Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and *C. difficile* infections, up to and including financial year April 2020 to March 2021

15 September 2021
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Executive Summary

In April 2020 to March 2021, the number of *S. aureus* and Gram-negative bacteraemia and CDI cases reported in England declined compared to previous years. This coincided with the COVID-19 pandemic and the extensive interventions put in place to mitigate the spread of the virus. The COVID-19 pandemic has impacted the counts and rates of infections covered in this report. Except with *Klebsiella* spp., incidence rates for all reported cases of each infection covered in this report declined in April 2020 to March 2021 compared to the previous years. This was likely due to the reduced number of cases as a result of the reduced hospital activity in the first and second wave of the pandemic. However, this also contributed to the increases in hospital-onset (HO) incidence rates. The number of beds occupied overnight is used as the population at risk to determine hospital-onset incidence rates. Therefore, the relatively large increases in hospital-onset incidence rates in April 2020 to March 2021 compared to previous years is partly due to the considerable reduction in admitted patients during that period.

At the height of the second wave of the COVID-19 pandemic in England, the number of HO meticillin resistant *Staphylococcus aureus* (MRSA), *Klebsiella* spp. and *Pseudomonas aeruginosa* bacteraemia peaked in January 2021. This was the largest monthly count of HO cases for the *Klebsiella* spp. and *Pseudomonas* bacteraemias, since the mandatory surveillance of these conditions started in April 2017 to March 2018. Furthermore, for *P. aeruginosa* and MRSA cases, this was also the first time there were more HO cases than community-onset (CO) cases during the pandemic period.

Overall, rates of all reported MRSA bacteraemia and *Clostridioides difficile* (CDI) infection have declined over time. This is testament to the success of the interventions introduced to combat these infections. Prior to April 2020 to March 2021, these declines were observed in both hospital-onset (HO) and community-onset (CO) cases of both infections however, in April 2020 to March 2021 the number of HO MRSA bacteraemia cases increase compared to the previous year. This is the first annual increase in HO-onset MRSA since April 2014 to March 2015 and one of only 2 annual increases since the start of mandatory surveillance.

In contrast, prior to April 2020 to March 2021, the overall rates of *Escherichia coli* and meticillin sensitive *Staphylococcus aureus* (MSSA) rates had been increasing since the start of their enhanced surveillance, with the most prominent rises seen in the community-onset cases.

Over time the community-onset cases have accounted for an increasing proportion of all reported cases. This is true even for MRSA and CDI, as although rates have reduced in both settings the reduction was steeper in the hospital setting. This highlights the need
to increase efforts to prevent cases in community settings. Nevertheless, hospital-onset infections remain important, representing thousands of cases a year.

Although many of the infections were community-onset it is estimated that a large proportion (up to 50% in the case of *E. coli*) have had recent healthcare interactions (Abernethy and others, 2017). Therefore, to reduce infection rates further, control efforts in the hospital setting must be maintained or strengthened, while increasing focus on healthcare interventions in the community and the interface between hospital and community infection control teams improved.

**Highlights**

Since the beginning of mandatory *E. coli* bacteraemia surveillance in 2011, rates of all reported cases increased each year until April 2020 to March 2021 when it declined to 65.3 cases per 100,000 population from 77.0 in the previous year.

After *E. coli*, *Klebsiella* spp. and *P. aeruginosa* are the most common causative organisms in Gram-negative bacteraemia. These species caused substantially lower rates of bacteraemia than *E. coli*. Rates of *Klebsiella* spp. increased slightly, from 19.6 in April 2019 to March 2020 to 19.8 in April 2020 to March 2021. Rates of *P. aeruginosa* bacteraemia decreased slightly, from 7.7 in April 2019 to March 2020 to 7.6 in April 2020 to March 2021. Urinary tract infection (UTI) remained the most important primary focus; 31.3% for *Klebsiella* spp. and 28.5% of *P. aeruginosa* cases respectively.

Rates of MSSA bacteraemia continued to increase moderately from April 2011 to March 2012 when the surveillance was introduced. However, the rate decreased from 21.7 cases per 100,000 population in April 2019 to March 2020 to 20.8 per 100,000 population in April 2020 to March 2021.

In contrast to MSSA, rates of MRSA bacteraemia and CDI in April 2020 to March 2021 have remained low at 1.2 and 22.2 per 100,000 population respectively in comparison to rates at their peak. However, rates of all reported MRSA cases peaked in January 2021 compared to other months in more recent years, which had relatively stable rates. This peak coincided with the second wave of the COVID-19 pandemic.

The high rates of Gram-negative bacteraemias and the diverse nature of the underlying causes of these infections compared to MRSA and CDI present a significant challenge to achieving the ambition to halve healthcare-associated Gram-negative bacteraemia by 2023 to 2024 (HM Government 2018).

Counts of cases across all collections except CDI and *Klebsiella* spp. are lower than would be expected given previous trajectories. This is a result of associated interventions and the global COVID-19 pandemic on the number of cases reported to
the surveillance of BSI and CDI. From an analysis of data from the voluntary laboratory surveillance scheme, there has also been a reduction in the number of cases of other bloodstream infections, not only those covered by mandatory surveillance. In response to the pandemic, many elective procedures in hospitals were cancelled. As hospital patient populations declined, so did the population at risk, however, this drop in the denominator was greater than that in the cases contributing to the rise in calculated hospital-onset incidence rates for April 2020 to March 2021. This artefact is more pronounced in Klebsiella spp. and P. aeruginosa bacteraemia cases due to actual increases in the count of hospital-onset relative to previous year. For us to understand the true incidence rate of infections we will need to consider these changes. Further work is ongoing to better understand these trends in the context of the changed hospital population and practises in England during the COVID-19 pandemic.

This report constitutes a full and descriptive analysis of the data from the mandatory surveillance of bacteraemia and CDI programmes in England. Detailed information on each pathogen can be found in the individual sections of the report.
Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and C. difficile infections

Effect of the COVID-19 pandemic on Bacteraemia and CDI surveillance

The first case of SARS-CoV-2 was detected in England on 30 January 2020 [Brown 2021]. A series of epidemics with cross-border transmission was declared a pandemic on 11 March 2020 [Cucinotta 2020]. Since then, England has experienced 2 major waves of increasing infection during March to May 2020 and September 2020 to March 2021, triggering national lockdowns. During the pandemic many elective procedures in hospitals were cancelled leading to reduced hospital activity. This led to large declines in the number of Gram-negative and S. aureus bacteraemia and CDI reported during this period. A similar analysis of the laboratory surveillance scheme showed similar declines in the number of processed bacteraemia isolates and thus cases over the same period. This suggests that the declines in reported cases are genuine and not a result of under-reporting in the mandatory surveillance scheme.

Except for Klebsiella spp. and CDI, there were considerable declines in the number of all reported cases of each the infections covered in this report over the course of the pandemic (Figure S0). Most of these declines occurred in community-onset cases.

The Gram-negative and MSSA bacteraemia saw the largest declines in cases which contrasts previously increasing trends. However, hospital-onset cases became more common during the pandemic, especially in MRSA and Pseudomonas bacteraemia cases, where in January 2021 hospital-onset cases exceeded community onset cases. In addition, during the pandemic, the dominant primary focus of Klebsiella spp. and P. aeruginosa infection was respiratory tract infection compared to urinary tract infection in the same period from previous years. Pneumonia as a source of MRSA cases became more common as well. Data from this report also shows increases in ICU-associated cases during the pandemic. The correlation between peaks of COVID-19 cases and hospital-onset bacterial infections is not unexpected. COVID-19 patients requiring hospitalisation are likely to need longer stays than the average admitted patient therefore increasing the risk of acquiring a HCAI. COVID-19 related care and IPC measures such as, proning, increased corticosteroid use and use of sessional PPE may have had adverse effects on HCAI but will require dedicated research to discern.

The calculated hospital-onset infection rates increased for all bacteraemia and CDI cases during the pandemic. However, it is important to note that the hospital population during much of pandemic reduced considerably. These population (based on overnight admissions) have been used in the calculation of hospital-onset incident rates. Therefore, in instances such an hospital-onset E. coli bacteraemia cases, the calculated incidence rates increased from the previous year despite a decline in case number.
Figure S0. Monthly counts of Gram-negative and *S. aureus* bacteraemia, and *C. difficile* infections in England, April 2017 to March 2021
For *Klebsiella* spp. and *P. aeruginosa* hospital-onset cases, the count of cases increased which when combined with reducing denominators resulted in steep rate increases.

The April 2020 to March 2021 trends for all infections covered in this report have been affected by COVID-19 pandemic. This report only covers data up to the end of March 2021, therefore, covering the whole of the first wave and the majority of the second COVID-19 wave in England. The COVID-19 pandemic in England entered its third wave towards the end of April 2021. Thus, the full effect of the active pandemic on healthcare-associated infections cannot yet be determined and it is impossible to estimate with any certainty at present if HCAI trends will return to those seen beforehand. If patient populations and NHS practice change substantially then the HCAI trends will need to be reassessed with consideration to these changes.
Bacteraemia caused by Gram-negative organisms

*Escherichia coli* bacteraemia

**Total reports**

A total of 36,728 cases of *E. coli* bacteraemia were reported by NHS Trusts in England between 1 April 2020 and 31 March 2021. Of the 36,728 *E. coli* cases, 6,544 (17.8%) were hospital-onset cases. The total number of cases reported in April 2020 to March 2021 decreased by 15.3% compared to April 2019 to March 2020 (n = 43,368) but is an increase of 13.7% when comparing over a longer period from 2012 to 13 (n = 32,309). Figure 1 shows the trends in the rates of *E. coli* cases from April 2012 to March 2013 to April 2020 to March 2021. Overall, the rate of *E. coli* cases per 100,000 population has risen from 60.4 in April 2012 to March 2013 to 65.3 in April 2020 to March 2021.

**Figure 1. Trends in the rate of *E. coli* bacteraemia in England, April 2012 to March 2013 to April 2020 to March 2021***

*Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.*
Hospital-onset cases

The rate (cases per 100,000 bed-days) of *E. coli* hospital-onset cases was relatively stable at 22.0 between April 2012 to March 2013 and April 2017 to March 2018 although, this dropped to 21.0 in April 2014 to March 2015. However, there has been a relatively small but consistent increase in the incidence rate of hospital-onset cases between April 2017 to March 2018 and April 2020 to March 2021 (23.7 cases per 100,000 bed-days).

Table 1. *E. coli* counts and rates by financial year, England: April 2012 to March 2013 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Mid-year population estimate</th>
<th>All reported cases</th>
<th>Rate (all reported cases per 100,000 population)*</th>
<th>Total bed days</th>
<th>Hospital-onset cases</th>
<th>Rate (hospital-onset cases per 100,000 bed days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012/2013</td>
<td>53,475,358</td>
<td>32,309</td>
<td>60.4</td>
<td>34,633,855</td>
<td>7,552</td>
<td>21.8</td>
</tr>
<tr>
<td>2013/2014</td>
<td>53,976,973</td>
<td>34,286</td>
<td>63.5</td>
<td>34,514,871</td>
<td>7,558</td>
<td>21.9</td>
</tr>
<tr>
<td>2014/2015</td>
<td>54,432,437</td>
<td>35,816</td>
<td>65.8</td>
<td>34,972,728</td>
<td>7,380</td>
<td>21.1</td>
</tr>
<tr>
<td>2015/2016</td>
<td>55,018,884</td>
<td>38,309</td>
<td>69.6</td>
<td>34,752,604</td>
<td>7,743</td>
<td>22.3</td>
</tr>
<tr>
<td>2016/2017</td>
<td>55,240,933</td>
<td>40,676</td>
<td>73.6</td>
<td>35,148,014</td>
<td>7,884</td>
<td>22.4</td>
</tr>
<tr>
<td>2017/2018</td>
<td>55,707,642</td>
<td>41,125</td>
<td>73.8</td>
<td>34,903,075</td>
<td>7,680</td>
<td>22.0</td>
</tr>
<tr>
<td>2018/2019</td>
<td>56,053,563</td>
<td>43,262</td>
<td>77.2</td>
<td>34,538,184</td>
<td>7,623</td>
<td>22.1</td>
</tr>
<tr>
<td>2019/2020</td>
<td>56,286,961</td>
<td>43,368</td>
<td>77.0</td>
<td>34,637,156</td>
<td>7,824</td>
<td>22.6</td>
</tr>
<tr>
<td>2020/2021</td>
<td>56,286,961</td>
<td>36,728</td>
<td>65.3</td>
<td>27,629,101</td>
<td>6,544</td>
<td>23.7</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
Rates of *E. coli* infections in ICUs have fluctuated over the years, with spikes seen in April 2017 to March 2018 and April 2020 to March 2021, with rates in both years rising to 0.48 cases per 1,000 ICU bed days greater than 2 days.

### Age and sex distribution

For all age and sex analyses, cases in which the sex was missing or given as unknown were excluded. In April 2012 to March 2013, the sex was unknown for 815 cases (2.5%), while in April 2020 to March 2021, the sex was unknown for 18 cases (less than 1%).

Figure 3 compared the age and sex distribution of *E. coli* cases as a proportion of all infections in April 2012 to March 2013 and April 2020 to March 2021. There has been little change to the distribution of cases. Most cases occur in adults aged 45 and over. The proportion of cases from male and female cases where broadly similar in each age group, except in the 15 to 44 and greater to or equal to 85 age groups. In these 2 age groups, cases were more common in female patients compared to males.
In general, the incidence rates of *E. coli* bacteraemia are greater in male patients compared to females, and particularly so among older age groups (Table 2, Table 3 and Figure 4). However, there is a notable exception to this. In young adulthood (15 to 44) the rate of *E. coli* bacteraemia is usually higher in women compared to among men. In April 2020 to March 2021 this was 17.0 per 100,000 population for males compared to 7.3 in females, giving a giving a male-to-female rate ratio of 0.4 (95% CI: 0.4 to 0.5).

**Table 2. E. coli counts and rates by age group and sex, England: April 2012 to March 2013**

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>353,705</td>
<td>336,393</td>
<td>306</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,503,696</td>
<td>4,294,578</td>
<td>81</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,724,195</td>
<td>10,658,628</td>
<td>712</td>
</tr>
</tbody>
</table>
### Table 3. E. coli counts and rates by age group and sex, England: April 2020 to March 2021

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population*</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>318,032</td>
<td>300,826</td>
<td>425</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,907,107</td>
<td>4,666,124</td>
<td>95</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,763,419</td>
<td>10,571,978</td>
<td>787</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,103,072</td>
<td>7,302,687</td>
<td>3,515</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,682,950</td>
<td>2,893,116</td>
<td>4,284</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,536,167</td>
<td>1,844,432</td>
<td>5,645</td>
</tr>
<tr>
<td>Over 85</td>
<td>517,084</td>
<td>879,967</td>
<td>3,968</td>
</tr>
</tbody>
</table>
Percentage changes in the age and sex-specific rates of *E. coli* bacteraemia relative to the first year of surveillance are shown in Figure 5. Except for females between the ages of one and 14, rates of *E. coli* bacteraemia have increased since the start of surveillance. Compared to the start of mandatory surveillance, the age group with the highest increases in incidence rates has been the less than 1 age group. However, the decline in incidence rates between April 2019 to March 2020 and April 2020 to March 2021 was observed in almost all age-groups but more so among female patients.
Seasonal trends in *E. coli* bacteraemia

In general, community-onset *E. coli* cases peaks in the July-September quarter of the year, a trend that has not changed since April 2012. There is much less seasonal variation in hospital-onset *E. coli* cases although, in April 2020 to March 2021, there was a considerable change to this trend when hospital-onset *E. coli* cases peaked in October to December 2020 and January and March 2021. This is the first time since April 2012 to March 2013 where increases in hospital-onset cases during these 2 quarters have been higher than the rest of financial year.
Primary focus of *E. coli* bacteraemia

The provision of data on the most likely primary focus of *E. coli* infection information is voluntary. The percentage of cases where this information has been provided has declined over time from 85.5% (n= 27,610) in April 2012 to March 2013 to 54.3% (n= 19,941) in April 2020 to March 2021.

Of cases with a reported primary focus of infection, urinary tract infection (UTI) has consistently been the most frequent primary focus for *E. coli* bacteraemia cases. In April 2012 to March 2013, 48.9% of cases had a most likely primary focus of UTI, by April 2020 to March 2021 it was 43.9% (n= 8,747). Conversely, the percentage of records for which the primary focus was reported as unknown has decreased from 20.2% in April 2012 to March 2013 to 17.7% in April 2020 to March 2021.
Table 4. *E. coli* counts and rates by primary focus of bacteraemia in England, April 2011 to March 2012 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial Year</th>
<th>Gastrointestinal (not hepatobiliary)</th>
<th>Hepatobiliary</th>
<th>UTI</th>
<th>Respiratory tract</th>
<th>Other</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
</tr>
<tr>
<td>2012/2013</td>
<td>1,782 (6.5)</td>
<td>3,756 (13.6)</td>
<td>13,501 (48.9)</td>
<td>1,050 (3.8)</td>
<td>1,936 (7)</td>
<td>5,585 (20.2)</td>
<td>27,610</td>
</tr>
<tr>
<td>2013/2014</td>
<td>1,711 (6)</td>
<td>3,855 (13.6)</td>
<td>13,393 (47.3)</td>
<td>1,016 (3.6)</td>
<td>1,873 (6.6)</td>
<td>6,452 (22.8)</td>
<td>28,300</td>
</tr>
<tr>
<td>2014/2015</td>
<td>1,640 (5.7)</td>
<td>3,818 (13.3)</td>
<td>13,087 (45.6)</td>
<td>1,099 (3.8)</td>
<td>1,851 (6.4)</td>
<td>7,233 (25.2)</td>
<td>28,728</td>
</tr>
<tr>
<td>2015/2016</td>
<td>1,491 (5.6)</td>
<td>3,556 (13.4)</td>
<td>12,219 (46.2)</td>
<td>1,068 (4)</td>
<td>1,703 (6.4)</td>
<td>6,407 (24.2)</td>
<td>26,444</td>
</tr>
<tr>
<td>2016/2017</td>
<td>1,237 (5.4)</td>
<td>3,277 (14.4)</td>
<td>10,724 (47.2)</td>
<td>1,027 (4.5)</td>
<td>1,553 (6.8)</td>
<td>4,907 (21.6)</td>
<td>22,725</td>
</tr>
<tr>
<td>2017/2018</td>
<td>1,717 (6.7)</td>
<td>4,035 (15.8)</td>
<td>12,566 (49.1)</td>
<td>1,575 (6.1)</td>
<td>1,757 (6.9)</td>
<td>3,963 (15.5)</td>
<td>25,613</td>
</tr>
<tr>
<td>2018/2019</td>
<td>1,969 (6.9)</td>
<td>4,686 (16.5)</td>
<td>13,913 (48.9)</td>
<td>1,728 (6.1)</td>
<td>1,989 (7)</td>
<td>4,182 (14.7)</td>
<td>28,467</td>
</tr>
<tr>
<td>2019/2020</td>
<td>1,774 (6.5)</td>
<td>4,346 (15.8)</td>
<td>13,238 (48.1)</td>
<td>1,671 (6.1)</td>
<td>1,898 (6.9)</td>
<td>4,575 (16.6)</td>
<td>27,502</td>
</tr>
<tr>
<td>2020/2021</td>
<td>1,325 (6.6)</td>
<td>3,637 (18.2)</td>
<td>8,747 (43.9)</td>
<td>1,219 (6.1)</td>
<td>1,493 (7.5)</td>
<td>3,520 (17.7)</td>
<td>19,941</td>
</tr>
</tbody>
</table>

* Urinary tract infection
** Gastrointestinal (not hepatobiliary)
*** ‘Other’ includes the following options HCAI DCS: bone and joint, central nervous system, genital tract (including prostate), indwelling intravascular device, other, respiratory tract, skin or soft tissue, no clinical signs of bacteraemia.

The primary focus of *E. coli* bacteraemia also varies according to time to onset (Figure 7). UTI as the primary focus was more common in cases with where the time to onset was less than 2 days (44.7%) compared to cases where it was between 2 and 6 days (31.5%).
Geographic distribution of *E. coli* bacteraemia

Regional distribution of cases is presented by Sustainability Transformation Partnerships (STP). Some geographical variation in rates of *E. coli* bacteraemia is noted (Figure 8). The highest incidence rates (cases per 100,000 population) were observed in Devon (84.0), Cumbria and North East (83.5) and Joined Up Care Derbyshire (83.4), while the lowest incidence rates (cases per 100,000 population) were observed in Gloucestershire (36.4), Bedfordshire, Luton and Milton Keynes (44.9) and Leicester, Leicestershire and Rutland (47.7).
Figure 8. Geographic distribution of *E. coli* rates per 100,000 population, England April 2020 to March 2021*

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

See Table 4b of the accompanying data sheet for a breakdown of STP-specific *E. coli* bacteraemia rates.

*Klebsiella* spp. bacteraemia

Total reports

A total of 11,123 cases of *Klebsiella* spp. bacteraemia were reported by NHS Trusts in England between 1 April 2020 and 31 March 2021. Of the 11,123 *Klebsiella* spp. cases, 3,785 (34.0%) were hospital-onset cases.
Figure 9. Trends in the rate of *Klebsiella* spp. in England, April 2017 to March 2018 to April 2020 to March 2021

* All cases*

* Hospital-onset cases

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

**Hospital onset cases**

The rate (cases per 100,000 bed-days) of hospital-onset *Klebsiella* spp. cases was 8.4 in April 2017 to March 2018 and 9.3 in April 2018 to March 2019 and April 2019 to March 2020. However, this increased to 13.7 in April 2020 to March 2021.
Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and *C. difficile* infections

Table 5. *Klebsiella* spp. counts and rates by financial year, England: April 2017 to March 2018 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Mid-year population estimate</th>
<th>All reported cases</th>
<th>Rate (all reported cases per 100,000 population)</th>
<th>Total bed days**</th>
<th>Hospital-onset cases</th>
<th>Rate (Hospital-onset cases per 100,000 bed days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017/2018</td>
<td>55,707,642</td>
<td>9,782</td>
<td>17.6</td>
<td>34,903,075</td>
<td>2,920</td>
<td>8.4</td>
</tr>
<tr>
<td>2019/2020</td>
<td>56,286,961</td>
<td>11,032</td>
<td>19.6</td>
<td>34,637,156</td>
<td>3,206</td>
<td>9.3</td>
</tr>
<tr>
<td>2020/2021</td>
<td>56,286,961</td>
<td>11,123</td>
<td>19.8</td>
<td>27,629,101</td>
<td>3,785</td>
<td>13.7</td>
</tr>
</tbody>
</table>

In April 2020 to March 2021, the counts of both all reported cases and hospital-onsets peaked in January 2021 at 1,074 and 487 cases respectively (Figure 10). These were the highest numbers of all reported cases and those that were hospital-onset ever observed since the start of mandatory surveillance. These increases coincided with the COVID-19 pandemic and are likely a result of the change to the usual hospital population and practices during this period.
Figure 10. Monthly counts of *Klebsiella* spp. bacteraemia by onset of infection, April 2018 to March 2019 to April 2020 to March 2021
Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and *C. difficile* infections

Figure 11. Rate of ICU-associated hospital-onset *Klebsiella* spp. bacteraemia cases, April 2016 to March 2017-April 2020 to March 2021

Rates of *Klebsiella* spp. infections in ICUs have remained below 0.5 per 1,000 ICU bed days greater than 2 days from April 2017 to March April 2018 to March April 2019 to March 2020. A steep rise was seen from April 2019 to March 2020 to April 2020 to March 2021, with the rate rising from 0.42 to 1.02 cases per 1,000 ICU bed days greater than 2 days.

Distribution of *Klebsiella* species

*K. pneumoniae* was the most frequently reported species, followed by *K. oxytoca*. This distribution was the same regardless of onset of infection.

Table 6. Counts and percentages of *Klebsiella* species, England, April 2020 to March 2021

<table>
<thead>
<tr>
<th>Species</th>
<th>All cases</th>
<th>Hospital-onset cases</th>
<th>Community-onset cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>K. pneumoniae</em></td>
<td>7,871 (18.5%)</td>
<td>2,572 (19.6%)</td>
<td>5,299 (18.0%)</td>
</tr>
<tr>
<td><em>K. oxytoca</em></td>
<td>1,937 (4.5%)</td>
<td>580 (4.4%)</td>
<td>1,357 (4.6%)</td>
</tr>
<tr>
<td><em>K. aerogenes</em></td>
<td>546 (1.3%)</td>
<td>346 (2.6%)</td>
<td>200 (0.7%)</td>
</tr>
<tr>
<td>Other named species</td>
<td>420 (1.0%)</td>
<td>147 (1.1%)</td>
<td>273 (0.9%)</td>
</tr>
<tr>
<td>Not speciated</td>
<td>349 (0.8%)</td>
<td>140 (1.1%)</td>
<td>209 (0.7%)</td>
</tr>
</tbody>
</table>
Age and sex distribution

For all age and sex analyses, cases in which the sex was missing or given as unknown were excluded. In April 2017 to March 2018, no case was reported with an ‘unknown’ sex, while 5 cases gave the sex as ‘unknown’ in April 2020 to March 2021.

Figure 12 compares the age and sex distribution of Klebsiella spp. cases as a proportion of all reported cases in April 2017 to March 2018 and April 2020 to March 2021. There has been little change to the distribution of cases. Most cases occur in adults aged 45 and over. Unlike E. coli bacteraemia cases, the proportion of Klebsiella spp. cases was usually greater in males of all age groups compared to their female counterparts.

Figure 12. Age and sex distribution of Klebsiella spp. bacteraemia by percentage of cases, England, April 2017 to March 2018 and April 2020 to March 2021

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

In general, incidence rates of Klebsiella spp. bacteraemia were greater in male patients and increased with age, except in the under 1 age group where rates were higher than
patients in the 1 to 14 and 15 to 44 age groups (Table 7, Table 8 and Figure 13). Compared to E. coli cases, the difference in incidence rates between sexes were greater. For example, the rate ratio for male and female patients in the Over 85 age group is 3.3 (95% CI: 3.0 to 3.7) in April 2020 to March 2021.

Table 7. *Klebsiella* spp. counts and rates by age group and sex, England: April 2017 to March 2018

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>333,130</td>
<td>316,482</td>
<td>105</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,827,472</td>
<td>4,595,038</td>
<td>68</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,750,236</td>
<td>10,570,942</td>
<td>304</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,027,291</td>
<td>7,219,864</td>
<td>1,265</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,652,198</td>
<td>2,855,857</td>
<td>1,446</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,446,314</td>
<td>1,757,576</td>
<td>1,719</td>
</tr>
<tr>
<td>Over 85</td>
<td>490,494</td>
<td>864,748</td>
<td>1,094</td>
</tr>
</tbody>
</table>

Table 8. *Klebsiella* spp. counts and rates by age group and sex, England: April 2020 to March 2021

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population*</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>318,032</td>
<td>300,826</td>
<td>131</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,907,107</td>
<td>4,666,124</td>
<td>83</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,763,419</td>
<td>10,571,978</td>
<td>448</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,103,072</td>
<td>7,302,687</td>
<td>1,783</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,682,950</td>
<td>2,893,116</td>
<td>1,648</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,536,167</td>
<td>1,844,432</td>
<td>1,818</td>
</tr>
<tr>
<td>Over 85</td>
<td>517,084</td>
<td>879,967</td>
<td>1,175</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
Figure 13. Trend in age and sex structure of *Klebsiella* spp. cases and rate per 100,000 population*, England, April 2017 to March 2018 to April 2020 to March 2021

*Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.*
Seasonal trends in *Klebsiella* spp. bacteraemia

In general, community-onset *Klebsiella* spp. cases peak in the July to September and October to December quarter of the year (Figure 14). This is a trend that has not changed since April 2017. A similar trend is observed with hospital-onset *Klebsiella* spp. cases. However, April 2020 to March 2021 saw a considerable change to this trend. Hospital-onset *Klebsiella* spp. cases peaked in October to December 2020 and January and March 2021. This was the first time since April 2017 to March 2018 where increases in hospital-onset cases during these 2 quarters have been higher than the rest of the financial year.

**Figure 14. Trends in the seasonality of Klebsiella spp. bacteraemia, April 2017 to March 2018 to April 2020 to March 2021**

Primary focus of *Klebsiella* spp. bacteraemia

The most frequently reported primary focus of bacteraemia for *Klebsiella* spp. cases was urinary tract infection (UTI), constituting 31.3% of cases with a reported primary focus of infection in April 2020 to March 2021. However, in that same period, the primary focus was not reported for 51.3% of all cases.
Table 9. *Klebsiella* spp. counts and rates by primary focus of bacteraemia, England, April 2017 to March 2018 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>UTI*</th>
<th>GI**</th>
<th>Hepatobiliary</th>
<th>Respiratory tract</th>
<th>Other*</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>2017/2018</td>
<td>1,680 (32.9)</td>
<td>374 (7.3)</td>
<td>1,032 (20.2)</td>
<td>469 (9.2)</td>
<td>603 (11.8)</td>
<td>946 (18.5)</td>
<td>5,104</td>
</tr>
<tr>
<td>2018/2019</td>
<td>1,941 (33.4)</td>
<td>492 (8.5)</td>
<td>1,104 (19)</td>
<td>585 (10.1)</td>
<td>768 (13.2)</td>
<td>916 (15.8)</td>
<td>5,806</td>
</tr>
<tr>
<td>2019/2020</td>
<td>2,050 (33.7)</td>
<td>484 (7.9)</td>
<td>1,215 (20)</td>
<td>581 (9.5)</td>
<td>744 (12.2)</td>
<td>1,015 (16.7)</td>
<td>6,089</td>
</tr>
<tr>
<td>2020/2021</td>
<td>1,698 (31.3)</td>
<td>399 (7.4)</td>
<td>972 (17.9)</td>
<td>696 (12.8)</td>
<td>688 (12.7)</td>
<td>964 (17.8)</td>
<td>5,417</td>
</tr>
</tbody>
</table>

* Urinary tract infection
** Gastrointestinal (not hepatobiliary)
*** ‘Other’ includes the following options HCAI DCS: bone and joint, central nervous system, genital tract (including prostate), indwelling intravascular device, other, respiratory tract, skin or soft tissue, no clinical signs of bacteraemia.

Amongst inpatients with a time to onset of less than 2 days, UTI forms a major primary focus of bacteraemia (35.9%, Figure 15) compared to where the time to onset was greater than or equal to 7 days (14.1%).
Figure 15. Distribution of primary focus of *Klebsiella* spp. bacteraemia, by time to onset, England, April 2017 to March 2018 to April 2020 to March 2021

Geographic distribution of *Klebsiella* spp. bacteraemia

Regional distribution of cases is presented by Sustainability Transformation Partnerships (STP). Some geographical variation in rates of *Klebsiella* spp. is noted (Figure 16). The highest incidence rates (cases per 100,000 population) were observed in Somerset (29.9), Cumbria and North East (24.9) and East London Health and Care Partnership (24.7), while the lowest incidence rates (cases per 100,000 population) were observed in Gloucestershire (10.2), Bedfordshire, Luton and Milton Keynes (14) and Bristol, North Somerset and South Gloucestershire (15.9).
Pseudomonas aeruginosa bacteraemia

Total reports

A total of 4,285 cases of *P. aeruginosa* bacteraemia were reported by NHS Trusts in England between 1 April 2020 and 31 March 2021. Of the 4,285 *P. aeruginosa* cases, 1,671 (39.0%) were hospital-onset cases.
Figure 17. Trends in the rate of *P. aeruginosa* in England, April 2017 to March 2018 to April 2020 to March 2021

* All cases*

* Hospital-onset cases

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

**Hospital onset cases**

The rate (cases per 100,000 bed-days) of *P. aeruginosa* hospital-onset cases was relatively stable April 2017 to March 2018 and April 2020 to March 2021 ranging from 4.4 to 4.6. However, this increased to 6.0 in April 2020 to March 2021.
Table 10. *P. aeruginosa* counts and rates by financial year, England: April 2017 to March 2018 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Mid-year population estimate</th>
<th>All reported cases</th>
<th>Rate (all reported cases per 100,000 population)</th>
<th>Total bed days**</th>
<th>Hospital-onset cases</th>
<th>Rate (Hospital-onset cases per 100,000 bed days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017/2018</td>
<td>55,707,642</td>
<td>4,305</td>
<td>7.7</td>
<td>34,903,075</td>
<td>1,624</td>
<td>4.7</td>
</tr>
<tr>
<td>2018/2019</td>
<td>56,053,563</td>
<td>4,186</td>
<td>7.5</td>
<td>34,538,184</td>
<td>1,518</td>
<td>4.4</td>
</tr>
<tr>
<td>2019/2020</td>
<td>56,286,961</td>
<td>4,344</td>
<td>7.7</td>
<td>34,637,156</td>
<td>1,581</td>
<td>4.6</td>
</tr>
<tr>
<td>2020/2021</td>
<td>56,286,961</td>
<td>4,285</td>
<td>7.6</td>
<td>27,629,101</td>
<td>1,671</td>
<td>6.0</td>
</tr>
</tbody>
</table>

*Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.*

In April 2020 to March 2021, the counts of all reported *P. aeruginosa* cases peaked in January 2021 at 391 cases and most cases were hospital-onset (54%). This was the first time since the start of mandatory surveillance when there were more hospital-onset cases than community-onset cases (Figure 18). These increases coincided with the COVID-19 pandemic and are likely a result of the change to the usual hospital population and practice during this period.
Figure 18. Monthly counts of *P. aeruginosa* bacteraemia by onset of infection, April 2018 to March 2019 to April 2020 to March 2021
Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and C. difficile infections

**Figure 19. Rate of ICU-associated hospital-onset *P. aeruginosa* bacteraemia cases, April 2017 to March 2018 to April 2020 to March 2021**

Rates of *P. aeruginosa* infections in ICUs have also gradually increased year on year between the April 2017 to March 2018 and April 2020 to March 2021 financial years. A steep rise was seen from April 2019 to March 2020 to April 2020 to March 2021, with the rate rising from 0.20 to 0.29 cases per 1,000 ICU bed days greater than 2 days.

**Age and sex distribution**

Cases in which the sex was missing or reported as ‘unknown’ were excluded. In April 2017 to March 2018, no case had an ‘unknown’ sex while in April 2020 to March 2021 one case was reported with an ‘unknown’.

Figure 20 compares the age and sex distribution of *P. aeruginosa* cases as a proportion of all reported cases in April 2017 to March 2018 and April 2020 to March 2021. There has been little change to the distribution of cases. Most cases occur in adults aged 45 and over. Unlike *E. coli* bacteraemia cases, the proportion of *P. aeruginosa* cases was usually greater in males of all age groups compared to their female counterparts.
In general, incidence rates of *P. aeruginosa* bacteraemia were greater in male patients and increased with age, except in the Under 1 age group where rates were higher than patients in the 1 to 14 and 15 to 44 age groups (Table 11, Table 12 and Figure 21). Compared to *E. coli* case, the difference in incidence rates between sexes were greater. For example, the rate ratio for male and female patients in the Over 85 age group was 3.5 (95% CI: 3.0 to 4.1) in April 2020 to March 2021.
Table 11. *P. aeruginosa* counts and rates by age group and sex, England: April 2017 to March 2018

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>333,130</td>
<td>316,482.30</td>
<td>36</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,827,472</td>
<td>4,595,037.80</td>
<td>60</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,750,236</td>
<td>10,570,942.20</td>
<td>180</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,027,291</td>
<td>7,219,863.60</td>
<td>539</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,652,198</td>
<td>2,855,856.80</td>
<td>650</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,446,314</td>
<td>1,757,575.70</td>
<td>748</td>
</tr>
<tr>
<td>Over 85</td>
<td>490,494</td>
<td>864,748.20</td>
<td>533</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

Table 12. *P. aeruginosa* counts and rates by age group and sex, England: April 2020 to March 2021

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>318,032</td>
<td>300,826</td>
<td>25</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,907,107</td>
<td>4,666,124</td>
<td>70</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,763,419</td>
<td>10,571,978</td>
<td>189</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,103,072</td>
<td>7,302,687</td>
<td>646</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,682,950</td>
<td>2,893,116</td>
<td>652</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,536,167</td>
<td>1,844,432</td>
<td>723</td>
</tr>
<tr>
<td>Over 85</td>
<td>517,084</td>
<td>879,967</td>
<td>465</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
Figure 21. Trend in age and sex structure of *P. aeruginosa* cases and rate per 100,000 population*, England, April 2017 to March 2018 to April 2020 to March 2021

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
Seasonal trends in *P. aeruginosa* bacteraemia

In general, community-onset *P. aeruginosa* cases peak in the July-September quarter of the year. This is a trend that has not changed since April 2017. A similar trend is observed with hospital-onset *P. aeruginosa* cases. However, April 2020 to March 2021 saw a considerable change to this trend. Hospital-onset *P. aeruginosa* cases peaked in October to December 2020 and January and March 2021. This was the first time since April 2017 to March 2018 where increases in hospital-onset cases during these 2 quarters have been higher than the rest of the financial year.

**Figure 22. Trends in the seasonality of *P. aeruginosa* bacteraemia, April 2017 to March 2018 to April 2020 to March 2021**

![Graph showing trends in seasonal distribution of *P. aeruginosa* bacteraemia from 2017/18 to 2020/21.]

**Primary focus of *P. aeruginosa* bacteraemia**

The most frequent primary focus of bacteraemia for *P. aeruginosa* was urinary tract infection (UTI), constituting 28.5% of cases with a reported primary focus of infection in April 2020 to March 2021. However, in that same period, the primary focus was not reported for 52.4% of cases.
Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and *C. difficile* infections

Table 13. *P. aeruginosa* counts and rates by primary focus of bacteraemia, England, April 2017 to March 2018 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>UTI* n (%)</th>
<th>GI** n (%)</th>
<th>Hepatobiliary n (%)</th>
<th>Respiratory tract n (%)</th>
<th>Other*** n (%)</th>
<th>Unknown n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017/18</td>
<td>638 (30)</td>
<td>125 (5.9)</td>
<td>102 (4.8)</td>
<td>300 (14.1)</td>
<td>491 (23.1)</td>
<td>471 (22.1)</td>
<td>2,127</td>
</tr>
<tr>
<td>2018/19</td>
<td>644 (29.8)</td>
<td>156 (7.2)</td>
<td>100 (4.6)</td>
<td>281 (13)</td>
<td>557 (25.8)</td>
<td>423 (19.6)</td>
<td>2,161</td>
</tr>
<tr>
<td>2019/20</td>
<td>716 (30.9)</td>
<td>160 (6.9)</td>
<td>123 (5.3)</td>
<td>313 (13.5)</td>
<td>549 (23.7)</td>
<td>459 (19.8)</td>
<td>2,320</td>
</tr>
<tr>
<td>2020/21</td>
<td>582 (28.5)</td>
<td>126 (6.2)</td>
<td>114 (5.6)</td>
<td>331 (16.2)</td>
<td>482 (23.6)</td>
<td>404 (19.8)</td>
<td>2,039</td>
</tr>
</tbody>
</table>

* Urinary tract infection  
** Gastrointestinal (not hepatobiliary)  
*** ‘Other’ includes the following options HCAI DCS: bone and joint, central nervous system, genital tract (including prostate), indwelling intravascular device, other, respiratory tract, skin or soft tissue, no clinical signs of bacteraemia.

Among inpatients with a time to onset of less than 2 days, UTI forms a major primary focus of bacteraemia (34.9%, Figure 23) compared to where the time to onset was greater than or equal to 7 days (13.9%).
Figure 23. Distribution of primary focus of *P. aeruginosa* bacteraemia, by time to onset, England, April 2017 to March 2018 to April 2020 to March 2021

Geographic distribution of *P. aeruginosa* bacteraemia

Regional distribution of cases is presented by Sustainability Transformation Partnerships (STP). Some geographical variation in rates of *P. aeruginosa* cases is noted (Figure 24). The highest incidence rates (cases per 100,000 population) were observed in North London Partners in Health and Care (11.7), Lincolnshire (10.6) and Sussex and East Surrey Health and Care Partnership (10.2), while the lowest incidence rates (cases per 100,000 population) were observed in Gloucestershire (4.2), Cornwall and the Isles of Scilly Health and Social Care Partnership (4.7) and Bedfordshire, Luton and Milton Keynes (4.7).
Figure 24. Geographic distribution of *P. aeruginosa* rates per 100,000 population, England April 2020 to March 2021*

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

See Table 13a of the accompanying data sheet for a breakdown of STP-specific *P. aeruginosa* bacteraemia rates.
Discussion

Data on bacteraemia caused by *E. coli*, *Klebsiella* spp. and *P. aeruginosa* show both similarities and differences in the epidemiology of these infections.

*E. coli* continues to have the highest rate of all the Gram-negative organisms, causing 65.3 cases of bacteraemia per 100,000 population in April 2020 to March 2021. This is followed by *Klebsiella* spp. (19.8) and *P. aeruginosa* cases (7.6). *P. aeruginosa* and *Klebsiella* spp. cases were more likely to be hospital-onset, accounting for 39% and 34% of all reported cases of each infection respectively. However, hospital-onset cases were much less common in *E. coli* cases, accounting for only 18% of all reported cases.

Amongst the 53% of all Gram-negative bacteraemia cases with a known focus of infection, UTIs remain a major source of bacteraemia - *E. coli* - 44%, *Klebsiella* spp. - 31% and *P. aeruginosa* - 29%. The respiratory tract is the focus for 16% of *P. aeruginosa* infections but only 8% in *E. coli* and 13% in *Klebsiella* spp. cases respectively.

The age distribution of cases is similar in all 3 bacteraemia. However, there are differences in the distribution of cases by sex. *E. coli* cases are more evenly distributed between male and female patients, while *Klebsiella* spp. and *P. aeruginosa* cases are considerably more common in male patients, particularly in the older age groups.

Rates of *E. coli* and *Klebsiella* spp. show similar geographic distributions in England with higher rates in the Northern parts of England compared to the South. In contrast, rates of *P. aeruginosa* bacteraemia are more evenly spread across England.

Long term trends of each bacteraemia show increasing incidence rates since the start of enhanced surveillance. *E. coli* cases averaged an annual increase of 5% between April 2012 to March 2013 and April 2018 to March 2019, except between April 2016 to March 2017 and April 2018 to March 2019 when the annual increase was 1%. Prior to this point, it was the lowest annual increase in rates ever recorded since the start of enhanced surveillance. However, since then, the incidence rate has declined considerably. A large part of this is likely due to the impacts of the COVID-19 pandemic such as reduced hospital activity and changes to the hospital populations during this period. However, unlike *E. coli* bacteraemia, there was no similar decline in the incidence of rates of all reported *Klebsiella* spp. and *P. aeruginosa* cases in April 2020 to March 2021. Furthermore, in contrast to *E. coli*, the number of hospital-onset *Klebsiella* spp. and *P. aeruginosa* cases increased during the COVID-19 pandemic. An initial analysis by PHE has found that these increases coincided with increase in hospital-onset *Klebsiella* spp. and *P. aeruginosa* cases that are a) secondary to COVID-19 cases, b) reported with respiratory tract infection as the primary focus of infection and c) reported in intensive care units. This suggests that these increases in hospital-onset
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cases are likely related to the COVID-19 pandemic. *E. coli* bacteraemia is less commonly associated with these factors compared to *Klebsiella* spp. and *P. aeruginosa* which may explain the different trend observed for *E. coli* bacteraemia. Further work is underway to investigate these trends in the context of the changing hospital population and practices during the COVID-19 pandemic.

Unlike *Klebsiella* spp. and *P. aeruginosa* cases, the proportion of hospital-onset cases of *E. coli* remained relatively stable, suggesting that much of the increase in incidence is occurring in community-onset cases. However, as community-onset cases include patients with recent hospital admissions and other healthcare interactions, increases of cases within this category will be in part associated with healthcare activity. For *E. coli* bacteraemia approximately half of the community-onset cases are likely to be healthcare-associated (Abernethy and others, 2017).

As described above, rates of *E. coli* bacteraemia have been rising since April 2011 to March 2012. The number of Gram-negative bacteraemias far exceeds those caused by *S. aureus*. In April 2019 to March 2020, a total of 6,005 people died within 30 days of having *E. coli* bacteraemia (PHE 2020). For these reasons and concerns about rising resistance, the Secretary of State for Health introduced an ambition to reduce healthcare-associated Gram-negative bacteraemia by March 2021 (NHSI 2017, HM Government 2018) which has now been extended to March 2024. The reduction in rates of *C. difficile* infection and MRSA bacteraemia show what is possible with targeted interventions. However, there are important differences in the epidemiology of *E. coli* bacteraemia and that of MRSA bacteraemia and CDI which means that the type of interventions introduced to control MRSA bacteraemia and CDI may not be enough to effectively control the increases in *E. coli* bacteraemia.

For both CDI and MRSA bacteraemia, at their peak, cases were more likely to occur in the hospital setting. This means that the patient’s environment could be more carefully controlled and healthcare interventions readily improved. With many of the cases of *E. coli* being community-onset, altering clinical practice to reduce infection rates is likely to be harder than it was for MRSA and CDI. Urinary tract infections were found to be the main source of Gram-negative bacteraemia cases and thus should be targeted by infection prevention control programs if substantial reductions are to be achieved. If urinary tract infections could be reduced, or, where they do occur, detected and resolved quickly, then a concomitant reduction in bacteraemias should follow (Wiley E 2019).
Epidemiological analysis of *Staphylococcus aureus* bacteraemia

A total of 12,390 *Staphylococcus aureus* bacteraemia cases were reported to PHE in April 2020 to March 2021 through both the meticillin resistant *S. aureus* (MRSA) bacteraemia and meticillin-susceptible *S. aureus* (MSSA) bacteraemia surveillance schemes. This represents a 5% decrease in the numbers of bacteraemias caused by *S. aureus* from April 2019 to March 2020 (n = 13,039) and a 25.4% increase from April 2011 to March 2012 (n = 9,883) when MSSA reporting was made mandatory.

In April 2020 to March 2021, 5.6% (n = 694) of *S. aureus* bacteraemia reports were caused by MRSA. This is a decrease from April 2011 to March 2012, in which 11.3% (n = 1,116) of reports were caused by MRSA and decrease from April 2019 to March 2020 in which 6.2% (n = 814) of reports were caused by MRSA. At its peak MRSA bacteraemias accounted for approximately 40% of all *S. aureus* bacteraemia cases in England (Johnson AP 2005).

The following sections will describe the epidemiology of MRSA and MSSA in England separately.

**Meticillin resistant *Staphylococcus aureus* bacteraemia**

**Total reports**

A total of 694 cases of MRSA bacteraemia were reported by acute NHS Trusts in England between 1 April 2020 and 31 March 2021. This is a decrease of 14.7% from April 2019 to March 2020 (n = 814), and a decrease of 84.4% from April 2007 to March 2008 (n = 4,451). Figure 26 shows the trends in rates of MRSA cases for all cases and hospital-onset cases from April 2007 to March 2008 to April 2020 to March 2021. The rate of all MRSA cases per 100,000 population, per year has fallen from 8.6 in April 2007 to March 2008 to 1.2 in April 2020 to March 2021.
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Figure 25. Trends in the all case and hospital-onset rate of MRSA bacteraemia in England, April 2007 to March 2008 to April 2020 to March 2021

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

MRSA all-case rate has remained relatively stable since April 2014 to March 2015 at about 1.4 to 1.5 cases per 100,000 population. However, the decline in rates between April 2019 to March 2020 (1.4) and April 2020 to March 2021 (1.2) is the largest change in rates during this period of relative stability.

Hospital-onset reports

Of the 694 total cases reported in FY April 2020 to March 2021, 281 were hospital-onset (1.0 per 100,000 bed days). Overall, there has been a declining trend in the rate of hospital-onset MRSA cases from 4.2 in April 2008 to March 2009 to 1.0 in April 2020 to March 2021. The hospital-onset incidence rate increased 35.5% during April 2020 to March 2021 compared to April 2019 to March 2020 from 0.8 per 100,000 bed-days. This
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is the largest annual increase in rates of infection since enhanced mandatory surveillance began in April 2007 to March 2008.

Despite the increase in hospital-onset rates, the percentage of cases that were hospital-onset has declined from 54.7% in April 2007 to March 2008 to 28.5% in April 2020 to March 2021.

Table 14. MRSA counts and rates by financial year, England: April 2007 to March 2008 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Mid-year population estimate</th>
<th>All reported cases</th>
<th>Rate (all reported cases per 100,000 population)</th>
<th>Total bed days**</th>
<th>Hospital-onset cases</th>
<th>Rate (Hospital-onset cases per 100,000 bed days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td>51,594,959</td>
<td>4,451</td>
<td>8.6</td>
<td>37,451,721</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2008/2009</td>
<td>51,803,017</td>
<td>2,935</td>
<td>5.7</td>
<td>37,823,023</td>
<td>1,606</td>
<td>4.2</td>
</tr>
<tr>
<td>2009/2010</td>
<td>52,306,371</td>
<td>1,898</td>
<td>3.6</td>
<td>37,441,615</td>
<td>1,004</td>
<td>2.7</td>
</tr>
<tr>
<td>2010/2011</td>
<td>52,757,040</td>
<td>1,481</td>
<td>2.8</td>
<td>35,206,316</td>
<td>688</td>
<td>2</td>
</tr>
<tr>
<td>2011/2012</td>
<td>53,312,604</td>
<td>1,116</td>
<td>2.1</td>
<td>34,669,499</td>
<td>473</td>
<td>1.4</td>
</tr>
<tr>
<td>2012/2013</td>
<td>53,475,358</td>
<td>924</td>
<td>1.7</td>
<td>34,633,855</td>
<td>398</td>
<td>1.1</td>
</tr>
<tr>
<td>2013/2014</td>
<td>53,976,973</td>
<td>862</td>
<td>1.6</td>
<td>34,514,871</td>
<td>364</td>
<td>1.1</td>
</tr>
<tr>
<td>2014/2015</td>
<td>54,432,437</td>
<td>800</td>
<td>1.5</td>
<td>34,972,728</td>
<td>285</td>
<td>0.8</td>
</tr>
<tr>
<td>2015/2016</td>
<td>55,018,884</td>
<td>823</td>
<td>1.5</td>
<td>34,752,604</td>
<td>298</td>
<td>0.9</td>
</tr>
<tr>
<td>2016/2017</td>
<td>55,240,933</td>
<td>825</td>
<td>1.5</td>
<td>35,148,014</td>
<td>315</td>
<td>0.9</td>
</tr>
<tr>
<td>2017/2018</td>
<td>55,707,642</td>
<td>850</td>
<td>1.5</td>
<td>34,903,075</td>
<td>276</td>
<td>0.8</td>
</tr>
<tr>
<td>2018/2019</td>
<td>56,053,563</td>
<td>807</td>
<td>1.4</td>
<td>34,538,184</td>
<td>271</td>
<td>0.8</td>
</tr>
<tr>
<td>2019/2020</td>
<td>56,286,961</td>
<td>814</td>
<td>1.4</td>
<td>34,637,156</td>
<td>260</td>
<td>0.8</td>
</tr>
<tr>
<td>2020/2021</td>
<td>56,286,961</td>
<td>694</td>
<td>1.2</td>
<td>27,629,101</td>
<td>281</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

In April 2020 to March 2021, the counts of all reported cases peaked in January 2021 at 84 cases and most cases where hospital-onset (52%). January and February 2021 were the first time in the most the most recent years when there were more hospital-onset cases than community-onset cases (Figure 26).
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Figure 26. Monthly counts of MRSA bacteraemia by onset of infection, April 2018 to March 2019-April 2020 to March 2021
Figure 27. Rate of ICU-associated hospital-onset MRSA bacteraemia cases, April 2017 to March 2018 to April 2020 to March 2021

Rates of MRSA infections in ICUs have fluctuated year on year between April 2017 to March 2018 and April 2020 to March 2021 financial years. Between April 2019 to March 2020 and April 2020 to March 2021, the rates increased from 0.026 to 0.035 cases per 1,000 ICU bed days greater than 2 days.

Age and sex distribution

For all age and sex analyses, cases in which the sex was missing or given as unknown were excluded. In April 2007 to March 2008, 52 cases (1.2%) gave the sex as unknown. In April 2020 to March 2021, no case gave the sex as unknown.

Figure 28 compares the age and sex distribution of MRSA cases as a proportion of all reported cases in April 2007 to March 2008 and April 2020 to March 2021. Some changes are observed in the distribution of cases in both periods. In general, proportion of cases from older age groups is lower in April 2020 to March 2021 compared to April 2007 to March 2008, while the opposite is the case for the younger age groups. Furthermore, there is a noticeable increase in the proportion of all cases that occurred in male patients in the 15 to 44 age group during April 2020 to March 2021 (11.1%) compared to April 2007 to March 2008 (5.7%).
In general, the rates of MRSA bacteraemia are greater among males than among females, and particularly so among older age groups. Incidence rates are greatest in the over 85 age group. The rate ratio for males to female in this age group was 3.3 (95% CI: 2.9 to 3.8) in April 2007 to March 2008 compared to 1.9 (95% CI: 1.3 to 2.7) in April 2020 to March 2021.
Table 15. MRSA counts and rates by age group and sex, England: April 2007 to March 2008

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>333,164</td>
<td>317,036</td>
<td>31</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,369,017</td>
<td>4,166,420</td>
<td>22</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,728,560</td>
<td>10,721,325</td>
<td>252</td>
</tr>
<tr>
<td>45 to 64</td>
<td>6,322,972</td>
<td>6,463,537</td>
<td>594</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,011,279</td>
<td>2,205,682</td>
<td>583</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,208,494</td>
<td>1,655,252</td>
<td>884</td>
</tr>
<tr>
<td>Over 85</td>
<td>337,200</td>
<td>755,019</td>
<td>497</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

Table 16. MRSA counts and rates by age group and sex, England: April 2020 to March 2021

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>318,032</td>
<td>300,826</td>
<td>12</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,907,107</td>
<td>4,666,124</td>
<td>10</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,763,419</td>
<td>10,571,978</td>
<td>80</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,103,072</td>
<td>7,302,687</td>
<td>132</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,682,950</td>
<td>2,893,116</td>
<td>77</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,536,167</td>
<td>1,844,432</td>
<td>96</td>
</tr>
<tr>
<td>Over 85</td>
<td>517,084</td>
<td>879,967</td>
<td>57</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

Trends in the age- and sex-specific rates of MRSA bacteraemia are shown in Figure 29. Rates of MRSA bacteraemia have fallen across all age and sex groups since the start of the surveillance in April 2007 to March 2008. Despite this, some fluctuations in rate are seen for both sexes in the under 1 age group in which rates increased in April 2015 to March 2016 and April 2016 to March 2017 (from 1.5 per 100,000 population in females in April 2013 to March 2014 to 2.2 in April 2016 to March 2017 and from 2.3 in males in April 2013 to March 2014 to 5.0 in April 2016 to March 2017).
Article: Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and *C. difficile* infections

**Source of MRSA bacteraemia**

The HCAI Data Capture System provides Trust users the opportunity to add information regarding the likely source of bacteraemia. Source of bacteraemia refers to the likely cause of the bacteraemia, such as an intravenous catheter, rather than an organ where the infection first arose as in primary focus for Gram-negative bacteraemia. The provision of this information is also voluntary and has declined over time for MRSA. In April 2007 to March 2008 a total of 2,414 (54.2%) of MRSA records had entries

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*Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.*
(including ‘Unknown’) for the source of bacteraemia. By April 2020 to March 2021 a total of 212 (30.5%) MRSA records had entries for the source of bacteraemia.

There have been large declines in the percentage of MRSA cases in which the source of bacteraemia was a catheter or line. In April 2007 to March 2008, catheters or lines were the source of 25.6% of cases. By April 2020 to March 2021, this had declined to 15.6% of cases. In contrast, the percentage of cases caused by skin and soft tissue infections has increased from 16.4% in April 2007 to March 2008 to 25.9% in April 2020 to March 2021. Between April 2007 to March 2008 and April 2014 to March 2015, the percentage of cases for which the source of bacteraemia was pneumonia increased from 6.6% to 15.4%. Between April 2014 to March 2015 and April 2020 to March 2021, the percentage of cases for which pneumonia was the source fluctuated between 15.4% to 12.7%. Trends in sources of bacteraemia are shown in Table 17.

### Table 17. MRSA counts and rates by source of bacteraemia, England: April 2007 to March 2008 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Catheters and lines*</th>
<th>SSTI**</th>
<th>Pneumonia</th>
<th>Other***</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>2007/2008</td>
<td>617 (25.6)</td>
<td>395 (16.4)</td>
<td>160 (6.6)</td>
<td>705 (29.2)</td>
<td>537 (22.2)</td>
<td>2,414 (100.0)</td>
</tr>
<tr>
<td>2008/2009</td>
<td>346 (22.5)</td>
<td>276 (17.9)</td>
<td>113 (7.3)</td>
<td>552 (35.8)</td>
<td>254 (16.5)</td>
<td>1,541 (100.0)</td>
</tr>
<tr>
<td>2009/2010</td>
<td>178 (19.5)</td>
<td>191 (20.9)</td>
<td>63 (6.9)</td>
<td>328 (35.8)</td>
<td>155 (16.9)</td>
<td>915 (100.0)</td>
</tr>
<tr>
<td>2010/2011</td>
<td>118 (17.5)</td>
<td>146 (21.6)</td>
<td>47 (7.0)</td>
<td>251 (37.1)</td>
<td>114 (16.9)</td>
<td>676 (100.0)</td>
</tr>
<tr>
<td>2011/2012</td>
<td>71 (14.7)</td>
<td>98 (20.3)</td>
<td>41 (8.5)</td>
<td>177 (36.7)</td>
<td>95 (19.7)</td>
<td>482 (100.0)</td>
</tr>
<tr>
<td>2012/2013</td>
<td>72 (18.3)</td>
<td>74 (18.8)</td>
<td>34 (8.6)</td>
<td>128 (32.5)</td>
<td>86 (21.8)</td>
<td>394 (100.0)</td>
</tr>
<tr>
<td>2013/2014</td>
<td>39 (13.3)</td>
<td>57 (19.4)</td>
<td>33 (11.2)</td>
<td>100 (34.0)</td>
<td>65 (22.1)</td>
<td>294 (100.0)</td>
</tr>
<tr>
<td>2014/2015</td>
<td>30 (11.9)</td>
<td>53 (20.9)</td>
<td>39 (15.4)</td>
<td>64 (25.3)</td>
<td>67 (26.5)</td>
<td>253 (100.0)</td>
</tr>
<tr>
<td>2015/2016</td>
<td>38 (15.5)</td>
<td>56 (22.9)</td>
<td>25 (10.2)</td>
<td>89 (36.3)</td>
<td>37 (15.1)</td>
<td>245 (100.0)</td>
</tr>
<tr>
<td>2016/2017</td>
<td>51 (20.0)</td>
<td>80 (31.4)</td>
<td>21 (8.2)</td>
<td>88 (34.5)</td>
<td>15 (5.9)</td>
<td>255 (100.0)</td>
</tr>
<tr>
<td>2017/2018</td>
<td>50 (15.4)</td>
<td>101 (31.1)</td>
<td>40 (12.3)</td>
<td>118 (36.3)</td>
<td>16 (4.9)</td>
<td>325 (100.0)</td>
</tr>
<tr>
<td>2018/2019</td>
<td>37 (12.8)</td>
<td>97 (33.6)</td>
<td>30 (10.4)</td>
<td>115 (39.8)</td>
<td>10 (3.5)</td>
<td>289 (100.0)</td>
</tr>
<tr>
<td>2019/2020</td>
<td>33 (12.8)</td>
<td>80 (31.1)</td>
<td>24 (9.3)</td>
<td>96 (37.4)</td>
<td>24 (9.3)</td>
<td>257 (100.0)</td>
</tr>
<tr>
<td>2020/2021</td>
<td>33 (15.6)</td>
<td>55 (25.9)</td>
<td>27 (12.7)</td>
<td>91 (42.9)</td>
<td>6 (2.8)</td>
<td>212 (100.0)</td>
</tr>
</tbody>
</table>

*‘Catheters and lines’ includes the following options from the HCAI DCS question: dialysis lines, central venous catheter (CVC) associated, peripheral venous catheter (PVC) associated and intravenous (IV) lines.

**‘Skin and Soft Tissue Infection’ includes the following options HCAI DCS: endocarditis, osteomyelitis, other, prosthetic joint, surgical site infection (SSI), septic arthritis, urinary tract infection (UTI) and ventilator-associated pneumonia.

***‘Other’ includes the following options HCAI DCS: endocarditis, osteomyelitis, other, prosthetic joint, surgical site infection (SSI), septic arthritis, urinary tract infection (UTI) and ventilator-associated pneumonia.
Geographic distribution of MRSA bacteraemia

Regional distribution of cases is presented by Sustainability Transformation Partnerships (STP). There is little geographical variation in rates of MRSA (Figure 30). The highest incidence rate (cases per 100,000 population) were observed in Bristol, North Somerset and South Gloucestershire (3.2), Mid and South Essex (2.2) and Frimley Health and Care ICS (2.1), while the lowest incidence rate (cases per 100,000 population) were observed in Humber, Coast and Vale (0.4), Birmingham and Solihull (0.5) and Devon (0.6).

Figure 30. Geographic distribution of MRSA rates per 100,000 population, England: April 2020 to March 2021

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

See Table 17a of the accompanying data sheet for a breakdown of STP-specific MRSA bacteraemia rates.

Discussion

MRSA bacteraemia rates have declined consistently each year between April 2007 to March 2008 and April 2014 to March 2015. In April 2015 to March 2016 the rate increased slightly but remained relatively stable until April 2020 to March 2021, when
there was a considerable decline in the rate of infection compared to the previous years. Conversely, in the most recent financial year, the rate of hospital-onset cases increased considerably. This was the largest annual increase in rates of hospital-onset MRSA since the initiation of mandatory surveillance in April 2016 to March 2017. The exact reasons for this increase in hospital-onset cases is under investigation, but there is a correlation around the timing of the COVID-19 peaks during 2020 and early 2021.

Over time, numerous interventions aimed at reducing the incidence of MRSA bacteraemia and other infections have been introduced. These include the Department of Health (DoH) policy document ‘Winning Ways,’ published in 2003 (Department of Health 2003b); The ‘CleanYourHands’ campaign launched by the National Patient Safety Agency in 2014 (Stone and others. 2012); the ‘Saving Lives’ programme launched by the DoH in 2005 which included the ambition to halve MRSA rates by 2008 (Department of Health 2005); the 2006 Health Act which introduced a code of practice to provide guidance on reducing HCAI including MRSA (Department of Health 2006); and the Health and Social Care Act, 2008 which requires the code of practice to be regularly updated (Department of Health 2008).

The epidemiology of MRSA has changed since its peak, with community onset cases now being more common. This switch in setting is most likely due to most MRSA bacteraemia interventions being focused on the acute care setting, and thus the largest reductions in MRSA bacteraemias were seen in hospital-onset cases. The duration of stay of hospital patients is also on the decline. In 2001 the average length of stay for a hospitalised patient was 7.4 days in the UK, this decreased to 5.9 days in 2013 (Organisation of Economic Co-operation and Development 2018). The reduced hospital stay lessens the risk of acquiring a hospital-acquired infection (HAI). However, it could also result in patients acquiring an MRSA infection in an acute care setting and yet not displaying symptoms until they have returned to the community. Such cases would then be readmitted, at which point they would be considered community-onset, according to the definitions used here. It is also possible that early detection of MRSA bacteraemia is improving with advances in diagnostics as well as general improvements in clinical awareness of sepsis (Sepsis Trust, 2013).

The percentage of MRSA bacteraemia where the likely source of infection was a catheter or a line has shown steady decrease between April 2007 to March 2008 and April 2014 to March 2015, with a sudden sharp rise between April 2015 to March 2016 to April 2016 to March 2017, and subsequently returned to levels seen prior to April 2015 to March 2016. Declines in the proportion of MRSA bacteraemia where the most likely source of infection is a catheter or line have been noted previously and may be due to greater clinical awareness of the importance of this route of infection and the introduction of care bundles aimed at reducing infections in intra-vascular lines and selective decolonization of patients with MRSA carriage.
The percentage where the primary focus is something other than catheters or intravenous lines have fluctuated considerably over time. The percentage of infections whose likely source is skin or soft tissue infection does appear to have increased over time, from 16.4% in April 2007 to March 2008 to 25.9% in April 2020 to March 2021. However, in April 2020 to March 2021 approximately 30.5% of records had information on the likely source of bacteraemia and therefore, interpretation of these data should be approached cautiously.

Considered together, the stabilisation in the rate of hospital-onset cases and the increase in the percentage of infections due to catheters since April 2014 to March 2015 and lines may point to a need to maintain a focus on trust-based infection prevention initiatives to reduce hospital-onset cases further. In addition to maintaining good practice in an acute trust setting, interventions are required in the community setting, considering most MRSA cases are community onset. The rates of MRSA bacteraemia are relatively evenly distributed across England.

**Meticillin-susceptible *Staphylococcus aureus* bacteraemia**

**Total reports**

A total of 11,696 cases of MSSA bacteraemia were reported by NHS acute Trusts in England between 1 April 2020 and 31 March 2021. This is a decrease of 4.3% compared to April 2019 to March 2020 (n = 12,225), and an increase of 33.4% compared to April 2011 to March 2012 (n = 8,767). Figure 30 shows the trends in rates of MSSA cases for all cases and hospital-onset cases from April 2011 to March 2012 to April 2020 to March 2021. The rate of all MSSA cases per 100,000 population, per year has risen from 16.4 in April 2011 to March 2012 to 20.8 in April 2020 to March 2021. This, however, is a decrease from the previous year; 21.7 in April 2019 to March 2020.
Hospital-onset reports

Of the 11,696 total cases reported in FY April 2020 to March 2021, 3,339 were hospital-onset (12.1 per 100,000 bed days). Overall, there has been an increasing trend in the rate of hospital-onset MSSA cases from 8.2 in April 2011 to March 2012 to 12.1 in April 2020 to March 2021, a change of 55%. The incidence rate levelled off between April 2018 to March 2019 and April 2019 to March 2020 at about 9.5 cases per 100,000 bed days but subsequently increased by 26.7% between April 2019 to March 2020 and April 2020 to March 2021. The exact reasons for this sharp increase in hospital-onset cases in April 2020 to March 2021 are under investigation but are likely related to the impact of the COVID-19 pandemic on hospital activity and population during that period. 28.5% of all cases were hospital-onset ion April 2020 to March 2021, which was a decline from 32.6% in April 2011 to March 2012. However, it was slight increase compared the previous financial year 27.0% in April 2019 to March 2020.
Table 18. MSSA counts and rates by financial year, England: April 2011 to March 2012 to April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Mid-year population estimate</th>
<th>All reported cases</th>
<th>Rate (all reported cases per 100,000 population)*</th>
<th>Total bed days</th>
<th>Hospital-onset cases</th>
<th>Rate (Hospital-onset cases per 100,000 bed days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011/2012</td>
<td>53,312,604</td>
<td>8,767</td>
<td>16.4</td>
<td>34,669,499</td>
<td>2,854</td>
<td>8.2</td>
</tr>
<tr>
<td>2012/2013</td>
<td>53,475,358</td>
<td>8,812</td>
<td>16.5</td>
<td>34,633,855</td>
<td>2,700</td>
<td>7.8</td>
</tr>
<tr>
<td>2013/2014</td>
<td>53,976,973</td>
<td>9,290</td>
<td>17.2</td>
<td>34,514,871</td>
<td>2,696</td>
<td>7.8</td>
</tr>
<tr>
<td>2014/2015</td>
<td>54,432,437</td>
<td>9,862</td>
<td>18.1</td>
<td>34,972,728</td>
<td>2,807</td>
<td>8</td>
</tr>
<tr>
<td>2015/2016</td>
<td>55,018,884</td>
<td>10,608</td>
<td>19.3</td>
<td>34,752,604</td>
<td>2,921</td>
<td>8.4</td>
</tr>
<tr>
<td>2016/2017</td>
<td>55,240,933</td>
<td>11,497</td>
<td>20.8</td>
<td>35,148,014</td>
<td>3,098</td>
<td>8.8</td>
</tr>
<tr>
<td>2017/2018</td>
<td>55,707,642</td>
<td>11,955</td>
<td>21.5</td>
<td>34,903,075</td>
<td>3,154</td>
<td>9</td>
</tr>
<tr>
<td>2018/2019</td>
<td>56,053,563</td>
<td>12,097</td>
<td>21.6</td>
<td>34,538,184</td>
<td>3,328</td>
<td>9.6</td>
</tr>
<tr>
<td>2019/2020</td>
<td>56,286,961</td>
<td>12,225</td>
<td>21.7</td>
<td>34,637,156</td>
<td>3,305</td>
<td>9.5</td>
</tr>
<tr>
<td>2020/2021</td>
<td>56,286,961</td>
<td>11,696</td>
<td>20.8</td>
<td>27,629,101</td>
<td>3,339</td>
<td>12.1</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.

Figure 32. Rate of ICU-associated hospital-onset MSSA bacteraemia cases, April 2017 to March 2018-April 2020 to March 2021

Rates of MSSA infections in ICUs have fluctuated year on year between April 2017 to March 2018 and April 2020 to March 2021 financial years, dropping to its lowest levels in
April 2019 to March 2020. A steep increase of 69.7% was seen between April 2019 to March 2020 to April 2020 to March 2021, from 0.26 to 0.44 cases per 1,000 ICU bed days greater than 2 days.

Age and sex distribution

For all age and sex analyses, cases in which the sex was missing or given as unknown were excluded. In April 2011 to March 2012, 265 cases (3%) gave the sex as ‘unknown’ compared to 7 cases (Under 1%) in April 2020 to March 2021.

Figure 33 compared the age and sex distribution of MSSA cases as a proportion of all reported cases in April 2011 to March 2012 and April 2020 to March 2021. There has been little change to the distribution of cases.

Figure 33. Age and sex distribution of MSSA bacteraemia by percentage, April 2011 to March 2012 to April 2020 to March 2021*

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
In general, the rates of MSSA bacteraemia are greater among male patients than among female, and particularly so among older age groups. The rate ratio for MSSA between male and female patients in the over 85 age group was 2.0 (95% CI: 1.8-2.3) in April 2011 to March 2012 compared to 2.2 (95% CI: 2.0-2.5) in April 2020 to March 2021.

Table 19. MSSA counts and rates by age group and sex, England: April 2011 to March 2012

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>350,818</td>
<td>333,993</td>
<td>251</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,476,176</td>
<td>4,269,122</td>
<td>283</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,799,092</td>
<td>10,738,537</td>
<td>849</td>
</tr>
<tr>
<td>45 to 64</td>
<td>6,678,566</td>
<td>6,837,399</td>
<td>1,409</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,241,804</td>
<td>2,422,556</td>
<td>947</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,295,415</td>
<td>1,666,592</td>
<td>964</td>
</tr>
<tr>
<td>Over 85</td>
<td>394,885</td>
<td>807,649</td>
<td>531</td>
</tr>
</tbody>
</table>

Table 20. MSSA counts and rates by age group and sex, England: April 2020 to March 2021*

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Under 1</td>
<td>318,032</td>
<td>300,826</td>
<td>228</td>
</tr>
<tr>
<td>1 to 14</td>
<td>4,907,107</td>
<td>4,666,124</td>
<td>265</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,763,419</td>
<td>10,571,978</td>
<td>1,069</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,103,072</td>
<td>7,302,687</td>
<td>2,095</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,682,950</td>
<td>2,893,116</td>
<td>1,385</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,536,167</td>
<td>1,844,432</td>
<td>1,378</td>
</tr>
<tr>
<td>Over 85</td>
<td>517,084</td>
<td>879,967</td>
<td>968</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
Source of MSSA bacteraemia

In April 2011 to March 2012, a total of 3,305 (37.7%) records had entries for the source of bacteraemia. By April 2020 to March 2021, a total of 3,439 (29.4%) had entries for the source of bacteraemia.

The percentage of cases caused by skin and soft tissue infections has increased from 20.3% in April 2011 to March 2012 to 27.4% in April 2020 to March 2021. The percentage of infections caused by pneumonia has also risen substantially from 6% in
April 2011 to March 2012 to 12.5% in April 2020 to March 2021. The percentage of MSSA cases with catheter or line as the reported source of infection fluctuated between 13.1% and 15.6% between April 2012 to March 2013 and April 2016 to March 2017. However, since April 2017 to March 2018 there has been a relatively small but consistent increase from 14.6% in April 2017 to March 2018 to 16.3% in April 2020 to March 2021.

Although the percentage of records for which the source of infection was not reported has declined, the percentage of cases for which the source of infection was reported as ‘unknown’ has decreased from 23.6% in April 2011 to March 2012 to 2.2% in April 2020 to March 2021. Trends in sources of MSSA bacteraemia are shown in Table 2.

Table 2. MSSA counts and rates by source of bacteraemia, England: April 2020 to March 2021

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Catheters and lines*</th>
<th>SSTI**</th>
<th>Pneumonia</th>
<th>Other***</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>2011/2012</td>
<td>565 (17.1)</td>
<td>670 (20.3)</td>
<td>197 (6.0)</td>
<td>1093 (33.1)</td>
<td>780 (23.6)</td>
<td>3,305 (100.0)</td>
</tr>
<tr>
<td>2012/2013</td>
<td>492 (15.1)</td>
<td>699 (21.4)</td>
<td>232 (7.1)</td>
<td>1088 (33.3)</td>
<td>755 (23.1)</td>
<td>3,266 (100.0)</td>
</tr>
<tr>
<td>2013/2014</td>
<td>435 (13.4)</td>
<td>684 (21.1)</td>
<td>218 (6.7)</td>
<td>1124 (34.7)</td>
<td>775 (23.9)</td>
<td>3,236 (100.0)</td>
</tr>
<tr>
<td>2014/2015</td>
<td>445 (13.1)</td>
<td>706 (20.8)</td>
<td>305 (9.0)</td>
<td>1087 (32.0)</td>
<td>855 (25.2)</td>
<td>3,398 (100.0)</td>
</tr>
<tr>
<td>2015/2016</td>
<td>493 (15.3)</td>
<td>769 (23.9)</td>
<td>306 (9.5)</td>
<td>1169 (36.3)</td>
<td>487 (15.1)</td>
<td>3,224 (100.0)</td>
</tr>
<tr>
<td>2016/2017</td>
<td>499 (15.7)</td>
<td>871 (27.4)</td>
<td>365 (11.5)</td>
<td>1279 (40.2)</td>
<td>169 (5.3)</td>
<td>3,183 (100.0)</td>
</tr>
<tr>
<td>2017/2018</td>
<td>516 (14.6)</td>
<td>1003 (28.4)</td>
<td>445 (12.6)</td>
<td>1440 (40.8)</td>
<td>125 (3.5)</td>
<td>3,529 (100.0)</td>
</tr>
<tr>
<td>2018/2019</td>
<td>578 (15.5)</td>
<td>1030 (27.6)</td>
<td>450 (12.1)</td>
<td>1596 (42.8)</td>
<td>78 (2.1)</td>
<td>3,732 (100.0)</td>
</tr>
<tr>
<td>2019/2020</td>
<td>633 (15.3)</td>
<td>1173 (28.3)</td>
<td>502 (12.1)</td>
<td>1729 (41.7)</td>
<td>112 (2.7)</td>
<td>4,149 (100.0)</td>
</tr>
<tr>
<td>2020/2021</td>
<td>559 (16.3)</td>
<td>942 (27.4)</td>
<td>430 (12.5)</td>
<td>1434 (41.7)</td>
<td>74 (2.2)</td>
<td>3,439 (100.0)</td>
</tr>
</tbody>
</table>

*‘Catheters and lines’ includes the following options from the HCAI DCS question: dialysis lines, central venous catheter (CVC) associated, peripheral venous catheter (PVC) associated and intravenous (IV) lines.
**‘Skin and Soft Tissue Infection’
***‘Other’ includes the following options HCAI DCS: endocarditis, osteomyelitis, other, prosthetic joint, surgical site infection (SSI), septic arthritis, urinary tract infection (UTI) and ventilator-associated pneumonia.

Geographic distribution of MSSA bacteraemia

Regional distribution of cases is presented by Sustainability Transformation Partnerships (STP). In April 2020 to March 2021, there was a general North-South divide in rates of MSSA bacteraemia, with greater in the North compared to the South (Figure 35). The highest incidence rates (cases per 100,000 population) were observed in Dorset (29.6), Cumbria and North East (27.2) and Nottingham and Nottinghamshire Health and Care (26.9), while the lowest incidence rates (cases per 100,000 population) were observed in Gloucestershire (12.4), Cambridgeshire and Peterborough (12.7) and Hertfordshire and West Essex (14.3).
Figure 35. Geographic distribution of MSSA rates per 100,000 population, England April 2020 to March 2021

Like the national trend, rates in most STP increased over time (2010 to 2011 to April 2020 to March 2021), albeit by varying degrees. The largest increases in rate over this period were observed in Somerset (from 13.3 to 25.3), Cumbria and North East (from 17.3 to 27.2) and Buckinghamshire, Oxfordshire and Berkshire West (from 12.8 to 22.6). However, more recently between April 2018 to March 2019 and April 2020 to March 2021, a considerable number of STPs have observed relatively stable or declining rates of infection. The biggest changes in rates during this period were increases in Frimley Health and Care ICS (from 17.5 to 22.1) and Buckinghamshire, Oxfordshire and Berkshire West (from 19 to 22.6) and reductions in Northamptonshire (from 21.9 to 15.5) and Cheshire and Merseyside (from 30.8 to 24.8).

See Table 21a of the accompanying data sheet for a breakdown of STP-specific MSSA bacteraemia rates.
Discussion

Mandatory surveillance of MSSA bacteraemia was introduced in January 2011. In the first year, MSSA bacteraemia rates were stable (April 2011 to March 2012 to April 2012 to March 2013), before increasing each subsequent year. In contrast, hospital-onset rates fell slightly in the first year of the mandatory surveillance programme being introduced; beyond this, rates have broadly been increasing and observed a sharp rise between April 2019 to March 2020 and April 2020 to March 2021 from 9.5 to 12.1 cases per 100,000 bed-days.

Age and sex structure of MSSA bacteraemia show rates to increase with age group, with the highest rate seen in the Over 85 age group. Furthermore, males also show higher rates of MSSA bacteraemia compared to females. However, rates of MSSA bacteraemia are also seen to be very high in the youngest age group, Under 1 year old, compared to young patients (1 to 14 years old) and adults (15 to 74 years old). This contrasts with MRSA bacteraemia in which rates among the Under 1 age group are close to the rates in the 1 to 14 age group.

Research using data gathered by the mandatory surveillance found that cases arising in very young patients were most likely attributable to healthcare-associated infections, rather than community-associated infections and were related to intravascular devices (Abernethy and others. 2017). Despite the increase in MSSA bacteraemia rates over the years, little change has been observed in rates between male and females, with the rate in males Over 85 2.2 times greater in April 2020 to March 2021 than amongst females in the same age group, 187.2 and 83.6, respectively.

Levels of completion of the likely source of infection have declined over time. In April 2020 to March 2021, only 29.4% of records had a reported source of infection information, a slight decrease on 33.9% from the previous financial year. Skin or soft tissue is the most frequently reported source of MSSA bacteraemia. Prior to April 2016 to March 2017, there was a gradual increase in the percentage of such cases however, this has remained relatively at 27 to 28% since then.

In April 2020 to March 2021, there appears to be no similarities between the geographical distribution of MRSA and MSSA. MSSA appears to be most prevalent in the Northern part of England compared to the South, while rates of MRSA bacteraemia are more evenly distributed.

The 30-day mortality in April 2019 to March 2020 was reported as 25.7% for MRSA and 19.5% for MSSA (PHE 2020). As rates of MRSA continue to fall, we see the MSSA bacteraemia rates have slowly increased, in both hospital and community onset cases. The increase in MSSA cases appears to be driven by the increases in community onset cases: in April 2020 to March 2021, 71.5% of all reported MSSA bacteraemias were community onset. The reasons for this are unclear. This indicates that the focus for interventions needs to be placed on community onset MSSA cases.
Epidemiological analysis of *Clostridioides difficile* infection

A total of 12,503 cases of *Clostridioides difficile* infection (CDI) were reported by NHS Trusts in England between 1 April 2019 and 31 March 2020. This is a decrease of 5.4% from April 2019 to March 2020 (n = 13,213), and a decrease of 77.5% from April 2007 to March 2008 (n = 55,498). Figure 34 shows the trends in rates of CDI cases for all cases and hospital-onset cases from April 2007 to March 2008 to April 2020 to March 2021. The rate of all CDI cases per 100,000 population, per year has fallen from 107.6 in April 2007 to March 2008 to 22.2 in April 2020 to March 2021.

Figure 36. Trends in the rate of *C. difficile* infection in England, April 2007 to March 2008 to April 2020 to March 2021

*Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.*
Hospital-onset reports

Of the 12,503 total cases reported in FY April 2020 to March 2021, 4,254 were hospital-onset (15.4 per 100,000 bed-days). It should be noted that CDI cases are considered hospital-onset if they occur 4 or more days after admission to an acute trust, where day of admission is day 1. This contrasts with 3 or more days for bacteraemia cases. The incidence rate for hospital-onset CDI cases mirrors the trends in incidence for all cases, with declining rates from April 2007 to March 2008 to April 2013 to March 2014 which then remained approximately stable to April 2018 to March 2019. However, since April 2018 to March 2019, the rate of hospital-onset CDI cases has increased each year. This was a 11.8% increase between April 2018 to March 2019 (12.2) and April 2019 to March 2020 (13.6), and a 13.2% increase between April 2019 to March 2020 (13.6) and April 2020 to March 2021 (15.4).

Table 22. CDI counts and rates by financial year, England, April 2007 to March 2008 to April 2020 to March 2021*

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Mid-year population estimate</th>
<th>All reported cases</th>
<th>Rate (all reported cases per 100,000 population)*</th>
<th>Total bed days</th>
<th>Hospital-onset cases</th>
<th>Rate (Hospital-onset cases per 100,000 bed days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td>51,594,959</td>
<td>55,498</td>
<td>107.6</td>
<td>37,451,721</td>
<td>33,434</td>
<td>89.3</td>
</tr>
<tr>
<td>2008/2009</td>
<td>51,803,017</td>
<td>36,095</td>
<td>69.7</td>
<td>37,823,023</td>
<td>19,927</td>
<td>52.7</td>
</tr>
<tr>
<td>2009/2010</td>
<td>52,306,371</td>
<td>25,604</td>
<td>49.0</td>
<td>37,441,615</td>
<td>13,220</td>
<td>35.3</td>
</tr>
<tr>
<td>2010/2011</td>
<td>52,757,040</td>
<td>21,707</td>
<td>41.1</td>
<td>35,206,316</td>
<td>10,417</td>
<td>29.6</td>
</tr>
<tr>
<td>2011/2012</td>
<td>53,312,604</td>
<td>18,022</td>
<td>33.8</td>
<td>34,669,499</td>
<td>7,689</td>
<td>22.2</td>
</tr>
<tr>
<td>2012/2013</td>
<td>53,475,358</td>
<td>14,694</td>
<td>27.5</td>
<td>34,633,855</td>
<td>5,980</td>
<td>17.3</td>
</tr>
<tr>
<td>2013/2014</td>
<td>53,976,973</td>
<td>13,362</td>
<td>24.8</td>
<td>34,514,871</td>
<td>5,034</td>
<td>14.6</td>
</tr>
<tr>
<td>2014/2015</td>
<td>54,432,437</td>
<td>14,193</td>
<td>26.1</td>
<td>34,972,728</td>
<td>5,233</td>
<td>15.0</td>
</tr>
<tr>
<td>2015/2016</td>
<td>55,018,884</td>
<td>14,143</td>
<td>25.7</td>
<td>34,752,604</td>
<td>5,162</td>
<td>14.9</td>
</tr>
<tr>
<td>2016/2017</td>
<td>55,240,933</td>
<td>12,849</td>
<td>23.3</td>
<td>35,148,014</td>
<td>4,621</td>
<td>13.1</td>
</tr>
<tr>
<td>2017/2018</td>
<td>55,707,642</td>
<td>13,296</td>
<td>23.9</td>
<td>34,903,075</td>
<td>4,739</td>
<td>13.6</td>
</tr>
<tr>
<td>2018/2019</td>
<td>56,053,563</td>
<td>12,274</td>
<td>21.9</td>
<td>34,538,184</td>
<td>4,201</td>
<td>12.2</td>
</tr>
<tr>
<td>2019/2020</td>
<td>56,286,961</td>
<td>13,213</td>
<td>23.5</td>
<td>34,637,156</td>
<td>4,712</td>
<td>13.6</td>
</tr>
<tr>
<td>2020/2021</td>
<td>56,286,961</td>
<td>12,503</td>
<td>22.2</td>
<td>27,629,101</td>
<td>4,254</td>
<td>15.4</td>
</tr>
</tbody>
</table>

* Mid-year population estimates for April 2020 to March 2021 were not available at time of publication and so population data for April 2019 to March 2020 were used as a proxy.
Prior trust exposure

In April 2017, the mandatory surveillance programme began capturing information on whether a patient with CDI had previously been admitted to the same reporting trust within the past 84 days. With the prior trust exposure, cases are split into the following groups:

**Hospital-onset, healthcare associated (HOHA)**
Cases where the date of onset is 2 or more days after the date of admission, where date of admission is day zero and the patient was admitted to an NHS acute trust at time of specimen.

**Community-onset, healthcare associated (COHA)**
Cases which are not HOHA but have previously been discharged from the reporting organisation within the 28 days prior to specimen date.

**Community-onset, indeterminate association (COIA)**
Cases which are not HOHA or COHA but have previously been discharged from the reporting organisation within the 84 days prior to specimen date.

**Community-onset, community associated (COCA)**
Cases which are not HOHA, COHA or COIA and have had no prior admission within the past 84 days.

Cases for which ‘Don’t know’ was recorded against the prior trust exposure status are grouped into ‘Unknown’ and cases for which no information about the prior trust exposure was entered are grouped into ‘No information.’ Both groups are subsets of the community-onset group and so are known not be HOHA cases.
Table 23. Prior healthcare exposure of CDI cases by financial year, England April 2017 to March 2018 to April 2020 to March 2021*

<table>
<thead>
<tr>
<th>Financial year</th>
<th>Total beds</th>
<th>HOHA</th>
<th>COHA</th>
<th>COIA</th>
<th>COCA</th>
<th>Unknown*</th>
<th>No information**</th>
<th>Total cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Count</td>
<td>Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017/2018</td>
<td>34,903,075</td>
<td>5,463</td>
<td>15.7</td>
<td>1,891</td>
<td>1,064</td>
<td>2,858</td>
<td>262</td>
<td>1,758</td>
</tr>
<tr>
<td>2018/2019</td>
<td>34,538,184</td>
<td>4,869</td>
<td>14.1</td>
<td>2,318</td>
<td>1,335</td>
<td>3,442</td>
<td>305</td>
<td>5</td>
</tr>
<tr>
<td>2019/2020</td>
<td>34,637,156</td>
<td>5,358</td>
<td>15.5</td>
<td>2,472</td>
<td>1,525</td>
<td>3,803</td>
<td>53</td>
<td>2</td>
</tr>
<tr>
<td>2020/2021</td>
<td>27,629,101</td>
<td>4,900</td>
<td>17.7</td>
<td>2,209</td>
<td>1,436</td>
<td>3,931</td>
<td>24</td>
<td>3</td>
</tr>
</tbody>
</table>

*The record indicates that it is unknown whether the patient was admitted to the reporting organisation in the past 3 months.

**No information was entered in regard to the prior trust exposure.

The count of hospital-onset, healthcare associated cases declined from 5,463 in April 2017 to March 2018 to 4,900 in April 2020 to March 2021. In contrast, the number of COHA cases increased between April 2017 to March 2018 (n = 1,891) and April 2019 to March 2020 (n = 2,472) but declined to 2,209 in April 2020 to March 2021.

Seasonal trends in CDI

Data from previous Annual Epidemiological Commentaries have indicated a shift in the seasonality of hospital-onset CDI. In April 2010 to March 2011, 28.8% of hospital-onset cases were reported in the first quarter of the financial year, with declining percentages reported in the subsequent quarters of the financial year (Figure 37). Hospital-onset cases in April 2011 to March 2012 showed a similar distribution. However, in April 2014 to March 2015, hospital-onset cases were more evenly distributed throughout the year. Cases reported in the first quarter of the year made up 23.0% of cases and cases reported in the fourth quarter of the year made up 26.1%. Between April 2015 to March 2016 and April 2018 to March 2019, the second quarter of the year (July to September) saw the greatest proportion of cases reported (between 26% and 29% of cases each year).

In contrast, community-onset cases have always shown a peak in the second quarter of the financial year, with this quarter forming 28% to 29% of cases for the financial year.
Age and sex distribution

For all age and sex analyses, cases in which the sex was missing or given as unknown were excluded. In April 2007 to March 2008, the sex was not reported as unknown in any cases, while in April 2020 to March 2021, the sex was reported as unknown for only 1 case.

Table 24 show counts and rates of CDI in April 2007 to March 2008 and April 2020 to March 2021. For both years, CDI rates were highest among patients over 85 years of age. In April 2007 to March 2008, the rate among males were 1504.7 per 100,000 population and 1490.2 among females. In April 2020 to March 2021, the rate among males were 215.6 per 100,000 population and 209.0 among females.
In April 2020 to March 2021, there was little difference in the distribution of CDI rates by sex. In this period, the rate ratio between male and female over 85 years old is 1.0 (95% CI: 1.0 to 1.1).
Table 24. CDI counts and rates by age group and sex, England: April 2007 to March 2008

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>2 to 14</td>
<td>4,046,150</td>
<td>3,858,1422</td>
<td>178</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,728,560</td>
<td>10,721,325</td>
<td>1,251</td>
</tr>
<tr>
<td>45 to 64</td>
<td>6,322,972</td>
<td>6,463,537</td>
<td>3,479</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,011,279</td>
<td>2,205,682</td>
<td>4,970</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,208,494</td>
<td>1,655,252</td>
<td>7,974</td>
</tr>
<tr>
<td>Over 85</td>
<td>337,2000</td>
<td>755,019</td>
<td>5,074</td>
</tr>
</tbody>
</table>

Table 25. CDI counts and rates by age group and sex, England: April 2019 to March 2020

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Population</th>
<th>Cases</th>
<th>Rate, per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>2 to 14</td>
<td>4,576,609</td>
<td>4,352,566</td>
<td>154</td>
</tr>
<tr>
<td>15 to 44</td>
<td>10,763,419</td>
<td>10,571,978</td>
<td>427</td>
</tr>
<tr>
<td>45 to 64</td>
<td>7,103,072</td>
<td>7,302,687</td>
<td>903</td>
</tr>
<tr>
<td>65 to 74</td>
<td>2,682,950</td>
<td>2,893,116</td>
<td>1,135</td>
</tr>
<tr>
<td>75 to 84</td>
<td>1,536,167</td>
<td>1,844,432</td>
<td>1,586</td>
</tr>
<tr>
<td>Over 85</td>
<td>517,084</td>
<td>879,967</td>
<td>1,115</td>
</tr>
</tbody>
</table>

**Trends in age and sex**

Although CDI rates are greatest among the elderly, as a percentage of cases reported to the mandatory surveillance, there has been an increase among younger age groups, and a concomitant decline in the percentage of cases that are from older age groups.

Figure 38 compares the age and sex structure of CDI cases in England in April 2007 to March 2008 and April 2020 to March 2021. In April 2007 to March 2008, among females, the percentage of cases that occurred among those aged 85 and over was 35.3%. In April 2020 to March 2021, this had declined to 25.6%. Trends in the percentage of cases among females between 75 and 84 years old has also declined over the same period. In April 2007 to March 2008, among females, the percentage of cases that occurred among those between 75 and 84 years old was 33.6%. In April 2020 to March 2021, this had declined to 26.5%.

In contrast, the percentage of cases that occurred among females between 65 to 74 years old was 15.4% in April 2007 to March 2008 and 19.0% in April 2020 to March 2021. Younger age groups have also seen increases in the percentage of cases which they form.
The increase in percentage of cases among younger age groups has not been seen in males. In April 2007 to March 2008, 22.1% of cases among males occurred in the 85 and over age group. In April 2020 to March 2021, this was 21.0%. A small increase has been observed among the 15 to 44 age group in males from 5.5% in April 2007 to March 2008 to 8.0% in April 2020 to March 2021.

It is important to note that this only reflects percentages of cases and that, because of the age and sex structure of the population of England, the incidence rate by age and sex can be very different.

**Figure 39. Trend in age- and sex-specific rates of CDI per 100,000 population, England, April 2007 to March 2008 to April 2020 to March 2021**

![Graph showing trend in age- and sex-specific rates of CDI per 100,000 population](image)

**Geographic distribution of CDI**

Regional distribution of cases is presented by Sustainability Transformation Partnerships (STP). Some geographical variation in rates of CDI is noted (Figure 40). The highest incidence rates (cases per 100,000 population) were observed in Cornwall and the Isles
of Scilly Health and Social Care Partnership (33.6), Healthier Lancashire and South Cumbria (33.3) and Bristol, North Somerset and South Gloucestershire (30.5), while the lowest incidence rates (cases per 100,000 population) were observed in East London Health and Care Partnership (10.3), Frimley Health and Care ICS (11.4) and Bedfordshire, Luton and Milton Keynes (12.3).

**Figure 40. Geographic distribution of CDI rates per 100,000 population, England April 2020 to March 2021**

See table 25b of the accompanying data sheet for a breakdown of STP-specific CDI bacteraemia rates.

**Discussion**

Between April 2007 to March 2008 and April 2012 to March 2013, rates of CDI fell rapidly. Since April 2012 to March 2013 there has been relatively stable rates of all reported cases. The rapid decline in the rate of all cases of CDI was mirrored in hospital-onset cases. However, the decline in community-onset cases has not been so rapid and community-onset cases now constitute 66% of cases. Many of the interventions aimed at the reduction of CDI rates were targeted at the hospital setting, which likely explains
the greater reduction in hospital-onset cases compared to community-onset cases. However, the division of cases into hospital-onset and community-onset cases ignores the effect of any prior admissions to hospital which could increase the risk of CDI. For this reason, and to better align surveillance in England with that performed by ECDC and CDC, information on prior trust exposure was introduced in April 2017.

The prior trust exposure classification groups cases according to whether the patient has previously been admitted to the reporting organisation in the past 3 months (84 days). The prior trust exposure classification has now been running for 3 years and from the first to the second year, data completion improved markedly due to changes in the way questions are asked in the Data Capture System. Hospital-onset, healthcare-associated cases formed the largest group by the new apportioning method. In contrast, the counts of cases for community-onset groups have each increased since April 2017 to March 2018. This was at least partly because of a change in the provision of information on prior trust exposure and partly due to an overall increase in the count of cases. More recently, only COCA cases increased between April 2019 to March 2020 and April 2020 to March 2021. The proportion of cases which lack any information on prior trust exposure declined from 13% in April 2017 to March 2018 to less than 0.1% in April 2020 to March 2021, as a result of making the questions around prior trust exposure mandatory.

Although the prior trust exposure only records admission to the reporting organisation, work by the mandatory surveillance team using data from the Hospital Episodes Statistics estimates that this captures over 80% of all hospital interactions.

Rates of CDI are highest among older age groups; those aged 85 and over. Recent research has shown that over time, elderly individuals are getting frailer and experiencing polypharmacy (Melzer and others. 2015). A frailer population, receiving greater levels of medication would suggest that greater levels of healthcare interaction were being experienced by this age group. Despite this, rates of CDI have decreased considerably among the oldest age group. The reason for this difference is likely to be due to the care bundle introduced by the DHSC which recommended the use of personal protective equipment, cohort nursing and environmental decontamination which were geared towards preventing HCAI in acute care settings and not community settings. (Department of Health 2007).

The decline in rates has done little to affect the age- and sex-specific rates of CDI. Those patients 85 years or older are the most frequently affected and there is little difference in the rates between the sexes. This marks a difference in epidemiology between CDI and bacteraemia in which rates are higher among male patients most age groups.
The shift in seasonality is intriguing and currently lacks an explanation. Between April 2010 to March 2011 and April 2013 to March 2014, most hospital-onset cases occurred in the April to June quarter of the financial year. From April 2016 to March 2017 onwards, the quarter with the greatest number of cases was the July to September quarter. However, in April 2020 to March 2021, case of hospital-onset cases peaked in the October to December quarter.

Unlike in previous years where there has been a clear North-South divide in rates of CDI, this year the difference is less stark. There are generally higher rates in the North of England compared to the South. Previous work by this group has indicated an association between higher levels of deprivation and higher rates of CDI.

The decline in rates of CDI is difficult to explain fully. Several interventions aimed at reducing MRSA rates were also aimed at reducing CDI (the ‘CleanYourHands’ and Saving Lives campaigns). It is perhaps not surprising, then, that the trends in rates of CDI mirror those of MRSA. In addition, targets to reduce CDI cases were introduced in 2008. These aimed to reduce the number of cases reported annually to 30% of the April 2007 to March 2008 count by April 2010 to March 2011 (Department of Health 2008). Failure to achieve targets was associated with financial penalties. Financial sanctions against acute trusts for exceeding expected numbers of CDI were reduced in April 2014 to March 2015 from £10,000 to £50,000 per case (NHS England 2014). In addition, only those cases deemed to be associated with a lapse in care are now subject to the financial sanctions. This was introduced in recognition of the fact that some cases can occur even if best practice is followed, and the patient receives flawless care from the acute trusts. In addition to the objectives and the ‘CleanYourHands’ and Saving Lives campaigns, guidance was issued aiming to reduce clindamycin, cephalosporin or fluoroquinolone prescribing, which had been shown to promote the spread of epidemic strains of *C. difficile* (Department of Health and Health Protection Agency, 2008). The resulting reduction in prescribing of fluoroquinolones and cephalosporins was associated with a significant decline in the incidence of CDI (Dingle and others. 2017).

There is wide recognition that the epidemiology of CDI is changing. The *C. difficile* ribotype (ribotype 027) associated with the high numbers of CDI cases in the early 2000s is no longer as prevalent (Wilcox and others, 2012). Due to the high all-cause mortality associated with this ribotype (Inns and others, 2013), the reduction in the prevalence of the ribotype may also be associated with reductions in the case fatality rate of CDI, which has fallen from 26.3% of cases in April 2007 to March 2008 to 26.3% in April 2019 to March 2020.
Appendix

Background to the mandatory surveillance of MRSA and MSSA bacteraemia

During the 1990s, voluntary surveillance of antibiotic resistance by microbiology laboratories across England, Wales and Scotland saw increasing reports of MRSA (Johnson, Pearson, and Duckworth 2005). In response to the concerns about the rising number of reports of MRSA, the Department of Health and Social Care (DHSC) made surveillance of MRSA bacteraemia mandatory from April 2001 (Department of Health 2003a).

Public Health England (PHE) has managed the mandatory surveillance on behalf of the DHSC since the inception of the surveillance. The surveillance initially captured aggregate counts of bacteraemia due to *S. aureus* and the number of those that were MRSA. The results were reported every 6 months.

The frequency of data collection was increased to every quarter in 2004 and then monthly in 2005. Enhanced surveillance of MRSA bacteraemia was introduced in October 2005, allowing reporting of individual cases, rather than aggregated counts for a time period. This had the advantage of providing information about the date of onset of bacteraemia, relative to the date of admission and the department or specialty in which the patient was being treated (Department of Health 2005).

In 2011, the surveillance was further expanded to include enhanced surveillance of MSSA bacteraemia which had not shown the same decline in incidence that MRSA had.

Between 2013 and 2014, the outcome of a Post Infection Review (PIR) assigned cases to either a clinical commissioning group (CCG) or an NHS acute trust. On 1 April 2014, a ‘third-party’ category for cases such as patients not resident in England or intractable cases was added to process (NHS England 2014b). The PIR process was halted in April 2018 when it became a local-only process (NHSI 2018).

Current surveillance of MRSA and MSSA bacteraemia allows reporting of cases through a web-based data capture system (DCS) which provides the means to capture clinical information on the patient and the infection, the likely source of infection and previous healthcare interactions. The DCS also provides dynamic, on-demand reporting to acute trusts, CCGs and other organisations allowing those involved in the care of patients to investigate trends at a local level.
Mandatory surveillance of *C. difficile* infection

Voluntary surveillance of CDI by microbiology laboratories identified a steady increase in the number of reports between 1990 and 2001. From 2002, this increase accelerated rapidly (Department of Health 2007). In 2004, quarterly surveillance of CDI in patients aged 65 years or above was made mandatory (Department of Health and Health Protection Agency, 2005). This involved reporting aggregate numbers of cases to PHE on the behalf of the DHSC. From 2007, the surveillance was expanded to include all patients 2 or more years old and was extended to enhanced surveillance to capture patient-level information (Department of Health 2018). Since 2007, rates of CDI have declined dramatically.

In April 2017, prior healthcare exposure questions were introduced to the CDI mandatory surveillance programme, to determine onset status of cases. This involved further classification of cases into the following onset statuses, hospital-onset healthcare associated, community-onset healthcare associated, community-onset indeterminate associated and community-onset community associated. Thus, allowing the CDI surveillance to be more comparable with international definitions.

Mandatory surveillance of Gram-negative bacteraemia

**E. coli** bacteraemia

Since the mid-2000s onwards, *E. coli* has been the most common pathogen causing bacteraemia in England and has seen year-on-year increases. Given this sustained increasing trend in the number of *E. coli* bacteraemia reports made through the voluntary service, the DoH made reporting of *E. coli* bacteraemia mandatory in June 2011 (Department of Health 2011).

**Klebsiella and P. aeruginosa** bacteraemia

From April 2017, it became mandatory for acute trusts to report bacteraemias caused by any species of *Klebsiella* bacteria and *P. aeruginosa*. This was introduced to support the UK Government’s ambition to reduce Healthcare-associated Gram-negative bacteraemias by 50% by 2023 to 2024.

In 2017, *Enterobacter aerogenes* was reclassified to *Klebsiella aerogenes*. *K. aerogenes* was eligible for surveillance from April 2017 and trusts which identify isolates on or after 1 April 2017 are expected to report them as *K. aerogenes*. 
A note on terminology

In financial year April 2018 to March 2019, mandatory surveillance stopped using the term Trust-apportioned and started using the terms hospital-onset and community-onset instead. This change was introduced due to the need to increase awareness of cases that occur in the community. The algorithm for the separation of cases into hospital-onset or trust-apportioned and those that are not is unchanged. Clostridium difficile taxonomy classification has been changed to Clostridioides difficile.

Use of mandatory surveillance statistics

The data presented in this commentary, and in the accompanying data files serve several purposes:

- they provide information to clinicians in trusts about rates of bacteraemia and CDI in their organisation, helping to improve care and infection control at their trust
- they provide information on the epidemiology of these infections to clinicians, healthcare researchers and other interested parties, identifying the likely sources of infection
- the information at CCG level allows commissioners of care to understand healthcare-associated infection rates in their catchment area
- the national picture provides information to the DHSC, NHS England and NHS Improvement regarding the infection rates across the country, and how these are changing over time, while also providing information about where new interventions could be targeted
- they are utilised by NHS Choices to assist in providing information to the general public about healthcare-associated infection rates in their area and in facilities where they might receive care

Further information on data purpose, relevance and associated user-need can be found in the Mandatory Health Care Associated Infection Surveillance Data Quality Statement.

Data included in the April 2020 to March 2021 Annual Epidemiological Commentary (AEC) Counts and rates of MRSA, MSSA, Gram-negative bacteraemias and CDI included in this report are those with dates of specimens found to be positive within the period 1 April 2007 to 31 March 2021. This report includes data, extracted from the Healthcare Associated Infections (HCAI) DCS on 27 April 2021, from 140 NHS acute trusts, 135 clinical commissioning groups (CCGs), each mapped to 42 Sustainability Transformation Partnerships (STP). Data is published in line with organisational arrangements on the HCAI DCS as of 31 March 2021. Data by acute trust and CCG are presented on an annual and quarterly (Quarterly Epidemiology Commentary) basis. Epidemiological commentaries are presented on an annual basis. Data tables included in the Annual
Epidemiological Commentary can also be found in OpenDocument Spreadsheets (.ods) format on the Annual Epidemiological Commentary web page.

This publication forms part of a range of National Statistics outputs routinely published by PHE. Epidemiological analyses included in this report are on an annual (financial year) basis. Further epidemiological analyses by quarter can be found in our quarterly epidemiological commentaries. Data is also reported monthly for MRSA, MSSA, *E. coli*, *Klebsiella* spp., *P. aeruginosa* bacteraemia and CDI.

We are always striving to ensure that routine outputs meet user need as much as possible. If you have any suggestions for changes and/or additions please email mandatory.surveillance@phe.gov.uk.

*E. coli* bacteraemia

Table 1: Financial year counts and rates of *E. coli* bacteraemia aggregated cases and by onset status (April 2012 to March 2013 to April 2020 to March 2021).

*Klebsiella* spp. bacteraemia

Table 2: Financial year counts and rates of *Klebsiella* spp. bacteraemia aggregated cases and by onset status (April 2017 to March 2018 to April 2020 to March 2021).

*P. aeruginosa* bacteraemia

Table 3: Financial year counts and rates of *P. aeruginosa* bacteraemia aggregated cases and by onset status (April 2017 to March 2018 to April 2020 to March 2021).

MRSA bacteraemia

Table 4: Financial year counts and rates of MRSA bacteraemia aggregated cases and by onset status (April 2008 to March 2009 to April 2020 to March 2021).

MSSA bacteraemia

Table 5: Financial year counts and rates of MSSA bacteraemia aggregated cases and by onset status (April 2011 to March 2012 to April 2020 to March 2021).

*C. difficile* infections

Table 6: Financial year counts and rates of *C. difficile* infections bacteraemia aggregated cases, by onset status (April 2007 to March 2008 to April 2019 to March 2020), and by prior healthcare exposure (April 2017 to March 2018 to April 2020 to March 2021).
Commentary

This document contains national and regional level (STP) epidemiological commentaries for Gram-negative bacteraemias, MRSA and MSSA bacteraemias and C. difficile infections. Mandatory surveillance data series included in this report start from financial year April 2007 to March 2008 or the earliest full quarter of data collection.

All STP analyses in this report are based on the STP covering the attributable CCG for each case.

However, CCGs only came into existence on 1 April 2013. These may become less accurate the older the data is and; therefore, these have only been performed back to financial year April 2009 to March 2010 reports. The temporal data before April 2013 to March 2014 contained in this report with regards to CCGs and STPs has only been provided as an indication of the trend over time for a given CCG or STP and thus, should be treated with caution.

Alternative presentations of the annual data

Data included in this report is also available on PHE Fingertips. This is a user-friendly application that enables access to local data. It is ideal for both healthcare professionals and the general public alike. Fingertips enables access to these data in a succinct format. Much of the mandatory surveillance data is available in graphical format, facilitating easy understanding of key trends and geographical differences.

Please note that there is a one-month delay between the publication of our statistics on gov.uk and the publication of the same data on Fingertips. For example, data published on gov.uk at the start of April 2021 would be available on Fingertips in May 2021.
Glossary

Average
Scientifically speaking, this is a measure of location. It is a way of describing data and helps to distribute any inequalities in the data across the whole series. There are 3 main mathematical measures which can be used to calculate an ‘average’ value; the mean, mode and median. Each of these methods has their own strengths and weaknesses.

Bacteraemia
The presence of bacteria in blood.

Bias
Bias is the systematic deviation of either results and/or inferences from the real situation.

Confidence interval (CI)
Confidence intervals indicate the likely range in which an estimated parameter (such as a mean or rate) is likely to fall. For most scientific studies, it is impractical or impossible to measure every single member of a population and therefore the true population mean cannot be determined. Instead, a representative sample is taken and the sample mean is used as an estimate of the population mean. Although the sample is intended to be representative, a different sample from the same population may provide a different result simply by chance. A confidence interval, over unlimited repetitions of the sample, should contain the true value of a parameter (such as the true population mean) no less than its confidence interval. It is usual to calculate the 95% confidence interval. That means that if we were to draw several independent, random samples from the same population and calculate 95% confidence intervals from each of them, then 95% of such confidence intervals would contain the true population mean. If we took 20 samples from the same population and calculated 95% confidence intervals then 19 of 20 (95%) of these 95% confidence intervals would contain the true population meanwhile 1 of 20 (5%) will not.

Denominator
The lower portion of a rate or ratio. This should reflect the population at risk of developing a disease.

Epidemiology
Study of the occurrence and distribution of events (mostly health-related) in a population.
Gram-negative

Class of bacteria that do not retain crystal violet stain as used as part of a differential staining technique (called the Gram stain). The Gram stain is used as a way of identifying bacteria and the difference in staining results are due to differences in the bacterial cell wall, which has important implications for antimicrobial usage.

Incidence and incidence rate

New cases of a disease occurring in a study population. An incidence rate is then the number of new cases that occur in a defined population in a defined period of time.

NHS Sustainability Transformation Partnerships

An administrative unit of the NHS. NHS England has 4 administrative regions: North of England, Midlands and East of England, London and South of England. Below these regions are 42 administrative geographies referred to as STPs.

Mean

The arithmetic mean is often what people think of when they say ‘average value’. The mean is calculated by summing all of the values in a series \( (a_1 + a_1 + \cdots + a_n) \) and then dividing by the number of values included in the series \( (n) \). Mathematically, this is described by the following formula:

\[
\text{mean} = \frac{a_1 + a_1 + \cdots + a_n}{n}
\]

A real-world example would be if you wanted to calculate the mean amount spent on food shopping over a 4-week period (that is, the average amount per week) having spent £51 in week one, £59 in week 2, £67 in week 3 and £52 in week 4:

\[
\text{mean cost of food per week} = \frac{\£51 + \£59 + \£67 + \£52}{4} = \£57.25
\]

Median

The median of a series of numbers is the mid-point of that series. This provides a measure of an average value that is not overly affected by a few extreme values. The median of the following set of numbers \([1, 2, 3]\) is 2, while the median of the set of numbers \([1, 1, 1, 2, 10, 15, 16, 20, 100, 105, 110]\) is 15. To calculate the median value, the set of numbers needs to be arranged in order of magnitude, the median is the number that is exactly in the middle. If there is an even number of values in a set, then the median value is the arithmetic mean of the 2 central values.
Mode

Is the most frequent value in a set of data (numbers or text values), for example, in the following set of numbers [1, 1, 1, 2, 10, 15, 16, 20, 100, 105, 110] the mode is 1 as it was included in the set 3 times, while the other numbers were only included once.

Rate ratio

Is the ratio between 2 rates. For example, if the rate of MRSA bacteraemia was 2 per 100,000 population in a year among men, and 4 per 100,000 population in a year among women, the rate ratio would be 2.0. The rate would be 2 times higher among women than men.

Secular trends

Changes over long periods of time.
Methods

Inclusion criteria for reporting to the surveillance system

MRSA bacteraemia

The following positive blood cultures must be reported to PHE, for the mandatory MRSA surveillance: all cases of bacteraemia caused by *S. aureus* resistant to meticillin, oxacillin, cefoxitin or flucloxacillin.

MSSA bacteraemia

The following positive blood cultures must be reported to PHE, for the mandatory MSSA surveillance: all cases of bacteraemia caused by *S. aureus* which are susceptible to meticillin, oxacillin, cefoxitin, or flucloxacillin, that is, not subject to MRSA reporting.

*E. coli* bacteraemia

The following *E. coli* positive blood cultures must be reported to PHE: all laboratory confirmed cases of *E. coli* bacteraemia.

*C. difficile* infection

Any of the following defines a *C. difficile* infection in patients aged 2 years and above and must be reported to the PHE:

- diarrhoea stools (Bristol Stool types 5 to 7) where the specimen is *C. Difficile* toxin positive
- toxic megacolon or ileostomy where the specimen is *C. difficile* toxin positive
- pseudomembranous colitis revealed by lower gastro-intestinal endoscopy or Computed Tomography
- colonic histopathology characteristic of *C. difficile* infection (with or without diarrhoea or toxin detection) on a specimen obtained during endoscopy or colectomy
- faecal specimens collected post-mortem where the specimen is *C. difficile* toxin positive or tissue specimens collected post-mortem where pseudomembranous colitis is revealed or colonic histopathology is characteristic of *C. difficile* infection

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1 DH/APRHAI have released guidance which incorporates *C. difficile* testing recommendations:
Methods of reporting data on the HCAI Data Capture System (DCS)

The HCAI DCS is a web portal designed by PHE to facilitate the collection of the enhanced data set.

Trusts using the website have access to all the data they have entered, which enables them to assess their burden of these HCAIs. This can be compared to a regional and national aggregate also available to trusts from the website. Clinical Commissioning Groups (CCGs), Local Authorities, Sustainability Transformation Partnerships (STP), and Directors of Public Health (DPHs) are also able to register users, allowing them to access data specific to their patients.

The dataset to be collected is described in the mandatory HCAI surveillance protocol available on the DCS(pdf) and in the case capture user guide available on the same site here(pdf) Case unlocks can be requested by reporting organisations using the process described in the Unlock Requests User Guide. Revisions to data are covered by a data specific revisions and correction policy(pdf).

An R package for working with data downloaded from the DCS can be found on GitHub.

Deadline for entering data

All cases reported by the NHS with specimen dates during the previous month must be entered onto the website by the 15 of the following month. The previous month’s data must then be signed off by the trust’s Chief Executive Officer (CEO) by the 15th of every month. For example, data concerning specimens collected in October must be entered and signed off by 15 November.

CCG attribution process

All cases of bacteraemia and C. difficile infection are attributed to a CCG, regardless of onset.

PHE’s HCAI DCS does not currently request NHS organisations to record patient CCG details for any of bacteraemia or C. difficile infection cases. To obtain this data an extract, comprising patient NHS number and date of birth are submitted to NHS Digital, via Demographics Batch Services (DBS), on a daily basis to identify patient GP registration details and patient residential postcode.

Overview of CCG attribution

The CCG for each case is attributed, in the following order:
• if the patient’s GP practice code is available (and is based in England), the case will be attributed to the CCG at which the patient’s GP is listed
• if the patient’s GP practice code is unavailable but the patient is known to reside in England, the case is attributed to the CCG catchment area in which the patient resides
• if both the patient’s GP practice code and patient post code are unavailable or if a patient has been identified as residing outside England, then the case is attributed to a CCG based upon the postcode of the HQ of the acute trust that reported the case

Note that the retrospective attribution of cases to a CCG may become less accurate the older the data are. Therefore, the data contained in this report for time periods prior to April 2013 to March 2014 should be treated with caution and only used as an indication of the trend over time for a given CCG.

Algorithms for apportioning cases

Please note that the algorithm applied for the determining onset of bacteraemia versus CDI infection uses a different number of days between specimen collection and admission to apportion cases however, the principle is the same. All cases of bacteraemia and CDI infection are either hospital onset or community-onset based on the algorithms below (see also Appendix Figure A1).

It is not possible for PHE to change the onset status of a case, as this process is based on the data entered by the acute trust and the algorithm is applied to the entire dataset not on a case by case basis; a case may only change from one category to another if the relevant case details are incorrect and require amendment by the trust.

In addition to onset, all cases are also attributed to a CCG (see above). Thus, all hospital-onset and community-onset cases will be attributed to a CCG. The apportioning algorithm changed slightly with the launch of the new DCS.

Bacteraemia

Hospital-onset
Any NHS patient specimens taken on the third day of admission onwards (eg day 3 when day 1 equals day of admission) at an acute trust (including cases with unspecified specimen location) for Inpatients, Day-patients, Emergency Assessment, or unspecified patient category.

Records with a missing admission date (where the specimen location is acute trust or missing and the patient category is Inpatient, Day-patient, Emergency Assessment, or unspecified) are also included.
Community-onset
Any NHS patient specimens not apportioned to the above. This will typically include the following groups: * any acute trust specimens taken on either the day of admission or the subsequent day (for example, days 1 or 2, where day 1 equals day of admission) * any specimens from patients attending an acute trust who are not Inpatients, Day patients or under Emergency Assessment (ie non admitted patients) * any specimens from patients attending an identifiable healthcare location except an acute trust. This will typically include GP, nursing home, non-acute NHS hospital and private patients

CDA

Hospital-onset
Any NHS patient specimens taken on the third day of admission onwards (for example, day 3 when day 1 equals day of admission) at an acute trust (including cases with unspecifed specimen location) for Inpatients, Day-patients, Emergency Assessment, or unspecified patient category. Records with a missing admission date (where the specimen location is acute trust or missing and the patient category is Inpatient, Day-patient, Emergency Assessment, or unspecified) are also included.

Community-onset
Any NHS patient specimens not apportioned to the above. This will typically include the following groups:

- any acute trust specimens taken on either the day of admission or the subsequent day (for example, days 1, 2 where day 1 equals day of admission)
- any specimens from patients attending an acute trust who are not Inpatient, Day-patient or under Emergency Assessment (for example, non-admitted patients)
- any specimens from patients attending an identifiable healthcare location except an acute trust; this will typically include GP, nursing home, non-acute NHS hospital and private patients.

Prior trust exposure algorithm
In April 2017, the mandatory surveillance captured information on prior trust exposure, and introduced specific prior healthcare categories, detailed below:

Hospital-onset, healthcare associated (HOHA)
Cases where the date of onset is 2 or more days after the date of admission, where date of admission is day zero and the patient was admitted to an NHS acute trust at time of specimen.

Community-onset, healthcare associated (COHA)
Cases which are not HOHA but have previously been discharged from the reporting organisation within the 28 days prior to specimen date.
Community-onset, indeterminate association (COIA)
Cases which are not HOHA but have previously been discharged from the reporting organisation but have been discharged from the reporting organization between 28 and 84 days prior to specimen date.

Community-onset, community associated (COCA)
Cases which are not HOHA and have not previously been discharged from the reporting organisation within the past 84 days.

ICU (intensive care unit) association algorithm
Cases are considered ICU-associated if the patient had been in the ICU for more than 2 nights after ICU admission at the point when the positive blood culture sample was taken.

Analysis of data

Time to onset calculations
To describe time to onset of an episode (bacteraemia or CDI) among inpatients, the number of days between the date of admission to an NHS acute trust and the date of positive specimen were calculated. This was only performed for patients who were admitted to an acute trust (defined as either an inpatient, day patient or emergency assessment, ie patients who should have an admission date to an acute trust) and for those whose specimen was taken on or after the date of admission also at an NHS acute trust.

The number of days between the date of admission and the date of specimen can then be described in 2 different ways; by grouping the number of days into meaningful categories or by describing the ‘average’. Both have been provided in this report. As mentioned in the glossary, there are 3 metrics which can be used to describe the average value; the mean, median and mode. In this report, the median was used, providing us with the central value of the number of days between date of admission and date of positive specimen. The median was selected rather than the mean, because the latter can provide spurious ‘average’ values if the data are skewed, ie if a few inpatients had very long hospital stays before they had a CDI infection, then the mean value would become much greater as it would be largely influenced by the value of the numbers in the range.
Denominator data

Trust denominators NHS acute trust-level population data does not currently exist in England as NHS acute trusts do not treat patients within defined geographical boundaries. Therefore, a suitable proxy for population is required in order to calculate trust apportioned or assigned rates. The occupied overnight beds (from the national KH03 dataset) provides the daily average overnight bed occupation for a specific time period; full financial years for April 2007 to March 2008 to March 2009 to 2010 and by quarter for financial years 2010 to 2011 to April 2020 to March 2021. This dataset is an open access return published by NHS England and provides a measure of clinical activity in each trust, which is used as a proxy measure of the patient population.

KH03 data can be found on the NHS England website.

Where data for trusts were missing, data for the same quarter in the preceding year were used. These included the following trusts and periods:

Moorfields Eye Hospital NHS Foundation Trust (RP6) – KH03 data was missing for FY April 2007 to March 2008. Last recorded data from 2006 to 2007 were used as a proxy.

Moorfields Eye Hospital NHS Foundation Trust (RP6) – KH03 data was missing for FY April 2007 to March 2008. Last recorded data from 2006 to 2007 were used as a proxy.

The Rotherham NHS Foundation Trust (RFR) – KH03 data were missing for FY April 2009 to March 2010, Q1 April 2010 to March 2011 to Q1 of April 2011 to March 2012. Last recorded data from April 2008 to March 2009 were used as a proxy.

Sheffield Teaching Hospitals NHS Foundation Trust (RHQ) – KH03 data were missing for Q1 April 2010 to March 2011 to Q1 April 2011 to March 2012. Data from 2009 to 2010 were used as a proxy

The Princess Alexandra Hospital NHS Trust (ROW) – Data were missing from Q1 April 2014 to March 2015. Data from Q1 April 2013 to March 2014 were used as a proxy.

Data were missing from Q April 2014 to March 2015 and Q3 April 2013 to March 2014 data were used as a proxy

In Annual Epidemiological Commentaries published prior to 7 July 2016, April to June 2014 to October to December 2014 quarterly KH03 figures for one acute trust (RWD) had a percentage change of more than 20% compared to the previous quarter and the same quarter in the previous year. As a result, it was replaced with the KH03 data of the same quarter in the previous year (April to June 2013 to October to December 2013). However, PHE has reviewed its policy for processing KH03 data. All data irregularities identified are now flagged with colleagues at NHS England (data owners of the KH03 dataset). Until we receive confirmation that any identified change in the occupied
overnight bed-days for an acute trust is anomalous, PHE will use the data as published in the KH03 dataset. This affects all reports published since 1 December 2015. In order for the KH03 data used to calculate rates included in this report to be consistent over the full-time period, previously amended KH03 data for trust RWD for FY April 2014 to March 2015 has been altered to reflect that published in the KH03 dataset. Please note that this could lead to slight differences in trust-apportioned or assigned rates when compared with publications prior to 1 December 2015.

Other affected organisations and time periods include:

- Shrewsbury and Telford Hospital NHS Trust (RXW) financial year April 2009 to March 2010
- Imperial College Healthcare NHS Trust (RYJ) April to June 2012

**Rate calculations**

**CCG rates**

All cases are attributed to a CCG (see above) and using this data we calculate rates per 100,000 population for each CCG. Data at a CCG level can be scaled up to both NHS Commissioning Board, STP and a national level; therefore, to calculate rates for CCGs, STPs and nationally the following equation is applied:

\[
\text{Rate, per 100,000 population} = \left( \frac{n \text{ new cases attributed to CCG}}{\text{Financial year population}} \right) \times 100,000
\]

We use the ONS mid-year population estimated data for relevant time periods, adjusted as described above. For instance, for financial year April 2010 to March 2011 mandatory surveillance data we have used mid-year April 2010 to March 2011 population estimates. Rates for CCG assigned MRSA cases for April 2013 to March 2014 onwards have also been calculated using the following equation:

\[
\text{Rate, per 100,000 population} = \left( \frac{n \text{ new cases assigned to CCG}}{\text{Financial year population}} \right) \times 100,000
\]

**Trust rates**

We calculate acute trust rates using trust-apportioned (or trust-assigned cases). The total occupied bed days (KH03) data are used as an indicator of the total activity in each trust during the relevant time period(s). Since April 2010 to March 2011 KH03 have been published quarterly, prior to this they were published on a financial year basis. The average daily overnight bed occupancy for all acute trusts has been multiplied by the number of days in the relevant time period. The relevant rate per 100,000 bed days was calculated as follows:
Rate, per 100,000 bed days = \( \frac{n \text{ new cases reported by trust}}{\text{Average daily occupancy} \times n \text{ days in period}} \) \times 100,000

Prior to trust apportioning, all-reports rates were calculated per acute trust. Therefore, for historical purposes to retain the time series, we also calculate an all-reports rate per acute trust. ‘All reported cases’ refers to all bacteraemias or \( C. \text{ difficile} \) infections that were detected by the acute trust that processed the specimen. It is important to note that this does not necessarily imply that the infection was acquired there.

Healthcare associated infections in Wales, Scotland and Northern Ireland

Surveillance for \( C. \text{ difficile} \) infections and MRSA and MSSA bacteraemias is also performed in Wales, Scotland and Northern Ireland. Links to the relevant web pages are as follows:

- Wales
- Northern Ireland
- Scotland

Please note that there are several differences between the English mandatory surveillance systems and the systems run by the devolved administration, including case definitions or protocols for diagnosing the infections, definitions re: inpatient episode vs. trust apportioned or assigned episodes and the way in which data are presented. Therefore, the data provided in the published reports from Public Health Agency Northern Ireland, Public Health Wales and Health protection Scotland are not directly comparable with those data published by Public Health England, found in this report and annual tables.
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Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and C. difficile infections


Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and C. difficile infections


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Annual epidemiological commentary: Gram-negative bacteraemia, MRSA bacteraemia, MSSA bacteraemia and C. difficile infections

About Public Health England

Public Health England exists to protect and improve the nation’s health and wellbeing, and reduce health inequalities. We do this through world-leading science, research, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health and Social Care, and a distinct delivery organisation with operational autonomy. We provide government, local government, the NHS, Parliament, industry and the public with evidence-based professional, scientific and delivery expertise and support.

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