Western Australian Methicillin-Resistant *Staphylococcus aureus* (MRSA) Epidemiology and Typing Report

July 1 2016 to June 30 2017

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2. Summary

Reporting period: 2016/2017:

- The number of MRSA referred to the Gram-positive Typing Laboratory increased by 10% compared to 2015/2016.
- Micro-alert C MRSA clones (MRSA with the potential to spread within and between institutions) made up 12% of all MRSA and 19% of MRSA in the Perth Metropolitan health region.
- In the remote health regions (Kimberley, Pilbara, Goldfields and the Midwest), micro-alert C MRSA account for less than 5% of MRSA.
- In Western Australia (WA), 50% of all MRSA harbour the genetic determinants for Panton-Valentine leucocidin (PVL).
- PVL positive MRSA were more common than PVL negative MRSA in the remote health regions: Kimberley (79% of MRSA), Pilbara (73%), Midwest (65%) and Goldfields (60%).
- Although 25 PVL positive clones were identified in WA, two PVL positive clones dominated:
  - ST93-IV [2B] (Qld Clone) – 33% of all MRSA
  - ST5-IV [2B] (WA 121) – 9% of all MRSA
- In the past year the number of ST5-IV [2B] (WA 121) has decreased in the Kimberley (from 405 in 2015/2016 to 348 in 2016/2017, P=0.001) and Pilbara (97 to 70, P=0.002).
- The burden of MRSA colonisation/infection is highest in the Kimberley, Midwest, Pilbara and Goldfields health regions (4,547, 985, 857 and 685/100,000 population respectively).
- Patients with PVL positive MRSA are significantly younger than patients with PVL negative MRSA (mean 29 years vs. 57 years, P<0.001).

Reporting period: 2003/2004 to 2016/2017:

- The number of micro-alert C MRSA has increased significantly (P<0.001) in WA due to the increase in ST22-IV [2B] (EMRSA-15) and the introduction of ST772-V [5C2] (Bengal Bay Clone), ST8-IV [2B] (USA300) and PVL-positive ST22-IV [2B].
- The number of PVL-positive and the number of PVL-negative micro-alert B MRSA (MRSA with limited potential to spread within and between institutions) has increased significantly (P<0.001) in all health regions.
- The number of ST93-IV [2B] (Qld clone MRSA) increased significantly (P<0.001) in all health regions
- The number of ST5-IV [2B] (WA 121) increased significantly (P<0.05) in all health regions except the Great Southern
- The number of ST30-IV [2B] (WSPP) increased significantly (P<0.001) in the Perth Metropolitan health region
3. Background

To prevent MRSA from becoming established in Western Australian acute care hospitals a statewide management policy was introduced in 1982. The mainstays of the program include a comprehensive and effective outbreak, identification and management policy. The incorporation of a central epidemiological typing laboratory that uses techniques to enable the rapid identification of MRSA clones has been pivotal in preventing MRSA from becoming established in Western Australian hospitals (1).

As a result of the MRSA policy Western Australian hospitals have maintained a low prevalence of hospital-onset MRSA compared with the rest of Australia (2). In the 2016 Australian Group for Antimicrobial Resistance (AGAR) programs 26.4% of all MRSA bacteraemia cases were classified as hospital-onset infections. Western Australia had the lowest rate of hospital-onset MRSA bacteraemia (9.4%).

Since 1991, community-associated MRSA (CA-MRSA) clones (micro-alert B MRSA) have been associated with a dramatic ascent in the number of MRSA notifications and infections in WA, and are increasingly recognized as a major cause of nosocomial-onset MRSA infections (3). However the proportion of S. aureus nosocomial infections that are caused by CA-MRSA clones is similar to that found in the Western Australian community, suggesting CA-MRSA clones have not successfully found a niche in the Western Australian healthcare system but are imported from the community into hospitals (4).

In addition to distinguishing micro-alert C MRSA clones from micro-alert B MRSA clones the typing laboratory at Fiona Stanley Hospital PathWest-WA and ACCESS Typing and Research provides information on the emergence, transmission and evolution of novel MRSA clones in the Western Australian community (5-12). Since 2010 there has been an exponential increase in PVL-positive CA-MRSA clones in WA; particularly in the Pilbara, Kimberley and Midwest health regions (7, 13, 14). Of recent concern has been the widespread emergence of the trimethoprim resistant PVL-positive ST5-IV [2B] clone (WA 121). Having an understanding on the emergence of such clones may assist in antimicrobial prescribing recommendations and patient health care (15-17).
4. Introduction

In Western Australia (WA) methicillin-resistant *Staphylococcus aureus* (MRSA) is a notifiable condition and as per the Western Australian Department of Health operational directive (OP0478/13 Infection Prevention and Control of Methicillin-resistant *Staphylococcus aureus* [MRSA] in Western Australian Healthcare Facilities: http://www.health.wa.gov.au/circularsnew/circular.cfm?Circ_ID=13040) medical microbiology laboratories are required to refer all non-environmental isolates to the PathWest Gram-positive Typing Laboratory at Fiona Stanley Hospital for strain characterisation.

Isolates are characterised as:

- Micro-alert B Panton Valentine leucocidin (PVL)-negative MRSA
- Micro-alert B PVL-positive MRSA. The clone type is identified
- Micro-alert C MRSA. The clone type is identified

Micro-alert C clones include all healthcare-associated MRSA (HA-MRSA) and community-associated MRSA (CA-MRSA) clones with increased virulence or transmissibility of antimicrobial resistance as determined by the WA Multi-Resistant Organism Expert Advisory Group. Currently two PVL-positive CA-MRSA (ST8-IV [2B] [USA300] and ST772-V [5C2] [Bengal Bay MRSA]) are characterised as micro-alert C. Micro-alert B clones include all other CA-MRSA.

Based on the strain type and type of micro-alert assigned (i.e. micro-alert B or C) and on the specific setting, a risk assessment is made by the healthcare facility in the management of MRSA-positive patients.

5. MRSA Nomenclature

Since July 2003, the PathWest Gram-positive Typing Laboratory has employed the international MRSA nomenclature system described by Dr Mark Enright *et al* (18). This system provides a universally standardised MRSA nomenclature allowing MRSA clones to be readily compared between laboratories. It is based upon the combination of seven housekeeping genes sequence types (STs) using multilocus sequence typing (MLST) and the SCC\textit{mec} type using multiplex PCR. The MRSA genotype is therefore the sum of the SCC\textit{mec} type and the type of its recipient chromosome. For example, an MRSA clone of ST22 and SCC\textit{mec} type IV [2B] is referred to as ST22-IV [2B].

6. Methods

MRSA are characterised by phenotypic and genotypic methods. Phenotyping includes antibiogram (as provided by the referring laboratory) and urease detection. If required, susceptibility testing is performed by disc diffusion (CLSI) to gentamicin, erythromycin, tetracycline, ciprofloxacin, trimethoprim, fusidic acid, rifampicin and high-level mupirocin.

The genotyping methods selectively employed are:

- Polymerase chain reaction (PCR) targeting \textit{mecA}, \textit{nuc}, PVL and \textit{aroE}
- Restriction enzyme assays:
  - Pulsed-field gel electrophoresis
  - Restriction fragment length polymorphisms of the \textit{coa} gene
- Hybridisation assays (DNA microarray) and
- Whole genome sequencing.
7. MRSA Isolated in Western Australia, July 2016 to June 2017

From July 1 2016 to June 30 2017, 12,456 MRSA were referred to the PathWest Gram-positive Typing Laboratory (a 10.2% increase from the 11,302 MRSA referred in 2015/2016). Unique isolate data (n = 10,437), i.e. duplicate isolates excluded, are presented in this report. A duplicate isolate is defined as an isolate with an identical phenotype to an isolate received from the same patient within the previous 12 months.

Table 1: Unique isolates of MRSA in Western Australia, July 2016 to June 2017

<table>
<thead>
<tr>
<th>MRSA</th>
<th>Patient Isolates n = 10,349 (99.2%)</th>
<th>HCW isolates n = 88 (0.8%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clinical</td>
<td>Screen</td>
</tr>
<tr>
<td>Micro-alert C, PVL Negative</td>
<td>652</td>
<td>287</td>
</tr>
<tr>
<td>Micro-alert C, PVL Positive</td>
<td>228</td>
<td>28</td>
</tr>
<tr>
<td>Micro-alert B, PVL Negative</td>
<td>3,125</td>
<td>1,076</td>
</tr>
<tr>
<td>Micro-alert B, PVL Positive</td>
<td>4,771</td>
<td>182</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8,776</td>
<td>1,573</td>
</tr>
</tbody>
</table>

PVL: Panton-Valentine leucocidin; HCW: Healthcare worker
8. Micro-alert C MRSA

Of the 10,437 unique isolates referred to the PathWest Gram-positive Typing Laboratory in 2016/2017, 1,216 (11.7%) were identified as micro-alert C MRSA (Table 2).

Table 2: Micro-alert C MRSA in Western Australia, July 2016 to June 2017

<table>
<thead>
<tr>
<th>MLST-SCCmec</th>
<th>Clone</th>
<th>Patient Isolates</th>
<th>HCW isolates</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Clinical</td>
<td>Screen</td>
<td>Clinical</td>
</tr>
<tr>
<td>HA-MRSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST22-IV [2B]</td>
<td>EMRSA-15</td>
<td>629</td>
<td>279</td>
<td>0</td>
</tr>
<tr>
<td>ST22-IV [2B]</td>
<td></td>
<td>75</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>ST239-III [3A]</td>
<td>Aus-2/3 EMRSA</td>
<td>7</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>ST5-II [2A]</td>
<td>New York Japan MRSA/USA100</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ST36-II [2A]</td>
<td>EMRSA-16</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST8-VI [4B]</td>
<td>Irish 2 EMRSA</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST217- IV [2B]</td>
<td>EMRSA-15 Variant A</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total HA-MRSA</td>
<td></td>
<td>720</td>
<td>304</td>
<td>0</td>
</tr>
<tr>
<td>CA-MRSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST8-IV [2B]</td>
<td>USA300</td>
<td>97</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>ST772-V [5C2]</td>
<td>Bengal Bay MRSA</td>
<td>63</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total CA-MRSA</td>
<td></td>
<td>160</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Total Micro-alert C MRSA</td>
<td></td>
<td>880</td>
<td>315</td>
<td>0</td>
</tr>
</tbody>
</table>

HA-MRSA: Healthcare-associated MRSA; CA-MRSA: community-associated MRSA

The average age of patients with a micro-alert C MRSA was 65 years (median 74 years). Patients with a PVL-positive micro-alert C MRSA have a significantly lower average age (36 years [median 31 years]) compared to patients with a PVL-negative microalert C MRSA (73 years [median 80 years]) (P <0.0001). The high average age for the PVL-negative microalert C MRSA patient is a reflection of the dominance of the healthcare associated ST22-IV [2B] (EMRSA-15) clone which has become endemic in Western Australian aged care facilities (19).
9. Micro-alert B MRSA

Of the 10,437 unique isolates referred to the PathWest Gram-positive Typing Laboratory in 2016/2017, 9,221 (88.3%) were identified as micro-alert B MRSA (Table 3).

Table 3: Micro-alert B MRSA in Western Australia, July 2016 to June 2017

<table>
<thead>
<tr>
<th>MLST-SCCmec</th>
<th>Clone</th>
<th>Patient Isolates 9,154 (99.3%)</th>
<th>HCW isolates 67 (0.7%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Clinical</td>
<td>Screen</td>
<td>Clinical</td>
</tr>
<tr>
<td>Panton Valentine leucocidin Negative CA-MRSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total PVL Negative</td>
<td></td>
<td>3,125</td>
<td>1,076</td>
<td>0</td>
</tr>
<tr>
<td>Panton Valentine leucocidin Positive CA-MRSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST93-IV [2B]</td>
<td>Queensland</td>
<td>3,371</td>
<td>103</td>
<td>0</td>
</tr>
<tr>
<td>ST5-IV [2B]</td>
<td>WA 121</td>
<td>909</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>ST30-IV [2B]</td>
<td>WSPP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>251</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>ST59/952-V [5C2&amp;5]</td>
<td>Taiwan/A</td>
<td>88</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>ST5-IV [2B]</td>
<td>WA 3</td>
<td>32</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>ST1-IV [2B]</td>
<td>WA 1</td>
<td>27</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ST1232-V [5C2]</td>
<td>LA-MRSA&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ST59-IV [2B]</td>
<td>WA 55</td>
<td>13</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ST923-IV [2B]</td>
<td>WA 62</td>
<td>13</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ST78-IV [2B]</td>
<td>WA 2</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ST1633-V [5C2]</td>
<td>WA 89</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ST30-V [5C2]</td>
<td>WA 124</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ST1-V [5C2&amp;5]</td>
<td>WA 137</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST80/728-IV [2B]</td>
<td>European/B</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST88-V [5C2]</td>
<td>WA 117</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST1420-IV [2B]</td>
<td>WA 126</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST6-IV [2B]</td>
<td>WA 51</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST5-V [5C2]</td>
<td>WA 109</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST573-V [5C2]</td>
<td>WA 10</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST834-IV [2B]</td>
<td>WA 13</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST2974-V [5C2]</td>
<td>WA 129</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total PVL Positive</td>
<td></td>
<td>4,771</td>
<td>182</td>
<td>0</td>
</tr>
<tr>
<td>Total Micro-alert B MRSA</td>
<td></td>
<td>7,896</td>
<td>1,258</td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>a</sup>WSPP: Western Samoan Phage Pattern, also known as the South Western Pacific (SWP) clone or Oceanic clone

<sup>b</sup>LA-MRSA: Livestock-associated MRSA

The average age of patients with a micro-alert B MRSA was 40 years (median 36 years). Patients with a PVL-positive micro-alert B MRSA have a significantly lower average age (28
years [median 26 years]) compared to patients with a PVL-negative micro-alert B MRSA (53 years [median 54 years]) (P<0.0001).

A significant difference in the mean ages of micro-alert C (65 years) and micro-alert B (40 years) infected patients was also identified (P<0.0001). This was primarily due to the predominance of ST22-IV [2B] (EMRSA-15) in micro-alert C patients and PVL–positive CA-MRSA in micro-alert B patients.

10. Micro-alert C versus Micro-alert B MRSA Clones

Since 2003/2004 the number of unique isolates of MRSA referred to the Gram-positive Typing laboratory has increased almost four-fold from 2,649 to 10,437 (Figure 1).

Although the increase has been primarily been due to the increasing number of micro-alert B MRSA (2,074 in 2003/2004 to 9,221 in 2016/2017) there has also been an increase in micro-alert C MRSA isolates (575 in 2003/2004 to 1,216 in 2016/2017). The increase in micro-alert C MRSA has primarily been due to ST22-IV [2B] (EMRSA-15), a healthcare-associated MRSA (HA-MRSA) predominately found in Western Australian long term care facilities (19, 20).

Figure 1: Annual number of referred isolates of MRSA in Western Australia, 2003/2004 to 2016/2017

In contrast to the micro-alert C HA-MRSA clones, the non-Western Australian CA-MRSA clones have emerged from diverse genetic backgrounds and frequently harbour the genes expressing PVL (19, 20).

In WA, although the vertical and horizontal transmission of SCCmec elements into S. aureus has occurred on multiple occasions, only a small number of clones have successfully adapted to the Western Australian community environment (3). Furthermore these clones typically lack the PVL-associated genes. However, several PVL-positive clones have been identified in WA, including ST93-IV [2B], known colloquially as “Queensland CA-MRSA”. First described in the early 2000s in Queensland (21), ST93-IV [2B] has become the dominant PVL-positive CA-MRSA clone in WA (Figure 2). In addition to ST93-IV [2B] several international PVL-positive MRSA have been identified in WA including: ST30-IV [2B] (WSPP

PVL-positive ST22-IV [2B], ST8-IV [2B] (USA300) and ST772-V [5C2] (Bengal Bay MRSA) have been reported to cause single strain hospital outbreaks and therefore have been classified as micro-alert C MRSA (22-25).

**Figure 2: Annual number of referred isolates of PVL-positive MRSA in Western Australia, 2003/2004 to 2016/2017**

As PVL-positive MRSA are known to cause severe skin and soft tissue infections that often require hospitalisation in young otherwise healthy people, the increasing percentage of MRSA isolated in WA identified as PVL positive is a public health concern (Figure 3). Of particular concern has been the rapid emergence of PVL-positive MRSA in the state’s north-west, particularly amongst the aboriginal populations. In 2016/2017 in the Kimberley, Pilbara and Midwest health regions, PVL-positive ST93-IV [2B] was identified in 2,754, 517 and 370 per 100,000 population respectively and PVL-positive ST5-IV [2B] (WA 121) was identified in 792, 92 and 226 per 100,000 population respectively (Table 4).
Figure 3: Annual percentage of referred MRSA identified as PVL-positive MRSA in Western Australia, 2003/2004 to 2016/2017
Table 4: New MRSA cases notified to Department of Health by Health Region according to postcode of residence, July 2016 to June 2017

<table>
<thead>
<tr>
<th>Health Region</th>
<th>MLST/SCCmec</th>
<th>PFGE</th>
<th>Kimb</th>
<th>Pilb</th>
<th>Midw</th>
<th>Gold</th>
<th>Wheat</th>
<th>Metro</th>
<th>SthW</th>
<th>GSth</th>
<th>Not WA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Micro-alert C Clones</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST22-IV [2B]</td>
<td>EMRSA-15, PVL negative</td>
<td></td>
<td>1</td>
<td>1</td>
<td>24</td>
<td>14</td>
<td>20</td>
<td>816</td>
<td>31</td>
<td>16</td>
<td>2</td>
<td>925</td>
</tr>
<tr>
<td>ST22-IV [2B]</td>
<td>EMRSA-15, PVL positive</td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>90</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>96</td>
</tr>
<tr>
<td>ST239-III [3A]</td>
<td>Aus-2/3 EMRSA, PVL negative</td>
<td></td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>ST5-II [2A]</td>
<td>New York/Japan MRSA, PVL negative</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>ST8-IV [2B]</td>
<td>USA300, PVL positive</td>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>89</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>106</td>
</tr>
<tr>
<td>ST772-V [5C2]</td>
<td>Bengal Bay Clone, PVL positive</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>55</td>
<td>5</td>
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<td>2</td>
<td>66</td>
</tr>
<tr>
<td>Other</td>
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<td>3</td>
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<td>19</td>
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<td>18</td>
<td>14</td>
<td>1,216</td>
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<td></td>
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<tr>
<td>ST93-IV [2B]</td>
<td>Qld Clone, PVL positive</td>
<td></td>
<td>1,210</td>
<td>393</td>
<td>277</td>
<td>208</td>
<td>81</td>
<td>1,113</td>
<td>97</td>
<td>53</td>
<td>44</td>
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<td>ST5-IV [2B]</td>
<td>WA MRSA-121, PVL positive</td>
<td></td>
<td>348</td>
<td>70</td>
<td>169</td>
<td>52</td>
<td>22</td>
<td>243</td>
<td>21</td>
<td>5</td>
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<td>ST30-IV [2B]</td>
<td>WSPP MRSA, PVL positive</td>
<td></td>
<td>20</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>204</td>
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<td>8</td>
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<td>276</td>
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<td>Other Micro-alert B, PVL positive Clones</td>
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<td></td>
<td>2</td>
<td>1</td>
<td>26</td>
<td>4</td>
<td>7</td>
<td>195</td>
<td>22</td>
<td>3</td>
<td>10</td>
<td>270</td>
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<td>Micro-alert B, PVL negative MRSA</td>
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<td>414</td>
<td>178</td>
<td>231</td>
<td>165</td>
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<td>76</td>
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<td><strong>Total Micro-alert B Clones</strong></td>
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<td>648</td>
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<td>436</td>
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<td>4,535</td>
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<td>145</td>
<td>114</td>
<td>9,221</td>
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<tr>
<td><strong>Total MRSA</strong></td>
<td></td>
<td></td>
<td>1,998</td>
<td>651</td>
<td>736</td>
<td>455</td>
<td>298</td>
<td>5,595</td>
<td>413</td>
<td>163</td>
<td>128</td>
<td>10,437</td>
</tr>
</tbody>
</table>

Kimb = Kimberley, Pilb = Pilbara, Midw = Midwest, Gold = Goldfields, Wheat = Wheatbelt, Metro = Metropolitan Perth, SthW = South West, GSth = Great Southern, Not WA = Outside WA.
Table 5: MRSA notification rates per 100,000 population by Health Region according to postcode of residence, July 2016 to June 2017

<table>
<thead>
<tr>
<th>MLST/SCCmec</th>
<th>PFGE</th>
<th>Kimb</th>
<th>Pilb</th>
<th>Midw</th>
<th>Gold</th>
<th>Wheat</th>
<th>Metro</th>
<th>SthW</th>
<th>GSth</th>
<th>WA</th>
</tr>
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<tbody>
<tr>
<td><strong>Micro-alert C Clones</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST22-IV [2B]</td>
<td>UK EMRSA-15, PVL negative</td>
<td>2.3</td>
<td>1.3</td>
<td>32.1</td>
<td>21.1</td>
<td>24.5</td>
<td>36.8</td>
<td>16.6</td>
<td>25.8</td>
<td>33.0</td>
</tr>
<tr>
<td>ST22-IV [2B]</td>
<td>UK EMRSA-15, PVL positive</td>
<td>1.3</td>
<td>1.5</td>
<td>1.5</td>
<td>4.1</td>
<td>1.1</td>
<td>1.6</td>
<td>0.5</td>
<td>0.5</td>
<td>3.4</td>
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<tr>
<td>ST239-III [3A]</td>
<td>Aus-2/3 EMRSA, PVL negative</td>
<td>4.6</td>
<td>2.7</td>
<td>3.0</td>
<td>1.2</td>
<td>0.1</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
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<td>ST5-II [2A]</td>
<td>New York/Japan MRSA, PVL negative</td>
<td>0.1</td>
<td>0.5</td>
<td>1.2</td>
<td>3.4</td>
<td>2.1</td>
<td>3.8</td>
<td>2.1</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>ST8-IV [2B]</td>
<td>USA300, PVL positive</td>
<td>1.3</td>
<td>3.0</td>
<td>3.7</td>
<td>4.0</td>
<td>2.1</td>
<td>3.8</td>
<td>2.1</td>
<td>2.1</td>
<td>3.8</td>
</tr>
<tr>
<td>ST772-V [5C2]</td>
<td>Bengal Bay Clone, PVL positive</td>
<td>2.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.2</td>
<td>2.5</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Micro-alert C Clones</strong></td>
<td>9.1</td>
<td>3.9</td>
<td>37.5</td>
<td>28.6</td>
<td>30.6</td>
<td>47.9</td>
<td>24.1</td>
<td>29.0</td>
<td>43.4</td>
<td></td>
</tr>
</tbody>
</table>

| **Micro-alert B Clones** |      |      |      |      |      |       |       |      |      |      |
| ST93-IV [2B] | Qld Clone, PVL positive | 2753.8 | 517.2 | 370.6 | 313.2 | 99.1  | 50.2  | 51.9 | 85.4 | 123.9 |
| ST5-IV [2B]  | WA MRSA-121, PVL positive | 792.0 | 92.1  | 226.1 | 78.3 | 26.9  | 11.0  | 11.2 | 8.1  | 33.5 |
| ST30-IV [2B] | WSPP MRSA, PVL positive | 45.5  | 7.9   | 6.7   | 10.5 | 3.7   | 9.2   | 7.0  | 12.9 | 9.8  |
| **Other Micro-alert B, PVL positive Clones** | 4.6  | 1.3  | 34.8  | 6.0  | 8.6   | 8.8   | 11.8 | 4.8  | 9.6  |
| **Micro-alert B, PVL negative MRSA** | 942.2 | 234.2 | 309.0 | 248.5 | 195.8 | 125.5 | 115.1 | 122.5 | 151.8 |
| **Total Micro-alert B Clones** | 4538.1 | 852.8 | 947.1 | 656.5 | 334.1 | 204.7 | 197.0 | 233.7 | 328.7 |
| **Total MRSA** | 4547.2 | 856.7 | 984.6 | 685.1 | 364.7 | 252.6 | 221.1 | 262.7 | 372.1 |

Kimb = Kimberley, Pilb = Pilbara, Midw = Midwest, Gold = Goldfields, Wheat = Wheatbelt, Metro = Metropolitan Perth, SthW = South West, GSth = Great Southern.

Population figures (2017 - projected) obtained from the Epidemiology Branch, Department of Health WA.
11. Significant Micro-alert C Clones

11.1 ST22-IV [2B] (EMRSA-15) – PVL NEGATIVE

Initially introduced into WA in 1997 by overseas healthcare workers (20), ST22-IV [2B] (EMRSA-15) has become the dominant Micro-alert C MRSA clone isolated in WA (n=925 in 2016/2017) accounting for 9% of all MRSA and 76% of micro-alert C MRSA. Globally ST22-IV [2B] (EMRSA-15) is one of the most predominant healthcare-associated MRSA clones (10).

**Phenotypic Features:** Typically urease negative and ciprofloxacin resistant. Approximately 44% of isolates were also erythromycin resistant.

**Western Australian Notification Rate:** 33.0 per 100,000 (Table 5).

**Geographic Distribution:** Although isolated in all health regions, 88% of isolates were from patients/healthcare workers residing in the Perth metropolitan area (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST22-IV [2B] (EMRSA-15) was 74 years (median 80 years); a reflection of the frequent isolation of ST22-IV [2B] from patients residing in aged care facilities.

![Figure 4: Annual number of referred isolates of PVL-negative ST22-IV [2B] (EMRSA-15) in Western Australia, July 1997 to June 2017](image)

![Figure 5: PVL-negative ST22-IV [2B] (EMRSA-15) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017](image)
11.2 ST8-IV [2B] (USA300)
PVL-positive ST8-IV [2B] (USA300) is the predominant community MRSA strain in North America (26). In recent years ST8-IV [2B] (USA300) has become established in many North American hospitals (22). ST8-IV [2B] (USA300) was first reported in WA in 2003 (7). Recent travel to the USA is frequently reported in patients with a USA300 infection. In 2016/2017, the 106 PVL-positive USA300 accounted for 1% of all MRSA and 9% of micro-alert C MRSA.

**Phenotypic Features:** ST8-IV [2B] (USA300) is urease positive. The USA300 antibiogram is variable with 36% of isolates susceptible to the non-β-lactams tested and 8% resistant to at least three non-β-lactam antimicrobials.

**Western Australian Notification Rate:** 3.8 per 100,000 (Table 5).

**Geographic Distribution:** In 2016/2017 although predominantly isolated in the Perth Metropolitan health region a small number of isolates were identified in all health regions except the Pilbara and Great Southern. Seven ST8-IV [2B] (USA300) were isolated from patients with an interstate or overseas address (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST8-IV [2B] (USA300) was 38 years (median 32 years).

**Figure 6:** Annual number of referred isolates of ST8-IV [2B] (USA300) in Western Australia, July 1997 to June 2017

**Figure 7:** ST8-IV [2B] (USA300) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
11.3 ST22-IV [2B] – PVL POSITIVE

Although PVL-positive ST22-IV [2B] shares the same MLST sequencing housekeeping genes as PVL-negative ST22-IV [2B] (EMRSA-15) the two clones are genetically distinct. PVL-positive ST22-IV [2B] was first isolated in WA from an Indian healthcare worker employed in a long-term care facility. In 2016/2017 PVL-positive ST22-IV [2B] (n=96) accounted for 1% of all MRSA and 8% of micro-alert C MRSA. Internationally PVL-positive ST22-IV [2B] has been reported to cause hospital single strain outbreaks (24).

**Phenotypic Features:** Typically urease negative with a gentamicin MIC $\geq 4$ mg/L. Approximately 74% and 82% of isolates were also trimethoprim and ciprofloxacin resistant respectively.

**Western Australian Notification Rate:** 3.4 per 100,000 (Table 5)

**Geographic Distribution:** Although in 2016/2017 most isolates (94%) were from the Perth metropolitan health region, PVL-positive ST22-IV was also isolated in the Pilbara, Goldfields, South West and Great Southern health regions (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST22-IV was 37 years (median 31 years) which is significantly younger than the mean age of patients infected with PVL-negative ST22-IV (EMRSA-15) ($P<0.001$).

**Figure 8:** Annual number of referred isolates of PVL-positive ST22-IV [2B] in Western Australia, July 1997 to June 2017

**Figure 9:** PVL-positive ST22-IV [2B] as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
11.4 ST772-V [5C2] (Bengal Bay MRSA)

PVL-positive ST772-V [5C2] (Bengal Bay MRSA) is a multiresistant PVL-positive MRSA first reported in Bangladesh, and subsequently in India, Malaysia and several European countries (25, 27-33). In Europe ST772-V [5C2] has been associated with single strain outbreaks in long term care facilities and in a neonatal intensive care unit. ST772-V [5C2] was first identified in WA in 2007 and was associated with a healthcare worker from the subcontinent. Recent travel to, or residents from the subcontinent is frequently reported in patients with a ST772-V [5C2] infection. In 2016/2017 ST772-V [5C2] (n=66) accounted for 0.6% of all MRSA and 5% of micro-alert C MRSA.

**Phenotypic Features:** Typically urease positive and erythromycin, trimethoprim, gentamicin and ciprofloxacin resistant.

**Western Australian Notification Rate:** 2.4 per 100,000 (Table 5).

**Geographic Distribution:** In 2016/2017 although predominantly isolated in the Perth Metropolitan health region a small number of isolates were identified in all health regions except the Goldfields and Great Southern.

**Patient Age:** The mean age of patients infected/colonised with ST772-V [5C2] was 30 years (median 27 years).

Figure 10: Annual number of referred isolates of ST772-V [5C2] (Bengal Bay MRSA) in Western Australia, July 1997 to June 2017

Figure 11: ST772-V [5C2] (Bengal Bay MRSA) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
11.5 ST239-III [3A] (Aus-2/3 EMRSA)

ST239-III [3A] has been a predominant healthcare associated MRSA clone in most Australian states since the early 1980s (2). The “search and destroy” MRSA policy implemented by the WA Health Department in 1982 has prevented ST239-III [3A] from becoming established in Western Australian hospitals. In 2016/2017 ST239-III [3A] (n=11) accounted for 0.1% of all MRSA and 0.9% of micro-alert C MRSA.

**Phenotypic Features:** Typically urease positive erythromycin, tetracycline, trimethoprim, gentamicin and ciprofloxacin resistant.

**Western Australian Notification Rate:** 0.4 per 100,000 (Table 5).

**Geographic Distribution:** In 2016/2017 isolates were identified in all health regions except the Pilbara and Great Southern.

**Patient Age:** The mean age of patients infected/colonised with ST239-III was 49 years (median 50 years).

Figure 12: Annual number of referred isolates of ST239-III [3A] (Aus-2/3 EMRSA) in Western Australia, July 1997 to June 2017

Figure 13: ST239-III [3A] (Aus-2/3 EMRSA) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
11.6 ST5-II [2A] (New York Japan MRSA/USA100)

ST5-II [2A] is the predominant healthcare associated MRSA in Japan and the USA (4). A single strain outbreak of ST5-II [2A] was identified in the South West region of WA in 2005 (4). The index case was a colonised healthcare worker who had previously been hospitalised in New York. By having a state-wide MRSA policy, the outbreak was able to be managed and controlled by the WA Health Department. In 2016/2017 ST5-II [2A] (n=5) accounted for 0.05% of all MRSA and 0.4% of micro-alert C MRSA.

**Phenotypic Features:** Typically urease positive and ciprofloxacin and erythromycin resistant.

**Western Australian Notification Rate:** 0.2 per 100,000 (Table 5).

**Geographic Distribution:** In 2016/2017 a small number of isolates were identified in the Perth metropolitan, South West and Great Southern health regions (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST5-II [2A] was 67 years (median 69 years).

**Figure 14:** Annual number of referred isolates of ST5-II [2A] (New York Japan MRSA/USA100) in Western Australia, July 1997 to June 2017

**Figure 15:** ST5-II [2A] (New York Japan MRSA/USA100) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
12. Significant PVL-Positive Micro-alert B Clones

12.1 ST93-IV [2B] (Queensland CA-MRSA)

ST93-IV [2B] (Queensland CA-MRSA), initially identified in Ipswich, Queensland in the Caucasian population in 2000 (21), has become the predominant community associated MRSA in Australia (34). Although ST93-IV [2B] was not detected in WA until 2001, PVL-positive ST93 MSSA was identified as the most prevalent S. aureus lineage in WA’s remote indigenous communities in the mid-1990s (6). In 2016/2017 ST93-IV [2B] (n=3,476) accounted for 33% of all MRSA and 38% of micro-alert B MRSA.

**Phenotypic Features:** Typically urease positive and susceptible to the non β-lactam antimicrobials however, approximately 8% of ST93-IV [2B] are erythromycin resistant.

**Western Australian Notification Rate:** 123.9 per 100,000 (Table 5).

**Geographic Distribution:** In 2016/2017 ST93-IV [2B] was frequently isolated in all WA health regions, with 2,754 per 100,000 notifications reported in the Kimberley (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST93-IV [2B] was 28 years (median 27 years).

![Figure 16: Annual number of referred isolates of ST93-IV [2B] (Queensland CA-MRSA) in Western Australia, July 1997 to June 2017](image)

![Figure 17: ST93-IV [2B] (Queensland CA-MRSA) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017](image)
12.2 ST5-IV [2B] (WA 121)

ST5-IV [2B] (WA 121) was initially isolated in 2010 from an abdominal abscess in a 62 year old non-aboriginal male patient living in the Kimberley region. However, the majority of patients with WA 121 are young Aboriginal patients living in the Kimberley and Pilbara regions. Unlike other Western Australian clonal cluster 5 MRSA clones, ST5-IV [2B] (WA 121) carries the *edinA* epidermal cell differentiation inhibitor gene and a type IVc SCCmec element; a SCCmec subtype rarely identified in WA community-associated MRSA suggesting ST5-IV [2B] (WA 121) was imported into WA. In 2016/2017 ST5-IV (WA 121) (n=941) accounted for 9% of all MRSA and 10% of micro-alert B MRSA.

**Phenotypic Features:** Typically urease positive and trimethoprim resistant.

**Western Australian Notification Rate:** 33.5 per 100,000 (Table 5).

**Geographic Distribution:** In 2016/2017 although isolated in all WA health regions, ST5-IV [2B] (WA 121) was primarily isolated in the Kimberley, Midwest and Pilbara health regions with 792, 226 and 92 notifications per 100,000 population respectively (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST5-IV [2B] (WA 121) was 25 years (median 19 years).

**Figure 18:** Annual number of referred isolates of ST5-IV [2B] (WA 121) in Western Australia, July 1997 to June 2017

**Figure 19:** ST5-IV [2B] (WA 121) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
12.3 ST30-IV [2B] (WSPP MRSA)
ST30-IV [2B], also known as the Western Samoan Phage Pattern (WSPP) MRSA, South West Pacific (SWP) or Oceania MRSA was first identified in Australia in 1997 in Polynesian patients residing on the east coast presenting with furunculosis (34-36). ST30-IV was initially isolated in WA in 2003 (19). In 2016/2017 ST30-IV [2B] (WSPP) (n=276) accounted for 3% of all MRSA and 3% of micro-alert B MRSA.

**Phenotypic Features:** Typically urease positive and susceptible to the non β-lactam antimicrobials.

**Western Australian Notification Rate:** 9.8 per 100,000 (Table 5)

**Geographic Distribution:** In 2016/2017 ST30-IV [2B] (WSPP) was primarily isolated in the Perth metropolitan health region with small numbers isolated in all other health regions. Ten WSPP were isolated from patients with an overseas or interstate address (Table 4).

**Patient Age:** The mean age of patients infected/colonised with ST30-IV [2B] (WSPP) was 33 years (median 33 years).

**Figure 20:** Annual number of referred isolates of ST30-IV [2B] (WSPP) in Western Australia, July 1997 to June 2017

**Figure 21:** ST30-IV [2B] (WSPP) as a percentage of the annual number of referred MRSA in Western Australia, July 1997 to June 2017
13. Trend Data, July 1 2003 to June 30 2017

13.1 Western Australia (Figures 20 - 22)

Micro-alert C
Increase predominantly due to the transmission of ST22-IV [2B] (EMRSA-15) primarily in aged care nursing homes.

Micro-alert B
PVL positive CA-MRSA are now more frequently isolated than PVL negative CA-MRSA. PVL-positive clones (ST93-IV [2B] [Queensland CA-MRSA] and ST5-IV [2B] (WA 121) dominate.

13.2 Perth Metropolitan Health Region (Figures 23 - 25)

Micro-alert C
Increase predominantly due to the transmission of ST22-IV [2B] (EMRSA-15) primarily in aged care nursing homes. PVL-positive ST22-IV [2B] increased significantly (P=0.02) in the past year.

Micro-alert B
Increase in PVL-negative CA-MRSA clones and PVL-positive ST93-IV [2B] (Queensland CA-MRSA), ST30-IV [2B] (WSPP), and ST5-IV [2B] (WA 121).

13.3 South West Health Region (Figures 26 - 28)

Micro-alert C

Micro-alert B
Increase in PVL-negative CA-MRSA clones and PVL-positive ST93-IV [2B] (Queensland CA-MRSA).

13.4 Great Southern Health Region (Figures 29 - 31)

Micro-alert C

Micro-alert B
Increase in PVL-negative CA-MRSA clones and PVL-positive ST93-IV [2B] (Queensland CA-MRSA).

13.5 Midwest Health Region (Figures 32 - 33)

Micro-alert C

Micro-alert B
Increase in PVL-negative CA-MRSA clones and PVL-positive ST93-IV [2B] (Queensland CA-MRSA) and ST5-IV (WA 121). In 2016/2017 65% of all MRSA were PVL positive.
13.6 Wheatbelt Health Region (Figures 35 - 37)

Micro-alert C

Micro-alert B

13.7 Goldfields Health Region (Figures 38 - 40)

Micro-alert C

Micro-alert B
Sevenfold increase (56 isolates in 2003/2004 to 436 isolates in 2016/2017). Increase in PVL-negative CA-MRSA clones and PVL-positive ST93-IV [2B] (Queensland CA-MRSA) and ST5-IV [2B] (WA 121). In 2016/2017 60% of all MRSA were PVL positive.

13.8 Pilbara Health Region (Figures 38 - 40)

Micro-alert C

Micro-alert B
Eightfold increase (79 isolates in 2003/2004 to 648 isolates in 2016/2017). After large increases in numbers of ST5-IV [2B] (WA 121) from 4 (2% of all MRSA) in 2011/2012 to a high of 111 (28% of all MRSA) in 2014/2015, numbers have declined over the past two years. In 2016/2017 11% of all MRSA were ST5-IV [2B] (WA 121). In contrast the ST93-IV [2B] (Queensland CA-MRSA) continues to increase as a proportion of all MRSA (from 45% in 2015/2016 to 60% in 2016/2017). In 2016/2017 73% of all MRSA were PVL positive.

13.9 Kimberley Health Region (Figures 41 - 43)

Micro-alert C

Micro-alert B

As for the Pilbara, ST93-IV [2B] (Queensland CA-MRSA) clone continues to dominate (61% of all MRSA in 2016/2017) while ST5-IV [2B] (WA 121) has declined over the past two years (From 469 [27% of all MRSA] in 2014/2015 to 348 [17%] in 2016/2017). In 2016/2017 79% of all MRSA were PVL positive.
Western Australia

Figure 22: Annual number of Micro-alert B and Micro-alert C MRSA, Western Australia July 2003 to June 2017

![Graph showing annual number of Micro-alert B and Micro-alert C MRSA from 2003/04 to 2016/17.](image1)

Figure 23: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Western Australia July 2003 to June 2017

![Graph showing annual number of PVL-positive and –negative CA-MRSA and HA-MRSA from 2003/04 to 2016/17.](image2)
Figure 24: Annual number of CA-MRSA and HA-MRSA, Western Australia July 2003 to June 2017

Perth Metropolitan Health Region

Figure 25: Annual number of Micro-alert B and Micro-alert C MRSA, Perth Metropolitan Health Region July 2003 to June 2017
Figure 26: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Perth Metropolitan Health Region July 2003 to June 2017

Figure 27: Annual number of CA-MRSA and HA-MRSA, Perth Metropolitan Health Region July 2003 to June 2017
South West Health Region

Figure 28: Annual number of Micro-alert B and Micro-alert C MRSA, South West Health Region July 2003 to June 2017

Figure 29: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, South West Health Region July 2003 to June 2017
Figure 30: Annual number of CA-MRSA and HA-MRSA, South West Health Region July 2003 to June 2017

Great Southern Health Region

Figure 31: Annual number of Micro-alert B and Micro-alert C MRSA, Great Southern Health Region July 2003 to June 2017
Figure 32: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Great Southern Health Region July 2003 to June 2017

Figure 33: Annual number of CA-MRSA and HA-MRSA, Great Southern Health Region July 2003 to June 2017
Midwest Health Region

Figure 34: Annual number of Micro-alert B and Micro-alert C MRSA, Midwest Health Region July 2003 to June 2017

Figure 35: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Midwest Health Region July 2003 to June 2017
Figure 36: Annual number of CA-MRSA and HA-MRSA, Midwest Health Region July 2003 to June 2017

Figure 37: Annual number of Micro-alert B and Micro-alert C MRSA, Wheatbelt Health Region July 2003 to June 2017
Figure 38: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Wheatbelt Health Region July 2003 to June 2017

Figure 39: Annual number of CA-MRSA and HA-MRSA, Wheatbelt Health Region July 2003 to June 2017
Goldfields Health Region

Figure 40: Annual number of Micro-alert B and Micro-alert C MRSA, Goldfields Health Region July 2003 to June 2017

Figure 41: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Goldfields Health Region July 2003 to June 2017
Figure 42: Annual number of CA-MRSA and HA-MRSA, Goldfields Health Region July 2003 to June 2017

Pilbara Health Region

Figure 43: Annual number of Micro-alert B and Micro-alert C MRSA, Pilbara Health Region July 2003 to June 2017
Figure 44: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Pilbara Health Region July 2003 to June 2017

Figure 45: Annual number of CA-MRSA and HA-MRSA, Pilbara Health Region July 2003 to June 2017
Figure 46: Annual number of Micro-alert B and Micro-alert C MRSA, Kimberley Health Region July 2003 to June 2017

Figure 47: Annual number of known PVL-positive and –negative CA-MRSA and HA-MRSA, Kimberley Health Region July 2003 to June 2017
Figure 48: Annual number of CA-MRSA and HA-MRSA, Kimberley Health Region July 2003 to June 2017
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15. References


