptibility summary for *Proteus mirabilis* (England); 2015

Antimicrobial	No. tested	% Resistant†
Gentamicin and Ciprofloxacin	2151	3
Gentamicin and 3rd Generation Cephalosporins*	1313	<1
Ciprofloxacin and 3rd Generation Cephalosporins*	1312	<1

*Cefotaxime, Ceftazidime, Ceftriaxone, Cefpodoxime
†defined as reduced- or non-susceptible

Table 4b. Pair-Wise antimicrobial testing and non-susceptibility summary for *Proteus vulgaris* (England); 2015

Antimicrobial	No. tested	% Resistant†
Gentamicin and Ciprofloxacin	59	3
Gentamicin and 3rd Generation Cephalosporins*	37	0
Ciprofloxacin and 3rd Generation Cephalosporins*	37	0

*Cefotaxime, Ceftazidime, Ceftriaxone, Cefpodoxime
†defined as reduced- or non-susceptible

Table 4c. Pair-Wise antimicrobial testing and non-susceptibility summary for *Morganella morganii* (England); 2015

Antimicrobial	No. tested	% Resistant†
Gentamicin and Ciprofloxacin	356	7
Gentamicin and 3rd Generation Cephalosporins*	213	4
Ciprofloxacin and 3rd Generation Cephalosporins*	213	6

*Cefotaxime, Ceftazidime, Ceftriaxone, Cefpodoxime
†defined as reduced- or non-susceptible

Table 4d. Pair-Wise antimicrobial testing and non-susceptibility summary for *Providencia stuartii* (England); 2015

Antimicrobial	No. tested	% Resistant†
Gentamicin and Ciprofloxacin	55	7
Gentamicin and 3rd Generation Cephalosporins*	34	6
Ciprofloxacin and 3rd Generation Cephalosporins*	35	0

*Cefotaxime, Ceftazidime, Ceftriaxone, Cefpodoxime
†defined as reduced- or non-susceptible

For treatment or antibiotic-resistant advice of these opportunistic pathogens or reference services (species identification, molecular comparison and confirmation of susceptibility testing results) laboratories may 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 in London [7].

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