Antimicrobial use in

South Australian hospitals – 2017

Report from the National Antimicrobial Utilisation Surveillance Program, August 2018

Disclaimer

Contents

Introduction

The National Antimicrobial Utilisation Surveillance Program (NAUSP) collects data relating to antimicrobial usage in Australian hospitals. These data are used to support the objectives of the National Antimicrobial Resistance Strategy 2015-2019 [1, 2] and enable implementation of antimicrobial stewardship (AMS) practices.

NAUSP focuses on standardised measurement of antimicrobial use in Australian adult public and private hospitals.

This report provides information for South Australian hospitals participating in NAUSP in 2017, and supplements data published every six months for statewide usage, found at SA Health's Antimicrobial Utilisation Surveillance Statistics. Data from South Australian hospitals have been further analysed to show variation in usage rates for a selected number of antimicrobial classes.

Statewide data are useful for informing policy development, for benchmarking with interstate and overseas surveillance data, for checking year-by-year changes in prescribing practices, and measuring improvements following AMS interventions.

Methods

Data elements

Pharmacy departments of participating hospitals supply NAUSP with aggregate monthly details of antimicrobials issued to individual inpatients and ward imprest supplies (i.e. ward stock managed by the pharmacy) via dispensing reports. Hospital occupancy data are collected in the form of overnight occupied-bed days (OBDs) supplied by hospital patient administrative and clinical record systems.

NAUSP assigns each contributing hospital a unique code. The code is used to report in a de-identified way on usage rates of 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 at hospital level and converted to standardised usage density rates – these are based on the World Health Organization (WHO) definition of defined daily dose (DDD) per 1000 OBDs [3]. The DDD for any medicine is the average maintenance dose per day for an average adult for the main indication of the medicine. Note the DDD, as defined by WHO, occasionally does not match usual daily doses used in Australian hospital clinical practice (see Appendix 2 for more information). NAUSP uses WHO DDDs so that comparisons can be made with international surveillance programs.

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 1000 OBDs)
- three- or five-month moving averages of the usage rates.

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 [4-6]. 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 case mix of patients and in international healthcare practices.

Data quality

Automated and manual processes are used to validate all data submitted to NAUSP. The database used provides alerts when quantities fall outside a usual or expected range. This enables verification of data at an early stage of data submission. Rolling data validation activities are undertaken monthly, and additional checks are performed before production of the annual report. Semi-automated statistical algorithms are used to compare data with

previous submissions, detect irregular values, validate suspect values against original contributor data and processed usage data, and confirm denominator and numerator data that are used to calculate usage rates. 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.

Each contributing site is responsible for the accuracy of its data.

Data exclusions

The data collected by NAUSP exclude:

- data on most topical antimicrobial formulations (except some inhalations), antimycobacterials (except rifampicin), antiparasitics, and infusor packs of antibacterials for use outside of hospital settings

- data on 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 data for outpatient areas, discharge prescriptions and external services (e.g. hospital in the home), to ensure that data reflect in-hospital use of antimicrobials

- data on antimicrobials issued by pharmacies to individuals and wards classified as specialty areas, such as psychiatric, rehabilitation, dialysis and day-surgery units.

Data classification, restrictions and limitations

Data provided to NAUSP do not include the indication for which antimicrobials are used, or any patient-specific data. Although some contributing hospitals provide data on ward-by-ward antimicrobial consumption, data for specialist areas (with the exception of intensive care units) are often not available.

This report presents usage rates for the most commonly used antibacterials and antibacterial classes.[a] A comprehensive list of antimicrobials for which data are collected by NAUSP, the WHO Anatomical Therapeutic Classification and the DDD for each route of administration are available from the NAUSP website.[b]

The data presented in this report are correct at the time of publication, and reflect usage rates based on data on antibacterial quantities and OBDs supplied by individual contributors. Minor discrepancies between annual reports may occur as a result of data submitted retrospectively by contributing hospitals.

---

[a] Because this report is confined to reporting on use of systemic antibacterials in South Australian hospitals, the term 'antibacterial' is used when referring to the output of analyses of the NAUSP data, and when comparisons are made with data reported by other countries.

[b] www.sahealth.sa.gov.au/nausp

Overview of antibacterial usage rates in South Australia, 2017

Contributing hospitals

The participating hospitals for 2017 were from the following AIHW peer groups:

- Principal Referral Hospital – 2 contributors
- Specialist Women's Hospital – 1 contributor
- Public Acute Group A Hospital – 3 contributors
- Public Acute Group B Hospital – 3 contributors
- Public Acute Group C Hospital – 4 contributors
- Private Acute Group A Hospital - 2 contributors
- Private Acute Group B Hospital – 4 contributors
- Private Acute Group C Hospital – 1 contributor.

    Note: In this report data from 20 hospitals are included – since 2016 one hospital joined the program and two were unable to supply sufficient data.

Variation in usage rates

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

- differences in case-mix
- differences in antimicrobial resistance rates
- changes in hospital formularies, policies, protocols and regulation
- differences in implementation and impact of AMS programs.

The usage rates of six high-use antibacterial classes are shown in Figure 2. These antibacterial classes have been highlighted because they represent more than 60% of antibacterials used in SA NAUSP contributor hospitals. Beta-lactamase inhibitor combinations are the antibacterial class used most across all SA NAUSP hospitals. Usage rates for other antibacterial classes are shown in figures 3 and 4.

Figure 1   Annual total-hospital antibacterial use in SA NAUSP contributor hospitals, 2008–17

Figure 2   Annual usage rates for the five most commonly used antibacterial classes in SA NAUSP contributor hospitals, 2008–17
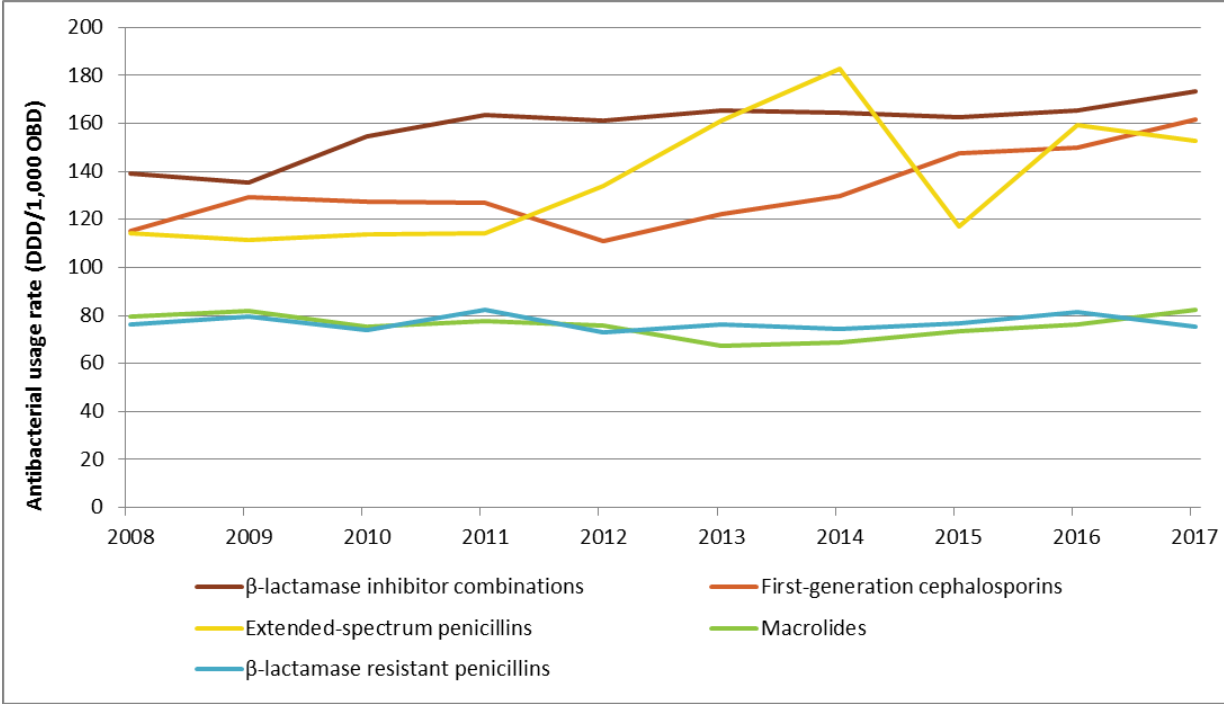
a These five antibacterial classes represent more than 60% of antibacterials used in SA NAUSP contributor hospitals each year from 2008 to 2017.

Figure 3   Annual usage rates for low usage antibacterial classes[a] in SA NAUSP contributor hospitals, 2008–17
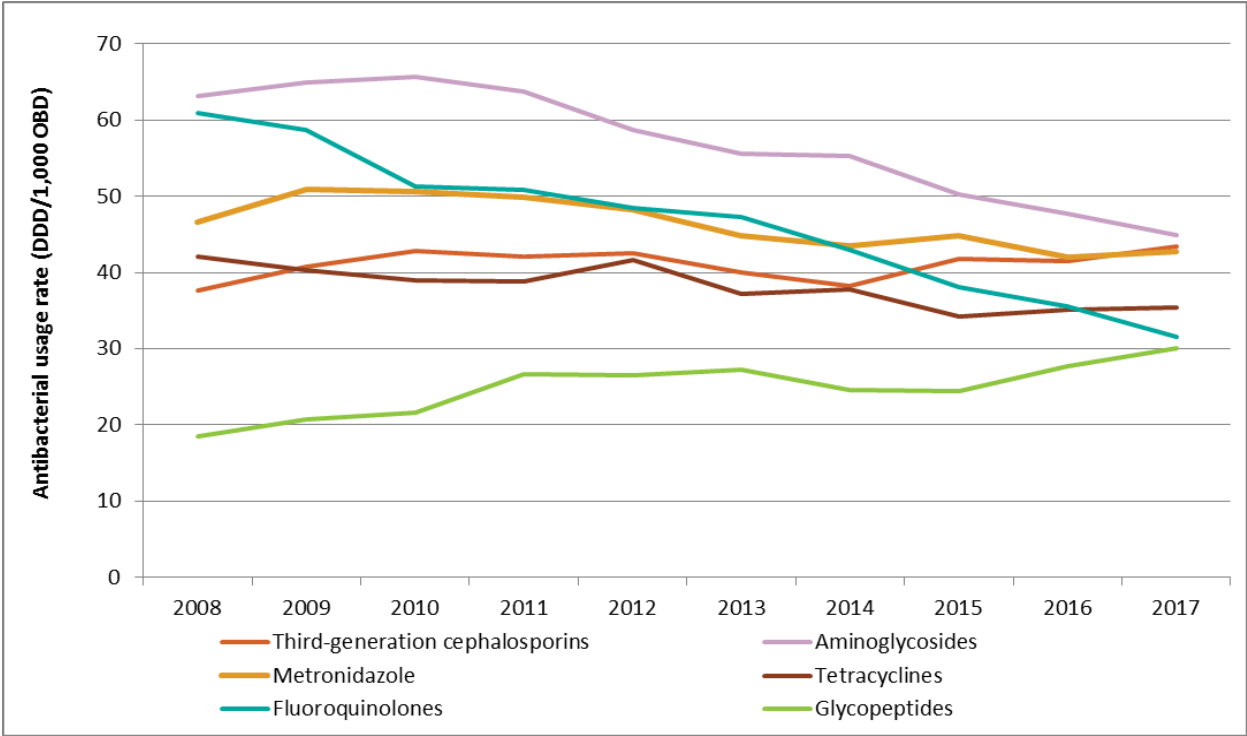
[a] Aminoglycosides, fluoroquinolones, glycopeptides, third-generation cephalosporins, metronidazole and tetracyclines combined represent approximately 25% of antibacterials used in SA NAUSP contributor hospitals each year from 2008 to 2017.
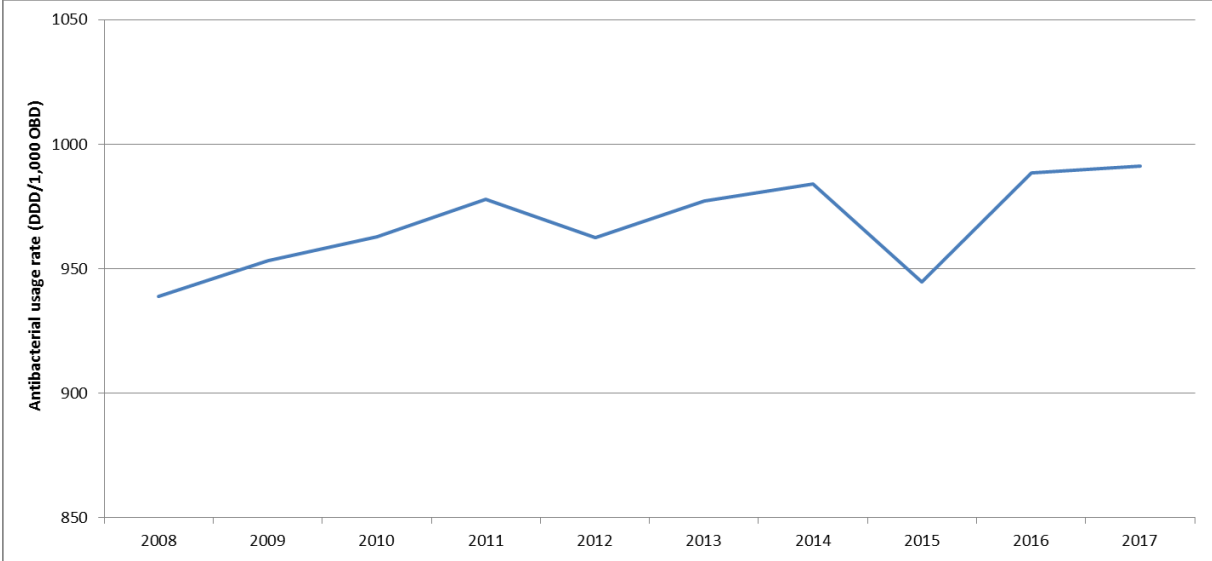
Figure 4   Annual usage rates for very low usage antibacterial classes[a] in SA NAUSP contributor hospitals, 2008–17
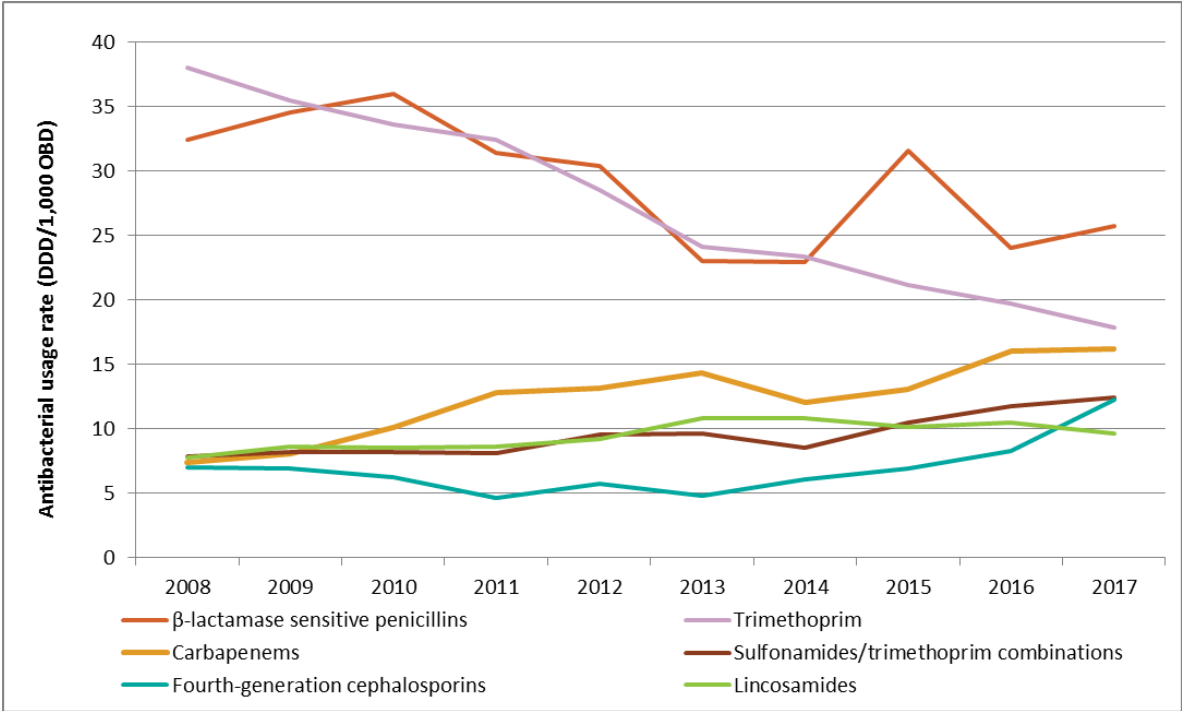
a β-lactamase sensitive penicillins, carbapenems, fourth-generation cephalosporins, lincosamides, sulfonamide/trimethoprim combinations and trimethoprim combined account for approximately 10% of antibacterials used in NAUSP contributor hospitals from 2008 to 2017.

Annual hospital antibacterial usage rates by antibacterial class, 2013–2017

Antibacterial classes are categorised into therapeutic groups using the WHO Anatomical Therapeutic Classification system (see Appendix 2). The Anatomical Therapeutic Classification system and use of DDDs enables international and other comparisons of drug consumption statistics [7].

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.

Changes in usage rates over time may occur as a result of several factors, such as changes in prescribing practice, evolving clinical practice and establishment of AMS programs. Another factor that may indirectly change usage rates is the increasingly common reduced length of acute hospital inpatient stay. Changes in usage rates may also reflect simple variations between WHO-defined DDDs and the doses used in Australian hospital clinical practice.

Total-hospital and intensive care unit usage rates

Annual usage rate data from SA NAUSP contributors, aggregated by year and antibacterial class, for the five years to 2017 show a continuing reduction in usage rates for aminoglycosides, fluoroquinolones and trimethoprim. In contrast, consistent increases in aggregated annual usage rates were seen for first-generation cephalosporins, fourth-generation cephalosporins, and macrolides (see Table 1).

Aggregate Intensive Care Unit (ICU) usage rates have declined between 2013 and 2016, then rose slightly in 2017 (see Table 2). The increase in carbapenem usage rates noted in 2016 was followed by a decrease in 2017. Continued reductions in use in ICU have occurred for fluoroquinolones, macrolides, and extended-spectrum penicillins (amoxicillin and ampicillin).

Table 1   Total-hospital antibacterial usage rates (DDD/1000 OBD) in SA NAUSP contributor hospitals, by antibacterial class, 2013–17

Antibacterial class	2013 (n=19)	2014 (n=20)	2015 (n=21)	2016 (n=21)	2017 (n=21)
Alimentary antibiotics	0.0	0.1	0.1	0.2	6.7
Aminoglycosides	55.5	55.3	50.2	47.7	44.9
Amphenicols	0.0	0.0	0.0	0.0	0.0
β-lactamase inhibitor combinations	165.4	164.3	162.8	165.4	173.5
β-lactamase-resistant penicillins	76.2	74.5	76.9	81.4	75.2
β-lactamase-sensitive penicillins	23.0	23.0	31.5	24.0	25.7
Carbapenems	14.4	12.1	13.0	16.0	16.2
Extended-spectrum penicillins	161.3	182.9	117.1	159.3	152.6
First-generation cephalosporins	122.2	129.8	147.4	149.8	161.6
Fluoroquinolones	47.2	42.9	38.0	35.6	31.6
Fourth-generation cephalosporins	4.8	6.1	6.9	8.3	12.3
Glycopeptides	27.3	24.6	24.5	27.7	30.1
Lincosamides	10.8	10.8	10.2	10.5	9.7
Macrolides	67.4	68.7	73.6	76.5	82.4
Monobactams	0.1	0.3	0.1	0.1	0.2
Nitrofurans	0.4	0.8	1.0	1.4	3.6
Nitroimidazoles (metronidazole + tinidazole)	45.0	43.6	45.0	42.2	42.9
Other antibacterials (daptomycin + linezolid + fosfomycin)	2.1	2.1	2.0	2.7	3.0
Other cephalosporins (ceftaroline + ceftolazone/tazobactam)	0.1	0.1	0.1	0.0	0.2
Polymyxins	0.2	0.3	0.2	0.4	0.3
Rifamycins	3.7	2.8	3.2	2.7	3.0
Second-generation cephalosporins	4.8	4.4	5.0	3.9	5.6
Steroids (fusidic acid)	1.0	0.8	0.6	0.6	0.7
Streptogramins	0.1	0.2	0.2	0.2	0.7
Streptomycins	0.0	0.0	0.0	0.0	0.0
Sulfonamide/trimethoprim combinations	9.7	8.5	10.5	11.7	12.4
Tetracyclines	37.2	37.8	34.2	35.2	35.4
Third-generation cephalosporins	40.0	38.3	41.7	41.5	46.7
Trimethoprim	24.1	23.3	21.2	19.7	17.8
Total	**943.9**	**958.3**	**917.2**	**964.9**	**991.5**

Notes:
1. Figures may vary slightly from previous reports as a result of retrospective data adjustments. Statistical analyses of change over time have not been undertaken because of small numbers. The potential to assess the significance of change over time will be explored in future analyses.
2. Fosfomycin rates, included in Other antibacterials, were less than 0.005 DDD per 1,000 OBDs each year 2013-2017.

Table 2   Antibacterial usage rates (DDD/1000 OBD) in SA NAUSP contributor hospital intensive care units, by antibacterial class, 2013–17

Antibacterial class	2013 (n=6)	2014 (n=6)	2015 (n=7)	2016 (n=7)	2017 (n=8)
Alimentary antibiotics	0.0	0.0	0.0	0.3	16.5
Aminoglycosides	37.1	52.9	42.0	27.3	31.5
Amphenicols	0.0	0.0	0.0	0.0	0.0
β-lactamase inhibitor combinations	252.0	255.7	263.0	263.6	251.4
β-lactamase-resistant penicillins	88.7	91.2	104.1	72.0	57.6
β-lactamase-sensitive penicillins	32.6	27.0	26.8	17.7	21.3
Carbapenems	149.9	105.2	104.3	132.6	108.4
Extended-spectrum penicillins	118.8	122.1	88.0	81.8	81.5
First-generation cephalosporins	91.0	104.6	114.3	129.2	174.3
Fluoroquinolones	142.4	120.7	97.4	97.3	77.2
Fourth-generation cephalosporins	38.0	47.9	37.9	36.4	50.3
Glycopeptides	180.1	154.7	147.6	138.1	143.3
Lincosamides	24.6	18.9	19.7	15.0	17.0
Macrolides	192.4	190.9	175.9	169.5	156.3
Monobactams	0.0	0.5	0.0	0.8	0.0
Nitrofurans	0.0	0.5	0.0	0.0	2.8
Nitroimidazoles (metronidazole)	61.7	55.1	53.5	43.1	51.5
Other antibacterials (linezolid + daptomycin + fosfomycin)	13.8	13.8	14.0	10.6	10.1
Other cephalosporins and penems (ceftaroline)	0.4	0.7	0.6	0.2	0.8
Polymyxins	3.6	0.6	3.2	2.7	2.2
Rifamycins	12.8	9.0	5.4	2.9	2.1
Second-generation cephalosporins	0.7	0.1	0.4	0.3	0.3
Steroids (fusidic acid)	0.8	0.6	0.2	0.1	0.3
Streptogramins	0.0	0.0	0.0	0.0	0.1
Streptomycins	0.0	0.0	0.0	0.0	0.0
Sulfonamide/trimethoprim combinations	34.9	26.0	31.7	38.3	35.5
Tetracyclines	18.8	11.0	22.7	11.1	11.7
Third-generation cephalosporins	126.8	121.9	128.3	119.3	111.8
Trimethoprim	5.5	5.4	6.1	7.1	7.2
Total	**1627.3**	**1536.9**	**1487.2**	**1417.4**	**1422.7**

Note: Figures may vary slightly from previous reports as a result of retrospective data adjustments. Statistical analyses of change over time have not been undertaken because of small numbers

Annual antibacterial usage rates by antibacterial agent and hospital (de-identified), 2017

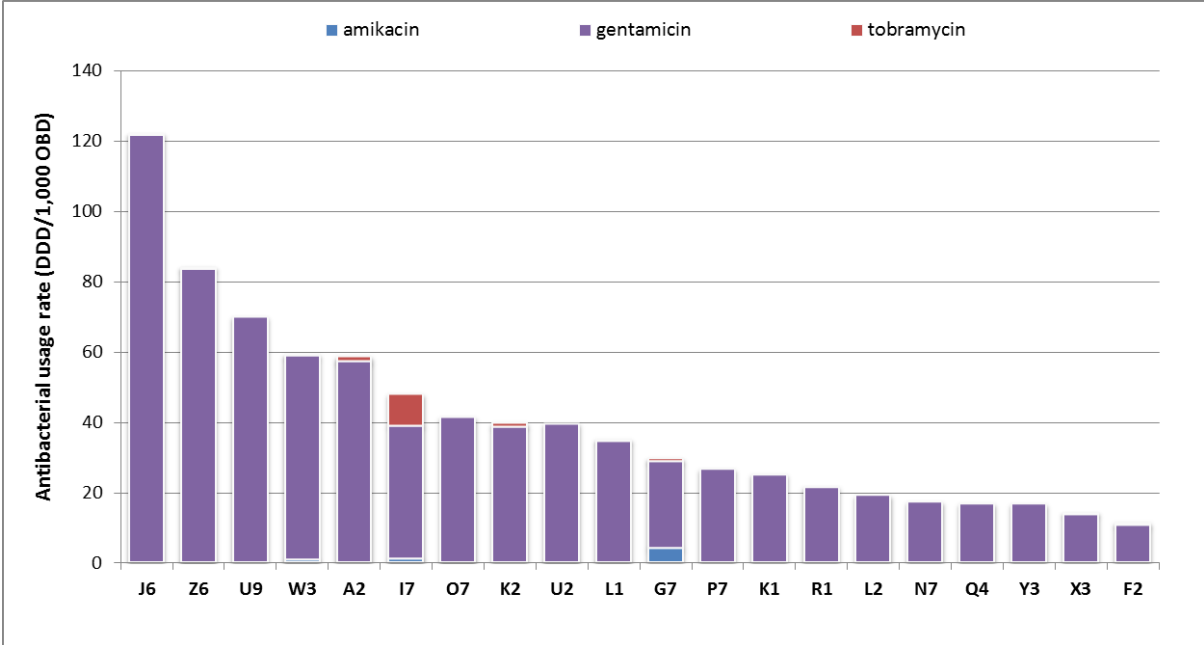**Figure 5**   Annual usage rates for aminoglycosides in SA NAUSP contributor hospitals, 2017

Figure 6   Annual usage rates for first and second generation cephalosporins in SA NAUSP contributor hospitals, 2017
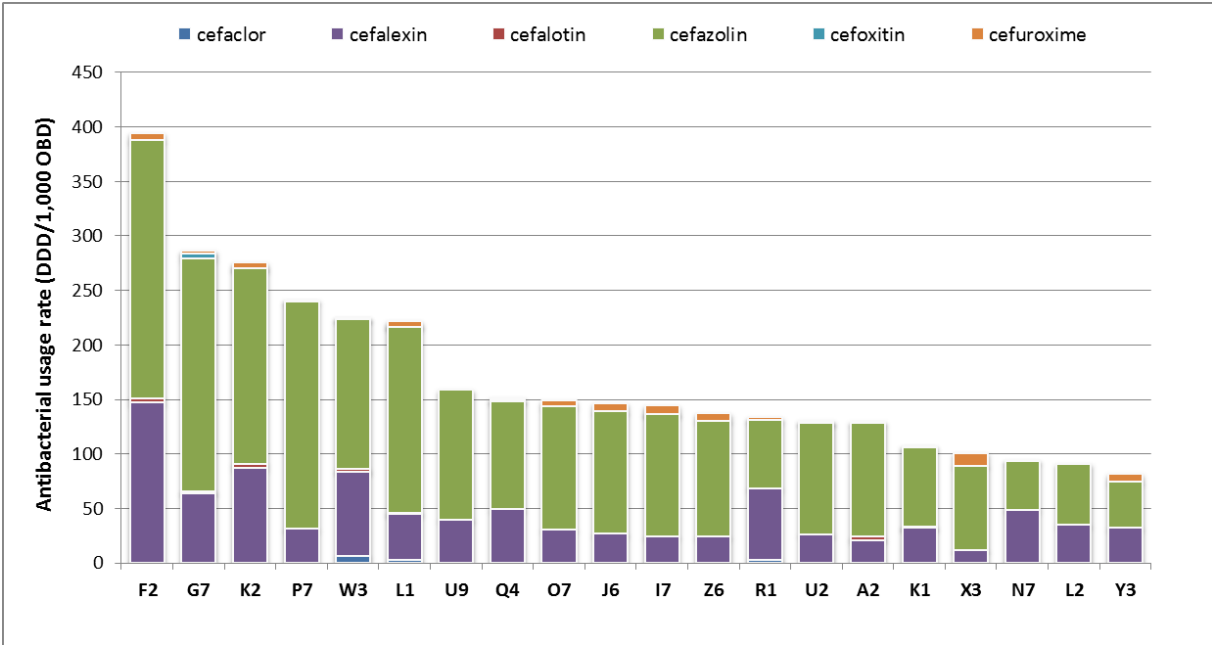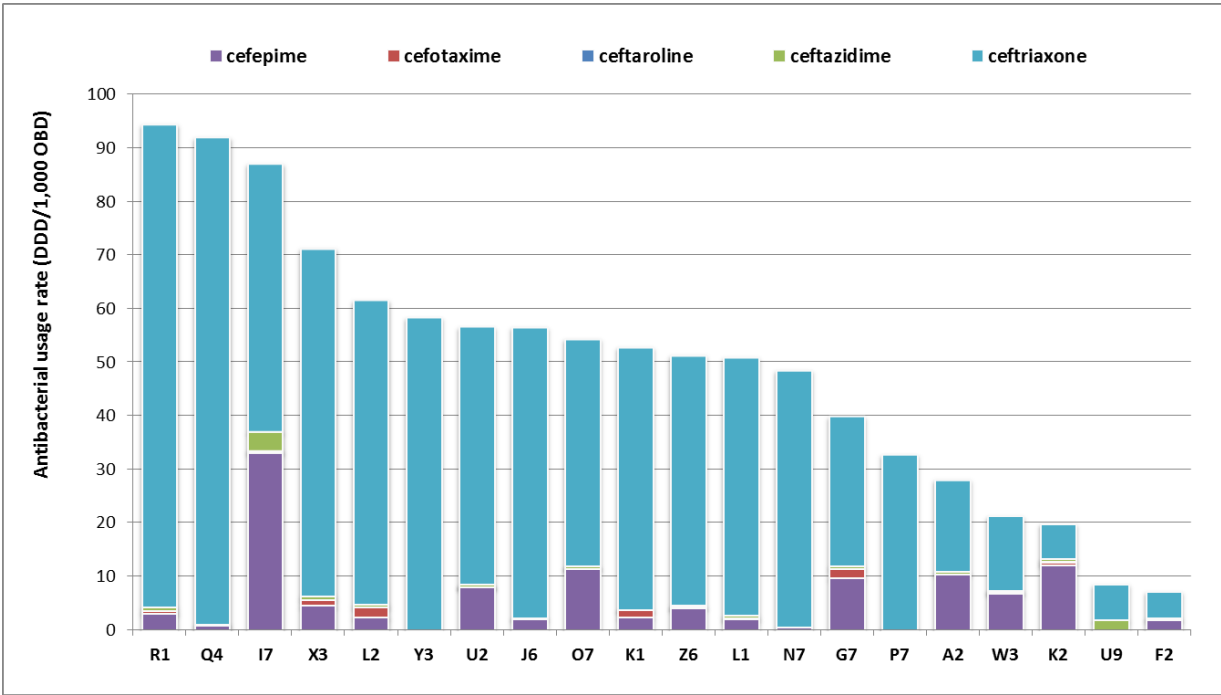
Figure 7   Annual usage rates for third and fourth generation cephalosporins in SA NAUSP contributor hospitals, 2017

Highest usage rates of ceftriaxone were observed in smaller regional facilities. Highest usage rates of cefepime occurred in principal referral and large private and public hospitals.

Longitudinal usage rates were investigated for seven SA rural hospitals. Usage rates at one regional facility (X3) declined sharply in the latter half of 2016 (Figure 8). Ceftriaxone was removed from ward imprest stores to after-hours cupboard access. Since mid-2017 usage rates have increased again. Usage at Hospitals K1, Q4 and X3 showed upward trends in the latter months of 2017, possibly reflecting difficulties in supporting AMS practices in hospitals with high numbers of locum medical practitioners and an absence of formalised infectious diseases (ID) support to offer advice prior to continuing therapy.

Figure 8   Monthly ceftriaxone usage rates in Country Health SA (CHSA) hospitals (3 month moving average applied) for period January 2013 to December 2017
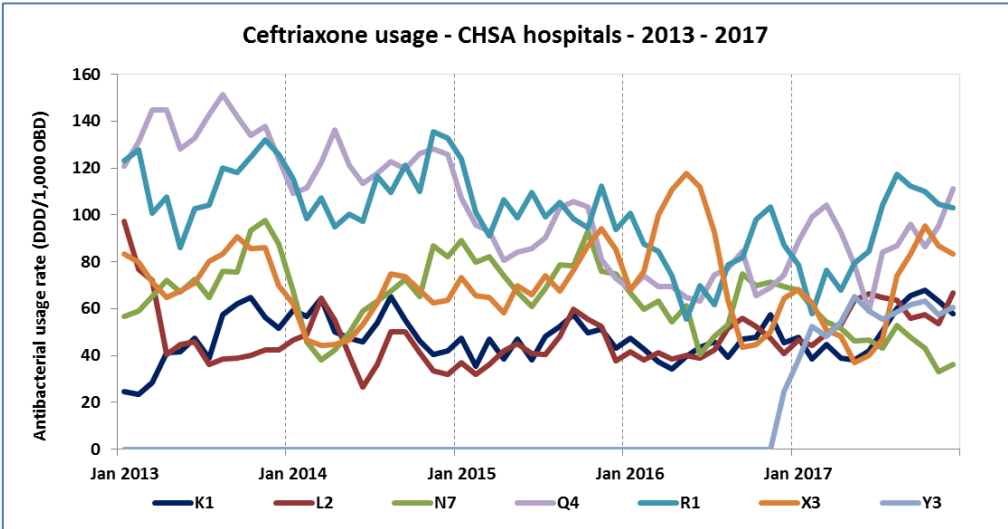
Note: Zero reported usage by Hospital Y3 in 2013 – 2016 explained by submission to NAUSP commencing only in December 2016.

Figure 9   Annual usage rates for carbapenems in SA NAUSP contributor hospitals, 2017
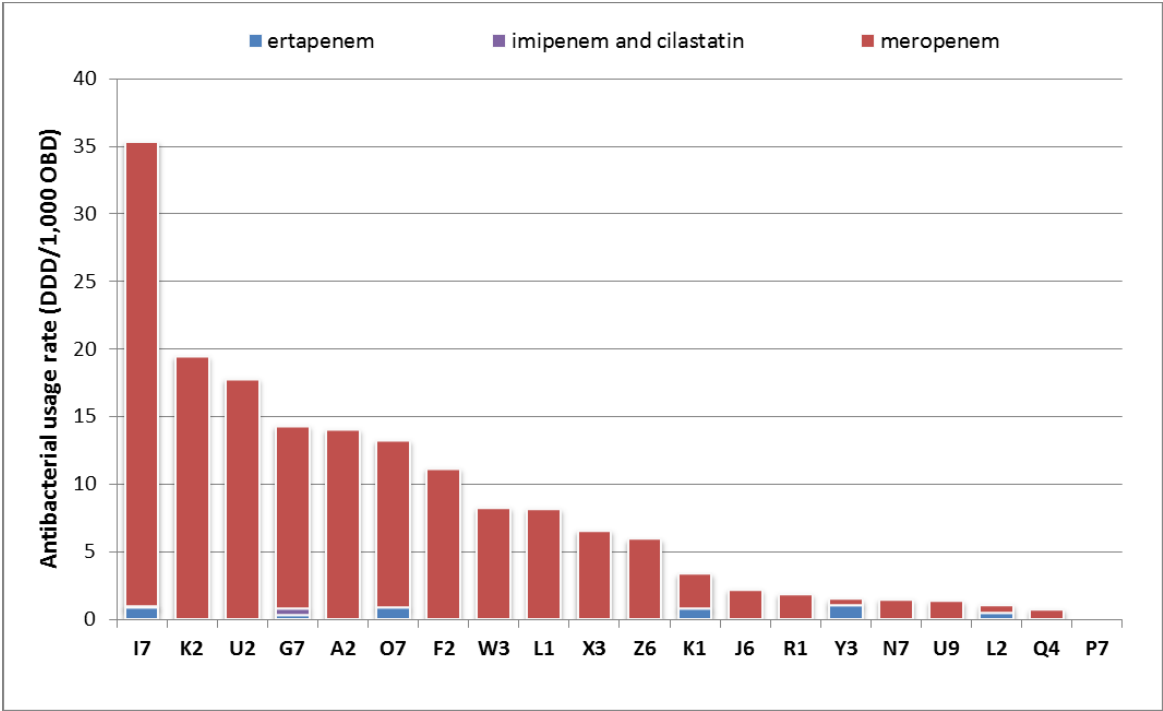
Highest rates of use of carbapenems occurred at principal referral hospitals and large private hospitals.

Figure 10   Annual usage rates for β-lactamase resistant penicillins in SA NAUSP contributor hospitals, 2017
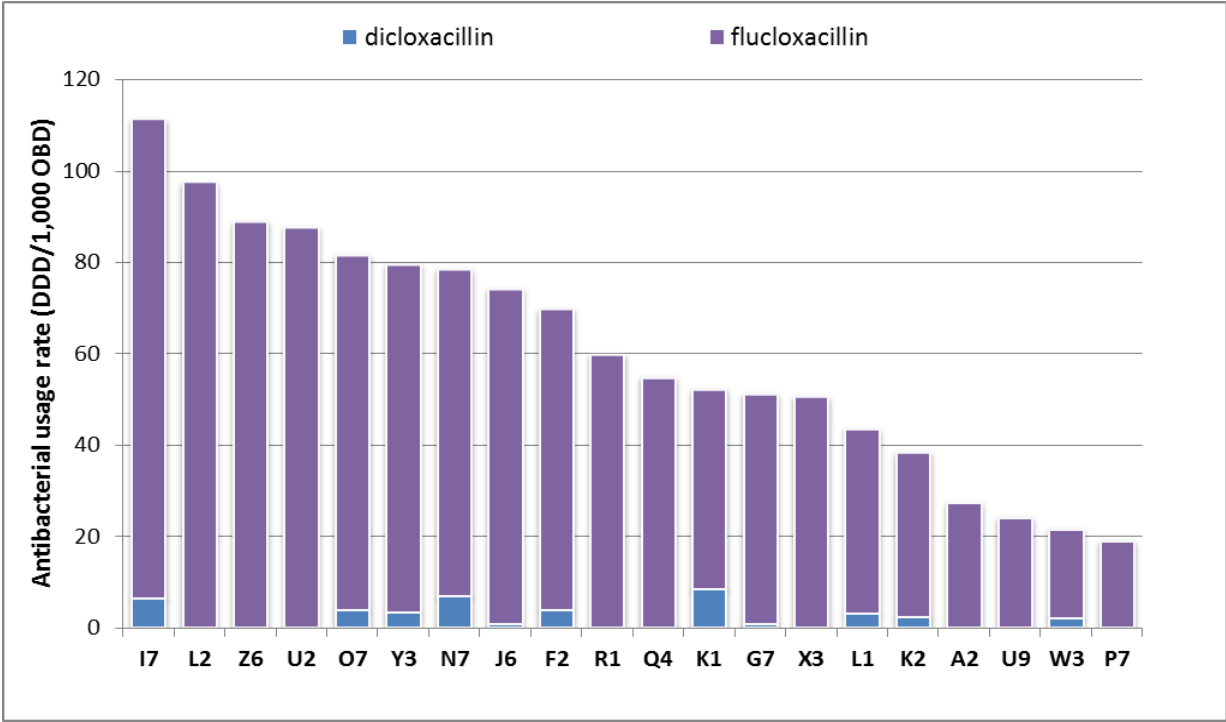
Figure 11   **Annual usage rates for extended-spectrum penicillins in SA NAUSP contributor hospitals, 2017**
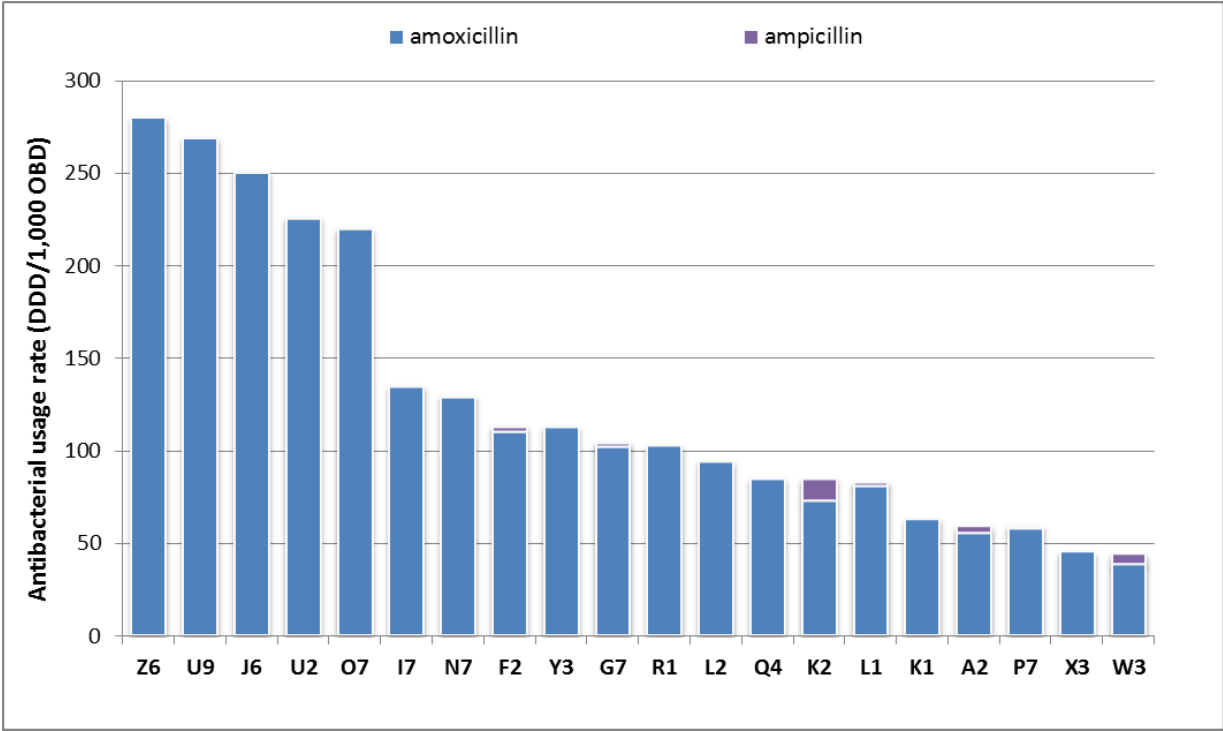

Figure 12:   **Annual usage rates for amoxicillin-clavulanate (penicillin-β-lactamase inhibitor combination without antipseudomonal activity) in SA NAUSP contributor hospitals, 2017**
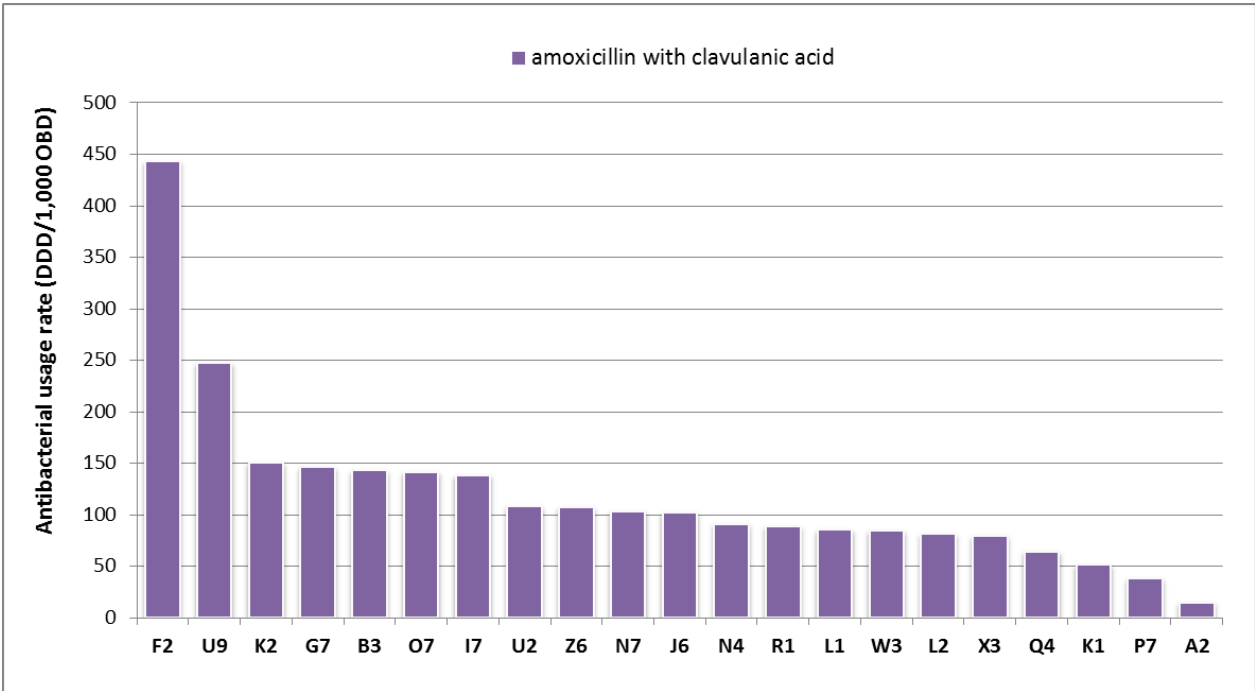
Figure 13   Annual usage rates for piperacillin-tazobactam (penicillin-β-lactamase inhibitor combination with antipseudomonal activity)* in SA NAUSP contributor hospitals, 2017
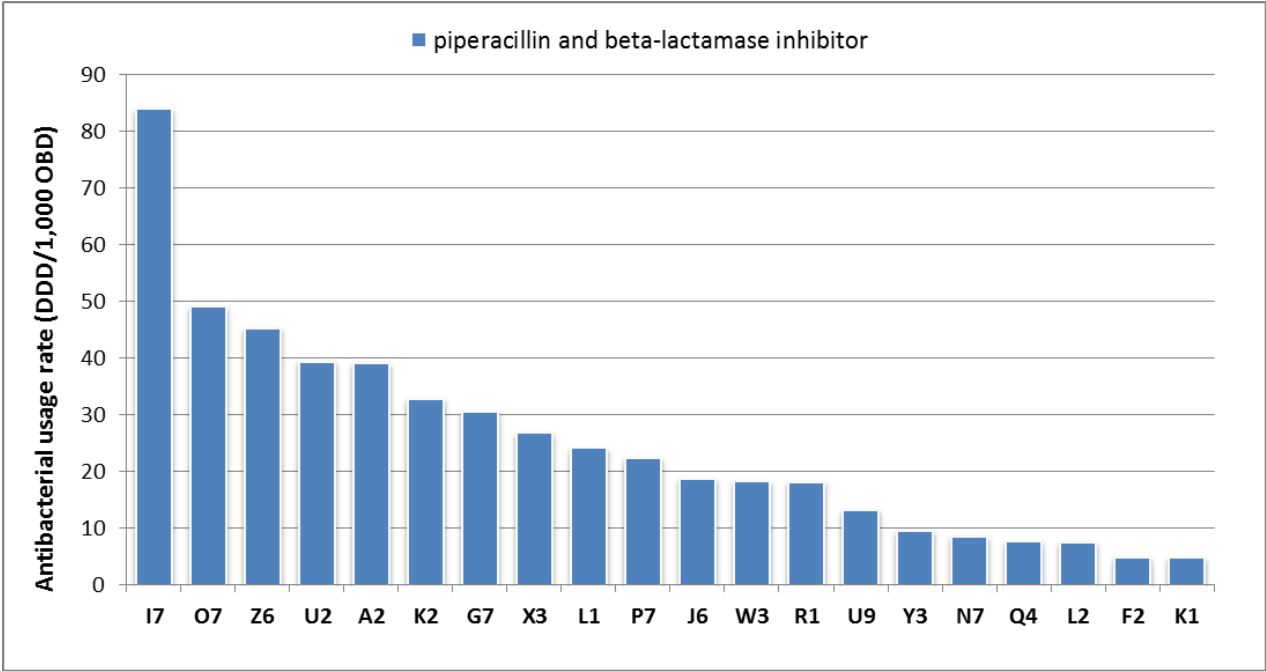
* Zero usage of ticarcillin-clavulanate in 2017

Note: Careful interpretation is required for data pertaining to piperacillin-tazobactam. The DDD published by WHO is 14 grams. This DDD does not accurately reflect the Australian setting, where doses of 12 to 16 grams per day are routinely used (4 grams three to four times per day).

Figure14   Annual usage rates for fluoroquinolones in SA NAUSP contributor hospitals, 2017
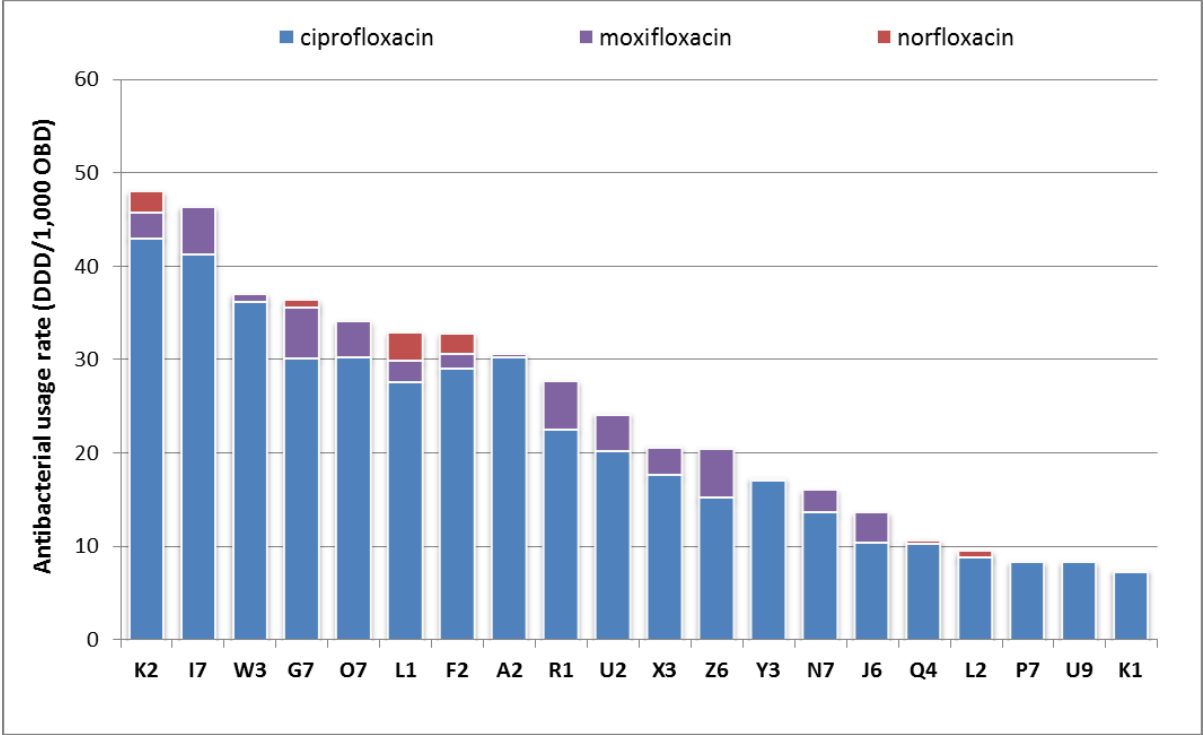
The notable differences in the usage rates of fluoroquinolones between SA principal referral hospitals (I7 and U2) is thought to be due to differences in case mix (use in allogenic stem

cell prophylaxis). Use of moxifloxacin in SA hospitals varies, and appears disproportionate in hospitals G7 (a private hospital) and R1 (a rural hospital) and Z6 (a large public hospital).

Figure 15   Annual usage rates for glycopeptides in SA NAUSP contributor hospitals, 2017
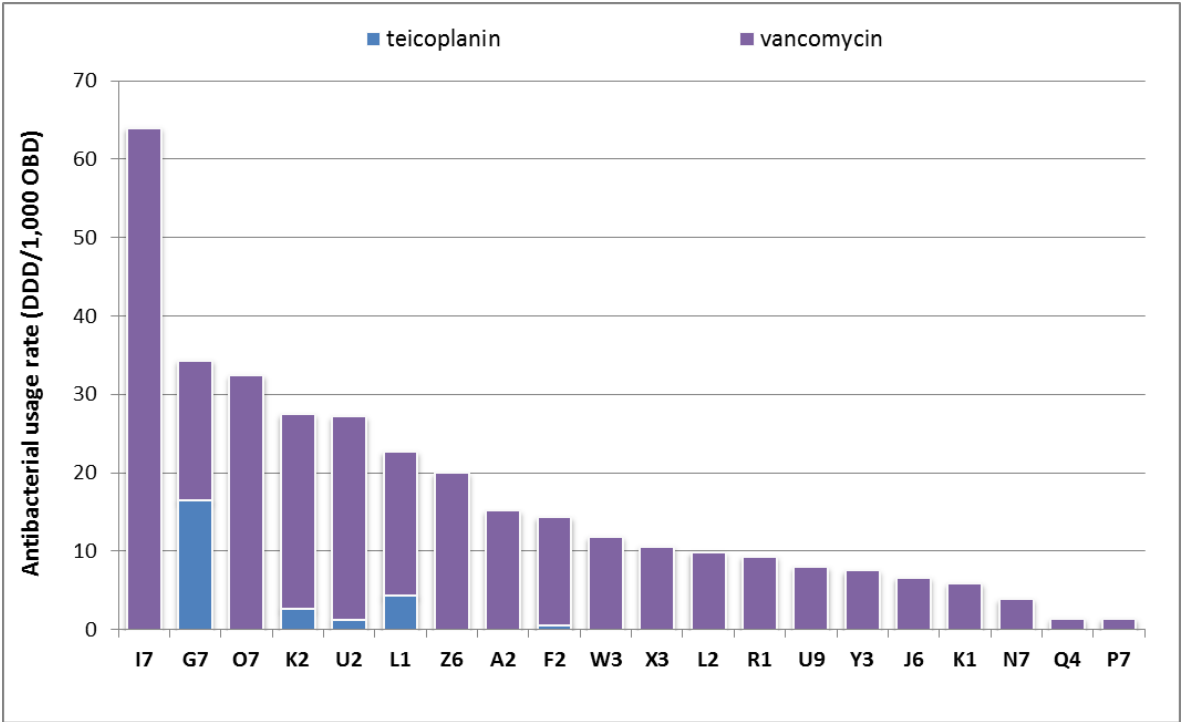
Higher usage rates of vancomycin at Hospital I7 may be explained by the different population at this hospital that includes allogeneic stem cell transplant patients. Hospital G7 is a private facility with a dedicated cardiac theatre, which could account for its use of teicoplanin if cardiothoracic surgeons prefer teicoplanin over vancomycin.

Figure 16   Annual usage rates for lincosamides in SA NAUSP contributor hospitals, 2017
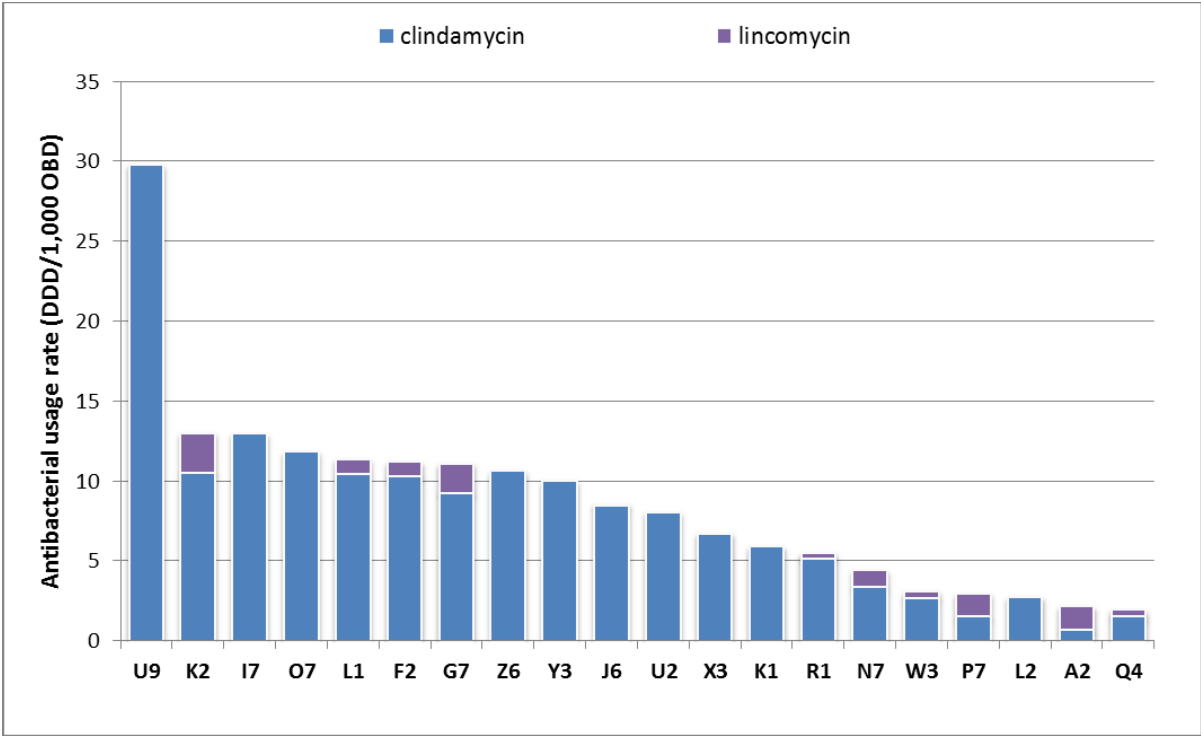
High usage rates at Hospital U9 result from low denominator numbers and highly protocolised use in a specific group of patients.

Figure 17   Annual usage rates for macrolides in SA NAUSP contributor hospitals, 2017
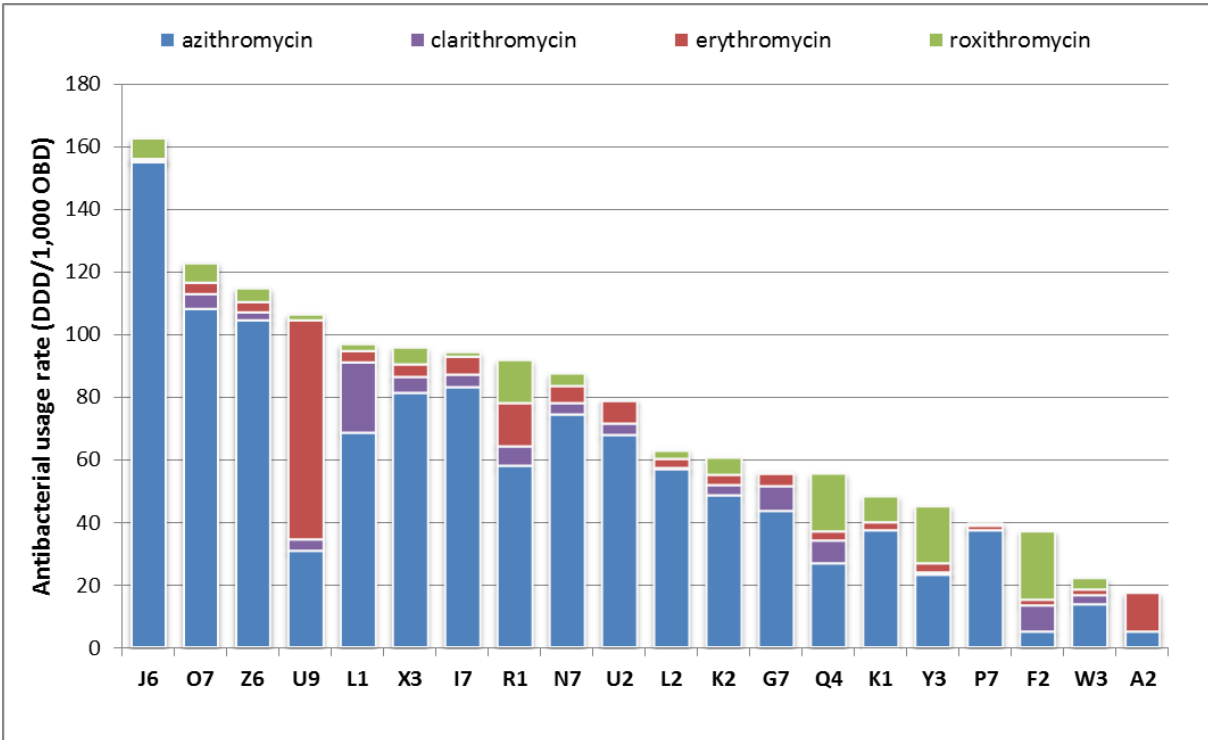
Figure 18   Annual usage rates for nitroimidazoles in SA NAUSP contributor hospitals, 2017
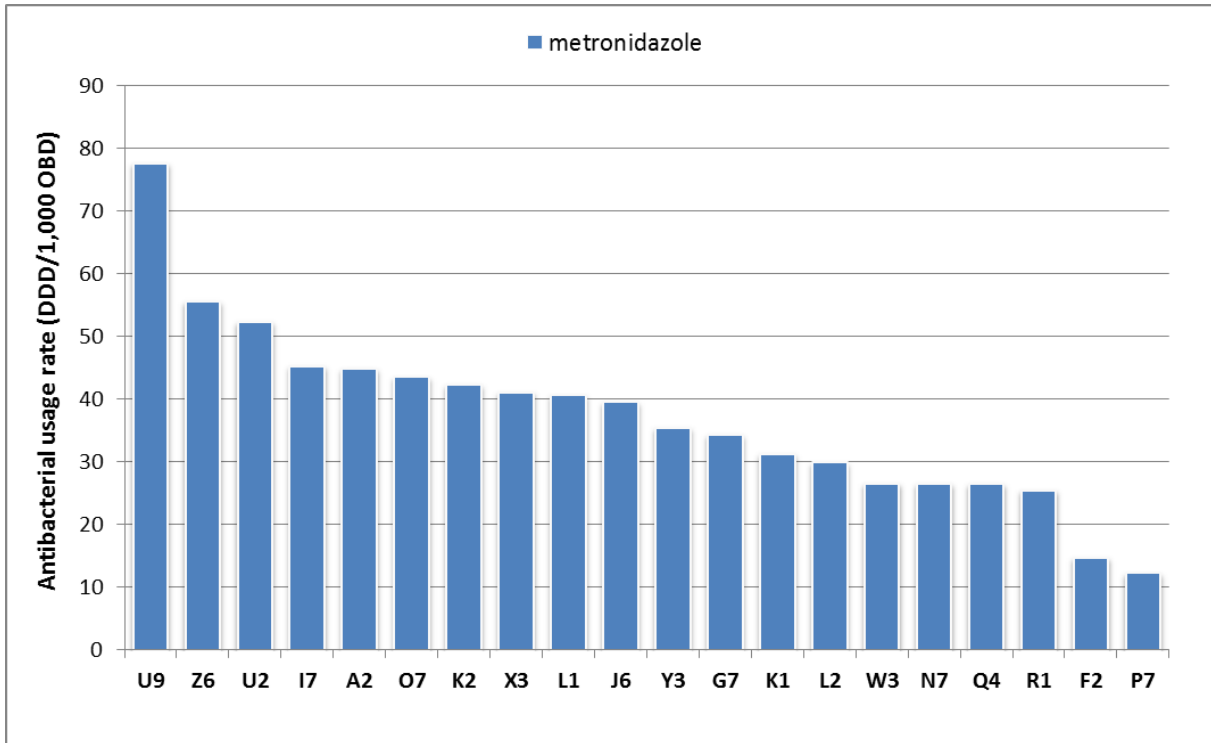
High usage rates at Hospital U9 result from low denominator numbers and highly protocolised use in a specific group of patients.

Figure 19   Annual usage rates for tetracyclines in SA NAUSP contributor hospitals, 2017

Figure 20   Annual usage rates for trimethoprim and trimethoprim-sulfamethoxazole in SA NAUSP contributor hospitals, 2017
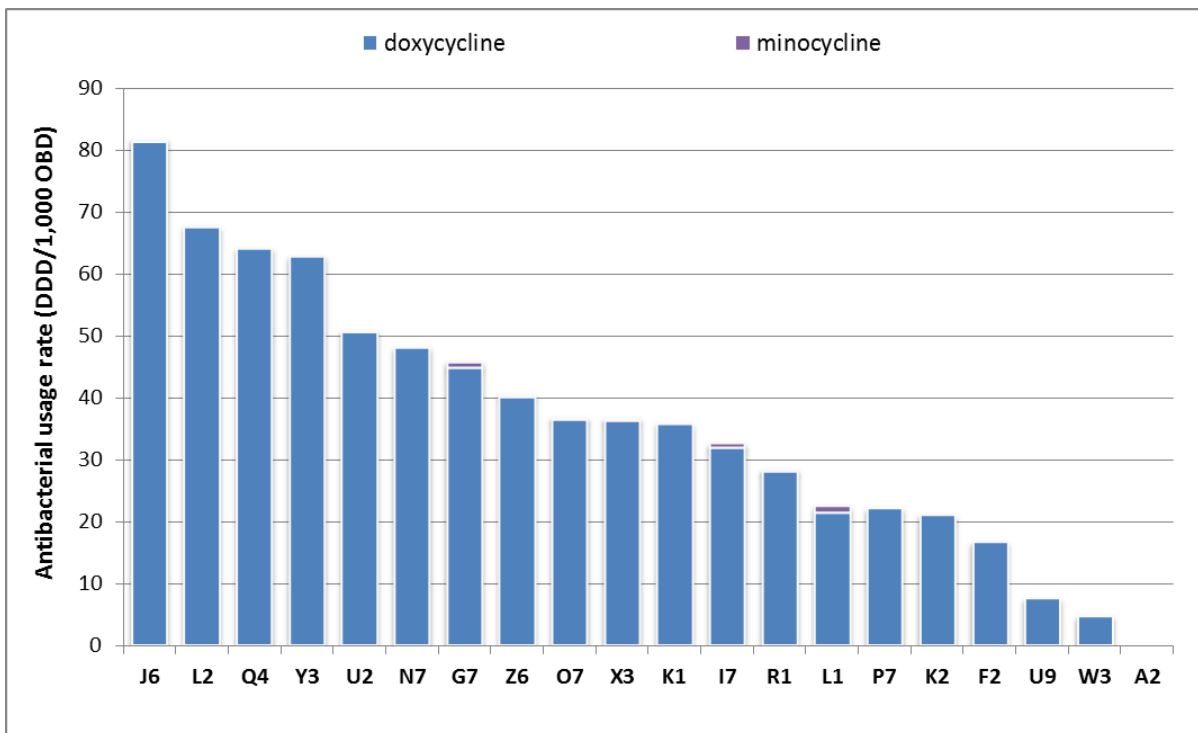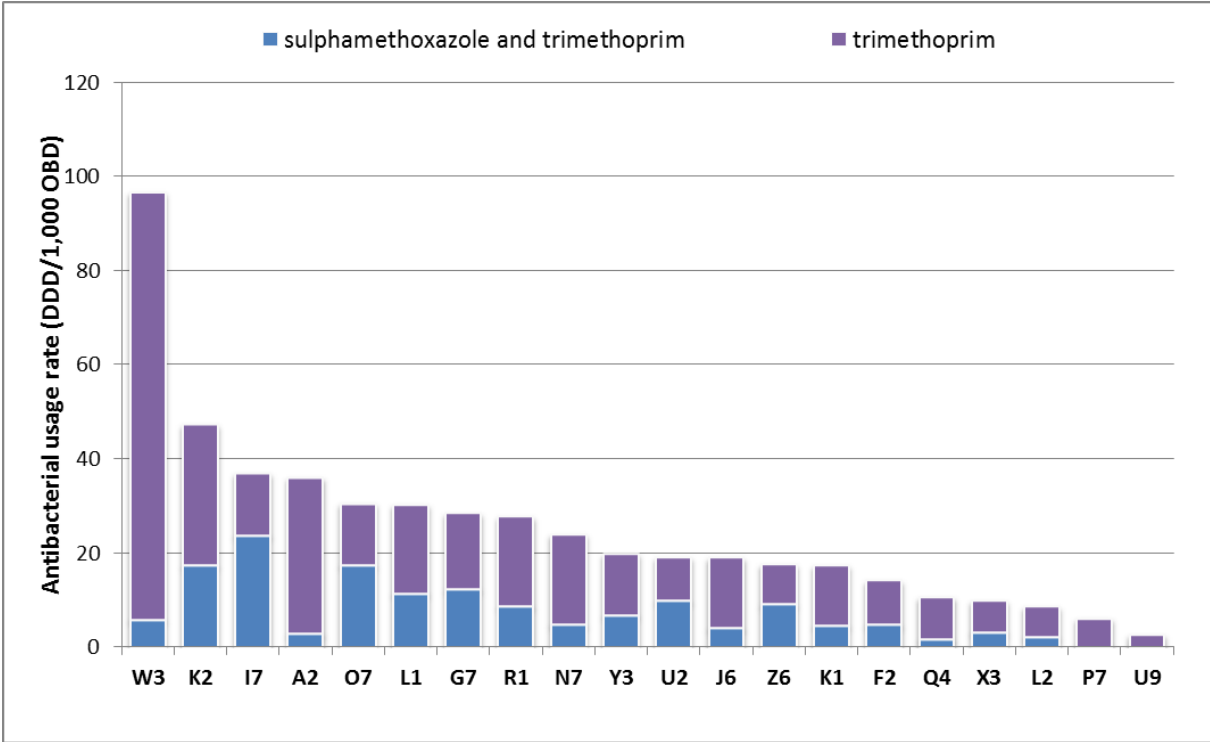

Trimethoprim use at Hospital W3 is disproportionately higher than other SA hospitals. The reason for this is being investigated at this hospital.

Findings and discussion

Aggregate usage rates of antibacterials have increased in both 2016 and 2017. Increases in the 5 years to 2017 were noted for first generation cephalosporins, fourth-generation cephalosporins and macrolides. Decreases were noted for aminoglycosides, fluoroquinolones and trimethoprim.

Usage rates in ICUs rose slightly in 2017 after declining in 2016, but use of some classes has decreased. Most notable of these is carbapenems. In the 2016 SA NAUSP annual report data from the SA Healthcare Associated Infection (HAI) Surveillance program were reported showing that the number of ICU-associated multi-resistant organism (MRO) infections associated with extended spectrum beta lactamase (ESBL) and AmpC-carrying bacteria had increased since 2010. In 2017 the number of ESBL-associated HAIs decreased (Table 3). This may account for the decreased usage rate of carbapenems in 2017.

Table 3   MRO (excluding methicillin-resistant Staphylococcus aureus (MRSA) infections* by resistance category - ICU

Resistance Code	Number of ICU associated infections [#]							
	2010	2011	2012	2013	2014	2015	2016	2017
AMP C	0	0	2	2	3	3	6	8
CR GNB	0	0	0	0	2	2	1	0
ESBL	8	11	9	20	14	15	28	18
MBL	0	0	0	1	0	0	0	0
MR PAER	9	9	12	12	7	11	10	11
VRE	16	10	11	16	9	10	11	11
Total	33	30	34	51	35	41	56	48

* Note: these datasets also include infections from previously colonised patients.
# Data from Multidrug-resistant Organisms Annual Report 2017 (June 2018), available from Infection Control Service, CDCB or on-line.

Findings for 2017 have similarities to those reported in the Antimicrobial use in South Australian hospitals - 2016 Report from the National Antimicrobial Utilisation Surveillance Program [8]. Aminoglycoside use remains lowest in rural hospitals, possibly explained by the difficulties in obtaining timely therapeutic drug monitoring required with aminoglycoside use for more than three days. It is likely that aminoglycosides are restricted to one to two doses and patients with more serious infections are referred to a higher level hospital.

As in 2016, the highest use of first-generation cephalosporins occurred in private hospitals. This could be associated with the relatively large number of elective surgical procedures in private hospitals. Cefazolin is the first-line antibiotic therapy recommended for most surgical procedures in the Therapeutic Guidelines: Antibiotic [9] and local surgical prophylaxis guidelines.

Usage rates of ceftriaxone remain highest in four CHSA hospitals. There are multi-factorial reasons for this, including preference for a once-daily antibiotic, prescriber perception of indications for use, difficulties in differentiating severe and moderate community acquired pneumonia without some of the diagnostic tools available in metropolitan hospitals, and

resource issues around antimicrobial stewardship education, academic detailing and follow up.

Cefepime use increased in 2017 and the greatest use of cefepime was in a metropolitan principal referral hospital. A shortage of piperacillin-tazobactam necessitated use in patients with febrile neutropenia or sepsis who have a non-life threatening allergy to penicillins. Cefepime is also used as a carbapenem-sparing agent in treating some resistant Gram negative organisms.

The difference in rates of fluoroquinolone use between the two Adelaide principal referral hospitals was apparent again in 2017. This is thought to be due to differences in case mix (use in allogeneic stem cell transplant prophylaxis). High glycopeptide usage rates in an Adelaide principal referral hospital are thought due to increases in recommended daily doses following an audit that found under-dosing frequently occurred. Additionally, allogeneic stem cell transplants take place at this hospital where large loading doses (25mg/kg) are used, and maintenance doses tend to be high as patients are often young and have high clearance rates.

Trimethoprim use at one Adelaide private hospital was five times the average rate of other SA hospitals, and had increased by 28% since 2016. This hospital will investigate possible causes for this and assess the appropriateness of use.

Tetracycline and macrolide usage rates varied greatly between SA hospitals in 2017. Possible causes for these variations are still to be determined.

Conclusion

NAUSP continues to provide data that informs both local and state AMS initiatives. Hospitals use NAUSP data to target resources for auditing and education, and to follow up outcomes of previous interventions, at an institutional and local health district level.

Data in this report do not support the assumption that usage rates are lower in smaller hospitals. A possible reason for this is that effective AMS programs are operating in larger hospitals where the majority of antimicrobial usage occurs. Larger hospitals have the benefit of on-site infectious diseases consultants and pharmacists to drive AMS initiatives.

NAUSP will continue to provide participating South Australian hospitals with a rich data source for analysis and monitoring of antibacterial usage patterns and trends, and measurement of improvement in clinical prescribing practice. Measuring and evaluating antibacterial use, and assessing interventions to improve appropriateness of prescribing are key elements of AMS programs.

Appendix 1: Contributor information

Table A1   **SA Hospitals contributing to the National Antimicrobial Utilisation Surveillance Program, 2017**

South Australia	Ashford Hospital, Calvary Central Districts Hospital, Calvary North Adelaide Hospital, Flinders Medical Centre, Flinders Private Hospital, Gawler Health Service, Lyell McEwin Hospital, Memorial Hospital, Modbury Hospital, Mount Gambier Hospital, Port Augusta Hospital, Port Pirie Hospital, Queen Elizabeth Hospital, Riverland Regional Health Service (Berri), Royal Adelaide Hospital, St Andrew's Hospital, Calvary Wakefield Hospital, Whyalla Hospital, Women's and Children's Hospital

Appendix 2 - WHO Anatomical Therapeutic Classification and defined daily doses for antibacterial agents included in NAUSP analyses

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	Amoxycillin	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	β-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

ATC classification	Generic name	DDD (g)	Route
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
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	1.92	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

ATC classification	Generic name	DDD (g)	Route
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		
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

ATC classification	Generic name	DDD (g)	Route
J01XX09	Daptomycin	0.28	P
J04	Antimycobacterials		
J04AB03	Rifampicin	0.6	O, P

ATC = Anatomical Therapeutic Classification; DDD = defined daily dose; Inh = inhalation; O = oral; P = parenteral; R = rectal.
Source: WHO (2017)[3]

Abbreviations

AIHW   Australian Institute of Health and Welfare

AMS   antimicrobial stewardship

AURA   Antimicrobial Use and Resistance in Australia

CHSA   Country Health South Australia

DDD   defined daily dose

ESBL   extended spectrum beta-lactamase

HAI   Healthcare associated infection

ICU   intensive care unit

ID   infectious diseases

MRO   multi-resistant organism

NAUSP   National Antimicrobial Utilisation Surveillance Program

OBD   occupied-bed day

SA Health   South Australian Department for Health and Ageing

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 used to treat or prevent infections caused by microbes, including antibacterial, antifungal, antiviral and antiparasitic medicines.
	In this report, the term 'antimicrobial' is used to refer to data on all, or almost all, classes of antimicrobials. Because this report is confined to reporting on use of systemic antibacterials in Australian hospitals, the term 'antibacterial' is used when referring to the output of analyses of the NAUSP data, and when comparisons are made with data reported by other countries.
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 DDDs used per 1000 OBDs. Data for outpatient areas, including hospital-in-the-home, day treatment centres, day surgery and dialysis clinics, is excluded.

The rate is calculated as follows:

$$\text{Usage density rate} = \frac{\text{Number of DDDs/time period}}{\text{OBDs/time period}} \times 1000$$

References

1. Australian Government Department of Health & Australian Government Department of Agriculture, *Responding to the threat of antimicrobial resistance: Australia's first National Antimicrobial Resistance Strategy 2015–2019*. 2015, Department of Health, Department of Agriculture: Canberra.
2. Australian Government Department of Health &Australian Government Department of Agriculture and Water Resources, *Implementation plan: Australia's first National Antimicrobial Resistance Strategy 2015–2019*. 2016, Department of Health, Department of Agriculture and Water Resources: Canberra.
3. WHO. *ATC/DDD Index*. [cited 2015, 13th April]; Available from: http://www.whocc.no/atcddd/.
4. DANMAP. *Use of antimicrobial agents and occurence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark*. 2015 [cited 2018 13 July]; November 2016:[Available from: http://www.danmap.org/~/media/Projekt%20sites/Danmap/DANMAP%20reports/DANMAP%20%202015/DANMAP%202015.ashx.
5. SWAB. *NethMap 2016 Consumption of antimicrobial agents and antimicrobial resistance among medically important bacteria in The Netherlands in 2015*. 2016 [cited 2018 13 July]; Available from: http://www.wur.nl/upload_mm/0/b/c/433ca2d5-c97f-4aa1-ad34-a45ad522df95_92416_008804_NethmapMaran2016+TG2.pdf.
6. SWEDRES SVARM. *Consumption of antibiotics and occurrence of antibiotic resistance in Sweden*. 2015 [cited 2018 13 July]; Available from: http://www.sva.se/globalassets/redesign2011/pdf/om_sva/publikationer/swedres_svarm2015.pdf.
7. WHO Collaborating Centre for Drug Statistics Methodology. *The purpose of the ATC/DDD system*. [cited 2018, 13th April]; Available from: http://www.whocc.no/atc_ddd_methodology/purpose_of_the_atc_ddd_system/.
8. NAUSP. *Antimicrobial use in South Australian hospitals - 2016. Report from the National Antimicrobial Utilisation Surveillance Program*. 2018 [cited 2018 13 July]; Available from: http://www.sahealth.sa.gov.au/wps/wcm/connect/0a6a68f4-005e-4088-8104-8ab784a7c6bb/NAUSP-report-AU-in-South-Australian-Hospitals-2016-report-cdcb-ics-20180313.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-0a6a68f4-005e-4088-8104-8ab784a7c6bb-m8Im04G.
9. Antibiotic Expert Group, *Therapeutic Guidelines: Antibiotic (version 15)*. 2014: Melbourne.

Acknowledgements