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Laboratory surveillance of *Klebsiella* spp. bacteraemia in England, Wales and Northern Ireland: 2017

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Laboratory surveillance of *Klebsiella* spp. bacteraemia in England, Wales and Northern Ireland: 2017

The following analysis is based on voluntary surveillance of diagnoses of bloodstream infections caused by *Klebsiella* spp. reported by laboratories between 2009 and 2017 in England, Wales and Northern Ireland. *Klebsiella* spp. became mandatory for reporting as of 1 April 2017. As a result, data presented from the mandatory surveillance scheme will be reported in future HPR reports. Voluntary surveillance data for England were extracted on 18 April 2018 from Public Health England's (PHE) Second Generation Surveillance System (SGSS). Data for Wales and Northern Ireland were extracted separately from DataStore and CoSurv systems, on 6 February and 14 March 2018, respectively.

Rates of laboratory reported bacteraemia were calculated using mid-year resident population estimates for the respective year and geography with the exception of 2017, which were based on 2016 population estimates, as data were not yet available at the time of producing this report [1,2]. Geographical analyses were based on the patient's residential postcode. Where this information was unknown, the postcode of the patient's General Practitioner was used. Failing that, the postcode of the reporting laboratory was used. Cases in England were further assigned to one of nine local PHE Centres (PHECs), formed from the administrative local authority boundaries [3].

The following report will look at the trends and geographical distribution of *Klebsiella* spp. bacteraemia rates. Cases are further broken down by species, age and sex. Single-agent antimicrobial susceptibility trends since 2015 are reported for England and Northern Ireland based on SGSS AMR and CoSurv data, respectively. Multi-drug antimicrobial resistance trends since 2015 are reported for England, based on SGSS AMR data. A web appendix is available featuring the findings of this report including only data submitted to SGSS from laboratories in England.

It should be noted that the data presented here for earlier years may differ from those in previous publications due to the inclusion of late reports; also, in 2017, *Enterobacter aerogenes* were reclassified as part of the genus *Klebsiella*, increasing overall infection reports by approximately 5% [4].

Key points

- in 2017, the rate of *Klebsiella* spp. bacteraemia for England, Wales and Northern Ireland combined was 16.7 per 100,000 population, an 8% increase from 2016
- rates of *Klebsiella* spp. bacteraemia remain higher among the very young (less than one year of age) and in older age groups (age 65 and older)
- across the majority of age groups, rates are higher for males than females
- in 2017, rates of *Klebsiella* spp. bacteraemia per 100,000 residents by country were 16.5 for England, 19.4 for Wales and 18.0 for Northern Ireland
- while rates have increased in all countries from 2016, the greatest increase was seen in Northern Ireland (14.2 to 18.0 per 100,000)
- in England, rates varied across the nine PHECs. The highest rate was in the North East (20.4 per 100,000 residents), while the lowest rate was in Yorkshire and Humber (13.8 per 100,000 residents).
- *K. pneumoniae* and *K. oxytoca* remain the two most prevalent species (73.8% and 17.0%, respectively). *K. aerogenes* now make up the third most prevalent species (4.1%).
- in 2017, tested *Klebsiella* spp. isolates had the highest resistance to the following single antimicrobial agents: netilmicin (22.97%), piperacillin/tazobactam (13.50%), cefotaxime (12.17%) and ceftazidime (11.57%)
- there has been a slight gradual increase in resistance to the third-generation cephalosporins and ciprofloxacin for tested *Klebsiella* spp. isolates and the *K. pneumoniae* species isolates specifically from 2015 to 2017 (*K. pneumoniae* species - cefotaxime 8.82% to 12.92%; ceftazidime: 9.67% to 12.95%; ciprofloxacin: 9.35% to 11.29%). Resistance to these agents is very low for *K. oxytoca*. However, resistance to cefotaxime increased from 1.72% in 2015 to 4.12% in 2017.
- resistance to carbapenems remains low (< 2%) for *Klebsiella* spp. and individual species
- multi-drug resistance to four antibiotics (a third-generation cephalosporin, ciprofloxacin, gentamicin and meropenem) remains relatively uncommon, for example, in 0.42% of *K. pneumoniae* isolates and 0.07% of *K. oxytoca* isolates

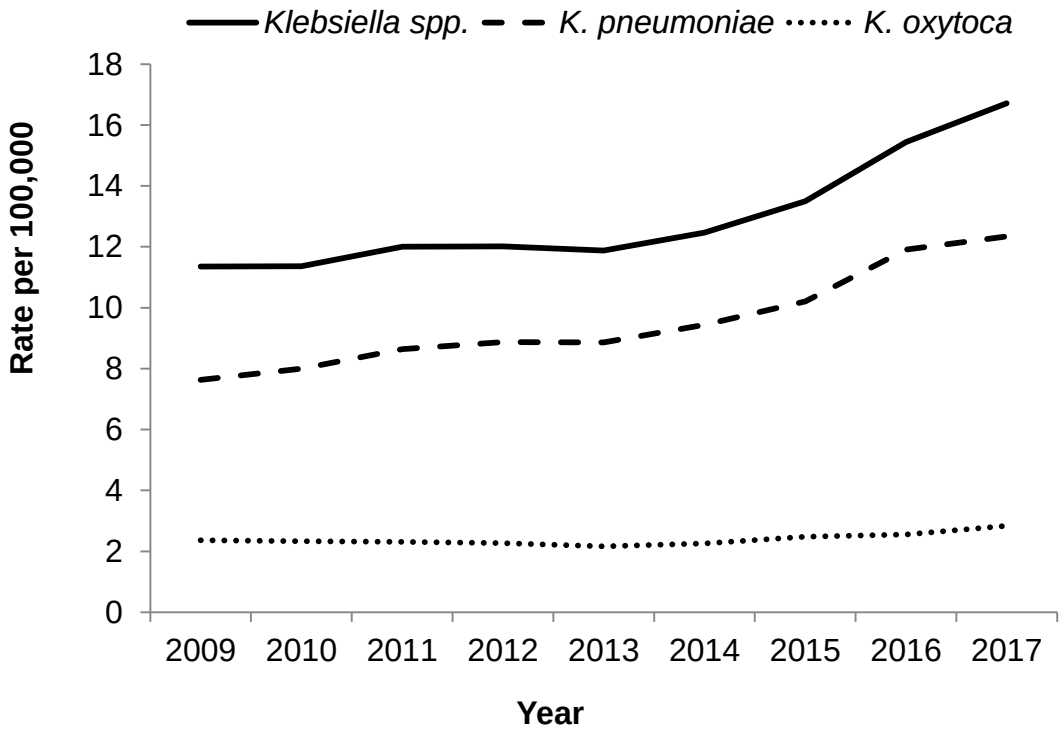
Trends

Figure 1 shows the annual rate of *Klebsiella* spp. bacteraemia from 2009 to 2017. From 2009 to 2013, the annual rate was relatively stable. Since then gradual increases have been observed, with a 40% increase from 2013 to 2017. In 2017, the combined rate for England, Wales and Northern Ireland was 16.7 per 100,000 population (n = 10,069). This represents an 8% increase from the previous year, when the combined rate was 15.4 per 100,000.

Trends for the two leading species, *K. pneumoniae* and *K. oxytoca*, are also shown in figure 1 below. The rate of *K. pneumoniae* shows a similar trend to that of the overall genus. Between 2016 and 2017 however, we see a smaller percent increase (3%) from 11.9 to 12.3 per 100,000. *K. oxytoca* rates have remained relatively stable from 2009 to 2017, accounting for two-three bacteraemia infections for every 100,000 residents. From 2013 to 2017, there has been a slight increase in the rate from 2.2 to 2.8 per 100,000 population.

Overall trends mirror those seen in the rates of monomicrobial and polymicrobial bacteraemia and/or fungaemia notifications for England, Wales and Northern Ireland. Rates for monomicrobials and polymicrobials have shown steady increases from 2014 [5]. This may be partly because of more extensive laboratory reporting in England following the transition from LabBase2 to SGSS in October 2014.

Figure 1. *Klebsiella* spp. bacteraemia rate per 100,000 population (England, Wales and Northern Ireland): 2009 to 2017



Geographic distribution

In 2017, the population rate of reported *Klebsiella* spp. bacteraemia by country was 16.5 per 100,000 for England, 19.4 per 100,000 for Wales and 18.0 per 100,000 for Northern Ireland (Table 1). While rates for all three countries continued to increase from 2016, the percent change was smaller for England and Wales (7% and 11%, respectively). Rates for Northern Ireland increased by 27% from 2016 to 2017 (14.2 to 18.0 per 100,000).

It is important to note that there are differences in the way data are collected between the three countries. In England and Northern Ireland, different microbiology laboratories link to SGSS or CoSurv to report clinically significant isolates. In Wales, data are collected by extraction from a single laboratory information system used by all the microbiology laboratories. The system extracts all positive blood cultures, including those not thought to be clinically significant.

Figure 2 shows the geographical distribution across the three countries, as well as further regional breakdowns in England by the nine PHECs. Variation is also observed among the PHECs. The 2017 rate for the majority of PHECs (seven) was between 15 to 18%. North East had the highest rate of reported *Klebsiella* spp. bacteraemia at 20.4 per 100,000 residents, while Yorkshire and Humber had the lowest rate of reported *Klebsiella* spp. bacteraemia at 13.8 per 100,000 residents. Rates in Yorkshire and Humber have remained consistently low compared to other PHECs over the last five years, whereas North East has reported the highest rate since 2015. Rates for North East however, saw a much smaller percent increase from 2016 to 2017 than that observed from 2015 to 2016. This was also the case for North West, South East and South West. East Midlands actually saw a slight percent decrease (3%) from 2016 to 2017.

Differences exist that may account for the variation observed between PHECs. These include completeness of reporting, local outbreaks, as well as different resident populations and distribution of specialist care units.

Figure 2. Geographical distribution of *Klebsiella* spp. bacteraemia rates per 100,000 population (England, Wales and Northern Ireland): 2017

Table 1. *Klebsiella* spp. bacteraemia per 100,000 population by region (England, Wales and Northern Ireland): 2013 to 2017

		Rate, per 100,000				
Region	**PHE Centre**	**2013**	**2014**	**2015**	**2016**	**2017**
North of England	North East	12.3	13.8	15.4	18.7	20.4
	North West	14.3	14.1	14.5	15.3	15.4
	Yorkshire and Humber	8.4	9.5	10.8	12.3	13.8
Midlands and East of England	East Midlands	11.4	11.2	14.3	17.0	16.4
	East of England	10.4	12.0	12.6	14.6	17.2
	West Midlands	11.9	13.4	14.6	15.0	16.4
London	London	13.3	13.6	14.5	15.9	17.6
South of England	South East	10.5	10.9	11.7	15.5	16.5
	South West	11.0	12.0	13.2	15.7	16.5
England		11.6	12.3	13.4	15.4	16.5
Wales		17.0	15.4	15.8	17.5	19.4
Northern Ireland		12.4	12.9	13.5	14.2	18.0
England, Wales and Northern Ireland		**11.9**	**12.5**	**13.5**	**15.4**	**16.7**

Species distribution

As in previous years, the two most common species associated with the majority of infections in 2017 were *K. pneumoniae* and *K. oxytoca* (table 2). Among all monomicrobial and polymicrobial bacteraemia and/or fungaemia reports in England, Wales and Northern Ireland for 2017, *K. pneumoniae* was the fourth most commonly reported species. *K. oxytoca* was the fifteenth most common pathogen, and accounted for only 0.8% of monomicrobials and 1.8% of polymicrobials [5].

The total number of *Klebsiella* spp. bacteraemia reports has continued to increase over the last five years (6,982 isolates in 2013 to 10,069 isolates in 2017). Due to the recent reclassification of *Enterobacter aerogenes*, *K.aerogenes* now makes up the third most prevalent species. *K. variicola,* which was first reported in 2016, was also reported in increasing numbers in 2017 (n = 232). This may reflect the use of more advanced diagnostic technology in laboratories which allow for further distinction of species. A small number of reports of *K. ornithinolytica* continue to be reported into 2017, but these were excluded from analyses in this report due to the taxonomic change to *Raoultella ornithinolytica* in 2001.

Table 2. Reports of *Klebsiella* spp. bacteraemia by species (England, Wales and Northern Ireland): 2013 to 2017

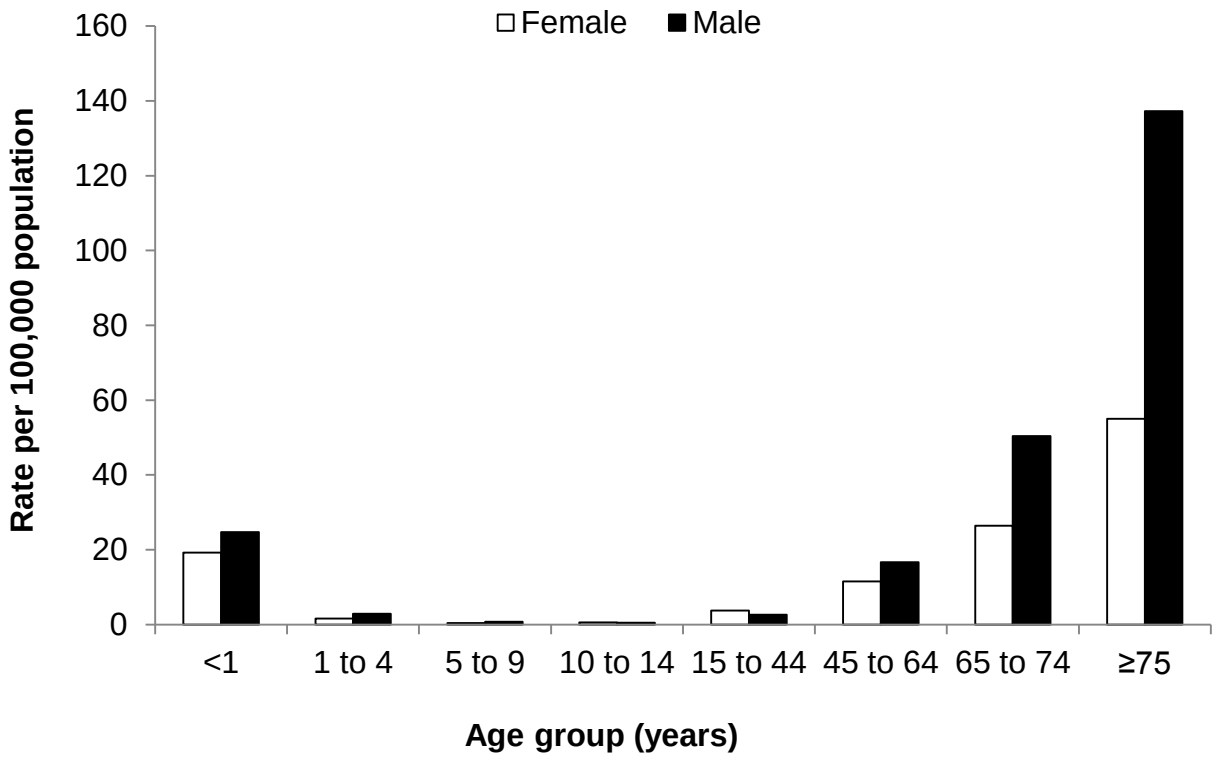
	2013		2014		2015		2016		2017	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
***Klebsiella* spp.**	**6,982**	**100**	**7,386**	**100**	**8,066**	**100**	**9,305**	**100**	**10,069**	**100**
K. pneumoniae	5,210	74.6	5,591	75.7	6,099	75.6	7,175	77.1	7,432	73.8
K. oxytoca	1,274	18.2	1,341	18.2	1,480	18.3	1,541	16.6	1,707	17.0
K. aerogenes	364	5.2	336	4.5	368	4.6	395	4.2	415	4.1
K. variicola	0	0.0	0	0.0	0	0.0	47	0.5	232	2.3
Klebsiella spp., other named	13	0.2	10	0.1	10	0.1	6	0.1	11	0.1
Klebsiella spp., species not recorded	121	1.7	108	1.5	109	1.4	141	1.5	272	2.7

Age and sex distribution

As shown in figure 3, rates of *Klebsiella* spp. bacteraemia vary by age and sex. Rates are highest amongst the youngest (less than one year of age) and oldest age groups (age 65 and older).

For the majority of age groups, higher rates are also reported for males compared to females. This excludes those aged 10 to 14, where counts are quite small in general, and the 15 to 44 years old age group. This difference is most pronounced in those aged 75 and older, where the rate of bacteraemia in males is approximately 2.5 times higher than females.

Figure 3. *Klebsiella* spp. bacteraemia rates by age and sex (England, Wales and Northern Ireland): 2017



Antimicrobial resistance: England and Northern Ireland

Tables 3, 3a and 3b present antibiotic susceptibility trends from 2015 to 2017 for England and Northern Ireland. In 2017, the number of *Klebsiella* spp. isolates tested for resistance to various antimicrobial agents ranged from 74 for netilmicin to 9,143 for gentamicin.

Many klebsiella species are sensitive to cephalosporins, carbapenems and aminoglycosides. However, there is evidence of emerging resistance to antibiotics. For example, if the klebsiellae causing infection produce an extended spectrum beta lactamase enzyme, they will be resistant to cephalosporins [6].

For *Klebsiella* spp. isolates and *K. pneumoniae* species isolates, netilmicin remains the agent with the highest resistance among the tested antibiotics and showed the greatest increase in resistance from 2016 to 2017 (9.76% to 22.97% for *Klebsiella* spp. and 13.11% to 28.07% for *K. pneumoniae* species specifically). However, this is based on very small numbers of tested isolates for this agent (n = 74 in 2017 for *Klebsiella* spp.; n = 57 in 2017 for *K. pneumoniae* species). The second most highly resistant agent based on available testing results was piperacillin/tazobactam (13.50% for *Klebsiella* spp. and 13.86% for *K. pneumoniae* species specifically). Resistance to piperacillin/tazobactam has remained relatively stable over the last three years (at about 13%), however results with intermediate or reduced susceptibility, have slightly increased over time (2.83% to 4.39% for *Klebsiella* spp; 3.56% to 5.29% for *K. pneumoniae* species specifically). For the tested *K. oxytoca* species isolates, piperacillin/tazobactam was the most highly resistant antimicrobial agent (10.86%), compared to < 5% resistance for all other tested antimicrobials.

Resistance to third-generation cephalosporins (ceftazidime and cefotaxime) for *Klebsiella* spp. showed a greater percent increase from 2016 to 2017 than 2015 to 2016 (ceftazidime: 20% increase vs. 7% increase; cefotaxime: 24% increase vs. 14% increase). This was also the case for *K. pneumoniae* species isolates specifically (ceftazidime: 29% increase vs. 4% increase; cefotaxime: 27% increase vs. 16% increase). Resistance to the third-generation cephalosporins remains low for the *K. oxytoca* species isolates in general. However, cefotaxime resistance increased from 1.72% in 2015 to 4.12% in 2017.

Similar to the third-generation cephalosporins, ciprofloxacin resistance has increased slightly by about 2% from 2015 to 2017 for all *Klebsiella spp.* isolates (7.48% to 8.97%), as well as *K. pneumoniae* species isolates specifically (9.35% to 11.29%).

Gentamicin resistance has remained relatively stable since 2015 for *Klebsiella* spp. isolates (at about 7%). This was also the cases at the species level (at about 8% for *K. pneumoniae* and 1% for *K. oxytoca*).

The carbapenem class of antibiotics is considered the last line of defense against Gram-negative infections that are resistant to other antibiotics. As a result, close vigilance of antimicrobial resistance to these antibiotic agents remains important [7]. Resistance to carbapenems (meropenem and ertapenem) remains low among tested *Klebsiella spp.* isolates (0.72% for meropenem and 1.20% for ertapenem).

By acquiring a combination of resistance mechanisms, *Klebsiella* species can become multi-drug resistant. Tables 4a and 4b show susceptibility testing results for different “drug-bug” resistance combinations for England from 2015 to 2017. This analysis examined five classes of antibiotics: third-generation cephalosporins (any of cefotaxime, ceftazidime, ceftriaxone or cefpodoxime), a floroquinolone (ciprofloxacin), carbapenems (meropenem), a penicillin/beta-lactamase inhibitor combination (piperacillin/tazobactam), and an aminoglycoside (gentamicin).

K. pneumoniae showed higher levels of multi-drug resistance for all tested antibiotic combinations compared to *K. oxytoca*. Of the pairwise antibiotic combinations tested, the highest resistance seen for *K. pneumoniae* was 7.49% for the combination of a third-generation cephalosporin and ciprofloxacin (472 of 6,298); 7.00% for the combination of a third-generation cephalosporin and piperacillin/tazobactam (424 of 6,057); and 6.22% for the combination of a third-generation cephalosporin and gentamicin (391 of 6,288). As seen in table 4b, multi-drug resistance for *K. oxytoca* was low (< 1%) for almost all of the tested drug combinations. However, 4.74% of *K. oxytoca* isolates tested were resistant to the combination of a third-generation cephalosporin and piperacillin/tazobactam (67 of 1,413).

Resistance to a combination of four antibiotics (a third-generation cephalosporin, ciprofloxacin, gentamicin and meropenem) remains relatively uncommon - 0.42% of *K. pneumoniae* isolates (25 of 5,939) and 0.07% of *K. oxytoca* isolates (1 of 1,382).

Table 3. Antimicrobial susceptibility* for *Klebsiella* spp. bacteraemia (England and Northern Ireland): 2015 to 2017

	2015			2016			2017		
Antimicrobial agent	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**
Gentamicin	93.38	0.10	6.52	93.02	0.14	6.84	93.10	0.15	6.75
Ciprofloxacin	91.29	1.23	7.48	90.60	1.32	8.08	89.10	1.93	8.97
Ceftazidime	89.79	1.19	9.03	89.06	1.26	9.68	87.05	1.38	11.57
Cefotaxime	90.27	1.11	8.62	89.35	0.83	9.83	87.15	0.68	12.17
Meropenem	99.38	0.15	0.48	99.27	0.26	0.47	99.10	0.18	0.72
Ertapenem	98.50	0.57	0.93	98.71	0.31	0.98	98.44	0.36	1.20
Tobramycin	89.70	0.33	9.96	90.11	0.56	9.33	89.78	0.42	9.81
Amikacin	98.37	0.79	0.84	97.76	1.41	0.83	97.13	1.87	1.01
Netilmicin	91.30	0.00	8.70	87.80	2.44	9.76	74.32	2.70	22.97
Colistin	96.09	0.00	3.91	97.26	0.00	2.74	97.09	0.00	2.91
Piperacillin/tazobactam	83.40	2.83	13.77	82.99	3.51	13.49	82.11	4.39	13.50

*__S__ = susceptible; __I__ = intermediate (reduced susceptibility); __R__ = resistant

Table 3a. Antimicrobial susceptibility* for *K. pneumoniae* bacteraemia (England and Northern Ireland): 2015 to 2017

	2015			2016			2017		
Antimicrobial agent	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**
Gentamicin	91.70	0.11	8.19	91.55	0.12	8.32	91.25	0.16	8.59
Ciprofloxacin	89.20	1.45	9.35	88.53	1.62	9.85	86.35	2.37	11.29
Ceftazidime	89.06	1.27	9.67	88.45	1.51	10.04	85.51	1.54	12.95
Cefotaxime	90.19	0.99	8.82	88.96	0.83	10.21	86.43	0.65	12.92
Meropenem	99.26	0.16	0.58	99.22	0.29	0.50	99.03	0.17	0.80
Ertapenem	98.62	0.46	0.92	98.76	0.20	1.04	98.45	0.32	1.24
Tobramycin	87.00	0.39	12.61	88.08	0.53	11.39	87.07	0.39	12.54
Amikacin	97.97	1.03	1.00	97.38	1.65	0.97	96.51	2.26	1.23
Netilmicin	88.24	0.00	11.76	83.61	3.28	13.11	68.42	3.51	28.07
Colistin	95.51	0.00	4.49	97.06	0.00	2.94	96.57	0.00	3.43
Piperacillin/tazobactam	82.37	3.56	14.06	82.64	4.04	13.31	80.85	5.29	13.86

*__S__ = susceptible; __I__ = intermediate (reduced susceptibility); __R__ = resistant

Table 3b. Antimicrobial susceptibility* for *K. oxytoca* bacteraemia (England and Northern Ireland): 2015 to 2017

	2015			2016			2017		
Antimicrobial agent	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**
Gentamicin	98.91	0.07	1.02	98.48	0.14	1.39	98.60	0.19	1.21
Ciprofloxacin	98.20	0.38	1.43	97.88	0.21	1.91	98.19	0.39	1.42
Ceftazidime	98.25	0.35	1.40	97.01	0.43	2.57	97.73	0.63	1.64
Cefotaxime	97.10	1.19	1.72	97.10	0.76	2.14	95.15	0.73	4.12
Meropenem	99.77	0.08	0.15	99.49	0.15	0.37	99.80	0.00	0.20
Ertapenem	99.37	0.27	0.36	99.58	0.17	0.25	99.77	0.00	0.23
Tobramycin	99.15	0.00	0.85	98.45	0.39	1.17	98.70	0.32	0.97
Amikacin	99.65	0.00	0.35	99.34	0.33	0.33	99.41	0.49	0.10
Netilmicin	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00
Colistin	98.11	0.00	1.89	97.22	0.00	2.78	98.25	0.00	1.75
Piperacillin/tazobactam	89.06	0.38	10.57	86.99	1.09	11.92	87.81	1.33	10.86

*__S__ = susceptible; __I__ = intermediate (reduced susceptibility); __R__ = resistant

Table 4a. Multi-drug antimicrobial testing and resistance summary* for *K. pneumoniae* bacteraemia (England): 2015 to 2017

	2015			2016			2017		
Antimicrobial agent	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**
3rd gen cephalosporin† and ciprofloxacin	93.74	0.65	5.61	92.96	0.80	6.24	91.38	1.13	7.49
3rd gen cephalosporin† and gentamicin	94.09	0.02	5.89	94.15	0.10	5.75	93.54	0.24	6.22
3rd gen cephalosporin† and meropenem	99.36	0.17	0.48	99.25	0.23	0.51	99.02	0.14	0.83
3rd gen cephalosporin† and piperacillin/tazobactam	92.71	1.77	5.52	92.46	2.19	5.36	90.28	2.72	7.00
Ciprofloxacin and gentamicin	94.11	0.36	5.53	93.93	0.34	5.72	93.66	0.56	5.78
Ciprofloxacin and meropenem	99.37	0.19	0.44	99.33	0.25	0.42	99.25	0.11	0.64
Ciprofloxacin and piperacillin/tazobactam	93.80	1.52	4.67	94.02	1.89	4.10	92.36	2.53	5.12
Gentamicin and meropenem	99.67	0.10	0.23	99.47	0.13	0.40	99.40	0.11	0.49
Gentamicin and piperacillin/tazobactam	94.46	1.11	4.43	94.79	1.17	4.04	94.16	1.60	4.24
3rd gen cephalosporin†, ciprofloxacin and gentamicin	95.37	0.31	4.32	95.20	0.32	4.48	94.72	0.42	4.85
3rd gen cephalosporin†, ciprofloxacin and meropenem	99.39	0.21	0.40	99.36	0.22	0.42	99.26	0.10	0.64
3rd gen cephalosporin†, ciprofloxacin and piperacillin/tazobactam	95.51	1.11	3.38	95.32	1.44	3.23	93.98	1.86	4.16
3rd gen cephalosporin†, gentamicin and meropenem	99.71	0.08	0.21	99.48	0.12	0.40	99.39	0.12	0.49
3rd gen cephalosporin†, gentamicin and piperacillin/tazobactam	95.91	0.78	3.30	95.94	1.02	3.04	95.04	1.38	3.58
Ciprofloxacin, gentamicin and meropenem	99.69	0.10	0.21	99.49	0.15	0.36	99.48	0.10	0.42
Ciprofloxacin, gentamicin and piperacillin/tazobactam	95.69	0.91	3.40	96.04	1.09	2.88	95.18	1.49	3.33
3rd gen cephalosporin†, ciprofloxacin, gentamicin and meropenem	99.70	0.11	0.19	99.50	0.14	0.36	99.48	0.10	0.42

*__S__ = susceptible; __I__ = intermediate (reduced susceptibility); __R__ = resistant † Any of Cefotaxime, Ceftazidime, Ceftriaxone, or Cefpodoxime

Table 4b. Multi-drug antimicrobial testing and resistance summary* for *K. oxytoca* bacteraemia (England): 2015 to 2017

	2015			2016			2017		
Antimicrobial agent	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**
3rd gen. cephalosporin† and ciprofloxacin	99.29	0.08	0.63	98.74	0.07	1.19	99.39	0.07	0.55
3rd gen. cephalosporin† and gentamicin	99.46	0.15	0.39	99.41	0.00	0.59	99.66	0.00	0.34
3rd gen. cephalosporin† and meropenem	99.92	0.00	0.08	99.54	0.15	0.31	99.79	0.00	0.21
3rd gen. cephalosporin† and piperacillin/tazobactam	96.72	0.40	2.88	95.05	0.46	4.49	95.12	0.14	4.74
Ciprofloxacin and gentamicin	99.61	0.08	0.31	99.34	0.00	0.66	99.59	0.14	0.28
Ciprofloxacin and meropenem	99.84	0.08	0.08	99.77	0.00	0.23	99.93	0.00	0.07
Ciprofloxacin and piperacillin/tazobactam	99.19	0.08	0.73	98.99	0.15	0.85	98.99	0.29	0.72
Gentamicin and meropenem	100.00	0.00	0.00	99.85	0.00	0.15	99.93	0.00	0.07
Gentamicin and piperacillin/tazobactam	99.76	0.08	0.16	99.39	0.08	0.53	99.36	0.21	0.43
3rd gen. cephalosporin†, ciprofloxacin and gentamicin	99.68	0.08	0.24	99.55	0.00	0.45	99.79	0.00	0.21
3rd gen. cephalosporin†, ciprofloxacin and meropenem	99.92	0.00	0.08	99.77	0.00	0.23	99.93	0.00	0.07
3rd gen. cephalosporin†, ciprofloxacin and piperacillin/tazobactam	99.43	0.08	0.49	99.06	0.08	0.86	99.57	0.07	0.36
3rd gen. cephalosporin†, gentamicin and meropenem	100.00	0.00	0.00	99.85	0.00	0.15	99.93	0.00	0.07
3rd gen. cephalosporin†, gentamicin and piperacillin/tazobactam	99.76	0.16	0.08	99.61	0.00	0.39	99.64	0.00	0.36
Ciprofloxacin, gentamicin and meropenem	100.00	0.00	0.00	99.85	0.00	0.15	99.93	0.00	0.07
Ciprofloxacin, gentamicin and piperacillin/tazobactam	99.84	0.00	0.16	99.61	0.00	0.39	99.63	0.07	0.29
3rd gen cephalosporin†, ciprofloxacin, gentamicin and meropenem	100.00	0.00	0.00	99.84	0.00	0.16	99.93	0.00	0.07

*__S__ = susceptible; __I__ = intermediate (reduced susceptibility); __R__ = resistant † Any of Cefotaxime, Ceftazidime, Ceftriaxone, or Cefpodoxime

Microbiology services

For advice on treatment of antibiotic-resistant infections caused by these opportunistic pathogens, laboratories should contact the Medical Microbiologists at PHE's Bacteriology Reference Department in Colindale (colindalemedmicro@phe.gov.uk). For reference services, including species identification and confirmation of sensitivity testing results, laboratories should contact PHE's Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit in London [8].

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Health Protection Report is a national public health bulletin for England and Wales, published by Public Health England. It is PHE's principal channel for the dissemination of laboratory data relating to pathogens and infections/communicable diseases of public health significance and of reports on outbreaks, incidents and ongoing investigations.

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