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AURA
Antimicrobial Use and Resistance in Australia

Antimicrobial use in Australian Hospitals

National Antimicrobial Utilisation Surveillance Program: 2019 Key Findings

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Summary

This report presents a summary of the key findings of analyses of 2019 data submitted to the National Antimicrobial Utilisation Surveillance Program (NAUSP) by 208 public and private hospitals, and trends for the period 2015 to 2019.

Key findings:

- Total aggregate use of antibacterials has increased annually in NAUSP contributor hospitals since 2016; usage increased by 2.6% from 2018 to 2019 (*n* = 205)
- There were variations between states and territories in the increase in total-hospital usage between 2018 and 2019; the largest increase was in Tasmania (4.2%) and the smallest increase was in New South Wales/Australian Capital Territory (1.7%)
- There was ongoing substantial variation in antimicrobial usage from 2018 to 2019 between states and territories for multiple antimicrobial classes, notably in classes for reserve-line antimicrobials:
    - Carbapenem usage increased in all states and territories except for South Australia. The largest relative increase was in Tasmania (31.9%), and Western Australia continued to report the highest usage rate for carbapenems. It is important to consider that populations with a low baseline use can see a high proportional increase when a few individuals require directed and prolonged therapy.
    - Fluoroquinolone usage decreased in most states and territories. The largest decreases in usage were in New South Wales/Australian Capital Territory (8.9%) and Tasmania (7.3%), and usage was highest in Western Australia.
    - Usage of third-generation cephalosporins was unchanged in New South Wales/Australian Capital Territory, decreased in Western Australia and Queensland/Northern Territory, and increased in all other states and territories; the largest increase was in Tasmania (14.1%). There was substantial variability in usage rates between states and territories; in 2019, usage was lowest in Western Australia and highest in Victoria.
    - Trimethoprim use decreased in all states and territories, except Western Australia. However, usage in Western Australia was lower than all other states and territories.
- This is the first report to utilise the *Priority Antibacterial List for Antimicrobial Resistance Containment*. Antibacterials in the Access category are recommended as first-line treatment for common infections, and have low potential to increase the development of antimicrobial resistance (AMR) and healthcare-associated infection (HAI). Antibacterials in the Review/Curb category are recommended as first-line treatments for common bacterial infections, but have high potential for promoting the development of AMR. In many Australian hospitals the proportion of antibacterial usage categorised as Curb in the Priority Antibacterial List [1] is greater than usage of antimicrobials categorised in the Access category.
- In 2019, in Principal Referral hospitals that contributed to NAUSP, the median proportion of antibacterial usage in the Curb category was 56.8%. The median proportion of antibacterial usage in the Contain category across the Principal Referral hospitals was 4.4%. However, one of these hospitals reported 12.7% of usage in this category, and four Principal Referral hospitals reported more than 8% of their antibacterial use in this category.
- In some states, the usage of third- and fourth-generation cephalosporins has remained higher than levels prior to the piperacillin–tazobactam shortage in 2017, potentially increasing the risk of gram-negative organism resistance. Between 2018 and 2019, there was a 1.2% increase in the national usage of third-generation cephalosporins, and a 21.8% decline nationally in the use of fourth-

generation cephalosporins. This indicates the lasting impact medication shortages can have on usage patterns.

- Total annual antifungal use increased in NAUSP contributor hospitals annually between 2017 and 2019. Triazole antifungals (fluconazole, itraconazole, posaconazole, voriconazole) accounted for approximately 84.9% of total antifungal usage in NAUSP contributor hospitals in 2019. Usage of fluconazole in Western Australia was 28.5% higher than the Australian average rate. Usage of posaconazole increased in all states and territories except Queensland/Northern Territory between 2018 and 2019; the largest increases were in South Australia (23.8%) and Western Australia (32.5%).

- Aggregate use of echinocandins (anidulafungin, caspofungin, micafungin) accounted for 6.4% of total antifungal usage in 2019. Usage of echinocandins in Tasmania increased by 20.3% between 2018 and 2019. The aggregate usage rate in Tasmania was more than 1.5 times greater than the aggregate use in other states and territories.

- In 2019, the average aggregate usage of amphotericin formulations across all states and territories in 2019 was 1.7 defined daily doses (DDDs) per 1,000 occupied bed days (OBDs). The usage rate more than doubled in Tasmania from 2018 to 2019; and in 2019, aggregate usage of amphotericin formulations was highest in New South Wales/Australian Capital Territory.

- Inpatient usage of chloramphenicol 1% eye ointment varied across NAUSP contributor hospitals. In 2019, total aggregate usage of chloramphenicol (measured in grams per 1,000 OBDs) was highest in Queensland/Northern Territory, New South Wales/Australian Capital Territory and Tasmania, and was more than double the usage in other states and territories. Measurement of usage of chloramphenicol ointment is of interest, because it is often used inappropriately for topical surgical prophylaxis.[2]

Implications for clinical practice

Total antibacterial usage in Australian hospitals increased annually from 2016 to 2019, following sustained reductions in total usage between 2010 and 2016.[3]

There was marked variation in antimicrobial usage between the states and territories, across multiple antibacterial and antifungal classes. While some variation is to be expected due to differing casemix between hospitals, the large differences in aggregate usage of some broad-spectrum agents across the states and territories is not readily explained.

The increase of antibacterial usage in the context of minimal progress in antimicrobial appropriateness results from the Hospital National Antimicrobial Prescribing Survey (NAPS) report is concerning. Whilst there have been some improvements in appropriateness of antimicrobial prescribing, analyses of the 2019 Hospital NAPS data confirm issues identified in successive surveys since 2013. The overall appropriateness of antimicrobial use in Australian public and private hospital contributors has essentially remain static since 2013, and was 75.7% in 2019. Compliance with national and local prescribing guidelines is frequently less than optimal.

Understanding the underlying reasons for these differences in clinical practice would help inform policies and Antimicrobial Stewardship (AMS) strategies to reduce overall use, increase consistency of antimicrobial prescribing in accordance with clinical guidelines, and ultimately limit the development and spread of AMR.

Issues that require investigation by states, territories, private health service providers and individual hospitals include:

- Large variation between hospitals in the proportional usage of antibacterials included in the Curb category of the Priority Antibacterial List[1]

- The reasons for large increases in the usage of some broad-spectrum antimicrobial classes between 2018 and 2019, for example, the increase in carbapenem usage in Tasmanian hospitals
- Use of last-line Contain category[1] antimicrobials which, whilst relatively low across all peer groups, is trending upwards. Although this may be driven by clinical need, due to infections caused by multidrug-resistant organisms, understanding the reasons for increasing usage would help inform stewardship interventions at a local and jurisdictional level
- The variation in usage of topical antimicrobials between the states and territories. Although topical antimicrobials are appropriate for the treatment and prophylaxis of some ophthalmic and otolaryngeal infections, they are not routinely recommended for use post-operatively on surgical wounds as this contributes to the emergence of AMR.[4] Inappropriate usage of topical antimicrobials should be a focus of stewardship interventions, because there is inadequate evidence illustrating the benefits outweigh the potential harms.[5]

What action will be taken?

The Australian Commission on Safety and Quality in Health Care will:

- Communicate findings to state and territories to enable reflection on the reasons for variation in usage and what possible targets may be considered for AMS programs
- Facilitate access for state and territory health authorities to NAUSP data for their public hospital contributors to enhance their capacity for system-wide and targeted AMS Interventions
- Encourage health service organisations to review their NAUSP results against their peers, disseminate findings to prescribers and implement targeted strategies
- The recent 2019 Hospital NAPS report has an increased emphasis on the role of hospital clinical governance committees on their roles in responding to these issues. The results of this 2019 NAUSP report will be communicated to clinical governance units in combination with the Hospital NAPS report to convey the concerning results of antimicrobial usage and appropriateness from both of these reports.
- Continue to raise awareness of the Priority Antibacterial List, and encourage health service organisations and states and territories to consider antimicrobial usage within the categories of Access; Review-Curb and Review-Contain.

Introduction

Antimicrobial resistance (AMR) continues to be a major public health concern, compromising the safety of modern healthcare and contributing to increased patient morbidity and mortality, as well as increased economic burden due to reduced productivity and poorer patient outcomes. *Australia's National Antimicrobial Resistance Strategy - 2020 and beyond* aims to provide a nationally coordinated approach to combatting antimicrobial resistance.[6] The national strategy is aligned with the goals and framework of the World Health Organization (WHO) *Global Action Plan on antimicrobial resistance.*[7]

One of the objectives of the *Global Action Plan* is to strengthen the knowledge and evidence base through surveillance and research.[7] The Antimicrobial Use and Resistance in Australia (AURA) Surveillance System is coordinated by the Australian Commission on Safety and Quality in Health Care (the Commission) with funding provided by the Australian Government Department of Health and states and territories. The National Antimicrobial Utilisation Surveillance Program (NAUSP) was established in 2004, and since 2013 has been a collaborative partner of the AURA Surveillance System, playing a pivotal role in supporting antimicrobial stewardship (AMS), and informing local, state, territory and national policy to contain AMR.

NAUSP provides a standardised measurement of antimicrobial use in Australian acute public and private hospitals using the WHO defined daily doses (DDDs) per 1,000 occupied bed days (OBDs). Hospitals contribute antimicrobial usage data to NAUSP on a voluntary basis via an online portal. Participation in NAUSP supports hospitals in meeting the AMS requirements of the National Safety and Quality Health Service (NSQHS) standards.[8] The number of hospitals participating in NAUSP has increased annually. All Principal Referral Hospitals and 92% (98/106) of Public Acute Group A and Public Acute Group B hospitals[9] participated in NAUSP in 2019 (Table 1).

Table 1: NAUSP participation by public hospitals (by peer group) and private hospitals, 2015–2019

Year ending	Total number	Principal Referral Hospitals	Public Acute Group A Hospitals	Public Acute Group B Hospitals	Public Acute Group C Hospitals	All private hospitals	Specialist Women's Hospitals
2015	157	30	55	36	13	19	4
2016	169	30	56	37	16	26	4
2017	191	30	58	37	26	36	4
2018	212	31	60	40	33	43	4
2019	219	31	60	38	38	49	4

Note: This table shows the number of hospitals registered to participate in NAUSP. Not all participating hospitals were able to provide validated data for the analyses in this report. Numbers shown may differ from those previously reported due to hospitals merging, closing or withdrawing from the program.

The methods, limitations and considerations for interpretation of NAUSP data are included in Appendices 1 and 2 respectively. A list of all hospitals that contributed data for this report is in Appendix 3. Data for this report were extracted from the NAUSP portal between the 12 and 13 October 2020. Usage rates may vary slightly from previous reports as a result of retrospective usage data adjustments, the number of hospitals contributing to aggregate data, and changes to DDD values assigned by the WHO.

Annual usage rates for all antibacterial classes

Table 2 provides the annual total-hospital systemic antibacterial usage rates reported by NAUSP contributor hospitals from 2015 to 2019. There was an increase of 2.8% in the total-hospital aggregate usage rate between 2018 and 2019. Relative change in usage of antibacterial classes is illustrated in Figure 1.

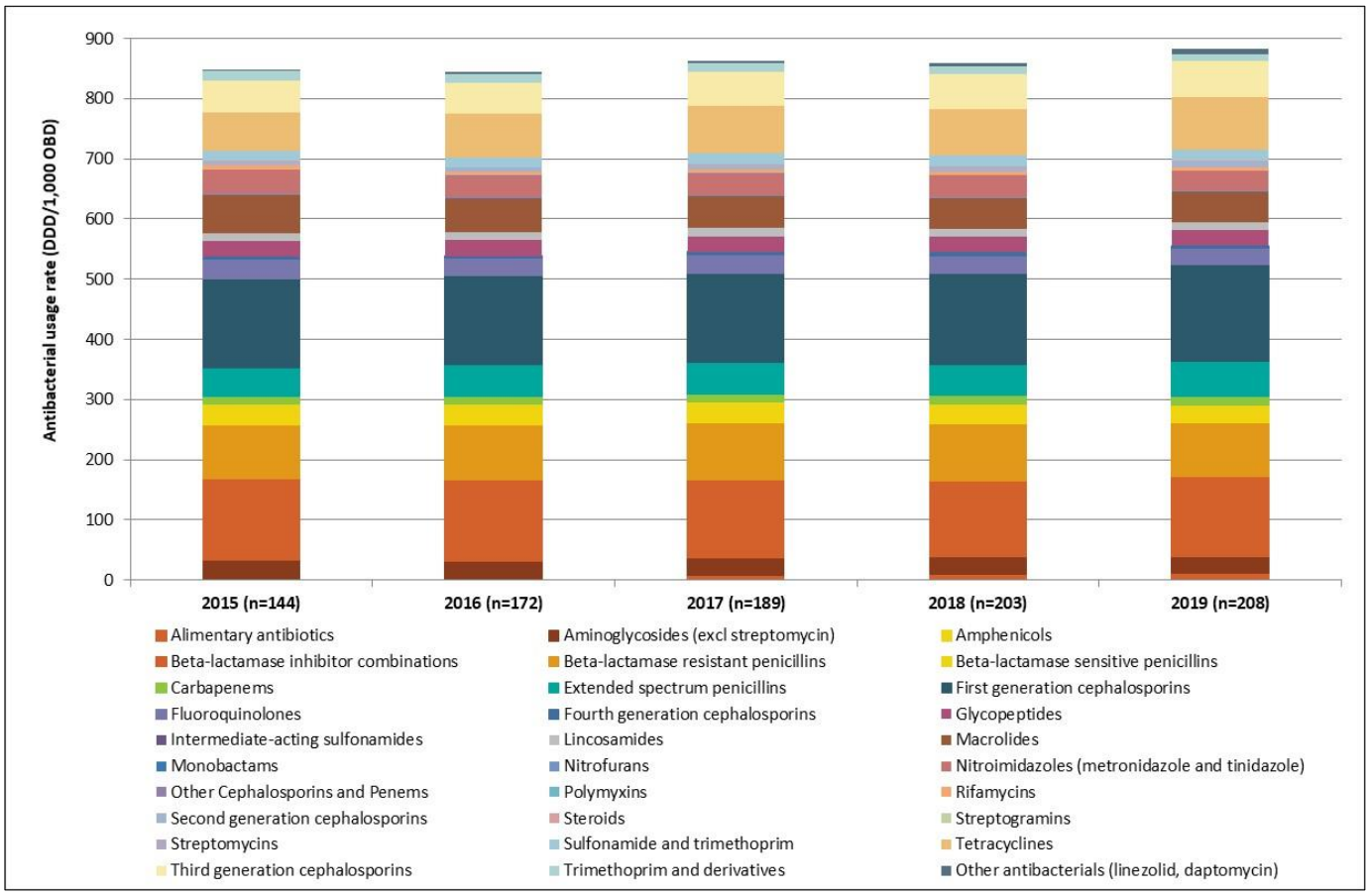
Table 2: Annual total-hospital systemic antibacterial usage rates (DDDs/1,000 OBDs) in NAUSP contributor hospitals, by antibacterial class, 2015–2019

Antibacterial (WHO) classification	2015 n = 144	2016 n = 172	2017 n = 189	2018 n = 203	2019 n = 208	% change 2018 - 2019	% change 2015 - 2019
Alimentary antibiotics*	0.8	1.3	8.2	8.7	11.0	25.9%	---
Aminoglycosides (excl streptomycin)	32.3	30.8	29.7	30.9	28.5	-7.8%	-11.8%
Amphenicols	0.0	0.0	0.0	0.0	0.0	---	---
Beta-lactamase inhibitor combinations	135.3	133.6	129.1	125.0	131.7	5.4%	-2.7%
Beta-lactamase resistant penicillins	89.3	92.8	93.7	95.3	91.2	-4.4%	2.1%
Beta-lactamase sensitive penicillins	34.0	33.8	35.0	32.5	29.1	-10.6%	-14.6%
Carbapenems	12.7	13.0	13.4	14.1	14.8	4.5%	16.2%
Extended-spectrum penicillins	48.5	53.2	51.9	51.3	57.1	11.2%	17.8%
First-generation cephalosporins	147.1	146.9	148.7	152.1	160.7	5.6%	9.3%
Fluoroquinolones	34.0	30.1	30.2	28.8	27.3	-5.3%	-19.9%
Fourth-generation cephalosporins	3.1	3.0	5.8	5.6	4.4	-21.8%	42.7%
Glycopeptides	26.5	26.2	25.6	25.6	25.7	0.1%	-3.0%
Intermediate-acting sulfonamides	0.0	0.0	0.0	0.0	0.0	---	---
Lincosamides	13.2	13.1	13.4	13.2	13.1	-0.7%	-0.6%
Macrolides	63.3	55.9	54.1	51.0	51.0	0.1%	-19.4%
Monobactams	0.2	0.4	0.3	0.4	0.3	-15.9%	51.5%
Nitrofurans	1.0	1.2	1.4	1.4	1.6	16.8%	59.4%
Nitroimidazoles (metronidazole, tinidazole)	41.2	36.8	35.2	36.3	32.5	-10.5%	-21.0%
Other antibacterials (linezolid, daptomycin)	2.7	2.8	3.6	4.8	8.6	78.6%	219.8%
Other cephalosporins and penems	0.1	0.1	0.1	0.2	0.2	37.8%	276.2%
Polymyxins	0.5	0.4	0.4	0.3	0.3	-11.2%	-42.4%
Rifamycins	6.1	5.5	5.3	5.0	5.0	-0.2%	-18.4%
Second-generation cephalosporins	6.5	6.9	8.4	8.7	9.9	13.4%	51.1%
Steroids	1.2	1.1	1.0	0.8	0.7	-12.7%	-42.9%
Streptogramins	0.3	0.4	0.4	0.4	0.4	1.4%	37.2%
Streptomycins	0.0	0.0	0.0	0.0	0.0	---	---
Sulfonamide and trimethoprim	15.8	16.6	17.7	18.0	19.2	6.8%	21.6%
Tetracyclines	64.7	71.7	79.4	76.2	86.2	13.0%	33.3%
Third-generation cephalosporins	52.0	51.4	56.3	59.8	60.5	1.2%	16.3%
Trimethoprim	15.9	14.8	13.8	12.9	12.3	-4.8%	-22.9%
Grand Total	**848.2**	**843.7**	**862.0**	**859.3**	**883.0**	**2.8%**	**4.1%**

Note: Rates (DDD/1,000 OBD) may vary slightly from previous reports as a result of retrospective usage data adjustments, the number of hospitals contributing to aggregate data and changes to DDD values assigned by the WHO.

* Alimentary antibiotics were not collected by NAUSP prior to 2017.

Figure 1: Annual total-hospital systemic antibacterial usage rates (DDDs/1,000 OBDs) in NAUSP contributor hospitals, by antibacterial class, 2015–2019



* Alimentary antibiotics were not collected by NAUSP prior to 2017.

Antibacterial usage rates by state and territory

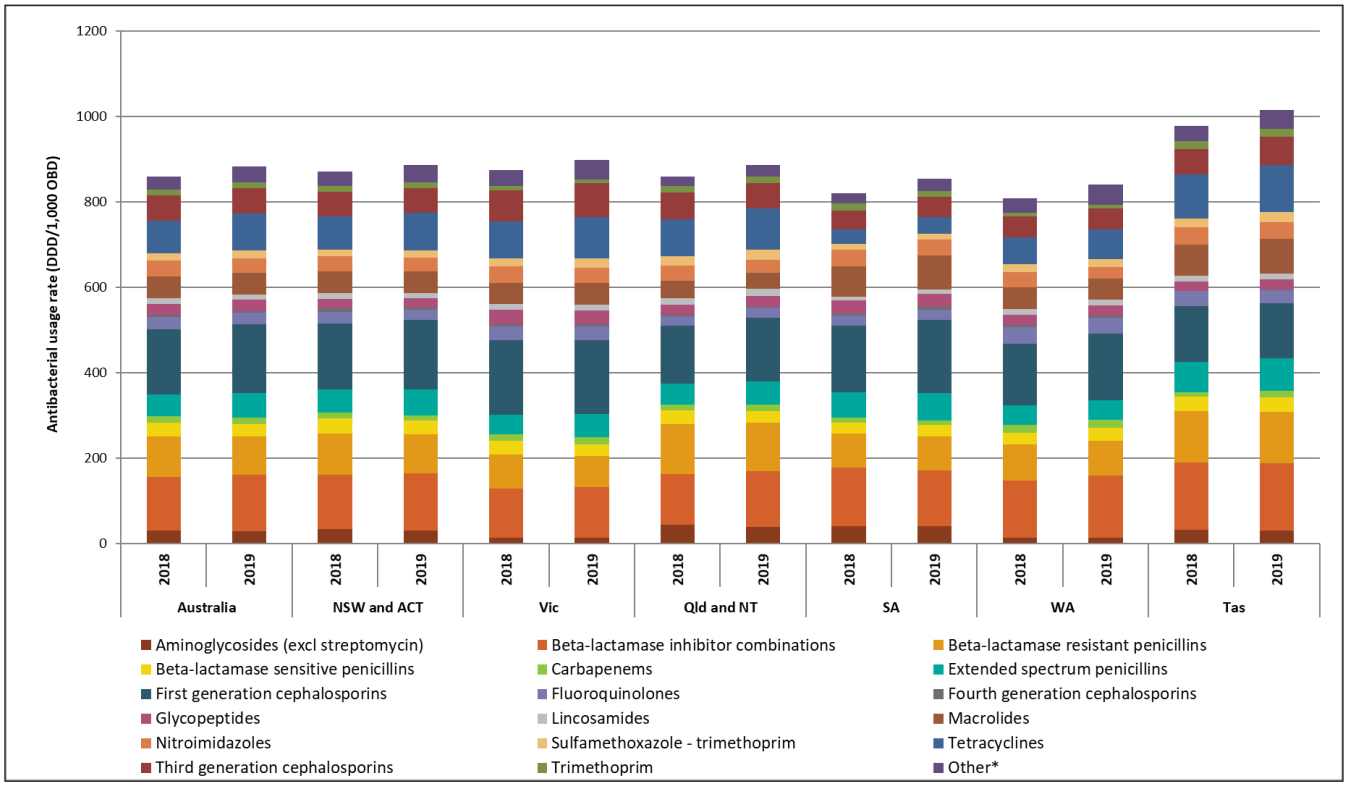
Figure 2 illustrates total-hospital antibacterial use for NAUSP contributors nationally and by state and territory in 2018 and 2019. Aggregate usage rates for 2019 were higher than rates in 2018 for every state and territory. The greatest increases occurred in South Australia (4.2%), Western Australia (3.9%) and Tasmania (3.8%).

Table 3 shows usage rates for all states and territories, by antibacterial class from 2018 to 2019. During this period:

- Usage of aminoglycosides decreased in all states and territories, except South Australia
- Carbapenem usage increased across all states and territories except South Australia; the greatest increase was in Tasmania, where annual statewide aggregate usage increased by 31.9% from 11.3 DDD/1,000 OBD to 14.9 DDD/1,000 OBD
- Total annual aggregate use of β-lactamase inhibitor combinations, piperacillin–tazobactam and amoxicillin–clavulanic acid, increased nationally by 5.4%; this was driven by increased usage in all but two states and territories, with the greatest percentage increase seen in Queensland/Northern Territory (10.4%) and Western Australia (9.6%).
- Usage of third-generation cephalosporins increased markedly in Tasmania (14.1%), Victoria (7.8%) and South Australia (6.6%); decreased was reported in Queensland/Northern Territory (-5.4%) and Western Australia (-4.0%), and usage was stable in New South Wales/Australian Capital Territory.

Figure 3 illustrates the variability in proportional use of antibacterial classes in 2019 across state and territories. There were notable differences in the percentage of total usage rates for macrolides, third- and fourth-generation cephalosporins and aminoglycosides.

Figure 2: Aggregate total-hospital antibacterial usage rates by class in NAUSP contributor hospitals, by state and territory, 2018–2019



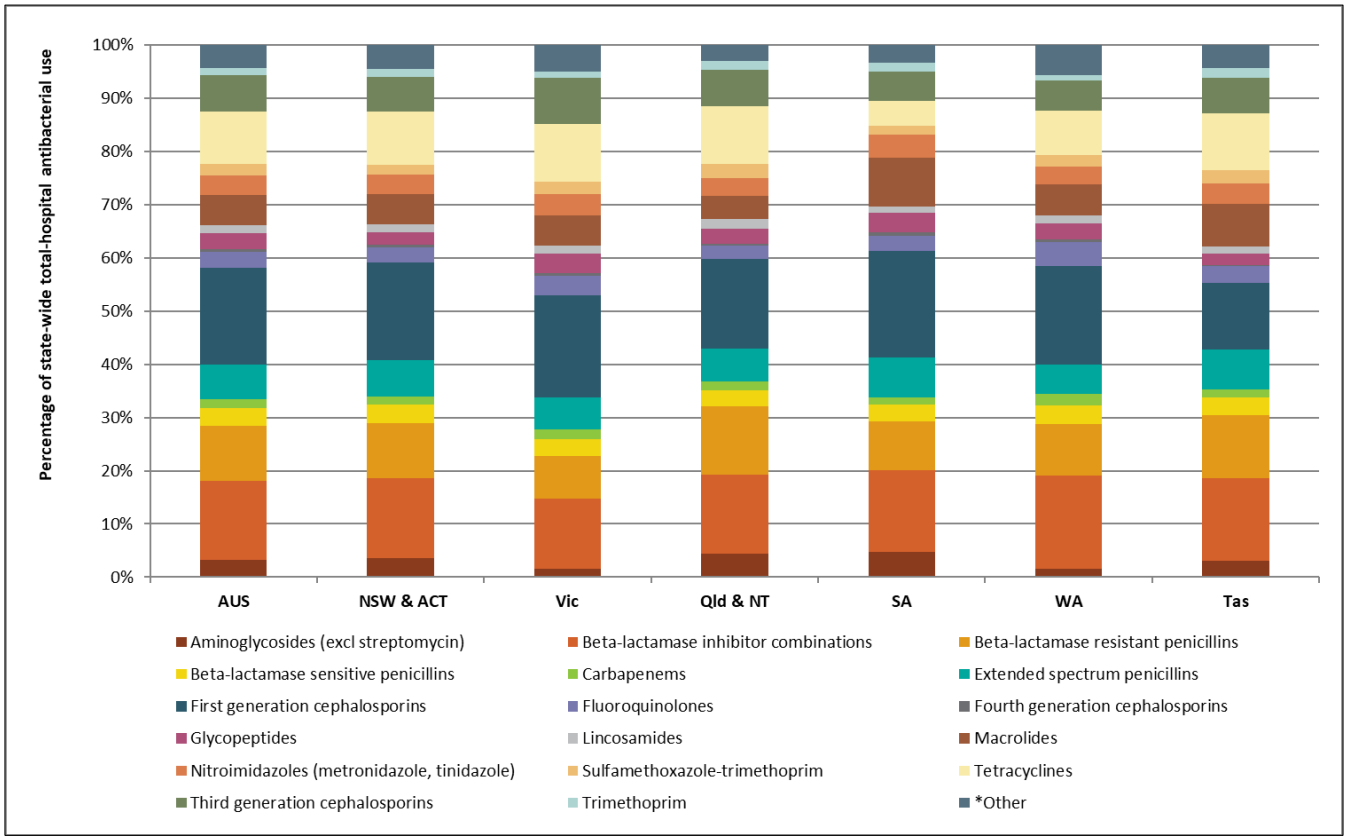
*Other = alimentary antibiotics, amphenicols, combinations for eradication of *Helicobacter pylori*, intermediate-acting sulphonamides, monobactams, nitrofurans, fosfomycin, linezolid, daptomycin, polymyxins, rifamycins, second-generation cephalosporins, steroids, streptogramins, streptomycins.

Table 3: Total-hospital antibacterial usage rates (DDD/1,000 OBD) by class in NAUSP contributor hospitals, by state and territory, 2018–2019

Antibacterial	Australia		NSW and ACT		Qld and NT		SA		Tas		Vic		WA	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Aminoglycosides (excl streptomycin)	30.9	28.5	34.7	30.9	43.6	39.7	40.1	40.1	31.6	31.2	14.2	13.5	13.8	13.6
Beta-lactamase inhibitor combinations	125.0	131.7	126.8	133.8	118.3	130.6	137.3	130.9	158.8	157.0	114.8	118.4	133.8	146.6
Beta-lactamase resistant penicillins	95.3	91.2	95.7	91.2	117.7	113.5	80.3	79.3	119.7	121.0	78.9	72.7	85.1	80.9
Beta-lactamase sensitive penicillins	32.5	29.1	36.5	31.7	32.0	26.6	25.3	26.7	33.2	33.1	32.0	27.5	27.1	29.2
Carbapenems	14.1	14.8	12.4	13.0	14.4	15.3	11.6	11.4	11.3	14.9	16.1	16.7	18.4	19.0
Extended-spectrum penicillins	51.3	57.1	54.3	60.6	48.6	54.3	59.3	64.6	71.1	76.3	46.1	54.4	45.9	45.7
First-generation cephalosporins	152.1	160.7	154.7	162.2	134.7	149.2	155.8	170.1	130.6	128.3	173.1	173.0	143.4	156.3
Fluoroquinolones	28.8	27.3	27.1	24.7	23.4	23.5	24.6	24.6	34.3	31.8	33.7	31.7	39.3	37.3
Fourth-generation cephalosporins	5.6	4.4	8.0	4.8	2.6	2.2	4.9	6.6	1.6	1.5	5.2	5.1	5.8	5.0
Glycopeptides	25.6	25.7	22.6	21.2	24.0	25.3	30.5	31.1	21.5	22.9	33.3	33.2	22.3	24.5
Lincosamides	13.2	13.1	13.0	12.4	14.6	15.7	8.8	9.5	13.6	13.4	13.1	13.3	14.6	12.2
Macrolides	51.0	51.0	52.1	50.9	41.1	38.6	70.7	78.6	72.4	81.4	49.1	51.0	50.4	49.6
Nitroimidazoles	36.3	32.5	35.1	32.5	35.0	30.1	38.6	37.4	40.1	39.1	38.9	35.2	35.9	27.7
Sulfamethoxazole–trimethoprim	18.0	19.2	15.4	16.1	23.0	23.8	13.1	14.5	21.4	24.4	18.2	21.4	19.0	19.2
Tetracyclines	76.2	86.2	78.0	89.0	85.8	96.2	33.9	39.3	103.6	109.4	87.5	97.4	61.4	68.9
Third-generation cephalosporins	59.8	60.5	57.6	57.6	63.5	60.1	43.9	46.8	58.7	67.0	73.0	78.7	49.5	48.2
Trimethoprim	12.9	12.3	12.8	12.3	15.2	14.7	17.4	14.2	19.3	18.8	10.0	9.6	8.5	9.1
Other*	30.7	38.0	33.5	40.5	20.9	26.7	24.1	28.9	35.3	43.8	37.4	45.0	34.2	47.0
Grand Total	**859.3**	**883.0**	**870.2**	**885.4**	**858.5**	**886.1**	**820.3**	**854.6**	**978.1**	**1015.2**	**874.7**	**897.8**	**808.4**	**840.0**

*Other = alimentary antibiotics, amphenicols, combinations for eradication of Helicobacter pylori, intermediate-acting sulphonamides, monobactams, nitrofurans, fosfomycin, linezolid, daptomycin, polymyxins, rifamycins, second-generation cephalosporins, steroids, streptogramins, streptomycins.

Figure 3: Aggregate total-hospital antibacterial usage rates by class as a percentage of total statewide usage rates in NAUSP contributor hospitals, 2019



*Other = alimentary antibiotics, amphenicols, combinations for eradication of Helicobacter pylori, intermediate-acting sulphonamides, monobactams, nitrofurans, fosfomycin, linezolid, daptomycin, polymyxins, rifamycins, second-generation cephalosporins, steroids, streptogramins, streptomycins.

Analysis of acute hospital antibacterial use using the *Priority Antibacterial List for Antimicrobial Resistance Containment*

The *Priority Antibacterial List for Antimicrobial Resistance Containment* (Priority Antibacterial List)[1] was developed by the Commission in 2020 as a tool to support AMS. The Priority Antibacterial List aims to promote improved prescribing and reduce the total quantity of antibacterial use. It can be used for analysis of antimicrobial usage in terms of preferred or optimal prescribing choices, and to support analyses of usage surveillance data. The Priority Antibacterial List may also be used for local AMS programs in both hospital and community settings. Using the Priority Antibacterial List provides additional information, which complements usage volume data for trend analyses. For example, the volume of use measured in DDDs per 1,000 OBDs may not change over time, but the proportionate use of restricted antimicrobials may change.

The Priority Antibacterial List is stratified according to preferred use categories for containment of AMR in human health in Australia (Table 4). In general, the preferred use category includes antibacterials that are recommended as first-line treatment for infections where there is a low resistance potential. The categories also describe preferred antibacterial agents as a larger class for surveillance purposes.

There are two overarching categories in the Priority Antibacterial List: the Access and the Review groups. The Review group is further classified into two subgroups based on their indications for use and their resistance potential; these are the Curb and Contain groups.[1]

Table 4: Classification framework for the Access, Review, Curb and Contain categories[1]

Category		Inclusion criteria
Access		• Includes antibacterials recommended as first-line treatment for common infections with a low AMR or HAI potential; and • Antibacterials not recommended as first-line treatment for common infections but with a low resistance potential
Review	**Curb**	• Includes antibacterials recommended as first-line agents for common bacterial infections, despite a high AMR potential; and • Antibacterials not recommended as first-line treatment but with moderate to high AMR or HAI potential; and • Antibacterials only recommended as first-line for prophylaxis as opposed to treatment
	Contain	• Includes antibacterials with high AMR or HAI potential that are not recommended as first-line options for common bacterial infections

Systemic antimicrobials included in NAUSP are listed in Appendix 3 and antibacterials included in the Priority Antibacterial List according to the Access, Curb, and Contain classification are listed in Appendix 4.

Usage by Priority Antibacterial List category, by state and territory, 2015–2019

Figure 4 illustrates the trend in total-hospital antibacterial usage from 2015 to 2019, according to the Priority Antibacterial List categories (Access, Curb, Contain) for NAUSP contributor hospitals, by state and territory. Figure 5 illustrates the same data according to proportional use.

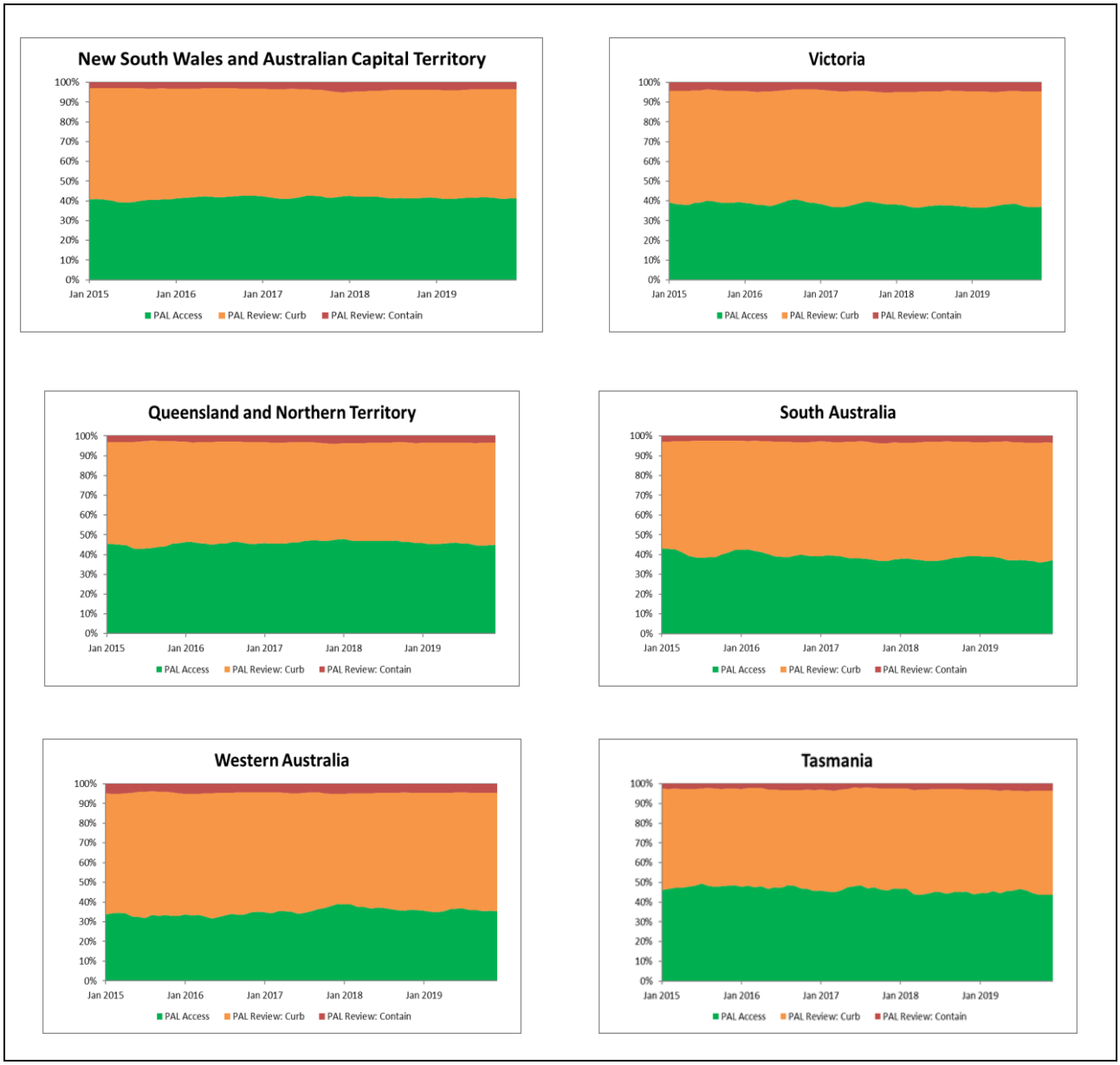
Figure 4: Aggregate antibacterial usage rates by Priority Antibacterial List category in NAUSP contributor hospitals, by state and territory, 2015–2019

DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed days

Overall, the antibacterial usage rate was lowest on average in Western Australia for all three Priority Antibacterial List groups combined, as illustrated in Figure 4. However, Western Australia reported the highest proportionate usage of antibacterials in the Curb category (Figure 5). On average, between 2015 and 2019, 60.4% of antibacterial usage in Western Australia was in the Curb category. Although the total reported antibacterial usage in Tasmanian hospitals was the highest nationally, Tasmania had the highest proportionate use in the Access category. The average monthly proportionate use in the Access category

over the five-year period from 2015 to 2019 was 46.4% in Tasmania, compared to 35.0% in Western Australia.

Figure 5: Proportional antibacterial usage by Priority Antibacterial List category in NAUSP contributor hospitals, by state and territory, 2015–2019



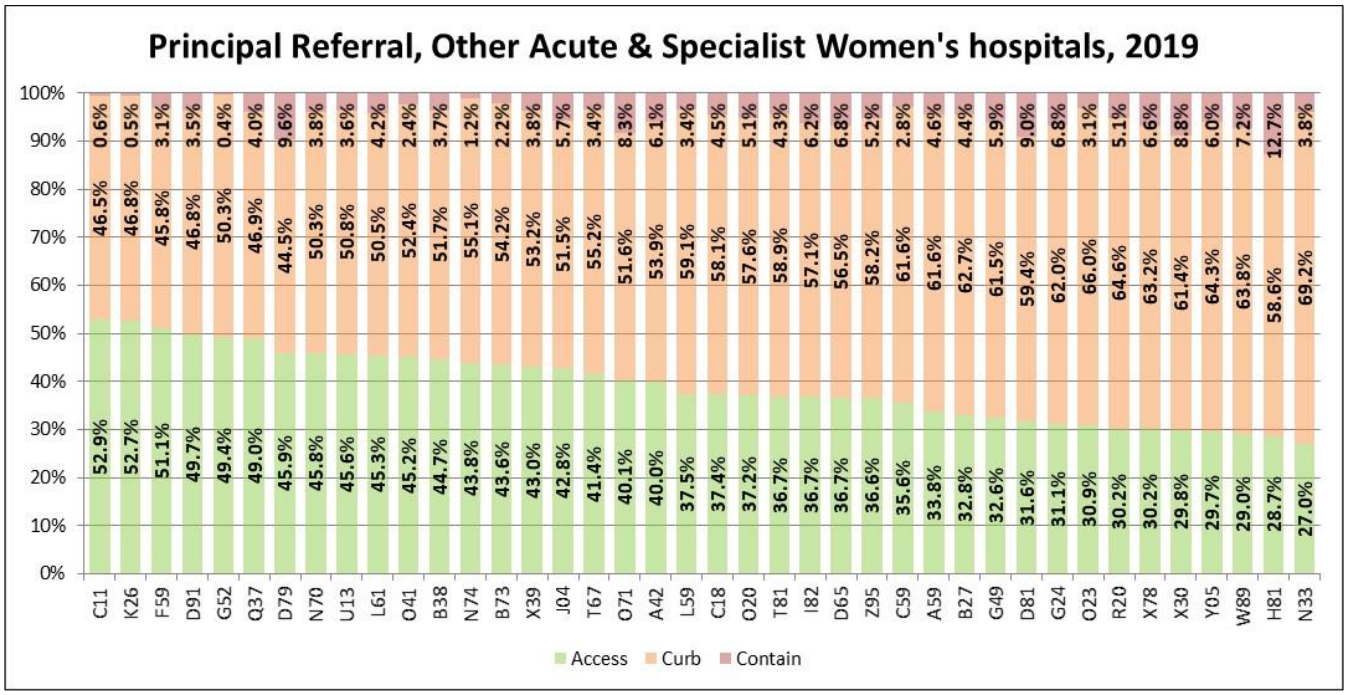
Contributor usage by Priority Antimicrobial List category, by peer group

Figures 6 to 9 show the proportion (as a percentage) of antimicrobial usage in 2019 by Priority Antimicrobial List category and peer group for NAUSP contributor hospitals. Hospital peer groupings define groups of similar hospitals based on shared characteristics, allowing benchmarking within peer groups, or comparisons between different peer groups. Private hospitals are assigned by NAUSP to comparable Australian Institute of Health and Welfare (AIHW) public hospital peer groups for analysis.

Principal Referral and Specialist Women's hospitals

The proportion of total-hospital usage in the Access category ranged from 29.7% to 52.9% for Principal Referral and Specialist Women's hospitals. For many hospitals in these two peer groups, the proportion of usage in the Curb category was greater than the Access Category. In general, the proportion of usage in the Contain category was greater in Principal Referral hospitals compared to hospitals in other peer groups, reflecting the more complex casemix in larger tertiary hospitals. Curb usage in Principal Referral hospitals was predominantly driven by usage of ß-lactamase-inhibitor combination penicillins. On average, amoxicillin–clavulanic acid and piperacillin–tazobactam usage accounted for 38.7% of Curb usage in this peer group.

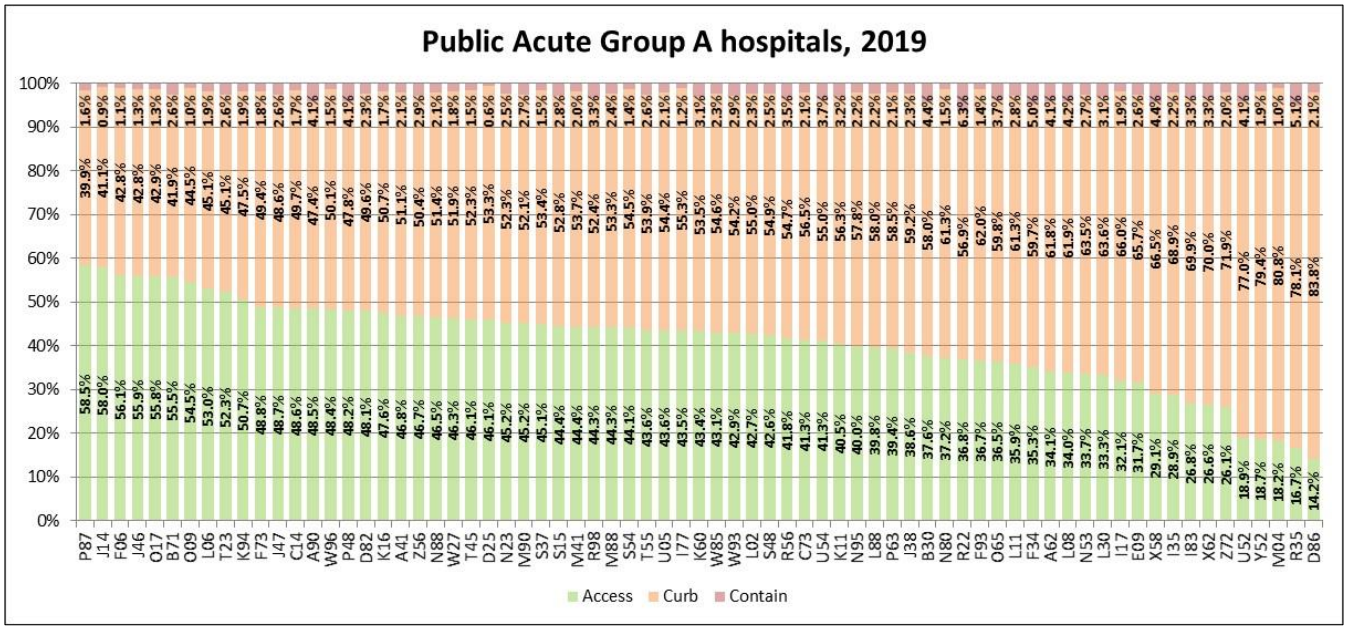
Figure 6: Percentage of aggregate total-hospital usage by Priority Antimicrobial List category in Principal Referral, Other Acute and Specialist Women's hospitals, 2019



Public Acute Group A hospitals

The proportion of total-hospital antibacterial usage categorised as Curb was extremely variable between Public Acute Group A contributors, with the proportion of usage in this category ranging from 39.9% to 83.8% (Figure 7). Usage of antimicrobials in the Contain category was low (2.5%) in this peer group.

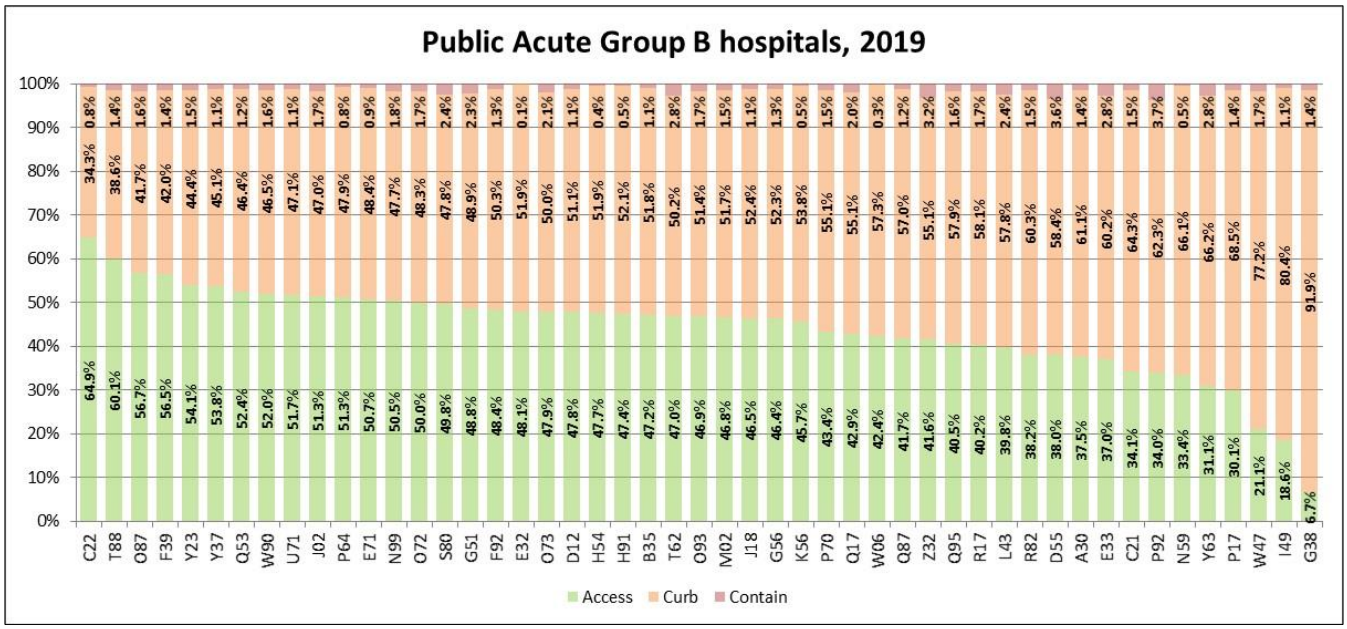
Figure 7: Percentage of aggregate total-hospital usage by Priority Antimicrobial List category in Public Acute Group A hospitals, 2019



Public Acute Group B hospitals

Similar to Public Acute Group A hospitals, there was wide variability in the proportion of usage of Curb category antibacterials in Public Acute Group B hospitals (Figure 8), ranging from 34.3% to 91.9% of total use. A large majority of the hospitals in this peer group (87%) used proportionately more antibacterials in the Curb category than the Access category, and proportionate use of antimicrobials in the Contain category was low (mean of 1.6% of total annual use in 2019).

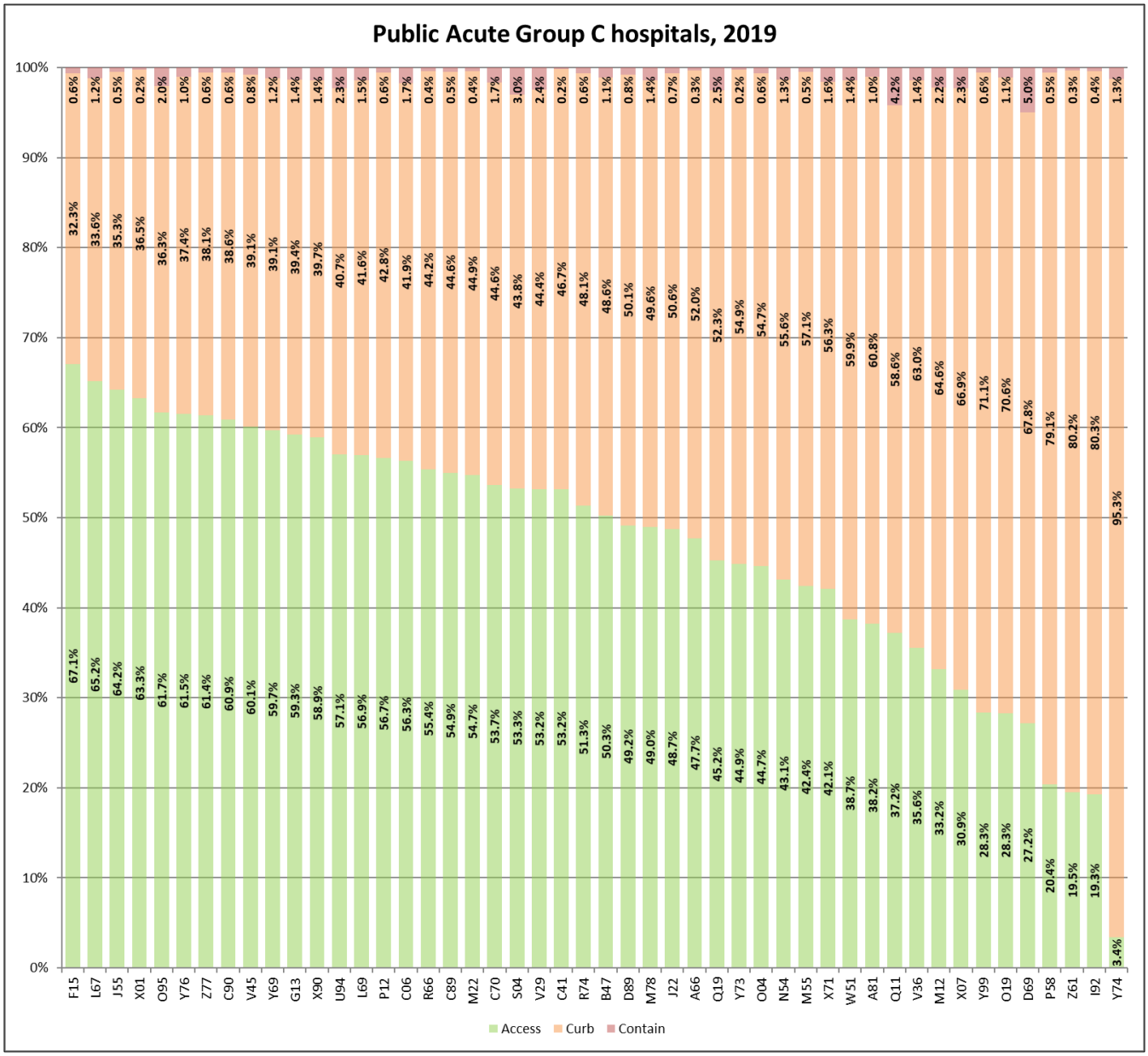
Figure 8: Percentage of aggregate total-hospital antibacterial usage by Priority Antimicrobial List category in Public Acute Group B hospitals, 2019



Public Acute Group C hospitals

In 2019, the proportion of antimicrobial usage categorised as Access ranged from 3.4% to 67.1% in Public Acute Group C hospitals (Figure 9). Similar to Acute Group B hospitals, the proportionate usage of antimicrobials in the Curb category was extremely variable, ranging from 32.3% to 95.3% of total usage. High proportionate rates of usage in the Curb category were reported by hospitals that predominantly provide short-stay surgical services. While the proportionate use of Curb antimicrobials was high, this was likely driven by cefazolin usage, especially where total hospital usage of other antimicrobials was comparatively low. In general, proportionate usage of antimicrobials in the Contain category was very low in this peer group.

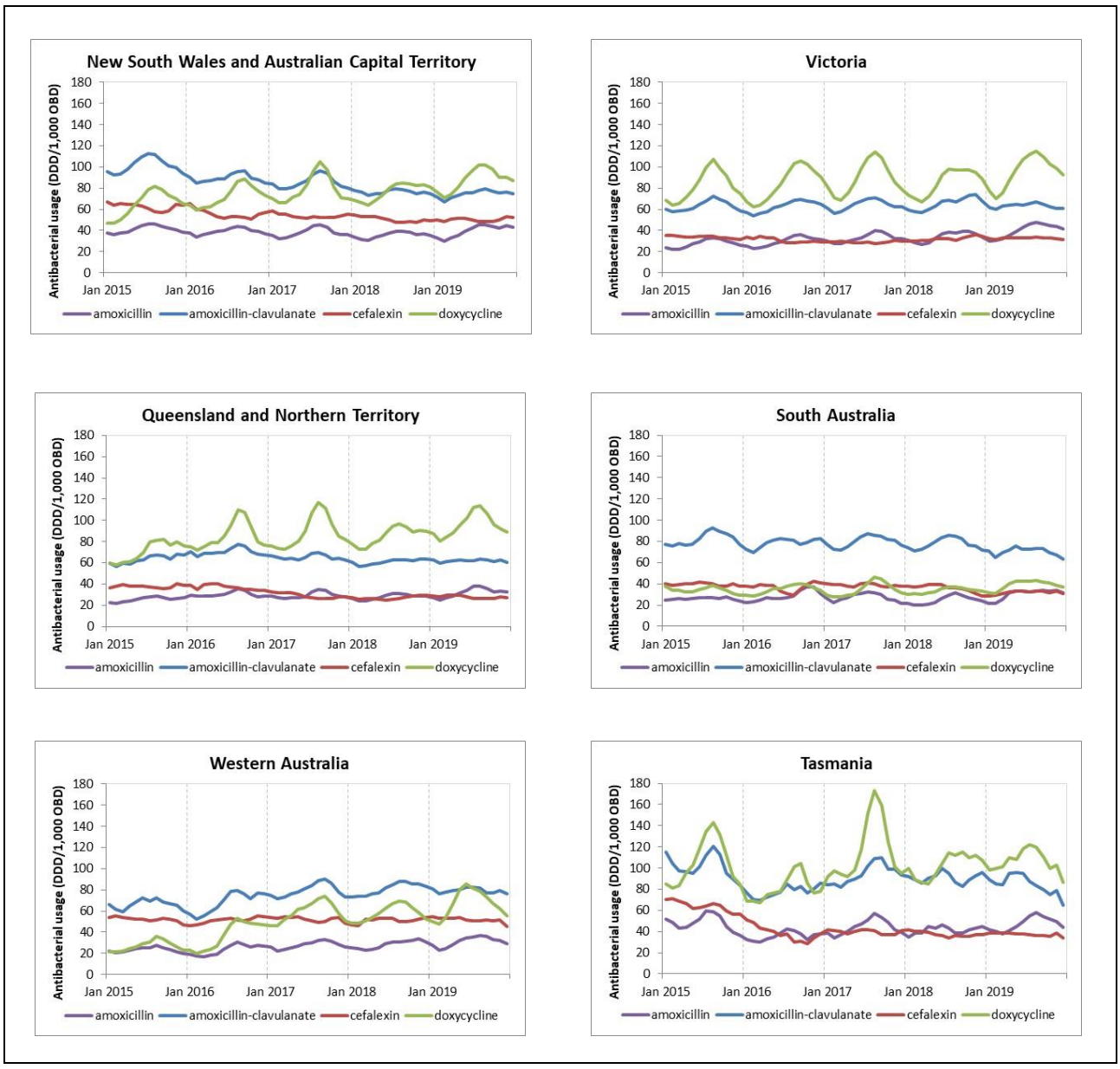
Figure 9: Percentage of aggregate total-hospital antibacterial usage by Priority Antimicrobial List category in Public Acute Group C hospitals, 2019



Usage rates for high-volume antibacterials, 2015–2019

The most commonly prescribed oral antibacterials in NAUSP contributor hospitals were amoxicillin–clavulanic acid, doxycycline, cefalexin and amoxicillin. Figure 10 illustrates the usage rates for these four antibacterials across the states and territories between 2015 and 2019. There was seasonal variation in the use of doxycycline; although on average, monthly usage in 2019 was highest in Tasmania, Victoria and Queensland/Northern Territory. Usage of oral amoxicillin–clavulanic acid varied between states and territories; the highest monthly usage rates were reported in Tasmania, Western Australia and New South Wales/Australian Capital Territory.

Figure 10: High-volume antibacterial usage rates (DDD/1,000 OBDs) in NAUSP contributor hospitals, by state and territory, 2015–2019 (3-month moving average)



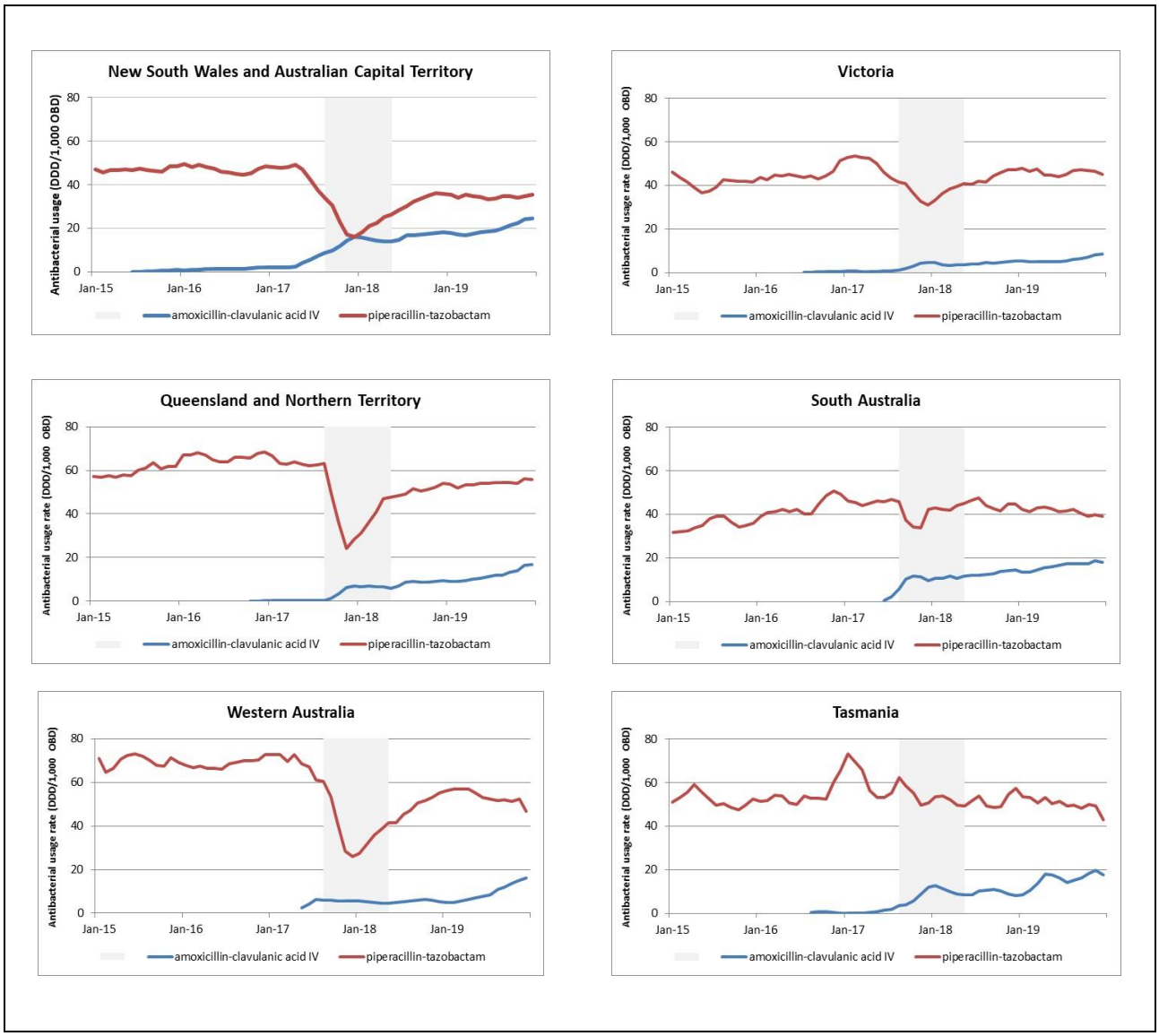
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Usage rates for intravenous broad-spectrum antimicrobials, 2015–2019

The global shortage of piperacillin–tazobactam in 2017 resulted in a consequent increase in usage of intravenous amoxicillin–clavulanic acid and third- and fourth-generation cephalosporins (Figures 11, 12 and 13).

Penicillin-β-lactamase inhibitor combinations: intravenous amoxicillin–clavulanic acid and piperacillin–tazobactam

Figure 11: Penicillin-β-lactamase inhibitor combination usage rates in NAUSP contributor hospitals, by state and territory, 2015–2019 (3-month moving average)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Shaded area represents the period of piperacillin–tazobactam shortage
Note: Intravenous amoxicillin-clavulanic acid was registered in Australia in January 2017[10]

Third- and fourth-generation cephalosporins – cefepime, ceftazidime, ceftriaxone

Usage of third- and fourth-generation cephalosporins increased during the nationwide piperacillin–tazobactam shortage as illustrated in Figure 12.

Figure 12: Cephalosporin usage rates (DDD / 1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2015–2019 (3-month moving average)

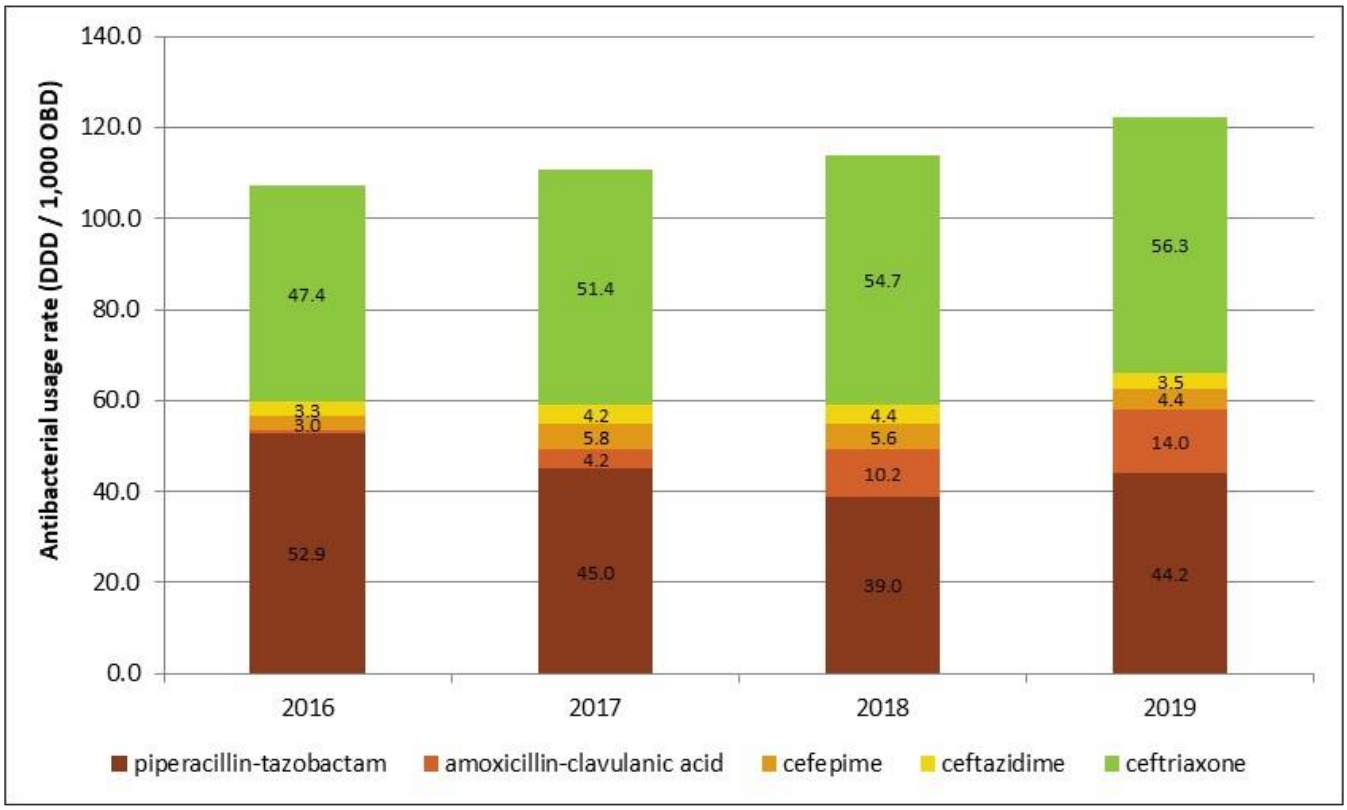
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Shaded area represents the period of piperacillin–tazobactam shortage

National proportional annual use of penicillin-β-lactamase inhibitor combinations and third- and fourth-generation cephalosporins, 2016–2019

Figure 13 illustrates the proportional change in annual use of piperacillin–tazobactam, intravenous amoxicillin–clavulanic acid and third- and fourth-generation cephalosporins in NAUSP contributor hospitals before and after the piperacillin–tazobactam shortage in 2017. Overall use of these broad-spectrum agents has increased annually in NAUSP contributor hospitals since 2016. Prior to 2017, piperacillin–tazobactam was the only intravenous penicillin-β-lactamase inhibitor combination available in Australia. The use of intravenous amoxicillin–clavulanic acid has increased since it was registered in Australia in January 2017. In

2019, use of intravenous amoxicillin–clavulanic acid accounted for 24.0% of all intravenous penicillin-β-lactamase inhibitor use in NAUSP contributor hospitals.

Figure 13: National aggregate total-hospital usage rates for intravenous penicillin-β-lactamase inhibitor combinations and third- and fourth-generation cephalosporins in NAUSP contributor hospitals, 2016–2019



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Intravenous amoxicillin–clavulanic acid was registered in Australia in January 2017[10]

Carbapenems – meropenem and ertapenem

Carbapenem usage increased nationally by 16.2% between 2015 and 2019 (Table 1); usage increased by 4.5% between 2018 and 2019, driven by a 31.9% increase in Tasmania. Figure 14 shows the usage of meropenem and ertapenem between 2015 and 2019. Imipenem–cilastatin and doripenem are rarely used, and have not been included in the figure below.

Figure 14: Carbapenem usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2015–2019 (3-month moving average)

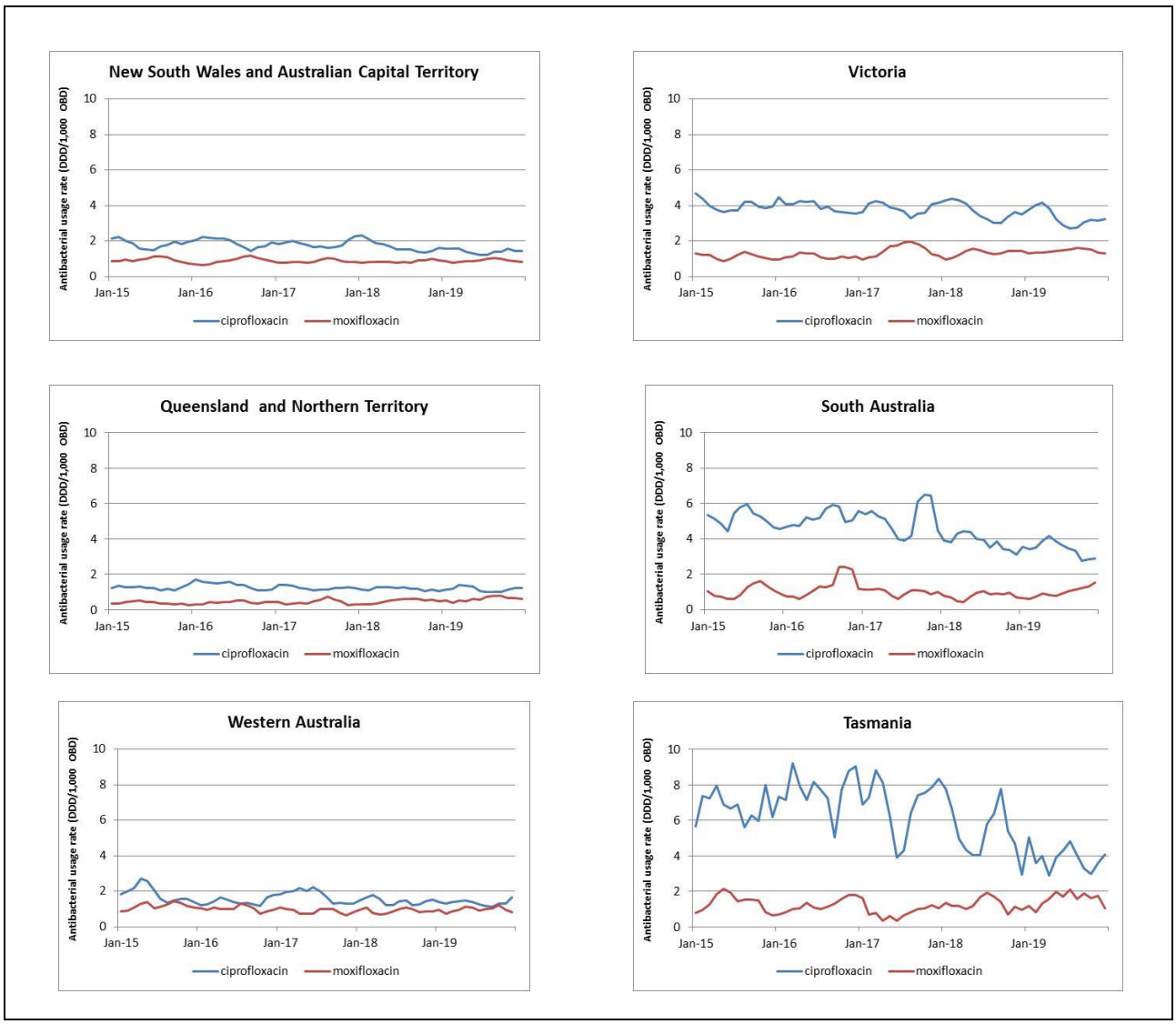
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Usage rates for reserve-line antibacterials, 2015-2019

Intravenous fluoroquinolones - ciprofloxacin, moxifloxacin

Figure 15 shows the comparative usage rates of the two intravenous fluoroquinolones registered for use in Australia. Usage rates have decreased annually from 2016 to 2019, however there was an increase in reported use in Tasmania between 2018 and 2019.

Figure 15: Intravenous fluoroquinolone usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2015–2019 (3-month moving average)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Usage of levofloxacin, which is not registered in Australia, is negligible and is not shown

Ceftaroline, ceftazidime-avibactam, ceftolozane–tazobactam

Usage of reserve-line, newly introduced cephalosporins remains low (Figure 16); usage of ceftolozane–tazobactam is increasing, especially in Western Australia.

Figure 16: Reserve-line cephalosporin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2015–2019 (5-month moving average)*

DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
*Low usage antimicrobials have a 5 month moving average, rather than a 3 month moving average to optimise the visual trends

Daptomycin, linezolid, pristinamycin

Usage of daptomycin, whilst comparatively low, increased in all states and territories (Figure 17). Usage of linezolid, which is a reserve-line antimicrobial commonly used for treatment of vancomycin-resistant enterococci (VRE), varied between states and territories, and increased from 2017 in Tasmania. Usage of pristinamycin, an oral reserve-line agent used for treatment of methicillin-resistant *Staphylococcus aureus* (MRSA) and VRE, was generally low (less than 1 DDD/1,000 OBD), although usage in Tasmania was higher than other states and territories.

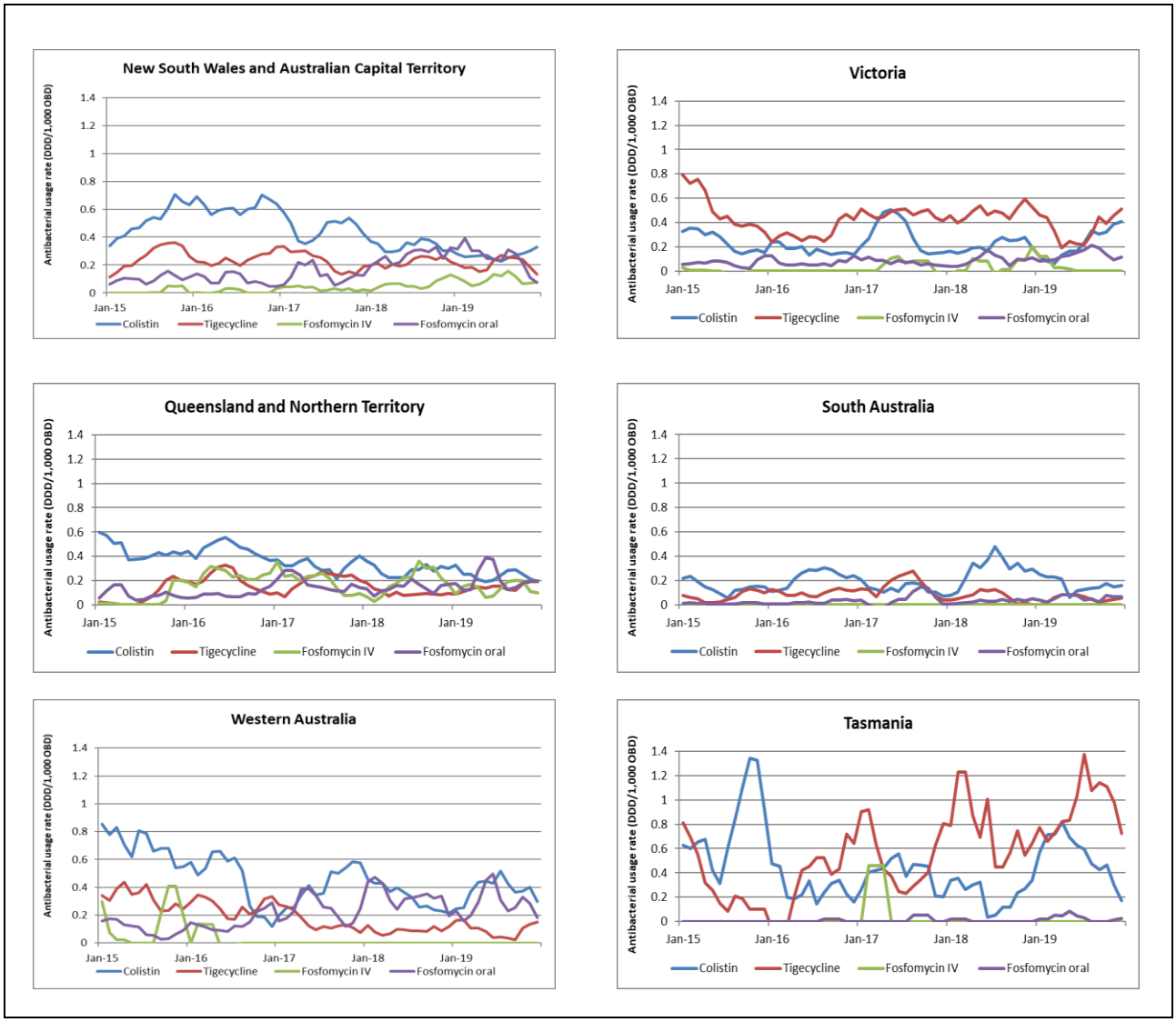
Figure 17: Daptomycin, linezolid and pristinamycin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2015–2019 (5-month moving average)

DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Colistin, tigecycline, fosfomycin

Colistin and tigecycline are reserve-line antibacterials used as salvage treatment for multidrug-resistant infections. Colistin is bactericidal against gram-negative bacteria that are resistant to other drug classes, including strains of *Pseudomonas aeruginosa* and *Acinetobacter baumannii*.[11,12] Usage of both these antibacterials was very low in Australian hospitals (Figure 18), although usage is increasing in Tasmania. Fosfomycin has activity against many strains of multidrug-resistant gram-negative bacteria, but is inactive against *P. aeruginosa.* Oral fosfomycin is used to treat multidrug-resistant urinary tract infections. Intravenous fosfomycin is rarely used in NAUSP contributor hospitals, although use in Queensland/Northern Territory is higher than other states.

Figure 18: Colistin and tigecycline usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2015–2019 (5-month moving average)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Antifungal use

Routine submission of data on antifungal usage by NAUSP contributors commenced in 2017. Similar to antimicrobial-resistant bacterial infections, overuse and inappropriate use of antifungals may lead to the development of resistant organisms, increased treatment costs and mortality. *Candida auris* is an emerging multidrug-resistant fungus first identified in 2009,[13] which is resistant to a number of antifungal drugs including fluconazole. There are uncertainties regarding the impact of antifungal use and the acquisition of antifungal resistance, however there are concerns that overuse of antifungal drugs may contribute to the incidence of *C. auris* infections.[14]

Antifungal usage in Australian hospitals

Fluconazole is the most commonly used antifungal agent in NAUSP contributor hospitals. Triazole antifungals (fluconazole, itraconazole, itravuconazole, posaconazole, and voriconazole) accounted for approximately 84.9% of total antifungal usage in 2019 (Table 5).

Echinocandin (anidulafungin, caspofungin, micafungin) use remained stable between 2018 and 2019, and accounted for 6.4% of total antifungal usage in 2019. Anidulafungin is currently the most commonly used echinocandin, but the total-hospital usage rate in 2019 was less than two DDDs/1,000 OBDs (Table 5).

Amphotericin (liposomal) usage increased from approximately 3% of total antifungal use in 2018 to 4.5% in 2019. The usage rates of amphotericin B and amphotericin lipid complex remained relatively unchanged from 2018 to 2019, and accounted for 0.67% of total antifungal usage.

Table 5: Annual antifungal usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, 2017–2019

Antifungal	2017 (*n* = 178)	2018 (*n* = 192)	2019 (*n* = 204)
Amphotericin B (desoxycholate)	0.26	0.25	0.23
Amphotericin, lipid complex	0.03	0.01	0.01
Amphotericin, liposomal*	1.00	1.04	1.59
Anidulafungin	1.16	1.55	1.66
Caspofungin	0.63	0.51	0.37
Fluconazole	18.06	18.75	18.67
Flucytosine	0.15	0.13	0.16
Griseofulvin	0.03	0.15	0.14
Isavuconazole	0.01	0.01	0.01
Itraconazole	3.04	2.43	2.39
Ketoconazole	0.09	0.08	0.05
Micafungin	0.11	0.18	0.24
Posaconazole	5.05	5.68	5.82
Terbinafine	0.92	0.94	0.90
Voriconazole	3.11	3.11	3.16
Total	**33.63**	**34.83**	**35.39**

DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
*DDD for liposomal amphotericin assigned by NAUSP as 0.21g

Antifungal usage in Australian hospitals by state and territory

There were variations in total aggregate rates of antifungal use, as well as agents used, between states and territories (Figure 19). For 2019, notable observations included:

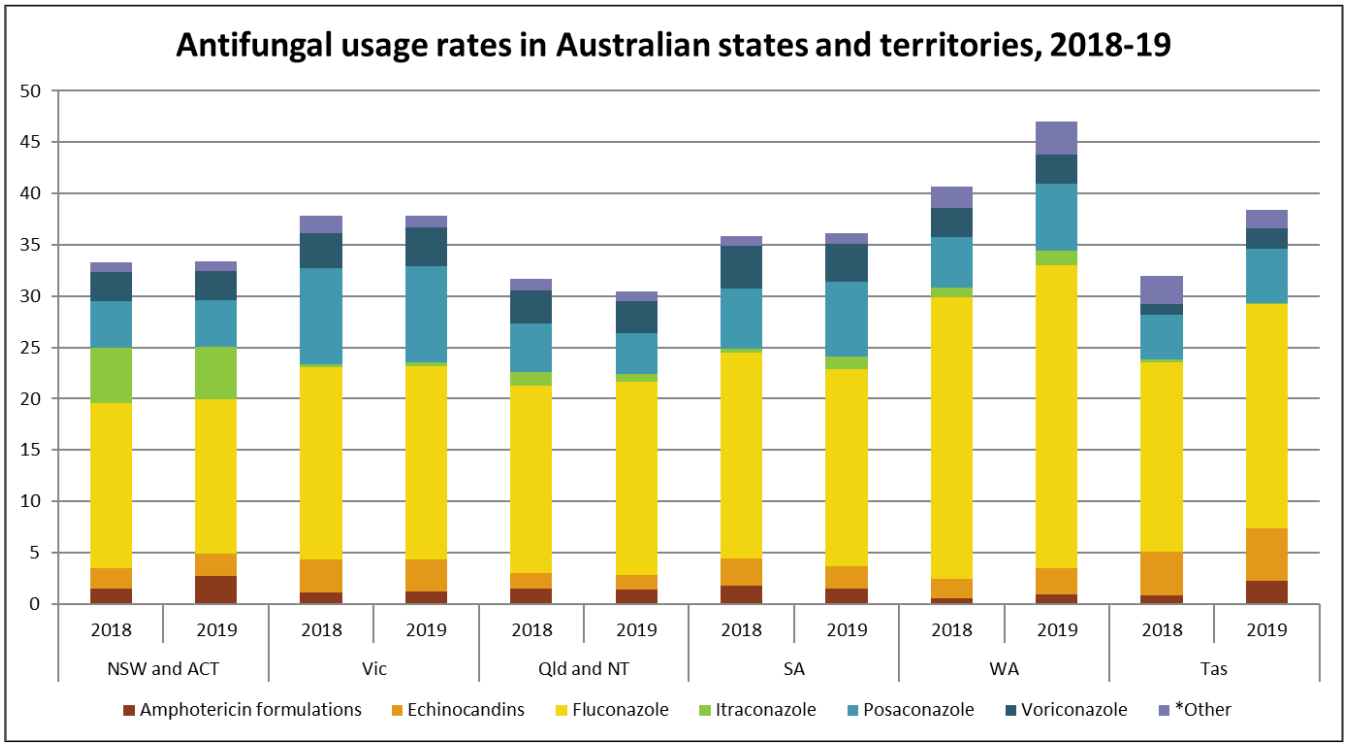
- Aggregate usage of itraconazole was more than three times greater in New South Wales/Australian Capital Territory than other states and territories
- Aggregate usage of fluconazole was highest in Western Australia followed by Tasmania, and was 25% higher than the aggregate use in the other states and territories
- Aggregate usage of Echinocandins in Tasmania was more than 1.5 times greater than the aggregate use in other states and territories

From 2018 to 2019:

- Usage of amphotericin formulations approximately doubled in Tasmania and New South Wales/Australian Capital Territory; however, this represents a small absolute change in the total aggregate usage rate
- The largest increase in total annual antifungal usage was reported by Tasmanian NAUSP contributor hospitals; (20.0%)
- Total annual usage increased markedly in Western Australia (15.6%).

In 2019, national usage rates increased for all antifungal classes. The largest annual increases were reported for fluconazole and posaconazole. The reasons for these increases are not clear, but could relate to historical under-reporting, differences in casemix, prescriber preferences or formulary listings.

Figure 19: Antifungal usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2018–2019



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day.
† Echinocandins includes anidulafungin, caspofungin and micafungin
*Other comprises flucytosine, griseofulvin, isavuconazole, ketoconazole and terbinafine.

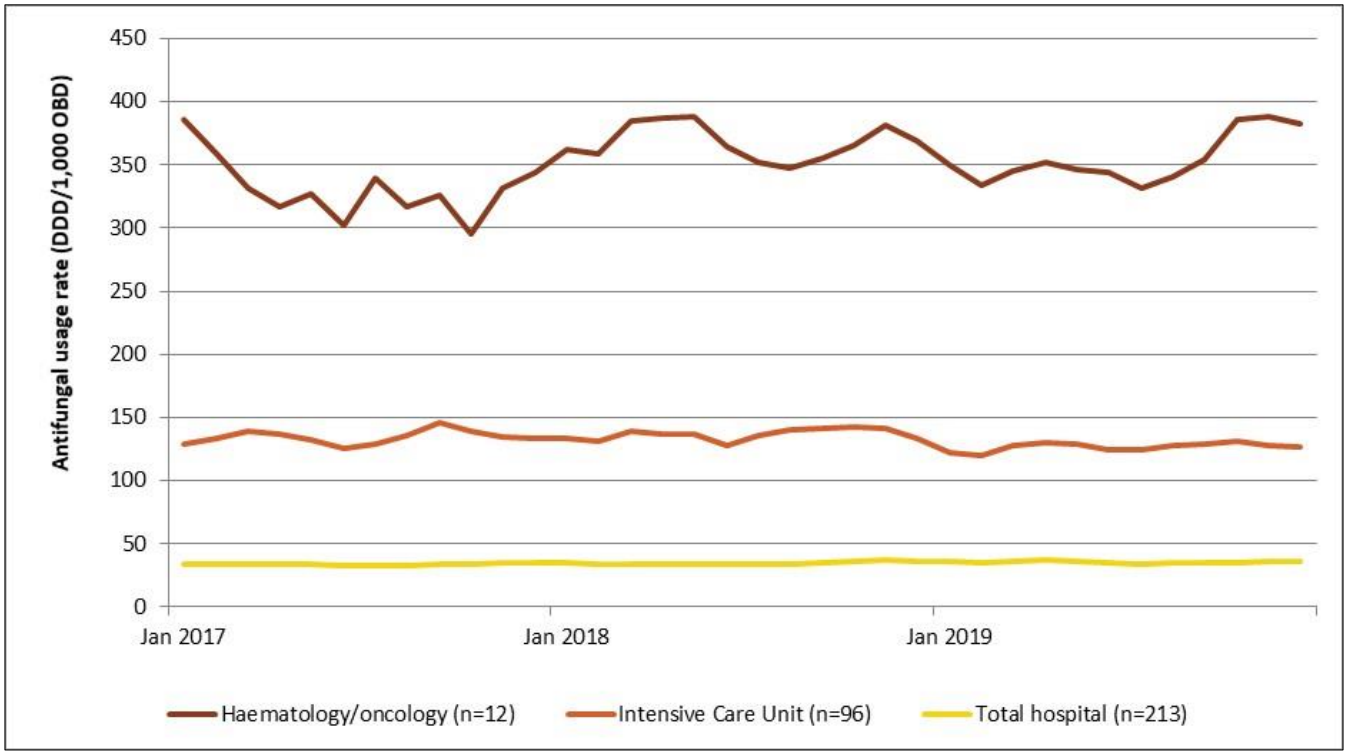
Antifungal usage in Australian hospitals by specialty

There were major variations in antifungal usage in Australian hospitals that contribute specialty unit data to NAUSP. In 2017, a small number of NAUSP participants (*n* = 9) commenced contributing antimicrobial usage data for haematology/oncology specialty units. There is a much higher rate of antifungal use in this specialty setting compared with non-specialty units, because of the risk of fungal infections in the patient population.

Figure 20 shows usage rates since 2017 for all antifungals in haematology/oncology (*n* = 12) and intensive care (*n* = 96) settings compared with total-hospital use (*n* = 213). Specialist cancer wards use antifungals both prophylactically for immunocompromised patients, and for treatment of invasive fungal disease. Rates of use were approximately 10 times higher than overall hospital use, highlighting the importance of antifungal stewardship in these units.

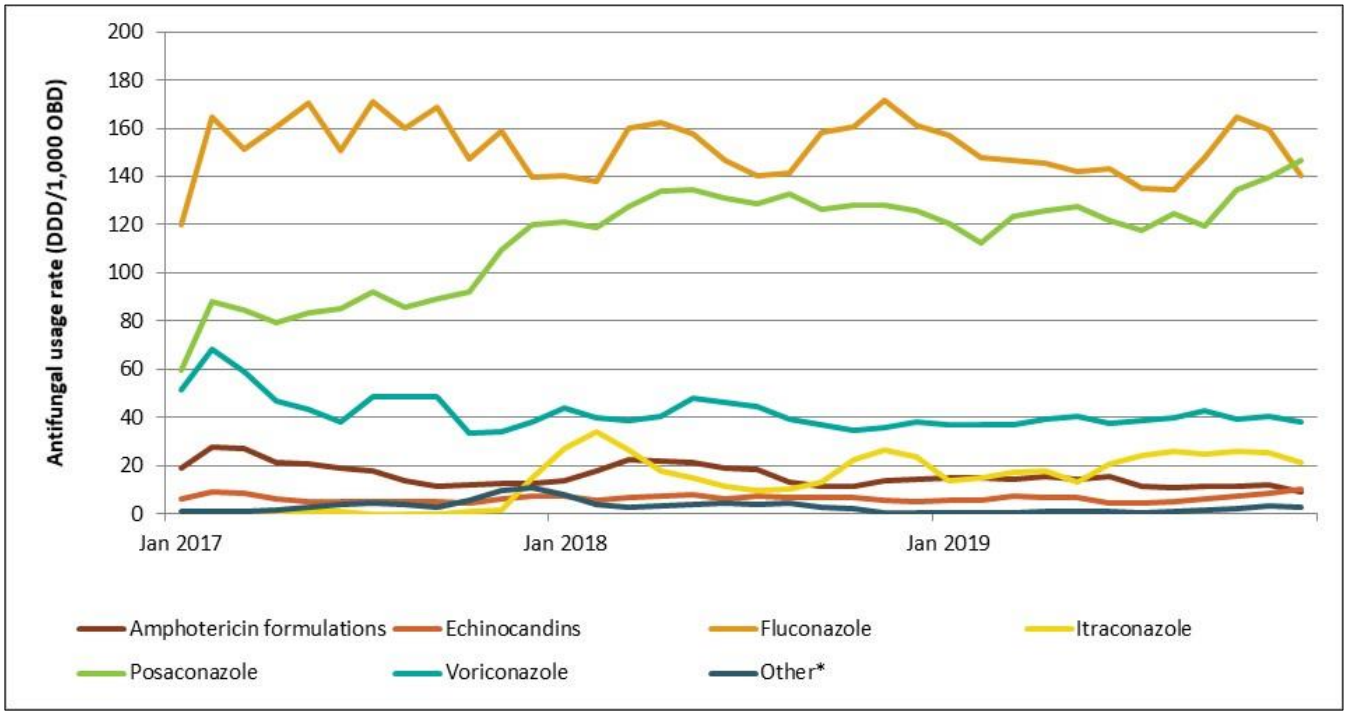
Analysis of haematology/oncology specialty unit data shows usage rates of posaconazole have increased since January 2017. There was also a small decrease in the usage rates of amphotericin formulations and voriconazole (Figure 21).

Figure 20: Antifungal usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by specialty and total hospital, 2017–2019



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day.

Figure 21: Antifungal usage rates (DDD/1,000 OBD) in haematology/oncology specialty units in NAUSP contributor hospitals, 2018–2019



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day.
* Echinocandins includes anidulafungin, caspofungin and micafungin
† Other comprises flucytosine, griseofulvin, isavuconazole, ketoconazole and terbinafine

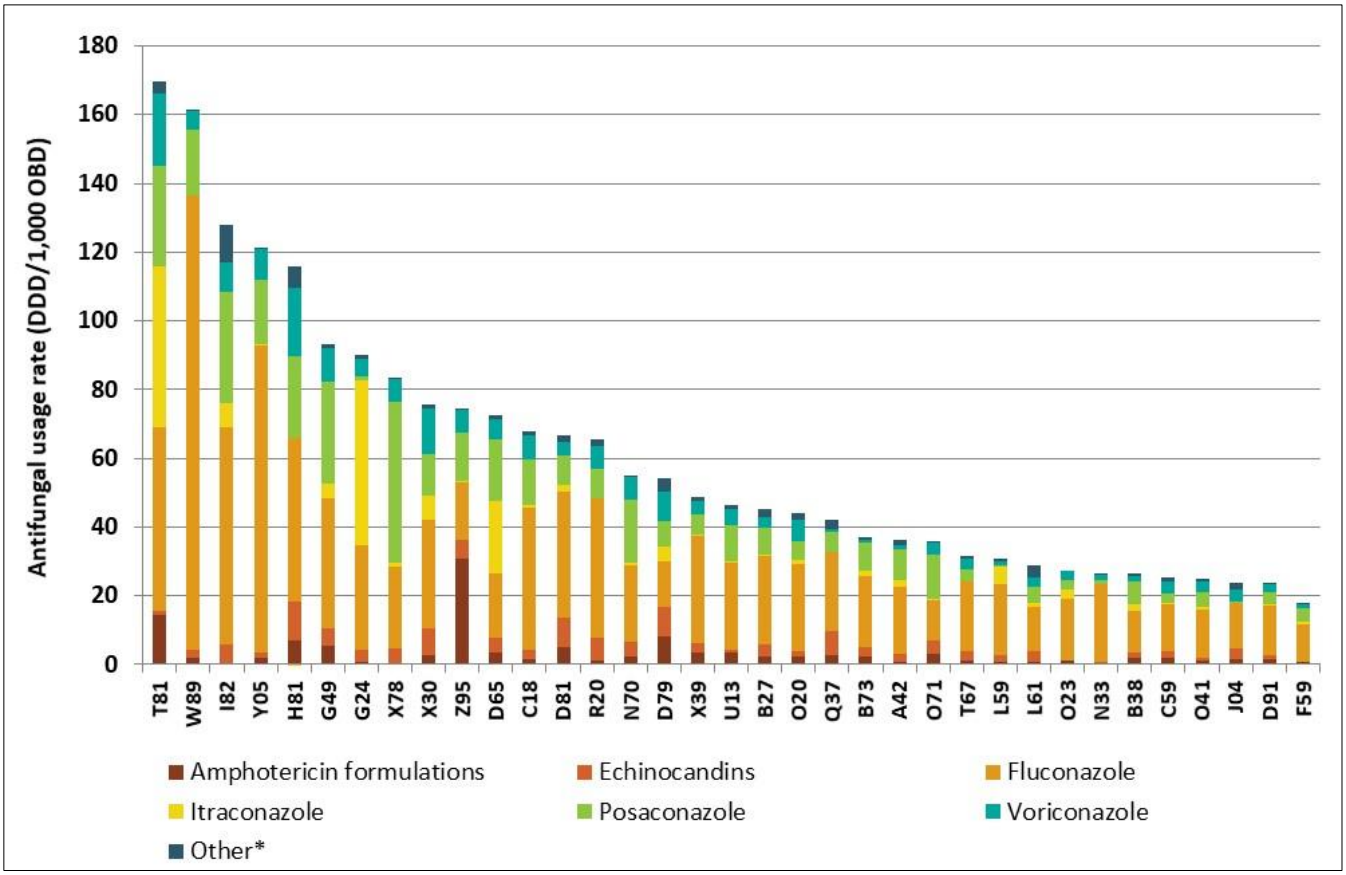
Antifungal usage in Australian hospitals by peer group

As would be expected, usage of systemic antifungals is higher in larger hospitals, particularly Principal Referral and Public Acute Group A NAUSP contributors. Usage rates for antifungal agents are highly dependent on the casemix of the hospital, including whether it provides transplant services.

Figures 22 and 24 show aggregated usage rates for all antifungals in 2019 for NAUSP contributor Principal Referral and Public Acute Group A hospitals respectively. Triazole antifungals accounted for the most antifungal usage in these hospitals. Amphotericin and echinocandin usage was minimal in comparison.

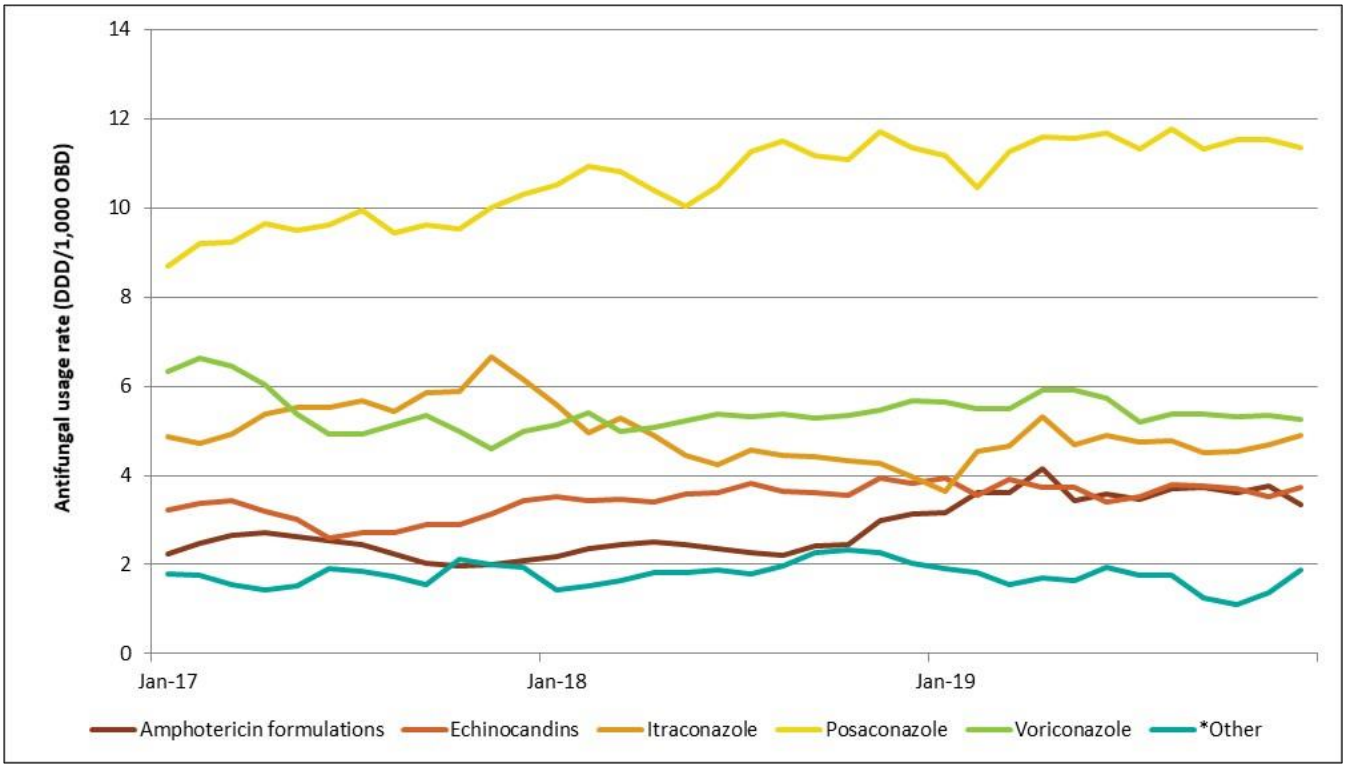
Fluconazole use was highest in both Principal Referral and Public Acute Group A hospitals, however, use has remained relatively stable since 2017. There was an increase in posaconazole use in Principal Referral hospitals from 2017 to 2019 (Figure 23), as well as an upward trend in usage of amphotericin formulations. In Public Acute Group A hospitals there was an increase in posaconazole, voriconazole and echinocandin usage rates from 2017 to 2019 (Figure 25). Itraconazole usage in Public Acute Group A hospitals decreased during the same period.

Figure 22: Antifungal usage rates (DDD/1,000 OBD) in NAUSP Principal Referral hospitals, 2019



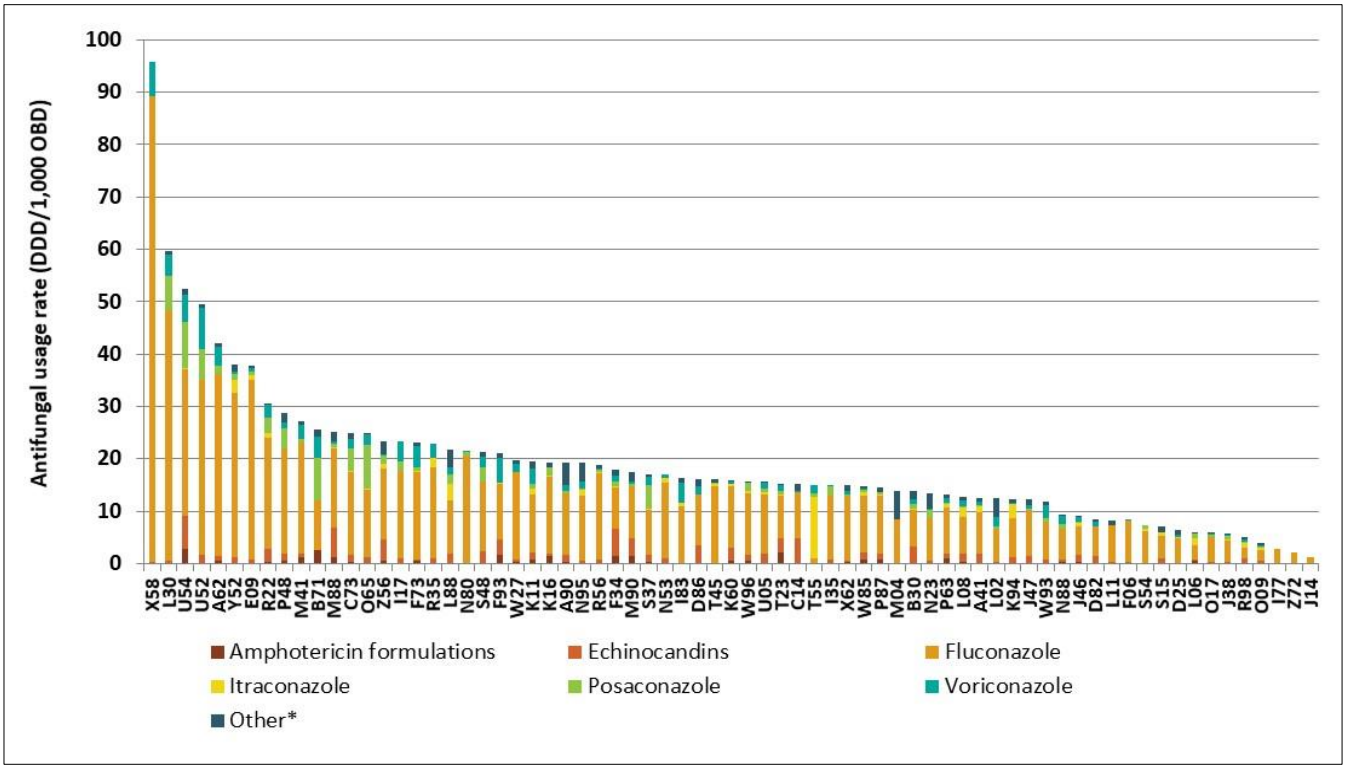
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day.
† Echinocandins includes anidulafungin, caspofungin and micafungin
*Other comprises flucytosine, griseofulvin, isavuconazole, ketoconazole and terbinafine

Figure 23: Antifungal usage rates (DDD/1,000 OBD) for selected antifungals in NAUSP Principal Referral hospitals, 2017–2019



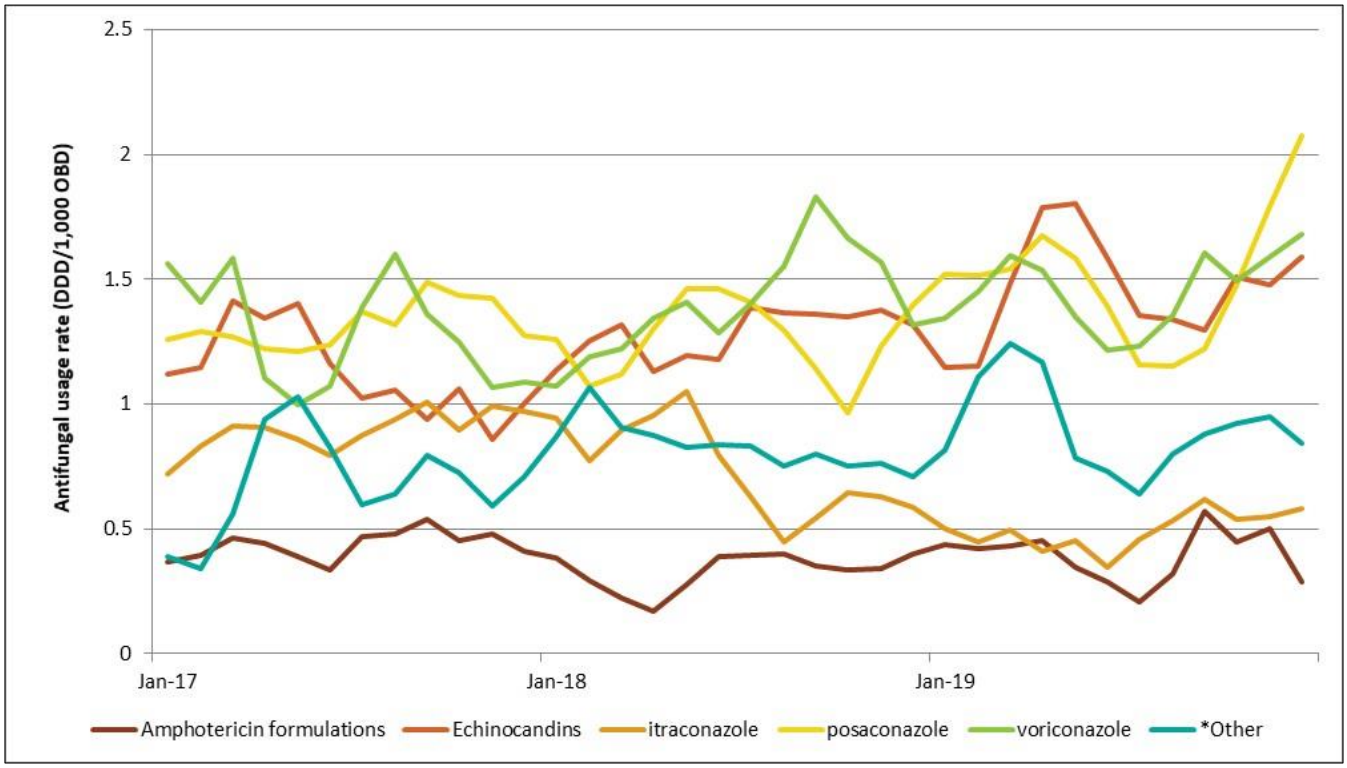
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day.
† Echinocandins includes anidulafungin, caspofungin and micafungin
*Other comprises flucytosine, griseofulvin, isavuconazole, ketoconazole and terbinafine.

Figure 24: Antifungal usage rates (DDD/1,000 OBD) in NAUSP Public Acute Group A hospitals, 2019



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day.
† Echinocandins includes anidulafungin, caspofungin and micafungin
*Other comprises flucytosine, griseofulvin, isavuconazole, ketoconazole and terbinafine

Figure 25: Antifungal usage rates (DDD/1,000 OBD) for selected antifungals in NAUSP Public Acute Group A hospitals, 2017–2019



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
† Echinocandins includes anidulafungin, caspofungin and micafungin
*Other comprises flucytosine, griseofulvin, isavuconazole, ketoconazole and terbinafine

Topical antimicrobial usage in Australian hospitals

Since January 2019, topical antimicrobials have been included in the NAUSP data definitions. Very few clinical situations require treatment with topical antibacterials. Despite not being used systemically, topical antimicrobial usage adds to antimicrobial burden and increases the risk of antimicrobial resistance. There are currently 160 different topical antimicrobial formulations included in the NAUSP database, comprised of at least one of 46 unique antimicrobials. Of the topical antimicrobial formulations reported to NAUSP, 30.6% (*n* = 49) were for ocular use.

The proportion of NAUSP contributors providing data on inpatient usage of topical antimicrobials has increased since the program definitions changed in January 2019, with 74% of contributors submitting topical antimicrobial usage data in December 2019.

There are no DDDs for topical antimicrobials; topical usage has been reported as the number of milligrams (mg) of active ingredient per 1,000 OBDs.

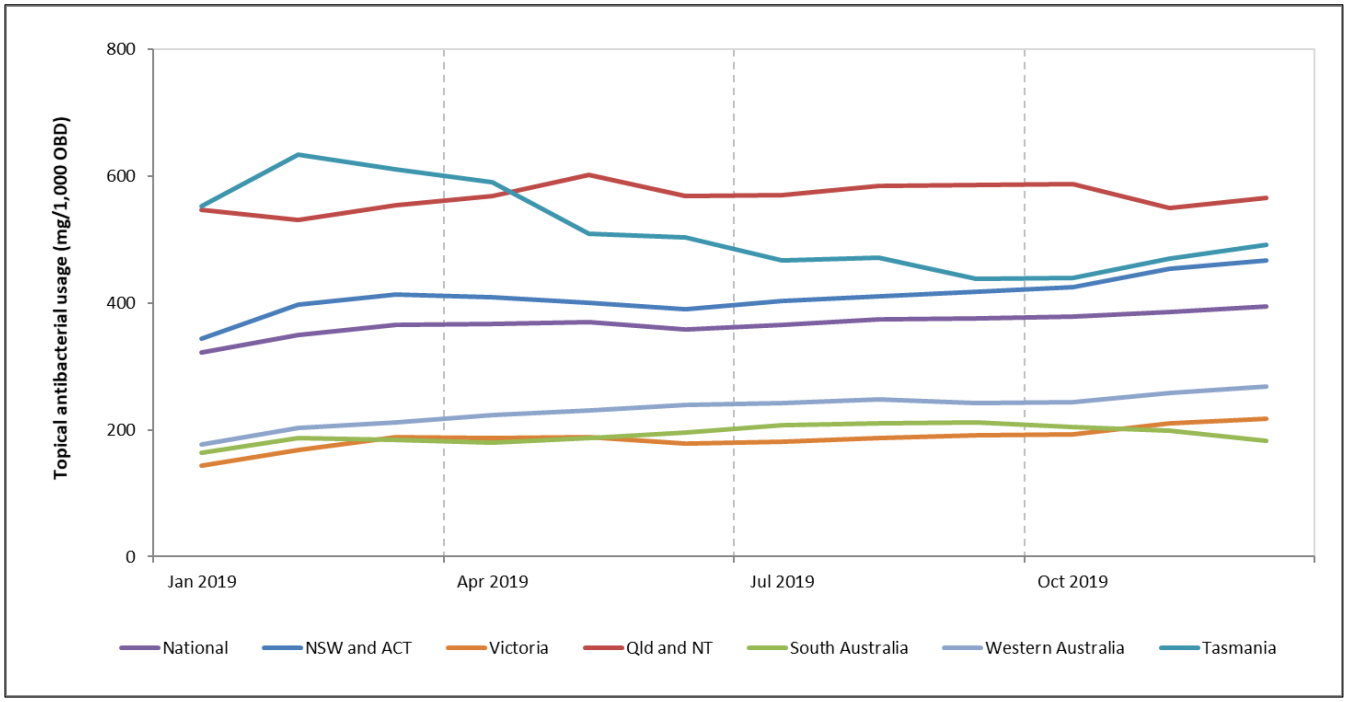
High volume topical antimicrobials

This section provides the 2019 usage rates for some of the high volume topical antimicrobials used in Australian hospitals.

Chloramphenicol eye ointment

Topical antibacterials are appropriate for use in confirmed or suspected ophthalmological infections, and are also used for surgical prophylaxis in ophthalmology. There is a paucity of evidence to support widespread use of chloramphenicol in surgical wounds outside of its main ophthalmic indication. A limitation of the NAUSP dataset is that it is not possible to differentiate chloramphenicol usage in ophthalmology from other usage, however it is notable that discharge and outpatient usage is excluded from this analysis. Comparative inpatient usage of 1% chloramphenicol ointment across the states and territories is shown in Figure 26.

Figure 26: Inpatient use of chloramphenicol 1% eye ointment (milligrams of active ingredient/1,000 OBDs) in NAUSP contributor hospitals, by state and territory, 2019 (3-month moving average)



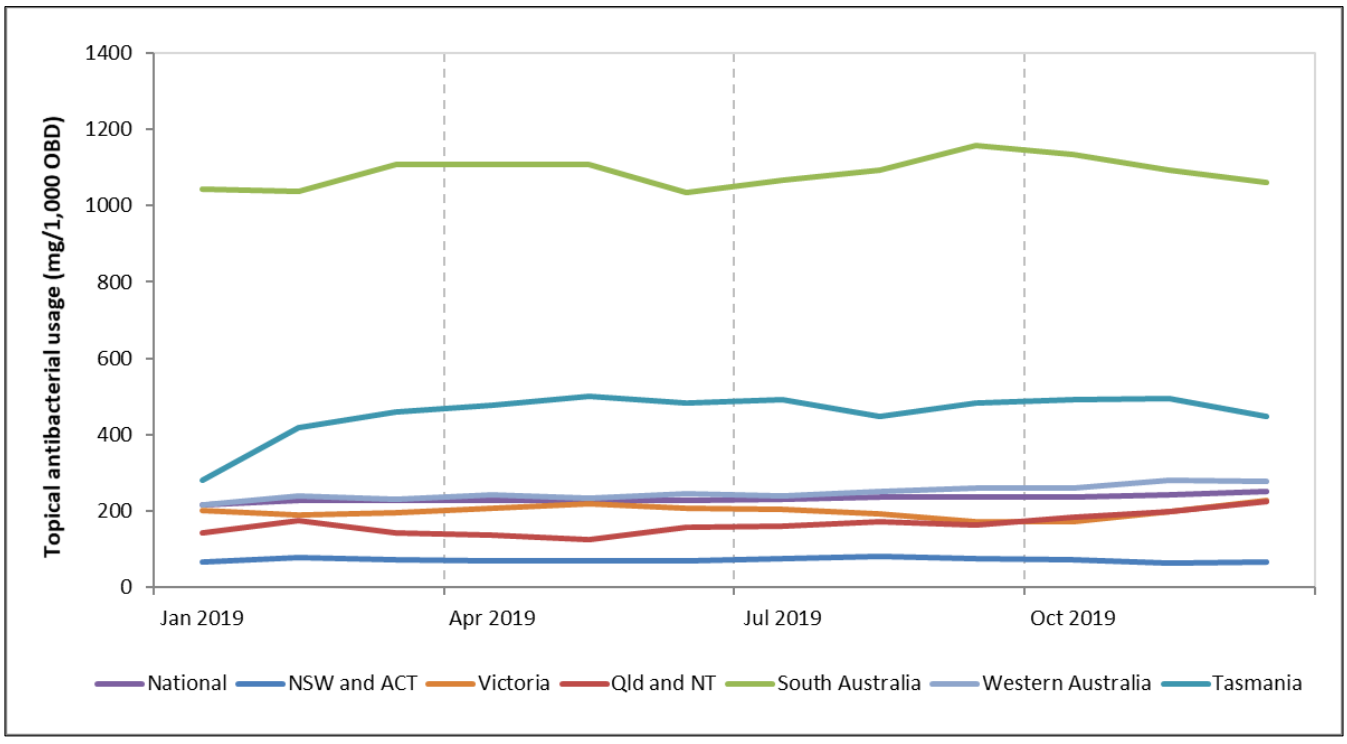
Mupirocin

Mupirocin is available in Australia as a 2% cream or ointment, including an intranasal ointment. The prevalence of mupirocin-resistant *S. aureus* varies globally, and a number of studies have reported increased rates of resistance associated with overuse in the community.[15,16] Use of mupirocin to treat MRSA skin infections has been associated with emergence of mupirocin-resistant community-associated strains of MRSA.[15] Reported mupirocin-resistance in MRSA in Australia is currently 1.9%.[17]

At the time of data extraction, 53% of NAUSP contributors had submitted mupirocin usage data for 2019. A lack of compliance with this data inclusion was identified during data quality assurance processes, and attributed to an error in data extraction from iPharmacy® dispensing systems.

There was wide variability in the use of mupirocin among the sites that contributed usage data. The median usage was 89.3mg/1000 OBDs (inter-quartile range [IQR]: 44.2–250.8, *n* = 113), however there were some (*n* = 5) extreme outliers with total annual usage rates greater than 2,000mg/1,000 OBDs. Inpatient usage of mupirocin was over five times higher in South Australia than most other states and territories (Figure 27); however, this comparative usage may be skewed as some large hospitals in other states and territories did not submit data on mupirocin usage.

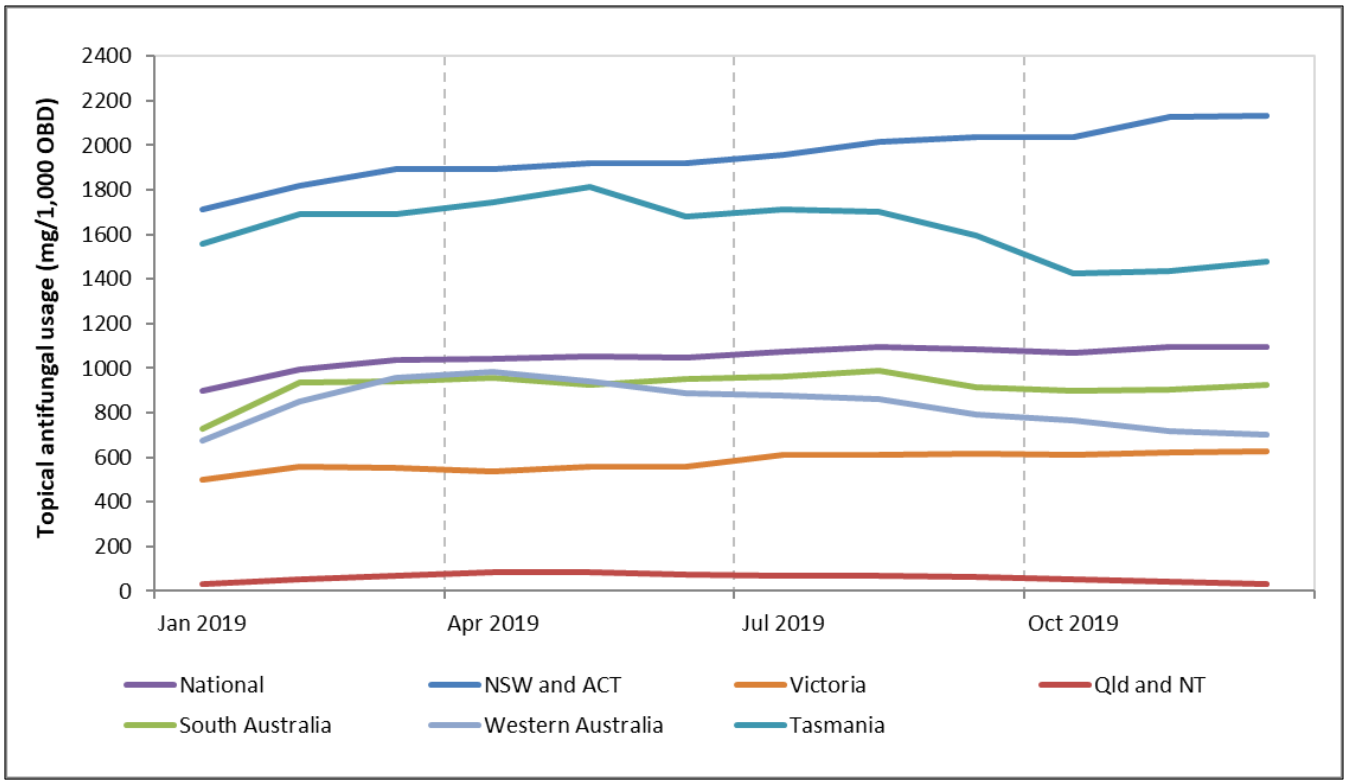
Figure 27: Usage of topical mupirocin (mg of active ingredient/1,000 OBDs) in NAUSP contributor hospitals, by state and territory, 2019



Clotrimazole

Clotrimazole usage reported to NAUSP included topical creams, topical liquids, pessaries and vaginal creams. Inpatient use of clotrimazole is extremely variable across the states and territories, as illustrated in Figure 28.

Figure 28: Dermatological usage of clotrimazole (mg/1,000 OBDs) in NAUSP contributor hospitals, by state and territory, 2019 (3-month moving average)



*Excludes vaginal usage

Discussion and conclusions

Total antibacterial usage in Australian hospitals increased annually from 2016 to 2019, following sustained reductions in total usage between 2010 and 2016.

There was marked variation in antimicrobial usage between the states and territories, and between and within hospital peer groups, across multiple antibacterial and antifungal classes. While some variation is to be expected due to differing casemix between hospitals, the large differences in aggregate usage of some broad-spectrum agents across the states and territories and peer groups is not readily explained.

Previous NAUSP reports have highlighted appreciable changes in patterns of broad-spectrum antimicrobial use in response to a significant national shortage of piperacillin–tazobactam. During the shortage, use of third- and fourth-generation cephalosporins increased in addition to the increased uptake of intravenous amoxicillin–clavulanic acid use in all states and territories following registration in Australia.

Analysis of longitudinal data shows that although annual usage of beta-lactamase inhibitor combinations was declining overall prior to the 2017 shortage, there has been a sustained increase in use of third- and fourth-generation cephalosporins, despite the resumption of piperacillin–tazobactam supply. Some of this may be accounted for by changes in national recommendations for ceftriaxone doses for certain conditions (e.g. sexually-acquired pelvic inflammatory disease; peritonitis due to perforated viscus for patients hypersensitive to penicillin; infected pancreatic necrosis for patients hypersensitive to penicillin and high severity community acquired pneumonia). The new guidelines suggest administration of two grams for a number of conditions, whereas in previous versions one gram was generally recommended. The increased use from the new dosage recommendations should be reviewed in all facilities to ensure that optimal prescribing practices are maintained.

Last-line antimicrobial use continues to increase in Australian hospitals that contribute to NAUSP. Although usage was low overall, there were relative increases of over 200% for some antimicrobials used to treat highly resistant organisms such as VRE, and multidrug-resistant gram-negative infections. The increasing use may be related to the increasing incidence of invasive infections with multidrug-resistant organisms. Australia has reported rates higher than all European countries except Cyprus, Greece and Poland in rates of resistance to vancomycin in *E. faecium* and the incidence of infections with carbapenemase-producing *Enterobacterales* (CPE) is increasing.[18,19]

Use of cefalexin and oral amoxicillin–clavulanic acid and optimising surgical antimicrobial prophylaxis have been identified as focus areas in previously published AURA reports.[20] There have not been large changes in combined usage of the classes of β-lactamase inhibitor combinations (including piperacillin–tazobactam and intravenous amoxicillin–clavulanic acid) and first-generation cephalosporins since 2015. However, usage of second-generation cephalosporins has increased by over 50%. This increase may be attributable to increased use of cefuroxime, perhaps because of improved use for community-acquired pneumonia in patients who are allergic to penicillin in preference to cefalexin. Anecdotally, this practice is common, but not recommended.

Another focus of the AURA reports has been the use of carbapenems. Usage increased by 16.2% from 2015 to 2019 in NAUSP contributor hospitals; and by 4.5% from 2018 to 2019, predominantly due to a 31.95% increase in Tasmania. Ertapenem is often used in the outpatient or hospital-in-the-home settings due to its stability and cost considerations; NAUSP only captures data for adult acute admitted care settings. This limits capacity to measure and benchmark antimicrobial usage in these and other admitted and non-admitted settings such as non-acute, paediatric, dialysis and oncology day clinics. Ensuring appropriate use of carbapenems in all healthcare settings is important for patient safety and to minimise the risk of AMR. The data should be used for health service organisations to reflect upon their own trends and reasons for variation with comparators. For example in Tasmania, investigation of increased carbapenem usage was attributed to prolonged directed therapy in a few individual patients. It is important to consider that small

states such as Tasmania, where there are relatively few hospitals to contribute data, may show substantial variation as a few individuals can make a large proportional difference to usage.

This is the first NAUSP report that has included analysis of antibacterial usage categorised using the Priority Antibacterial List. This AMS tool enables Australian hospitals to benchmark their usage of Curb and Contain antibacterials against other similar hospitals and to monitor their usage over time. This first analysis shows large variation in the proportion of Access category antibacterial use between facilities. While some variation among hospitals can be explained by casemix differences, analysis using the Priority Antibacterial List provides an alternative benchmarking method to highlight potential undesirable trends in usage. Preferential use of Access versus Curb and Contain category antibacterials should be prioritised where possible to preserve these for use only when clinically necessary. This categorisation is useful when interpreting usage data. For example, whilst Tasmania had the highest reported antibacterial usage nationally, it also had the highest proportionate use in the Access category. This demonstrates that a high volume of antibacterial usage may not always be inappropriate. Ideally, if the majority of antimicrobial use should be in the Access category, representing antimicrobials that are recommended as first-line treatments for infections or where there is low resistance potential.

Current NAUSP methodology is unable to capture usage in the outpatient setting. The increasing implementation of electronic medicines management systems in Australian health service organisations provides an opportunity to expand data collection to include usage in non-admitted and non-acute settings. These systems also enable the use of different metrics for antimicrobial usage such as days of therapy (DOTs), which are particularly useful for paediatric settings, where DDDs cannot be used.

The substantial variation in usage rates of topical antimicrobials and antifungals may be due to casemix or facility-specific approaches to prophylaxis for organisms such as invasive fungal infections or MRSA decolonisation with topical antibacterials. Benchmarking against like facilities will assist with investigating these issues, as will review of usage to ensure it is consistent with prescribing guidelines.

In summary, as seen in previous NAUSP reports, there is ongoing substantial variation in antimicrobial usage across the states and territories for multiple antimicrobial classes. For many Australian hospitals contributing data to NAUSP, the proportion of antibacterial usage categorised as Curb in the Priority Antibacterial List[1] is greater than usage of antimicrobials categorised as Access. This finding indicates that there are opportunities to promote improved use, which will enhance the safety of care provided to patients.

States, territories, private health service providers and individual hospitals should use these analyses to inform development of AMS interventions to improve antimicrobial prescribing and patient safety.

Appendix 1: Methods

This section describes data elements, quality assurance processes and analyses.

Data elements

Pharmacy departments of Australian hospitals that participate in NAUSP supply monthly antimicrobial utilisation data, based on dispensing and distribution reports for the different clinical departments or wards for inpatient use. Hospital occupancy data are collected on a monthly basis in the form of occupied bed days (OBDs).

Each contributing hospital is assigned a unique code by NAUSP. Contributor codes allow de-identified comparative usage rates to be reported, enabling hospitals to benchmark their usage against other similarly peered hospitals. All hospitals currently contributing data to NAUSP were issued with a new de-identified contributor code on 1 January 2020.

Data quality

Each contributing hospital is responsible for the accuracy of antimicrobial usage data submitted to NAUSP, including compliance with NAUSP data definitions.[21] Alerts are generated automatically during the data submission process if quantities fall outside a usual or expected range. This enables validation of data at an early stage of data submission.

The NAUSP team performs periodic quality assurance processes to validate the accuracy and integrity of the data uploaded into the portal.[22] The NAUSP team notifies contributors if data anomalies are identified or if resubmission of data is required.

Measurement of consumption rates

Antimicrobial surveillance data are reported by NAUSP as a standardised usage density rate on a monthly basis. Usage rates are only calculated for inpatient use, with OBDs being the denominator used. Consumption data submitted to NAUSP are aggregated into the total number of grams used each month for each individual antimicrobial. Antimicrobial usage is then converted from total grams used into the Defined Daily Dose (DDD) metric assigned for each antimicrobial by the World Health Organization (WHO). These DDD values are based on “the assumed average maintenance dose per day for the main indication in adults”.[23] One limitation of the DDD as a consumption metric is that for some antimicrobials the DDD does not always reflect the usual daily doses used in Australian clinical practice (see Appendix 2, Limitations).

DDDs are reviewed by the WHO annually as dosing recommendations change over time and may no longer correlate with DDD values. On 1 January 2019, new increased DDD values were assigned to nine broad-spectrum antimicrobials (Table A1).

Table A1: Changes to DDD values from 1 January 2019[24]

Antibacterial	Anatomical Therapeutic Chemical Classification	Route of administration	DDD prior to January 2019	DDD from January 2019
Amoxicillin	J01CA04	Oral	1g	1.5g
Amoxicillin	J01CA05	Parenteral	1g	3g
Amoxicillin with clavulanic acid	J01CR02	Oral	1g	1.5g
Ampicillin	J01CA01	Parenteral	2g	6g
Ampicillin with sulbactam	J01CR01	Parenteral	2g	6g
Cefepime	J01DE01	Parenteral	2g	4g
Ciprofloxacin	J01MA02	Parenteral	0.5g	0.8g
Colistin	J01XB01	Parenteral	0.1g (3MU)	0.3g (9MU)
Meropenem	J01DH02	Parenteral	2g	3g

Utilisation rates in this report have been calculated using the DDD values as at 1 January 2019.[25] As a result, rates reported will differ from previous NAUSP reports that used the DDD values that applied prior to 1 January 2019. In addition to changes to the DDD values (Table A1), care is required when interpreting NAUSP data because of possible anomalies relating to DDD definitions for other antimicrobials.

There are no DDDs for topical antimicrobials; topical usage has been reported as the number of grams or milligrams (mg) of active ingredient per 1,000 OBDs.

The data presented in this report are correct at the time of publication, and reflect usage rates based on data on antibacterial and antifungal quantities and OBDs supplied by individual contributors. Minor discrepancies between NAUSP reports may occur as a result of data submitted retrospectively by contributing hospitals or by the inclusion of hospitals that were excluded from previous reports due to issues regarding data validity.

Box 1: Antimicrobial usage rates explained

- Defined daily dose (DDD): the DDD for any medicine is the average maintenance dose per day for an average adult for the main indication of the medicine.
- Occupied bed days (OBD): a measure of hospital activity. One patient admitted for 10 days = 10 OBD; 10 patients admitted overnight = 10 OBD.
- Aggregate: the sum of all DDDs used in the state or territory divided by the sum of all OBDs in the state or territory – the overall antimicrobial usage rate for the state or territory.
- DDD per 1,000 OBD: a measure of the rate of antimicrobial use, referenced to hospital activity and therefore allowing some comparison between hospitals of different sizes.
- Mean: the average of individual hospitals' DDDs/1,000 OBDs (this is not the same as the aggregate as larger hospitals are over-represented in NAUSP data for most states and territories.)
- Median: the middle value of individual hospital's usage rates

Appendix 2: Limitations

The antimicrobial usage rates calculated for this report are correct at the time of publication, and are contingent on the accuracy of the antibacterial and antifungal quantities and occupied bed days (OBDs) supplied by individual contributors, including compliance with NAUSP data definitions. Minor discrepancies between annual reports may occur as a result of data submitted retrospectively by contributing hospitals or by the inclusion of hospitals that were excluded from previous reports due to issues regarding data validity. Due to smaller numbers of private hospitals contributing data to NAUSP, data from private hospitals has been benchmarked with public hospitals of similar size and acuity. Data from Public Acute Group D, Private Acute Group D, Public Acute Group C and Private Acute Group C have been combined as a single benchmarking group.

Usage reflects antimicrobials distributed or dispensed from pharmacy and does not reflect actual antimicrobial consumption at patient level. Reported usage rates are limited to acute-hospital usage only and does not include antimicrobial use in subacute specialties. Outpatient usage and day-only usage is currently not included in NAUSP data. Inpatient theatre usage is included in NAUSP on the assumption a corresponding OBD is recorded in the inpatient ward where the patient is transferred to following theatre. For hospitals that are not able to differentiate between usage for inpatient surgery as opposed to usage for day surgery, this introduces a level of uncertainty into the rates calculated.

Antimicrobials currently included in the NAUSP dataset are the most commonly used antibacterials and antifungals in Australian hospitals. The Defined Daily Doses (DDDs) assigned by the World Health Organization (WHO) Anatomical Therapeutic Classification (ATC) system are used to calculate the usage rates. Care is required when interpreting NAUSP data where the WHO DDD does not accurately reflect the Australian setting. If routine doses used in the Australian setting are higher or lower than the WHO-assigned DDD, this may contribute to an over- or under-estimation of usage rates.

Appendix 3: Contributors

Table A2: Hospitals that contributed data included in the analyses for this 2019 NAUSP report

State or territory	Hospital		
New South Wales	Armidale Hospital	Grafton Base Hospital	Port Macquarie Base Hospital
	Auburn Hospital	Griffith Base Hospital	Prince of Wales Hospital
	Bankstown Hospital	Hornsby Ku-Ring-Gai Hospital	Queanbeyan Hospital
	Batemans Bay District Hospital	John Hunter Hospital	Royal North Shore Hospital
	Bathurst Base Hospital	Kempsey District Hospital	Royal Prince Alfred Hospital
	Belmont Hospital	Lismore Base Hospital	Ryde Hospital
	Blacktown Hospital	Lithgow Hospital	Scott Memorial Hospital
	Bowral Hospital	Liverpool Hospital	Shellharbour Hospital
	Broken Hill Base Hospital	Maclean District Hospital	Shoalhaven Hospital
	Calvary Riverina Hospital	Maitland Hospital	Singleton District Hospital
	Campbelltown Hospital	Manning Base Hospital	South East Regional Hospital
	Canterbury Hospital	Mater Hospital North Sydney	St George Hospital
	Cessnock District Hospital	Milton-Ulladulla Hospital	St Vincent's Hospital Sydney
	Chris O'Brien Lifehouse	Mona Vale Hospital	St Vincent's Private Hospital Sydney
	Coffs Harbour Hospital	Moruya Hospital	Sutherland Hospital
	Concord Hospital	Mt Druitt Hospital	Sydney Adventist Hospital
	Cooma Hospital	Mudgee District Hospital	Tamworth Hospital
	Dubbo Base Hospital	Muswellbrook Hospital	The Tweed Hospital
	Fairfield Hospital	Nepean Hospital	Wagga Wagga Base Hospital
	Forbes District Hospital	Newcastle Mater	Westmead Hospital
	Gosford Hospital	Northern Beaches Hospital	Wollongong Hospital
	Gosford Private Hospital	Orange Health Service	Wyong Hospital
	Goulburn Base Hospital	Parkes Hospital	Young Health Service
Australian Capital Territory	Calvary Public Hospital Bruce	Canberra Hospital	

State or territory	Hospital		
Queensland	Atherton Hospital	Mareeba Hospital	Queen Elizabeth 2 Jubilee Hospital
	Bundaberg Hospital	Maryborough Hospital	Redcliffe Hospital
	Caboolture Hospital	Mater Bundaberg	Redland Hospital
	Cairns Base Hospital	Mater Gladstone	Robina Hospital
	Gladstone Hospital	Mater Hospital Brisbane	Rockhampton Hospital
	Gold Coast Private Hospital	Mater Mackay	Royal Brisbane And Women's Hospital
	Gold Coast University Hospital	Mater Mothers' Hospital	St Stephen's Hospital Hervey Bay
	Greenslopes Hospital	Mater Private Hospital Brisbane	St Vincent's Private Hospital Brisbane
	Gympie Health Service	Mater Private Hospital Springfield	St Vincent's Private Hospital Northside
	Hervey Bay Hospital	Mater Redland Private	Sunshine Coast University Hospital
	Innisfail Hospital	Mater Rockhampton	The Prince Charles Hospital
	Ipswich Hospital	Mt Isa Hospital	Toowoomba Hospital
	Kingaroy Hospital	Nambour General Hospital	Townsville Hospital
	Logan Hospital	Princess Alexandra Hospital	Warwick Hospital
	Mackay Base Hospital		
Northern Territory	Alice Springs Hospital	Gove District Hospital	Palmerston Regional Hospital
	Darwin Private Hospital	Katherine District Hospital	Royal Darwin Hospital
South Australia	Ashford Hospital	Lyell McEwin Hospital	Port Pirie Hospital
	Berri Hospital	Memorial Hospital	Queen Elizabeth Hospital
	Calvary Adelaide Private Hospital	Modbury Hospital	Royal Adelaide Hospital
	Calvary Central Districts Hospital	Mt Gambier Hospital	South Coast District Hospital
	Calvary North Adelaide Hospital	Noarlunga Hospital	St Andrew's Hospital
	Flinders Medical Centre	Port Augusta Hospital	Whyalla Hospital
	Flinders Private Hospital	Port Lincoln Hospital	Women’s and Children’s Hospital
	Gawler Health Service		
Tasmania	Calvary Lenah Valley	Launceston General Hospital	North West Regional Hospital
	Hobart Private Hospital	Mersey Community Hospital	Royal Hobart Hospital

State or territory	Hospital		
Victoria	Albury Wodonga - Albury	Frankston Hospital	St John Of God Geelong
	Albury Wodonga - Wodonga	Geelong Hospital	St Vincent's Hospital Melbourne
	Alfred Hospital	Holmesglen Private Hospital	St Vincent's Private East Melbourne
	Angliss Hospital	Maroondah Hospital	St Vincent's Private Fitzroy
	Austin Hospital	Mercy Women's Hospital	St Vincent's Private Hospital Kew
	Ballarat Base Hospital	Monash Medical Centre Clayton	St Vincent's Private Werribee
	Bendigo Health	Monash Moorabbin Hospital	The Northern Hospital
	Box Hill Hospital	Northeast Health Wangaratta	Warrnambool Base Hospital
	Cabrini Hospital Brighton	Peter Maccallum Cancer Centre	Werribee Mercy Hospital
	Cabrini Hospital Malvern	Rosebud Hospital	West Gippsland Hospital
	Casey Hospital	Royal Melbourne Hospital	Western Health Footscray
	Central Gippsland Health	Sandringham Hospital	Western Health Sunshine
	Dandenong Hospital		
Western Australia	Albany Hospital	Geraldton Hospital	Osborne Park Hospital
	Bentley Health Service	Hedland Health Campus	Rockingham Hospital
	Broome Hospital	Joondalup Health Campus	Royal Perth Hospital
	Bunbury Regional Hospital	Kalgoorlie Health Campus	Sir Charles Gairdner Hospital
	Busselton Health	King Edward Memorial Hospital	St John Of God Bunbury
	Derby Hospital	Kununurra Hospital	St John Of God Midland
	Esperance Hospital	Mount Hospital	St John Of God Mt Lawley
	Fiona Stanley Hospital	Narrogin Hospital	St John Of God Murdoch
	Fremantle Hospital	Northam Hospital	St John Of God Subiaco

Appendix 4: Antimicrobial agents – WHO Anatomical Therapeutic Classification for antimicrobial agents included in NAUSP analyses

Antibacterial agents

ATC classification	Generic name	DDD (g)	Route
J01AA	Tetracyclines		
J01AA02	Doxycycline	0.1	O, P
J01AA08	Minocycline	0.2	O, P
J01AA12	Tigecycline	0.1	P
J01B	Amphenicols		
J01BA01	Chloramphenicol	3	O, P
J01C	β–lactam antibacterials, penicillins		
J01CA	Penicillins with extended spectrum		
J01CA01	Ampicillin	6*	O, P
J01CA04	Amoxicillin	1.5*	O
J01CA04	Amoxicillin	3*	P
J01CA17	Temocillin	4	P
J01CE	β–lactamase-sensitive penicillins		
J01CE01	Benzylpenicillin	3.6	P
J01CE02	Phenoxymethylpenicillin	2	O
J01CE08	Benzathine benzylpenicillin	3.6	P
J01CE09	Procaine benzylpenicillin	0.6	P
J01CF	B-lactamase-resistant penicillins		
J01CF01	Dicloxacillin	2	O, P
J01CF05	Flucloxacillin	2	O, P
J01CR	Combinations of penicillins, including β–lactamase inhibitors		
	Without antipseudomonal activity		
J01CR02	Amoxicillin and enzyme inhibitor	1.5*	O
J01CR02	Amoxicillin and enzyme inhibitor	3	P
	With antipseudomonal activity		
J01CR03	Ticarcillin and enzyme inhibitor	15	P
J01CR05	Piperacillin and enzyme inhibitor	14	P
J01D	Other β-lactam antibacterials		
J01DB	First-generation cephalosporins		
J01DB01	Cefalexin	2	O
J01DB03	Cefalotin	4	P
J01DB04	Cefazolin	3	P
J01DC	Second-generation cephalosporins		

ATC classification	Generic name	DDD (g)	Route
J01DC01	Cefoxitin	6	P
J01DC02	Cefuroxime	0.5	O
J01DC04	Cefaclor	1	O
J01DD	Third-generation cephalosporins		
J01DD01	Cefotaxime	4	P
J01DD02	Ceftazidime	4	P
J01DD04	Ceftriaxone	2	P
J01DD08	Cefixime	0.4	O
J01DD52	Ceftazidime and enzyme inhibitor	6	P
J01DE	Fourth-generation cephalosporins		
J01DE01	Cefepime	4	P
J01DH	Carbapenems		
J01DH02	Meropenem	3	P
J01DH03	Ertapenem	1	P
J01DH04	Doripenem	1.5	P
J01DH51	Imipenem and enzyme inhibitor	2	P
J01DF	Monobactam		
J01DF01	Aztreonam	4	P
J01DI	Other cephalosporins and penems		
J01DI02	Ceftaroline	1.2	P
J01DI03	Faropenem	0.75	O
J01DI54	Ceftolozane and β-lactamase inhibitor	3	P
J01E	Sulfonamides and trimethoprim		
J01EA01	Trimethoprim	0.4	O, P
J01EC02	Sulfadiazine	0.6	O
J01EE01	Sulfamethoxazole and trimethoprim	1.9	O, P
J01F	Macrolides, lincosamides and streptogramins		
J01FA	Macrolides		
J01FA01	Erythromycin	1	O, P
J01FA01	Erythromycin ethylsuccinate	2	O
J01FA02	Spiramycin	3	O
J01FA06	Roxithromycin	0.3	O
J01FA09	Clarithromycin	0.5	O
J01FA10	Azithromycin	0.3	O
J01FA10	Azithromycin	0.5	P
J01FF	Lincosamides		
J01FF01	Clindamycin	1.2	O
J01FF01	Clindamycin	1.8	P
J01FF02	Lincomycin	1.8	P
J01FG	Streptogramins		

ATC classification	Generic name	DDD (g)	Route
J01FG01	Pristinamycin	2	O
J01FG02	Quinupristin/dalfopristin	1.5	P
J01GB	Aminoglycoside antibacterials		
J01GA01	Streptomycin	1	P
J01GB01	Tobramycin	0.24	P
J01GB01	Tobramycin	0.3	Inh solution
J01GB01	Tobramycin	0.112	Inh powder
J01GB03	Gentamicin	0.24	P
J01GB05	Neomycin	1	O
J01GB06	Amikacin	1	P
J01MA	Quinolone antibacterials		
J01MA02	Ciprofloxacin	1	O
J01MA02	Ciprofloxacin	0.8	P
J01MA06	Norfloxacin	0.8	O
J01MA12	Levofloxacin	0.5	O, P
J01MA14	Moxifloxacin	0.4	O, P
J01X	Other antibacterials		
J01XA	Glycopeptide antibacterials		
J01XA01	Vancomycin	2	O, P
J01XA02	Teicoplanin	0.4	P
J01XA04	Dalbavancin	1.5	P
J01XA05	Oritavancin	1.2	P
J01XB	Polymyxins		
J01XB01	Colistin	3MU	Inh
J01XB01	Colistin	9MU	P
J01XB02	Polymyxin B	0.15	P
J01XC	Steroid antibacterials		
J01XC01	Fusidic acid	1.5	O, P
J01XD	Imidazole derivatives		
J01XD01	Metronidazole	1.5	P
P01AB01	Metronidazole	2	O, R
P01AB02	Tinidazole	2	O
J01XX	Other antibacterials		
J01XX01	Fosfomycin	3	O
J01XX01	Fosfomycin	8	P
J01XX08	Linezolid	1.2	O, P
J01XX09	Daptomycin	0.28	P
J04	Antimycobacterials		
J04AB03	Rifampicin	0.6	O, P
A07AA	Intestinal anti-infectives		

ATC classification	Generic name	DDD (g)	Route
A07AA11	Rifaximin	0.6	O
A07AA12	Fidaxomicin	0.4	O

ATC = Anatomical Therapeutic Classification; DDD = defined daily dose; Inh = inhalation; MU = Million units; O = oral; P = parenteral; R = rectal

Antifungal agents

ATC classification	Generic name	DDD (g)	Route
J02AB, J02AC	Triazole antifungals		
J02AC01	Fluconazole	0.2	O, P
J02AC02	Itraconazole	0.2	O, P
J02AC02	Itraconazole MR	0.1	O (MR)
J02AC03	Voriconazole	0.4	O, P
J02AC04	Posaconazole	0.8	O
J02AC04	Posaconazole	0.3	P
J02AA	Polyene antifungals		
J02AA01	Amphotericin B	0.035	P
J02AA01	Liposomal amphotericin	0.21*	P
J02AA01	Amphotericin lipid complex	0.35*	P
J02AX	Echinocandins		
J02AX04	Caspofungin	0.05	P
J02AX05	Micafungin	0.1	P
J02AX06	Anidulafungin	0.1	P
J02AX01	Flucytosine	10	O, P
D01BA01	Griseofulvin	0.5	O
D01BA02	Terbinafine	0.25	O
J02AB02	Ketoconazole	0.2	O

ATC = Anatomical Therapeutic Classification; DDD = defined daily dose; MR = Modified Release; O = oral; P = parenteral

* DDD assigned by NAUSP

Source: WHO (2019)[24]

Topical antimicrobials

Dermatological

ATC classification	Generic name
D01AA01	Nystatin
D01AC01	Clotrimazole
D01AC02	Miconazole
D01AC03	Econazole
D01AC08	Ketoconazole
D01AC10	Bifonazole
D01AC20	Imidazoles / triazoles in combination with corticosteroids
D01AC52	Miconazole, combinations
D01AC60	Bifonazole, combinations
D01 AE14	Ciclopirox
D01AE15	Terbinafine
D01AE16	Amorolfine
D01AE18	Tolnaftate
D06AX01	Sodium fusidate
D06AX09	Mupirocin
D06BA01	Silver sulfadiazine
D06BB01	Idoxuridine
D06BB03	Aciclovir
D06BB06	Penciclovir
D06BX01	Metronidazole
D07CB01	Triamcinolone and antibiotics, combinations
D10AF01	Clindamycin

ATC = Anatomical Therapeutic Classification

Vaginal

ATC classification	Generic name
G01AA01	Nystatin (gynaecological)
G01AA10	Clindamycin (gynaecological)
G01AF01	Metronidazole (gynaecological)
G01AF02	Clotrimazole (gynaecological)
G01AF04	Miconazole (gynaecological)

ATC = Anatomical Therapeutic Classification

Appendix 5: Antibacterials included in the Priority Antibacterial List[1], according to the ARCC classification

Access	Review	
	Curb	Contain
Amoxicillin	Amoxicillin–clavulanic acid	Amikacin
Ampicillin	Azithromycin	Aztreonam
Benzathine benzylpenicillin	Cefaclor	Cefepime
Benzylpenicillin	Cefalexin	Ceftaroline
Chloramphenicol	Cefalothin	Ceftazidime
Dicloxacillin	Cefazolin	Ceftazidime–avibactam
Doxycycline	Cefotaxime	Ceftolozane–tazobactam
Flucloxacillin	Cefoxitin	Colistin
Gentamicin	Ceftriaxone	Daptomycin
Metronidazole	Cefuroxime	Doripenem
Minocycline	Clarithromycin	Ertapenem
Nitrofurantoin	Ciprofloxacin	Fosfomycin
Phenoxymethylpenicillin	Clindamycin	Imipenem–cilastatin
Procaine benzylpenicillin	Erythromycin	Linezolid
Streptomycin	Fidaxomicin	Meropenem
Sulfamethoxazole–trimethoprim	Lincomycin	Moxifloxacin
Tetracycline	Norfloxacin	Pivmecillinam
Tinidazole	Piperacillin–tazobactam	Polymyxin B
Tobramycin	Rifampicin	Pristinamycin
Trimethoprim	Rifaximin	Tigecycline
	Roxithromycin	
	Sodium fusidate	
	Spiramycin	
	Teicoplanin	
	Vancomycin	

Appendix 6: Glossary

Term	Definition
AIHW	Australian Institute of Health and Welfare
Aggregate total-hospital antibacterial usage rate	The total number of defined daily doses of antibacterials divided by the total hospital occupancy measured in occupied bed days.
AMS	antimicrobial stewardship
Antimicrobials	Medicines used to treat or prevent infections caused by microbes, including antibacterial, antifungal, antiviral and anti-parasitic medicines. In this report, the term 'antimicrobial' is used to refer to data on all, or almost all, classes of antimicrobials. Because this report is confined to reporting on use of systemic antibacterials in Australian hospitals, the term 'antibacterial' is used when referring to the output of analyses of the NAUSP data, and when comparisons are made with data reported by other countries.
AURA	Antimicrobial Use and Resistance in Australia
Defined daily dose (DDD)	The average maintenance dose per day for an average adult for the main indication of the medicine.
ICU	intensive care unit
Mean total-hospital antibacterial usage rate	The mean antibacterial usage rate for all hospitals, calculated using the total rate for individual hospitals.
Median total-hospital antibacterial usage rate	The median antibacterial usage rate for all hospitals, calculated using the total rate for individual hospitals.
NAPS	National Antimicrobial Prescribing Survey
NAUSP	National Antimicrobial Utilisation Surveillance Program
Occupied bed day (OBD)	The sum of the length of stay for each acute adult inpatient separated during the reporting period who remained in hospital overnight (adapted from the definition of the Australian Institute of Health and Welfare). Day patients, outpatients, Hospital in the Home, and psychiatric and rehabilitation units are excluded.
SA Health	South Australian Department of Health and Wellbeing
Usage rate	The number of defined daily doses (DDDs) used per 1,000 occupied bed days (OBDs). Data for outpatient areas, including Hospital in the Home, day

	treatment centres, day surgery and dialysis clinics are excluded. The rate is calculated as follows: Usage density rate = Number of DDDs/time period x 1,000 OBDs/time period
WHO	World Health Organization

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Additional NAUSP data are available at www.sahealth.sa.gov.au/nausp and a range of information and AURA Surveillance System reports is available at https://www.safetyandquality.gov.au/our-work/antimicrobial-resistance/antimicrobial-use-and-resistance-australia-surveillance-system.

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For more information

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