AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

AURA
Antimicrobial Use and Resistance in Australia

Antimicrobial use in Australian Hospitals

Biennial report of the National Antimicrobial Utilisation Surveillance Program: 2017-2018

March 2020

Government of South Australia
SA Health

NAUSP

Published by the Australian Commission on Safety and Quality in Health Care
Level 5, 255 Elizabeth Street, Sydney NSW 2000

Phone: (02) 9126 3600
Fax: (02) 9126 3613

Email: aura@safetyandquality.gov.au
Website: www.safetyandquality.gov.au

ISBN: 978-1-925948-15-8

The Commission's preference is that you attribute this publication (and any material sourced from it) using the following citation:

> SA Health, Australian Commission on Safety and Quality in Health Care. Antimicrobial use in Australian hospitals: biennial report of the National Antimicrobial Utilisation Surveillance Program, 2017–2018. Sydney: ACSQHC; 2020.

Disclaimer

The content of this document is published in good faith by the Australian Commission on Safety and Quality in Health Care for information purposes. The document is not intended to provide guidance on particular healthcare choices. You should contact your healthcare provider on particular healthcare choices.

This document includes the views or recommendations of its authors and third parties. Publication of this document by the Commission does not necessarily reflect the views of the Commission, or indicate a commitment to a particular course of action. The Commission does not accept any legal liability for any injury, loss or damage incurred by the use of, or reliance on, this document.

CONTENTS

Summary

The analyses of 2017 and 2018 data submitted to the National Antimicrobial Utilisation Surveillance Program (NAUSP) identified a number of results that require close review at both local and jurisdictional levels to improve the safety of care provided to patients in Australian public and private hospitals.

These include:

- Stable overall antibacterial usage from 2016 to 2018, after six years of sustained reductions from 2010 to 2016. This pattern occurred in conjunction with a sustained increase in usage of broad-spectrum antibacterials from 2017 to 2018
- Antibacterial usage in Australian hospitals is much higher than in the Netherlands and Sweden
- Substantial variation in antimicrobial usage between states and territories across multiple antimicrobial classes, notably in classes for which access is usually restricted in hospitals. This is concerning due to their potential to contribute to the development of antimicrobial resistance (AMR).
- Higher volumes of antibacterial usage and greater variability in usage across smaller hospitals (Acute Group B and C hospitals), compared with that of large hospitals (Principal Referral and Acute Group A hospitals).

What do these results mean for patient safety?

Given the much lower overall hospital antibacterial usage in some northern European countries, there is potential for further reduction in the overall usage in Australian hospitals to limit the development of AMR, whilst also ensuring appropriate antibacterial use and delivery of safe care to patients.

The substantial variation in antimicrobial usage between states and territories, across multiple antimicrobial classes, including classes for which access is usually restricted in hospitals, requires local review to identify opportunities for improvement. Whilst there are a small number of first line recommended indications for restricted classes of antibacterials, the majority of use is overseen by infectious diseases specialists or local AMS programs. Differences between states and territories may be due to local AMR patterns or specialist prescribing practices. Investigation of these differences by states and territories will inform strategies to reduce use, promote consistency of prescribing with local and national guidelines, limit the progression of AMR and increase the safety of care provided to patients. Differences in prescribing practices within states and territories should also be investigated, in conjunction with local AMR patterns to inform local and jurisdictional AMS intervention strategies.

NAUSP data, stratified by state and hospital peer group, are routinely made available to states and territories. In addition, hospitals can access their own data and generate benchmarking reports from the NAUSP portal, to inform development of local response strategies.

The sustained increase in use the broad-spectrum third- and fourth-generation cephalosporins since the resumption of normal piperacillin–tazobactam supply, together with increased fluoroquinolone use in smaller hospitals in 2017 and 2018, has the potential to contribute to increased resistance in gram-negative organisms. These organisms are a major cause of urinary tract, biliary tract and intra-abdominal infections. Improvement activities that promote appropriate use of these agents should be a priority for state, territory and hospital AMS programs, to assist in the containment of AMR.

Despite overall stable antibacterial use from 2016 to 2018, antibacterial usage in several hospitals increased by more than 20% from 2017 to 2018. This increase was more pronounced in smaller (Public Acute Group B and C) hospitals, compared with larger (Public Acute Group A and Principal Referral) hospital contributors to NAUSP. This finding highlights the need for AMS programs in all Australian hospital settings, in accordance with the National Safety and Quality Health Service Standards, and for state and territory led activities to review individual hospital results, identify the factors that contribute to high usage rates and develop interventions to reduce usage.

Whilst the overall use of last-line antimicrobials is low, there was a clear upward trend in their use during 2017 and 2018, across remoteness and peer group categories. This may be due to the local prevalence of infections caused by antimicrobial-resistant organisms that require treatment with last-line agents. Transfer of patients to facilities closer to their homes, following initial care in tertiary centres, may also be a contributing factor. Developing a local understanding of the reasons for this trend will inform decisions regarding improvement action. Appropriate antimicrobial use and infection prevention and control practices will contribute to reducing healthcare-associated infections and the occurrence of antimicrobial-resistant infections.

AURA 2019: Third Australian Report on Antimicrobial Use and Resistance in Human Health identified a number of focus areas to improve antimicrobial use in Australian hospitals that are also relevant to the issues identified in analyses of the 2017 and 2018 NAUSP data. These include reducing the use of broad-spectrum antibiotics, and improving all aspects of prescribing these agents. Responses to support action on these focus areas are currently in development, particularly in relation to reducing inappropriate prescribing of amoxicillin–clavulanic acid and cefalexin, and targeted strategies and guidelines to improve appropriateness of prescribing for treatment of chronic obstructive pulmonary disease.

To support the response to issues identified by the NAUSP, the Commission will continue to:

- Communicate the findings of the NAUSP analyses to states, territories and private hospital provider organisations through more focussed short reports, to highlight variability in usage and encourage targeted AMS interventions
- Promote routine review of NAUSP data by each hospital and by states and territories, to focus improvement effort on hospitals where usage varies substantially from peers
- Collaborate with states and territories to identify and develop strategies and resources to further support AMS programs for smaller hospitals
- Review the *Antimicrobial Stewardship Clinical Care Standard* and associated implementation resources in 2020
- Work with states and territories and expert clinical groups to produce resources to develop strategies and resources to improve the appropriateness of prescribing broad-spectrum antibacterials in Australian hospitals.

Summary of key findings

Antibacterials

- Overall, the volume of antibacterial use in NAUSP contributor hospitals (n=201) was stable from 2016 to 2018, with a less than 1% change, despite increases in usage of a number of broad-spectrum antimicrobials in 2018, compared with 2016, including carbapenems and all cephalosporin classes, and increases in some Acute Group B and C hospitals
- The usage rate in 2018 was 959.6 defined daily doses (DDDs) per 1,000 occupied bed days (OBD)
- There were large variations in mean total hospital antimicrobial usage rate in NAUSP contributor hospitals in 2018; the overall mean was 991 DDDs per 1,000 OBD overall (range 212–2,457 DDDs per 1,000 OBD; n=201)
- Ceftriaxone and intravenous amoxicillin–clavulanic acid replaced piperacillin–tazobactam to varying degrees in 2018 in most states and territories, in response to a shortage of piperacillin–tazobactam in 2017
- Increased use of third- and fourth-generation cephalosporins was sustained in 2018 following the shortage of piperacillin–tazobactam; ceftriaxone use was elevated in all states and territories except New South Wales and the Australian Capital Territory, and cefepime use in Victoria stabilised at higher levels
- Usage rates for last-line antibacterials, such as linezolid and colistin, were very low (less than 1 DDD per 1,000 OBD)
- Fluoroquinolone use increased in Public Acute Group C contributor hospitals from mid-2017, in contrast to other peer groups, which requires investigation

Antifungals

- There were variations of between 150% and 500% in use of some antifungal agents between states and territories. In New South Wales and the Australian Capital Territory, usage of itraconazole was highest, and in Western Australia, usage of fluconazole was 50% more than the average usage of all other states and territories. These differences require investigation.
- There was variation in antifungal usage rates influenced by haematology/oncology specialist units, where usage is expected to be much higher because of the concentration of immunocompromised patients.

International comparison of hospital antibacterial usage

- Antibacterial usage in Australian hospitals is much higher than in the Netherlands and Sweden
- Fluoroquinolone usage in Australia is lower than northern European countries, and continuing to decrease, whilst Australian usage of cephalosporins is higher than in Denmark and Sweden.

Introduction

Antimicrobial resistance (AMR) is a risk to patient safety because it reduces the range of antimicrobials available to treat infections. It also increases mortality and morbidity associated with infections caused by multidrug-resistant organisms. AMR limits capacity to perform medical procedures such as organ transplantation, cancer chemotherapy, diabetes management and major surgery, where there is a lack of effective antimicrobials.

Antimicrobial use promotes AMR in both individuals and the community. Surveillance of antimicrobial use is essential to inform effective AMR prevention and containment strategies.

The National Antimicrobial Utilisation Surveillance Program (NAUSP) is a long-term program partner of the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System. The Australian Commission on Safety and Quality in Health Care (the Commission) coordinates AURA with funding provided by the Australian Government Department of Health and states and territories. The AURA Surveillance System plays a pivotal role in informing local, state, territory and national policy, and in the development of strategies to prevent and contain antimicrobial resistance, consistent with the *National Antimicrobial Resistance Strategy 2015–2019*.[1]

NAUSP focuses on standardised measurement of antimicrobial use in Australian adult public and private hospitals. The Infection Control Service, Communicable Disease Control Branch, South Australian Department of Health and Wellbeing (SA Health) administers NAUSP. Development and implementation of NAUSP has been an ongoing collaboration between SA Health and the Commission since 2013.

Since it began in July 2004, NAUSP has diversified and grown into a nationally representative program. Trend and benchmarking data, both for individual hospitals and aggregated at jurisdictional level, have contributed to local, state and territory, and national antimicrobial prescribing strategies to improve the quality of care delivered to patients.

Hospitals contribute to NAUSP on a voluntary basis. The number of contributing hospitals has more than doubled since the release of the National Safety and Quality Health Service (NSQHS) Standards in 2012. Participation in NAUSP supports successful implementation of the NSQHS Preventing and Controlling Healthcare-Associated Infections Standard.

This is the first biennial report of NAUSP. It includes analyses of national data on antimicrobial use in 189 public and private adult acute care hospitals in 2017 and 201 public and private adult acute care hospitals in 2018.

This report includes historical comparisons for 2014 to 2018, where data were available, as well as in-depth analysis of usage rates in 2017 and 2018. Interstate and intrastate data are presented, along with comparisons of antimicrobial usage rates between hospital peer groups for selected antibacterial and antifungal classes. Antibiotic usage data from 29 Queensland public hospitals are not included in some longitudinal trend analyses because of inconsistent application of surveillance definitions between 2013 and 2015. Revised 2016 data for these hospitals are included in the analyses for this report. As a consequence, national total-hospital antibiotic usage trend data in this report are not comparable with previously published data. A process is under way to obtain and reanalyse Queensland antibiotic usage data, and to publish updated Queensland and national antibiotic usage trend data in 2020.

Methods

This section describes the NAUSP contributor recruitment; and data elements, processes and analyses.

Contributing hospitals

Public and private hospitals contribute data voluntarily to NAUSP on an ongoing basis throughout each year, consistent with prescribed data definitions.

Hospitals must have submitted at least six months of data that comply with NAUSP definitions, as determined by data validation processes, for their data to be included in the analyses for this report. See Appendix 1 for a list of hospitals that contributed data for the 2017and 2018 analyses.

The Australian Institute of Health and Welfare (AIHW) peer groupings are used to categorise public and private hospitals for comparative analyses of data submitted to NAUSP.[2] The AIHW criteria were amended in November 2015 to include private hospital peer groups. Further amendments were made in July 2017 to include newly opened hospitals in Western Australia and Queensland. Historically, private hospitals have been assigned by NAUSP to an appropriate AIHW public hospital peer group for analyses, and for routine six-monthly reporting. This convention will continue until private hospital representation increases sufficiently to allow reporting by the AIHW private hospital peer group classifications. In this report, private hospital data have been included in intrastate usage rate analyses, where the hospitals are de-identified, and in aggregated statewide and peer group analyses.

A small number of recently opened hospitals had not been assigned to a peer group by the AIHW at the time of these analyses. These facilities were assigned to a peer group by NAUSP based on hospital size and activity.

Data elements

Pharmacy departments of participating hospitals supply NAUSP with aggregate monthly quantities of antimicrobial products issued to individual inpatients and ward imprest supplies (ward stock managed by the pharmacy) via dispensing reports. Hospital occupancy data are collected in the form of overnight occupied bed days (OBD).

NAUSP assigns each contributing hospital a unique code. The code is used to report in a de-identified way on usage rates for selected antimicrobials and therapeutic groups.

Units of measurement

Antimicrobial surveillance data are reported as usage rates. Quantities of antimicrobials are aggregated over the period of interest and converted to standardised usage metrics – these are based on the WHO definition of 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. NAUSP does not collect paediatric usage data because this unit of measurement is only applicable for adults.

Usage is converted to a standard rate used in comparable surveillance programs – DDDs per 1,000 OBD. A limitation of using the DDD as defined by WHO is that, occasionally, the DDD does not match usual daily doses used in Australian hospital clinical practice (see Appendix 2 for more information). At present, NAUSP uses published WHO DDDs to enable comparisons with international surveillance programs.

Standardised usage density rates are widely accepted as appropriate measures of adult medicine use in non-ambulatory settings, and are adopted by international antimicrobial surveillance programs.[3-5] Use of an internationally established standard rate enables comparison of usage data for antibacterials that have different doses, aggregation of data to assess use by antibacterial class, and comparisons with data from other surveillance programs or studies. However, such comparisons need to be made with care because of variations in the casemix of patients and in international healthcare practices.

Values calculated from raw data submitted to NAUSP include:

- The DDDs of the antimicrobial
- The aggregate number of grams of the antimicrobial used for a month
- Monthly antimicrobial usage rates (as DDDs per 1,000 OBD)
- Three- or five-month moving averages of the usage rates.

Data quality

Since the commencement of the NAUSP web-based application (the NAUSP Portal) in May 2016, NAUSP participants validate data during the automated submission process.
Alerts are generated automatically when quantities fall outside a usual or expected range. This enables validation of data at an early stage of data submission.

In addition, data quality assurance activities are performed by NAUSP officers after June and December data are submitted. Denominator data that are used to calculate usage rates are reviewed by the NAUSP team at least twice a year to confirm that numerator and denominator data are consistent. Pharmacists are involved in this process, enabling NAUSP officers to apply reasoned and skilled judgement, and to notify contributors of any anomalies that require attention or resubmission of data.

Other validation processes include:

- Confirming that mapping (aliasing) of antimicrobials to the NAUSP-defined formulation within the portal is performed correctly by NAUSP pharmacists
- Checking for incorrect parameter settings for automated usage and OBD reports generated by contributors.

The NAUSP team alerts contributors if data are suspected to be erroneous. However, each contributing site is responsible for the accuracy of its data.

Data analyses

Data analyses were performed using the NAUSP Portal and pre-defined rate calculations for antimicrobial classes and agents. First and third percentiles were calculated using MS Excel functions.

Data exclusions

Data collected by NAUSP for this report exclude:

- Most topical antimicrobial formulations (excluding some inhalations), antimycobacterials (except rifampicin), and antiparasitics
- Infusor packs of antibacterials for use outside of hospital settings
- Antimicrobial use in paediatric hospitals, and paediatric wards and neonatal units within general hospitals. Use in this population cannot easily be translated into a standard usage density rate based on the WHO definition of DDDs
- Antimicrobial usage for outpatient areas, discharge prescriptions and external services (for example, Hospital in the Home), to ensure that data reflect in-hospital use of antimicrobials

- Antimicrobials issued to individuals and wards such as psychiatric, rehabilitation wards where average length of stay is greater than 15 days, and dialysis and day surgery units to allow comparison with European surveillance programs that report only acute inpatient usage data.

Data classification, restrictions and limitations

As hospitals join the program, retrospective data may be added to the database. Incorporation of retrospective data into analyses may result in variation between reports.

Data from some contributor hospitals have not been included in generation of annual rates for this report due to:

- Inability to supply either dispensing or OBD data with confidence of accuracy
- Provision of retrospective data by new contributors
- Closure of hospitals
- Data anomalies that have not yet been corrected by nine contributors from the 2017–2018 cohort.

This report includes data from a small number of contributors that were previously omitted from annual reports due to their inability to supply accurate data.

Because the Northern Territory and the Australian Capital Territory have a small number of contributing hospitals, their results are presented with Queensland and New South Wales respectively, so that individual hospitals cannot be identified.

Data from Private Acute Group D hospitals are included with Public Acute Group C and Private Acute Group C hospital data due to small numbers.

Data provided to NAUSP do not include the indication for which antimicrobials are used, or any patient-level data. Although some contributing hospitals provide data on ward-by-ward antimicrobial consumption, data for specialist areas (with the exception of intensive care units [ICUs]) are available for only a limited number of hospitals. Expansion of NAUSP from March 2017 has enabled analyses of usage for haematology/oncology and respiratory specialties.

This report presents usage rates for the most commonly used antibacterials and antibacterial classes and antifungals. A full list of antimicrobials for which data are collected by NAUSP, the WHO Anatomical Therapeutic Classification (ATC)[6] and the DDD for each route of administration are available in Appendix 2. The ATC and use of DDDs enables international and other comparisons of drug consumption statistics.

Aggregation of NAUSP antibacterial usage data into therapeutic groups allows:

- Assessment of the relative use of particular classes of antibacterials
- Comparisons between contributing hospitals of pooled class-specific antibacterial usage rates
- Benchmarking with usage data from similar studies.

Care is required when interpreting NAUSP data because of possible anomalies relating to DDDs. The DDD for parenteral flucloxacillin published by WHO is 2 grams. This DDD does not accurately reflect the Australian setting, where doses of 8 grams per day are routinely used (2 grams, four times per day). This may contribute to an overestimation of usage rates for β–lactamase-resistant penicillins. Other examples of discrepancies between WHO DDDs and Australian commonly-used daily doses are:

- Cefazolin (doses of 2 grams every six to eight hours are recommended for a range of indications, whilst the WHO ATC DDD is 3 grams)
- Cefepime (usual daily dose is 4 grams, whilst the DDD is 2 grams)
- Vancomycin (doses are often required to be greater than the 2 gram ATC DDD).[6]

The WHO reviews DDDs annually; changes that came into effect in January 2019 will be incorporated in future analyses of NAUSP data.

There is a high rate of participation in NAUSP by large public hospitals, where antimicrobial stewardship (AMS) activities are generally well established. In 2015, NAUSP removed restrictions on participation that were based on minimum bed numbers. Participating hospitals are required to meet the criteria for categorisation into one of ten AIHW peer groups: Principal Referral hospital; Specialist Women's hospital; Public Acute Group A, B, C and D hospitals; or Private Acute Group A, B C or D hospitals. Hospitals classified in other AIHW categories may be considered for participation in NAUSP on a case by case basis.

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 annual reports may occur as a result of data submitted retrospectively by contributing hospitals.

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 per 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 hospitals' usage rates

Summary of findings

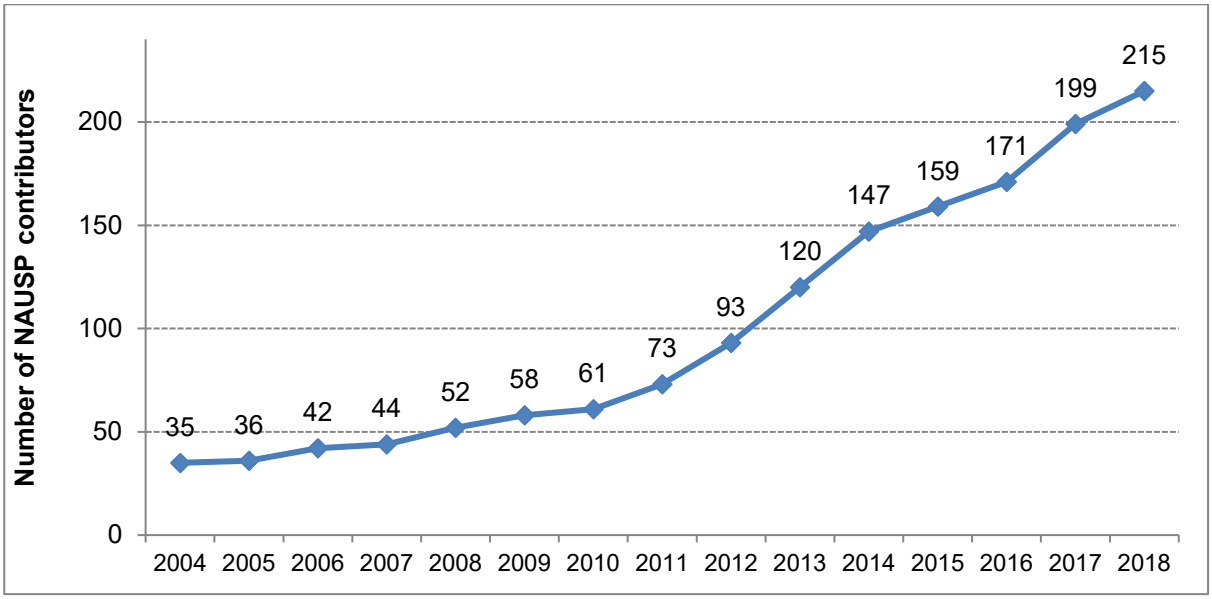
This section includes an overview of contributing hospitals, annual usage rates for antibacterial classes, the top 20 antibacterials used in contributing hospitals, and comparisons by state and territory for 2017 and 2018 and trends for 2014 to 2018.

Contributing hospitals

Participation in NAUSP has increased rapidly since 2011. Whilst 199 and 215 hospitals contributed data to NAUSP in 2017 and 2018 respectively, data were included in the analyses for this report from 189 public and private acute hospitals in 2017 and 201 hospitals in 2018, as shown in Tables 1 and 2. In 2018, all Principal Referral hospitals, and 90% of Public Acute Group A and 86% of Public Acute Group B hospitals participated in the program. The private hospital cohort increased to 36 in 2018. There were no Public Group C contributor hospitals from Tasmania or Victoria.

All Australian states and territories have been represented in NAUSP since 2012; 35 hospitals have contributed continuously since July 2004, and 13 South Australian hospitals have contributed continuously since the program began there in 2001. Figure 1 shows the growth in the number of hospitals participating in NAUSP since 2004.

Figure 1: Number of public and private hospitals that have participated in NAUSP, 2004–2018



Note: This figure shows the number of hospitals registered to participate in NAUSP. Not all of these registered hospitals were able to provide validated data for the analyses.

Voluntary participation has improved over time; however, the number of hospitals participating, and contributing data to aggregated annual reports, has varied since 2012. Tables 1 and 2 provide information on the cohort of hospitals included in trend analyses for 2017 and 2018 respectively.

Table 1: Number and percentage representation of hospitals included in the NAUSP cohort for analyses, by peer group* and state and territory, 2017

State	Principal Referral		Public Acute						Private Acute								Specialist Women's		Other§	Total
			Group A		Group B		Group C		Group A		Group B		Group C		Group D					
	No.	%†	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	No.
ACT / NSW	12	100	22	96	15	88	12	29	1	50	5	33	1	6	0	0	0	0	0	**68**
NT / QLD	7	100	13	100	7	88	7	26	4	44	1	20	4	33	1	8	1	100	1	**46**
SA	2	100	3	75	4	100	4	18	2	100	4	100	0	0	0	0	1	100	0	**20**
TAS	1	100	2	100	1	100	0	0	1	100	0	0	1	33	0	0	0	0	0	**6**
VIC	6	100	13	81	6	67	0	0	2	33	2	22	2	15	0	0	1	50	0	**32**
WA	3	100	4	80	3	60	2	13	1	50	2	67	0	0	0	0	1	100	1	**17**
Total	31	100	57	90	36	82	25	18	11	50	14	39	8	16	1	1	4	67	2	**189**

*Based on AIHW criteria.
† Percentages represent proportion of hospitals in each peer group contributing to NAUSP.
§ Includes 1 public unpeered hospital and 1 private mixed sub- and non-acute hospital.

Table 2: Number and percentage representation of hospitals included in the NAUSP cohort for analyses, by peer group* and state and territory, 2018

State	Principal Referral		Public Acute						Private Acute								Specialist Women's		Other§	Total
			Group A		Group B		Group C		Group A		Group B		Group C		Group D					
	No.	%†	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	No.
ACT / NSW	12	100	22	96	15	88	14	34	1	50	5	33	1	6	0	0	0	0	0	**70**
NT / QLD	7	100	13	100	7	88	7	26	4	44	1	20	4	33	1	8	1	100	1	**46**
SA	2	100	3	75	4	100	4	18	2	100	4	100	0	0	0	0	1	100	0	**20**
TAS	1	100	2	100	1	100	0	0	1	100	0	0	1	33	0	0	0	0	0	**6**
VIC	6	100	13	81	7	78	0	0	2	33	2	22	2	15	0	0	1	50	1	**34**
WA	3	100	4	80	4	80	9	56	1	50	2	67	0	0	0	0	1	100	1	**25**
Total	31	100	57	90	38	86	34	24	11	50	14	39	8	16	1	1	4	67	3	**201**

*Based on AIHW criteria.
† Percentages represent proportion of hospitals in each peer group contributing to NAUSP.
§ Includes 1 public unpeered hospital, 1 private mixed sub- and non-acute hospital and 1 private other acute specialised hospital.

Annual usage rates for all antibacterial classes

There was minimal change in aggregate total-hospital antibacterial usage from 2016 to 2018. Aggregate total-hospital antibacterial usage rate for all NAUSP contributor hospitals was 959.6 DDD per 1,000 OBD (n=201) in 2018, and 960.7 DDD per 1,000 OBDs (n = 189) in 2017 (see Table 2). Average annual usage was 991 DDD per 1,000 OBD (range 212–2,457 DDDs per 1,000 OBD) in 2018, and 972 DDD per 1,000 OBD (range 219–1,944 DDDs per 1,000 OBD) in 2017.

There were decreases in usage rates over the last three years for β-lactamase inhibitor combinations, fluoroquinolones, macrolides and trimethoprim (decreases of 6.9%, 4.5%, 9.3% and 13.1% respectively) (Table 2). There were large increases in usage of many broad-spectrum antibiotics over the last three years, including fourth-generation cephalosporins (84.8%), other antibacterials (68.2%), other cephalosporins and penems (57.4%), streptogramins (19.6%), and carbapenems (8.4%). There were also increases for other more commonly used antimicrobials, including trimethoprim–sulfamethoxazole (8.5%), third-generation cephalosporins (15.5%) and second-generation cephalosporins (23.1%).

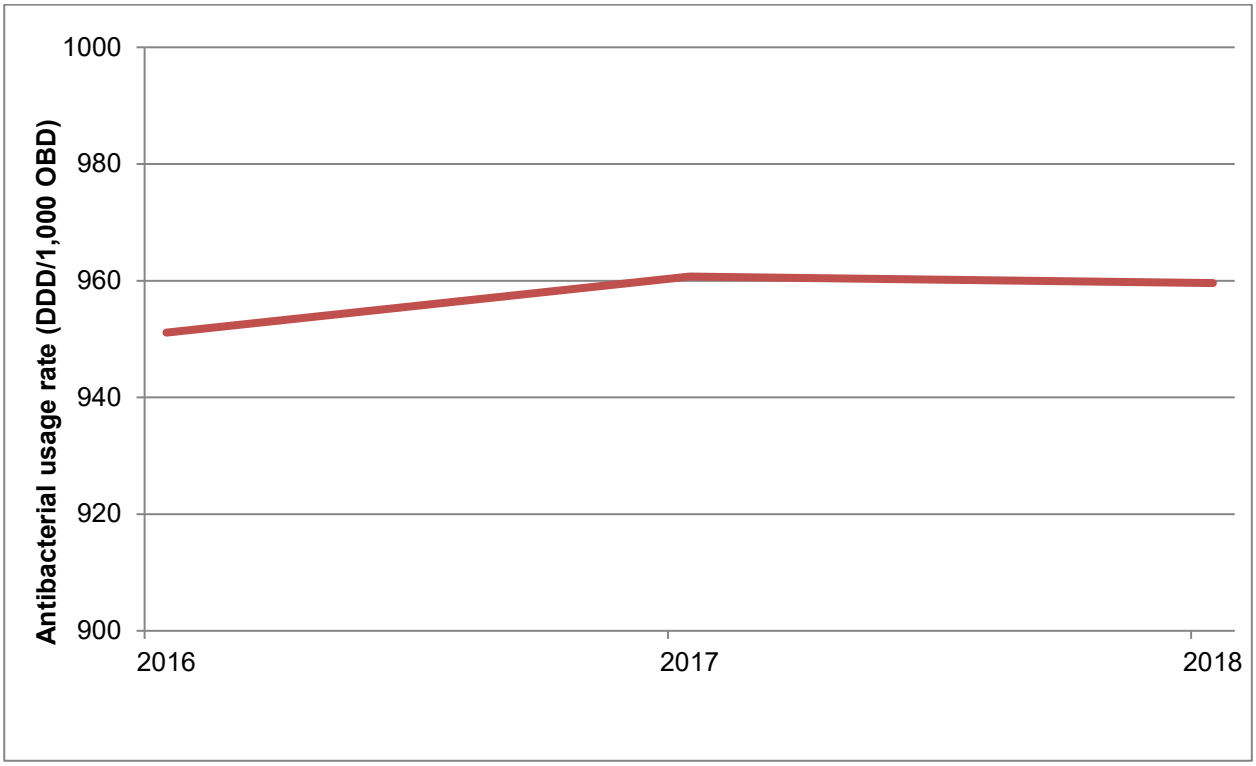
Annual aggregate total-hospital antibacterial usage rates (DDD per 1,000 OBD) for selected classes in NAUSP contributor hospitals from 2014 to 2018 are shown in Figures 2a to 2f.

Table 3: Annual total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by antibacterial class, 2016–2018

Antibacterial (WHO) classification	2016 (n = 170)	2017 (n = 189)	2018 (n = 201)	% change 2016-2018
Alimentary antibiotics	N/A*	8.1	8.7	N/A
Aminoglycosides	31.1	29.6	30.9	-0.7
Amphenicols	0.0	0.0	0.0	N/A
β-lactamase inhibitor combinations	173.3	167.2	161.4	-6.9
βeta-lactamase resistant penicillins	93.0	93.3	94.9	2.1
βeta-lactamase sensitive penicillins	34.1	34.9	32.4	-4.8
Carbapenems	19.2	19.6	20.8	8.4
Extended-spectrum penicillins	109.5	103.1	104.1	-5.0
First-generation cephalosporins	145.8	147.2	151.0	3.6
Fluoroquinolones	31.5	31.4	30.1	-4.5
Fourth-generation cephalosporins	6.0	11.5	11.1	84.9
Glycopeptides	26.2	25.5	25.6	-2.3
Lincosamides	13.0	13.3	13.2	1.3
Macrolides	55.9	53.6	50.7	-9.3
Monobactams	0.4	0.3	0.4	-3.9
Nitrofurans	1.2	1.4	1.4	19.9
Nitroimidazoles (metronidazole and tinidazole)	36.9	35.0	36.3	-1.7
Other antibacterials (linezolid and daptomycin)	2.8	3.4	4.7	69.2
Other cephalosporins and penems (ceftaroline, ceftolozane-tazobactam)	0.1	0.1	0.2	57.4
Polymyxins	0.7	0.6	0.4	-39.5
Rifamycins	5.4	5.3	5.0	-8.4
Second-generation cephalosporins	7.0	8.4	8.8	25.6
Steroids (fusidic acid)	1.1	1.0	0.8	-27.8
Streptogramins	0.4	0.4	0.4	19.6
Streptomycins	0.0	0.0	0.0	-33.3
Trimethoprim-sulfamethoxazole	16.5	17.6	17.9	8.5
Tetracyclines	72.4	79.3	76.1	5.0
Third-generation cephalosporins	51.5	55.9	59.5	15.5
Trimethoprim	14.7	13.7	12.8	-13.1
Grand Total	**949.8**	**960.7**	**959.6**	**1.0**

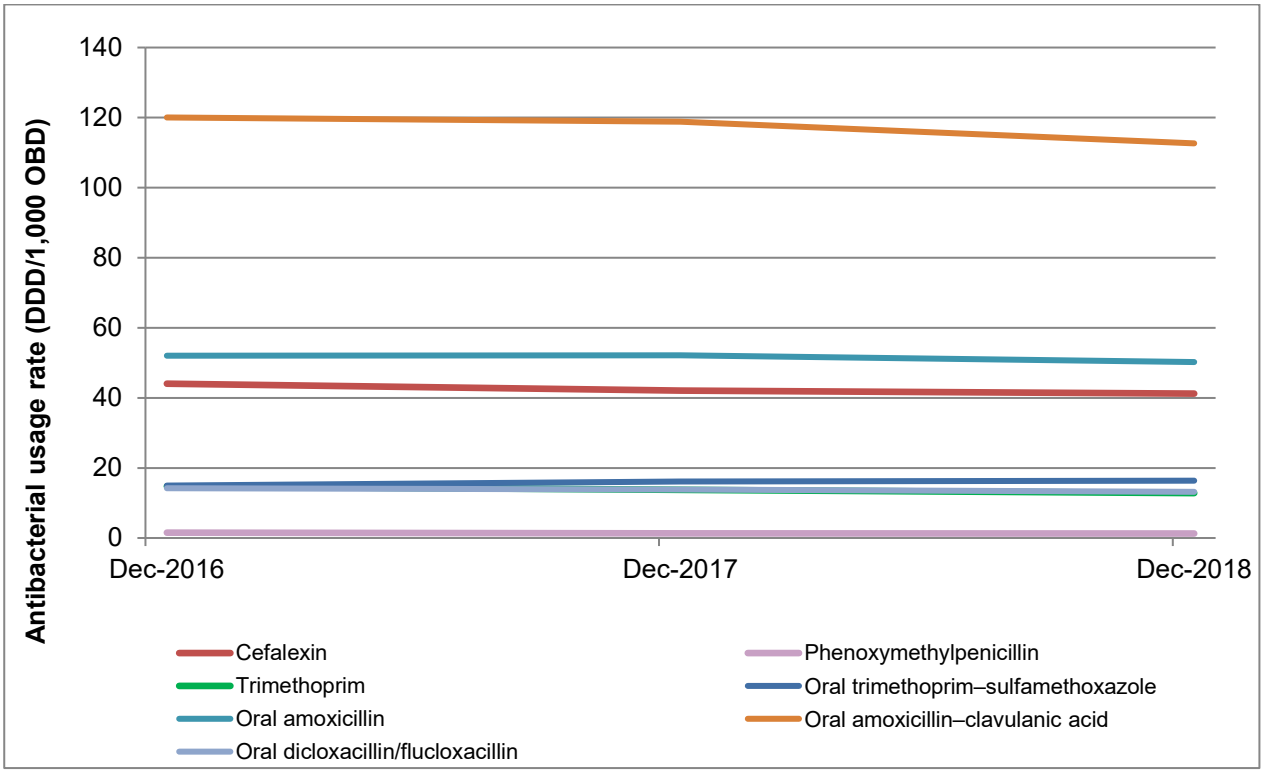
*Alimentary antibiotics were not routinely collected by NAUSP in 2016, so the volume is not included
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day; WHO = World Health Organization
Notes: Rates (DDD per 1,000 OBD) and percentage change have been rounded to one decimal place. Rates may vary slightly from previous reports as a result of retrospective usage data adjustments and number of hospitals contributing to aggregate data.

Figure 2a: Annual aggregate total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, 2016–2018



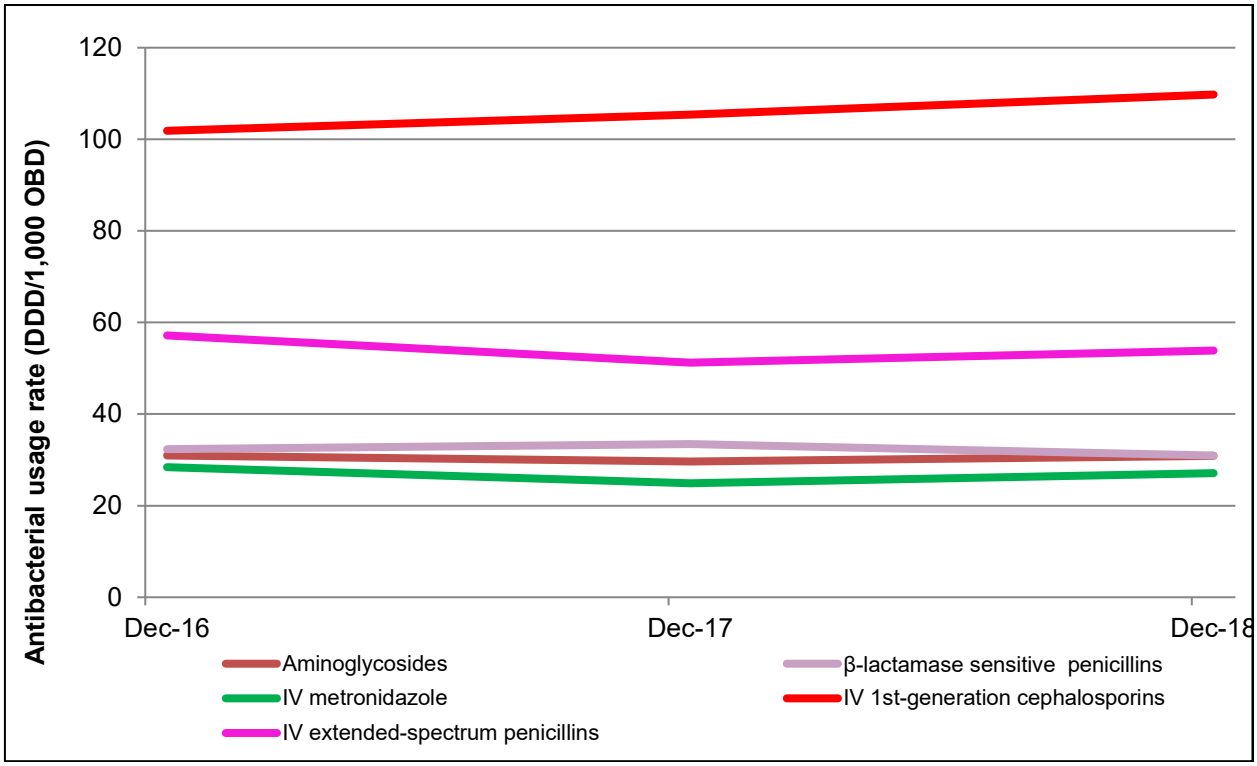
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: y-axis truncated to aid visibility of trend

Figure 2b: Annual aggregate total-hospital usage rates (DDD/1,000 OBD) for selected commonly used oral antibacterials in NAUSP contributor hospitals, 2016–2018



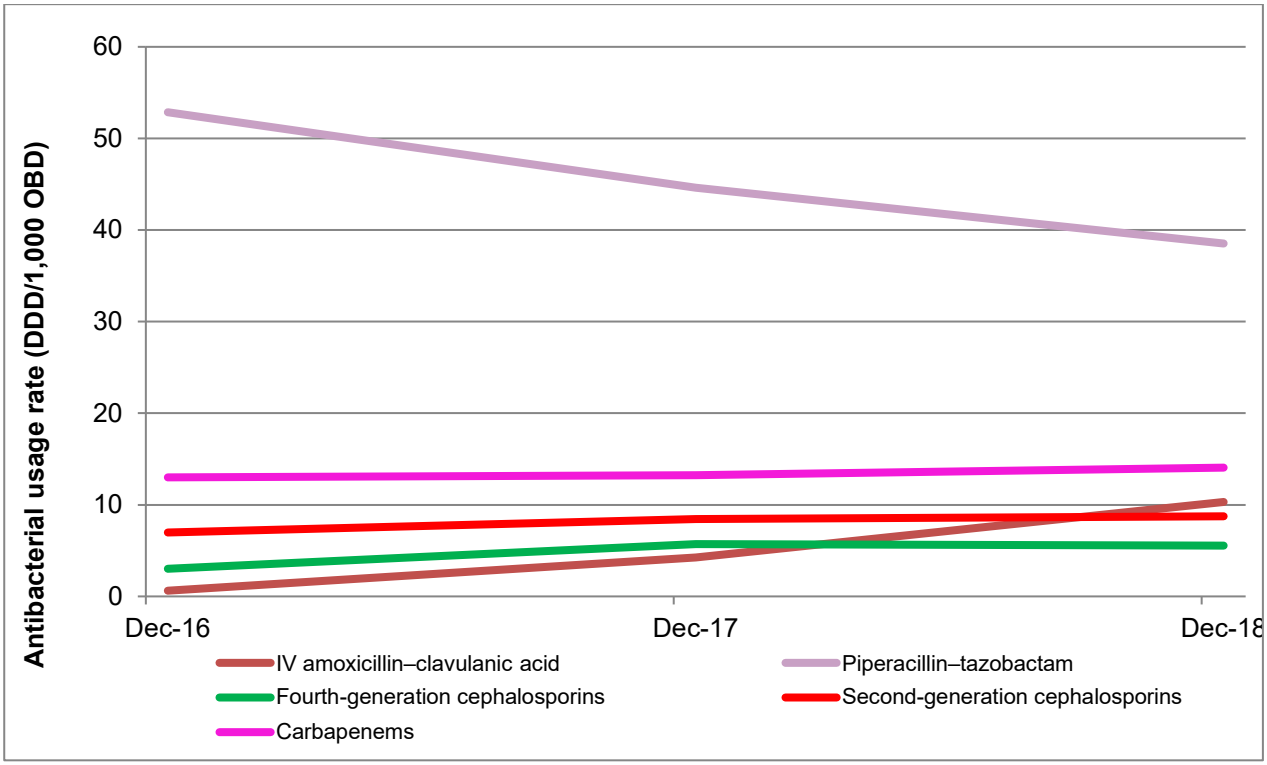
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Figure 2c: Annual aggregate total-hospital usage rates (DDD/1,000 OBD) for selected other antibacterial classes* in NAUSP contributor hospitals, 2016–2018



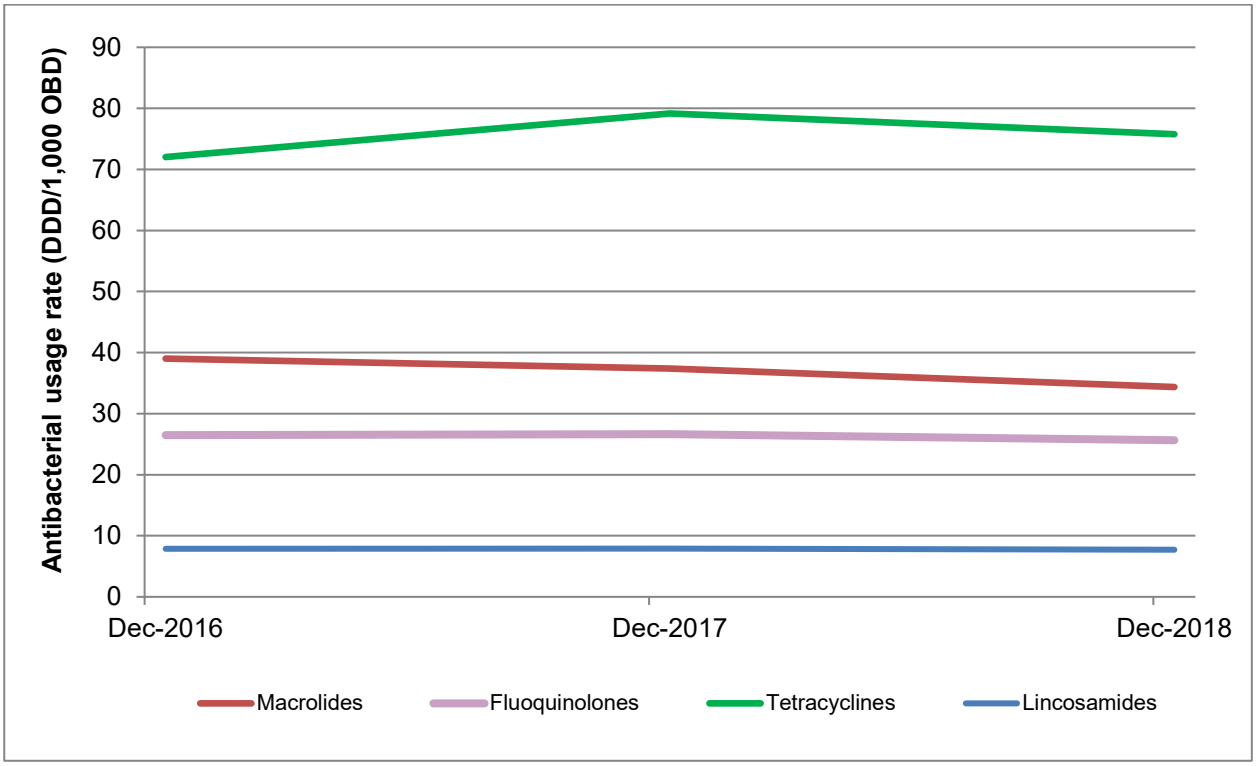
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* Included data for IV formulations only

Figure 2d: Annual aggregate total-hospital usage rates (DDD/1,000 OBD) for commonly used broad-spectrum antibacterial classes in NAUSP contributor hospitals, 2016–2018



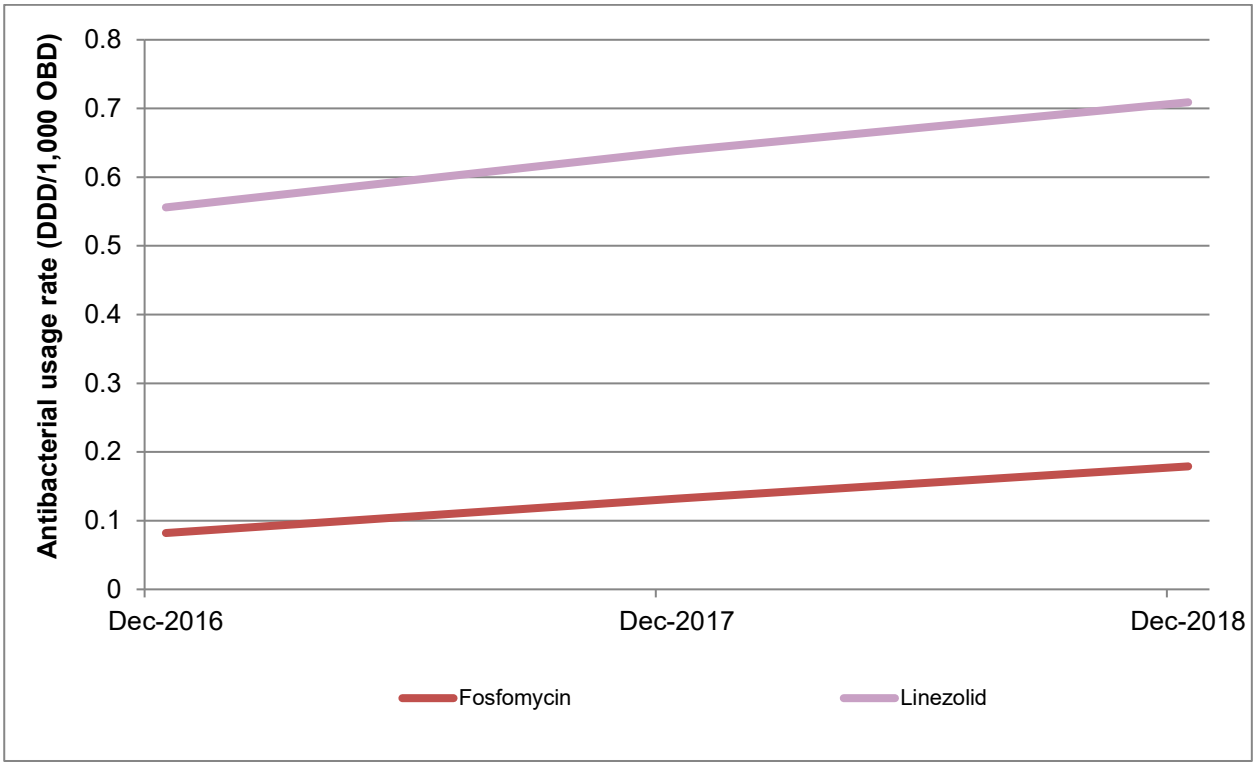
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Figure 2e: Annual aggregate total-hospital usage rates (DDD/1,000 OBD) for commonly used oral broad-spectrum antibacterial classes in NAUSP contributor hospitals, 2016–2018



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

Figure 2f: Annual aggregate total-hospital usage rates (DDD/1,000 OBD) for restricted oral broad-spectrum antibacterial classes in NAUSP contributor hospitals, 2016–2018



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

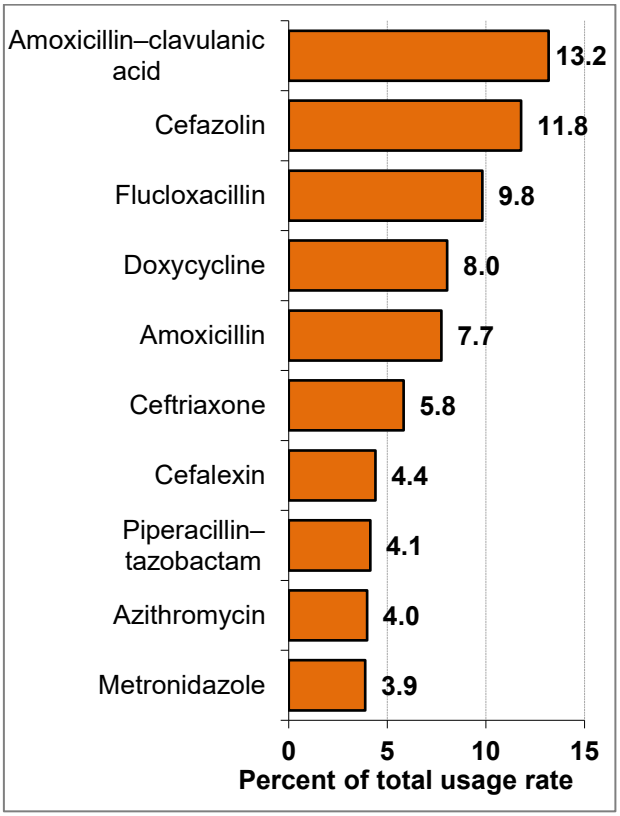
Top 20 antibacterials used in public and private hospitals that contributed to NAUSP in 2017–2018

The top 20 antibacterials accounted for 92.9% of all antibacterial usage reported to NAUSP in 2017 (Figures 3 and 4). Half (55%) of all antibacterial usage was accounted for by six agents. A similar usage pattern was reported in 2016.

Highly reserved antibacterials, which are high cost and used to treat highly resistant infections, accounted for very small percentages of total antibacterial use in 2017 and 2018; for example, daptomycin (0.216% and 0.266%), linezolid (0.121% and 0.115%), colistin (0.060% and 0.045%), and fosfomycin (0.021% and 0.027%).

The most commonly used antibacterials in 2017 and 2018 were similar in NAUSP and the National Antimicrobial Prescribing Survey (NAPS).[7] Cefazolin, ceftriaxone, amoxicillin–clavulanic acid, piperacillin–tazobactam and metronidazole were the most commonly prescribed antibacterials reported by NAPS contributor hospitals. The difference in order likely reflects the difference between methodologies used by NAUSP and NAPS. Slight differences in the most frequently used antibacterials between 2017 and 2018 are likely accounted for by the piperacillin–tazobactam shortage in 2017. These differences were less apparent in NAUSP than NAPS contributors.

Figure 3: Top 10 antibacterials as a percentage of all antibacterials used in NAUSP contributor hospitals, 2018

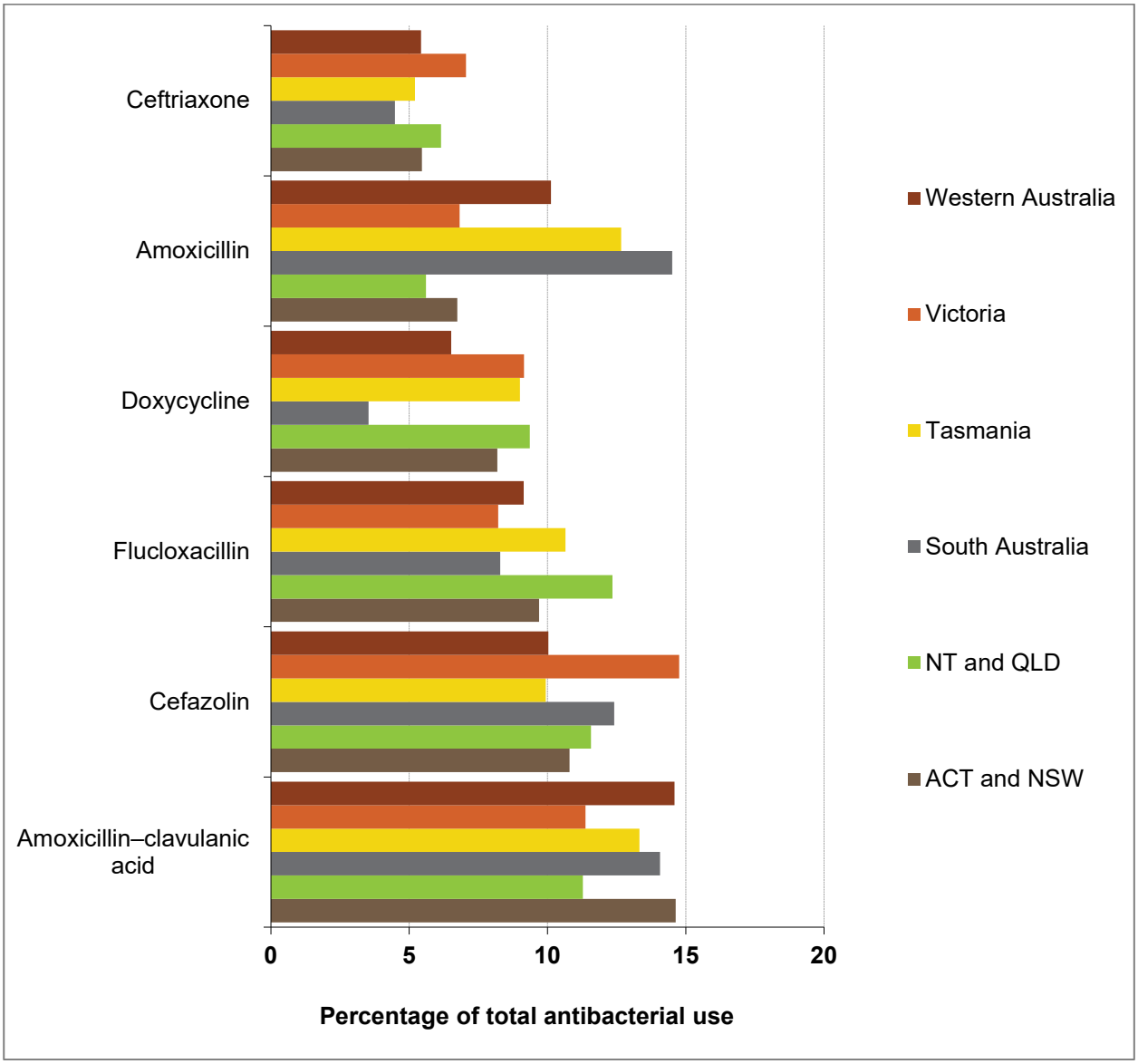


Refer to Appendix 4 for the 2017 top 20 antibacterials.

The most used antibacterials, as a percentage of total antibacterial use, varied between states and territories. Amoxicillin–clavulanic acid was the most used antibacterial in Australian Capital Territory/New South Wales, South Australia and Western Australia.

The six most used antimicrobials accounted for approximately 60% of all use in the states and territories (Figure 4). Cefazolin was the most used antibacterial in Victoria; use of doxycycline in South Australia was approximately half that of other states and territories.

Figure 4: Top six antibacterials as a percentage of all antibacterials used in NAUSP contributor hospitals by state and territory, 2018

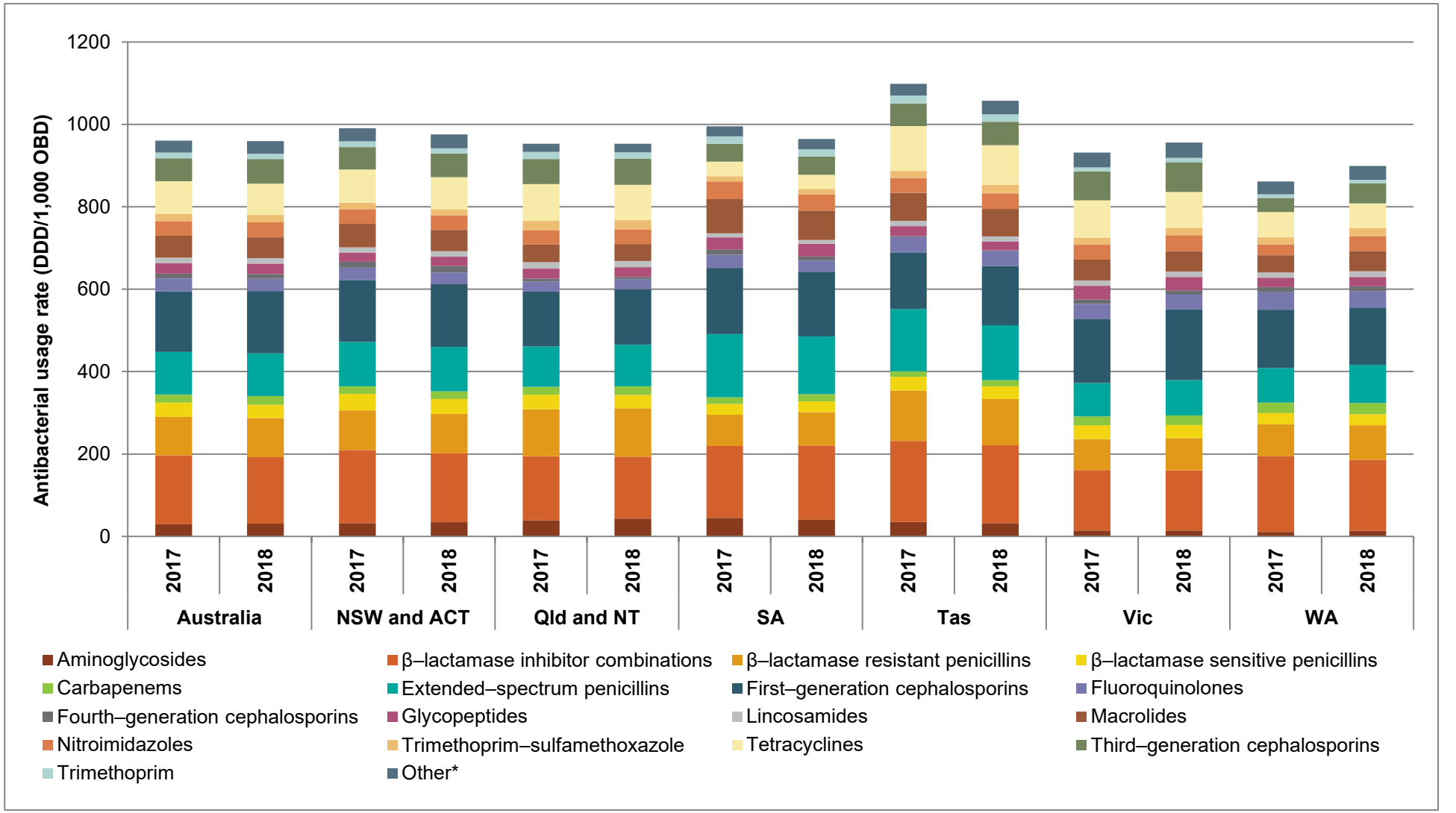


Comparison of antibacterial usage rates by state and territory

There was no change in ranking of total-hospital antibacterial use by state and territory from 2016 to 2018. See Figure 5 for total-hospital antibacterial use by state and territory in 2017 and 2018. Aggregate usage rates for Tasmania have decreased every year since 2016. Usage rates in Victoria and Western Australia increased during 2017 and 2018. Usage rates of β-lactamase inhibitor combinations decreased between 2017 and 2018 in all states and territories except South Australia. There were decreases of more than 10 DDDs per 1,000 OBDs in macrolides in South Australia, tetracyclines in Tasmania and extended-spectrum penicillins in South Australia and Tasmania. There were increases of the same magnitude in first-generation cephalosporin use in Victoria and third-generation cephalosporin use in Western Australia.

Figure 6 and Table 4 show usage rates for selected classes by state and territory as a percentage of total usage rates. There are notable differences in percentage of total usage rates for aminoglycosides, third- and fourth-generation cephalosporins and β-lactamase inhibitor combinations across state and territories. See Table 2 for information on usage rates for individual antibacterial classes, 2016 to 2018.

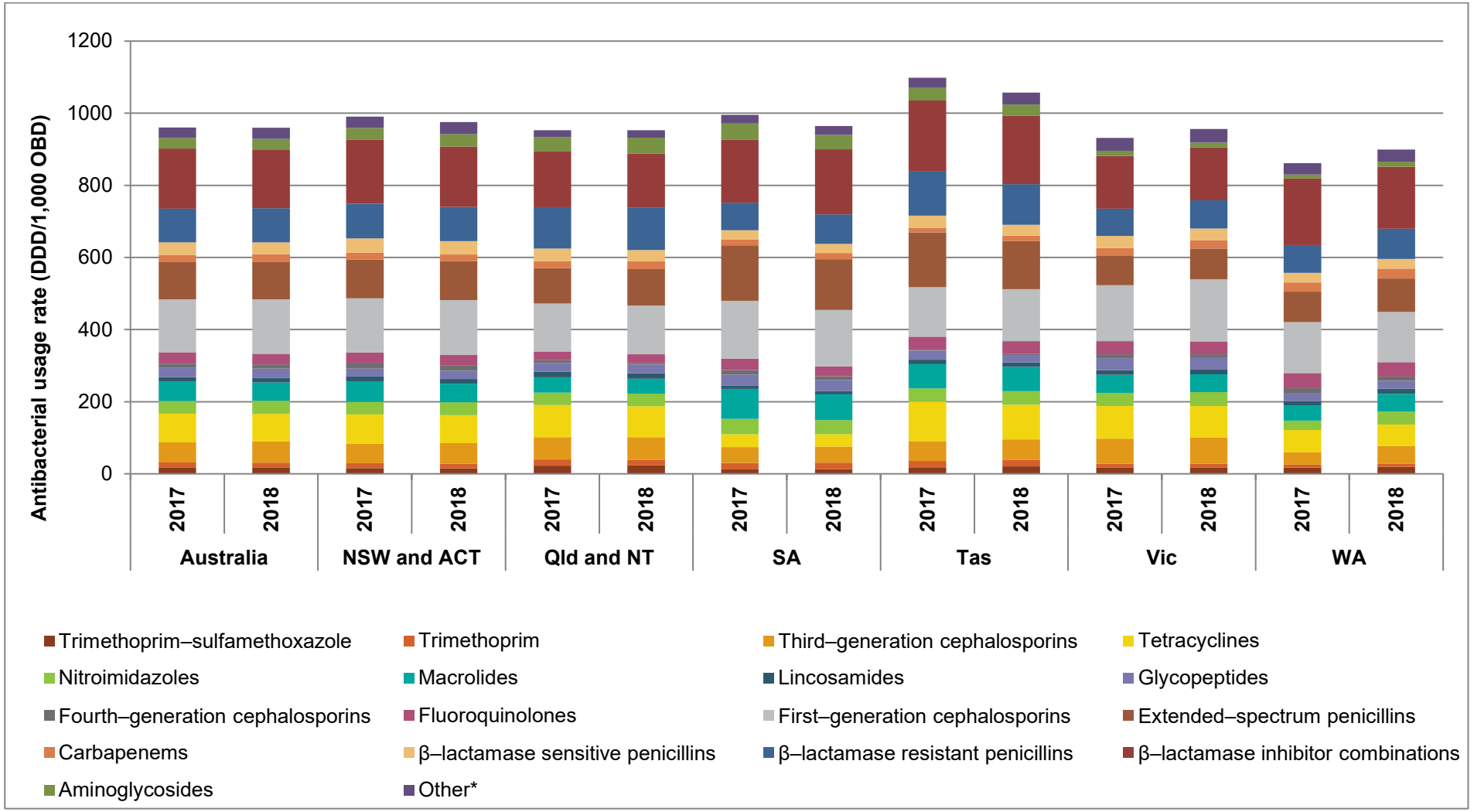
Figure 5: Aggregate total-hospital antibacterial usage rates (DDD/1,000 OBD) by class in NAUSP contributor hospitals, by state & territory, 2017–2018



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

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Figure 6: Aggregate total-hospital antibacterial usage rates (DDD/1,000 OBD) as a percent of total usage rates in NAUSP contributor hospitals, 2017–2018



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Table 4: Total-hospital antibacterial usage rates (DDD/1,000 OBD) by class in NAUSP contributor hospitals, by state and territory, 2017–2018

	Australia		NSW and ACT		Qld and NT		SA		Tas		Vic		WA	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Aminoglycosides	29.6	30.9	32.4	34.6	39.5	43.5	45.1	40.4	35.0	32.0	14.5	14.1	10.8	13.6
β-lactamase inhibitor combinations	167.2	161.4	177.1	167.1	154.9	150.0	174.5	180.3	196.8	189.1	146.4	146.2	184.6	172.2
β-lactamase resistant penicillins	93.3	94.9	96.3	95.2	114.6	117.6	75.7	81.3	122.2	112.7	75.5	78.2	77.0	84.2
β-lactamase sensitive penicillins	34.9	32.4	40.1	36.6	34.8	32.1	25.9	25.6	33.8	30.4	33.4	31.7	27.3	26.8
Carbapenems	19.6	20.8	18.4	18.4	19.2	21.3	16.3	17.5	13.2	14.9	21.7	23.4	25.2	27.3
Extended-spectrum penicillins	103.1	104.1	107.8	108.2	97.9	100.7	153.5	140.4	151.4	133.6	81.0	85.7	84.3	92.7
First-generation cephalosporins	147.2	151.0	150.4	152.3	133.3	134.9	160.7	156.8	137.2	143.8	155.6	171.9	141.4	139.1
Fluoroquinolones	31.4	30.1	29.9	28.2	24.3	24.1	31.8	27.3	36.9	35.5	36.2	35.8	42.0	39.9
Fourth-generation cephalosporins	11.5	11.1	14.5	16.0	7.0	5.3	12.4	9.9	2.1	2.8	10.9	10.1	12.7	11.6
Glycopeptides	25.5	25.6	21.7	22.7	24.6	24.1	29.9	30.9	24.8	20.8	33.0	32.8	22.6	22.2
Lincosamides	13.3	13.2	13.1	13.0	15.3	14.7	9.7	8.9	12.7	12.5	12.9	13.1	13.0	14.3
Macrolides	53.6	50.7	57.1	51.5	43.1	41.1	82.8	71.6	67.5	66.9	50.6	49.1	41.5	49.3
Nitroimidazoles	35.0	36.3	35.3	35.3	34.1	35.0	43.1	39.2	36.4	37.6	36.1	38.8	26.2	35.6
Tetracyclines	79.3	76.1	80.8	77.9	89.2	85.7	35.5	34.4	109.4	96.1	90.6	87.2	61.7	60.1
Third-generation cephalosporins	55.9	59.5	54.5	57.0	61.4	63.6	43.6	44.5	54.8	56.9	69.7	72.5	34.2	49.3
Trimethoprim	13.7	12.8	13.6	12.7	17.2	15.2	18.0	17.6	19.2	18.3	10.2	9.9	8.3	8.2
Trimethoprim-sulfamethoxazole	17.6	17.9	15.7	15.3	23.0	23.1	12.5	13.3	16.8	20.5	17.6	18.1	17.2	19.2
Other*	29.1	30.8	32.0	33.8	19.5	21.0	24.5	24.6	28.2	32.8	35.7	37.5	31.3	33.9

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Table 5: Total-hospital antibacterial usage rates (DDD/1,000 OBD) by class, as a percentage of total usage rates in NAUSP contributor hospitals, by state & territory, 2017–2018

	Australia		NSW and ACT		Qld and NT		SA		Tas		Vic		WA	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Aminoglycosides	3.1	3.2	3.3	3.5	4.1	4.6	4.5	4.2	3.2	3.0	1.6	1.5	1.3	1.5
β–lactamase inhibitor combinations	17.4	16.8	17.9	17.1	16.3	15.7	17.5	18.7	17.9	17.9	15.7	15.3	21.4	19.1
β–lactamase resistant penicillins	9.7	9.9	9.7	9.8	12.0	12.3	7.6	8.4	11.1	10.7	8.1	8.2	8.9	9.4
β–lactamase sensitive penicillins	3.6	3.4	4.0	3.7	3.7	3.4	2.6	2.7	3.1	2.9	3.6	3.3	3.2	3.0
Carbapenems	2.0	2.2	1.9	1.9	2.0	2.2	1.6	1.8	1.2	1.4	2.3	2.4	2.9	3.0
Extended–spectrum penicillins	10.7	10.8	10.9	11.1	10.3	10.6	15.4	14.6	13.8	12.6	8.7	9.0	9.8	10.3
First–generation cephalosporins	15.3	15.7	15.2	15.6	14.0	14.2	16.1	16.3	12.5	13.6	16.7	18.0	16.4	15.5
Fluoroquinolones	3.3	3.1	3.0	2.9	2.6	2.5	3.2	2.8	3.4	3.4	3.9	3.7	WA	4.4
Fourth-generation cephalosporins	1.2	1.2	1.5	1.6	0.7	0.6	1.2	1.0	0.2	0.3	1.2	1.1	1.5	1.3
Glycopeptides	2.7	2.7	2.2	2.3	2.6	2.5	3.0	3.2	2.3	2.0	3.5	3.4	2.6	2.5
Lincosamides	1.4	1.4	1.3	1.3	1.6	1.5	1.0	0.9	1.2	1.2	1.4	1.4	1.5	1.6
Macrolides	5.6	5.3	5.8	5.3	4.5	4.3	8.3	7.4	6.1	6.3	5.4	5.1	4.8	5.5
Nitroimidazoles	3.6	3.8	3.6	3.6	3.6	3.7	4.3	4.1	3.3	3.6	3.9	4.1	3.0	4.0
Tetracyclines	8.3	7.9	8.2	8.0	9.4	9.0	3.6	3.6	10.0	9.1	9.7	9.1	7.2	6.7
Third–generation cephalosporins	5.8	6.2	5.5	5.8	6.4	6.7	4.4	4.6	5.0	5.4	7.5	7.6	4.0	5.5
Trimethoprim	1.4	1.3	1.4	1.3	1.8	1.6	1.8	1.8	1.7	1.7	1.1	1.0	1.0	0.9
Trimethoprim–sulfamethoxazole	1.8	1.9	1.6	1.6	2.4	2.4	1.3	1.4	1.5	1.9	1.9	1.9	2.0	2.1
Other*	3.0	3.2	3.2	3.5	2.1	2.2	2.5	2.6	2.6	3.1	3.8	3.9	3.6	3.8

* ‘Other’ comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Surveillance of six major antibacterial classes by state and territory

For more than a decade NAUSP reports have highlighted six antibacterial classes which are high-priority for AMS programs. Reasons for prioritising these antibacterial classes include their potential impact on the development of antimicrobial resistance[9], the potential for inappropriate prescribing, high cost and unfavourable side-effect profiles (for example, for aminoglycosides). These six classes of antibacterials are:

- Aminoglycosides (amikacin, gentamicin and tobramycin)
- Antipseudomonal penicillin β-lactamase inhibitor combinations (piperacillin–tazobactam)
- Carbapenems (ertapenem and meropenem)
- Fluoroquinolones (ciprofloxacin, moxifloxacin and norfloxacin)
- Glycopeptides (teicoplanin and vancomycin)
- Third- and fourth-generation cephalosporins (cefepime, cefotaxime, ceftazidime and ceftriaxone).

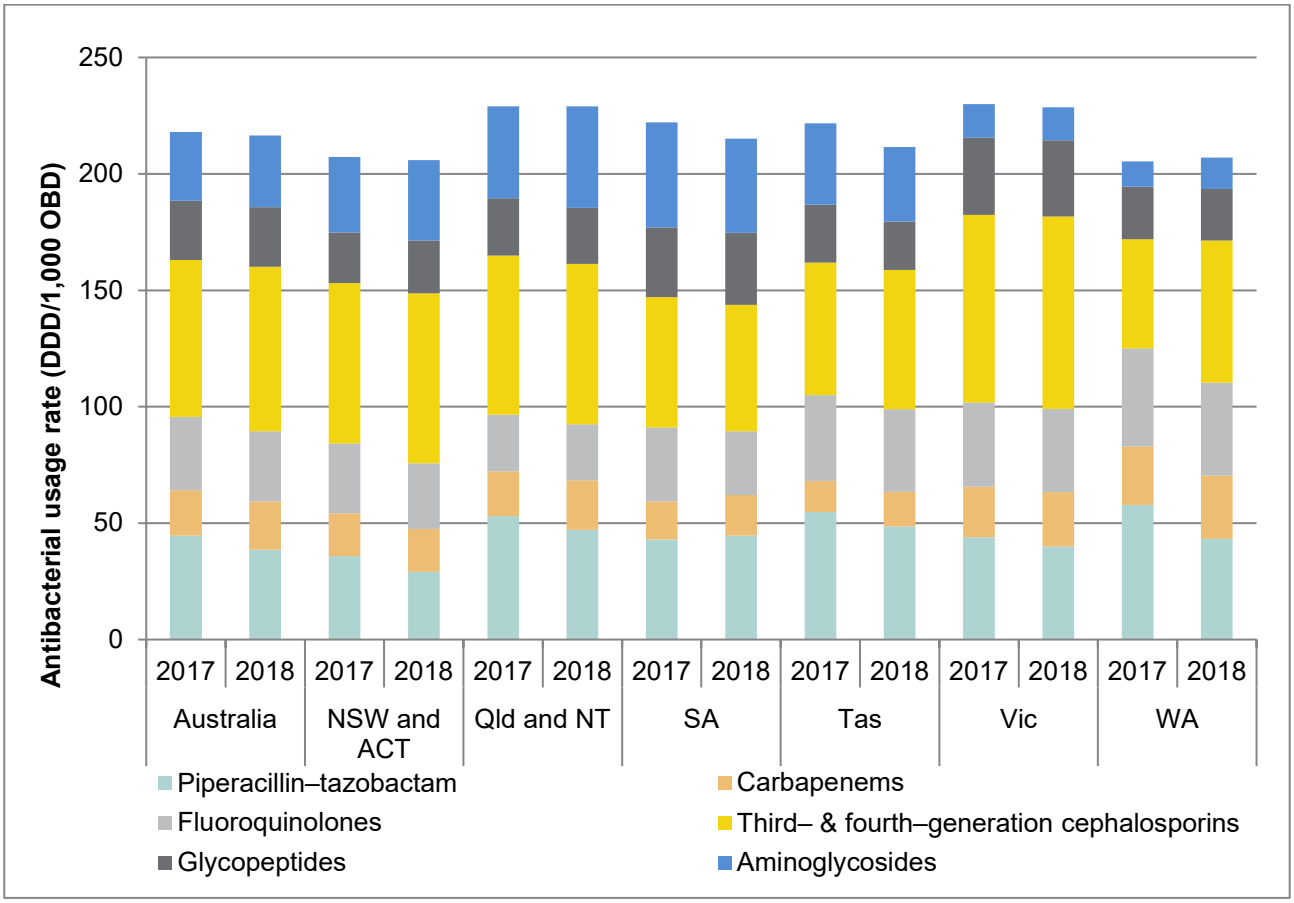
These classes accounted for nearly 25% of total use in Australian hospitals (range 21.4–23.9%) with an aggregate usage rate of 216.5 DDD per 1,000 OBD in 2018. Despite overall lower usage, total aggregate usage of these six major antibacterial classes was highest in Victoria in 2017 (24.7%) and Queensland in 2018 (24.0%).

In 2017 and 2018, the class for which use varied most between states and territories was the aminoglycosides (Figure 7). In 2018, usage rates in Queensland and the Northern Territory were three times greater than usage rates in Western Australia in 2018. Aminoglycoside use as a proportion of the six major antibacterial classes ranged from 6.2% in Victoria to 19.0% in Queensland and the Northern Territory.

Glycopeptide usage rates were highest in Victoria and lowest in New South Wales and the Australian Capital Territory and Tasmania. Usage rates for third- and fourth-generation cephalosporins were highest in Victoria and lowest in South Australia and Tasmania.

The reasons for these variations in usage patterns are unknown; multiple factors influence usage including local epidemiology, patient cohorts, formulary recommendations and hospital peer group. Jurisdictional and local investigation of the reasons for the variations identified in NAUSP data, will inform action to improve patient safety.

Figure 7: Aggregate total-hospital usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals for six major antibacterial classes, by state and territory, 2017–2018



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

Table 6: Aggregate total-hospital usage rates (DDD/1,000 OBD) and percentage of total usage rates in NAUSP contributor hospitals for six major antibacterial classes, by state and territory, 2017–2018

State / territory	Aggregate usage rate of six major antibacterial classes (DDD / 1,000 OBD)		Percentage of aggregate usage rate of all classes (%)	
	2017	2018	2017	2018
NSW and ACT	207.3	205.9	20.9	21.1
Vic	230.0	228.5	24.7	23.9
Qld and NT	229.0	229.0	24.0	24.0
SA	222.1	215.1	22.3	22.3
WA	205.4	207.0	23.8	23.0
Tas	221.7	211.6	20.2	20.0
National	218.0	216.5	22.7	22.6

Note: Six major antibacterial classes = aminoglycosides, carbapenems, fluoroquinolones, glycopeptides, piperacillin-tazobactam and third-and fourth-generation cephalosporins

Intrastate antibacterial usage rates

The following sections describe comparative antibacterial usage rates by state and territory collectively and for individual hospitals. Changes in the rates of antibacterial usage in individual hospitals from 2017 to 2018 are shown in Appendix 3.

Table 7 shows antibacterial usage rates in NAUSP contributor hospitals for states and territories. Some factors to consider in reviewing these rates include:

- There are no Public Acute Group C contributor hospitals from Victoria; total antibacterial usage rates are often higher in Group C hospitals compared to other facilities
- In 2018, eight small and remote Western Australian hospitals commenced participation in NAUSP.

Table 7: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2017–2018

	Year	*n*	Aggregate	Mean	Median	Range
National	2017	189	960.7	972	968	219–1,944
	2018	**201**	**959.6**	**991**	**988**	**212–2,457**
NSW and ACT	2017	68	990.7	1,038.8	1,009.4	349–1,944
	2018	**70**	**975.7**	**1,019.4**	**1,032.5**	**381–1,595**
Qld and NT	2017	46	953.0	1,005.7	1,029.2	219–1,891
	2018	**46**	**953.1**	**1,025.3**	**1,027.6**	**219–1,813**
SA	2017	20	995.6	877.8	810.9	537–1,210
	2018	**20**	**964.6**	**867.2**	**844.8**	**605–1,300**
Tasmania	2017	6	1,098.3	1,135.4	1,149.4	781–1,490
	2018	**6**	**1,057.4**	**1,050.2**	**1,141.7**	**808–1,210**
Victoria	2017	32	926.9	887.2	940.1	257–1,186
	2018	**34**	**947.8**	**910.6**	**934.3**	**335–1,207**
WA	2017	17	863.8	859.4	829.7	439–1,412
	2018	**25**	**901.9**	**1,033.7**	**872.8**	**426–2,457**

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

Analysis of total antibacterial usage rates by peer group, 2017 and 2018

Comparison of total antibacterial usage by peer group

Table 8 shows aggregate, average, median and the range of rates of antibacterial usage in large AIHW peer groups, where data are available. Average rates are similar for the Principal Referral and Public Group A hospitals. Public Group B and C hospitals have higher average rates than the larger hospital peer groups, but the range of usage rates is large. Interquartile ranges are narrowest in the Principal Referral hospitals.
To maintain anonymity due to small numbers, South Australian hospitals were combined with Western Australian hospitals, and Tasmanian and Victorian hospitals were combined for Figures 8 to 11.

Principal referral hospitals

Data from 35 Principal Referral hospitals (31 public and 4 private) are shown in Figure 8 (2017 data are shown in Figure A18). In 2018, the aggregate, average and median usage rates were similar. The highest use facility was approximately double the lowest in the Principal Referral hospital peer group.

Public Acute Group A hospitals

The Acute Group A hospital cohort included 16 private hospitals. Figure 9 shows aggregate usage rates in 73 hospitals in 2018 (2017 data are shown in Figure A19).

Public Acute Group B hospitals

The Acute Group B hospital cohort included nine private hospitals. Inter-hospital variation in this peer group is large. Each state/territory group has hospitals with usage rates above or below the middle range (Figures 10 and A20).

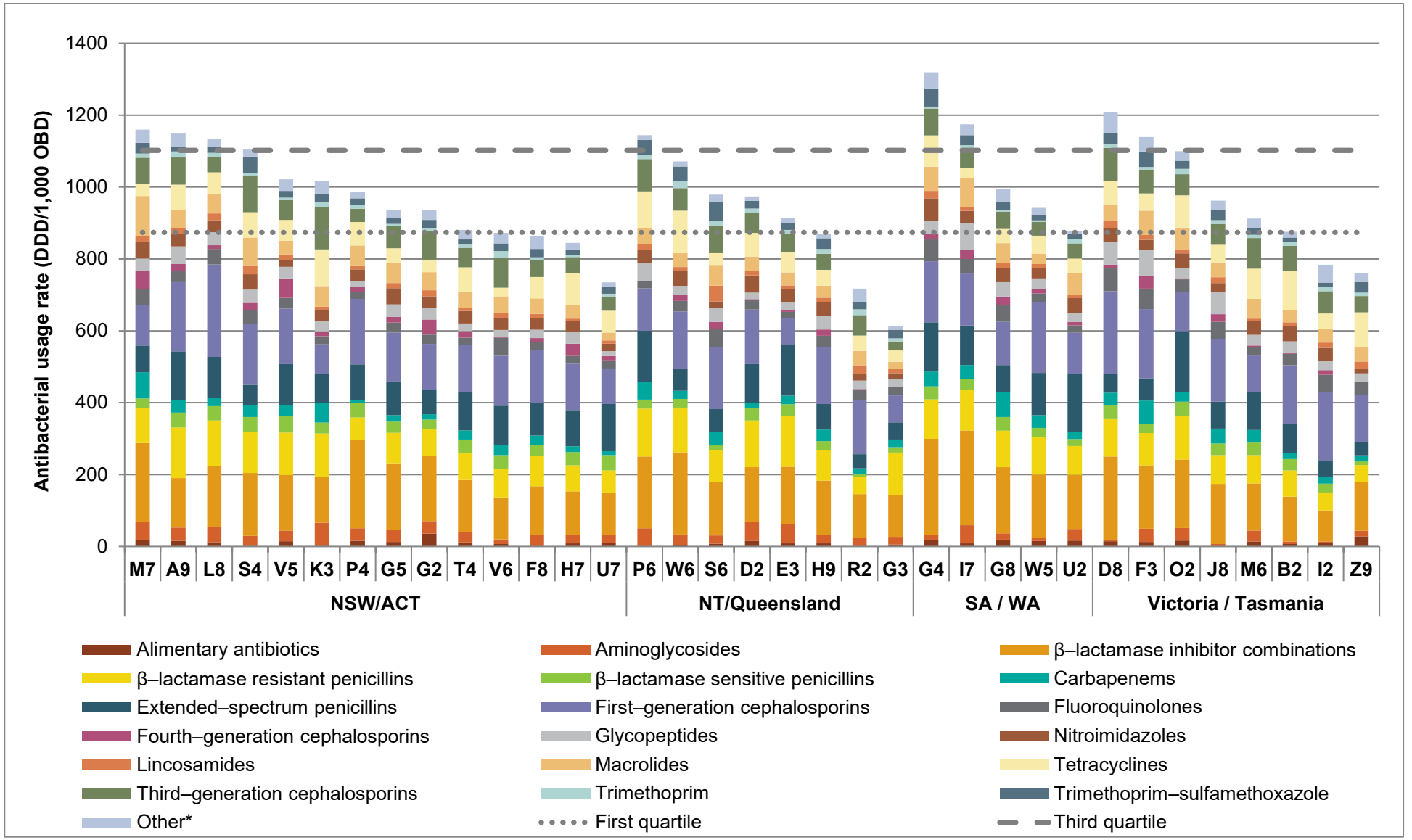
Public Acute Group C hospitals

The Acute Group C hospital cohort included five private hospitals. Inter-hospital variation in this peer group is large (Figures 11 and A21).

Table 8: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by AIHW peer group, 2017–2018

	Year	*n*	Aggregate	Average	Median	Range	Interquartile range
Principal Referral	2017	35	966.2	969.1	928.20	672.4-1356.4	222.1
	2018	**35**	**947.5**	**954.7**	**941.78**	**597.6-1319.0**	**228.1**
Public Acute Group A	2017	73	932.7	936.7	979.3	347.7-1489.7	320.6
	2018	**73**	**946.9**	**943.5**	**981.9**	**375.7-1365.2**	**301.1**
Public Acute Group B	2017	46	982.6	1023.7	997.8	529.4-1916.1	436.2
	2018	**47**	**946.6**	**999.8**	**992.5**	**341.9-1642.2**	**412.5**
Public Acute Group C	2017	29	838.67	937.71	912.83	437.3-1734.2	484.1
	2018	**38**	**931.56**	**1,061.28**	**958.04**	**425.5-2457.0**	**512.7**

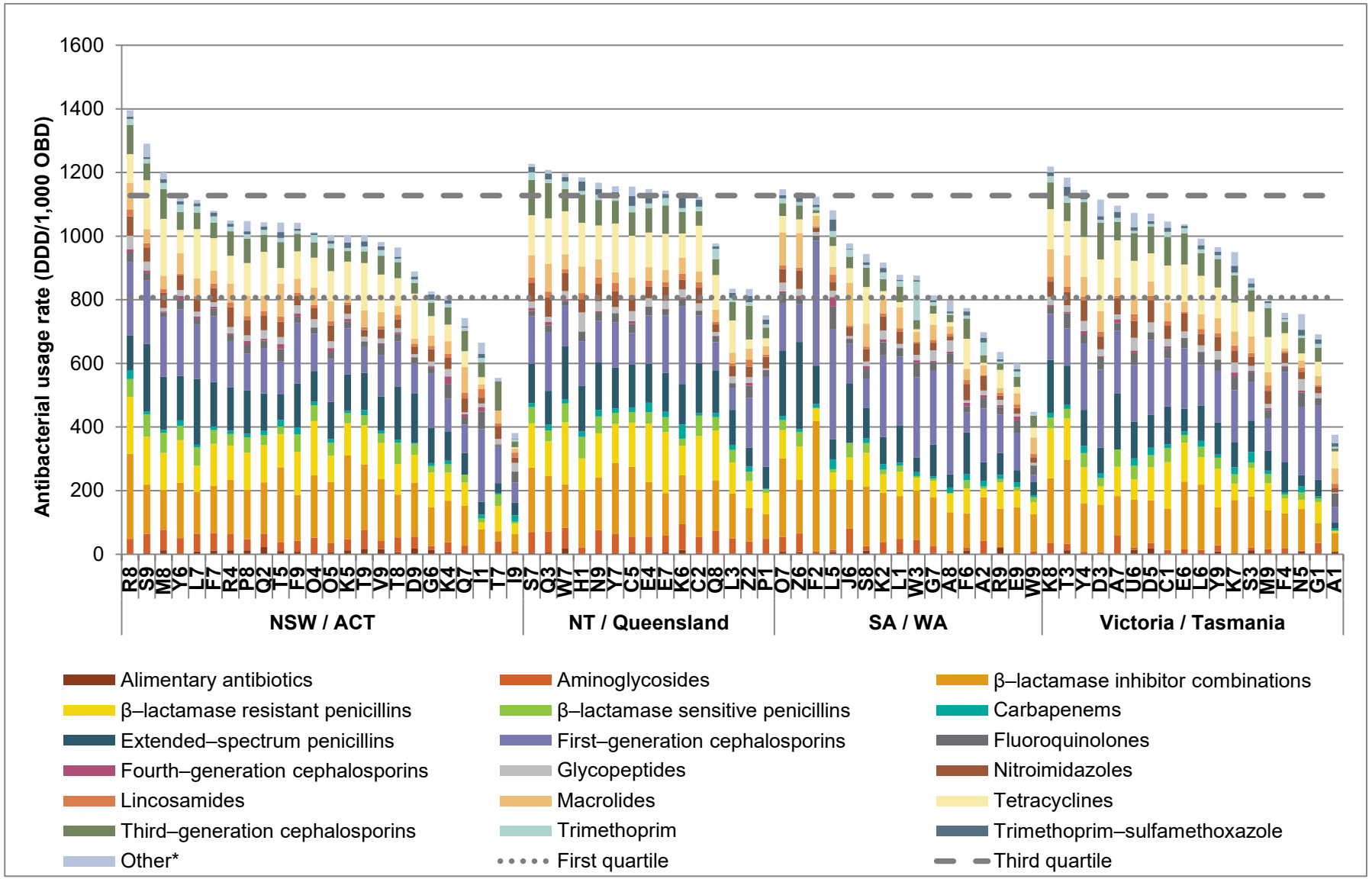
Figure 8: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Principal Referral contributor hospitals, 2018



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

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

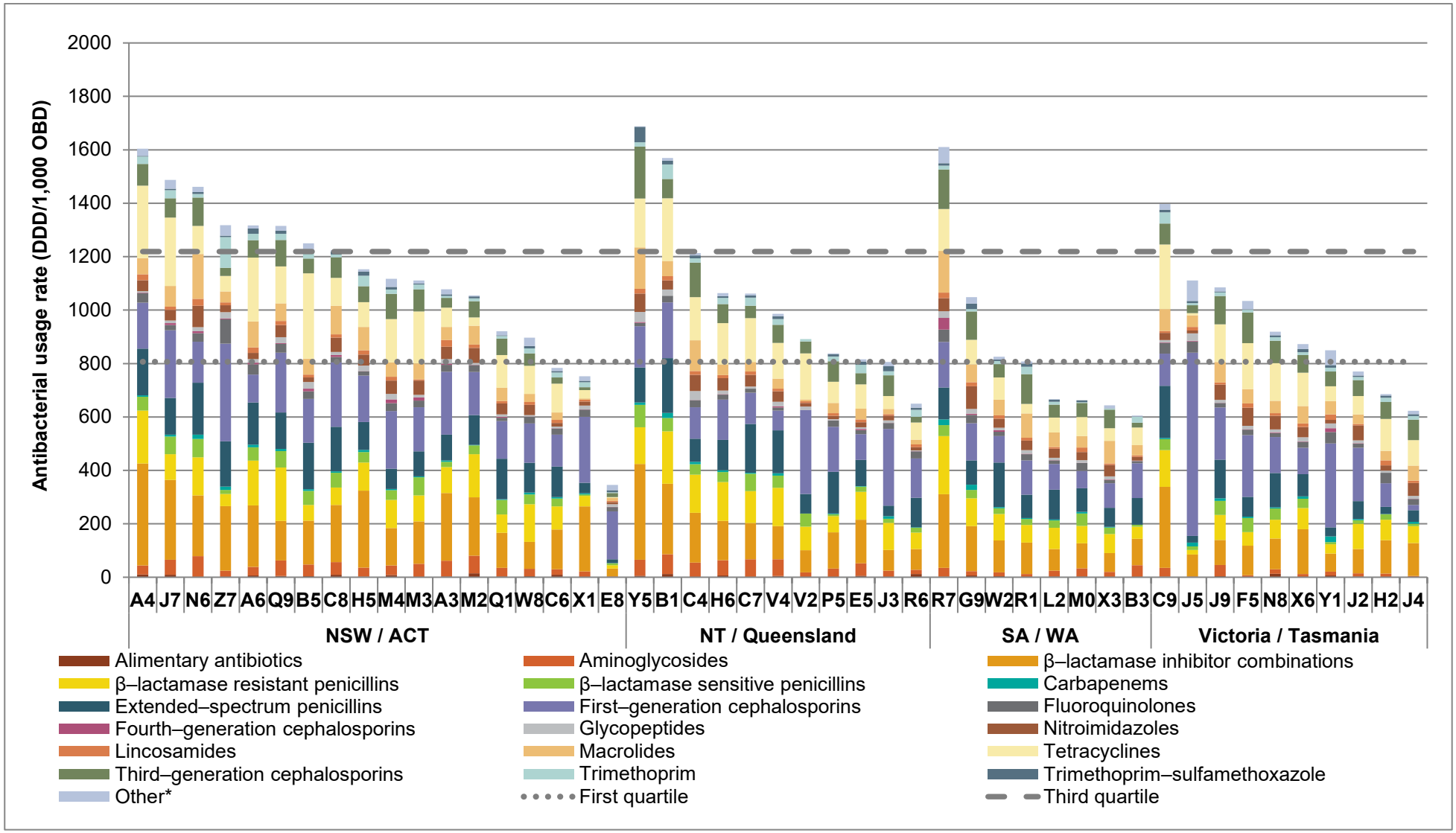
Figure 9: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Acute Group A contributor hospitals, 2018



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

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

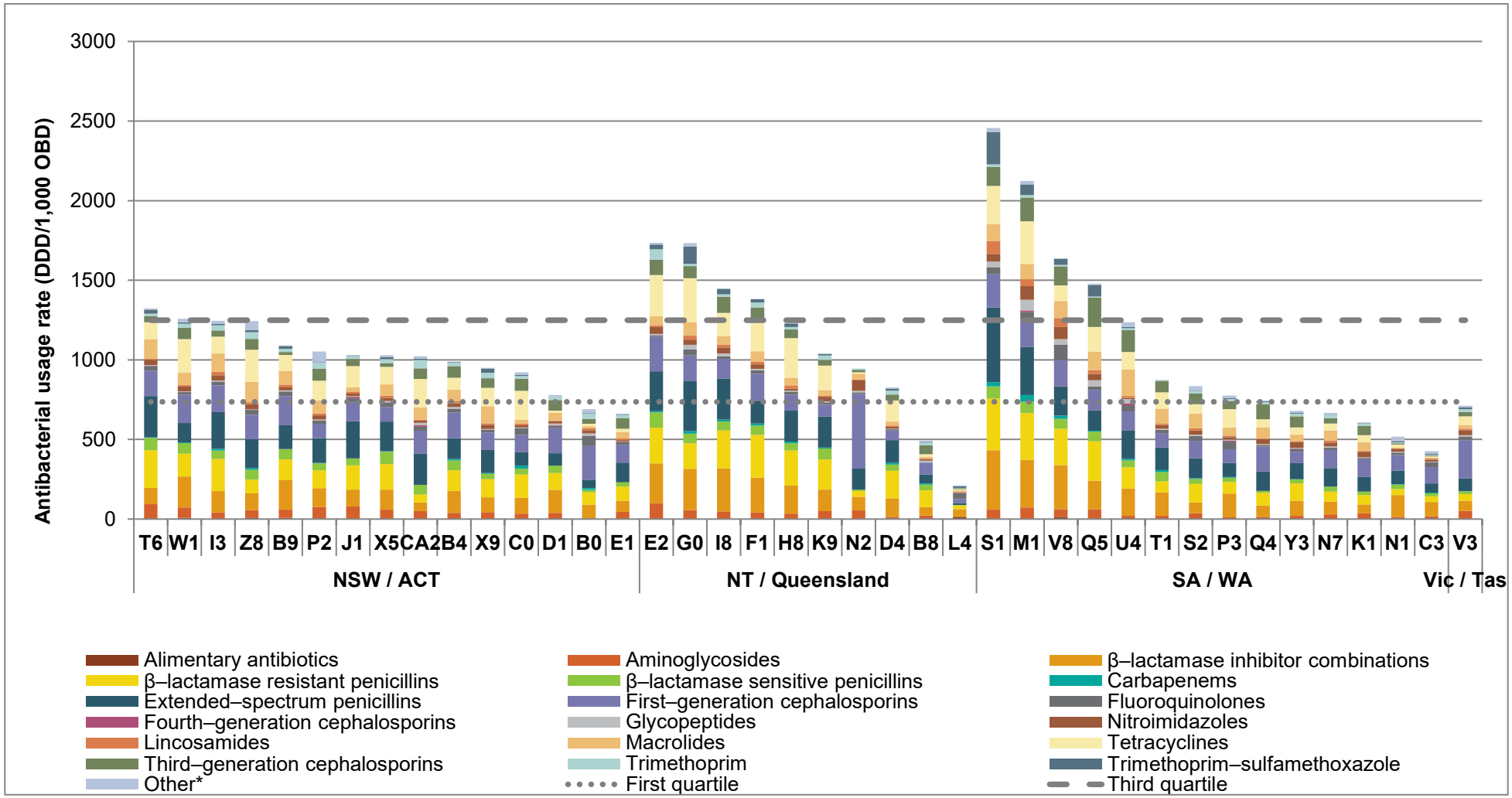
Figure 10: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Acute Group B contributor hospitals, 2018



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

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure 11: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Acute Group C contributor hospitals, 2018



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

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Differences in antimicrobial usage between public and private hospitals

Data from 34 private hospital contributors were included in the analyses for this report. Differences in antimicrobial utilisation, which are influenced by hospital and casemix, are expected. The following analyses highlight some of the similarities and differences between usage in public and private hospital contributors to NAUSP.

Reasons for differences in antibacterial usage rates within and between public and private hospitals are complex; they may include factors such as:

- Differences in casemix
- Differences in rates of AMR
- Differences in implementation and impact of AMS programs
- Changes in hospital formularies, policies, protocols and regulation.

Total-usage rates are similar in public and private hospitals (Figure A); however, differences are apparent in use of certain antimicrobial agents and classes.

Broad-spectrum antibiotics are used at lower rates in private hospitals, compared to public hospitals. Figures B and C show that usage rates of piperacillin–tazobactam and third-generation cephalosporins are higher in public hospitals than in private hospitals, but trends in usage over time are similar.

Figure A: Aggregate rates of antibacterial usage in public and private hospital NAUSP contributors, July 2016 – December 2018 (3-month moving average)

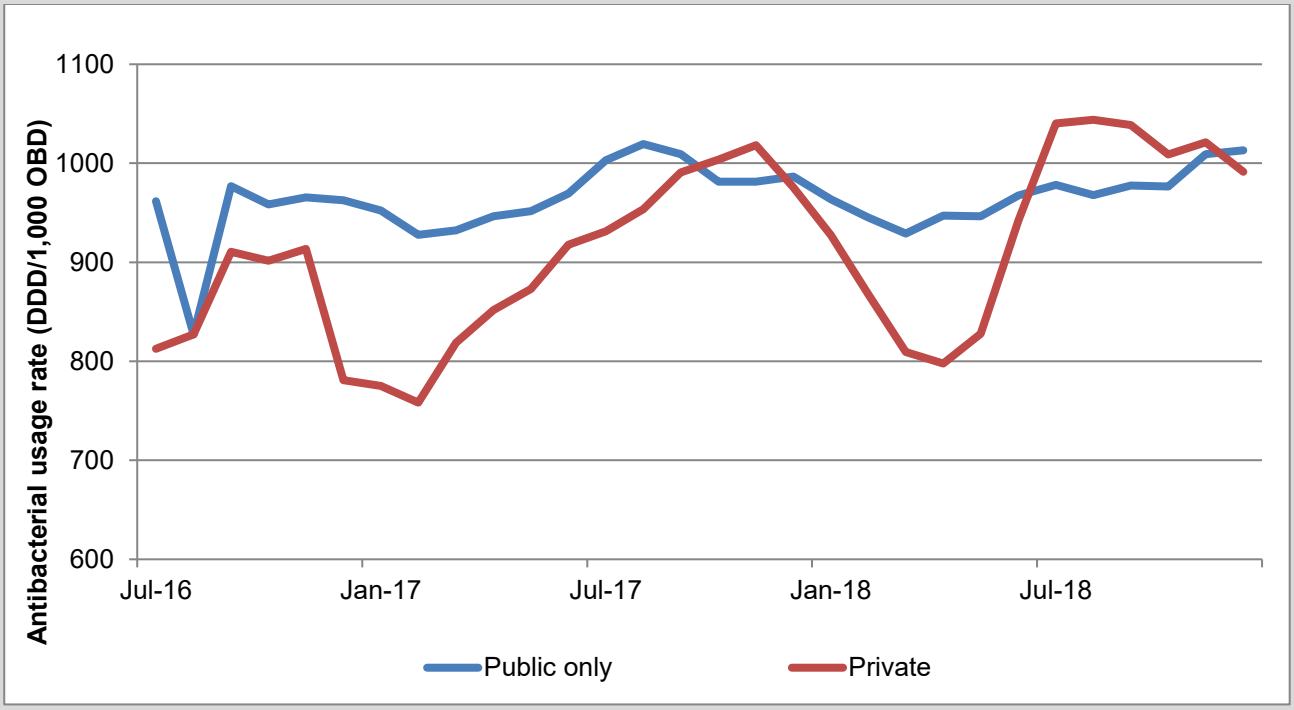


Figure B: Aggregate rates of piperacillin–tazobactam usage in public and private hospital NAUSP contributors, July 2016 – December 2018 (3-month moving average)

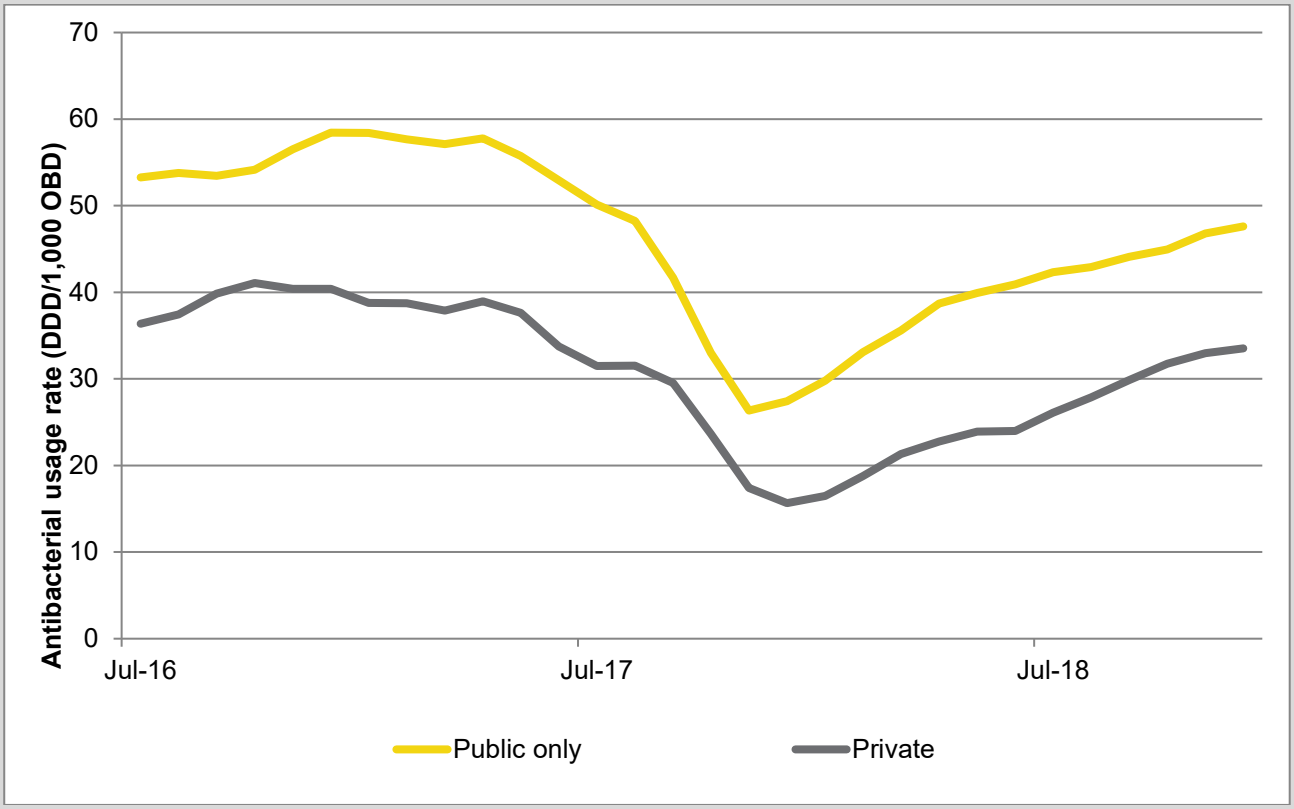
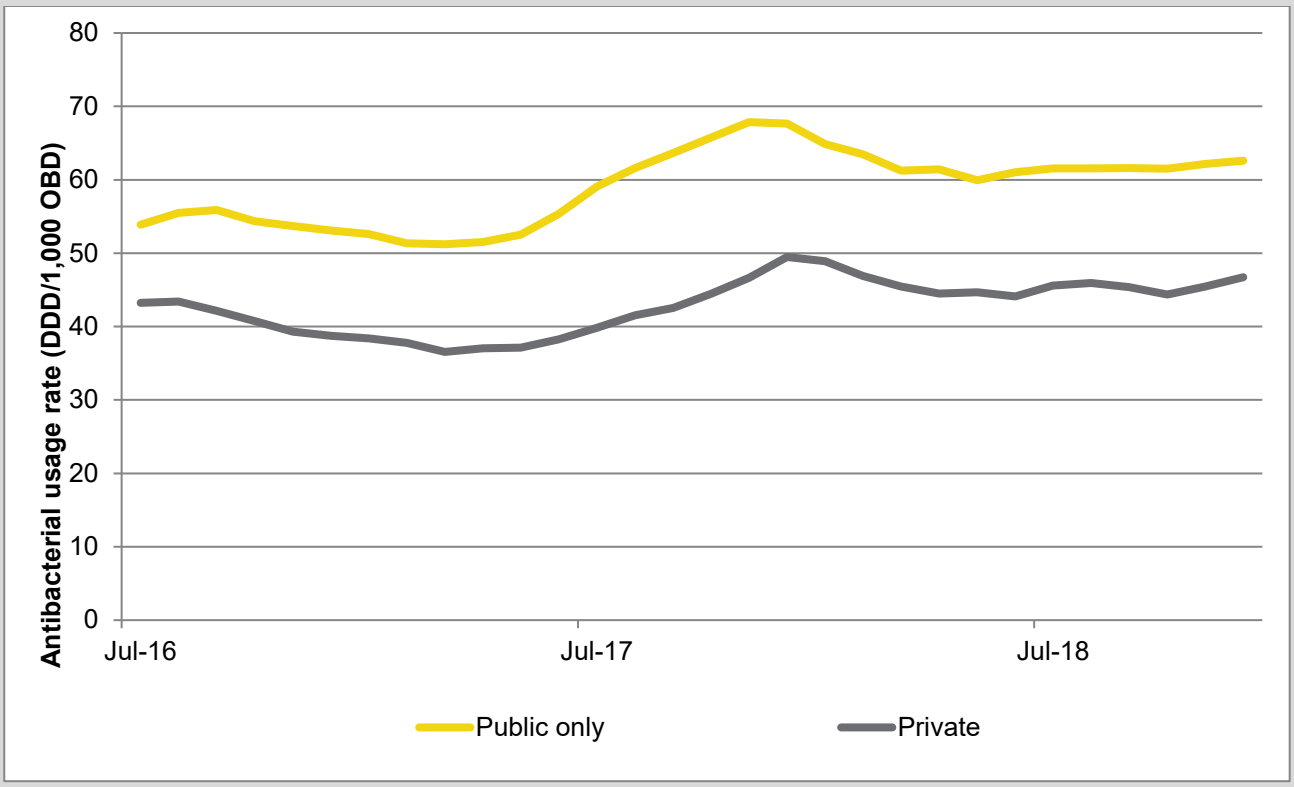
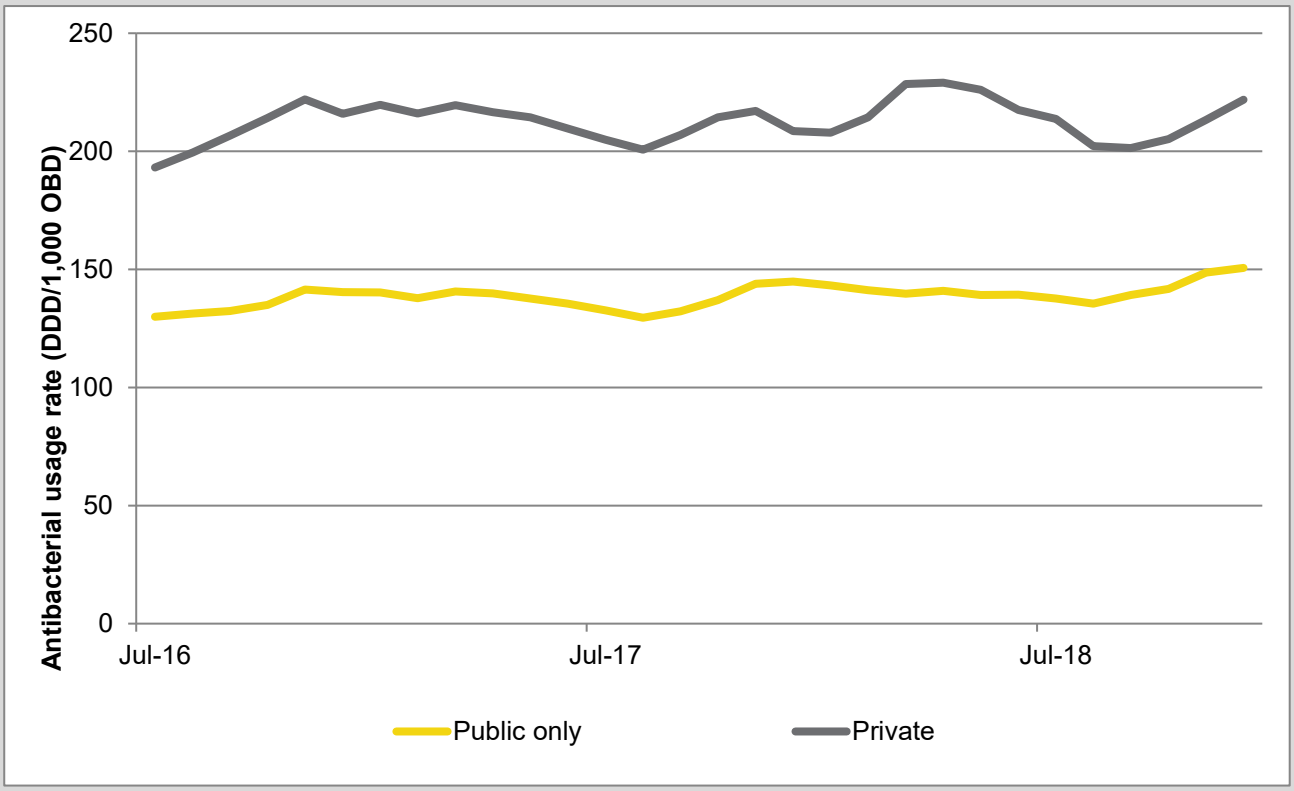


Figure C: Aggregate rates of third-generation cephalosporins usage in public and private hospital NAUSP contributors, July 2016 – December 2018 (3-month moving average)



In contrast, aggregate rates of first-generation cephalosporin usage in private hospitals are approximately 50% greater than in public hospitals (Figure D). This may reflect the higher proportion of surgical patients in many private hospitals, to public hospitals.

Figure D: Aggregate rates of first-generation cephalosporins usage in public and private hospital NAUSP contributors, July 2016 – December 2018



Usage rates for individual antibacterials, 2014–2018

This section summarises usage rates for individual antibacterials and trends from 2014 to 2018 for all states and territories except Queensland and Northern Territory, for which trends for 2016 to 2018 are shown.

High volume oral antibacterials

Amoxicillin–clavulanic acid and cefalexin are among the most commonly prescribed oral antibacterials in NAUSP contributor hospitals (Figures 3 and 4). Usage rates varied between states and territories, but similar rates (approximately 100 DDD per 1,000 OBD) were seen in all states for oral amoxicillin–clavulanic acid in 2018.

Figure 12: Oral amoxicillin–clavulanic acid and cefalexin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)

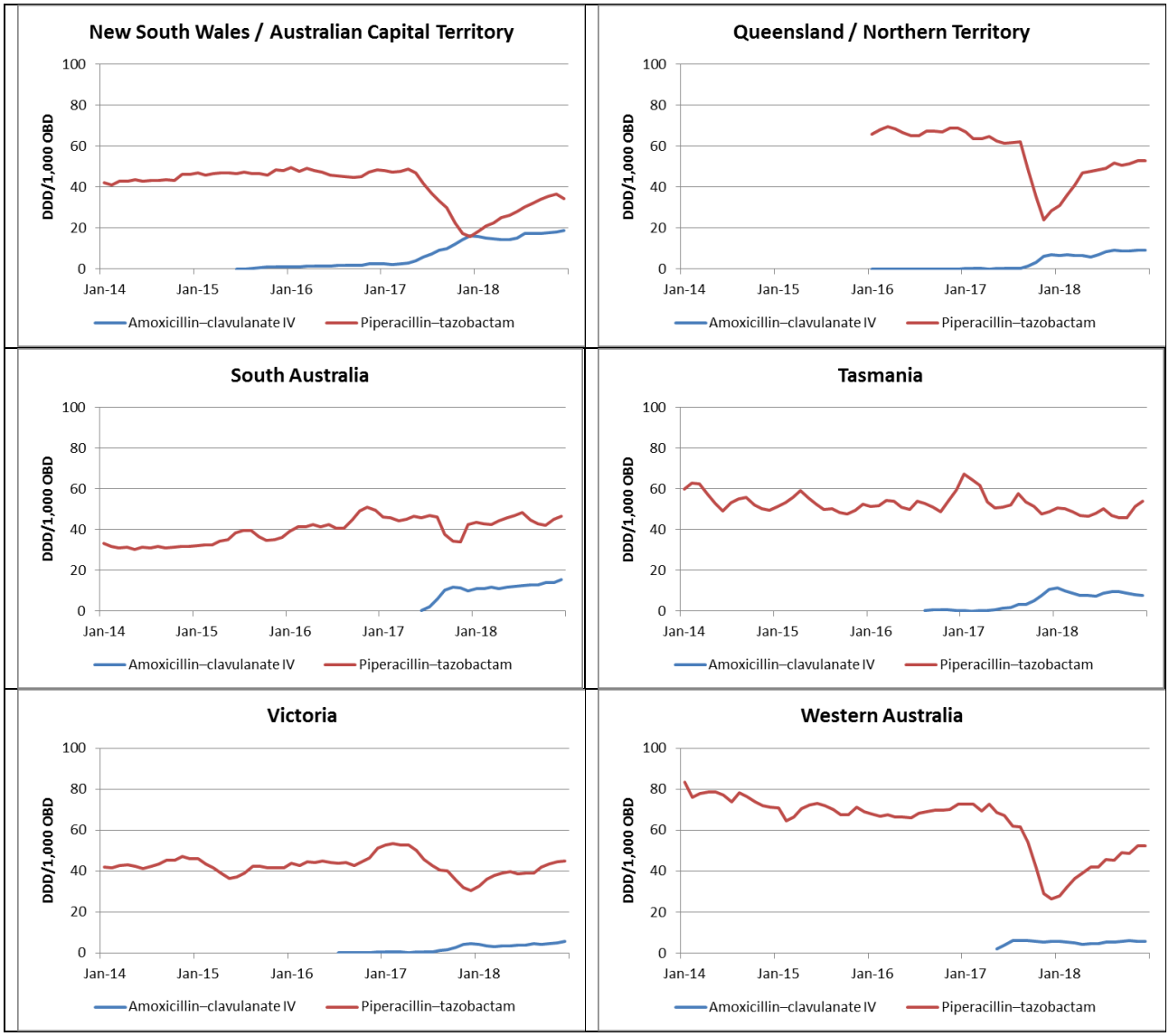
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Penicillin–β-lactamase inhibitor combinations: amoxicillin–clavulanate IV and piperacillin–tazobactam

Two intravenous penicillin–β-lactamase inhibitor combinations (amoxicillin–clavulanic acid and piperacillin–tazobactam) are available in Australia. Piperacillin–tazobactam is the primary penicillin–β-lactamase inhibitor combination used in NAUSP contributor hospitals. Piperacillin–tazobactam is recommended first first-line empiric therapy in ventilator-associated pneumonia and for febrile neutropenia. Amoxicillin–clavulanic acid has no anti-pseudomonal activity. Before 2017, it was only readily available in oral formulations in Australia. The intravenous formulation can be used in conditions including hospital-acquired pneumonia, ventilator-associated pneumonia and diabetic foot infections.[8,9] Intravenous use of amoxicillin–clavulanic acid accounted for less than 0.5% of total antibacterial use in NAUSP contributor hospitals in 2017, rose to 1.1% in 2018.

Figure 13 shows the effect of the 2017 piperacillin–tazobactam shortage. In some states and territories, use returned to previous levels after normal supply resumed in 2018. In Western Australia, where usage from 2014 to 2017 was higher than other states, the shortage appears to have changed prescribing practice. Although Western Australian usage rates increased in 2018 after normal supply resumed, they were lower than previous years.[10]

Figure 13: Penicillin–β-lactamase inhibitor combination usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)



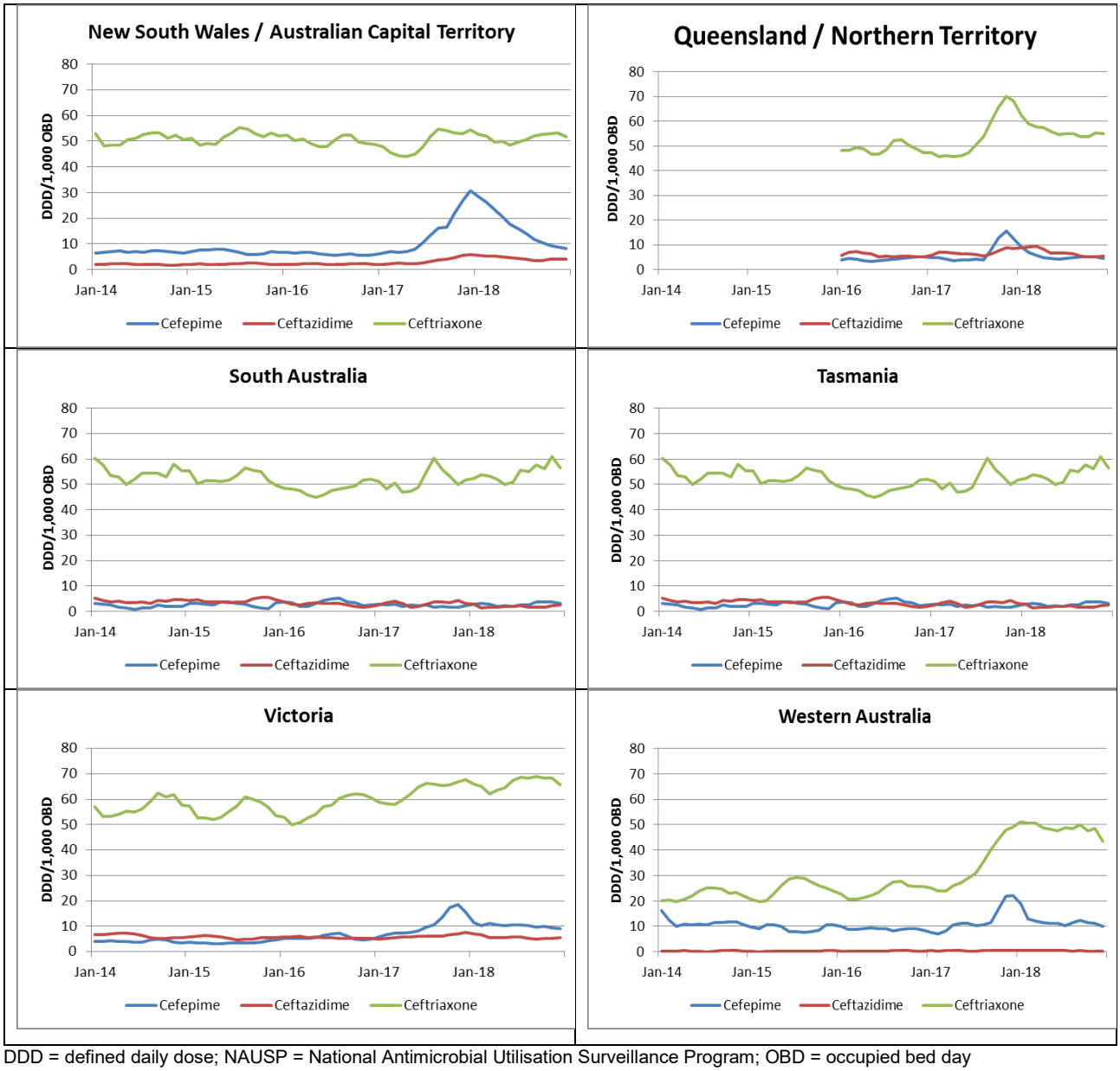
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

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

Figure 14 shows the usage rates of third- and fourth-generation cephalosporins (cefepime, ceftazidime and ceftriaxone) from 2014 to 2018, where data are available. As use of cefotaxime was minimal, it is not included.

The shortage of piperacillin–tazobactam led to increased use of third- and fourth-generation cephalosporins in all states and territories; the extent of this increase varied from state to state. In New South Wales and the Australian Capital Territory in 2017 and 2018, increased usage of cefepime aligns with the months of the shortage. The usage of both ceftriaxone and cefepime in Western Australia and Queensland/Northern Territory increased during the months of the shortage. Higher usage of ceftriaxone appears to have continued during and following the shortage in Victoria and Western Australia. Usage in Queensland reduced after the shortage but to a higher baseline.

Figure 14: Cephalosporin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)



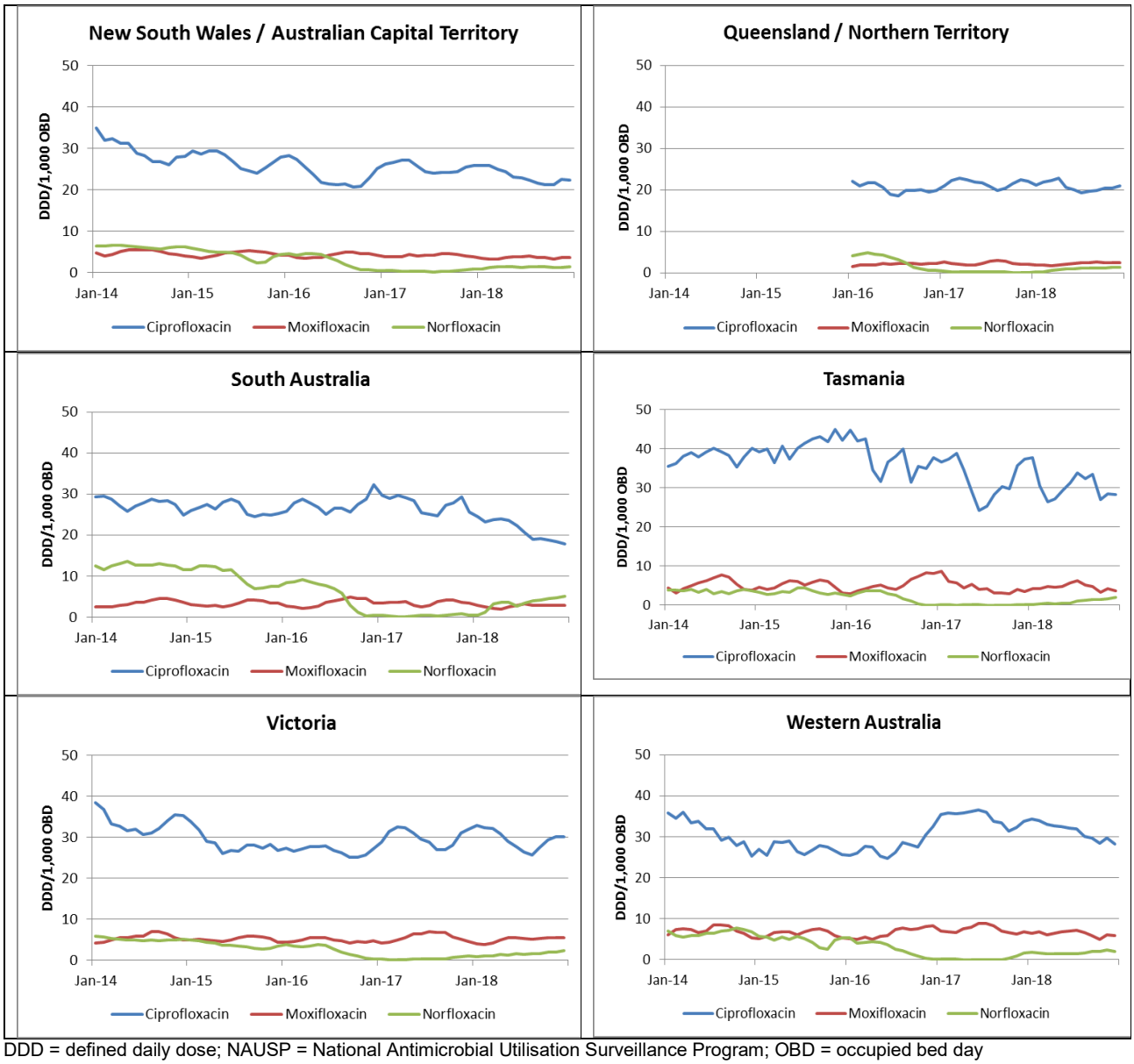
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Fluoroquinolones – ciprofloxacin, moxifloxacin, norfloxacin

Fluoroquinolone usage rates have decreased since 2014 in most states and territories (Figure 15). Ciprofloxacin usage rates have remained stable in Queensland/Northern Territory where usage rates have been relatively low since 2016. Most Australian hospitals and statewide formularies (where they exist) place restrictions on the use of fluoroquinolones, and there are few indications where a fluoroquinolone is the first-line recommendation.

Ciprofloxacin is the most frequently used fluoroquinolone; it has higher bioavailability than norfloxacin and a financial benefit over moxifloxacin. Usage rates of moxifloxacin have remained relatively constant because there are a limited number of standard indications. Norfloxacin usage rates declined in 2016, probably related to a nationwide shortage[11], rather than a specific AMS intervention; rates remained low in 2017 and 2018.

Figure 15: Fluoroquinolone usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)



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

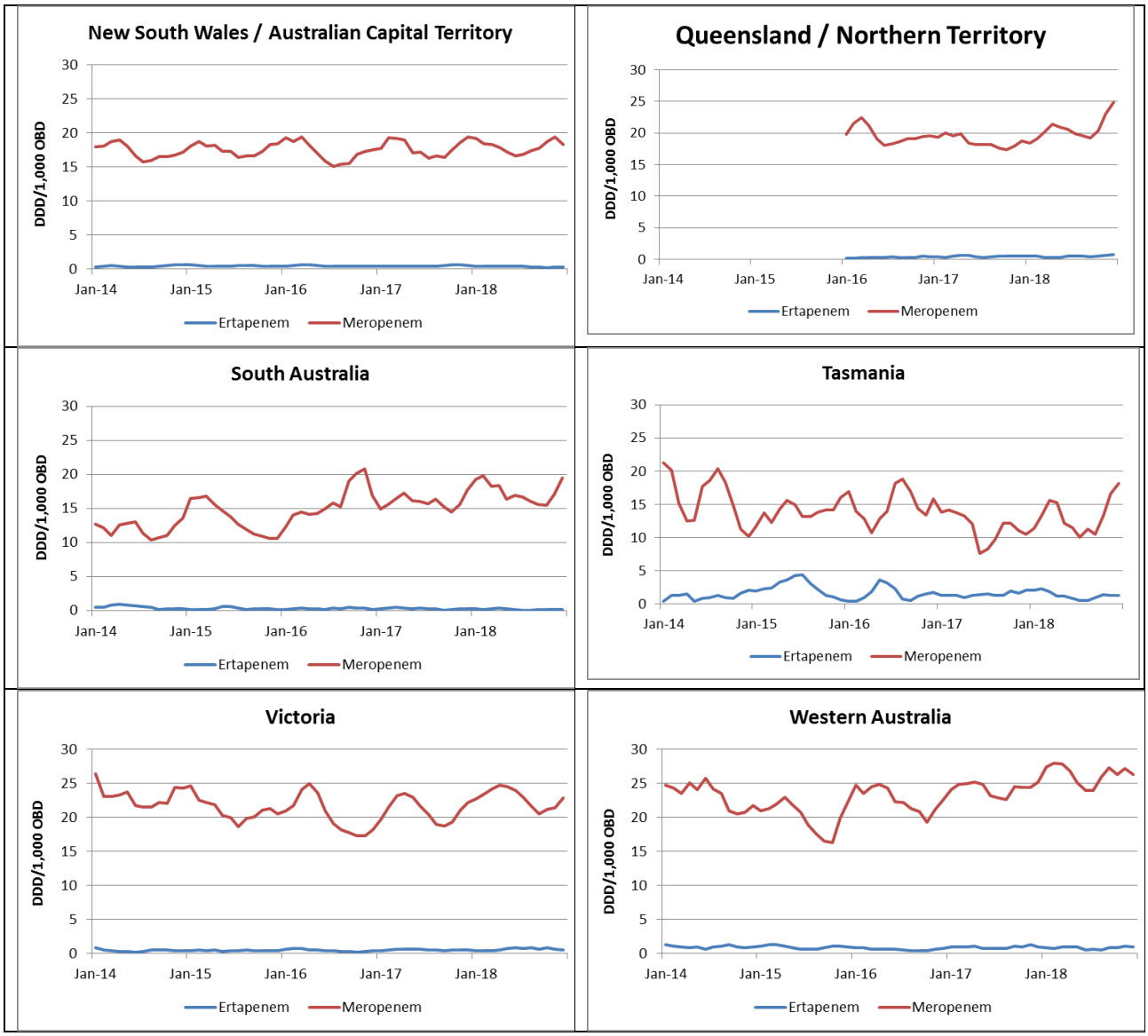
Carbapenems – ertapenem and meropenem

Meropenem is the main carbapenem used in NAUSP contributor hospitals, possibly as a result of the lower incidence of neurotoxicity, superior activity against *Pseudomonas* species and cost benefits compared with other carbapenems. Meropenem has become a key reserve-line antibacterial because it has a role in treating infections with resistance to multiple other classes once a switch from aminoglycosides is required.

Usage rates of meropenem fluctuate from month to month. The only state with a notable increase in carbapenem usage rates is South Australia. Usage in Western Australia and Victoria is generally higher than other states and territories.

Usage rates of other carbapenems are low, and possibly influenced by prescribing preferences in particular hospitals (Figure 16). Doripenem and imipenem–cilastatin are rarely used and have not been included in the figures below.

Figure 16: Carbapenem usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)

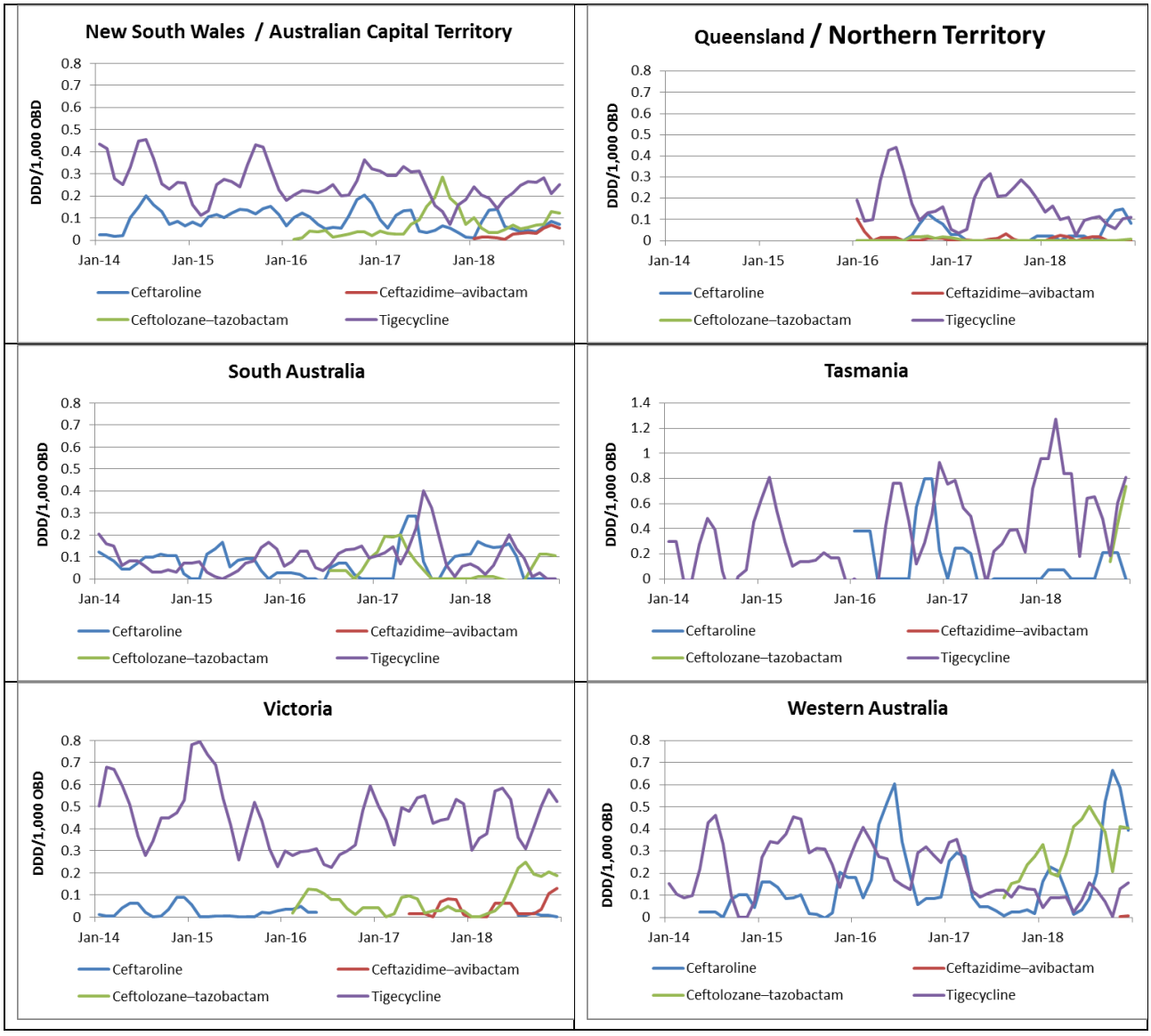


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Reserve-line broad spectrum antibacterials – ceftaroline, ceftazidime–avibactam, ceftolozane–tazobactam, tigecycline

Usage of the newer antibacterial agents, ceftaroline, ceftazidime–avibactam and ceftolozane–tazobactam, is low and variable between states and territories (Figure 17). Use in 2018 was 57% higher than 2016 overall, which may be related to changes in antimicrobial-resistant infections requiring last line therapeutic options. Tigecycline use remains very low in Australian hospitals (Figure 17), but has increased since 2016 and usage is consistently higher in Victoria. Ceftolozane–tazobactam has recently become available, and is being used with increasing frequency, likely representing its therapeutic place in antimicrobial-resistant infections in a small number of patients.

Figure 17: Broad-spectrum reserve-line antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)

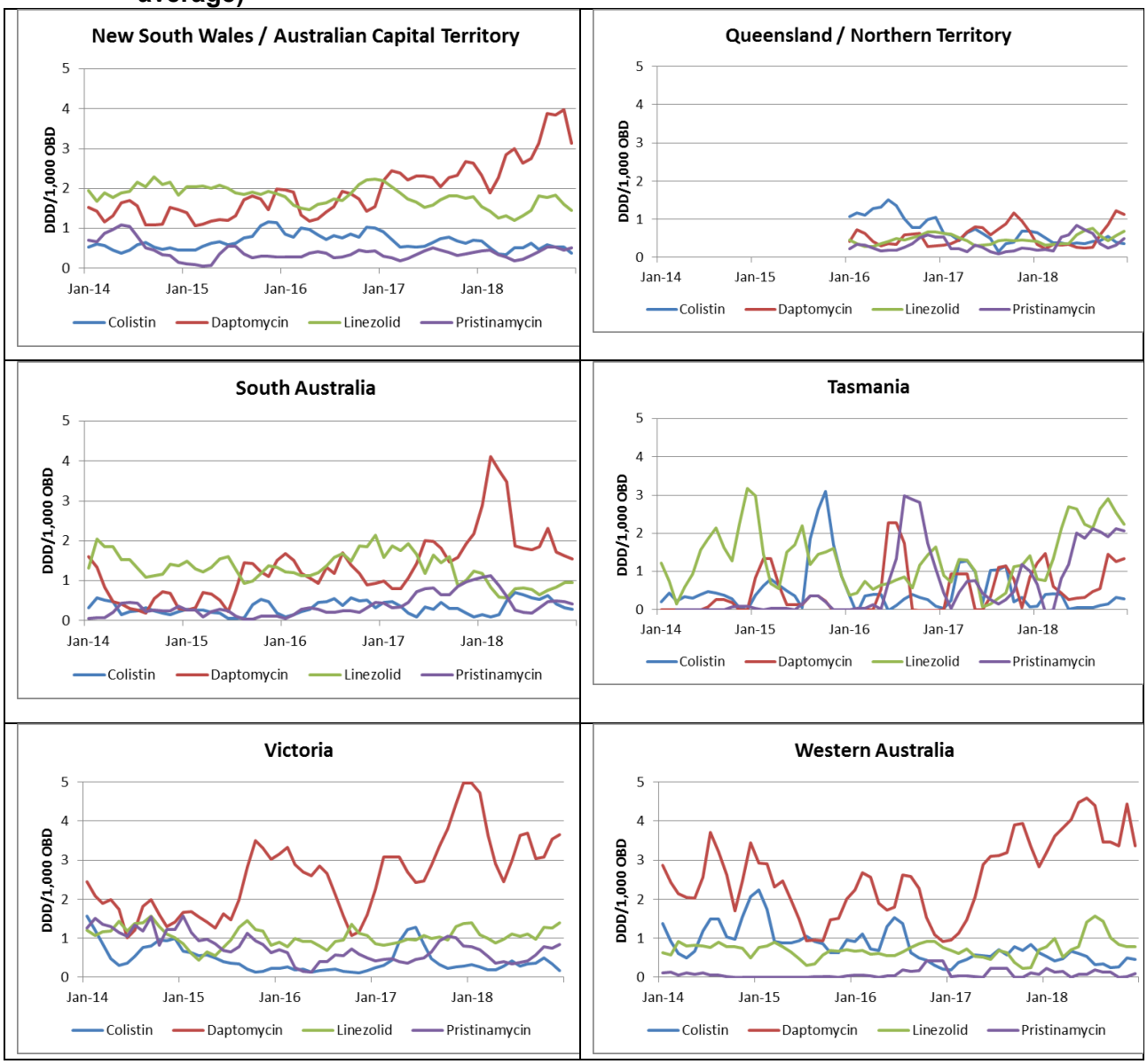


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: y-axis varies for Tasmania

Reserve-line narrow spectrum antibacterials – colistin, daptomycin, linezolid, pristinamycin

Parenteral colistin (methanesulphonate) has become an important antibacterial in the treatment of infections caused by carbapenemase-producing multiantimicrobial resistant gram-negative organisms, where meropenem is ineffective. Usage of daptomycin, while very low, is increasing substantially in New South Wales/the Australian Capital Territory, South Australia, Victoria and Western Australia (Figure 18). Aggregate usage rates of daptomycin were less than 5 DDDs per 1,000 OBDs per year from 2012 to 2016[12]; however, usage has risen to 14 DDDs per 1,000 OBDs in 2017 and 18 DDDs per 1,000 OBDs in 2018. Given the cross-resistance of glycopeptides and daptomycin, the use of this agent should be balanced against the therapeutic options for treatment of antimicrobial-resistant infections. There is marked variation in linezolid usage rates between hospitals; overall usage is highest in New South Wales and the Australian Capital Territory. Linezolid is commonly used for treatment of vancomycin-resistant enterococci (VRE).

Figure 18: Narrow-spectrum reserve-line antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2014–2018 (3-month moving average)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Colistin usage rates include both nebulised and parenteral formulations, as some NAUSP contributors are not able to provide separate data for each.

Analysis of antibacterial use by hospital peer group

Use of broader-spectrum antibacterials, including those reserved to treat infections caused by multidrug-resistant organisms, would be expected to occur mainly in Principal Referral and Public Acute Group A hospitals. Several antibacterial classes were analysed to determine whether this expectation was supported by usage data. For these analyses, private hospitals were included with public hospitals of similar size and patient mix.

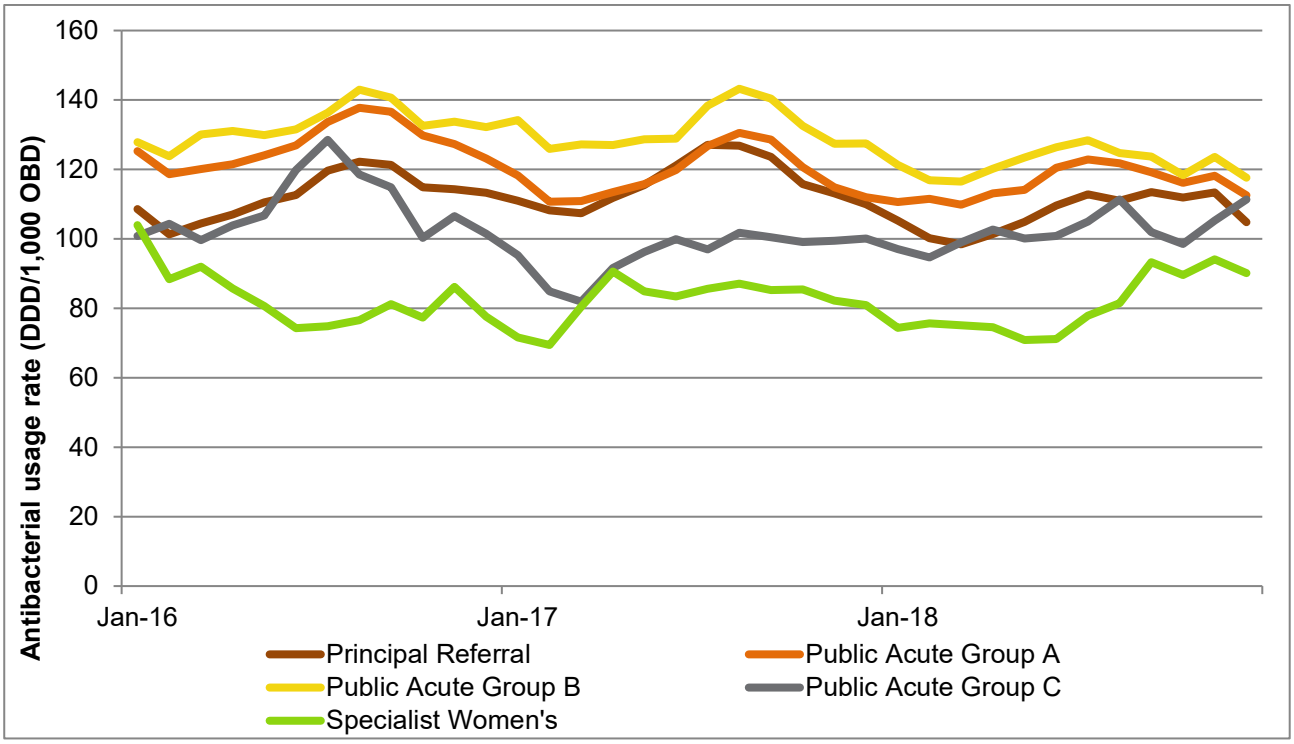
It is notable that for some antibacterial classes, usage is higher in Public Acute Group A, B and C hospitals than in Principal Referral hospitals. The reasons for these differences are not known; however, it may be that AMS programs are less well developed in smaller facilities.

High volume oral antibacterials

Oral amoxicillin–clavulanic acid

Usage of oral amoxicillin–clavulanic acid is similar in all peer groups. Seasonal variation (highest use in winter months) is apparent.

Figure 19: Oral amoxicillin–clavulanic acid usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

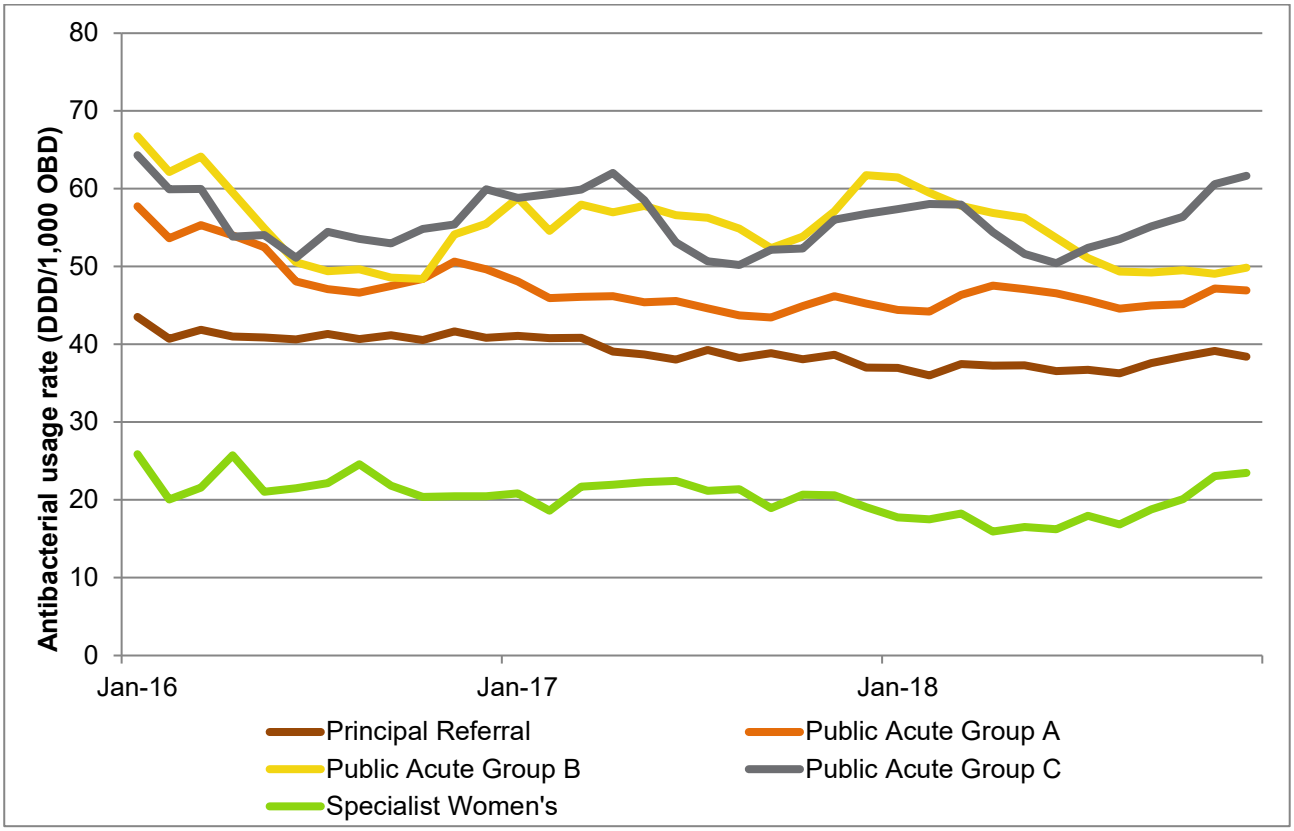


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Cefalexin

Cefalexin usage rates are higher in Public Acute Groups A, B and C hospitals than in Principal Referral hospitals. This may be due to differences in casemix.

Figure 20: Cefalexin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

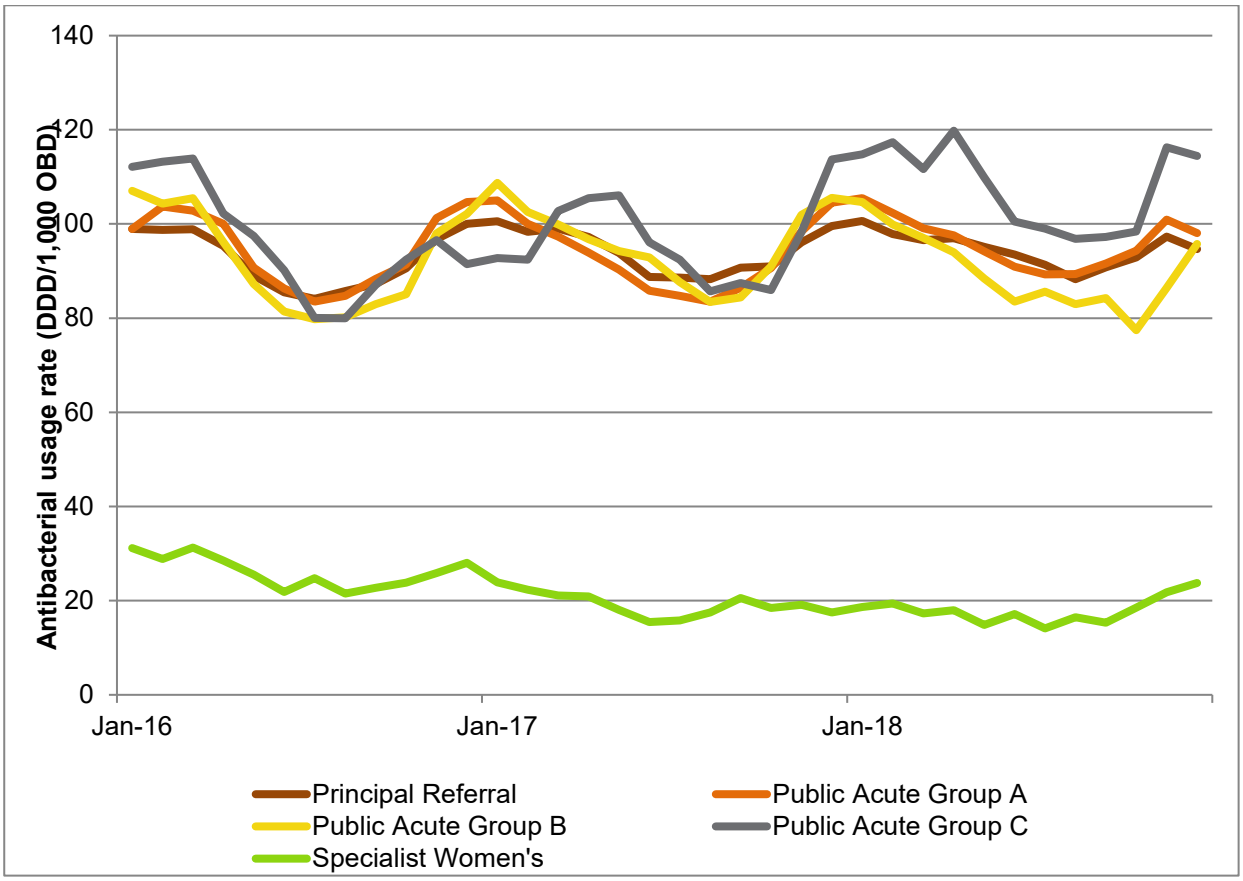


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Dicloxacillin and flucloxacillin

Usage rates of dicloxacillin and flucloxacillin are similar in all Australian hospital peer groups, with the exception of Specialist Women's hospitals. Use appears to be seasonal, with highest use in the summer months.

Figure 21: Dicloxacillin and flucloxacillin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

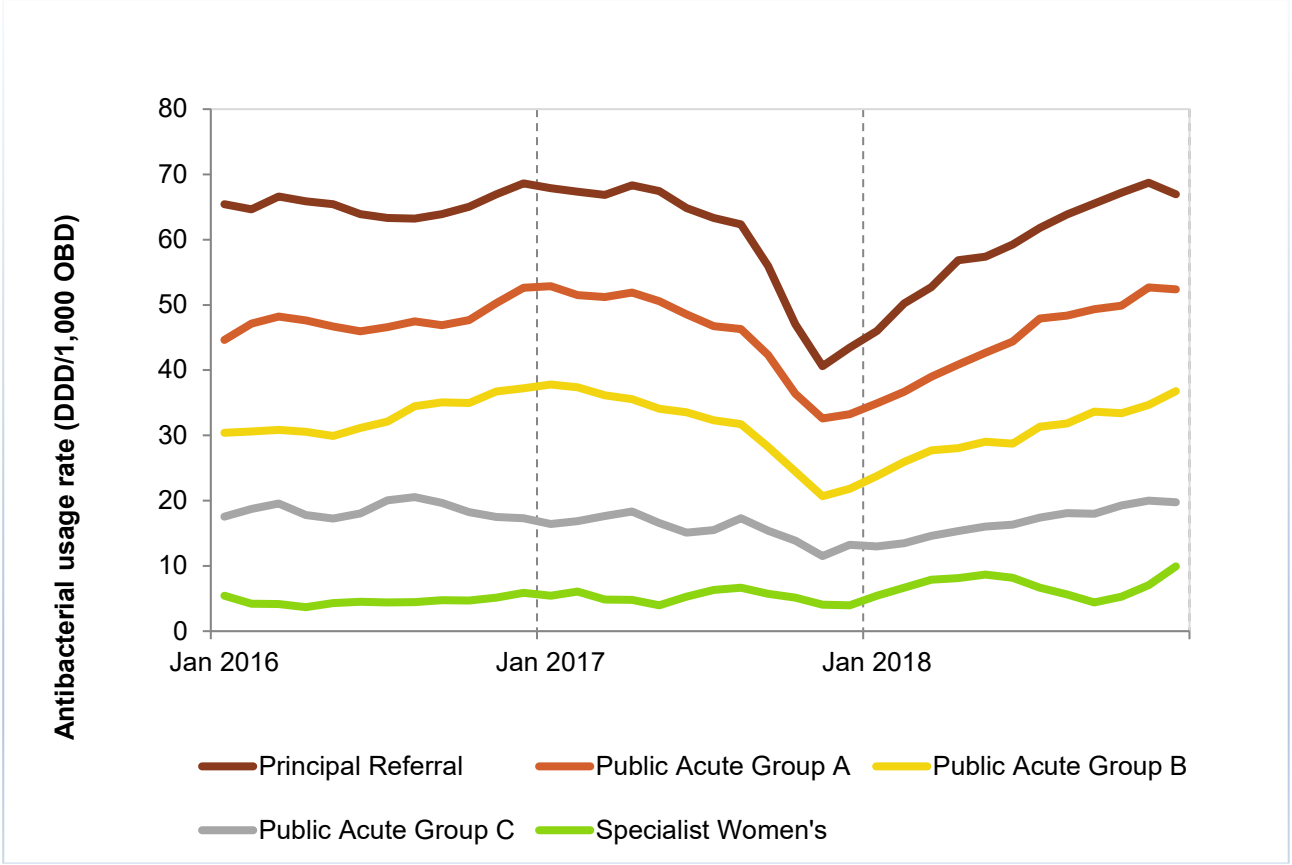


Note: this figure shows combined rates for flucloxacillin and dicloxacillin
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Antipseudomonal penicillin–β-lactamase inhibitor combinations: piperacillin–tazobactam

Usage rates of antipseudomonal penicillin–β-lactamase inhibitor combinations were greatest in larger hospitals that contributed to NAUSP from 2016 to 2018 (Figure 22). Because these antibacterials are generally restricted for use only in higher acuity patients, this pattern is to be expected. Use in smaller NAUSP contributor hospitals was affected by the 2017 shortage of piperacillin–tazobactam to a lesser extent than in the Principal Referral hospital cohort.[13] Usage rates of antipseudomonal penicillin–β-lactamase inhibitor combinations are low in Specialist Women's hospitals.

Figure 22: Piperacillin–tazobactam usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

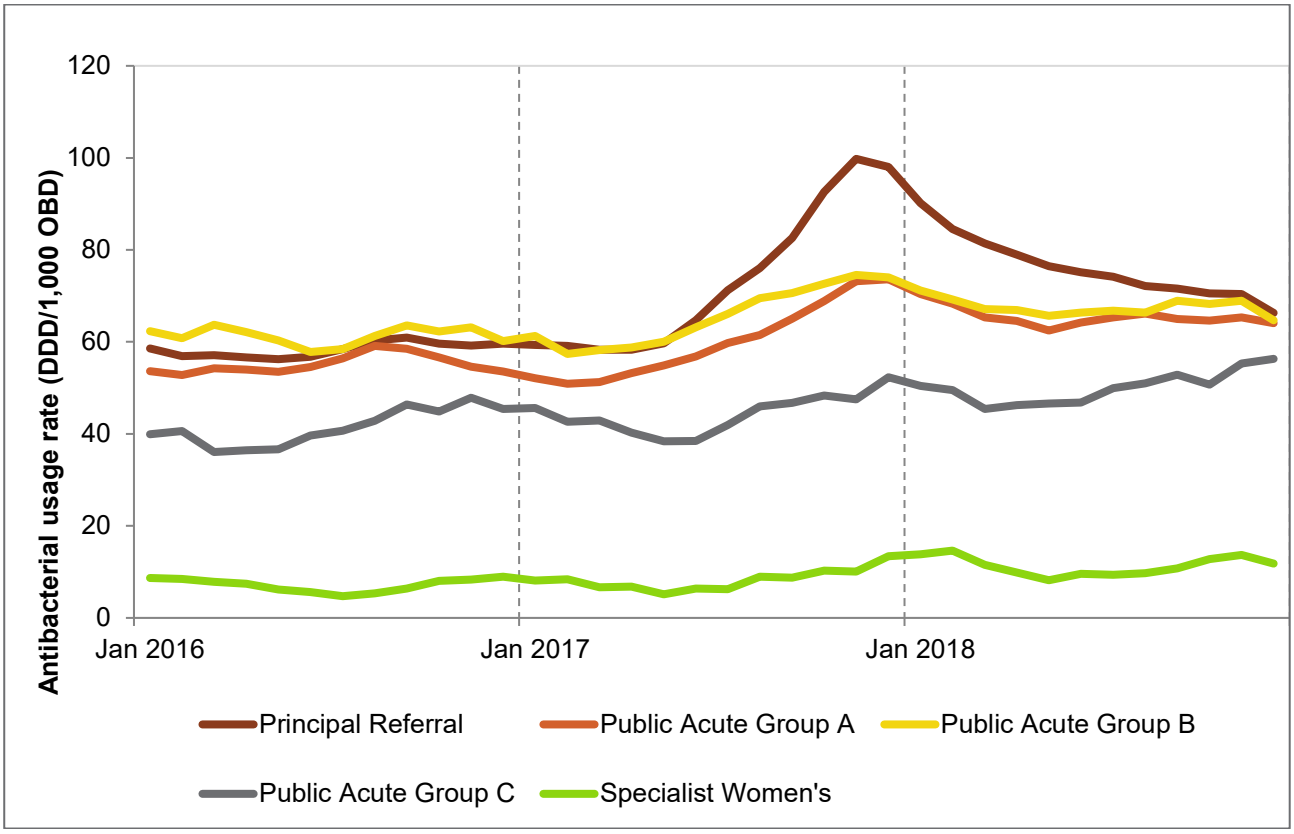


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

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

Usage rates of third- and fourth-generation cephalosporins were similar in the Principal Referral, Public Acute Group A and Public Acute Group B hospitals until mid-2017. Use increased in all peer groups from that time, likely due to piperacillin–tazobactam shortage; increases were greatest in the larger hospitals. After the supply of piperacillin–tazobactam was restored, third- and fourth-generation cephalosporin usage rates fell, but not to pre-2017 levels. Ceftriaxone is consistently amongst the most frequently inappropriately used antimicrobials in NAPS contributor hospitals; in 2018, 24.9% of prescriptions were assessed as inappropriate.[7]

Figure 23: Third- and fourth-generation cephalosporin usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

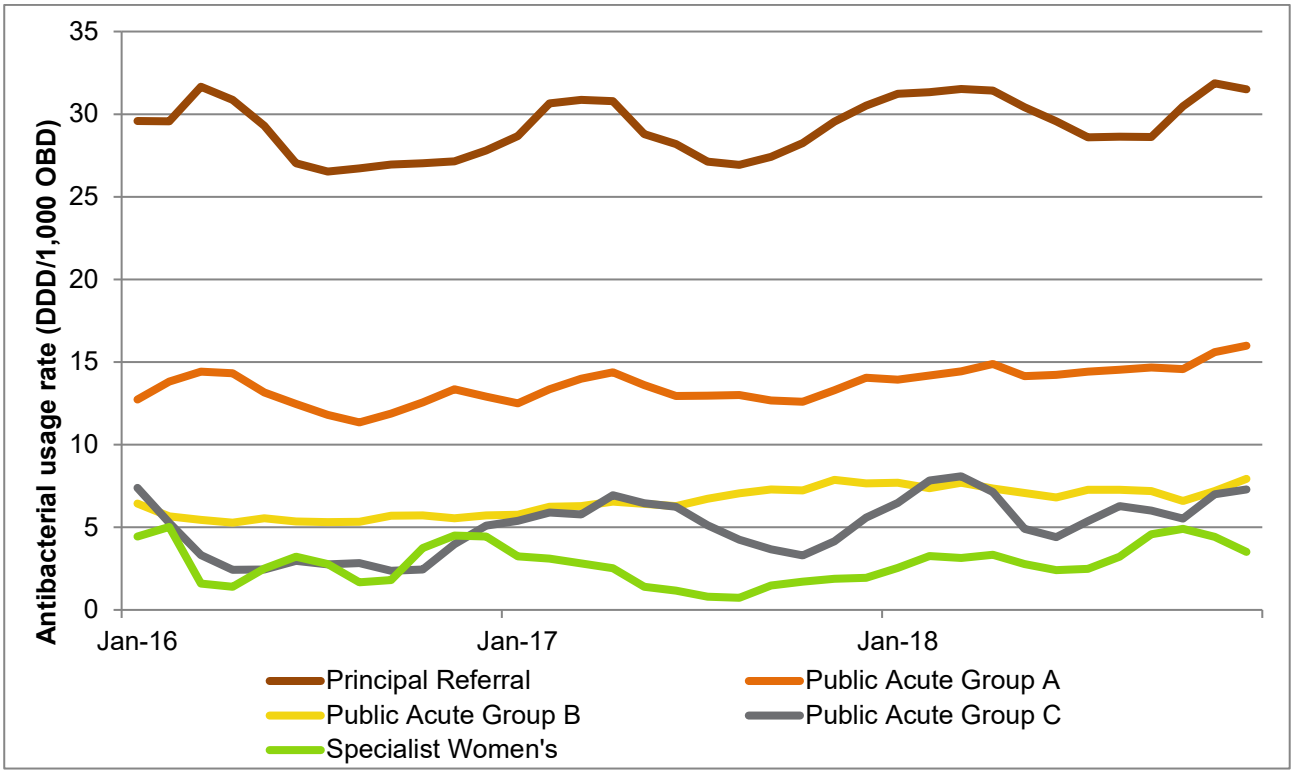


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Carbapenems – ertapenem, meropenem

Carbapenems (mainly meropenem) have a broad spectrum and are reserved for treatment of infections caused by multiantimicrobial resistant organisms. As expected, usage rates were highest in Principal Referral hospitals, followed by Public Acute Group A hospitals (Figure 24). Use in smaller hospitals (Public Acute Group B and C) and in Specialist Women's hospitals was minimal. There was an upward trend in usage in most peer groups.

Figure 24: Carbapenem usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

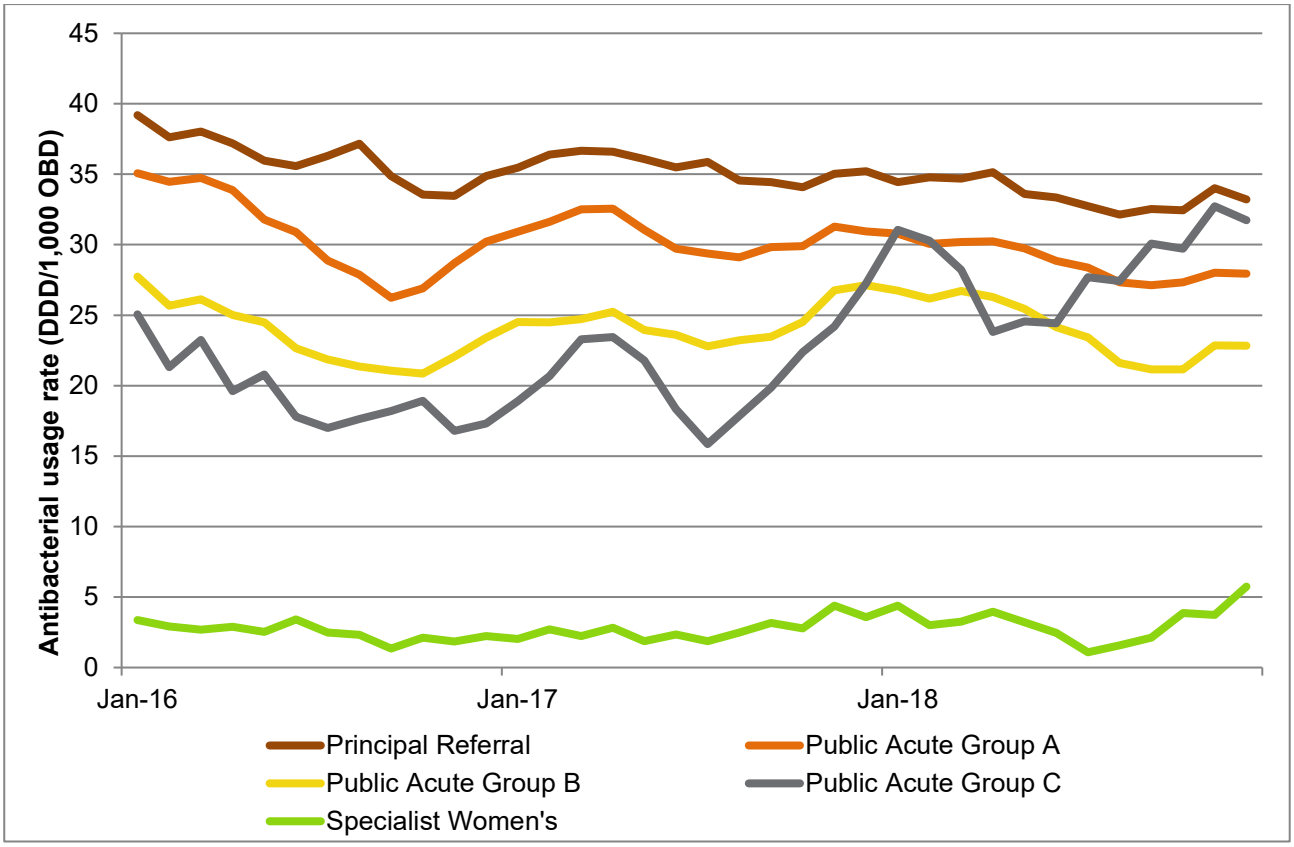


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Fluoroquinolones – ciprofloxacin, moxifloxacin, norfloxacin

Usage rates of fluoroquinolones in Principal Referral and Public Acute Group A NAUSP contributor hospitals declined from 2016 to 2018 (Figure 25). However, usage rates appear to have increased in Public Acute Group C hospitals since mid-2017. Seven hospitals in this group had increases of greater than 25%. Usage rates of fluoroquinolones were minimal in Specialist Women's hospitals.

Figure 25: Fluoroquinolone usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)

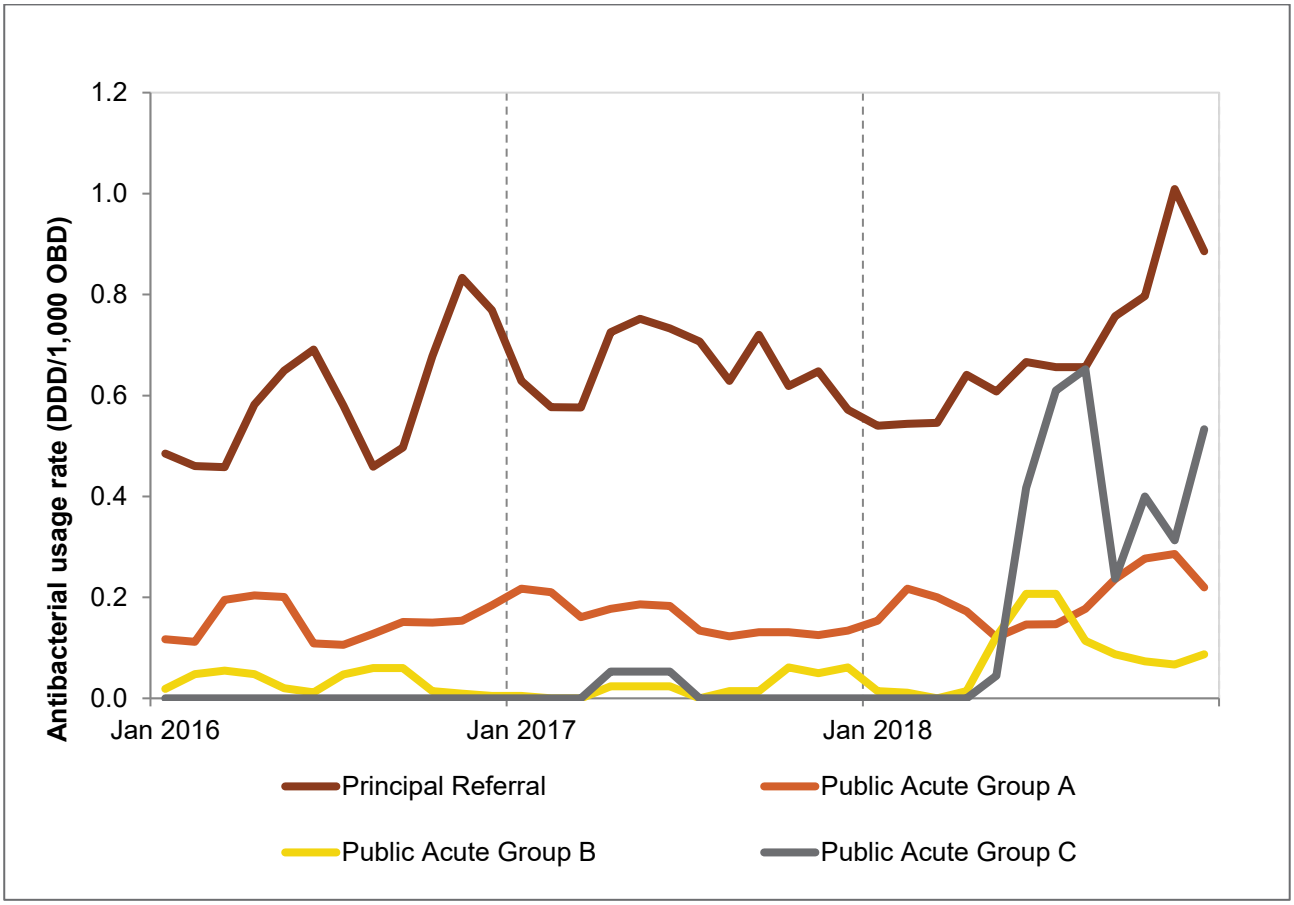


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Reserve-line broad spectrum antibacterials – ceftaroline, ceftazidime–avibactam, ceftolozane–tazobactam, tigecycline

These highly reserved broad-spectrum antibacterials are rarely used in Australian hospitals; usage was generally only reported in larger hospitals (Figure 26). In Principal Referral hospitals, the use of these high cost antibacterials is increasing, likely due to increases in antimicrobial-resistant infections. However, rates remain less than 1 DDD per 1,000 OBD. More recent increases are seen in the Public Group C hospitals. The reasons for this are unclear but may include patients returning closer to home but still requiring treatment for antimicrobial-resistant infections acquired elsewhere.

Figure 26: Broad-spectrum reserve-line antibacterial* usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by selected peer groups, 2016–2018 (3-month moving average)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* Ceftaroline, ceftazidime–avibactam, ceftolozane–tazobactam, tigecycline rates combined
#Minimal usage in Specialist Women's hospitals – not shown in this chart

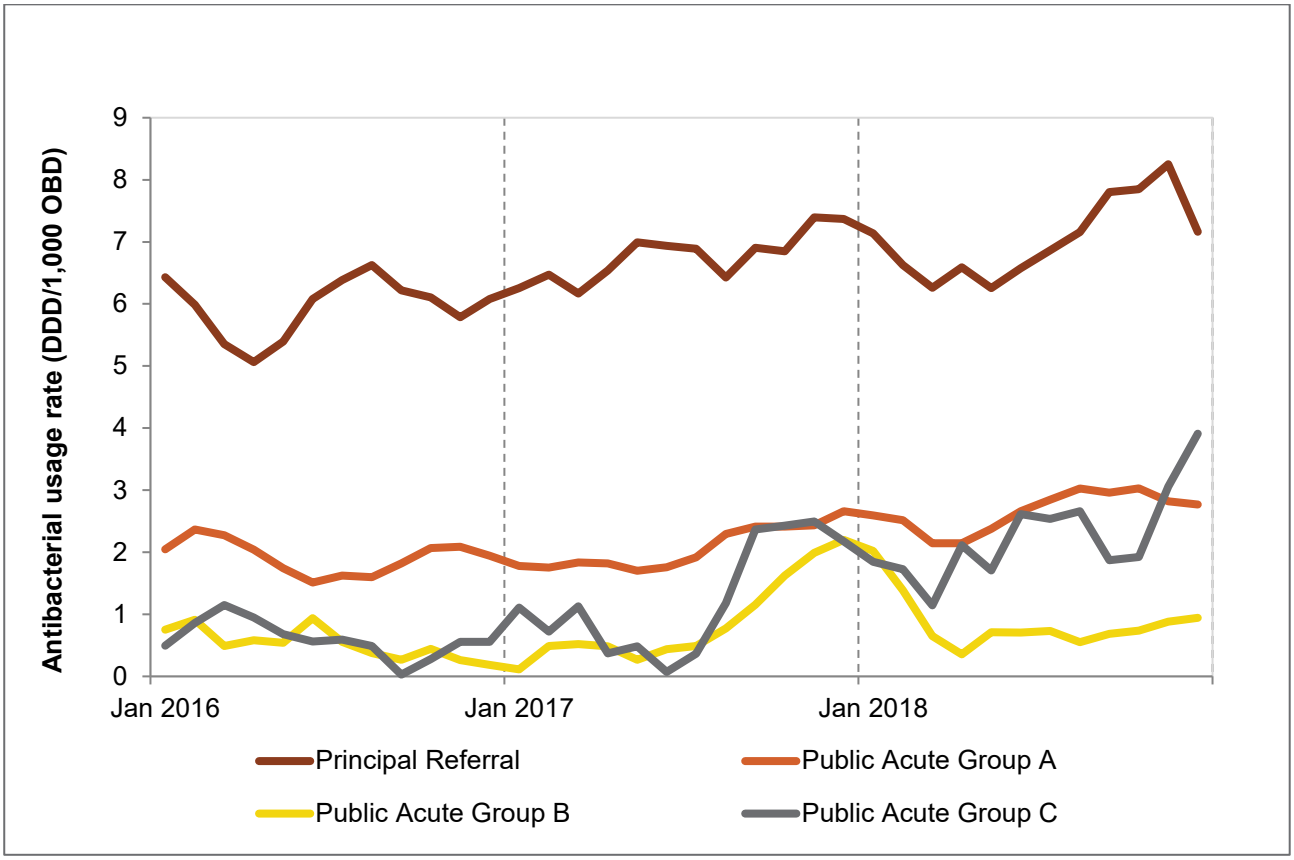
Reserve-line narrow-spectrum antibacterials – colistin, daptomycin, linezolid, pristinamycin

Use of highly reserved narrow-spectrum antibacterials is mostly confined to Principal Referral and Public Acute Group A hospitals that contributed to NAUSP from 2016 to 2018 (Figure 27). These antibacterials are used to treat people who are seriously ill when the causative organisms are resistant to standard treatment. Linezolid is also used to treat less severe infections such as those of the urinary tract. Patients requiring these treatments are usually admitted to Principal Referral hospitals for treatment. However, since mid-2017 usage rates in Public Acute Group C hospitals have increased similar to the reserve-line broad spectrum antibacterial group, and in 2018 were approximately equivalent to Public Acute Group A hospitals. Possible explanations include:

- Transfer of rural patients who required admission to large metropolitan hospitals to their local hospital to finish their reserved antibacterial course
- Smaller facilities may not have established AMS programs, including restrictions on prescribing broad-spectrum antibacterials
- Changes in prescribing preferences towards daptomycin, compared to other agents
- Increases in antimicrobial-resistant infections where prescriptions of these antimicrobials are indicated, such as VRE or difficult to treat methicillin-resistant *Staphylococcus aureus* (MRSA) infections.

There is variation in usage rates of these restricted antibacterials by Principal Referral hospitals. The average usage rates of colistin, daptomycin and linezolid in this peer group for 2017 and 2018 were 0.91, 3.57 and 1.66 DDD per 1,000 OBDs per month respectively.

Figure 27: Colistin, daptomycin, linezolid and pristinamycin (combined) usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals†, by selected peer groups, 2016–2018 (3-month moving average)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
† Minimal usage in Specialist Women's hospitals – not shown in this chart

Antifungal usage

Similar to antimicrobial-resistant bacterial infections, over-use and inappropriate use of antifungals may lead to the development of resistant organisms, increased treatment costs and mortality. NAUSP collects data on a number of systemic antifungals, although not all hospitals provide these data. Increased use of antifungals in hospitals has been noted in The Netherlands and Germany as well as in Australia, but usage rates are lower in Australia.[14]

Antifungal usage in Australian hospitals

Table 9 shows antifungal usage rates in NAUSP hospitals, where antifungal data were available. Fluconazole is the most commonly used antifungal agent in NAUSP contributor hospitals, and triazole antifungals (fluconazole, itraconazole, posaconazole, voriconazole) accounted for approximately 87% of total usage in each year from 2016 to 2018.

Echinocandins (anidulafungin, caspofungin, micafungin) accounted for 5.7%, 5.6% and 6.5% of total antifungal usage in the years 2016, 2017 and 2018 respectively. The usage of these agents has increased since 2012, when they accounted for 3.8% of total antifungal use.[12] Anidulafungin is the most commonly used echinocandin, but the total-hospital usage rate is less than 2 DDDs per 1,000 OBDs.

Table 9: Annual antifungal usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, 2016–2018

Antifungal	2016 (*n*=162)	2017 (*n*=179)	2018 (*n*=190)
Amphotericin B (desoxycholate)	0.37	0.26	0.26
Amphotericin, lipid complex	0.03	0.03	0.01
Amphotericin, liposomal	0.99	0.99	1.05
Anidulafungin	0.96	1.15	1.54
Caspofungin	0.71	0.63	0.49
Fluconazole	17.95	17.94	18.31
Flucytosine	0.15	0.15	0.13
Griseofulvin	0.01	0.03	0.15
Itraconazole	1.97	3.00	2.42
Ketoconazole	0.05	0.09	0.08
Micafungin	0.14	0.11	0.18
Posaconazole	4.54	5.01	5.63
Terbinafine	0.71	0.91	0.93
Voriconazole	3.33	3.08	3.08
Total	**31.91**	**33.36**	**34.22**

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

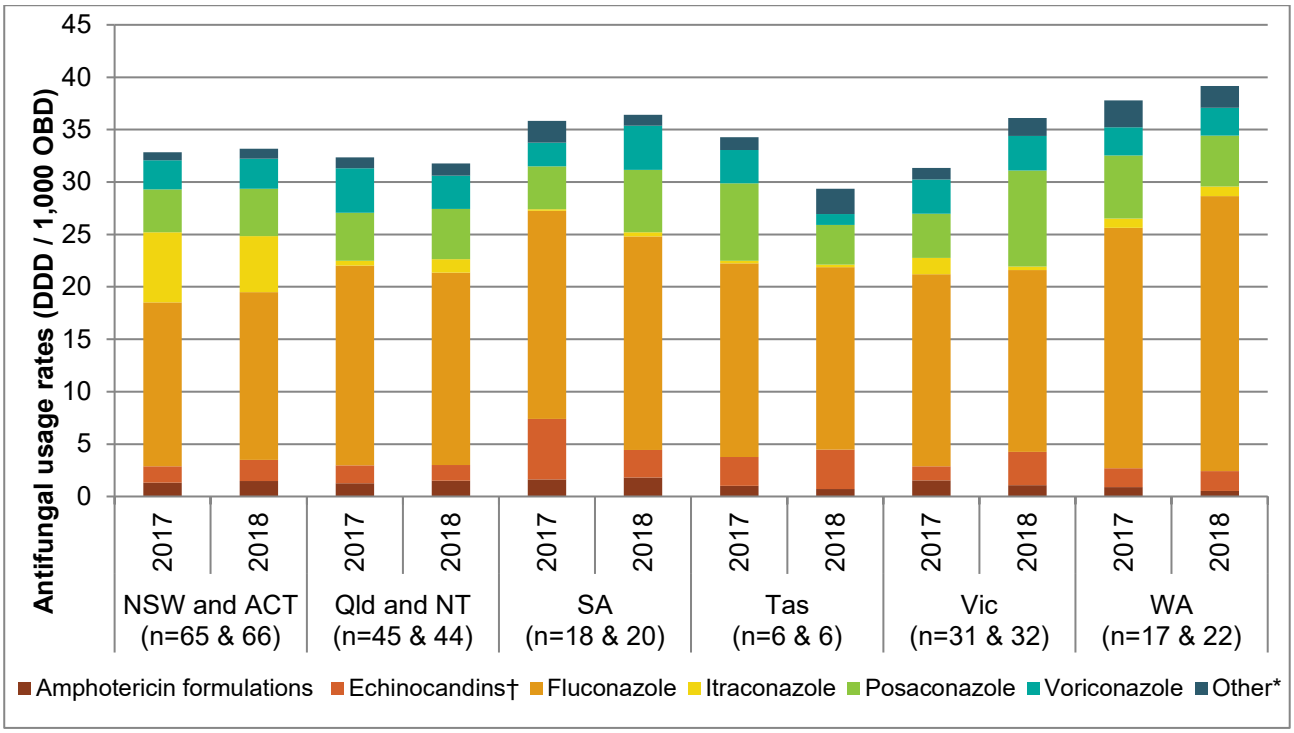
Antifungal usage in Australian hospitals by state and territory

There are variations in rates of usage and agents used between states and territories (Figure 28). In 2018, there were notable differences for:

- Itraconazole – the usage rate was more than five times greater in New South Wales and the Australian Capital Territory than the aggregate usage rate of other states and territories
- Fluconazole – the usage rate in Western Australia was 1.5 times greater than the aggregate use in the other states and territories
- Echinocandins – the usage rate in Tasmania was more than 1.5 times greater than the aggregate use in five other states and territories.

Reasons for these differences are unknown, but could relate to differences in casemix, prescriber preferences or formulary.

Figure 28: Antifungal usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by state and territory, 2017–2018



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* 'Other' comprises flucytosine, griseofulvin, ketoconazole and terbinafine. (Zero usage of amphotericin lipid complex)
† Echinocandins includes anidulafungin, caspofungin and micafungin
Number of included hospitals (n) refers to 2017 and 2018 respectively.

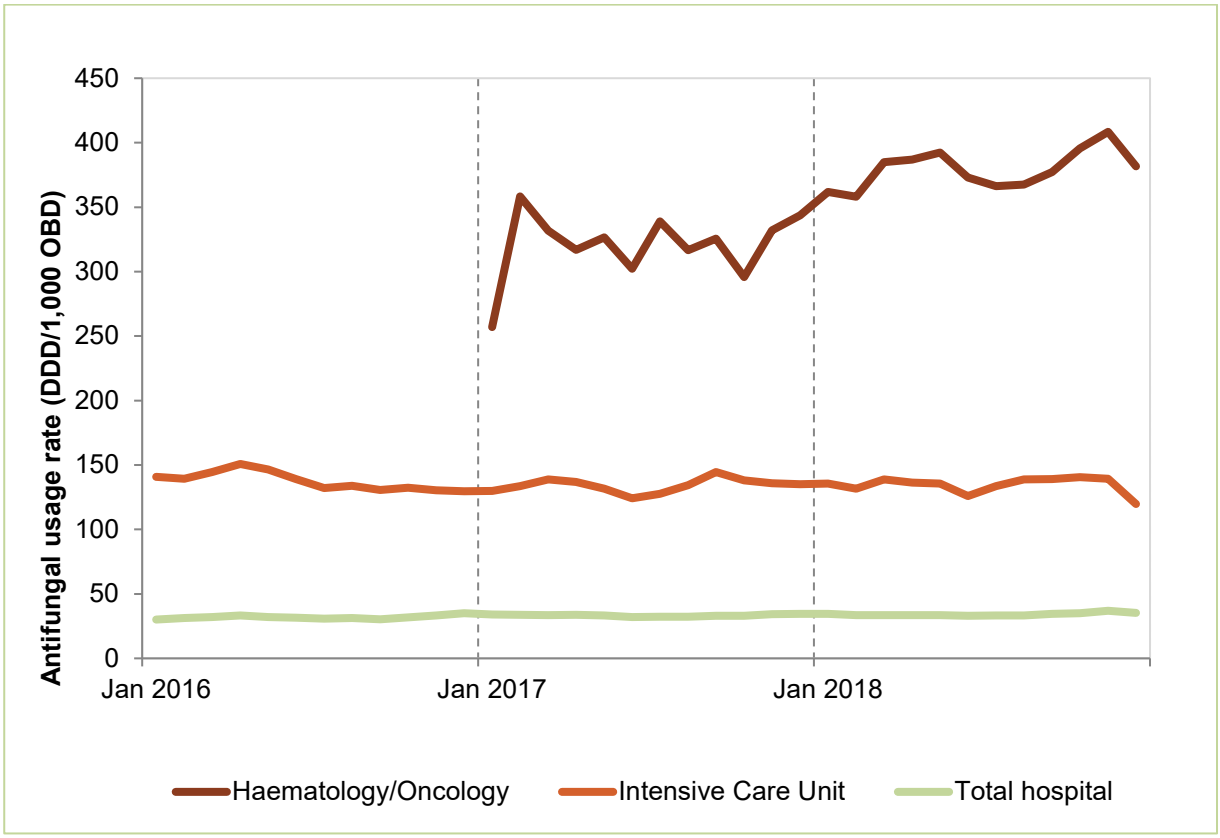
Antifungal usage in Australian hospitals by specialty

Major variations in usage volume occur in Australian hospitals, driven by usage in specialty units. In 2017, a small number of NAUSP participants (n=9) commenced contributing antimicrobial usage data for haematology/oncology specialist units. There is a much higher rate of antifungal use in this specialty setting, compared with non-specialty units.

Figure 29 shows usage rates for all antifungals in ICU (n=71) and haematology/oncology settings compared with total-hospital use. Specialist cancer wards use antifungals both prophylactically for immunocompromised patients and for treatment of invasive fungal disease; rates of use are approximately 10 times higher than overall hospital use, highlighting the importance of antifungal stewardship in these units[15].

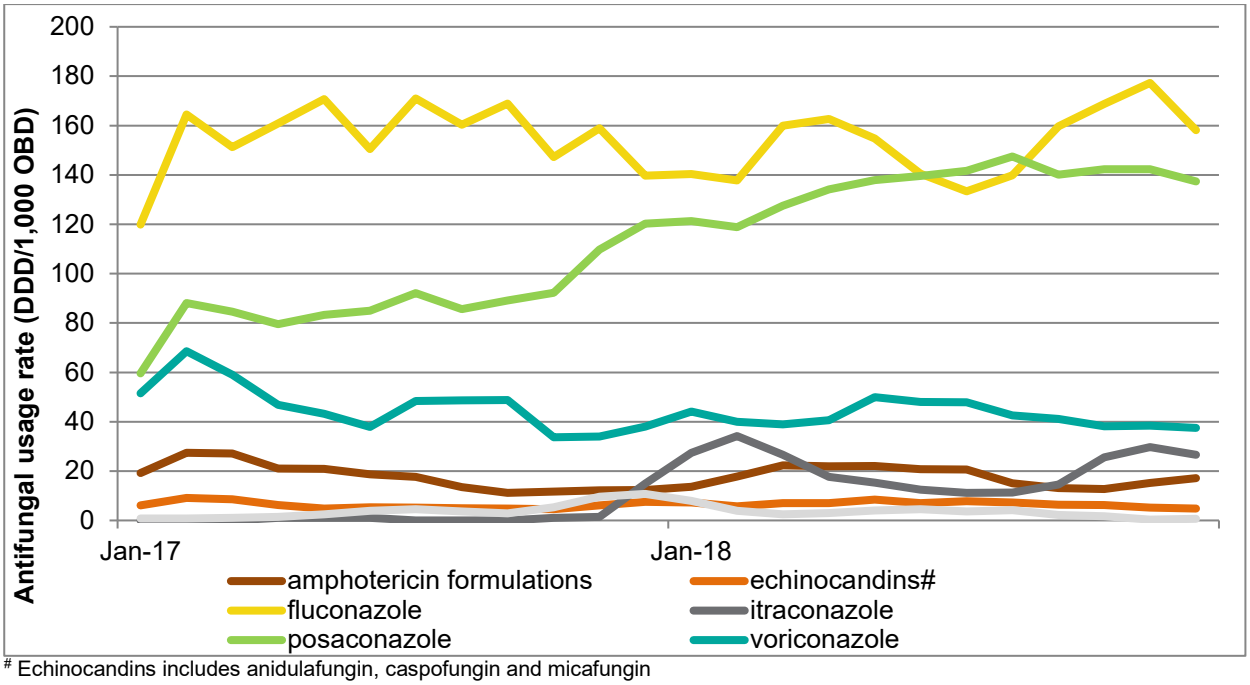
Analysis of haematology/oncology specialty unit data shows usage rates of posaconazole have increased since January 2017. A corresponding decrease in usage rates of another antifungal agent is not apparent from 2017 to 2018 (Figure 30).

Figure 29: Antifungal usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, by specialty* and total hospital, 2016–2018



*Note: Collection of haematology/oncology specialty data by NAUSP commenced in January 2017

Figure 30: Antifungal usage rates (DDD/1,000 OBD) in haematology/oncology specialty units in NAUSP contributor hospitals, 2017–2018



Echinocandins includes anidulafungin, caspofungin and micafungin

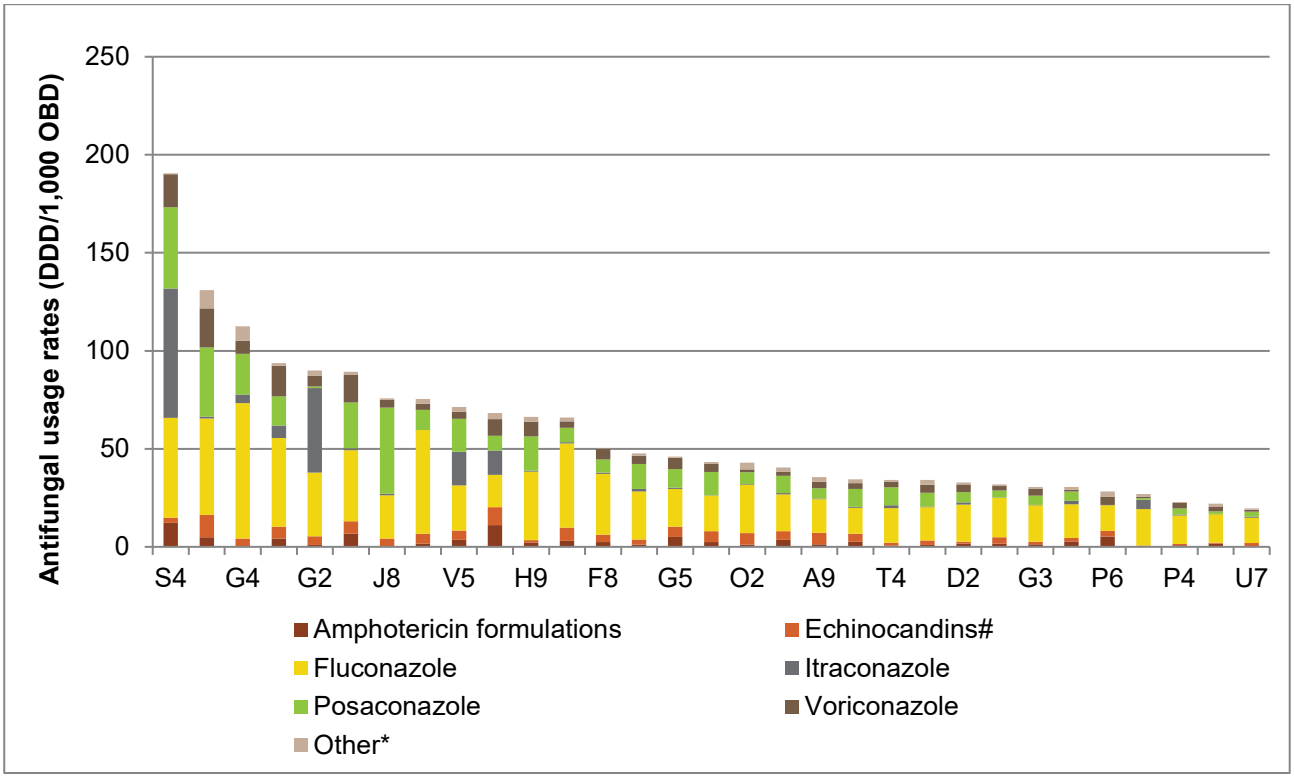
Antifungal usage in Australian hospitals by peer group

As would be expected, usage of systemic antifungals is higher in larger hospitals with a more complex casemix.

Figure 35 shows aggregated usage rates for all antifungals in 2018 for NAUSP contributor Principal Referral hospitals. Triazole antifungals account for the most antifungal usage in these hospitals. Echinocandin usage is minimal in comparison; however, there was a slight upward trend in usage in Principal Referral hospitals from 2016 to 2018 (Figure 31). There was also an increase in posaconazole use in Principal Referral hospitals during the same period (Figure 32). Usage of agents will be highly dependent on the casemix of the referral hospital, including whether it provides transplant services.

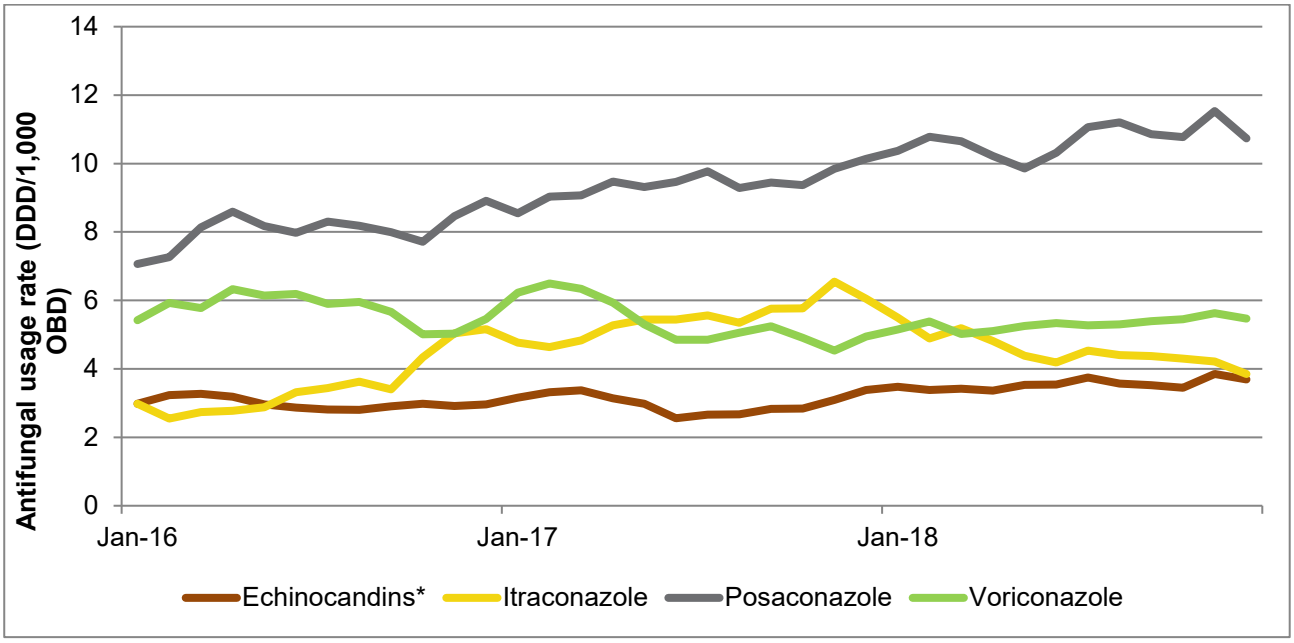
Usage of other antifungal agents is minimal; combined usage rates are less than 5 DDDs per 1,000 OBDs.

Figure 31: Antifungal usage rates (DDD/1,000 OBD) in NAUSP Principal Referral hospitals, 2018



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
# Echinocandins includes anidulafungin, caspofungin and micafungin
*'Other' comprises flucytosine, griseofulvin, ketoconazole and terbinafine. (Zero usage of amphotericin lipid complex).

Figure 32: Antifungal usage rates (DDD/1,000 OBD) of selected antifungal agents in NAUSP Principal Referral hospitals, 2016–2018



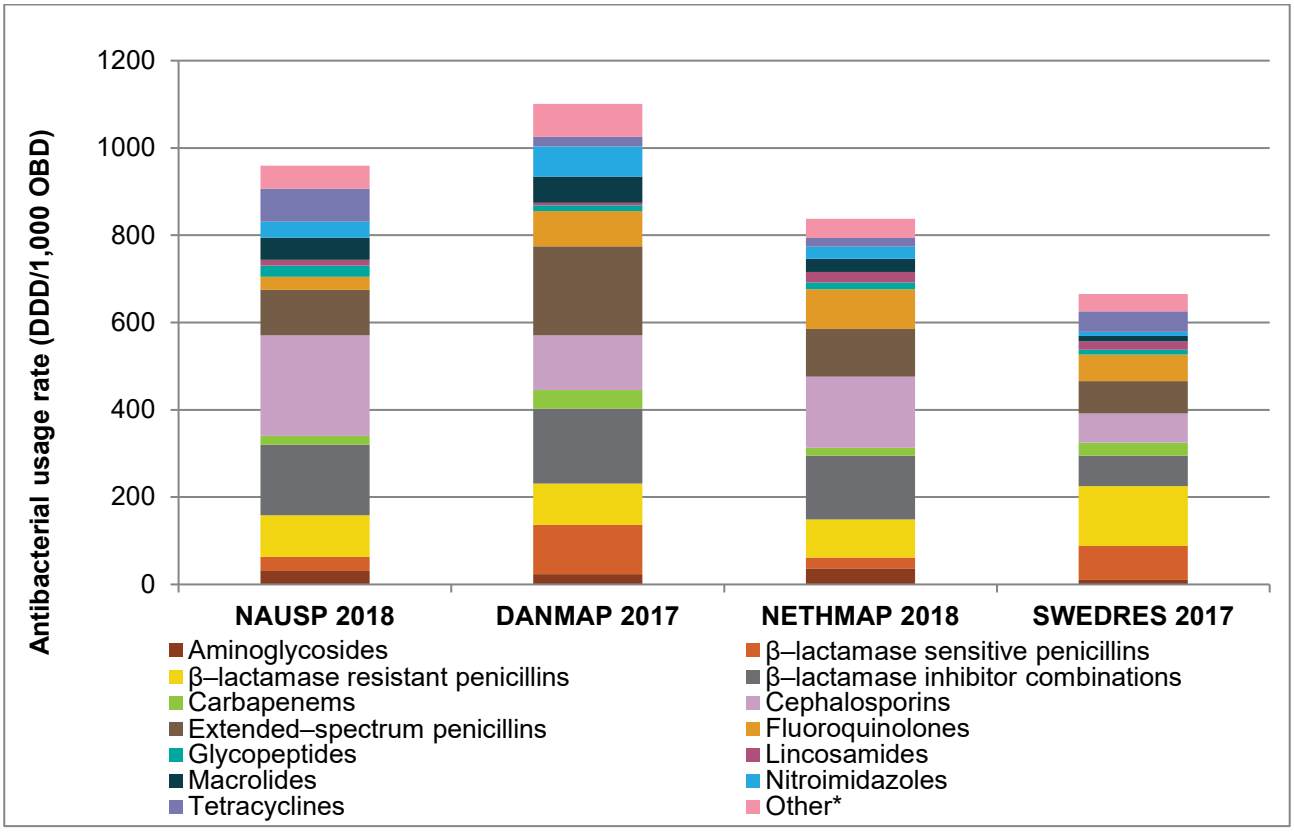
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* Echinocandins includes anidulafungin, caspofungin and micafungin

International surveillance programs and benchmarking

Antibacterial data

Comparison of NAUSP data with surveillance programs in Denmark (DANMAP), Sweden (SWEDRES) and the Netherlands (NethMap) is possible because these programs also use OBDs as a denominator for calculating rates of antibacterial use. Figure 33 shows antibacterial usage rates in Australian hospitals that contributed to NAUSP during 2018, compared with the most recent rates published in surveillance reports for Denmark (2017)[3], the Netherlands (2018)[4] and Sweden (2017).[5]

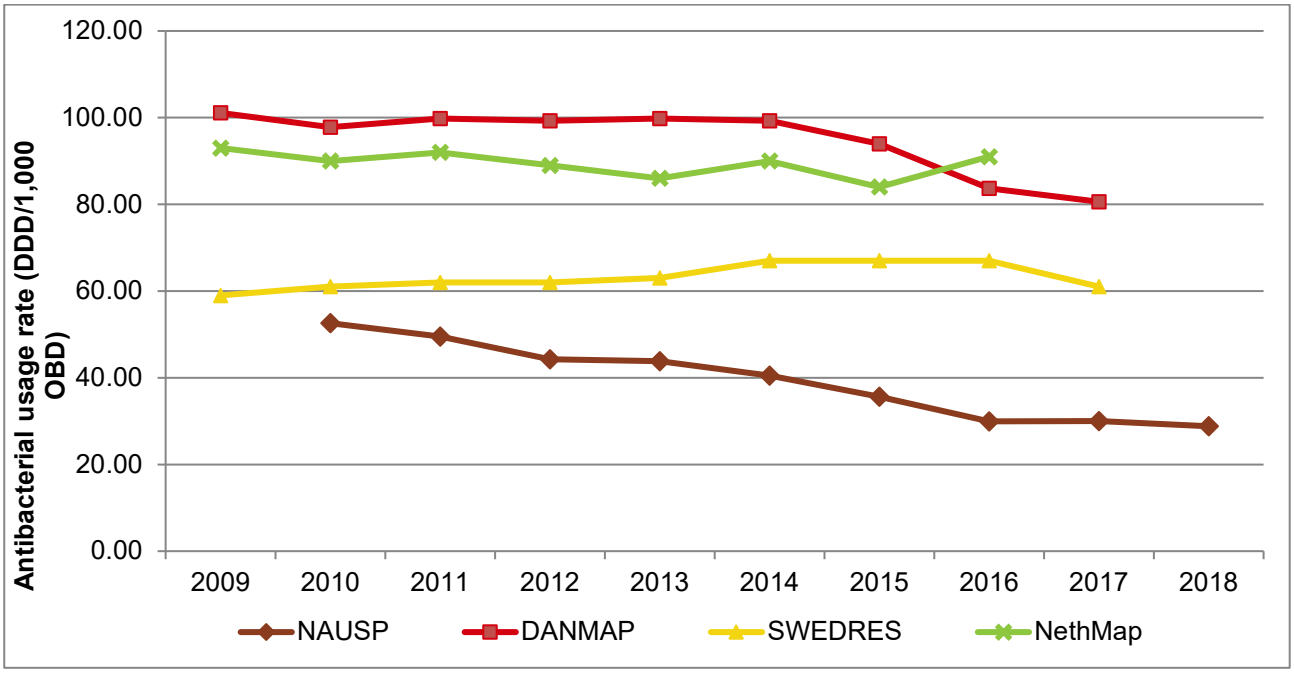
Figure 33: Antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, and hospitals in Denmark, the Netherlands and Sweden (most recent available data)



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Includes Australian data from NAUSP for January to December 2018 (201 hospitals), SWEDRES 2017 rates use denominator data from 2016.

Australian prescibing patterns vary considerably in comparison to northern European countries. Fluoroquinolone use is lower; however, the preference for narrower spectrum penicillins in Denmark and Sweden and relatively lower cephalosporin use is notable. Figure 34 shows annual usage rates of fluoroquinolones in NAUSP contributor hospitals compared with data from northern European countries. Australian rates of fluoroquinolone usage are lower and continuing to decrease. Rates appear to be decreasing in Denmark and Sweden in recent years, but are still much higher than Australian rates.

Figure 34: Annual hospital fluoroquinolone usage rates (DDD/1,000 OBD) in Australian hospitals compared to reported usage in Northern European countries, 2009–2018



DDD = defined daily dose; OBD = occupied bed day
Data source: DANMAP[3], SWEDRES[5], NethMap[4]
Note: Antibiotic usage data from 29 Queensland public hospitals are not included in NAUSP longitudinal trend analyses because of inconsistent application of surveillance definitions between 2013 and 2015

Surveillance of antibacterial use is well established in many other developed countries. The European Centre for Disease Prevention and Control publishes *Surveillance of Antimicrobial Consumption in Europe* for the European Surveillance of Antimicrobial Consumption Network (ESAC-Net)[16]. This report compiles usage data from 30 European countries in community and hospital sectors.

Although the ESAC-Net report represents a significant data holding, it cannot be directly compared with Australian data because the metric used is DDDs per 1,000 inhabitants per day (a population measure) rather than DDD per 1,000 OBDs.

Discussion

NAUSP continues to provide participating Australian hospitals, and states and territories with a regular source of data to inform both local and national AMS initiatives. Hospitals use NAUSP data to target resources for auditing and education, and to follow up outcomes of previous interventions at both institutional and local levels. National, state and territory and hospital peer group data are useful for informing policy development, benchmarking with overseas surveillance programs, monitoring year-by-year changes in prescribing practices and measuring improvements following AMS interventions.

Nationally, the overall usage rate did not change between 2017 and 2018 (Table 3). Total usage rates fell in Tasmania by 41 DDDs per 1,000 OBDs, and there were smaller decreases in New South Wales/the Australian Capital Territory and South Australia. There were increases in overall usage in Victoria and Western Australia. Factors contributing to these increases and decreases are not known, but should be investigated by states and territories to inform the strategic focus of AMS programs. States and territories should also investigate the range of antibacterial usage within and between peer groups, and the reasons for high levels of usage in smaller Acute Group B and C facilities.

Analyses of state and territory usage rates for six major antibacterial classes of importance to AMS programs show that these classes accounted for approximately a fifth to a quarter of total-hospital antimicrobial use. Victoria and Queensland/Northern Territory had the highest rates of usage of these classes, and rates were similar in 2017 and 2018. Rates fell in Western Australia and Victoria from 2017 to 2018, primarily due to increases in total aggregate antimicrobial use rather than large decreases in the total usage of these agents. A number of institutions had an increase of more than 100 DDD per 1,000 OBDs in antimicrobial usage in 2017 compared to 2018. The reasons for these differences and changes should be explored at a local level. Variation in specialist prescribing recommendations may be a factor, given the use of these agents is likely overseen by AMS programs or infectious diseases specialists.

A snapshot of the annual usage in each state and territory in 2017 and 2018 (Appendix 5, Figures A6–A17) shows the range of use within states and territories. Individual hospitals and states and territories are encouraged to review their position. Local AMR patterns, patient characteristics and specialty services may explain high use of particular antibacterial classes. For example, the use of glycopeptides in areas with high rates of infection with MRSA or higher usage of agents for treatment of febrile neutropenia in cancer hospitals. There are also opportunities to compare and contrast antimicrobial usage and AMR patterns between jurisdictions and facilities using other AURA Surveillance System or local data, to assess potential opportunities for local improvement action.

Analysis of NAUSP data by peer group did not identify any unexpected trends. Higher usage rates of broader-spectrum antibacterials (for example, carbapenems, glycopeptides and antipseudomonal penicillin–β-lactamase inhibitor combinations) are expected in higher acuity settings.

Increased usage of fluoroquinolones in Public Acute Group C hospitals in 2018, to approximately the same rate as in Principal Referral hospitals, is concerning (Figure 25), and requires local investigation.

Use of narrow-spectrum reserved agents, such as daptomycin and linezolid, appears to be increasing, although usage rates were less than 5 DDD per 1,000 OBD in 2018. Usage of these last-line antibacterials is common outside of Principal Referral hospitals among NAUSP contributors in Public Acute Group B and C facilities. Increased prescribing of reserve agents may be due to the transfer of patients closer to home to finish therapy for an antimicrobial-resistant infection acquired during treatment in a tertiary setting and/or more antimicrobial-resistant infections occurring in rural and regional centres. Ensuring that AMS programs meet the

requirements of the NSQHS Standards, and access to the AMS clinical expertise across all peer groups, will ensure optimal and safe use of antimicrobials and assist with accommodating the complexity of prescribing reserved agents outside tertiary centres.

The response to external factors, such as the piperacillin–tazobactam shortage, has shown clearly that short-term requirements to change prescribing practice have longer term impacts on antibacterial usage; in this case, increased use of third and fourth- generation cephalosporins. In contrast, the shortage also demonstrated that profound changes in antibacterial use can be implemented quickly and consistently in the Australian hospital system, in the event that it is necessary to do so to respond to AMR and/or specific healthcare-associated infections.

Upgrades to the NAUSP database in 2017 allowed contributors to submit specialty unit data. The use of antifungals by haematology/oncology units at rates approximately 10 times higher than total-hospital rates, and by ICUs at approximately three times higher than total-hospital usage, have implications for allocation of AMS resources. Given the emergence of *Candida auris,* a multidrug-resistant fungal infection, monitoring antifungals is important for the future for AMS programs.

In 2019, NAUSP commenced collecting data on a wider range of antimicrobial products including topical agents, as well as antimicrobials that are not absorbed through gut mucosa. This aligns with data collected by the National Antimicrobial Prescribing Survey (NAPS), and will support comparative analyses in the future.

As more Australian hospitals implement electronic medication management (EMM) systems, there is potential for downloading patient administration data, and using other metrics, such as days of therapy (DoT) as a surveillance metric. Whilst all metrics have limitations, DoTs may provide a more accurate measure of antibiotic burden than DDDs, and enable inclusion of paediatric hospital data in NAUSP.

The analyses presented in this report confirm the importance of providing targeted support to smaller hospitals for AMS interventions. Meaningful feedback on antimicrobial use for smaller sites is important, because they may not have direct access to specialist infectious disease services or other AMS resources.

The significant data holdings on volume (NAUSP) and appropriateness of use (NAPS) of antimicrobials, together with increased functionality of reporting, allow Australian hospitals to combine these datasets to identify, implement and monitor targeted AMS interventions.

In summary, NAUSP has identified important issues for the design of interventions to improve antimicrobial use and safety of care provided to patients in Australian hospitals. To address these, the Commission will continue to:

- Communicate the findings of the NAUSP analyses to states, territories and private hospital provider organisations through more focussed short reports, to highlight variability in usage and encourage targeted AMS interventions
- Promote routine review of NAUSP data by each hospital and by states and territories, to focus improvement effort on hospitals where usage varies substantially from peers
- Collaborate with states and territories to identify and develop strategies and resources to further support AMS programs for smaller hospitals
- Review the *Antimicrobial Stewardship Clinical Care Standard* and associated implementation resources in 2020
- Work with states and territories and expert clinical groups to produce resources to develop strategies and resources to improve the appropriateness of prescribing broad-spectrum antibacterials in Australian hospitals.

Appendix 1 Contributor information

State or territory	Hospital		
Australian Capital Territory	Calvary Public Hospital Bruce	Canberra Hospital	
New South Wales	Armidale Hospital	Griffith Base Hospital	Prince Of Wales Hospital
	Auburn Hospital	Hornsby Ku-Ring-Gai Hospital	Queanbeyan Hospital
	Bankstown Hospital	John Hunter Hospital	Royal North Shore Hospital
	Batemans Bay District Hospital	Kareena Private Hospital	Royal Prince Alfred Hospital
	Bathurst Base Hospital	Kempsey District Hospital	Ryde Hospital
	Belmont Hospital	Lismore Base Hospital	Scott Memorial Hospital
	Blacktown Hospital	Liverpool Hospital	Shellharbour Hospital
	Bowral Hospital	Maclean District Hospital	Shoalhaven Hospital
	Broken Hill Base Hospital	Maitland Hospital	Singleton District Hospital
	Calvary Riverina Hospital	Manly Hospital	South East Regional Hospital
	Campbelltown Hospital	Manning Base Hospital	St George Hospital
	Canterbury Hospital	Mater Hospital North Sydney	St Vincent's Hospital Sydney
	Cessnock District Hospital	Milton-Ulladulla Hospital*	St Vincent's Private Hospital Sydney
	Coffs Harbour Hospital	Mona Vale Hospital	Sutherland Hospital
	Concord Hospital	Moruya Hospital	Sydney Adventist Hospital
	Cooma Hospital	Mt Druitt Hospital	The Tweed Hospital
	Dubbo Base Hospital	Mudgee District Hospital	Wagga Wagga Base Hospital
	Fairfield Hospital	Muswellbrook Hospital	Westmead Hospital
	Forbes District Hospital	Nepean Hospital	Westmead Private Hospital
	Gosford Hospital	Newcastle Mater	Wollongong Hospital
	Gosford Private Hospital	Orange Health Service	Wyong Hospital
	Goulburn Base Hospital	Parkes Hospital	Young Health Service
	Grafton Base Hospital	Port Macquarie Base Hospital	
South Australia	Ashford Hospital	Lyell McEwin Hospital	Port Pirie Hospital
	Berri Hospital	Memorial Hospital	Queen Elizabeth Hospital
	Calvary North Adelaide Hospital	Modbury Hospital	Royal Adelaide Hospital
	Calvary Wakefield Private Hospital	Mt Gambier Hospital	St Andrew's Hospital
	Flinders Medical Centre	Noarlunga Hospital	Whyalla Hospital
	Flinders Private Hospital	Port Augusta Hospital	Womens and Childrens Hospital
	Gawler Health Service	Port Lincoln Hospital	
Tasmania	Calvary Lenah Valley	Launceston General Hospital	North West Regional Hospital
	Hobart Private Hospital	Mersey Community Hospital	Royal Hobart Hospital

State or territory	Hospital		
Queensland	Atherton Hospital	Mackay Base Hospital	Princess Alexandra Hospital
	Bundaberg Hospital	Mareeba Hospital	Queen Elizabeth 2 Jubilee Hospital
	Caboolture Hospital	Maryborough Hospital	Redcliffe Hospital
	Cairns Base Hospital	Mater Bundaberg	Redland Hospital
	Gladstone Hospital	Mater Gladstone	Robina Hospital
	Gold Coast Private Hospital	Mater Hospital Brisbane	Rockhampton Hospital
	Gold Coast University Hospital	Mater Mackay	Royal Brisbane and Women's Hospital
	Greenslopes Hospital	Mater Mothers' Hospital	St Vincent's Private Hospital Brisbane
	Gympie Health Service	Mater Private Hospital Brisbane	St Vincent's Private Hospital Northside
	Hervey Bay Hospital	Mater Private Hospital Springfield	Sunshine Coast University Hospital
	Innisfail Hospital	Mater Redland Private	The Prince Charles Hospital
	Ipswich Hospital	Mater Rockhampton	Toowoomba Hospital
	Kingaroy Hospital	Mt Isa Hospital	Townsville Hospital
	Logan Hospital	Nambour General Hospital	Warwick Hospital
Northern Territory	Alice Springs Hospital	Katherine District Hospital	
	Gove District Hospital	Royal Darwin Hospital	
Victoria	Albury Wodonga - Albury	Dandenong Hospital	St Vincent's Private East Melbourne
	Albury Wodonga - Wodonga	Frankston Hospital	St Vincent's Private Fitzroy
	Alfred Hospital	Geelong Hospital	St Vincent's Private Kew
	Angliss Hospital	Holmesglen Private Hospital	St Vincent's Private Werribee
	Austin Hospital	Maroondah Hospital	The Northern Hospital
	Ballarat Base Hospital	Mercy Women's Hospital	Warrnambool Base Hospital
	Bendigo Health	Monash Medical Centre Clayton	Werribee Mercy Hospital
	Box Hill Hospital	Monash Moorabbin Hospital	West Gippsland Hospital
	Cabrini Hospital Brighton	Northeast Health Wangaratta	Western Health Footscray
	Cabrini Hospital Malvern	Royal Melbourne Hospital	Western Health Sunshine
	Casey Hospital	Sandringham Hospital	
	Central Gippsland Health	St Vincent's Hospital Melbourne	
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 Midland
	Derby Hospital	Kununurra Hospital	St John Of God Murdoch
	Esperance Hospital	Mount Hospital	St John Of God Subiaco
	Fiona Stanley Hospital	Narrogin Hospital	
	Fremantle Hospital	Northam Hospital	

*Hospital commenced NAUP participation in July 2018 – 6 months' data included in this report

Appendix 2 WHO Anatomical Therapeutic Classification and defined daily doses 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	2	O, P
J01CA04	Amoxicillin	1	O, 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	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		
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
J01DE	Fourth-generation cephalosporins		
J01DE01	Cefepime	2	P
J01DI	Other cephalosporins and penems		

ATC classification	Generic name	DDD (g)	Route
J01DI02	Ceftaroline	1.2	P
J01DI54	Ceftolozane and tazobactam	3	P
J01DH	Carbapenems		
J01DH02	Meropenem	2	P
J01DH51	Imipenem and enzyme inhibitor	2	P
J01DH03	Ertapenem	1	P
J01DH04	Doripenem	1.5	P
J01DF	Monobactams		
J01DF01	Aztreonam	4	P
J01DI	Other cephalosporins		
J01DI02	Ceftaroline	1.2	P
J01E	Sulfonamides and trimethoprim		
J01EA01	Trimethoprim	0.4	O, P
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
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		
J01FG01	Pristinamycin	2	O
J01FG02	Quinupristin/dalfopristin	1.5	P
J01GB	Aminoglycoside antibacterials		
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	0.5	P
J01MA06	Norfloxacin	0.8	O
J01MA14	Moxifloxacin	0.4	O, P
J01X	Other antibacterials		
J01XA	Glycopeptide antibacterials		
J01XA01	Vancomycin	2	O, P
J01XA02	Teicoplanin	0.4	P
J01XB	Polymyxins		
J01XB01	Colistin	3MU	P, Inh
J01XC	Steroid antibacterials		

ATC classification	Generic name	DDD (g)	Route
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		
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 (2018)[1]

Appendix 3 Changes in total-hospital antibacterial usage rate in participating hospitals, 2017 to 2018.

Table A2: Total-hospital antibacterial usage rates in 2017 and 2018

NSW/ACT	Hospital	2017	2018	% change from 2017 to 2018
Principal Referral	A9	1236.9	1062.5	-14.1
	F8	850.6	795.6	-6.5
	G2	797.7	840.3	5.3
	G5	955	854.9	-10.5
	H7	895.6	786	-12.2
	L8	1102.7	1066.3	-3.3
	M7	1378.8	1058.4	-23.2
	P4	1004.7	920.5	-8.4
	S4	1197.7	1041.4	-13.1
	T4	928.2	807.4	-13.0
	U7	771.1	690.3	-10.5
	V5	953.5	954.3	0.1
	V6	880.5	803.3	-8.8
Public Acute Group A	D9	780.3	830.6	6.4
	F7	963.1	1017.7	5.7
	F9	1003.4	984	-1.9
	G6	848.7	765.7	-9.8
	I1	751.7	609	-19.0
	I9	349	347.2	-0.5
	K4	889.2	755.7	-15.0
	K5	743.4	939.9	26.4
	L7	1127.5	1053.2	-6.6
	M8	1240	1118.5	-9.8
	O4	1019.3	971.5	-4.7
	O5	1011.9	931.1	-8.0
	P8	1035.9	953.9	-7.9
	Q2	1023.4	960.1	-6.2
	Q7	892	673.4	-24.5
	R4	1059.8	963.6	-9.1
	R8	1306.6	1315.4	0.7
	S9	1330.9	1200.7	-9.8
	T5	1197.3	954.1	-20.3
	T7	638.3	503	-21.2
	T8	1057.7	900.7	-14.8
	T9	1119	945	-15.5
	V9	933.6	924.3	-1.0
	Y6	733.7	1062.1	44.8
Public Acute Group B	A3	1274	1526.9	19.9
	A4	1944.2	1404.6	-27.8
	A6	1022.1	1361	33.2
	B5	1068.3	1252.2	17.2
	C6	790.5	1276	61.4
	C8	1230.6	1246.6	1.3
	E8	614.3	1199.7	95.3
	H5	1531.8	1155.3	-24.6
	J7	1520	1100.2	-27.6
	M2	1045.7	1028.3	-1.7
	M3	1440.7	1046.7	-27.3
	M4	1006.9	1009.8	0.3
	N6	1235.1	980.3	-20.6
	Q1	928.1	861.9	-7.1
	Q9	1114.2	823.4	-26.1
	W8	870.4	749.3	-13.9
	X1	868.7	720.5	-17.1
	Z7	1622.5	318.4	-80.4

NSW/ACT	Hospital	2017	2018	% change from 2017 to 2018
Public Acute Group C	B0	650.1	1282.3	97.2
	B4	1128.4	1195.7	6.0
	B9	1092.2	1191	9.0
	C0	N/A	1143.7	N/A
	CA2	N/A	992.8	N/A
	D1	722.1	1060.8	46.9
	E1	690.5	955.9	38.4
	J3	1245.4	1012.1	-18.7
	J1	819	998.8	22.0
	P2	1002.1	965.1	-3.7
	T6	1369.1	912.3	-33.4
	W1	1199	889	-25.9
	X5	890.5	756.2	-15.1
	X9	965.8	646.1	-33.1
	Z8	1250.8	648.5	-48.2

Victoria	Hospital	2017	2018	% change from 2017 to 2018
Principal Referral	B2	930.1	875.5	-5.9
	D8	1134.3	1207.4	6.4
	F3	1186.2	1138.8	-4.0
	I2	759.8	783.8	3.2
	J8	976.1	962	-1.4
	M6	921.1	912.3	-1.0
	Z9	834.3	918.1	10.0
Public Acute Group A	A1	365.8	375.9	2.8
	A7	1062.6	1095.7	3.1
	C1	972.1	1045.7	7.6
	D3	1138.2	1114.7	-2.1
	D5	968	1071	10.6
	E6	1077.6	1037.7	-3.7
	F4	667.2	758.4	13.7
	K7	994.6	949.7	-4.5
	L6	1026.1	992.1	-3.3
	M9	789.6	800.1	1.3
	N5	708.2	755.3	6.7
	S3	979.3	867.9	-11.4
	U6	806.9	1072.8	33.0
	Y4	1020.2	1145.8	12.3
	Y9	923.6	965.4	4.5
Public Acute Group B and Specialist Women's	D7	256.5	334.7	30.5
	F5	1080.9	1034.3	-4.3
	H2	683.8	685.8	0.3
	J2	769.6	770.5	0.1
	J4	632.2	622.9	-1.5
	J5	1035.4	1110.8	7.3
	J9	1066	1085.1	1.8
	N8	950	918.8	-3.3
	V1		621.3	N/A
	X4		1206.4	N/A
	X6	876.8	872.9	-0.4
	Y1	797.6	849.4	6.5

QLD/NT	Hospital	2017	2018	% change from 2017 to 2018
Principal Referral	D2	937.8	931.4	-0.7
	E3	917.5	884.3	-3.6
	G3	707.1	596.8	-15.6
	H9	907.5	834.6	-8.0
	K3	1025.9	995.1	-3.0
	P6	1231	1108.2	-10.0
	R2	677.2	710.6	4.9
	S6	897.2	970.2	8.1
	W6	1135.7	1032.7	-9.1
Public Acute Group A	C2	1140.5	1082.8	-5.1
	C5	1188.1	1134.4	-4.5
	E4	1033.9	1115.5	7.9
	E7	1172.2	1105.2	-5.7
	H1	1214.9	1144.6	-5.8
	K6	1241.8	1112.6	-10.4
	L3	934	813.9	-12.9
	N9	1166.5	1125.2	-3.5
	P1	704.2	719.1	2.1
	Q3	1255.6	1156.5	-7.9
	Q8	1037.3	960.8	-7.4
	S7	1119.4	1174.8	4.9
	W7	640.2	1150	79.6
	Y7	1189.3	1121.8	-5.7
	Z2	850.4	809.7	-4.8
Public Acute Group B	B1	1287	1545.7	20.1
	C4	1222.1	1160.3	-5.1
	C7	1032.5	1024.2	-0.8
	E5	542.3	800	47.5
	H6	1068.7	1025.7	-4.0
	J3	803.6	791.3	-1.5
	P5	766	829.9	8.3
	R6	715.7	650.3	-9.1
	V2	898.9	877.8	-2.3
	V4	1058.8	953.8	-9.9
	Y5	1890.9	1619.6	-14.3
Public Acute Group C & Specialist Women's	B8	450.9	486.9	8.0
	D4	783.4	819.7	4.6
	E2	1825.5	1703	-6.7
	F1	1221.3	1354.4	10.9
	G0	1485.4	1704.7	14.8
	H8	939.9	1215	29.3
	I8	1483.9	1412.1	-4.8
	K9	1024	1013.7	-1.0
	L4	219.5	207.8	-5.3
	N2	814.2	878.9	7.9
	Q6	402.2	334.8	-16.8

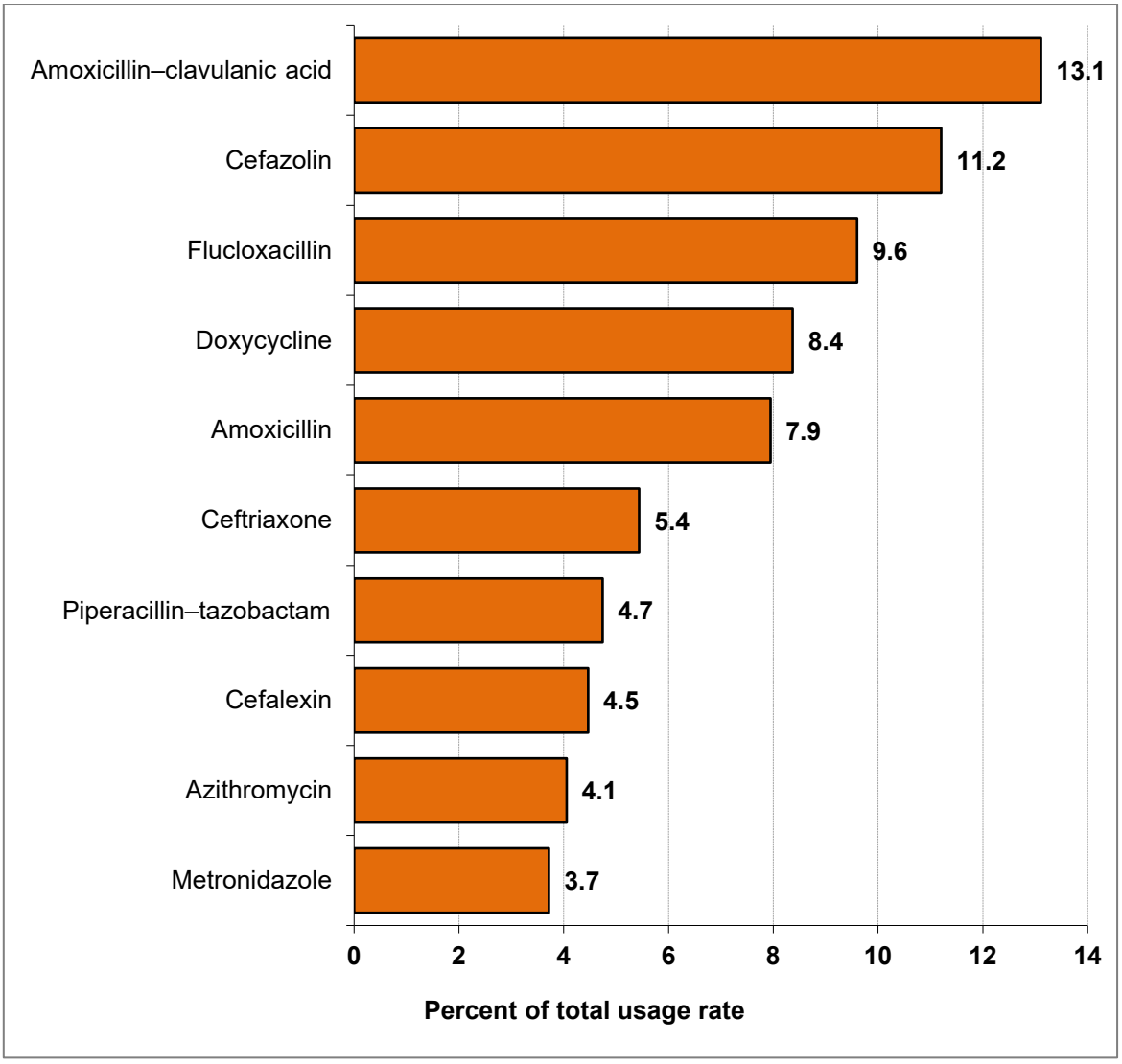
South Australia	Hospital	2017	2018	% change from 2017 to 2018
Principal Referral and Public Acute Group A	A2	549.7	698.4	27.1
	F2	1159.3	1124.4	-3.0
	G7	991.5	813.7	-17.9
	I7	1210.1	1174.8	-2.9
	J6	1182.7	976.9	-17.4
	K2	931.6	916.9	-1.6
	L1	843.9	878.9	4.1
	O7	1160.6	1147.6	-1.1
	U2	1017.6	877.7	-13.7
	W3	700	875.9	25.1
	Z6	1120.8	1138.4	1.6
Public Acute Group B	B3	777.8	604.9	-22.2
	L2	672.6	667.1	-0.8
	R1	763.1	807.7	5.8
	X3	627.6	643.7	2.6
Public Acute Group C and Specialist Women's	K1	537.2	607	13.0
	N7	697.1	667.1	-4.3
	Q4	663	744.6	12.3
	U9	1281.3	1299.8	1.4
	Y3	668.8	679.2	1.6

WA	Hospital	2017	2018	% change from 2017 to 2018
Principal Referral	G4	1250.8	1319	5.5
	G8	954.1	994.3	4.2
	W5	919.6	941.8	2.4
Public Acute Group A	A8	816	797.2	-2.3
	E9	602.8	599.6	-0.5
	F6	829.7	774.2	-6.7
	L5	1017.9	1081	6.2
	R9	596.4	635.6	6.6
	S8	905.2	943.5	4.2
	W9	500	447.9	-10.4
Public Acute Group B	G9	1197.7	1048.5	-12.5
	M0		659.1	N/A
	R7	1412.2	1610.1	14.0
	W2	803.5	825.7	2.8
Public Acute Group C	B6	745.7	804	7.8
	C3	439.1	425.5	-3.1
	M1		2124.4	N/A
	N1	497.4	517	3.9
	P3	1121.5	775.8	-30.8
	Q5		1479	N/A
	S1		2457	N/A
	S2		835.3	N/A
	T1		872.8	N/A
	U4		1236.4	N/A
	V8		1638.7	N/A

Tasmania	Hospital	2017	2018	% change from 2017 to 2018
	C9	1439.6	1396.9	-3.0
	G1	781.3	691.2	-11.5
	K8	1489.7	1218.3	-18.2
	O2	1053.3	1099.4	4.4
	T3	1245.6	1183.9	-5.0
	V3	802.8	711.4	-11.4

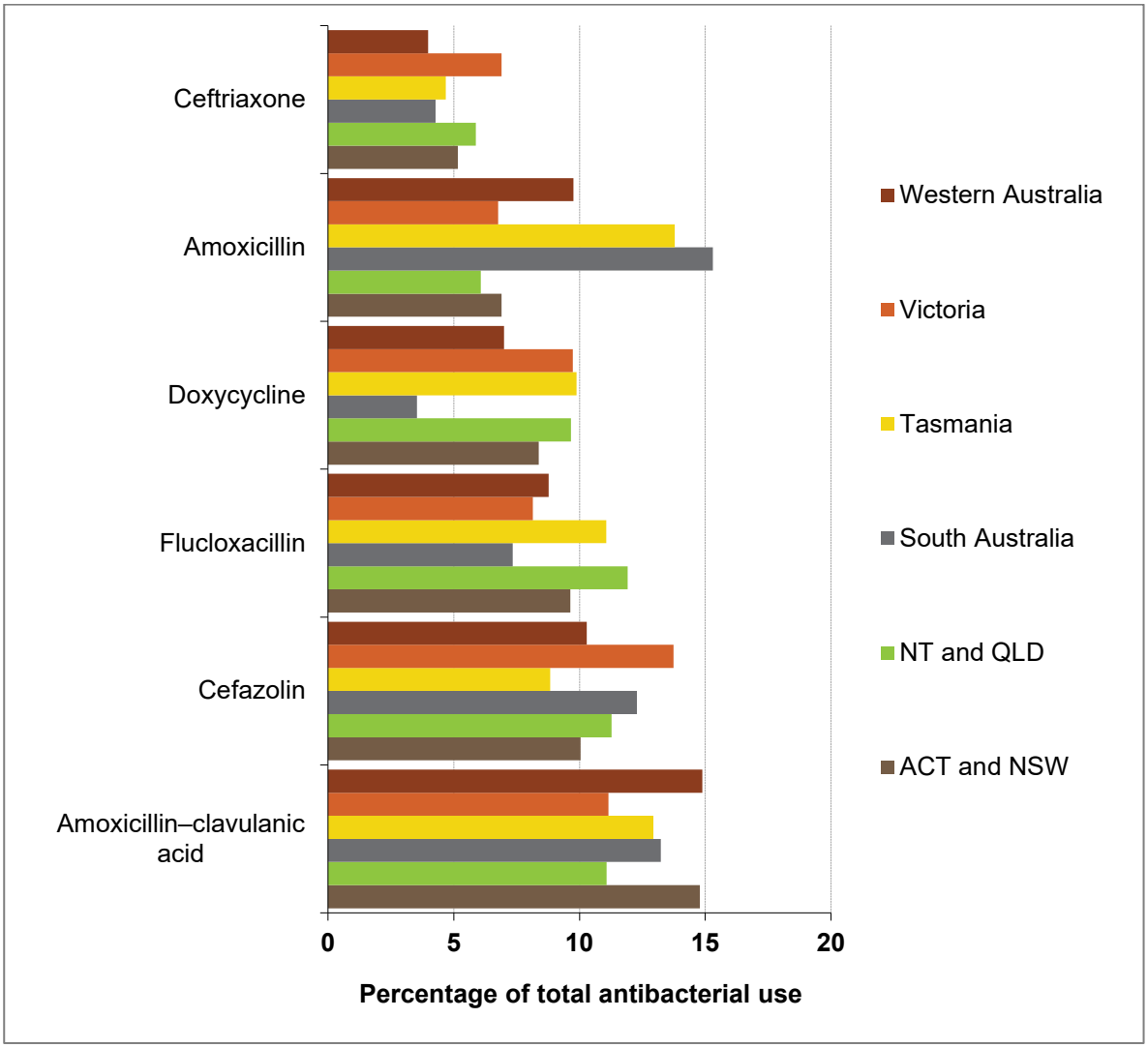
Appendix 4 Most frequently used antibacterials in public and private hospitals that contributed to NAUSP, additional information

Figure A4: Top 10 antibacterials as a percentage of all antibacterials used in NAUSP contributor hospitals, 2017



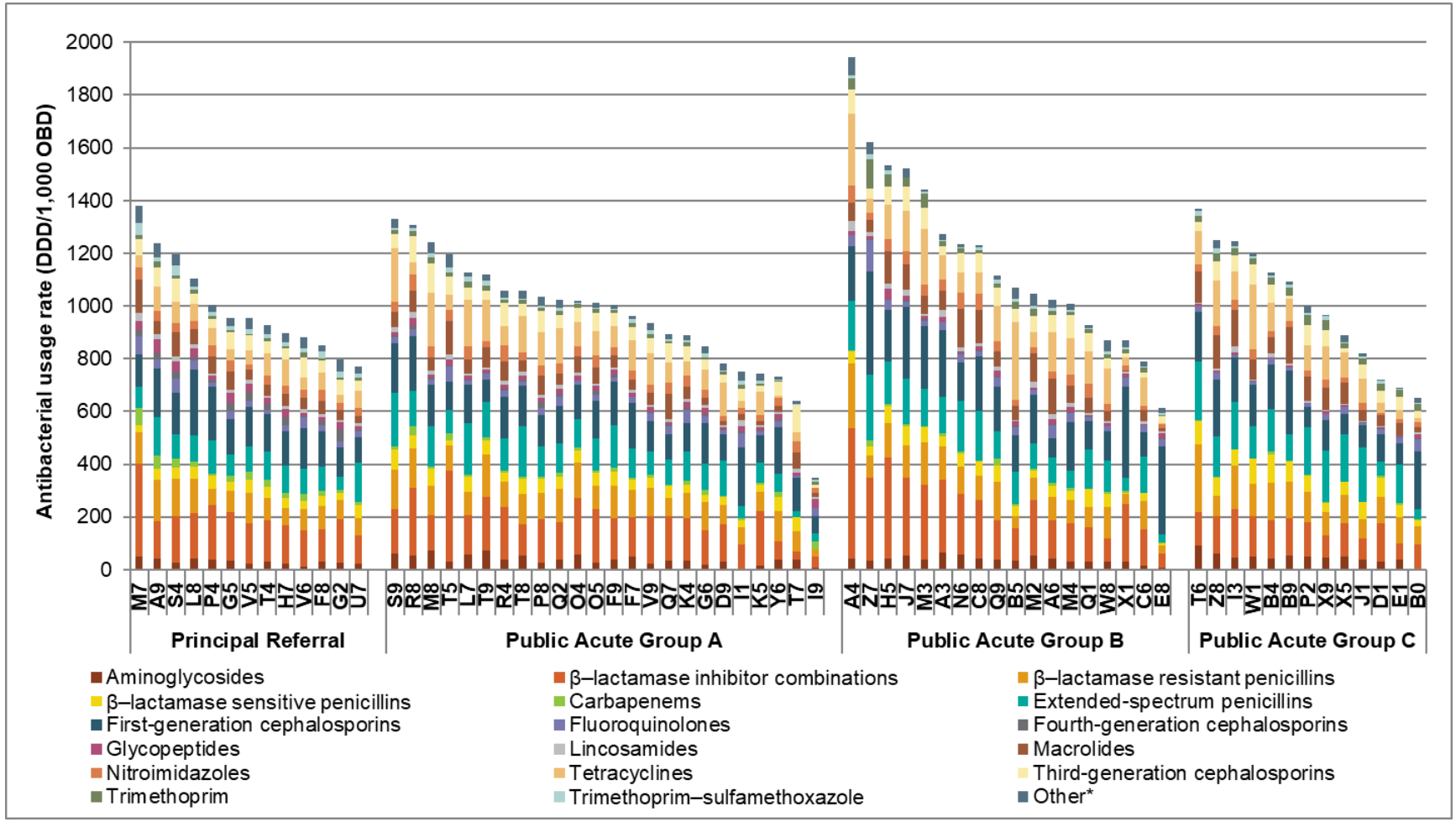
NAUSP = National Antimicrobial Utilisation Surveillance Program

Figure A5: Top 6 antibacterials as a percentage of all antibacterials used in NAUSP contributor hospitals by state and territory, 2017



Appendix 5 Comparison of antibacterial usage rates by peer group and state/territory

Figure A6: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, New South Wales and Australian Capital Territory, 2017

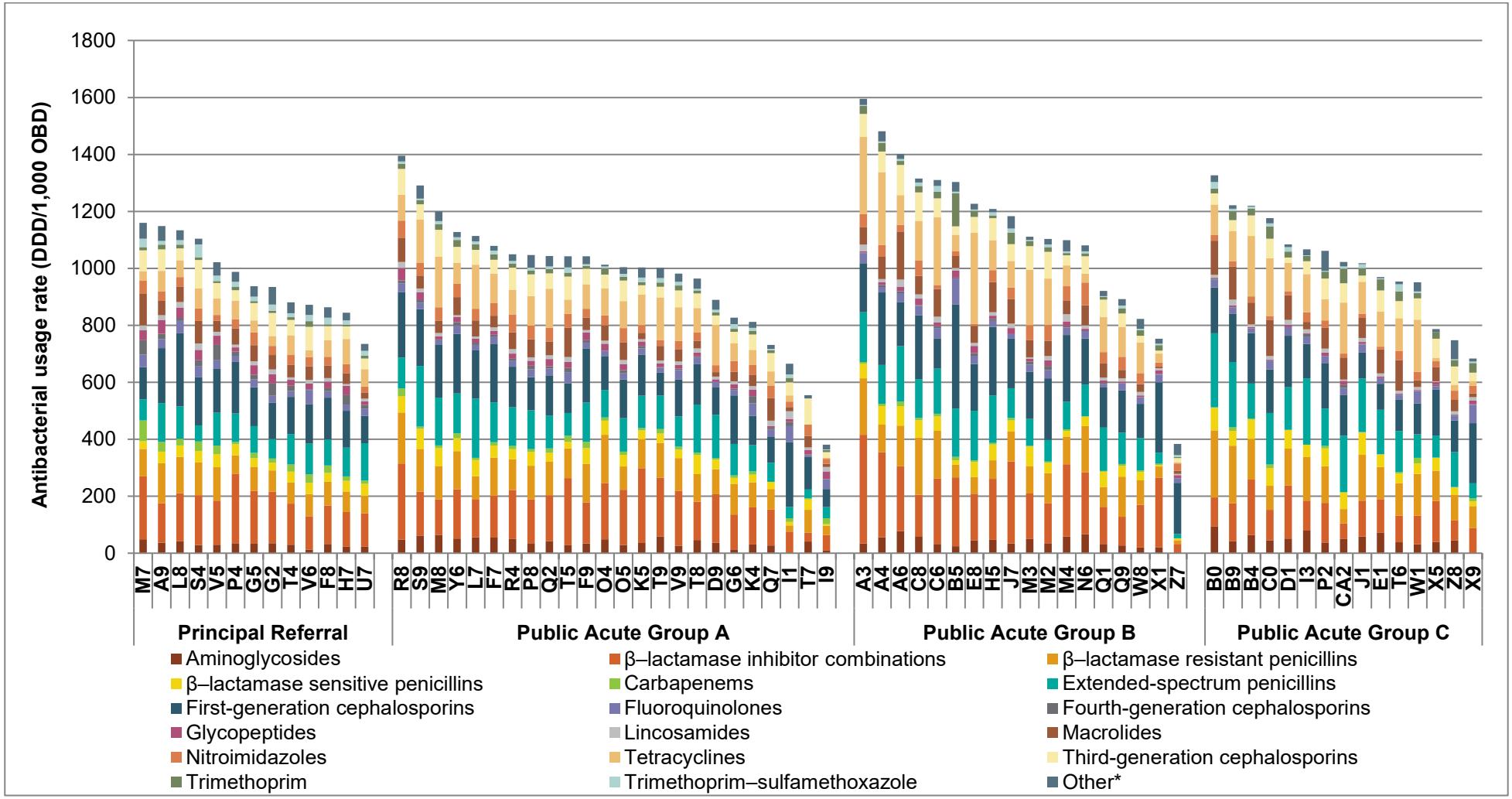


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Note: Data from seven private NSW hospitals are included (one with the Principal Referral Hospital cohort, two with Public Acute Group A, three with Public Acute Group B, and one with Public Acute Group C).

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second–generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Figure A7: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals†, New South Wales and Australian Capital Territory, 2018

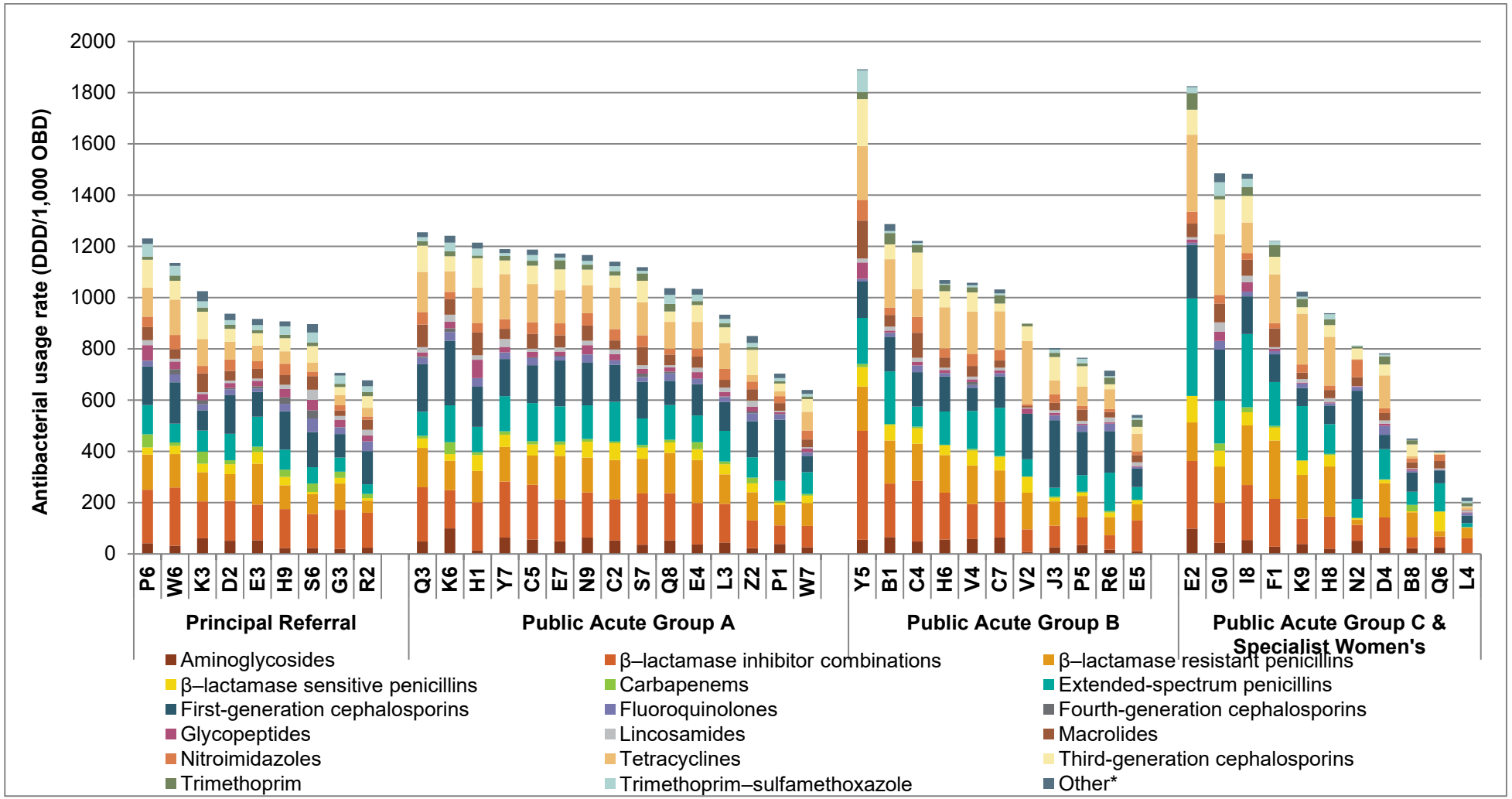


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Note: Data from seven private NSW hospitals are included (one with the Principal Referral Hospital cohort, two with Public Acute Group A, three with Public Acute Group B, and one with Public Acute Group C).

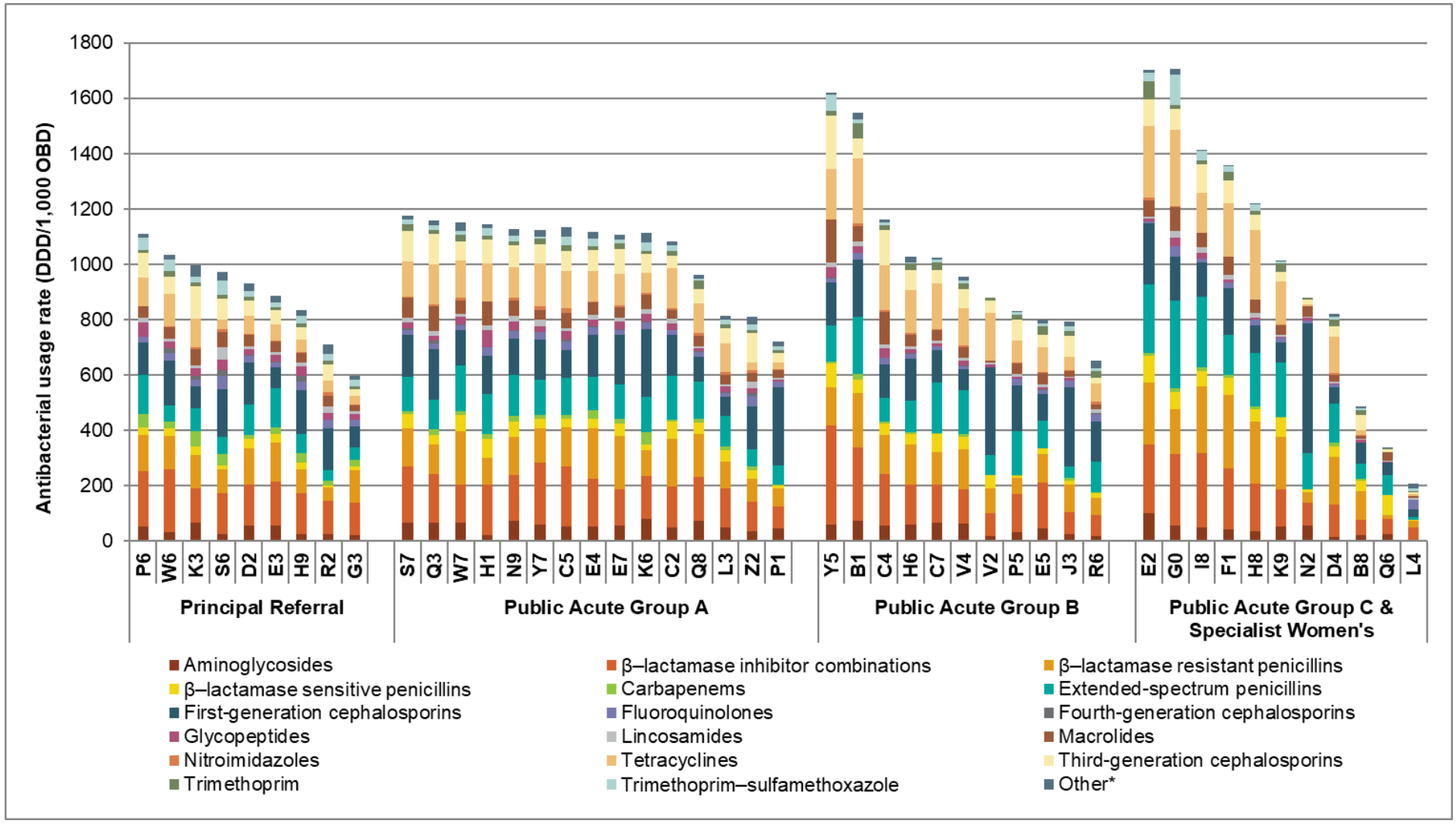
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Figure A8: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Queensland and Northern Territory, 2017



* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Figure A9: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Queensland and Northern Territory, 2018

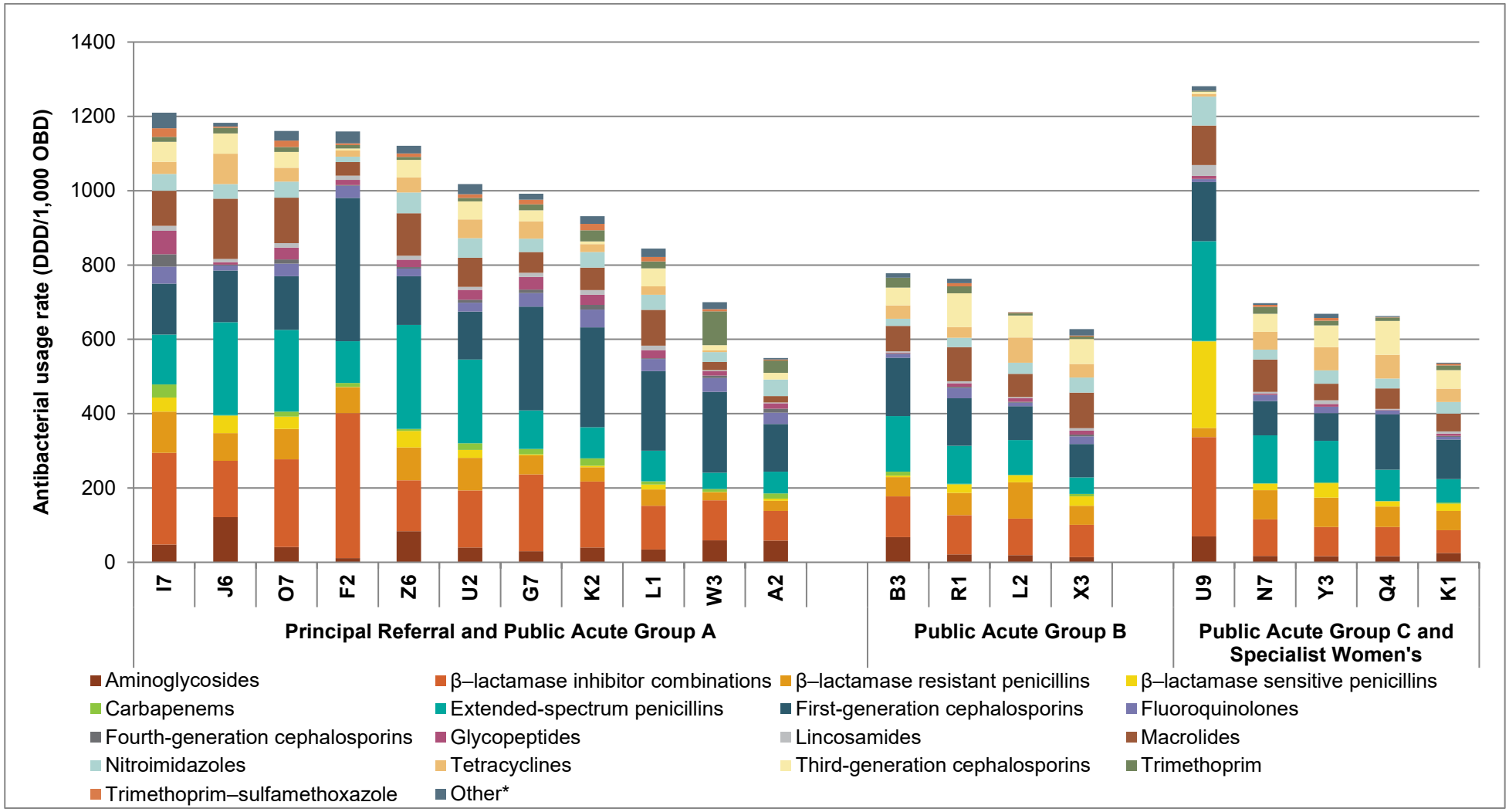


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Note: Data from 11 Queensland private hospitals are included (one with the Principal Referral Hospital cohort, three with Public Acute Group A, four with Public Acute Group B, and three with Public Acute Group C).

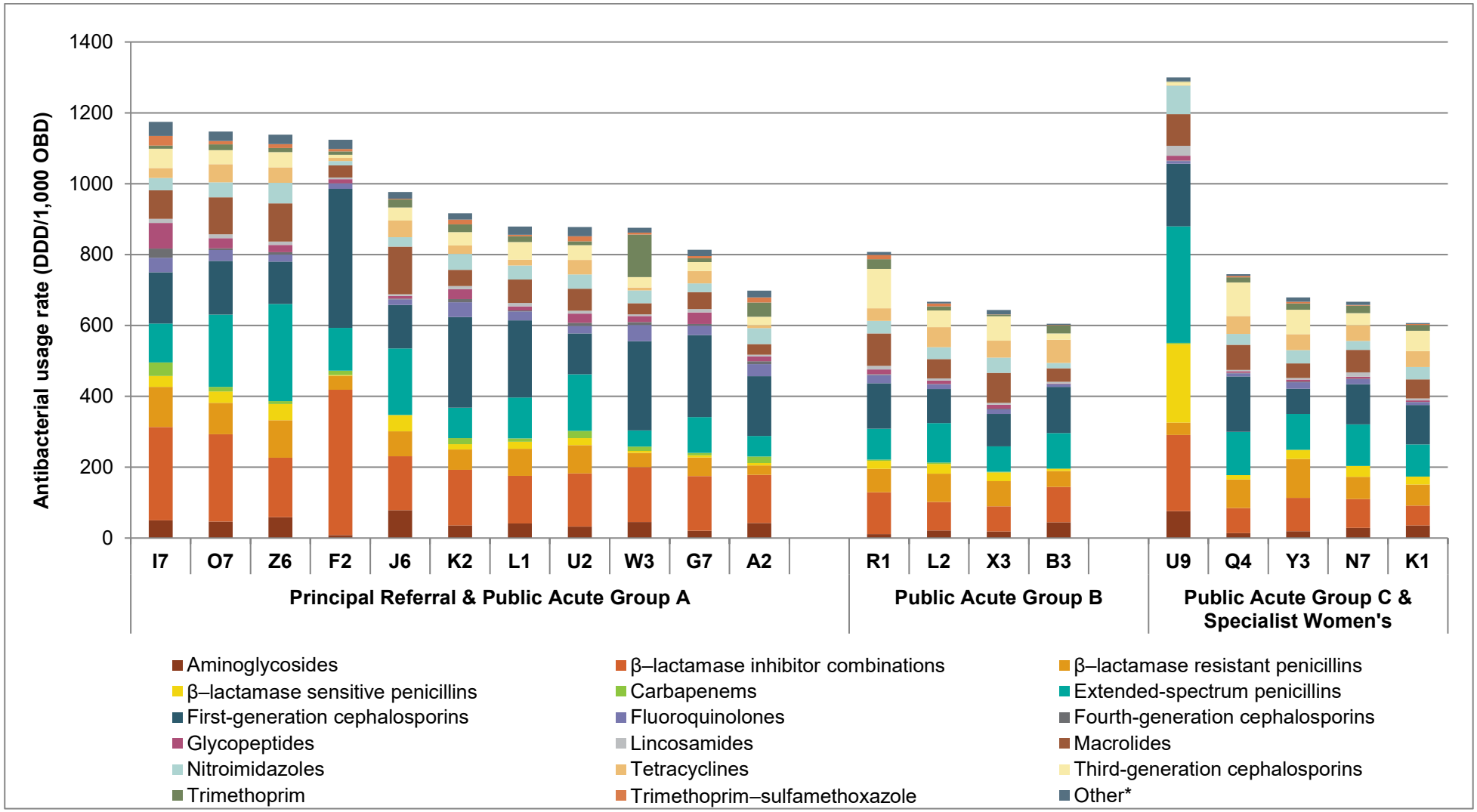
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Figure A10: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, South Australia, 2017



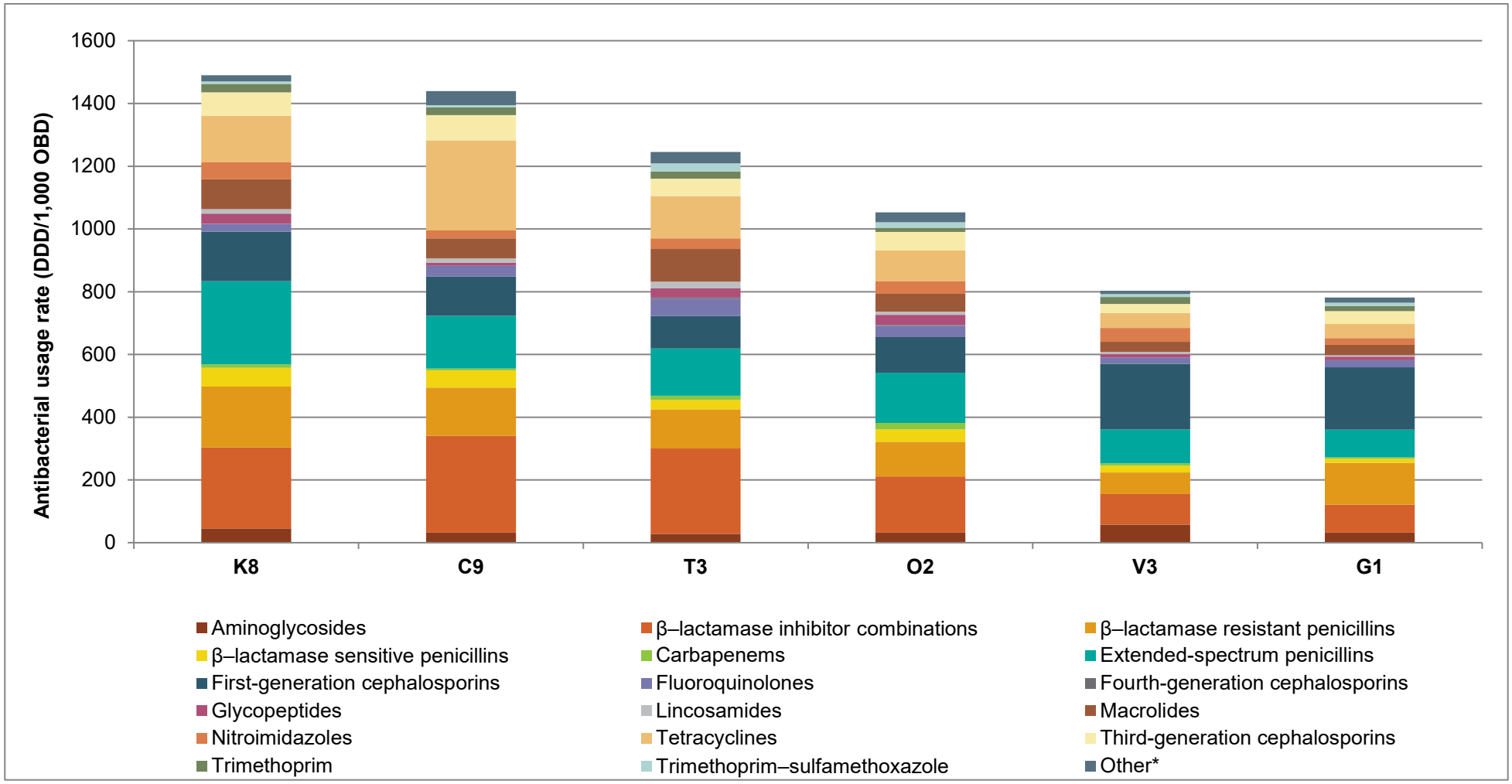
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Data from six South Australian private hospitals are benchmarked with the Principal Referral Hospital and Public Acute Group A cohort.
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins.

Figure A11: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, South Australia, 2018



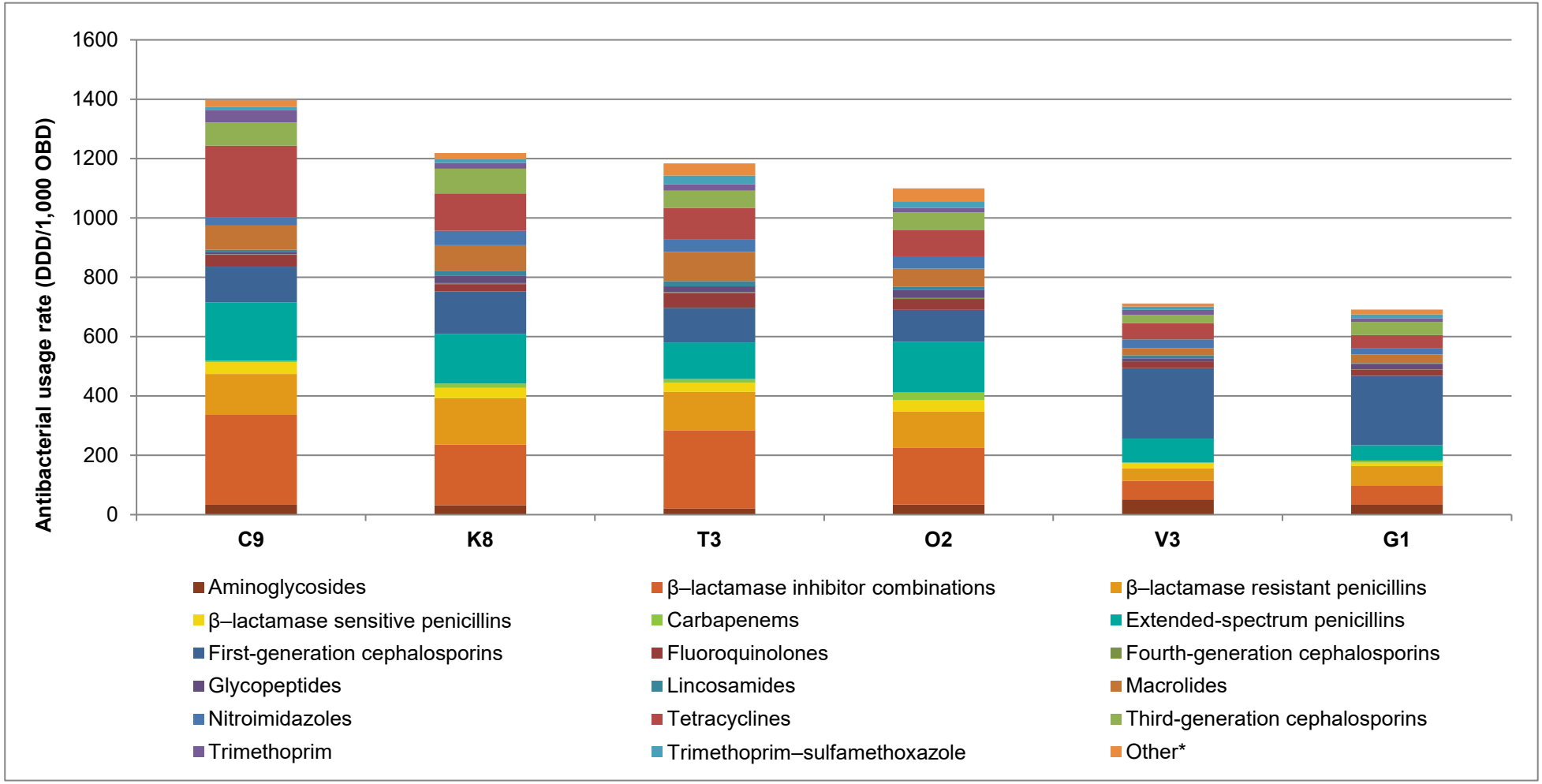
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Data from six South Australian private hospitals are included with the Principal Referral Hospital and Public Acute Group A cohort.
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A12: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Tasmania, 2017



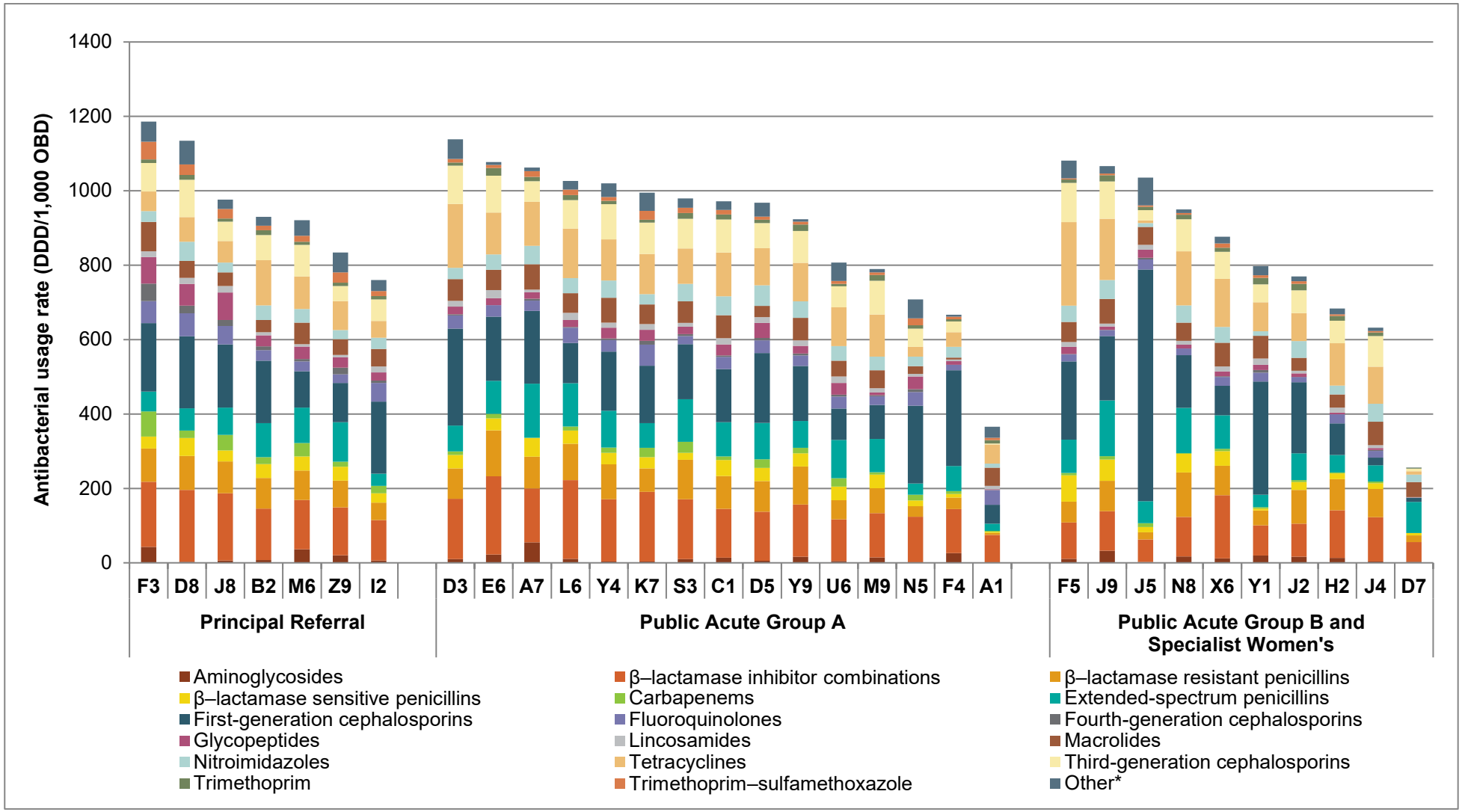
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Data from two Tasmanian private hospitals are included, peer groups are not displayed due to small numbers
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A13: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Tasmania, 2018



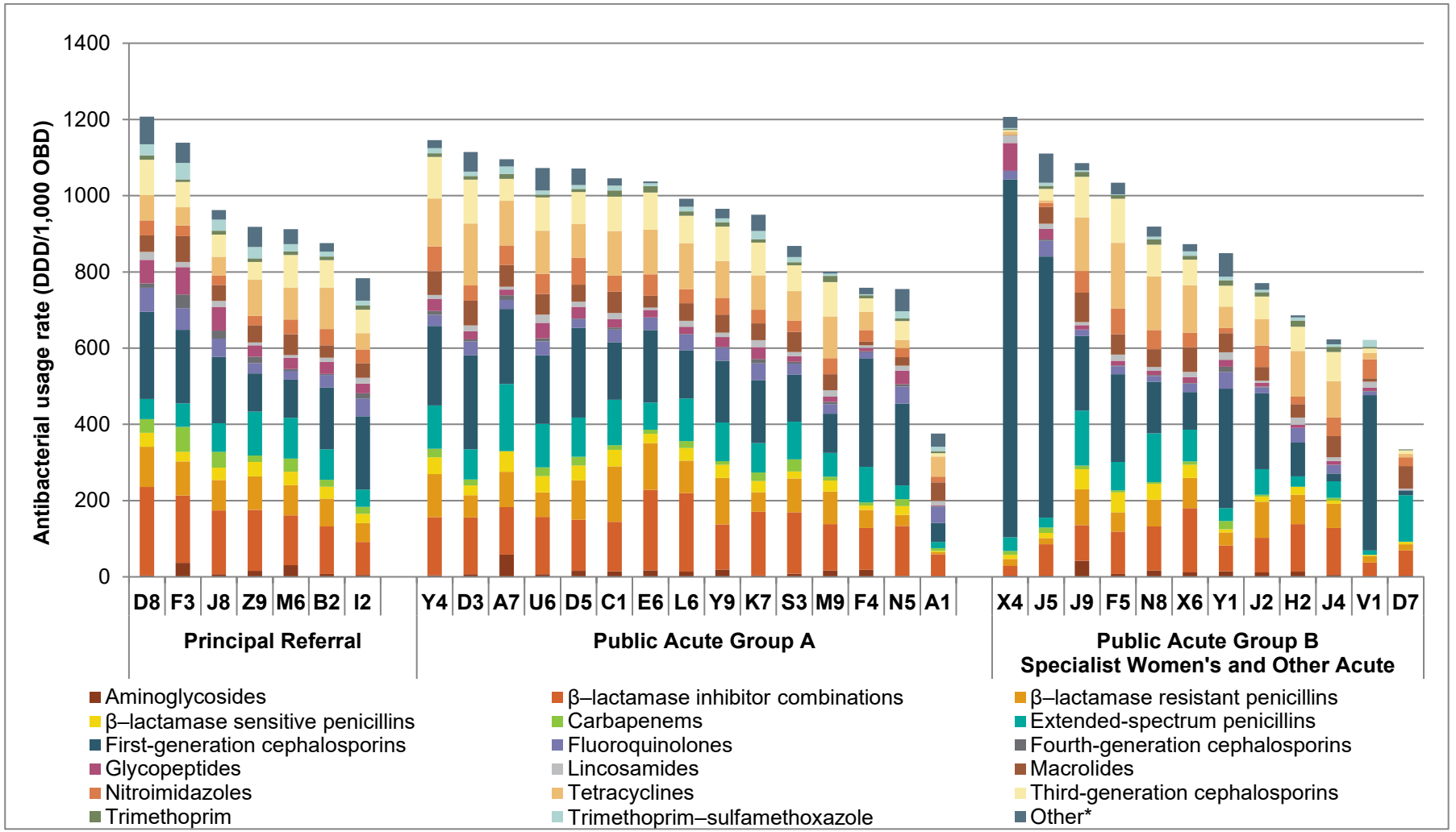
DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Data from two Tasmanian private hospitals are included, peer groups are not displayed due to small numbers.
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A14: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Victoria, 2017



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Data from five Victorian private hospitals are included (one with the Principal Referral Hospital cohort, two with Public Acute Group A, and two with Public Acute Group C)
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A15: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Victoria, 2018

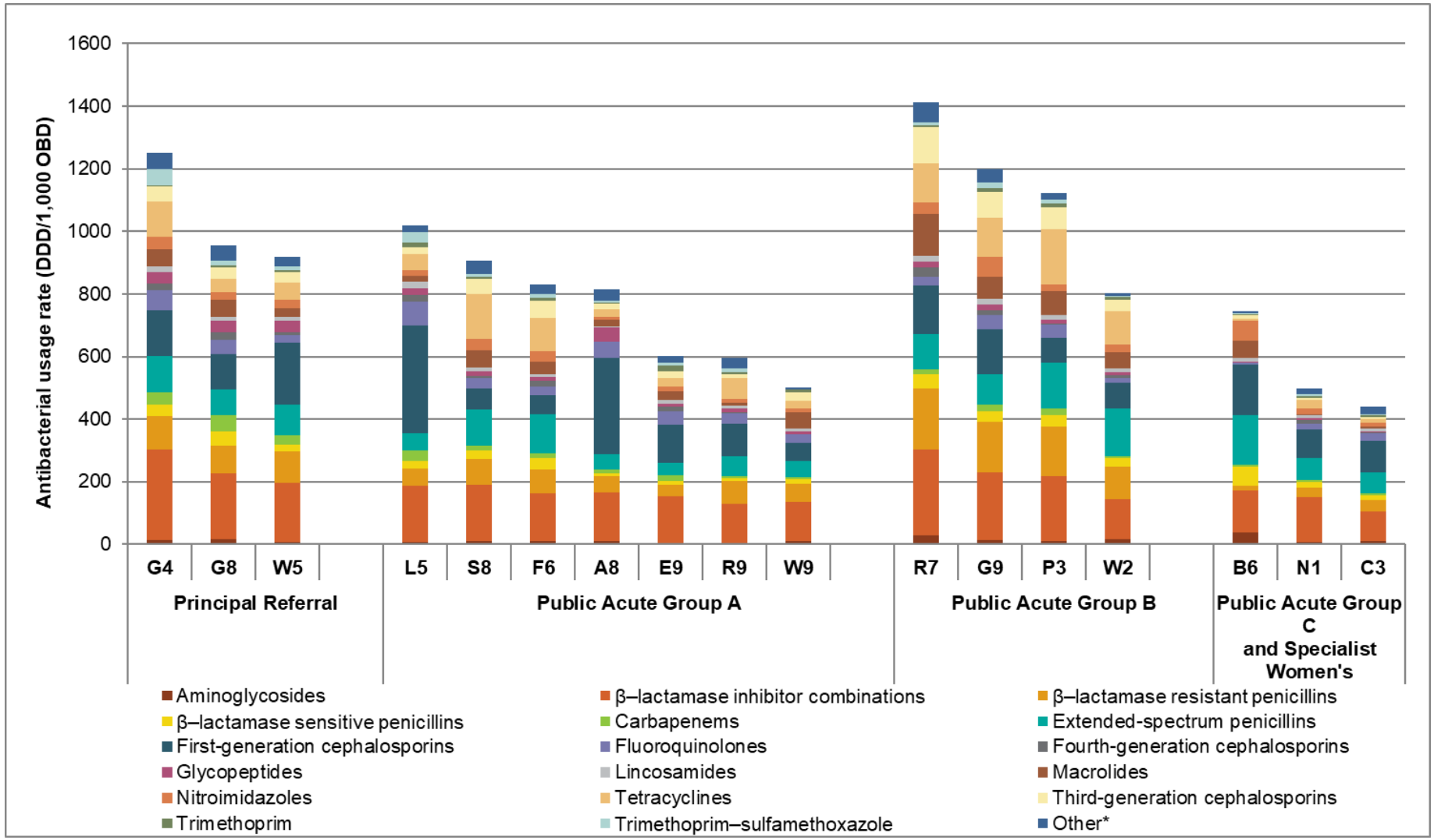


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Note: Data from seven Victorian private hospitals are included (one with the Principal Referral Hospital cohort, two with Public Acute Group A, three with Public Acute Group C and one with Other Acute). Hospital X4 is investigating its use of first-generation cephalosporins.

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A16: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Western Australia, 2017

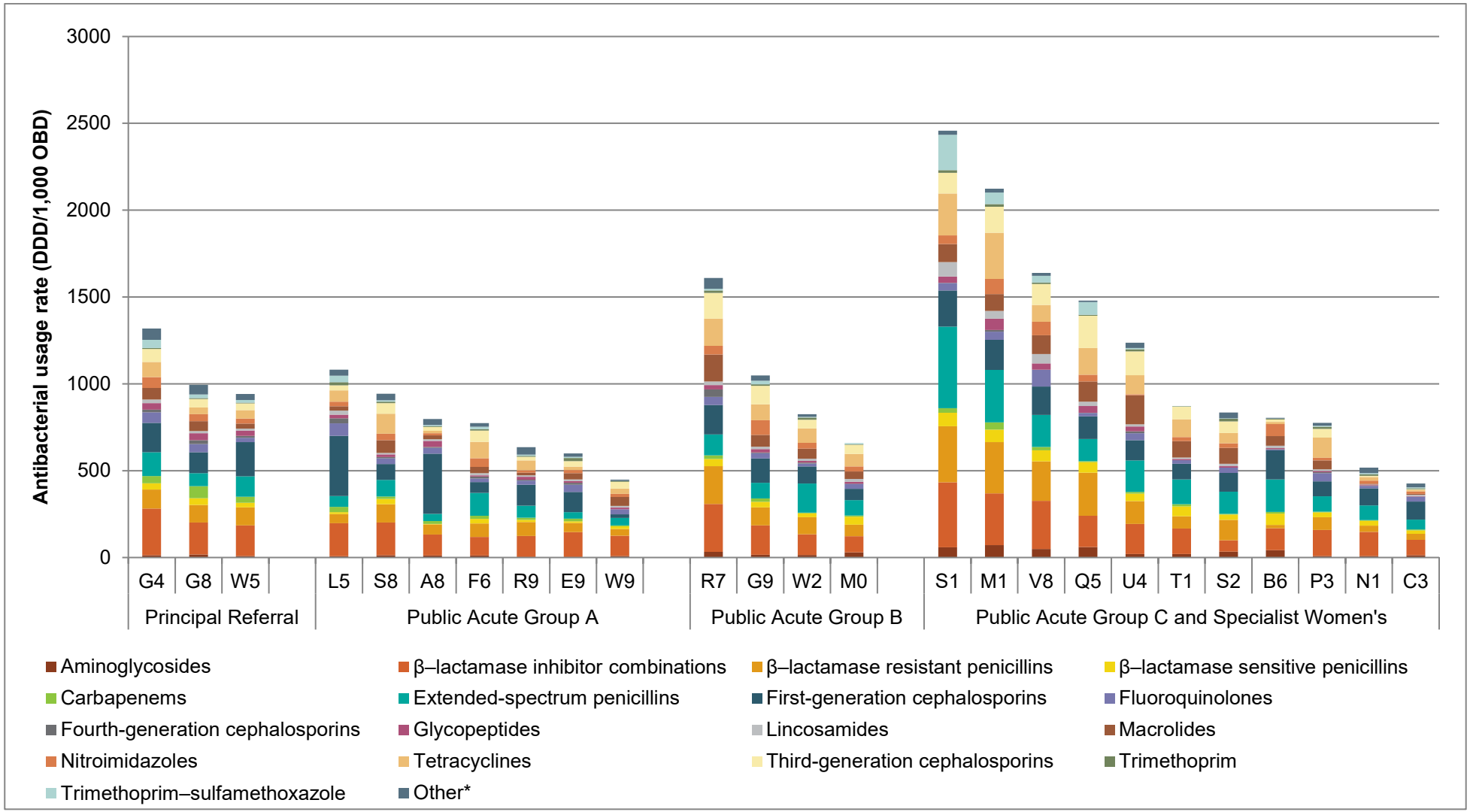


DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day

Note: Data from three Western Australian private hospitals are shown with the Public Acute Group A cohort.

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

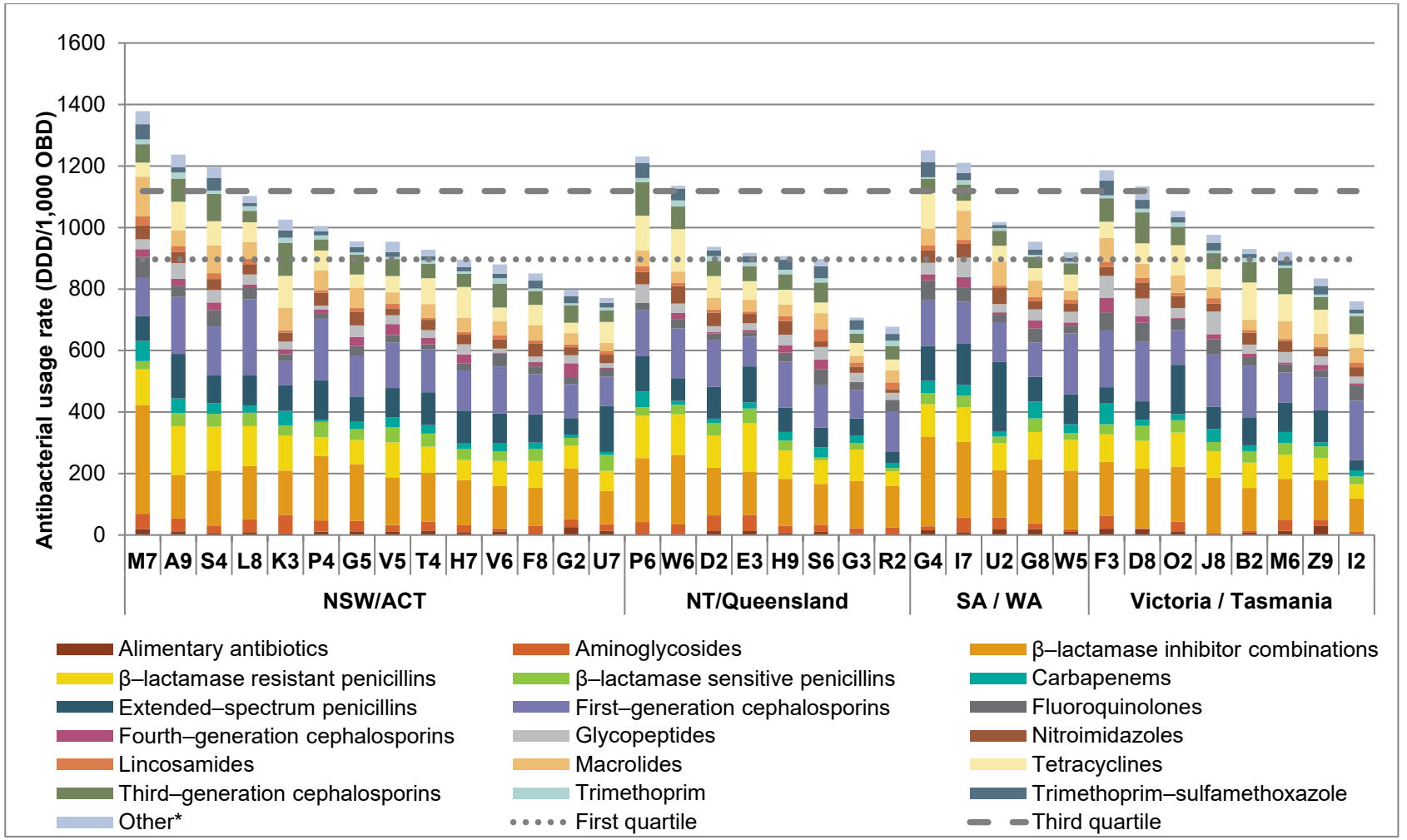
Figure A17: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP contributor hospitals, Western Australia, 2018



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
Note: Data from three Western Australian private hospitals are shown with the Public Acute Group A cohort
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Appendix 6 2017 antibacterial usage rates for Principal Referral, Acute Group A, B & C hospitals

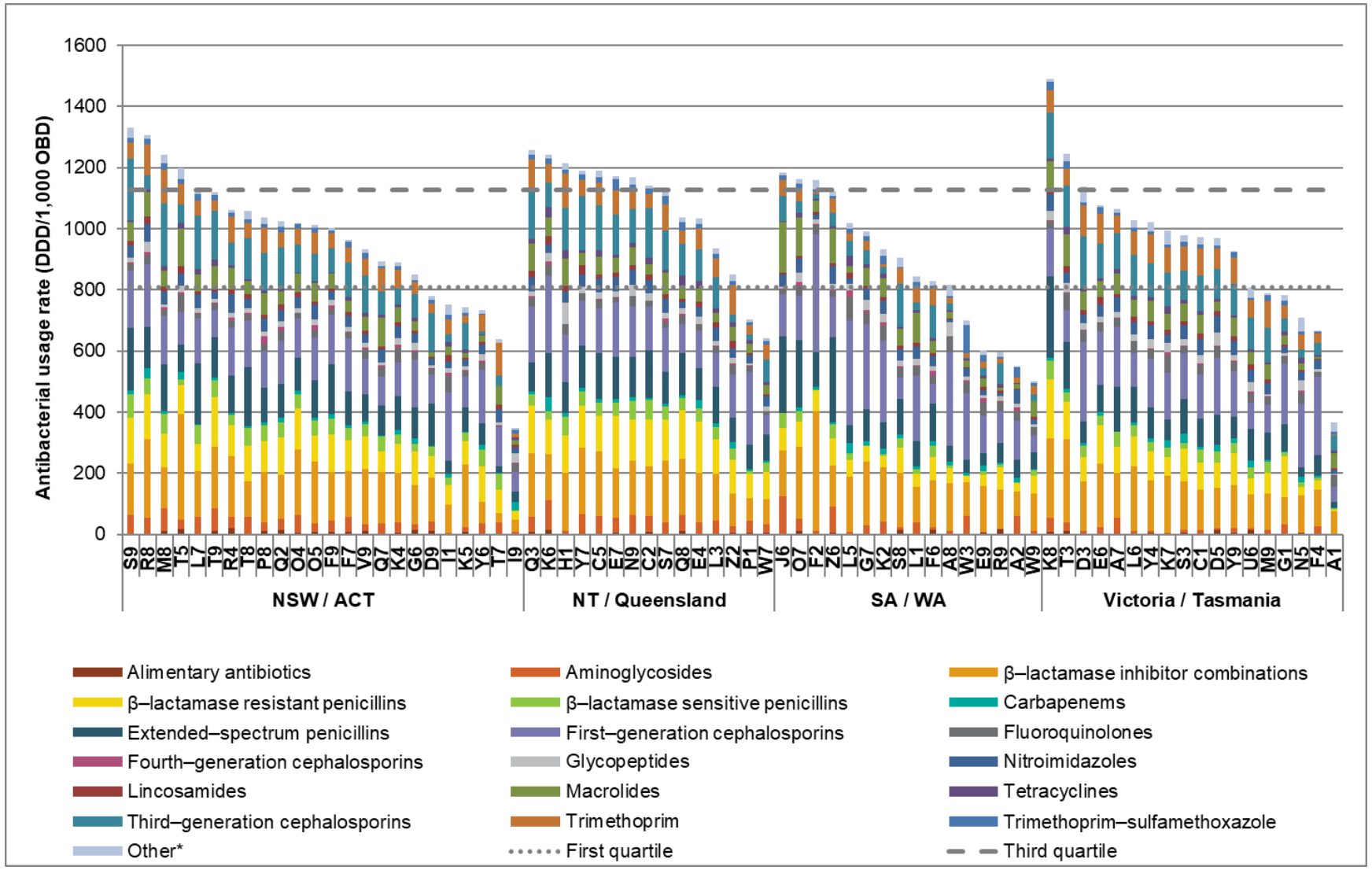
Figure A18: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Principal Referral contributor hospitals, 2017.



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

* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

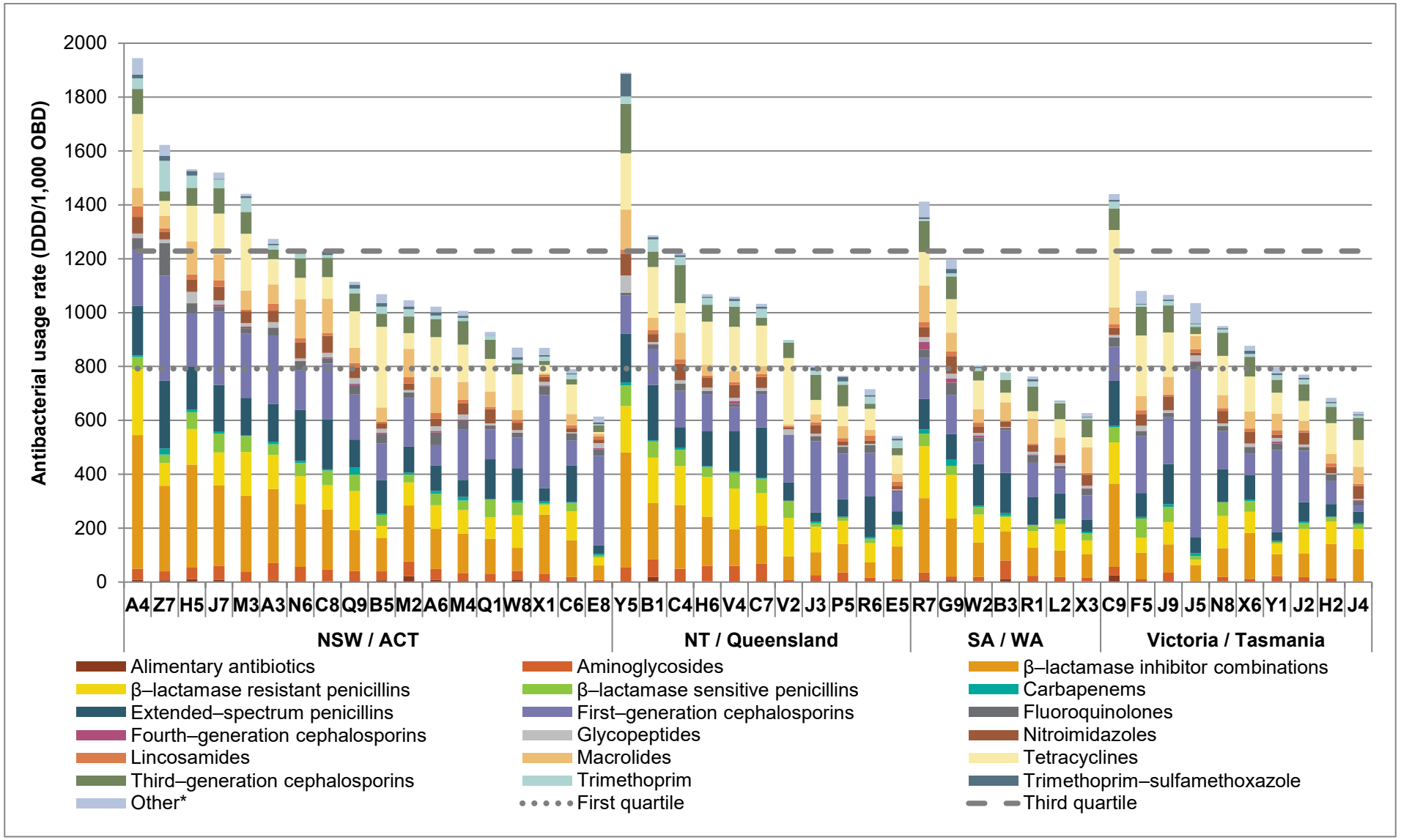
Figure A19: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Acute Group A contributor hospitals, 2017



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

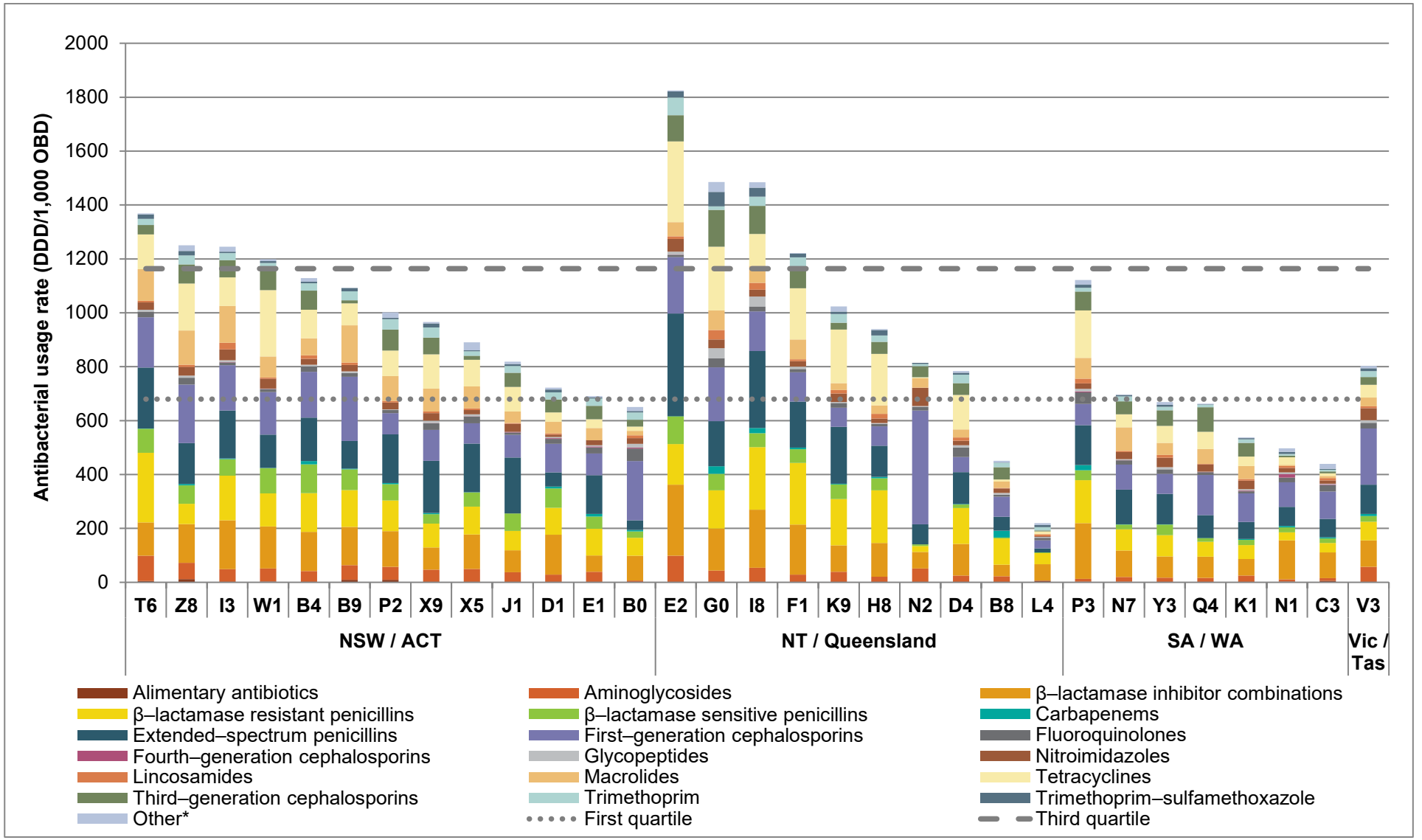
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A20: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Acute Group B contributor hospitals, 2017



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Figure A21: Total-hospital antibacterial usage rates (DDD/1,000 OBD) in NAUSP Acute Group C contributor hospitals, 2017



DDD = defined daily dose; NAUSP = National Antimicrobial Utilisation Surveillance Program; OBD = occupied bed day
* 'Other' comprises amphenicols, monobactams, nitrofurans, other antibacterials (linezolid and daptomycin), other cephalosporins and penems (ceftaroline), polymyxins, rifamycins, second-generation cephalosporins, steroids (fusidic acid), streptogramins and streptomycins

Abbreviations

Term	Definition
AIHW	Australian Institute of Health and Welfare
AMS	antimicrobial stewardship
AURA	Antimicrobial Use and Resistance in Australia
DDD	defined daily dose
ICU	intensive care unit
NAPS	National Antimicrobial Prescribing Survey
NAUSP	National Antimicrobial Utilisation Surveillance Program
OBD	occupied bed day
SA Health	South Australian Department of Health and Wellbeing
WHO	World Health Organization

Glossary

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.
antimicrobials	Medicines classified as anti-infective agents for systemic use within the World health Organization Collaboration Centre for Drug Statistics Methodology's Anatomical Therapeutic Chemical (ATC) classification system, including antibacterial, antimycolytic, antiviral and anti-parasitic medicines for systemic use. Antimycobacterial agents are not included.
defined daily dose	The average maintenance dose per day for an average adult for the main indication of the medicine.
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.
occupied bed day	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.
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 = $\frac{\text{Number of DDDs/time period}}{\text{OBDs/time period}} \times 1{,}000$

References

1. Australian Government Department of Health &Australian Government Department of Agriculture and Water Resources. Implementation plan: Australia's first National Antimicrobial Resistance Strategy 2015–2019. Canberra: Department of Health, Department of Agriculture and Water Resources, 2016.
2. AIHW, Australian Institute of Health and Welfare. Hospital resources 2017-18: Australian hospital statistics. 2018. https://www.aihw.gov.au/reports/hospitals/hospital-resources-2017-18-ahs/data.
3. DANMAP. Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark: Statens Serum Institut, 2017.
4. SWAB. NethMap 2018 Consumption of antimicrobial agents and antimicrobial resistance among medically important bacteria in the Netherlands, 2018.
5. SWEDRES. Consumption of antibiotics and occurrence of antibiotic resistance in Sweden. Solna/Uppsala, 2017.
6. WHO. ATC/DDD Index. http://www.whocc.no/atcddd/ (accessed 13th May 2019).
7. National Centre for Antimicrobal Stewardship, Australian Commission on Safety and Quality in Health Care. Antimicrobial prescribing practice in Australian hospitals: results of the 2018 Hospital National Antimicrobial Prescribing Survey. Sydney, 2019.
8. Antibiotic Expert Group. Therapeutic Guidelines: Antibiotic (version 16). Melbourne; 2019.
9. SAAGAR. Antimicrobial Guidelines https://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/clinical+resources/clinical+topics/medicines+and+drugs/antimicrobial+guidelines.
10. Australian Commission on Safety and Quality in Health Care. AURA 2019: third Australian report on antimicrobial use and resistance in human health. Sydney: ACSQHC, 2019.
11. Therapeutic Goods Administration. Medicine Shortages Information Initiative. 2019. https://apps.tga.gov.au/prod/MSI/search/ (accessed August 22 2019).
12. SA Health, Australian Commission on Safety and Quality in Health Care. Antimicrobial use in Australian Hospitals: 2016 annual report of the National Antimicrobial Utilisation Surveillance Program. Sydney: ACSQHC, 2018.
13. Ferguson J, Munnoch SA, Kozierowski K, Chui C, Oldmeadow C. Reduced VRE and MRSA colonisation and infection following sustained reduction in broad spectrum antibiotic use in a large tertiary hospital. *MJA*, 24 June 2019, 2019. https://www.mja.com.au/journal/2019/211/3/reduced-vre-and-mrsa-colonisation-and-infection-following-sustained-reduction (accessed 03 July 2019).
14. Gross BN, Steib-Bauert M, Kern WV, et al. Hospital use of systemic antifungal drugs: a multi-center surveillance update from Germany. *Infection* 2015; **43**: 423-9.
15. Urbancic K, Thursky K, Kong D, Johnson PDR, Slavin MA. Antifungal stewardship: developments in the field. *Current Opinion in Infectious Diseases* 2018; **31**(6): 490-8.
16. European Centre for Disease prevention and Control. Antimicrobial consumption database (ESAC-Net). 2019. https://ecdc.europa.eu/en/antimicrobial-consumption/surveillance-and-disease-data/database (accessed 22 August 2019).

Acknowledgements

This report was prepared by the Infection Control Service, Public Health and Clinical Systems, SA Health, in collaboration with the Australian Commission on Safety and Quality in Health Care (the Commission).

The Infection Control Service can be contacted at:

11 Hindmarsh Square
Adelaide, South Australia 5000
Phone: 1300 232 272

Enquiries should be directed to:

Email: Health.NAUSPhelp@sa.gov.au

Phone: (+61) 08 7425 7169

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.

The NAUSP team and the Commission thank all hospitals that voluntarily provide monthly data on antimicrobial use.

For more information

Infection Control Service
Public Health and Clinical Systems

SA Department for Health and Ageing
11 Hindmarsh Square
Adelaide, South Australia 5000

Telephone: 1300 232 272
www.sahealth.sa.gov.au

Level 5, 255 Elizabeth Street, Sydney NSW 2000

GPO Box 5480, Sydney NSW 2001

Phone: (02) 9126 3600

aura@safetyandquality.gov.au

www.safetyandquality.gov.au/our-work/anti-microbial-resistance