A Report from Public Health Wales
Healthcare Associated Infection, Antimicrobial Resistance & Prescribing Programme (HARP team)

Antibacterial Resistance in Blood Cultures
Wales 2009-2018
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Section 1: Introduction

In 2014, Lord O’Neill was commissioned by the UK Prime Minister to review the global impact of antimicrobial resistance. He estimated that by 2050, 10 million lives a year and a cumulative 100 trillion USD of economic output would be at risk due to the rise of drug resistant infections if no proactive solutions were found now to slow down the rise of drug resistance.

In response to Lord O’Neill’s report and recommendations, in January 2019, the UK Government published its 20-year vision for antimicrobial resistance, and its five-year national action plan to tackle antimicrobial resistance. The vision is that stakeholders at local, national, and global levels collectively strengthen policy and practice, improve research and surveillance, and develop effective regulation to contain and control resistance.

Antimicrobial resistance is an increasing problem in Wales and has already led to a small number of difficult to treat infections, leading to failed therapy and potential complications. Treatment for most infections is started empirically before antimicrobial susceptibilities are known. A particular problem with the spread of antimicrobial resistance is that it becomes more difficult to select empirical therapy that will have reliable activity.

The aim of this report from the HARP team at Public Health Wales is to provide surveillance data that can be used to design empirical therapy guidance, and to track antimicrobial resistance trends in Wales.

Useful links:

Review on Antimicrobial Resistance May 2016
https://amr-review.org/

UK Antimicrobial Resistance Strategy 2013 – 18


UK 20-year vision for antimicrobial resistance
https://www.gov.uk/government/publications/uk-20-year-vision-for-antimicrobial-resistance

Antimicrobial resistance: UK launches 5-year action plan and 20-year vision
Section 2: Key points of interest

**E. coli** (the commonest cause of blood stream infections in Wales)
- There was a statistically significant increase in piperacillin/tazobactam resistance in 2018 (12.9% in 2017 to 17.9% in 2018).
- There was significant variability between hospitals, with concerning levels of resistance emerging to the most commonly used antibacterials in some hospitals and Health Boards:
  - All-Wales resistance to co-amoxiclav was 39.3%, but locally for University Hospital Llandough (P), University Hospital of Wales (F), and Ysbyty Gwynedd (K) co-amoxiclav resistance was >45%, and was highest in Ysbyty Gwynedd at 47.2%.
  - All-Wales resistance to gentamicin was 12.2%, but locally resistance was 21.2% for University Hospital of Wales.
  - All-Wales resistance to piperacillin/tazobactam was 17.9%, but locally for Prince Philip (R), University Hospital Llandough, and University Hospital of Wales piperacillin/tazobactam resistance was >25%, and was highest in University Hospital Llandough at 25.6%.
  - All-Wales resistance to co-trimoxazole was 35.7%, but locally for Royal Glamorgan (C), University Hospital Llandough, and University Hospital of Wales co-trimoxazole resistance was >45%, and was highest in University Hospital Llandough at 50.0%.
  - All-Wales resistance to third generation cephalosporins was 13.8%, but locally resistance was 24.7% and 20.7% for University Hospital Llandough and University Hospital of Wales respectively.
  - All-Wales resistance to fluoroquinolones was 19.6%, but locally for Ysbyty Gwynedd, University Hospital Llandough, and University Hospital of Wales fluoroquinolones resistance was >30%, and highest in University Hospital Llandough at 43.0%.
- Carbapenem resistance remains below 1% in Wales
- The resistance patterns for University Hospital Llandough and University Hospital of Wales are reflected in the Health Board data. CAVUHB show similarly high resistance to those agents noted above.

**Staphylococcus aureus** (the 2nd commonest cause of bloodstream infections, and the commonest cause of wound infections in Wales)
- The number of *Staphylococcus aureus* bloodstream infections have not changed from 2017-2018.
- For both meticillin-sensitive (MSSA) and meticillin-resistant (MRSA) *S. aureus* bloodstream isolates, resistance remains relatively stable, although there is a trend to increasing resistance to fusidic acid in MRSA.

**Klebsiella spp.** (the 3rd commonest cause of bloodstream infections in Wales)
- There was a statistically significant increase in piperacillin/tazobactam resistance in 2018 (18.9% in 2017 to 26.6% in 2018).
  - All-Wales resistance to gentamicin was 10.1%, but locally resistance was 21.1% for Royal Gwent (D).
  - All-Wales resistance to carbapenems was 1.1% - 1.5%, but locally resistance was 12.1% for Glangwili (J).
Section 3: Methods

Resistance data

Data sources
Antimicrobial susceptibility testing data was extracted from the regional DataStore systems for all blood culture specimens. The codes and abbreviations for hospital and Health Board data included in this report are shown in Table 1.

Data interpretation
As with all surveillance schemes, appropriate interpretation of the data, with an appreciation of the potential biases, is key. The main potential biases, which should be considered in the data presented herein, are:

- **Sampling bias**
  - This occurs if the submission of samples to the laboratory does not represent all patients presenting with that infection, but is selective in some way. If this is the case, the published resistance rate may be skewed, and not representative of the true rate in patients presenting with uncomplicated infection. This effect is likely to be more of an issue with certain sample types. For example, bacteraemia data is felt to be representative, since most patients presenting with sepsis will have a blood culture sent. However if general practitioners only submit urine samples from patients who have failed initial therapy, the published rates of resistance will be falsely high.

- **Selective testing**
  - This occurs if a laboratory only tests susceptibility to a certain agent against selected organisms e.g. a laboratory might only test some agents when an organism is resistant to first-line drugs. This would result in falsely high rates of resistance. In order to reduce the effect of selective testing on the published rates, data is only included if >80% of a given isolate from a given specimen is tested against the agent.

- **Methodology**
  - In 2012/2013 EUCAST antimicrobial susceptibility testing (AST) methodology was implemented across the laboratories in Wales. [http://www.eucast.org/clinical_breakpoints/](http://www.eucast.org/clinical_breakpoints/)

- **Duplicate testing**
  - This occurs if a patient has multiple specimens tested from a single infection episode. Potentially this can skew the resistance data. In order reduce the effect of this; duplicate isolates are removed from analysis by a sub-routine in DataStore. Isolates are deemed duplicates if the same organism with the same antibiogram from the same patient is grown from the same sample type within 14 days.

- **Health Boards**
  - Health Board data are presented in the new (2019) structures of Cwm Taf Morgannwg University Health Board (CTMUHB) and Swansea Bay University Health Board (SBUHB). Note: Princess of Wales hospital data is included in CTMUHB.
Individual Hospital/Laboratory data

Individual hospital rates are only presented for organisms where ≥80% of such isolates from the given sample type was tested and where the number of isolates tested exceeds 9.

Duplicates

Data from duplicate isolates was removed prior to analysis. For community data, organisms from the same patient, with the same identification and susceptibility pattern isolated ≤ 91 days from the date of the initial isolate were excluded, and for hospital data the cut-off was ≤ 14 days.

Antimicrobial Groups

Prior to the introduction of EUCAST AST methodology in 2012/2013 there was variation AST methodologies between laboratories, and in antibiotic panels tested (e.g. differences in choice and number of third generation cephalosporins tested). In such cases, data is aggregated and resistance rates are expressed at group level. The antimicrobial groups included in this report comprise of the following aggregated susceptibility data:

- **Fluoroquinolones** – ciprofloxacin &/or levofloxacin, norfloxacin
- **Third generation cephalosporins** (3GC) – ceftriaxone, ceftazidime &/or cefotaxime, cefpodoxime.
- **Carbapenems** – imipenem &/or meropenem, ertapenem.

Susceptibility results

Throughout, data is presented in tables and on graphs as resistance rates with 95% confidence intervals (95% CI). For the purpose of this report, susceptibility results recorded as ‘intermediate’ are included in the category ‘resistant’, and in the case of penicillin susceptibility results for *S. pneumoniae* results recorded as intermediate, low-level or high-level resistance are included in the category ‘resistant’.

### Table 1: Codes for hospital and Health Board data

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Hospital Code</th>
<th>Health Board (code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nevill Hall</td>
<td>M</td>
<td>Aneurin Bevan (ABUHB)</td>
</tr>
<tr>
<td>Royal Gwent</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Wrexham Maelor</td>
<td>H</td>
<td>Betsi Cadwaladr (BCUHB)</td>
</tr>
<tr>
<td>Ysbyty Gwynedd</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>Ysbyty Glan Clwyd</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>University Hospital of Wales (UHW)</td>
<td>F</td>
<td>Cardiff &amp; Vale (CAVUHB)</td>
</tr>
<tr>
<td>University Hospital Llandough (UHL)</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>Prince Charles</td>
<td>N</td>
<td>Cwm Taf Morgannwg (CTMUHB)</td>
</tr>
<tr>
<td>Princess of Wales</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Royal Glamorgan</td>
<td>C</td>
<td>Hywel Dda (HDUHB)</td>
</tr>
<tr>
<td>Bronlais</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Glangwili</td>
<td>J</td>
<td></td>
</tr>
<tr>
<td>Prince Philip</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Withybush</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Morriston</td>
<td>E</td>
<td>Swansea Bay (SBUHB)</td>
</tr>
<tr>
<td>Singleton</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Velindre</td>
<td>Q</td>
<td>Velindre (VNHST)</td>
</tr>
<tr>
<td>All-Wales</td>
<td>Z</td>
<td></td>
</tr>
</tbody>
</table>

Note: Data presented at Health Board level includes data for all acute hospitals (listed above), and all non-acute and community hospitals.
Section 4: Monitoring Trends in Resistance
UK 5 Year Antimicrobial Resistance Strategy

In 2014, a sub-group of the Advisory Committee on Antimicrobial Prescribing, Resistance and Healthcare Associated Infection (APRHAI) was established to recommend surveillance outputs to support the UK Five Year Antimicrobial Resistance Strategy. Appendix C “Monitoring Trends in Resistance” of the Strategy document states: “Changes in the level of resistance to antibiotics like the carbapenems, which are often the last option for hard to treat infections, will be monitored”.

The agreed “drug-bug” combinations for monitoring resistance are listed in Table 2; the combinations were ratified by the Department of Health High-Level Steering Group. These data are not currently collected or published at UK level, but the Wales data is presented in this report.

Table 2: APRHAI Drug-Bug Combinations

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Organism</th>
<th>Data Set</th>
<th>Antimicrobial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Culture</td>
<td><em>Escherichia coli</em></td>
<td>Primary</td>
<td>cefotaxime or ceftazidime</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>imipenem or meropenem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ciprofloxacin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>gentamicin</td>
</tr>
<tr>
<td></td>
<td><em>Klebsiella pneumoniae</em></td>
<td>Secondary</td>
<td>piperacillin/tazobactam</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td></td>
<td>cefotaxime or ceftazidime</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>imipenem or meropenem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ciprofloxacin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>gentamicin</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td></td>
<td>piperacillin/tazobactam</td>
</tr>
<tr>
<td></td>
<td><em>Klebsiella oxytoca</em></td>
<td>Primary</td>
<td>cefotaxime or ceftazidime</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>imipenem or meropenem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ciprofloxacin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>gentamicin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>piperacillin/tazobactam</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td></td>
<td>ceftriaxone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>azithromycin</td>
</tr>
<tr>
<td></td>
<td>All specimens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Neisseria gonorrhoeae</em></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 5: Antimicrobial resistance rates for the most common organisms causing bacteraemia

Background

The 2018 top ten bacteraemia report for Wales comprises the commonest organisms isolated from blood cultures in Wales, see Table 3 below.

http://nww2.nphs.wales.nhs.uk:8080/WHAIPDocs.nsf/3dc04669c9e1eaa880257062003b246b/3242a36f7a99b9f18025846a00471cfb/$FILE/Wales%20Top%2010%20bacteraemia%20Report%202018.pdf

Table 3: Top Ten Bacteraemias 2018

<table>
<thead>
<tr>
<th>Rank</th>
<th>Organism</th>
<th>Rate per 100,000 bed days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Escherichia coli</em></td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td><em>Staphylococcus aureus</em> (MSSA)</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td><em>Klebsiella spp.</em></td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td><em>Enterococcus spp.</em></td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td><em>Streptococcus pneumoniae</em></td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>Coagulase-negative <em>Staphylococcus</em></td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td><em>Proteus spp.</em></td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td><em>Streptococcus group B</em></td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td><em>Pseudomonas aeruginosa</em></td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td><em>Enterobacter spp.</em></td>
<td>5</td>
</tr>
</tbody>
</table>

The datasets include infections originating from community and hospital sources (inpatient and outpatient), and so may be affected by local clonal strains which can result in marked variability in resistance rates between hospitals/regions; results should be interpreted with caution.

Since coagulase negative *staphylococci* are frequently contaminants when isolated from blood cultures, data on susceptibility are not presented here. *Streptococcus* group B has appeared in the top 10 but susceptibility data are not presented here. *Serratia* species and MRSA are no longer in the top ten however; data is presented since they appear in previous reports. The data in this report is not presented in rank order, but rather an order to allow easy comparison of resistances for related bacteria.

Figure 1 (over page) shows the number of isolates included in this data set per year (2009-2018) for *E. coli*, Enterobacter spp., *Klebsiella* spp., *Proteus* spp., *Pseudomonas aeruginosa*, *Serratia* spp. individually, and collectively as the group gram-negative bacilli (GNB). There has been a decrease in numbers of GNB in 2018, driven by the decrease in *E. coli* and *Klebsiella* spp.

Figure 2 shows the number of isolates per year (2009-8 for Enterococcus spp., MSSA, MRSA and *Streptococcus pneumoniae* individually and collectively as the group gram-positive cocci (GPC). There has been an increase in GPC in 2017/18, largely due to the increase in MSSA and Enterococcus spp.
Figure 1: Gram-negative bacteraemia numbers (2009 to 2018).

Figure 2: Gram-positive bacteraemia numbers (2009 to 2018).
*Escherichia coli* (n=2,645 in 2018)

*E. coli* is the commonest organism grown from blood cultures in Wales and the UK. The All-Wales patterns of resistance for 2009 to 2018 are shown in Figure 3. The 2018 resistance rates for individual acute hospitals and Health Boards are shown in Tables 4 & 5.

There has been a statistically significant increase in piperacillin/tazobactam (PTZ) resistance rates between 2017 and 2018. Co-amoxiclav (COA) and gentamicin (GEN) resistance continues to increase. Fluoroquinolone (FQ), and third generation cephalosporin (3GC) resistance shows no change. Imipenem and meropenem (CARB) resistance rates remain below 1% in the Wales.

![Figure 3: All-Wales resistance rates for *E. coli* bacteraemia (2009 to 2018).](image-url)
### Table 4: *Escherichia coli* – Acute Hospital Level

<table>
<thead>
<tr>
<th>Location Code (Number)</th>
<th>COA (95% C)</th>
<th>PTZ (95% C)</th>
<th>GEN (95% C)</th>
<th>PTZ/GEN (95% C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n=66)</td>
<td>29.4 (19.9,41)</td>
<td>11.8 (6.1,21)</td>
<td>11.8 (6.1,21)</td>
<td>2.9 (0.8,10)</td>
</tr>
<tr>
<td>B (n=148)</td>
<td>37.8 (30.4,45)</td>
<td>16.9 (11.7,23)</td>
<td>10.1 (6.2,16)</td>
<td>3.4 (1.5,7)</td>
</tr>
<tr>
<td>C (n=155)</td>
<td>42.5 (34.5,51)</td>
<td>14.4 (9.7,21)</td>
<td>18.4 (12.8,25)</td>
<td>4.4 (2.1,9)</td>
</tr>
<tr>
<td>D (n=276)</td>
<td>38.2 (30.4,46)</td>
<td>13.4 (8.9,17)</td>
<td>8.7 (5.9,12)</td>
<td>3.6 (2.0,6)</td>
</tr>
<tr>
<td>E (n=269)</td>
<td>35.9 (30.3,41)</td>
<td>15.4 (11.8,20)</td>
<td>8.9 (4.4,14)</td>
<td>1.5 (0.8,3)</td>
</tr>
<tr>
<td>F (n=268)</td>
<td>40.2 (34.3,52)</td>
<td>22.2 (15.1,31)</td>
<td>21.2 (15.1,31)</td>
<td>10.2 (5.6,15)</td>
</tr>
<tr>
<td>G (n=28)</td>
<td>30.6 (22.4,40)</td>
<td>9.3 (5.0,16)</td>
<td>10.2 (5.8,16)</td>
<td>1.0 (0.2,5)</td>
</tr>
<tr>
<td>H (n=178)</td>
<td>38.2 (31.4,45)</td>
<td>20.3 (15.1,29)</td>
<td>10.1 (6.5,15)</td>
<td>6.2 (3.5,10)</td>
</tr>
<tr>
<td>J (n=128)</td>
<td>44.5 (36,532)</td>
<td>18.8 (12.9,24)</td>
<td>11.7 (7.2,18)</td>
<td>6.3 (3.2,11)</td>
</tr>
<tr>
<td>K (n=161)</td>
<td>47.2 (38.6,54)</td>
<td>17.4 (12.3,24)</td>
<td>18.9 (13.4,25)</td>
<td>7.6 (4.3,12)</td>
</tr>
<tr>
<td>L (n=226)</td>
<td>32.7 (27.0,39)</td>
<td>21.7 (16.8,27)</td>
<td>12.8 (8.4,19)</td>
<td>6.7 (4.1,10)</td>
</tr>
<tr>
<td>M (n=128)</td>
<td>38.6 (28.9,45)</td>
<td>14.3 (9.2,21)</td>
<td>7.1 (3.8,13)</td>
<td>1.6 (0.4,6)</td>
</tr>
<tr>
<td>N (n=129)</td>
<td>37.6 (29.6,46)</td>
<td>11.6 (7.2,18)</td>
<td>6.2 (3.2,11)</td>
<td>1.6 (0.4,6)</td>
</tr>
<tr>
<td>P (n=93)</td>
<td>46.2 (38.0,58)</td>
<td>25.8 (19.0,35)</td>
<td>18.1 (10.0,24)</td>
<td>6.6 (3.0,13)</td>
</tr>
<tr>
<td>Q (n=11)</td>
<td>9.1 (1.6,37)</td>
<td>9.1 (1.6,37)</td>
<td>0.0 (0.0,25)</td>
<td>0.0 (0.0,25)</td>
</tr>
<tr>
<td>R (n=78)</td>
<td>44.9 (34.3,56)</td>
<td>25.6 (17.3,35)</td>
<td>14.1 (8.1,23)</td>
<td>10.3 (6.3,19)</td>
</tr>
<tr>
<td>S (n=52)</td>
<td>42 (318,529)</td>
<td>23.5 (15.6,33)</td>
<td>12.3 (6.8,21)</td>
<td>7.4 (3.4,15)</td>
</tr>
</tbody>
</table>

#### All-Wales Acute Rates

<table>
<thead>
<tr>
<th></th>
<th>35.7 (37.4,413)</th>
<th>17.9 (16.4,195)</th>
<th>12.2 (10.9,135)</th>
<th>5.1 (4.3,6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All-Wales Acute Rate</strong> Tested</td>
<td>2,457</td>
<td>2,460</td>
<td>2,458</td>
<td>2,455</td>
</tr>
</tbody>
</table>

#### Key
- **COA** = co-amoxiclav
- **PTZ** = piperacillin/tazobactam
- **GEN** = gentamicin
- **PTZ/GEN** = combined resistance to both agents
- **COT** = co-timoxazole
- **3GC** = resistance to third-generation fluoroquinolones
- **AML** = amikacin
- **FQ** = resistance to quinolones
- **ERT** = imipenem
- **IMI** = imipenem
- **MER** = meropenem
- **MER/IMI** = resistance to either or both agents

### Note
The resistance ranges are outlined e.g. the range for co-amoxiclav (COA) was 9.1% to 47.2%; individual hospital resistance rates statistically higher than the All-Wales rate are highlighted in amber. Resistance rates are not recorded when <80% of the isolates were tested.

The **‘All-Wales acute rate’** is the aggregate rate for the acute hospitals in Wales listed below: Bronglais (A), Princess of Wales (B), Royal Glamorgan (C), Royal Gwent (D), Morriston (E), UHW (F), Withybush (G), Wrexham Maelor (H), Glangwili (J), Ysbyty Gwynedd (K), Ysbyty Glan Clwyd (L), Nevill Hall (M), Prince Charles (N), UHL (P), Velindre (Q), Prince Philip (R), and Singleton (S).
Tables 4 & 5 show resistance rates for individual acute hospitals and Health Boards:

- Piperacillin/tazobactam (PTZ), gentamicin (GEN), co-trimoxazole (COT), third generation cephalosporin (3GC), amikacin (AMI) and fluoroquinolone (FQ) resistance is significantly higher for the University Hospital of Wales (F), University Hospital Llandough (P), and Cardiff & Vale University Health Board (CAVUHB).

- Co-trimoxazole (COT) resistance also significantly higher than the All-Wales acute rate in Royal Glamorgan (C).

Table 5: *Escherichia coli* – Health Board Level

<table>
<thead>
<tr>
<th>Location Code (Number)</th>
<th>COA (95% CI)</th>
<th>PTZ (95% CI)</th>
<th>GEN (95% CI)</th>
<th>PTZ/GEN (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABUHB (n=421)</td>
<td>38.4 (33.9,43.2)</td>
<td>13.6 (10.6,17.1)</td>
<td>8.8 (6.5,11.9)</td>
<td>3.1 (1.8,6.2)</td>
</tr>
<tr>
<td>BCUHB (n=576)</td>
<td>38.9 (35.0,42.9)</td>
<td>20.3 (17.3,23.8)</td>
<td>13.4 (10.8,16.3)</td>
<td>6.5 (5.0,9.2)</td>
</tr>
<tr>
<td>CAVUHB (n=364)</td>
<td>48.4 (41.3,51.6)</td>
<td>25.4 (21.7,29.2)</td>
<td>20.5 (18.4,22.7)</td>
<td>9.4 (8.1,10.9)</td>
</tr>
<tr>
<td>CTMUHB (n=421)</td>
<td>39.3 (34.8,44.1)</td>
<td>14.5 (11.4,18.2)</td>
<td>11.9 (9.1,15.4)</td>
<td>3.3 (2.0,5.5)</td>
</tr>
<tr>
<td>HDUHB (n=374)</td>
<td>38.5 (33.7,43.6)</td>
<td>16.9 (13.4,20.6)</td>
<td>12.2 (9.1,15.7)</td>
<td>5.4 (3.5,8.1)</td>
</tr>
<tr>
<td>SBUHB(n=363)</td>
<td>36.7 (31.9,41.8)</td>
<td>17.4 (13.8,21.6)</td>
<td>7.2 (5.4,11.0)</td>
<td>2.8 (1.5,5.0)</td>
</tr>
<tr>
<td>VNHST (n=11)</td>
<td>9.1 (6.3,12.7)</td>
<td>9.1 (6.3,12.7)</td>
<td>0.0 (0.0,25.9)</td>
<td>0.0 (0.0,25.9)</td>
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</table>

<table>
<thead>
<tr>
<th>Location Code (Number)</th>
<th>COT (95% CI)</th>
<th>3GC (95% CI)</th>
<th>AMI (95% CI)</th>
<th>FQ (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABUHB (n=421)</td>
<td>31.9 (27.6,36.5)</td>
<td>15.0 (11.9,18.7)</td>
<td>0.5 (0.1,1.7)</td>
<td>14.1 (11.1,17.7)</td>
</tr>
<tr>
<td>BCUHB (n=576)</td>
<td>38.7 (34.8,42.8)</td>
<td>11.8 (9.4,14.7)</td>
<td>0.5 (0.2,1.5)</td>
<td>20.3 (17.2,23.8)</td>
</tr>
<tr>
<td>CAVUHB (n=364)</td>
<td>49.0 (46.0,52.0)</td>
<td>22.1 (18.0,26.3)</td>
<td>4.7 (2.9,6.5)</td>
<td>35.4 (30.6,40.2)</td>
</tr>
<tr>
<td>CTMUHB (n=421)</td>
<td>36.1 (32.1,41.3)</td>
<td>12.6 (9.9,16.1)</td>
<td>0.5 (0.1,1.7)</td>
<td>16.2 (12.9,20.0)</td>
</tr>
<tr>
<td>HDUHB (n=374)</td>
<td>33.0 (28.4,37.9)</td>
<td>13.6 (10.5,17.5)</td>
<td>2.1 (1.1,4.2)</td>
<td>20.3 (18.6,24.7)</td>
</tr>
<tr>
<td>SBUHB (n=363)</td>
<td>29.7 (25.2,34.6)</td>
<td>10.2 (7.5,13.9)</td>
<td>1.5 (0.4,2.8)</td>
<td>15.2 (11.9,19.3)</td>
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<tr>
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<td>0.0 (0.0,25.9)</td>
<td>9.1 (6.3,12.7)</td>
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<table>
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<th>Location Code (Number)</th>
<th>ERT (95% CI)</th>
<th>IMI (95% CI)</th>
<th>MER (95% CI)</th>
<th>IMI/MER (95% CI)</th>
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</thead>
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<td>BCUHB (n=576)</td>
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<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
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<td>0.0 (0.0,0.7)</td>
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<td>0.0 (0.0,0.9)</td>
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<tr>
<td>SBUHB (n=363)</td>
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<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
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<tr>
<td>VNHST (n=11)</td>
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<table>
<thead>
<tr>
<th>Location Code (Number)</th>
<th>ERT (95% CI)</th>
<th>IMI (95% CI)</th>
<th>MER (95% CI)</th>
<th>IMI/MER (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABUHB (n=421)</td>
<td>0.2 (0.1,1.3)</td>
<td>0.0 (0.0,0.9)</td>
<td>0.0 (0.0,0.9)</td>
<td>0.0 (0.0,0.9)</td>
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<tr>
<td>BCUHB (n=576)</td>
<td>0.0 (0.0,0.7)</td>
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<td>0.0 (0.0,0.7)</td>
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<tr>
<td>CTMUHB (n=421)</td>
<td>0.3 (0.1,1.7)</td>
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<td>0.0 (0.0,0.9)</td>
<td>0.0 (0.0,0.9)</td>
</tr>
<tr>
<td>HDUHB (n=374)</td>
<td>0.3 (0.1,1.7)</td>
<td>0.0 (0.0,0.9)</td>
<td>0.0 (0.0,0.9)</td>
<td>0.0 (0.0,0.9)</td>
</tr>
<tr>
<td>SBUHB (n=363)</td>
<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
</tr>
<tr>
<td>VNHST (n=11)</td>
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<td>0.0 (0.0,0.7)</td>
<td>0.0 (0.0,0.7)</td>
</tr>
</tbody>
</table>

Note: Health Board resistance rates comprise data from all acute and non-acute hospitals within the Health Board. The ‘All-Wales rate’ is the aggregate rate for all acute and non-acute hospitals in Wales that refer specimens for microbiological testing to a laboratory in Wales, and may differ from the ‘All-Wales Acute rate’.
Interpretation Tables 6-10: The tables show trends in resistance to drug/bug combinations in the APRHAI primary data set at hospital level, across time. The tables use a colour gradation based on the lowest resistance to the highest resistance figures, to highlight local patterns of resistance across time. The first column in the tables show the hospital code and the median number of isolates tested across the time period e.g. in Table 6, hospital code A (65) denotes Bronglais hospital with a median number of 65 isolates tested per year across the eight-year period. Note: Individual hospital or laboratory resistance rates are only presented for organisms where ≥80% of such isolates from the given sample type was tested and where the number of isolates tested exceeds nine. It is important to remember when interpreting this data set that hospital level data often represents small numbers of organisms, and single isolate resistance within these numbers can produce misleadingly large changes in resistance.

Table 6: Trends in co-amoxiclav for *E. coli* by hospital (2011-2018)

<table>
<thead>
<tr>
<th>Hospital Co.</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (65)</td>
<td>31.8</td>
<td>33.3</td>
<td>37.3</td>
<td>20.0</td>
<td>18.8</td>
<td>28.2</td>
<td>26.7</td>
<td>29.4</td>
</tr>
<tr>
<td>B (124)</td>
<td>32.4</td>
<td>36.3</td>
<td>19.8</td>
<td>14.9</td>
<td>25.4</td>
<td>39.1</td>
<td>35.6</td>
<td>37.8</td>
</tr>
<tr>
<td>C (134)</td>
<td>52.0</td>
<td>44.0</td>
<td>50.0</td>
<td>43.2</td>
<td>40.3</td>
<td>38.5</td>
<td>34.8</td>
<td>42.5</td>
</tr>
<tr>
<td>D (246)</td>
<td>40.9</td>
<td>48.0</td>
<td>36.5</td>
<td>23.0</td>
<td>28.1</td>
<td>32.0</td>
<td>34.8</td>
<td>38.2</td>
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<tr>
<td>E (199)</td>
<td>45.9</td>
<td>47.9</td>
<td>34.5</td>
<td>31.3</td>
<td>24.9</td>
<td>32.8</td>
<td>37.2</td>
<td>35.9</td>
</tr>
<tr>
<td>F (267)</td>
<td>47.7</td>
<td>36.7</td>
<td>45.3</td>
<td>26.3</td>
<td>30.1</td>
<td>35.9</td>
<td>44.6</td>
<td>46.2</td>
</tr>
<tr>
<td>G (94)</td>
<td>19.0</td>
<td>20.5</td>
<td>22.2</td>
<td>22.9</td>
<td>30.1</td>
<td>31.4</td>
<td>36.4</td>
<td>30.6</td>
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<tr>
<td>H (173)</td>
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<td>36.1</td>
<td>31.0</td>
<td>39.2</td>
<td>44.0</td>
<td>38.2</td>
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<tr>
<td>J (150)</td>
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<td>23.8</td>
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<td>35.5</td>
<td>27.7</td>
<td>43.1</td>
<td>44.5</td>
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<td>K (141)</td>
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<td>36.7</td>
<td>39.3</td>
<td>47.2</td>
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<td>L (195)</td>
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<td>30.4</td>
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<td>32.7</td>
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<td>M (129)</td>
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<td>36.1</td>
<td>22.2</td>
<td>34.2</td>
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<td>N (120)</td>
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<td>25.0</td>
<td>18.2</td>
<td>5.9</td>
<td>15.4</td>
<td>9.1</td>
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<td>32.1</td>
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<td>40.4</td>
<td>44.9</td>
</tr>
<tr>
<td>S (124)</td>
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<td>45.1</td>
<td>30.9</td>
<td>38.9</td>
<td>31.5</td>
<td>22.4</td>
<td>37.3</td>
<td>42.0</td>
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<td>41.9</td>
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<td>30.3</td>
<td>33.0</td>
<td>37.0</td>
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</tbody>
</table>

The data in Tables 6 -10 show:

- Regionally high resistance rates to co-amoxiclav in *E. coli* isolated from blood cultures in Ysbyty Gwynedd (K), UHL (P), UHW (F), Glangwili (J) and Prince Philip (R) hospitals.
- An increase in third generation cephalosporin resistance in *E. coli* isolated from blood cultures in UHW (F) and UHL (P) between 2016 and 2018.
- An increase in fluoroquinoles resistance in resistance in *E. coli* isolated from blood cultures in UHW (F) and UHL (P) between 2015 and 2018.
- An increase in piperacillin/tazobactam resistance at an All-Wales level, driven by a general increase in resistance across most hospitals.
**Table 7: Trends in third generation cephalosporin resistance for E. coli by hospital (2011-2018)**

<table>
<thead>
<tr>
<th>Hospital Code</th>
<th>AB Code / Year</th>
<th>3GC</th>
<th>%R</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>2018</td>
<td>9.1</td>
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</tr>
</tbody>
</table>

**Key:**

A = Bronglais  
B = Princess of Wales  
C = Royal Glamorgan  
D = Royal Gwent  
E = Morriston  
F = UHW  
G = Withybush  
H = Wrexham Maelor  
J = Glangwili  
K = Ysbyty Gwynedd  
L = Ysbyty Glan Clwyd  
M = Nevill Hall  
N = Prince Charles  
P = UHL  
Q = Velindre  
R = Prince Philip  
S = Singleton

**Table 8: Trends in fluoroquinolone resistance for E. coli by hospital (2011-2018)**

<table>
<thead>
<tr>
<th>Hospital Code</th>
<th>AB Code / Year</th>
<th>FQ</th>
<th>%R</th>
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</thead>
<tbody>
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<tr>
<td></td>
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<tr>
<td></td>
<td>2018</td>
<td>26.5</td>
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</tbody>
</table>

**Key:**

A = Bronglais  
B = Princess of Wales  
C = Royal Glamorgan  
D = Royal Gwent  
E = Morriston  
F = UHW  
G = Withybush  
H = Wrexham Maelor  
J = Glangwili  
K = Ysbyty Gwynedd  
L = Ysbyty Glan Clwyd  
M = Nevill Hall  
N = Prince Charles  
P = UHL  
Q = Velindre  
R = Prince Philip  
S = Singleton
Table 9: Trends in gentamicin resistance for *E. coli* by hospital (2011-2018)

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<td>7.9</td>
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<td>10.6</td>
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<td>6.7</td>
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<td>9.6</td>
<td>5.8</td>
<td>10.2</td>
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Key:

A = Bronglais
B = Princess of Wales
C = Royal Glamorgan
D = Royal Gwent
E = Morriston
F = UHW
G = Withybush
H = Wrexham Maelor
J = Glangwili
K = Ysbyty Gwynedd
L = Ysbyty Glan Clwyd
M = Nevill Hall
N = Prince Charles
P = UHL
Q = Velindre
R = Prince Philip
S = Singleton
Z = All-Wales

Table 10: Trends in piperacillin/tazobactam resistance for *E. coli* (2011-2018)

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**Klebsiella spp. (n=545 in 2018)**

Klebsiella spp. are the second commonest group of gram-negative organisms grown from blood cultures. The All-Wales patterns of resistance for 2009 to 2018 are shown in Figure 4. The 2018 resistance rates for individual acute hospitals and Health Boards are shown in Tables 11 & 12.

There has been a statistically significant increase in piperacillin/tazobactam (PTZ) resistance rates between 2017 & 2018. Co-amoxiclav (COA), fluoroquinolone (FQ), and third generation cephalosporin (3GC) resistance continues on an upward trend. Gentamicin (GEN) resistance has levelled off. Imipenem and meropenem (CARB) resistance rates remain below 1% in the Wales.

![Graph showing antimicrobial resistance rates for Klebsiella species isolated from blood culture (2009 to 2018)](image)

**Figure 4: All-Wales antimicrobial resistance rates for Klebsiella species; isolated from blood culture (2009 to 2018)**

**Table 11** over page is a combined table showing the acute hospital resistance rates (top) and the Health Board resistance rates (bottom).

- Locally, carbapenem resistance (ertapenem, imipenem and meropenem) was reported in Glanwgili hospital (J).

- Gentamicin resistance rates for Klebsiella spp. bacteraemia from Royal Gwent (D) and Aneurin Bevan University Health Board (ABUHB) were notably higher than the rest of Wales.
### Table 11: Klebsiella spp.

#### Klebsiella spp. from blood cultures - Acute Hospital Level

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<th>PTZ (95%)</th>
<th>GEN (95%)</th>
<th>PTZ/GEN (95%)</th>
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**All-Wales Acute: Rates**

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**All-Wales Acute: No. tested**

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**All-Wales: No. tested**

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**Key:** CoA = carbapenem, PTZ = piperacillin/tazobactam, GEN = gentamicin, PTZ/GEN = combined resistance to both agents, CoT = carbapenem, Taz 2.0 = carbapenem, Taz 10.0 = carbapenem, Taz 10.0 = carbapenem, Taz 10.0 = carbapenem, Taz 10.0 = carbapenem, MER = meropenem, IMER = imipenem, IMER = meropenem, IMER = meropenem, MER = meropenem, MER = meropenem.
APRHAI Primary data Set

Interpretation Tables 13-17: The tables show trends in resistance to drug/bug combinations in the APRHAI primary data set at hospital level, across time. The tables use a colour gradation based on the lowest resistance to the highest resistance figures, to highlight local patterns of resistance across time. **Note 1:** The data is different to that shown in Table 3 (page 11); Table 3 shows the rates for *Klebsiella pneumoniae* as per APRHAI instructions, but the following tables show the data for all Klebsiella species to allow comparisons with previous reports. **Note 2:** Individual hospital or laboratory resistance rates are only presented for organisms where ≥80% of such isolates from the given sample type was tested and where the number of isolates tested exceeds nine. It is important to remember when interpreting this data set that hospital level data often represents small numbers of organisms, and single isolate resistance within these numbers can produce misleadingly large changes in resistance.

Table 13: Trends in third generation cephalosporin resistance for *Klebsiella spp.* (2011-2018)

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The data in Tables 13-17 show a continuing increasing trend in resistance to third generation cephalosporins, fluoroquinolones, and piperacillin/tazobactam at an All-Wales level, driven by increases in resistance to these agents across many hospitals.

Imipenem and/or meropenem resistance was reported in *Klebsiella spp.* in 2018, but the number of isolates was small.
Table 14: Trends in fluoroquinolone resistance for *Klebsiella* spp. (2011-2018)

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Key:

A = Bronglais  
B = Princess of Wales  
C = Royal Glamorgan  
D = Royal Gwent  
E = Morriston  
F = W/H  
G = Withybush  
H = Wrexham Maelor  
J = Glangwili  
K = Ysbyty Gwynedd  
L = Ysbyty Glan Clwyd  
M = Nevill Hall  
N = Prince Charles  
P = UHL  
Q = Velindre  
R = Prince Philip  
S = Singleton  
Z = All-Wales

Table 15: Trends in gentamicin resistance for *Klebsiella* spp. (2011-2018)

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Table 16: Trends in piperacillin/tazobactam resistance for *Klebsiella* spp. (2011-2018)

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Key:

A = Bronglais
B = Princess of Wales
C = Royal Glamorgan
D = Royal Gwent
E = Morriston
F = UHW
G = Withybush
H = Wrexham Maelor
J = Glanmgwili
K = Ysbyty Gwynedd
L = Ysbyty Glan Clwyd
M = Nevill Hall
N = Prince Charles
P = UHL
Q = Velindre
R = Prince Philip
S = Singleton
Z = All-Wales

Table 17: Trends in imipenem/meropenem resistance for *Klebsiella* spp. (2011-2018)

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Enterobacter spp., Serratia spp., Proteus spp., and Ps. aeruginosa

Table 18: Enterobacter spp., Serratia spp., Proteus spp., and Ps. aeruginosa

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<tr>
<th>Organism</th>
<th>COA (95% CI)</th>
<th>PTZ (95% CI)</th>
<th>GEN (95% CI)</th>
<th>PTZ/GEN (95% CI)</th>
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<td>Serratia spp.</td>
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<td>4.0 (1.6, 9.9)</td>
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<td>0.4 (0.1, 2.4)</td>
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<td>Pseudomonas aeruginosa</td>
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<td>3.1 (1.4, 6.7)</td>
<td>1.6 (0.5, 4.5)</td>
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<tr>
<td>All-Wales: Number of isolates</td>
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<table>
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<th>Location Code (Number)</th>
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<th>GEN (95% CI)</th>
<th>PTZ/GEN (95% CI)</th>
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<td>3.7 (1.4, 9.1)</td>
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<td>Serratia spp.</td>
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<td>0.9 (0.5, 3.9)</td>
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<td>All-Wales: Number of isolates</td>
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<tr>
<td>*Pseudomonas aeruginosa</td>
<td>--</td>
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<th>MER (95% CI)</th>
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<td>Serratia spp.</td>
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<td>0.0 (0.0, 4.1)</td>
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<td>0.0 (0.0, 1.7)</td>
<td>1.3 (2.2, 7.6)</td>
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<tr>
<td>All-Wales: Number of isolates</td>
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<td>228</td>
<td>228</td>
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<tr>
<td>Pseudomonas aeruginosa</td>
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<td>6.3 (3.6, 10.6)</td>
<td>9.4 (6.0, 14.3)</td>
<td>8.3 (5.2, 15.1)</td>
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<tr>
<td>All-Wales: Number of isolates</td>
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Key: COA = co-amoxiclav. PTZ = piperacillin-tazobactam. GEN = gentamicin. PTZ/GEN = combined resistance to both agents. COT = co-trimoxazole.

Note: Resistance rates are not recorded if the organisms are intrinsically resistant to an antibacterial agent e.g. Enterobacter spp. and co-amoxiclav (COA).
**Enterobacter spp. (n=109 in 2018)**

The All-Wales patterns of antimicrobial resistance for *Enterobacter* spp. are shown in Figure 5 & Table 18 with a notable increase in piperacillin/tazobactam (PTZ) in 2018.

![Figure 5: All-Wales antimicrobial resistance rates for Enterobacter species; isolated from blood culture (2009 to 2018)](image)

**Proteus spp. (n=228 in 2018)**

The All-Wales patterns of antimicrobial resistance in *Proteus* spp. are shown in Figure 6 & Table 18. Resistance rates are variable and show no particular pattern.

![Figure 6: All-Wales antimicrobial resistance rates for Proteus species; isolated from blood culture (2009 to 2018)](image)
**Pseudomonas aeruginosa** (n=190 in 2018)

The All-Wales patterns of antimicrobial resistance in *Pseudomonas aeruginosa* are shown in Figure 7 & Table 18. Resistance rates are variable and show no particular pattern.

![Figure 7: All-Wales antimicrobial resistance rates for Pseudomonas aeruginosa; isolated from blood culture (2009 to 2018)](image)

**Serratia spp.** (n=100 in 2018)

The All-Wales patterns of antimicrobial resistance for *Serratia* spp. are shown in Figure 8 and Table 18. The reduction in resistance seen between 2009 and 2014 appears to be reversing, with resistance increasing in recent years.

![Figure 8: All-Wales antimicrobial resistance rates for Serratia species; isolated from blood culture (2009 to 2018)](image)
**Staphylococcus aureus (n=993 in 2018)**

The All-Wales trends in *Staphylococcus aureus* bacteraemias are shown in Figure 9. In 2018, the number MSSA bacteraemia increased, MRSA decreased, and the overall *S. aureus* bacteraemia numbers have not changed.

![Figure 9: All-Wales Staphylococcus aureus bacteraemia numbers (2009 to 2018)](image)

Resistance rates for *Staphylococcus aureus* at hospital level are shown in Table 19 over page; the data includes all *S. aureus* both MSSA and MRSA.

- In 2018, clindamycin resistance rates for *S. aureus* bacteraemias in Bronglais hospital (A) were notably higher than the All-Wales rate.

- Flucloxacillin resistance reflects the proportion of *S. aureus* bacteraemias that were MRSA; the proportions of MRSA bacteraemias was higher in Bronglais hospital (16.7%) than other acute hospitals in Wales.

- Gentamicin and tetracycline resistance rates for *S. aureus* in Ysbyty Glan Clwyd (L) were significantly higher than the All-Wales Acute hospitals rate. Gentamicin resistance were also high in Wrexham Maelor hospital (H) and Ysbyty Gwynedd (K)
Table 19: *Staphylococcus aureus* (MSSA & MRSA)

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All-Wales Acute: Rates

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All-Wales Acute: No. tested

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<td>E (n=119)</td>
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<td>3.1</td>
</tr>
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<td>F (n=131)</td>
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</tr>
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<td>G (n=35)</td>
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<td>0.0</td>
<td>0.0</td>
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<td>H (n=60)</td>
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<td>4.6</td>
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<tr>
<td>J (n=43)</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>K (n=47)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>L (n=63)</td>
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<td>14.4</td>
</tr>
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<td>M (n=41)</td>
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<td>2.1</td>
<td>10.0</td>
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<td>N (n=59)</td>
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<td>1.6</td>
</tr>
<tr>
<td>P (n=24)</td>
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<td>0.0</td>
<td>4.0</td>
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<tr>
<td>R (n=20)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>S (n=23)</td>
<td>4.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

All-Wales Acute: No. tested

Note: The range of resistance is outlined e.g. the range for clindamycin (CLI) was 2.9% to 29.2%; individual hospital resistance rates statistically higher than the All-Wales rate are highlighted in amber.
APRHAI Primary data Set

**Interpretation Table 20:** The table shows trends in resistance to a drug/bug combination in the APRHAI primary data set at hospital level, across time. The tables use a colour gradation based on the lowest resistance to the highest resistance figures, to highlight local patterns of resistance across time.

**Table 20: Trends in meticillin resistance for *Staphylococcus aureus* (2011-2018)**

<table>
<thead>
<tr>
<th>Hospital Co.</th>
<th>AB Code / Year FLU</th>
<th>%R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (16)</td>
<td>10.0 23.1 14.3 0.0 16.7 3.7 16.7</td>
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</tr>
<tr>
<td>B (45)</td>
<td>15.6 13.0 11.8 20.5 10.5 20.7 14.3 13.8</td>
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</tr>
<tr>
<td>C (52)</td>
<td>19.4 17.1 12.5 21.1 4.2 0.0 11.6 8.1</td>
<td></td>
</tr>
<tr>
<td>D (84)</td>
<td>20.5 18.1 21.2 16.0 18.5 5.0 10.7 9.3</td>
<td></td>
</tr>
<tr>
<td>E (71)</td>
<td>17.9 25.8 12.3 23.6 4.1 9.2 12.6 7.0</td>
<td></td>
</tr>
<tr>
<td>F (153)</td>
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</tr>
<tr>
<td>G (35)</td>
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<td></td>
</tr>
<tr>
<td>H (56)</td>
<td>20.0 25.0 25.0 22.2 21.7 21.4 28.3 7.7</td>
<td></td>
</tr>
<tr>
<td>J (55)</td>
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<td></td>
</tr>
<tr>
<td>K (53)</td>
<td>42.5 38.0 32.7 31.4 21.8 20.5 18.2 13.0</td>
<td></td>
</tr>
<tr>
<td>L (57)</td>
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<td></td>
</tr>
<tr>
<td>M (37)</td>
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<td></td>
</tr>
<tr>
<td>N (49)</td>
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<td></td>
</tr>
<tr>
<td>P (24)</td>
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<td></td>
</tr>
<tr>
<td>R (21)</td>
<td>0.0 5.6 14.3 23.1 0.0 29.4 9.5 4.8</td>
<td></td>
</tr>
<tr>
<td>S (47)</td>
<td>20.0 11.3 14.1 9.7 9.1 8.3 5.3 4.2</td>
<td></td>
</tr>
<tr>
<td>T (875)</td>
<td>23.5 20.4 17.6 16.6 12.7 11.4 13.0 8.8</td>
<td></td>
</tr>
</tbody>
</table>

The data in Table 20 shows a notable reduction in meticillin resistance across time in *Staphylococcus aureus* isolated from blood cultures taken in Ysbyty Gwynedd (K) i.e. a reduction in the proportion of MRSA from 42.6% in 2011 to 13.0% in 2018.
**Meticillin Sensitive Staphylococcus aureus** (n=914 in 2018)

The All-Wales patterns of resistance for 2009 to 2018 are shown in Figure 10. The 2018 resistance rates for individual acute hospitals and Health Boards are shown in Tables 21 & 22.

![Figure 10: All-Wales antimicrobial resistance rates for Meticillin Sensitive Staphylococcus aureus (MSSA) isolated from blood culture (2009 to 2018)](image)

**Meticillin Resistant Staphylococcus aureus** (n=88 in 2018)

The All-Wales pattern of antimicrobial resistance in MRSA is shown in Figure 11. Note: The numbers of MRSA are too small to present in a table.

![Figure 11: All-Wales antimicrobial resistance rates for Meticillin Resistant Staphylococcus aureus (MRSA) isolated from blood culture (2009 to 2018)](image)
### Table 21: Meticillin Sensitive *Staphylococcus aureus* (MSSA) – Acute Hospital

Meticillin Sensitive *Staphylococcus aureus* from blood cultures - Acute Hospital Level

<table>
<thead>
<tr>
<th>Resistance rates including (95% Confidence Intervals)</th>
<th>Duplicate Cut Off: ≤14 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time period: 1 January - 31 December 2018</td>
<td></td>
</tr>
</tbody>
</table>

#### Location Code

<table>
<thead>
<tr>
<th>Location Code</th>
<th>CLI (95% CI)</th>
<th>ERY (95% CI)</th>
<th>FUS (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n=20)</td>
<td>25.0</td>
<td>25.0</td>
<td>5.0</td>
</tr>
<tr>
<td>B (n=50)</td>
<td>4.0</td>
<td>8.0</td>
<td>18.0</td>
</tr>
<tr>
<td>C (n=57)</td>
<td>12.5</td>
<td>21.1</td>
<td>26.3</td>
</tr>
<tr>
<td>D (n=107)</td>
<td>18.0</td>
<td>17.8</td>
<td>9.3</td>
</tr>
<tr>
<td>E (n=119)</td>
<td>12.8</td>
<td>13.4</td>
<td>16.8</td>
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<tr>
<td>F (n=131)</td>
<td>11.5</td>
<td>11.5</td>
<td>7.7</td>
</tr>
<tr>
<td>G (n=35)</td>
<td>2.9</td>
<td>14.7</td>
<td>5.9</td>
</tr>
<tr>
<td>H (n=60)</td>
<td>10.0</td>
<td>10.0</td>
<td>13.3</td>
</tr>
<tr>
<td>J (n=43)</td>
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<td>16.3</td>
<td>18.6</td>
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<tr>
<td>K (n=47)</td>
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<td>L (n=63)</td>
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<td>M (n=41)</td>
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<td>9.8</td>
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<tr>
<td>N (n=59)</td>
<td>5.1</td>
<td>13.6</td>
<td>10.2</td>
</tr>
<tr>
<td>P (n=24)</td>
<td>20.8</td>
<td>20.8</td>
<td>16.7</td>
</tr>
<tr>
<td>R (n=23)</td>
<td>5.0</td>
<td>30.0</td>
<td>25.0</td>
</tr>
<tr>
<td>S (n=53)</td>
<td>8.7</td>
<td>13.0</td>
<td>21.7</td>
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</table>

#### All-Wales Acute: Rates

<table>
<thead>
<tr>
<th>Location Code</th>
<th>CLI (95% CI)</th>
<th>ERY (95% CI)</th>
<th>FUS (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n=20)</td>
<td>11.2</td>
<td>14.8</td>
<td>13.6</td>
</tr>
<tr>
<td>B (n=50)</td>
<td>(9.3, 13.4)</td>
<td>(12.7, 17.3)</td>
<td>(11.5, 16.0)</td>
</tr>
<tr>
<td>C (n=57)</td>
<td>895</td>
<td>896</td>
<td>897</td>
</tr>
<tr>
<td>D (n=107)</td>
<td>2.4</td>
<td>2.4</td>
<td>0.5</td>
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<tr>
<td>E (n=119)</td>
<td>4.8</td>
<td>2.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F (n=131)</td>
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<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>G (n=35)</td>
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</tr>
<tr>
<td>J (n=43)</td>
<td>0.0</td>
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<td>0.0</td>
</tr>
<tr>
<td>K (n=47)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>L (n=63)</td>
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<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>M (n=41)</td>
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<td>2.4</td>
<td>0.5</td>
</tr>
<tr>
<td>N (n=59)</td>
<td>2.4</td>
<td>2.4</td>
<td>0.5</td>
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<tr>
<td>P (n=24)</td>
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<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>R (n=23)</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>S (n=53)</td>
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#### All-Wales Acute: No. tested

<table>
<thead>
<tr>
<th>Location Code</th>
<th>CLI (95% CI)</th>
<th>ERY (95% CI)</th>
<th>FUS (95% CI)</th>
</tr>
</thead>
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<td>A (n=20)</td>
<td>1.6</td>
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<td>0.5</td>
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<tr>
<td>B (n=50)</td>
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<td>870</td>
<td>877</td>
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<td>C (n=57)</td>
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<td>2.0</td>
<td>0.0</td>
</tr>
<tr>
<td>D (n=107)</td>
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<td>0.0</td>
<td>0.0</td>
</tr>
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<td>0.0</td>
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<tr>
<td>F (n=131)</td>
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<td>2.4</td>
<td>0.5</td>
</tr>
<tr>
<td>G (n=35)</td>
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<td>0.0</td>
</tr>
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<td>H (n=60)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>J (n=43)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>K (n=47)</td>
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<td>0.0</td>
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<tr>
<td>L (n=63)</td>
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<td>0.0</td>
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<tr>
<td>M (n=41)</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>N (n=59)</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>P (n=24)</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>R (n=23)</td>
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<tr>
<td>S (n=53)</td>
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</table>

#### Key

- CLI = clindamycin
- ERY = erythromycin
- FUS = fusidic acid
- GEN = gentamicin
- LZD = linezolid
- MUP = mupirocin
- COT = co-trimoxazole
- RIF = rifampicin
- TET = tetracycline
Resistance rates for Methicillin Sensitive *Staphylococcus aureus* (MSSA) at hospital and Health Board level are shown in Tables 20 & 21.

- Fusidic acid and tetracycline resistance rates for MSSA in Royal Glamorgan (C) were significantly higher than the All-Wales Acute hospitals rate.
- Co-trimoxazole resistance was high in University Hospital Llandough (P).
- At Health Board level, gentamicin resistance was highest in BCUHB.

Table 22: Meticillin Sensitive *Staphylococcus aureus* (MSSA) – Health Board

<table>
<thead>
<tr>
<th>Location Code</th>
<th>Resistance rates including (95% Confidence Intervals)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLJ (95% CI)</td>
</tr>
<tr>
<td>ABUHB (n=421)</td>
<td>14.1 (8.5, 20.4)</td>
</tr>
<tr>
<td>BCUHB (n=576)</td>
<td>10.8 (6.8, 16.1)</td>
</tr>
<tr>
<td>CAVUHB (n=364)</td>
<td>13.5 (9.0, 19.8)</td>
</tr>
<tr>
<td>CTMUHB (n=421)</td>
<td>7.2 (4.2, 12.2)</td>
</tr>
<tr>
<td>HDUHB (n=374)</td>
<td>9.3 (5.3, 16.9)</td>
</tr>
<tr>
<td>SBHUHB (n=363)</td>
<td>11.9 (7.5, 19.2)</td>
</tr>
<tr>
<td></td>
<td>All-Wales: Rates</td>
</tr>
<tr>
<td></td>
<td>All-Wales: No. tested</td>
</tr>
<tr>
<td>Location Code</td>
<td>Location Code</td>
</tr>
<tr>
<td></td>
<td>ABUHB (n=421)</td>
</tr>
<tr>
<td></td>
<td>BCUHB (n=576)</td>
</tr>
<tr>
<td></td>
<td>CAVUHB (n=364)</td>
</tr>
<tr>
<td></td>
<td>CTMUHB (n=421)</td>
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<tr>
<td></td>
<td>HDUHB (n=374)</td>
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<tr>
<td></td>
<td>SBHUHB (n=363)</td>
</tr>
<tr>
<td></td>
<td>All-Wales: Rates</td>
</tr>
<tr>
<td></td>
<td>All-Wales: No. tested</td>
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<tr>
<td>Location Code</td>
<td>Location Code</td>
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<td>ABUHB (n=421)</td>
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<td>CTMUHB (n=421)</td>
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<td></td>
<td>HDUHB (n=374)</td>
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<tr>
<td></td>
<td>SBHUHB (n=363)</td>
</tr>
<tr>
<td></td>
<td>All-Wales: Rates</td>
</tr>
<tr>
<td></td>
<td>All-Wales: No. tested</td>
</tr>
</tbody>
</table>

Key: CLJ = clindamycin, ERY = erythromycin, FUS = fusidic acid, GEN = gentamicin, LZD = linezolid, MUP = mupirocin, CDT = co-trimoxazole, Rif = rifampicin, TET = tetracycline.
Enterococcus spp. (n=484 in 2018)

The All-Wales pattern of antimicrobial resistance in Enterococcus spp. is shown in Figure 12. The 2018 resistance rates for individual acute hospitals and Health Boards are shown in Tables 23 & 24.

Figure 12: All-Wales antimicrobial resistance rates for Enterococcus spp. isolated from blood culture (2009 to 2018)

In 2018, the All-Wales resistance rate for amoxicillin was 44.5%. Susceptibility to amoxicillin is a guide to speciation of the organism, *E. faecalis* being normally susceptible and *E. faecium* being normally resistant, and suggests that in 2018, 55.5% of enterococcal bacteraemias were due to *E. faecalis*.

Table 23: Enterococcus spp. – Acute Hospital Level

<table>
<thead>
<tr>
<th>Location Code (Number)</th>
<th>AMO (95% CI)</th>
<th>VAN (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B (n=21)</td>
<td>33.3 (17.2, 54.6)</td>
<td>4.8 (0.8, 22.7)</td>
</tr>
<tr>
<td>C (n=22)</td>
<td>57.1 (36.5, 75.5)</td>
<td>40.0 (21.9, 61.3)</td>
</tr>
<tr>
<td>D (n=46)</td>
<td>34.8 (22.7, 49.2)</td>
<td>4.3 (1.2, 14.5)</td>
</tr>
<tr>
<td>E (n=46)</td>
<td>50.0 (36.1, 63.9)</td>
<td>19.6 (10.7, 33.2)</td>
</tr>
<tr>
<td>F (n=114)</td>
<td>58.2 (48.8, 67.0)</td>
<td>28.6 (21.0, 37.5)</td>
</tr>
<tr>
<td>G (n=14)</td>
<td>28.6 (11.7, 54.6)</td>
<td>0.0 (0.0, 21.5)</td>
</tr>
<tr>
<td>H (n=24)</td>
<td>29.2 (14.9, 49.2)</td>
<td>4.2 (0.7, 20.2)</td>
</tr>
<tr>
<td>J (n=20)</td>
<td>55.0 (34.2, 74.2)</td>
<td>25.0 (11.2, 46.9)</td>
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<tr>
<td>K (n=30)</td>
<td>55.2 (37.5, 71.6)</td>
<td>6.7 (1.8, 21.3)</td>
</tr>
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<td>L (n=36)</td>
<td>30.6 (18.0, 46.9)</td>
<td>8.3 (2.9, 21.8)</td>
</tr>
<tr>
<td>M (n=25)</td>
<td>53.8 (35.5, 71.2)</td>
<td>3.8 (0.7, 18.9)</td>
</tr>
<tr>
<td>N (n=15)</td>
<td>21.4 (7.6, 47.6)</td>
<td>13.3 (3.7, 37.9)</td>
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<tr>
<td>R (n=15)</td>
<td>28.6 (11.7, 54.6)</td>
<td>21.4 (7.6, 47.6)</td>
</tr>
<tr>
<td>S (n=27)</td>
<td>26.9 (13.7, 46.1)</td>
<td>7.4 (2.1, 23.4)</td>
</tr>
</tbody>
</table>

All-Wales Acute: Rates 44.5 (40.0, 49.2)
All-Wales Acute: No. tested 447

Key: AMO = amoxicillin, VAN = vancomycin.
Resistance rates for Enterococcus spp. at hospital and Health Board level are shown in Tables 23 & 24.

- Amoxicillin resistance ranged from 21% in Prince Charles hospital (N) to 58% in UHW (F).

- Amoxicillin resistance rates may simply reflect variation in the proportion of *E. faecalis* to *E. faecium*.

- Vancomycin resistance was significantly higher than the All-Wales acute rate in Royal Glamorgan (C) and UHW (F).

- At Health Board level, amoxicillin resistance and vancomycin resistance was significantly higher than the All-Wales rate in CAVUHB.

### Table 24: *Enterococcus* spp. – Health Board Level

<table>
<thead>
<tr>
<th>Location Code (Number)</th>
<th>AMO (95% CI)</th>
<th>VAN (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABUHB (n=75)</td>
<td>40.0 (29.7, 51.3)</td>
<td>4.0 (1.4, 11.1)</td>
</tr>
<tr>
<td>BCUHB (n=90)</td>
<td>38.2 (28.8, 48.6)</td>
<td>6.7 (3.1, 13.8)</td>
</tr>
<tr>
<td>CAVUHB (n=119)</td>
<td>59.1 (50.0, 67.7)</td>
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<td>19.0 (11.2, 30.4)</td>
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<td>14.0 (7.3, 25.3)</td>
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<td>All-Wales: No. tested</td>
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*Key: AMO = amoxicillin, VAN = vancomycin.*
APRHAIR Primary data Set

Interpretation Table 23: The table show trends in resistance to a drug/bug combination in the ARHAI primary data set at hospital level, across time. The tables use a colour gradation based on the lowest resistance to the highest resistance figures, to highlight local patterns of resistance across time. The number following the hospital code e.g. (9) represents the median number of isolates per year over the data set. Resistance rates are only shown when the number of isolates were 10 or more for any one year.

Table 23: Trends in vancomycin resistance for *Enterococcus spp.* (2011-2018)

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</table>

The data in Table 23 shows an increase in vancomycin resistance in *Enterococcus spp.* isolated from blood cultures taken in Royal Glamorgan (C) indicating an increase in the proportion VRE.
**Streptococcus pneumoniae** (n=398 in 2018)

The All-Wales pattern of antimicrobial resistance is shown in Figure 13, with no statistically significant change in resistance across time. The 2018 resistance rates for individual acute hospitals and Health Boards are shown in Table 25.

![Figure 13: All-Wales antimicrobial resistance rates for *Streptococcus pneumoniae* isolated from blood culture (2009 to 2018)](image)

**Table 25: Streptococcus pneumoniae**

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<thead>
<tr>
<th>Location Code</th>
<th>COT (95% CI)</th>
<th>CLA (95% CI)</th>
<th>PEN (95% CI)</th>
<th>TET (95% CI)</th>
</tr>
</thead>
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**Streptococcus pneumoniae from blood cultures - Health Board Level**

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APRHAI Primary data Set

Interpretation Table 26: The table shows trends in resistance to a drug/bug combination in the APRHAI primary data set at hospital level, across time. The tables use a colour gradation based on the lowest resistance to the highest resistance figures, to highlight local patterns of resistance across time.

Table 26: Trends in penicillin resistance for *S. pneumoniae* (2011-2018)

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Key:
- B = Princess of Wales
- C = Royal Glamorgan
- D = Royal Gwent
- E = Morriston
- F = UHW
- G = Withybush
- H = Wrexham Maelor
- J = Glangwili
- K = Ysbyty Gwynedd
- L = Ysbyty Glan Clwyd
- M = Nevill Hall
- N = Prince Charles
- R = Prince Philip
- S = Singleton
- Z = All-Wales

The data in Table 25 shows relatively low penicillin resistance in *Streptococcus pneumoniae* isolated from blood cultures in 2018 across Wales.