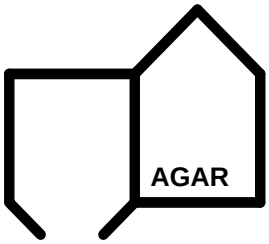

The Australian Group on Antimicrobial Resistance
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Staphylococcus aureus Programme 2010 (SAP 2010) Community Survey Antimicrobial Susceptibility Report

PREPARED BY:

Professor Graeme Nimmo
Division of Microbiology, Queensland Pathology Central Laboratory Brisbane, Queensland.

Ms Julie Pearson
Department of Microbiology and Infectious Diseases, PathWest Laboratory Medicine-WA, Royal Perth Hospital. Western Australia.

Mr Geoffrey Coombs
Department of Microbiology and Infectious Diseases, PathWest Laboratory Medicine-WA, Royal Perth Hospital. Western Australia. Molecular Genetics Research Unit, Curtin University, Western Australia.

Clinical Professor Keryn Christiansen
Australian Collaborating Centre for *Enterococcus* and *Staphylococcus* Species, Department of Microbiology and Infectious Diseases Royal Perth Hospital, Western Australia.

Professor Peter Collignon
Department of Microbiology and Infectious Diseases, The Canberra Hospital, Australian Capital Territory. School of Clinical Medicine, Australian National University, Australian Capital Territory.

Professor Mary-Louise McLaws
Hospital Infection Epidemiology & Surveillance Unit, School of Public Health & Community Medicine, The University of New South Wales.

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Contents

1 Executive Summary

The Australian Group on Antimicrobial Resistance (AGAR) performs regular multicentre period-prevalence studies to monitor changes in antimicrobial resistance. In 2010, thirty laboratories participated in national surveillance of *Staphylococcus aureus* resistance of community-onset infections. Two thousand nine hundred and ninety four isolates of *S. aureus* causing infections were collected prospectively from hospital outpatients and general practice patients and susceptibility testing performed by Vitek 2. Biennial community-onset *S. aureus* antimicrobial surveillance programmes have been performed in Australia by AGAR since 2000.

In the 2010 programme the percentage of *S. aureus* identified as MRSA ranged from 5.0% in Tasmania to 35.0% in the Northern Territory. The proportion of invasive and non-invasive MRSA isolates were not significantly different (p=0.1343).

Approximately 40% of all MRSA were resistant to erythromycin and ciprofloxacin and approximately a fifth were resistant to tetracycline, gentamicin and trimethoprim-sulphamethoxazole. Resistance to fusidic acid, mupirocin and rifampicin was uncommon. No resistance was detected to vancomycin, teicoplanin, daptomycin or linezolid. Significant differences in resistance across regions were evident for all antimicrobials except rifampicin and mupirocin. These differences may be explained by the different MRSA clones in circulation in each region.

Over the six biennial AGAR community surveys (2000 to 2010) the percentage of *S. aureus* identified as MRSA increased significantly (p<0.0001) by 6 percentage points (11.6% in 2000 to 18.0% in 2010). However in the same time period a significant decrease in resistance in MRSA to all the non-β-lactam antimicrobials except high-level mupirocin (which was only tested for in the last three surveys) was observed in Australia. This suggests that the increase in MRSA is due to the emergence and expansion of non-multiresistant clones in the community.

Among MSSA, resistance to non-β-lactams in 2010 was uncommon except for erythromycin (12.5%). Over the six AGAR surveys no trends in resistance, either increase or decrease, were evident for erythromycin, gentamicin or rifampicin. Small but significant increases were observed nationally for clindamycin, ciprofloxacin, fusidic acid, trimethoprim-sulphamethoxazole and high-level mupirocin resistance.

In conclusion, the MRSA rates continue to rise in strains causing infections in people in the community. The national rate is now 18.0%, with levels as high as 35.0% in the Northern Territory. This makes the empiric choice for the correct antibiotic therapy of community *S. aureus* infections increasingly difficult.

2 Introduction

2.1 Objective of the Program

The objective of the 2010 surveillance program was to determine the prevalence of antimicrobial resistance throughout Australia in clinical isolates of *S. aureus* causing infections with their onset in the community, in general practice patients and in hospital outpatients (excluding day-only patients but including emergency department patients).

2.2 Importance of *Staphylococcus aureus*

S. aureus continues to be the causative organism of a wide range of community-acquired infections ranging from relatively minor skin and soft tissue infections to serious and life threatening systemic sepsis with a high mortality[1]. In Australia, methicillin-resistant *S. aureus* (MRSA) were first detected in Sydney in the 1960s[2], but really became an endemic problem in hospitals, in particular the Eastern states, with the appearance of a multiresistant strain, an eastern-Australian MRSA strain (now divided into Aus-2 and Aus-3 EMRSA), in the 1970s and 80s[3,4]. Community MRSA strains, generally less resistant to a range of antibiotics and associated with skin and soft tissue sepsis, emerged in the 1990s, initially in Western Australia[5,6] and the Northern Territory[7], and subsequently in the Eastern states[8-10]. Strains harbouring the genes encoding Panton-Valentine leucocidin (PVL) were first detected in Australia in the late 1990s (the South Western Pacific or Oceania clone: ST30-IV). The PVL positive Queensland clone (ST93-IV) was characterized in 2000 and is now the dominant CA-MRSA in Australia[11]. Importation of several overseas PVL positive clones has occurred: USA300 (ST8-IV), the Bengal Bay Clone (ST772-V), Taiwan CA-MRSA (ST59-V_T) and European CA-MRSA (ST80-IV). PVL is associated with furunculosis and more severe infections including osteomyelitis, septicaemia and necrotising pneumonia.

The Australian Group on Antimicrobial Resistance (AGAR) has conducted surveillance of antimicrobial resistance in *S. aureus* for over 20 years[12]. This surveillance role is very important given the ability of *S. aureus* strains to acquire new resistance and virulence determinants and to undergo rapid clonal expansion. Since the 1960s multiple waves of MRSA clones have occurred in Australia influencing the susceptibility profiles of the isolates seen in clinical practice. Results of previous AGAR surveys provide the only longitudinal record of the epidemiology of MRSA at a national level[13-15]. Given the emergence of hyper-virulent community MRSA strains, AGAR changed its methodology in 2000 to conduct surveys of community isolates biennially. The community-based surveys performed in 2000, 2002, 2004, 2006 and 2008 have been reported previously[16-18].

The results of the sixth community-based survey of *S. aureus* infection conducted in 2010 are reported here.

3 Methods

Up to 100 clinically significant consecutive isolates of *S. aureus* from different patients were collected by each laboratory. Isolates were collected from non-inpatients. Day surgery and dialysis patients were excluded. Isolates from nursing homes, long-term care facilities and hospice patients were included. Each *S. aureus*

isolate was from an individual patient and was judged to have come from a potentially infected site.

3.1 Identification

At least two of the following tests for the identification of *S. aureus* were used and were positive: slide coagulase test, tube coagulase test, demonstration of deoxyribonuclease production, appropriate growth on chromogenic agar, *mec* and *nuc* gene PCR and mass spectrometry. Fermentation of mannitol or growth on mannitol-salt agar may have been performed for confirmation.

3.2 Antimicrobial Susceptibility Testing

Participating laboratories performed antimicrobial susceptibility tests using the Vitek 2 AST-P612 card (bioMérieux) (Table 1). Penicillin susceptible strains were tested for β-lactamase production using nitrocefin. High-level mupirocin resistance was determined by disc diffusion (200 µg).

Table 1. Vitek 2 AST-P612 card

Antibiotic	MIC Range (mg/L)
Benzylpenicillin	0.03 – 0.5
Oxacillin	0.25 – 4
Cefoxitin screen	+/-
Cefazolin	4 – 64
Vancomycin	0.5 – 32
Rifampicin	0.5 – 32
Fusidic acid	0.5 – 32
Gentamicin	0.5 – 16
Erythromycin	0.25 – 8
Clindamycin	0.25 – 8
Inducible clindamycin resistance	+/-
Tetracycline	1 – 16
Trimethoprim/Sulphamethoxazole	10 – 320
Ciprofloxacin	0.5 – 8
Teicoplanin	0.5 – 32
Linezolid	0.5 – 8
Nitrofurantoin	16 – 512
Mupirocin	2 – 8
Daptomycin	0.12 – 8

3.3 Quality Control

The quality control organism for this survey was *S. aureus* ATCC 29213. All participating laboratories are NATA accredited.

3.4 Statistical Analysis

The differences between proportions, adjusted for multiple comparisons, and 95% Confidence Intervals were calculated using GraphPad® Prism Software and EpiInfo version 6.0.

3.5 Participating Laboratories

Australian Capital Territory (1)
The Canberra Hospital

New South Wales (7)
Concord Hospital
Douglass Hanley Moir
Nepean Hospital
Royal North Shore Hospital
Royal Prince Alfred Hospital
Sydney South West Pathology Service - Liverpool
Westmead Hospital

Northern Territory (1)
Royal Darwin Hospital

Queensland (6)
Pathology Queensland, Princess Alexandra Hospital
Pathology Queensland Central Laboratory
Pathology Queensland, Prince Charles Hospital
Pathology Queensland, Gold Coast Hospital
Pathology Queensland, Cairns Base Hospital
Sullivan Nicolaides Pathology

South Australia (3)
SA Pathology - Flinders Medical Centre
SA Pathology - Institute of Medical Veterinary Science
SA Pathology - Women's and Children's Hospital

Tasmania (2)
Royal Hobart Hospital
Launceston General Hospital

Victoria (6)
Alfred Hospital
Austin Health
Healthscope Pathology
Monash Medical Centre
Royal Women's and Children's Hospital
St Vincent's Hospital

Western Australia (4)
PathWest, Fremantle Hospital
PathWest, QEII Medical Centre
PathWest, Royal Perth Hospital
Saint John of God Pathology

4 Demographics

4.1 Regional Source of Isolates

2,994 S. *aureus* were tested by the 30 institutions. Each state and mainland territory of Australia was represented. The contributions to the dataset from five states and territories ranged from 3.3% to 23.2% (Table 2).

Table 2. Number of institutions and *S. aureus* isolates collected in state/territory

Region	Number of Institutions	Total	%
Australian Capital Territory (ACT)	1	100	3.3
New South Wales (NSW)	7	696	23.2
Northern Territory (NT)	1	100	3.3
Queensland (Qld)	6	600	20.0
South Australia (SA)	3	299	10.0
Tasmania (Tas)	2	200	6.7
Victoria (Vic)	6	599	20.0
Western Australia (WA)	4	400	13.4
Total	30	2,994	100.0

4.2 Age

Few isolates were received from patients 0 years to 16 years (Table 3) with more isolates contributed by patients 17 years and older ($p<0.0001$).

Table 3. Age range of patients

Age Range (years)	n	%
0-1	143	4.8
2-16	361	12.1
17-40	902	30.1
41-61	678	22.6
62-105	910	30.4
Total	**2,994**	**100.0**

5 Specimen Source

The majority (97.2%) of isolates were from a non-invasive site (Table 4). Skin and soft tissue infection specimens contributed the majority (91.4%) of isolates followed by respiratory specimens (3.4%). Blood culture isolates contributed only 2.2% of the total.

Table 4. Number and proportion of isolates associated with specimen types

Specimen Source	n	%	95%CI
Skin and Soft Tissue	2,738	91.4	90.4-92.4
Respiratory	103	3.4	2.8-4.1
Urine	68	2.3	1.8-2.9
Blood	65	2.2	1.7-2.8
Sterile Body Cavity	16	0.5	0.3-0.9
Unknown	4	0.1	0.04-0.3
Total	**2,994**		
Invasive	80	2.7	2.1-3.3
Non-Invasive	2,910	97.2	96.5-97.7
Unknown	4	0.1	0.04-0.3

6 Susceptibility Testing Results

6.1 Methicillin-resistant *S. aureus*

The proportion of methicillin-resistant *S. aureus* was 18.0% (95%CI 16.6-19.4%) nationally (Table 5), ranging from 5.0% in Tasmania to 35.0% in the Northern Territory. The national proportion was similar for the 2008 survey but has increased slightly since 2006 (16.0%, 95%CI 14.7-17.3%, p=0.0405). At a regional level the proportions of MRSA identified in 2008 and 2010 were stable in all states except the Northern Territory where the proportion of MRSA increased from 21.0% to 35.0% (p=0.0401).

The proportion of invasive isolates (blood/sterile sites) that were MRSA was 25.0% (95%CI 16.0-35.9%) and similar (p=0.1347) to the proportion of non-invasive isolates at 17.8% (95%CI 16.5-19.3%). The proportion of MRSA was higher in blood and urine than in skin and soft tissue infections (p=0.006 and 0.01 respectively) (Table 6).

There were significant differences (p<0.0001) in the proportion of MRSA seen in different patient groups with hospital outpatients (17.6%, 95%CI 14.9-20.5%), patients from long term care facilities (57.1%, 95%CI 28.9-82.3%), patients attending emergency departments (21.3%, 95%CI 19.1-23.6%) and Other/unknown (22.1%, 95%CI 13.9%-32.3%) having high rates of MRSA.

Resistance in MRSA to non-β-lactam antimicrobials, with the exception of mupirocin and rifampicin, varied between states (Table 8). Resistance to erythromycin, clindamycin, ciprofloxacin, and trimethoprim-sulphamethoxazole was highest in the ACT, NSW and Victoria. Gentamicin resistance was highest in Victoria (26.8%). These antimicrobials are indicative of the resistance profile seen for Aus 2/3 EMRSA (ST239-III); a healthcare related strain. Resistance to gentamicin, tetracycline and trimethoprim-sulphamethoxazole is rare in other clones in Australia.

There were differences in the proportion of resistance to non-β-lactam antimicrobials in MRSA associated with various patient types (Table 9). MRSA resistance for many antimicrobials was high in hospital outpatients, emergency and

long-term care, with the exception of resistance to erythromycin, which is consistent with their having a higher proportion of healthcare-related acquisition.

No resistance was detected to vancomycin, teicoplanin, daptomycin or linezolid.

Table 5. Proportion of *S. aureus* that are MRSA by region and source

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aus	Aus 95%CI
All	**8.0** [8/100]	**24.0** [167/696]	**35.0** [35/100]	**17.7** [106/600]	**14.0** [42/299]	**5.0** [10/200]	**18.7** [112/599]	**14.8** [59/400]	**18.0** [539/2994]	**16.6-19.4**
Invasive	**0.0** [0/0]	**41.7** [10/24]	**25.0** [1/4]	**16.7** [3/18]	**44.4** [4/9]	**0.0** [0/4]	**11.1** [2/18]	**0.0** [0/3]	**25.0** [20/80]	**16.0-35.9**
Non-invasive	**8.0** [8/100]	**23.3** [157/672]	**35.4** [34/96]	**17.7** [103/582]	**13.1** [38/290]	**5.1** [10/196]	**19.1** [110/577]	**14.9** [59/397]	**17.8** [519/2910]	**16.5-19.3**

Table 6. Proportion of *S. aureus* that are MRSA by source (where known)

Specimen Source	MRSA	95%CI
Skin and Soft Tissue	**17.5** [479/2738]	**16.1-19.0**
Respiratory	**19.4** [20/103]	**12.3-28.4**
Urine	**29.4** [20/68]	**19.0-41.7**
Blood	**30.8** [20/65]	**19.9-43.4**
Sterile Body Cavity	**0.0** [0/16]	**0.0-20.6**

Table 7. Proportion of *S. aureus* that are MRSA by patient group

Specimen Source	MRSA	95%CI
Emergency Department	**21.3** [283/1329]	**19.1-23.6**
General Practice	**11.9** [96/808]	**9.7-14.3**
Hospital Outpatient	**17.6** [133/757]	**14.9-20.5**
Other/Unknown	**22.1** [19/86]	**13.9-32.3**
Long Term Care Facility	**57.1** [8/14]	**28.9-82.3**

Table 8. Proportion [and number] of MRSA non-susceptible to non-β-lactams

Drug	ACT [n=8]	NSW [n=167]	NT [n=35]	Qld [n=106]	SA [n=42]	Tas [n=10]	Vic [n=112]	WA [n=59]	Aus [n=539]	Aus 95%CI
Erythromycin	**50.0** [4]	**52.1** [87]	**37.1** [13]	**27.4** [29]	**40.5** [17]	**10.0** [1]	**47.3** [53]	**37.3** [22]	**41.9** [226]	**37.7-46.2**
Clindamycin*	**25.0** [2]	**27.5** [46]	**5.7** [2]	**12.3** [13]	**2.4** [1]	**10.0** [1]	**22.3** [25]	**5.1** [3]	**17.3** [93]	**14.2-20.7**
Tetracycline	**25.0** [2]	**19.2** [32]	**11.4** [4]	**19.8** [21]	**4.8** [2]	**0.0** [0]	**29.5** [33]	**5.1** [3]	**18.0** [97]	**14.8-21.5**
Trimethoprim-sulphamethoxazole	**25.0** [2]	**19.8** [33]	**11.4** [4]	**17.0** [18]	**4.8** [2]	**0.0** [0]	**25.9** [29]	**1.7** [1]	**16.5** [89]	**13.5-19.9**
Ciprofloxacin	**50.0** [4]	**53.9** [90]	**8.6** [3]	**24.5** [26]	**26.2** [11]	**40.0** [4]	**67.0** [75]	**10.2** [6]	**40.6** [219]	**36.4-44.9**
Gentamicin	**25.0** [2]	**19.2** [32]	**11.4** [4]	**19.8** [21]	**7.1** [3]	**0.0** [0]	**26.8** [30]	**1.7** [1]	**17.3** [93]	**14.2-20.7**
Fusidic Acid	**0.0** [0]	**4.2** [7]	**5.7** [2]	**0.9** [1]	**9.5** [4]	**0.0** [0]	**6.3** [7]	**13.6** [8]	**5.4** [29]	**3.6-7.6**
Mupirocin[#]	**0.0** [0]	**0.6** [1]	**0.0** [0]	**1.9** [2]	**0.0** [0]	**0.0** [0]	**0.9** [1]	**0.0** [0]	**0.7** [4]	**0.2-1.9**
Rifampicin	**0.0** [0]	**0.6** [1]	**0.0** [0]	**2.8** [3]	**0.0** [0]	**0.0** [0]	**2.7** [3]	**0.0** [0]	**1.3** [7]	**0.5-2.6**

* Constitutive resistance
[#] High level resistance

Table 9. Proportion [and number] of non-susceptible MRSA by patient type, Australia

Drug	Emergency Department [n=283]	Hospital Outpatient [n=133]	General Practice [n=96]	Long-term Care Facility [n=8]	Others or not specified [n=19]
Erythromycin	**38.2** [108]	**49.6** [66]	**41.7** [40]	**50.0** [4]	**42.1** [8]
Clindamycin*	**14.5** [41]	**27.1** [36]	**10.4** [10]	**25.0** [2]	**21.1** [4]
Tetracycline	**14.1** [40]	**30.8** [41]	**10.4** [10]	**12.5** [1]	**26.3** [5]
Trimethoprim-Sulphamethoxazole	**12.4** [35]	**30.1** [40]	**8.3** [8]	**12.5** [1]	**26.3** [5]
Ciprofloxacin	**38.2** [108]	**51.1** [68]	**32.3** [31]	**37.5** [3]	**47.4** [9]
Gentamicin	**13.4** [38]	**30.1** [40]	**9.4** [9]	**12.5** [1]	**26.3** [5]
Fusidic Acid	**4.2** [12]	**8.3** [11]	**6.3** [6]	**0.0** [0]	**0.0** [0]
Mupirocin[#]	**0.4** [1]	**0.8** [1]	**2.1** [2]	**0.0** [0]	**0.0** [0]
Rifampicin	**1.8** [5]	**1.5** [2]	**0.0** [0]	**0.0** [0]	**0.0** [0]

* Constitutive resistance
[#] High level resistance

6.2 Trends in Proportion of *S. aureus* that are MRSA 2000-2010

Significant increases in the proportion of S. aureus that are MRSA occurred in all regions except the ACT, Tasmania and Western Australia (Table 10).

Table 10. Trend data for proportion of *S. aureus* that are MRSA, 2000-2010.

Year	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aus	Aus 95%CI
2000	**5.0** [5/100]	**19.7** [138/700]	**7.0** [7/100]	**7.7** [23/300]	**7.5** [30/400]	**2.0** [2/100]	**9.6** [45/469]	**11.5** [46/400]	**11.5** [296/2569]	**10.3-12.8**
2002	**8.0** [8/100]	**25.4** [175/689]	**21.0** [21/100]	**12.3** [37/300]	**9.0** [36/400]	**6.0** [6/100]	**11.5** [46/399]	**13.8** [55/398]	**15.4** [384/2486]	**14.0-16.9**
2004	**6.0** [6/100]	**22.6** [159/703]	**28.8** [17/59]	**18.0** [54/300]	**10.3** [41/399]	**3.0** [3/99]	**12.2** [61/500]	**13.0** [52/400]	**15.4** [393/2560]	**14.0-16.8**
2006	**5.0** [5/100]	**25.3** [201/795]	**20.0** [20/100]	**13.8** [69/500]	**12.0** [36/299]	**6.8** [13/190]	**14.5** [87/598]	**11.3** [45/397]	**16.0** [476/2979]	**14.7-17.3**
2008	**7.0** [7/100]	**27.2** [214/786]	**21.0** [21/100]	**17.4** [104/598]	**14.0** [42/300]	**3.0** [6/198]	**16.8** [100/597]	**14.6** [58/396]	**18.0** [552/3075]	**16.6-19.3**
2010	**8.0** [8/100]	**24.0** [167/696]	**35.0** [35/100]	**17.7** [106/600]	**14.0** [42/299]	**5.0** [10/200]	**18.7** [112/599]	**14.8** [59/400]	**18.0** [539/2994]	**16.6-19.4**
X^2	0.2844	5.155	15.25	15.40	12.57	0.2466	24.84	1.455	48.52	
P for trend	0.5938	**0.0232**	**<0.0001**	**<0.0001**	**0.0004**	0.6195	**<0.0001**	0.2278	**<0.0001**	

6.3 Trends in MRSA non-susceptibility 2000-2010

Nationally, resistance to the non-β-lactam antimicrobials has significantly decreased for all agents except high-level mupirocin (Table 11). The biggest decreases were seen in antimicrobials associated with ST239-III: tetracycline [26 percentage points (PP)], erythromycin (25 PP) and gentamicin (24 PP). Trimethoprim-sulphamethoxazole resistance (also associated with ST239-III) has decreased by 8 PP since it was first tested in 2006. Ciprofloxacin resistance, associated with ST239-III but also many other HA- and CA-MRSA, has decreased by 11 PP since 2000.

Regionally, the largest significant decreases in resistance occurred for gentamicin and tetracycline in Victoria (53 and 41 PP respectively), NSW (31 and 34 PP) and South Australia (30 and 48 PP), for erythromycin in Victoria (46 PP), for ciprofloxacin in South Australia (31 PP) and for fusidic acid in Tasmania (50 PP).

Table 11. Trend data (%) for non-susceptibility in MRSA, 2000-2010.

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Aus
Erythromycin									
2000	20.0	70.3	57.1	52.2	66.7	0.0	93.3	45.7	66.6
2002	62.5	72.6	61.9	40.5	36.1	33.3	89.1	60.0	64.8
2004	66.7	61.6	41.2	31.5	41.5	33.3	93.6	48.1	56.0
2006	60.0	53.2	25.0	40.6	30.6	53.9	60.9	37.8	48.5
2008	28.6	48.6	47.6	30.8	28.6	66.7	59.0	32.8	43.8
2010	50.0	52.1	37.1	27.4	40.5	10.0	47.3	37.3	41.9
X^2 for trend	4.43	30.22	2.373	5.488	4.584	0.03615	52.02	6.005	87.84
p	0.4894	**<0.0001**	0.1234	**0.0191**	**0.0323**	0.8492	**<0.0001**	**0.0143**	**<0.0001**
Clindamycin									
2000	0.0	32.6	0.0	17.4	13.3	0.0	80.0	2.2	30.4
2002	12.5	52.6	47.6	16.2	2.8	16.7	50.0	7.3	35.9
2004	0.0	32.7	17.6	9.3	7.3	0.0	32.8	5.8	21.9
2006	20.0	22.4	5.0	17.4	0.0	33.8	24.1	2.2	17.9
2008	0.0	18.2	23.8	11.5	2.4	16.7	24.0	1.7	15.0
2010	25.0	27.5	5.7	12.3	2.4	10.0	22.3	5.1	17.3
X^2 for trend	1.096	26.61	5.446	0.4399	4.182	0.001198	47.35	0.0969	59.91
p	0.295	**<0.0001**	**0.0196**	0.5072	**0.0408**	0.9724	**<0.0001**	0.7565	**<0.0001**
Tetracycline									
2000	0.0	52.9	14.3	30.4	53.3	0.0	71.1	2.2	43.9
2002	62.5	53.7	52.4	35.1	19.4	33.3	87.0	5.5	45.6
2004	50.0	41.5	23.5	14.8	14.6	33.3	70.5	0.0	33.3
2006	40.0	30.8	20.0	20.3	2.8	46.2	42.5	0.0	26.5
2008	14.3	17.8	28.6	11.5	4.8	16.7	42.0	5.2	19.0
2010	25.0	19.2	11.4	19.8	4.8	0.0	29.5	5.1	18.0
X^2 for trend	0.4274	90.14	5.202	4.041	31.3	1.627	55.8	0.5414	136.6
p	0.5132	**<0.0001**	**0.0226**	**0.0444**	**<0.0001**	0.2022	**<0.0001**	0.4619	**<0.0001**
Trimethoprim-sulphamethoxazole									
2006	40.0	27.4	15.0	20.3	2.8	38.5	42.5	0.0	24.6
2008	14.3	16.4	28.6	11.5	4.8	16.7	38.0	1.7	17.4
2010	25.0	19.8	11.4	17.0	4.8	0.0	25.9	1.7	16.5
X^2 for trend	0.239	3.608	0.3323	0.1491	0.1813	5.151	6.24	0.5459	10.23
p	0.6249	0.0575	0.5643	0.6994	0.6703	**0.0232**	**0.0125**	0.46	**0.0014**
Ciprofloxacin									
2000	0.0	68.1	14.3	26.1	56.7	0.0	68.9	8.7	51.7
2002	62.5	70.3	52.4	37.8	33.3	16.7	84.8	23.6	56.8
2004	50.0	66.0	29.4	35.2	39.0	66.7	90.2	19.2	54.7
2006	40.0	55.7	20.0	26.1	27.8	76.9	63.2	11.1	45.4
2008	42.9	52.3	28.6	22.1	23.8	66.7	69.0	19.0	43.1
2010	50.0	53.9	8.6	24.5	26.2	40.0	67.0	10.2	40.6
X^2 for trend	0.5852	19.55	7.111	2.751	7.756	1.282	4.467	0.2667	30.53
p	0.4443	**<0.0001**	**0.0077**	0.0972	**0.0054**	0.2575	**0.0346**	0.6056	**<0.0001**
Gentamicin									
2000	0.0	50.0	14.3	17.4	36.7	0.0	80.0	2.2	41.2
2002	62.5	54.9	47.6	32.4	16.7	0.0	80.4	3.6	43.8
2004	50.0	42.1	23.5	14.8	17.1	33.3	68.9	0.0	33.6
2006	40.0	28.4	20.0	24.6	2.8	38.5	39.1	0.0	25.2
2008	14.3	16.4	28.6	8.7	0.0	16.7	36.0	0.0	16.1
2010	25.0	19.2	11.4	19.8	7.1	0.0	26.8	1.7	17.3
X^2 for trend	0.4274	90.95	4.141	1.413	19.29	0.05868	70.68	1.005	137.2
p	0.5132	**<0.0001**	**0.0419**	0.2346	**<0.0001**	0.8086	**<0.0001**	0.3161	**<0.0001**

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Aus
Fusidic acid									
2000	0.0	2.9	28.6	17.4	16.7	50.0	8.9	15.2	9.1
2002	0.0	4.6	4.8	5.4	25.0	50.0	2.2	5.5	7.0
2004	0.0	4.4	11.8	5.6	9.8	33.3	1.6	13.5	6.4
2006	0.0	3.0	10.0	8.7	11.1	0.0	2.3	11.1	5.3
2008	0.0	1.4	9.5	5.8	14.3	0.0	3.0	8.6	4.5
2010	0.0	4.2	5.7	0.9	9.5	0.0	6.3	13.6	5.4
X^2 for trend	-	0.342	0.9336	6.551	1.907	11.42	0.0069	0.0065	6.642
p	-	0.5587	0.3339	**0.0105**	0.1673	**0.0007**	0.9337	0.9354	**0.01**
High-level mupirocin									
2006	0.0	0.5	0.0	5.8	0.0	0.0	3.4	0.0	1.7
2008	0.0	0.9	0.0	2.9	0.0	0.0	1.0	1.7	1.3
2010	0.0	0.6	0.0	1.9	0.0	0.0	0.9	0.0	0.7
X^2 for trend	-	0.02186	-	1.921	-	-	1.806	0.01184	1.871
p	-	0.8825	-	0.1658	-	-	0.179	0.9133	0.1713
Rifampicin									
2000	0.0	2.9	0.0	0.0	3.3	0.0	8.9	0.0	3.0
2002	12.5	2.3	0.0	10.8	0.0	0.0	4.3	3.6	3.4
2004	0.0	4.4	0.0	3.7	0.0	33.3	1.6	0.0	2.8
2006	0.0	2.5	0.0	7.3	0.0	0.0	2.3	0.0	2.5
2008	0.0	0.9	4.8	1.9	2.4	0.0	2.0	0.0	1.4
2010	0.0	0.6	0.0	2.8	0.0	0.0	2.7	0.0	1.3
X^2 for trend	0.9215	3.625	0.3112	1.331	0.313	0.5745	2.848	1.757	6.576
p	0.3371	0.0569	0.5769	0.2485	0.5758	0.4485	0.0915	0.185	**0.0103**

6.4 Methicillin-susceptible *S. aureus*

Susceptibility testing of MSSA (Table 12) show resistance to non-β-lactam agents remains uncommon except for erythromycin where overall resistance is 12.5% (95%CI 11.2-13.9%). All isolates were susceptible to vancomycin, teicoplanin and daptomycin. One isolate from Tasmania was linezolid resistant. Resistance to penicillin was high and in similar proportions ranging from 78.3% to 92.3% across all regions.

Table 12. Proportion [and number] of MSSA non-susceptible

Drug	ACT [n=92]	NSW [n=529]	NT [n=65]	Qld [n=494]	SA [n=257]	Tas [n=190]	Vic [n=487]	WA [n=341]	Aus [n=2455]	Aus 95%CI
Penicillin	**78.3** [72]	**87.0** [460]	**92.3** [60]	**85.2** [421]	**82.1** [211]	**84.7** [161]	**87.9** [428]	**85.9** [293]	**85.8** [2106]	**84.3-87.1**
Erythromycin	**14.1** [13]	**12.7** [67]	**12.3** [8]	**13.0** [64]	**11.7** [30]	**7.9** [15]	**14.2** [69]	**12.0** [41]	**12.5** [307]	**11.2-13.9**
Clindamycin*	**0.0** [0]	**1.7** [9]	**0.0** [0]	**2.0** [10]	**1.2** [3]	**2.1** [4]	**2.9** [14]	**0.9** [3]	**1.8** [43]	**1.3-2.3**
Tetracycline	**3.3** [3]	**4.2** [22]	**1.5** [1]	**2.8** [14]	**3.1** [8]	**5.3** [10]	**4.1** [20]	**2.3** [8]	**3.5** [86]	**2.8-4.3**
Trimethoprim-Sulphamethoxazole	**2.2** [2]	**3.6** [19]	**1.5** [1]	**1.6** [8]	**3.5** [9]	**2.6** [5]	**4.7** [23]	**2.1** [7]	**3.0** [74]	**2.3-3.8**
Ciprofloxacin	**1.1** [1]	**3.2** [17]	**0.0** [0]	**2.6** [13]	**2.3** [6]	**3.7** [7]	**5.7** [28]	**2.9** [10]	**3.3** [82]	**2.7-4.1**
Gentamicin	**0.0** [0]	**1.1** [6]	**1.5** [1]	**0.6** [3]	**0.0** [0]	**0.5** [1]	**1.2** [6]	**0.3** [1]	**0.7** [18]	**0.4-1.2**
Fusidic Acid	**3.3** [3]	**4.2** [22]	**3.1** [2]	**9.5** [47]	**3.5** [9]	**3.2** [6]	**2.9** [14]	**1.8** [6]	**4.4** [109]	**3.7-5.3**
Mupirocin[#]	**1.1** [1]	**1.3** [7]	**1.5** [1]	**8.1** [40]	**1.2** [3]	**0.0** [0]	**0.2** [1]	**0.6** [2]	**2.2** [55]	**1.7-2.8**
Rifampicin	**0.0** [0]	**0.0** [0]	**0.0** [0]	**0.0** [0]	**0.0** [0]	**0.0** [0]	**0.2** [1]	**0.0** [0]	**0.04** [1]	**0.0-0.2**

* Constitutive resistance
[#] High level resistance

6.5 Trends in MSSA non-susceptibility 2000-2010

In spite of some survey to survey variability there were no long term trends for either an increase or decrease in resistance to the non-β-lactams either within regions or nationally for erythromycin, gentamicin or rifampicin. Clindamycin resistance remains low but increased significantly in Australia from 0.7% in 2000 to 1.8% in 2010 (p=0.0023), ciprofloxacin resistance increased from 1.4% to 3.3% (p=0.0057) and fusidic acid increased from 3.7% to 4.4% (p=0.0051). High-level mupirocin and trimethoprim-sulphamethoxazole were first tested in 2006. From 2006 to 2010, mupirocin resistance increased from 0.0% in 2006 to 2.2% (p<0.0001) and trimethoprim-sulphamethoxazole resistance increased from 2.0% to 3.0% (p=0.0288). The increases in resistance for fusidic acid and high-level mupirocin were due to significant increases in resistance to these antimicrobials in Queensland (5.8% to 9.5%, p=0.0015 and 0.0% to 8.1%, p<0.0001 respectively). The national increase in ciprofloxacin resistance was largely due to an increase in Victoria (1.4% to 5.7%, p=0.0414). Victoria also experienced a significant increase in clindamycin resistance since 2000 (0.9% to 2.9%, p=0.0044) and a significant decrease in tetracycline resistance (7.1% to 4.1%, p=0.0435) (raw data not shown).

7 Summary

Biennial community-based *S. aureus* antimicrobial surveillance programmes have been performed in Australia by AGAR since 2000.

In the 2010 programme the percentage of *S. aureus* identified as MRSA ranged from 5.0% in Tasmania to 35.0% in the Northern Territory. Blood and urine isolate were more likely to be MRSA than isolates from skin and soft tissue infections. More than one in ten *S. aureus* infections in patients attending general practice are MRSA. For patients attending emergency departments or outpatient clinics the figure is one in five, and for patients residing in long term care facilities more than one in two.

Resistance in MRSA to the non-β-lactams was: erythromycin 41.9%, ciprofloxacin 40.6%, tetracycline 18.0%, gentamicin 17.3%, clindamycin 17.3%, trimethoprim-sulphamethoxazole 16.5%, fusidic acid 5.4%, rifampicin 1.3% and high-level mupirocin resistance 0.7%. No resistance was detected to vancomycin, teicoplanin, daptomycin or linezolid. Significant differences in resistance across regions were evident for all antimicrobials except mupirocin and rifampicin. These differences may be explained by the different MRSA clones in circulation in each region, for example Aus 2/3 EMRSA (ST239-III) which are reliably resistant to gentamicin, erythromycin, tetracycline, ciprofloxacin and trimethoprim-sulphamethoxazole are commonly found in the ACT, NSW and Victoria.

There were significant differences in the proportion of resistance to non-β-lactam antimicrobials in MRSA associated with various patient types with gentamicin, tetracycline, ciprofloxacin, clindamycin, trimethoprim-sulphamethoxazole and fusidic acid resistance higher in hospital outpatients that other patient types. This is consistent with their having a higher proportion of healthcare-related acquisition.

Over the six AGAR community surveys (2000, 2002, 2004, 2006, 2008 and 2010) the percentage of *S. aureus* identified as MRSA increased significantly ($p<0.0001$) by 6 percentage points (11.6% in 2000 to 18.0% in 2010). However in the same time period a significant decrease in resistance in MRSA to all the non-β-lactams except high-level mupirocin (which was only tested for in the last three surveys) was observed in Australia. This suggests that the increase in MRSA is due to the emergence and expansion of non-multiresistant clones in the community. The PVL-positive Queensland clone (ST93-IV), typically susceptible to all the non-β-lactam antimicrobials, is of particular concern as numbers are increasing in several regions of Australia[19].

Resistance to non-β-lactams among the MSSA in 2010 was: erythromycin 12.5%, fusidic acid 4.4%, tetracycline 3.5%, ciprofloxacin 3.3%, trimethoprim-sulphamethoxazole 3.0%, high-level mupirocin resistance 2.2%, clindamycin 1.8%, gentamicin 0.7% and rifampicin 0.04%. One isolate was resistant to linezolid. Over the six AGAR surveys, no trends in resistance, increase or decrease, were evident for erythromycin, gentamicin or rifampicin. Nationally, small but significant increases were seen for clindamycin, ciprofloxacin, fusidic acid, high level mupirocin and trimethoprim-sulphamethoxazole.

In summary, resistance in MSSA remains uncommon except for erythromycin. Resistance in MRSA appears dynamic due to the success or decline of MRSA clones circulating in Australia.

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The following members of AGAR contributed to this report:

Victoria	
Alfred Hospital	Denis Spelman, Michael Huysmans
Austin Hospital	Barrie Mayall, Peter Ward
HealthScope Pathology	John Andrew, Di Olden
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Royal Women's and Children's Hospital	Suzanne Garland, Gena Gonis
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New South Wales	
Concord Hospital	Thomas Gottlieb, Glenn Funnell
Douglass Hanly Moir Pathology	Raed Simhairi, Richard Jones
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Australian Capital Territory	
The Canberra Hospital	Peter Collignon, Susan Bradbury
South Australia	
SA Pathology, Flinders Medical Centre	Kelly Papanoum, Hendrik Pruul
SA Pathology, Royal Adelaide Hospital	Morgyn Warner, Lance Mickan
SA Pathology, Women's and Children's Hospital	John Turnidge, Jan Bell
Western Australia	
PathWest, Fremantle Hospital	David McGechie, Graham Francis
PathWest, QEII Medical Centre	Ronan Murray, Barbara Henderson
PathWest, Royal Perth Hospital	Keryn Christiansen, Geoffrey Coombs
St John of God Pathology	Sasha Jaksic, Martin Thorsen
Queensland	
Pathology Queensland, Cairns Base Hospital	Enzo Binotto, Bronwyn Thomsett
Pathology Queensland, Gold Coast Hospital	Petra Derrington, Dale Thorley
Pathology Queensland, Prince Charles Hospital	Chris Coulter, Sonali Coulter
Pathology Queensland, Princess Alexandra Hospital	Joan Faoagali, Kate Greening
Pathology Queensland Central Laboratory	Graeme Nimmo, Narelle George
Sullivan Nicolaides Pathology	Jenny Robson, Lana Risse
Tasmania	
Launceston General Hospital	Mhisti Rele, Kathy Wilcox
Royal Hobart Hospital	Alistair McGregor, Rob Peterson
Northern Territory	
Royal Darwin Hospital	Jann Hennessy