AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

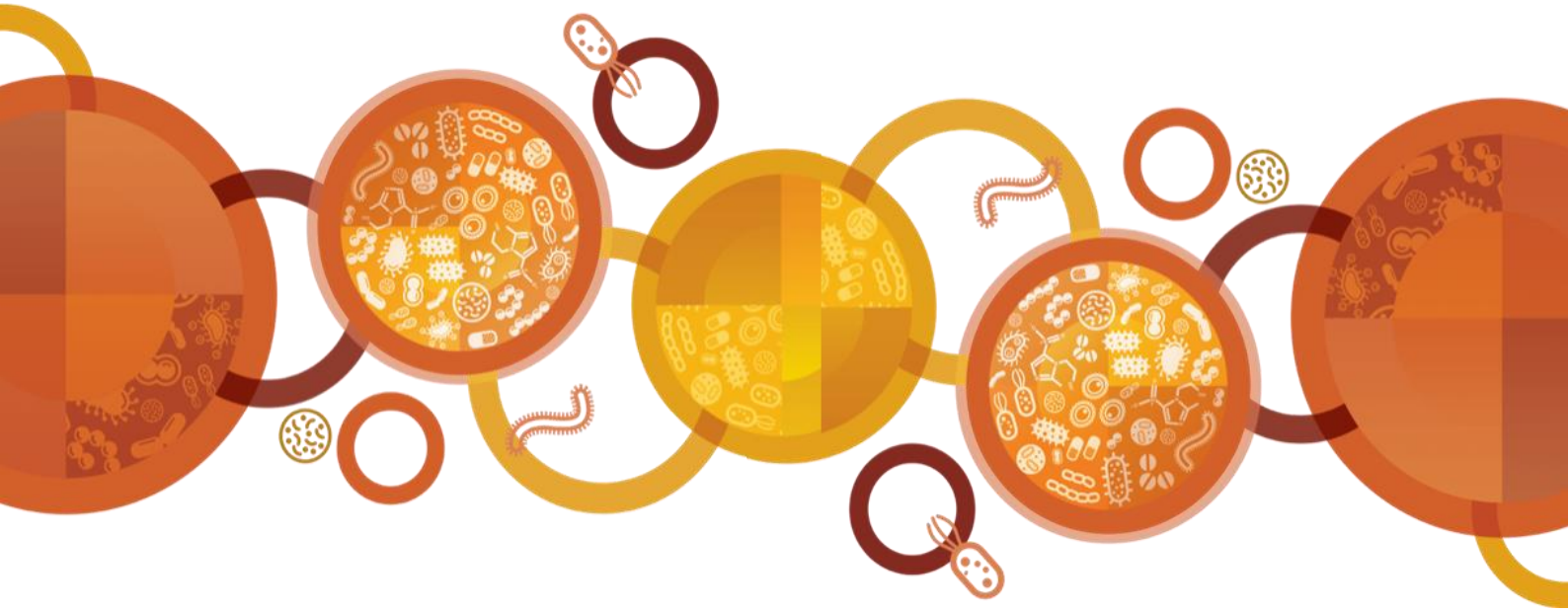
AURA Antimicrobial Use and Resistance in Australia

CARAlert THE NATIONAL ALERT SYSTEM FOR CRITICAL ANTIMICROBIAL RESISTANCE

CARAlert annual report

2020

April 2021



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Summary

This report provides analyses of data on confirmed critical antimicrobial resistances (CARs) submitted to the National Alert System for Critical Antimicrobial Resistances (CARAlert) for 2020, and trend data for 2017 to 2020.

Excluding new CARs introduced in 2019, there was an overall decrease of 21% in CARs reported in 2020 compared to 2019 (*n* = 1,904 in 2019; *n* = 1,499 in 2020). Carbapenemase-producing *Enterobacterales* (CPE) are of most concern, because this CAR poses a significant risk to patient safety; bacteria that produce carbapenemase enzymes are almost always resistant to other important antibiotic classes, such as other β-lactams, β-lactamase inhibitor combinations, fluoroquinolones and aminoglycosides. This means that effective treatment options for infections may be limited, and lengths of hospital admissions may increase.

Four additional CARs were added to CARAlert from July 2019. These were: transferrable resistance to colistin in *Enterobacterales*, carbapenemase-producing *Acinetobacter baumannii* complex, carbapenemase-producing *Pseudomonas aeruginosa* and *Candida auris*, which is a multidrug-resistant yeast that has caused outbreaks in multiple countries.

The Australian Commission on Safety and Quality in Health Care (the Commission) established CARAlert as a voluntary resistance reporting system, as part of the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System. Timely submission of CAR data by confirming laboratories (see Appendix 4) ensures that states and territories are able to rapidly follow up results, as needed to promote appropriate prevention and control action and ensure that CARs remain low, and risks to patients, due to infections that are difficult to treat, are minimised.

National overview of key findings: 2020 compared to 2019

- Carbapenemase-producing *Enterobacterales* (including those with ribosomal methyltransferase or transmissible colistin resistance) was the most frequently reported CAR (*n* = 646, 41%) in 2020, followed by multidrug-resistant (MDR) *Shigella* species (*n* = 299, 19%)
- The total number of CPE (either alone or in combination with other CARs) reported in 2020, compared to 2019, decreased by 26.4% (*n* = 646 versus *n* = 878). The decrease was seen in across all jurisdictions, except Western Australia, where reports increased by 22%
- The overall number of reports of MDR *Shigella* species decreased by 10% in 2020 (*n* = 299 versus *n* = 331), most notably in Victoria (*n* = 57 versus *n* = 185, down 69%). There was however a three-fold increase in reports from both New South Wales (*n* = 171, up 195%) and Western Australia (*n* = 20, up 186%)
- There was a decrease in the number of ceftriaxone non-susceptible *Salmonella* species (n = 30, down 33%)
- There were 16 reports of MDR *Mycobacterium tuberculosis*, compared with 24 reports in 2019
- The majority of CARs, where the setting was known, but excluding those from *Neisseria gonorrhoeae*, were reported from public hospitals (764/1,177, 65%). There were 274 from community settings, 90 from private hospitals, and 49 from aged care homes.

Implications for patient safety

Rates of carbapenemase-producing *Enterobacterales* in Australian hospitals

Enterobacterales commonly cause urinary tract, biliary tract and other intra-abdominal infections and blood stream infections. Patients are likely to be affected by CPE if they: are hospitalised for a long time; have been hospitalised or had surgery overseas; have had multiple, or recent exposure to different antimicrobial agents, especially cephalosporins, fluoroquinolones and carbapenems; have diabetes mellitus; are on mechanical ventilation; are admitted to the intensive care unit; or have an indwelling medical device (such as a central venous catheter, urinary catheter or biliary catheter).

There was a 26% decrease in the number of carbapenemase- and/or ribosomal methyltransferase-producing *Enterobacterales* reports in 2020 compared to 2019 (*n* = 878 in 2019; *n* = 646 in 2020). There has been a gradual decline in reports of this CAR from January 2019. Factors that may have contributed to this decline include improvements in recognition and infection control efforts over this period.

Almost one-quarter of hospitals that reported CPE in 2020, did so for the first time (31/130, 24%). Carbapenemase-producing *Enterobacterales* has also contributed to invasive disease in Australian patients of all ages; in 2020, one in 10 reports from clinical specimens were from blood. Just over one-quarter of (27%) were from settings other than hospitals.

Carbapenemase types identified in Australia to date primarily include IMP, NDM and OXA48-like. This list will evolve because of changing local and global epidemiology. Each carbapenemase type has a slightly different spectrum of activity against different beta-lactam antimicrobials.

Ongoing reports of CPE highlight the value of active surveillance and the importance of compliance with the *Australian Guidelines for the Prevention and Control of Infection in Healthcare*[1], and use of guidance for specific organisms, such as *Recommendations for the Control of Carbapenemase-Producing* Enterobacterales*: A guide for acute health service organisations*.[2]

Arrangements for specialist oversight of and access to restricted antimicrobials, such as carbapenems, should be a priority all Australian hospitals along with implementation of systems that meet the antimicrobial stewardship actions of the National Safety and Quality Health Service (NSQHS) Standards.[3]

Changes in community-onset critical antimicrobial resistances

Reports of MDR *Shigella* species decreased by 10% in 2020, compared with 2019 (*n* = 299 versus *n* = 331).

Reports MDR *Shigella* species increased during 2019, peaked in April 2019, and had halved by the third quarter of 2019. The majority of reports in 2019 were from Victoria (38/51; 75%). Reports of this CAR then doubled and peaked again in January 2020, followed by a sharp decrease in April 2020. The majority of reports in 2020 were from NSW (35/57; 61%). This decrease correlated with the introduction of coronavirus disease 2019 (COVID-19) restrictions in Australia.

Infections caused by *Shigella* species are generally food-borne or sexually transmitted, and are notifiable nationally. In 2019, New South Wales and Victoria reported increases in MDR *Shigella* amongst men who have sex with men. In response to the increase, both states issued public health alerts and implemented changes to management recommendations for shigellosis as part of their prevention and control strategies.[4-6]

The proportion of shigellosis notifications that were MDR increased in 2020 compared to 2019, most notably in New South Wales, Western Australia and Queensland.[7]

Increases in reports of MDR *Shigella* species require consideration of the reliability of empirical antimicrobial therapy recommendations for shigellosis. These increases also require ongoing close review by states and territories as, increasingly, there are limited oral antimicrobial options, and intravenous antimicrobials may be required to treat MDR infections of this type. There may also be additional resource implications for the health system because of increased testing, hospital admissions and transmission in the community. Public health messaging should continue to highlight the risk of sexual transmission of *Shigella* species, particularly through male-to-male sexual contact, and provide guidance on ways to reduce the risk of transmission.

From 2017 to 2020, *N. gonorrhoeae* was the most commonly reported CAR from the community setting. Reports of azithromycin-nonsusceptible *N. gonorrhoeae* (MIC < 256 mg/L) (LLR) continued to decline in 2020, and there were sporadic reports of ceftriaxone-nonsusceptible and/or azithromycin-nonsusceptible *N. gonorrhoeae* (MIC ≥ 256 mg/L). This decline in LLR occurred in the context of continuing annual increases in notifications of gonococcal infections nationally.[7 8]

Although most high MIC reports of this CAR were associated with a primary case related to overseas travel, local transmission may occur due to secondary cases acquired in Australia. Public health messages should include the risk of MDR *N. gonorrhoeae* related to travel, and the importance of culture and susceptibility testing to inform treatment decisions.

The reductions in 2020 in reports of CARS that cause community-onset infections, such as MDR *Shigella* and *N. gonorrhoeae*, may well have been due to reduced social contact as a result of lockdowns and travel restrictions associated with the COVID-19 pandemic.

Aged care homes

In 2020, there were 49 CARs reported from aged care homes; the majority of these (*n* = 35) were daptomycin-nonsusceptible *Staphylococcus aureus* (DNSA). There were 13 reports of CPE in aged care homes, of which 85% (*n* = 11) were from clinical isolates.

Skin and soft tissue infections are commonly caused by *S. aureus*, which is spread by contact with contaminated surfaces and hands of healthcare workers, which is why environmental cleaning and hand hygiene are so important. *S. aureus* can also be spread from person to person, especially in group living situations such as aged care homes when people with skin infections may inadvertently share personal things like bed linen, towels, or clothing. In aged care homes, skin and soft tissue infections are the most common reason for antimicrobial prescriptions.[9] In some states and territories, the number of reports of DNSA from aged care homes was higher than, or similar to, reports from public hospitals. These results may reflect variation between laboratories in routine testing and reporting practices for this CAR, as not all laboratories' routinely test for or report daptomycin susceptibility. Over 70% (41/57) of the reports of this CAR in aged care homes were from one Queensland laboratory.

There is a risk of transmission of CARs within aged care homes, and in hospitals due to the frequent movement of aged care home residents between these two settings.

Control of CPE requires specific infection prevention and control measures, in all care settings, including aged care homes. Compliance with the infection prevention and control requirements of the Aged Care Quality and Safety Standards, which include compliance with national guidelines, will support capacity to control and prevent transmission of CPE in aged care homes.[10] In addition, aged care homes should ensure that they implement policies and practices consistent with specific CPE prevention and control guidance.

Critical antimicrobial resistances in young Australians

The 0-4 year age group accounted for 23.3% (7/30) of all reports of ceftriaxone non-susceptible *Salmonella* species, 5.7% of all CPE (37/646) and 2.0% of multidrug-resistant *Shigella* (6/299). The long-term impacts of antimicrobial-resistant pathogens in children are unknown; expert opinion suggests that clearance of many CARs cannot be assured.[11] In addition, antimicrobial exposure in early childhood has been associated with a variety of health risks.[12-14]

Emerging critical antimicrobial resistances

Transmissible resistance to colistin was reported in *Enterobacterales* that co-produced a carbapenemase (mostly *Enterobacter cloacae* complex harbouring bla_{IMP-4} and *mcr-9.1*). *mcr-9* has recently been found among several species of *Enterobacterales*,[15] often on an IncHI2 plasmid, and the expression of *mcr-9* was inducible by subinhibitory concentrations of colistin. Preliminary evidence suggests that *mcr-9.1* is frequently not expressed.[16] Colistin resistance is concerning, because it limits the effectiveness of a last-line antimicrobial. This means it is an urgent priority for continued surveillance and rapid prevention and control action when detected.

Reports of linezolid non-susceptible *Enterococcus* species increased by 70% from 2018 to 2019 and were stable in 2020 (*n* = 14, *n* = 21 and *n* = 19 respectively); there were only four reports of this CAR in 2017. *Enterococcus* species commonly cause urinary tract, biliary tract and other intra-abdominal infections and blood stream infections. This CAR, in addition to CPE, has the potential

to become a significant problem in the future, if it is not prevented and controlled. Australia has a very high reported rate of vancomycin-resistant *E. faecium* compared with European countries.[17] Resistance in enterococci, similar to some CPE and other *Enterobacterales*, is transmitted in hospital environments from patients' bowel flora.

Increasing health service demands and complexity

Data reported to the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System signal implications for health services as a result of antimicrobial resistance (AMR). There was ongoing substantial variation in antimicrobial usage from 2018 to 2019 between states and territories for multiple antimicrobial classes, which may be extrapolated to 2020. Variation was notable in classes for reserve-line antimicrobials, which may be associated with treatment of CARs:

- Carbapenem usage increased in all states and territories except for South Australia.
- Fluoroquinolone usage decreased in most states and territories
- Usage of third-generation cephalosporins was unchanged in New South Wales/Australian Capital Territory, decreased in Western Australia and Queensland/Northern Territory, and increased in all other states and territories
- Trimethoprim use decreased in all states and territories, except Western Australia.[18] [19] [20]

Critical antimicrobial resistances increase hospital length of stay, deaths and health service resource needs. Estimates of the impacts of AMR vary by organism, and are not available for the majority of CARs. Recent estimates of the impact of CPE include an additional 29 inpatient days, compared to non-CPE cases, after the isolation of the organism.[21] Patients with MDR infections were also less likely to receive appropriate antimicrobial therapy initially.[21] For vancomycin-resistant enterococci, when they first emerged, estimated increases per case were 61.9% for hospital costs and an additional 13.8 days length of stay.[22]

What will be done to improve patient safety?

In response to the issues identified in analyses of CARAlert data from 2017 to 2020, the Commission will continue to:

- Maintain CARAlert and review CARs reported to CARAlert in collaboration with states, territories, the Australian Government Department of Health and relevant experts
- Liaise directly with states and territories and clinical stakeholders regarding specific CARs reported to CARAlert
- Ensure compliance with the *Australian Guidelines for the Prevention and Control of Infection in Healthcare* as required by the NSQHS Standards
- Develop guidance for specific organisms, which complements the *Australian Guidelines for the Prevention and Control of Infection in Healthcare*[1], such as such as the *Recommendations for the control of carbapenemase-producing* Enterobacterales *(CPE): A guide for acute care health facilities*
- Liaise with the Aged Care Quality and Safety Commission and aged care provider organisations regarding the importance of infection prevention and control in aged care homes, consistent with the mandatory Aged Care Quality Standards, and specific considerations for the response to CPE and other CARs
- Promote implementation of systems that meet the antimicrobial stewardship actions of the NSQHS Standards
- Support collaboration between states and territories and hospital and community care settings to prevent and control CARs.

Results from CARAlert, 2020

Between 1 January 2020 and 31 December 2020, a total of 1,582 CARs from 76 originating laboratories across Australia were entered into CARAlert by 23 confirming laboratories (Table 1). There was an average of 132 entries per month.

Critical antimicrobial resistances by state and territory

Most CARs were collected from patients who lived in the most populous states (New South Wales, 44%; Victoria, 23%; and Queensland (22%). There were less than 10 reports from Tasmania and the Northern Territory, and fewer than 30 reports from South Australia and the Australian Capital Territory (Table 1).

CPE (including those with ribosomal methyltransferase or transmissible resistance to colistin) were the most frequently reported CAR (40.8%) in 2020. Compared to 2019, there was a 26% decrease in overall reports of CPE in 2020; the greatest decrease was seen in South Australia (down 56%, *n* = 45 in 2019; *n* = 20 in 2020), likely related to the resolution of a local hospital outbreak. There were also decreases in Victoria (down 35%, *n* = 301 in 2019; *n* = 197 in 2020) and Queensland (down 29%, *n* = 182 in 2019; *n* = 129 in 2020). Western Australia had a 22% increase in CPE reports in 2020.

Although reports of multidrug-resistant *Shigella* species decreased overall by 10% from 2019 to 2020, there was considerable regional variation seen across Australia. There was a decrease in reports from Victoria (down 69%, *n* = 185 in 2019; *n* = 57 in 2020) and Queensland (down 28%, *n* = 65 in 2019; *n* = 47 in 2020). However, there was almost a three-fold increase in reports from New South Wales and Western Australia.

In 2020, the number of azithromycin-nonsusceptible *N. gonorrhoeae* (low-level) reports declined by 37%. The greatest decline was seen in Victoria (down 84%, *n* = 156 in 2019; *n* = 25 in 2020), and New South Wales (down 17%, *n* = 208; *n* = 173 in 2020). An increase in reports was seen in Queensland (up 32%) and Western Australia (19%). There were no reports of this CAR from South Australia and Tasmania.

Reports of daptomycin-nonsusceptible *S. aureus* increased 32% in 2020. The greatest increase was in Queensland (*n* = 42 in 2019; *n* = 106 in 2020).

Carbapenemase-producing *Pseudomonas aeruginosa* and carbapenemase-producing *Acinetobacter baumannii* complex were reported predominantly from New South Wales and Victoria. *Candida auris* was reported from Victoria (*n* = 3) and New South Wales (*n* = 2). *Enterobacterales* with transmissible resistance to colistin, other than in association with CPE, were reported from Victoria (*n* = 8).

Table 1: Number of critical antimicrobial resistances, by state and territory, 2020 and 2019

Species	Critical resistance	State or territory, 2020								Year		Relative change*
		NSW	Vic	Qld	SA	WA	Tas	NT	ACT	2019	2020	
Acinetobacter baumannii complex	Carbapenemase-producing[†]	11	2	1	0	0	0	1	0	32	15	–
	Carbapenemase and ribosomal methyltransferase-producing[†]	1	9	0	0	0	0	0	0	0	10	–
Candida auris	–[†]	2	3	0	0	0	0	0	0	3	5	–
Enterobacterales	Carbapenemase-producing (alone or in combination with other CARs)	253	197	129	20	33	2	3	9	878	646	▼ 26.4%
	Carbapenemase-producing	217	137	125	20	32	1	3	9	797	544	▼ 31.7%
	Carbapenemase and ribosomal methyltransferase-producing	15	13	1	0	1	1	0	0	40	31	▼ 22.5%
	Carbapenemase-producing and transmissible colistin resistance[†]	21	45	3	0	0	0	0	0	41	69	–
	Carbapenemase and RMT-producing and transmissible resistance to colistin[†]	0	2	0	0	0	0	0	0	0	2	–
	Ribosomal methyltransferase-producing	1	0	0	0	0	1	0	0	8	2	▼ 75.0%
	Transmissible colistin resistance[† §]	0	8	0	0	0	0	0	0	3	8	–
Enterococcus species	Linezolid non-susceptible	4	6	0	1	7	1	0	0	22	19	▼ 13.6%
Mycobacterium tuberculosis	Multidrug-resistant – at least rifampicin- and isoniazid-resistant strains	8	4	1	0	0	0	1	2	24	16	▼ 33.3%
Neisseria gonorrhoeae	Azithromycin non-susceptible (low-level)	173	25	41	0	19	0	2	7	424	267	▼ 37.0%
	Azithromycin non-susceptible (high-level)	0	0	1	0	0	0	0	0	7	1	▼ 85.7%
	Ceftriaxone non-susceptible	1	2	0	0	0	0	0	0	4	3	▼ 25.0%
	Ceftriaxone non-susceptible and azithromycin non-susceptible	0	0	0	0	0	0	0	0	0	0	–

Continued

Table 1: *continued*

Species	Critical resistance	State or Territory								Year		
		NSW	Vic	Qld	SA	WA	Tas	NT	ACT	2019	2020	Relative change*
Pseudomonas aeruginosa	Carbapenemase-producing†	22	11	2	2	3	1	0	1	27	42	–
	Carbapenemase and ribosomal methyltransferase-producing†	1	1	0	0	0	0	0	0	0	2	–
Salmonella species	Ceftriaxone non-susceptible	8	5	12	2	3	0	0	0	45	30	▼ 33.3%
Shigella species	Multidrug-resistant	171	57	47	3	20	0	1	0	331	299	▼ 9.7%
Staphylococcus aureus	Daptomycin non-susceptible	43	27	106	0	35	0	0	2	161	213	▲ 32.3%
	Daptomycin and vancomycin non-susceptible	1	0	0	0	0	0	0	0	0	1	–
	Linezolid non-susceptible	0	0	2	0	0	0	0	0	0	2	–
	Vancomycin non-susceptible	0	0	0	0	0	0	0	0	0	0	–
Streptococcus pyogenes	Penicillin reduced susceptibility	0	0	0	0	0	0	0	0	0	0	–
	Total (reported by 31 January 2021)	**700**	**358**	**342**	**28**	**120**	**5**	**8**	**21**	**1,969**	**1,582**	**▼ 19.7%**
										1904#	**1,499#**	**▼ 21.3%**

High-level = azithromycin MIC ≥ 256 mg/L; Low-level = azithromycin MIC < 256 mg/L; RMT =ribosomal methyltransferase; – = not applicable

* Relative change = absolute change between 2019 and 2020, for each CAR, expressed as a percentage of 2019 base

† New CAR added in July 2019 (retrospective data for 2019 included if available)

§ When not seen in combination with CPE

Total minus new CARS introduced in 2019

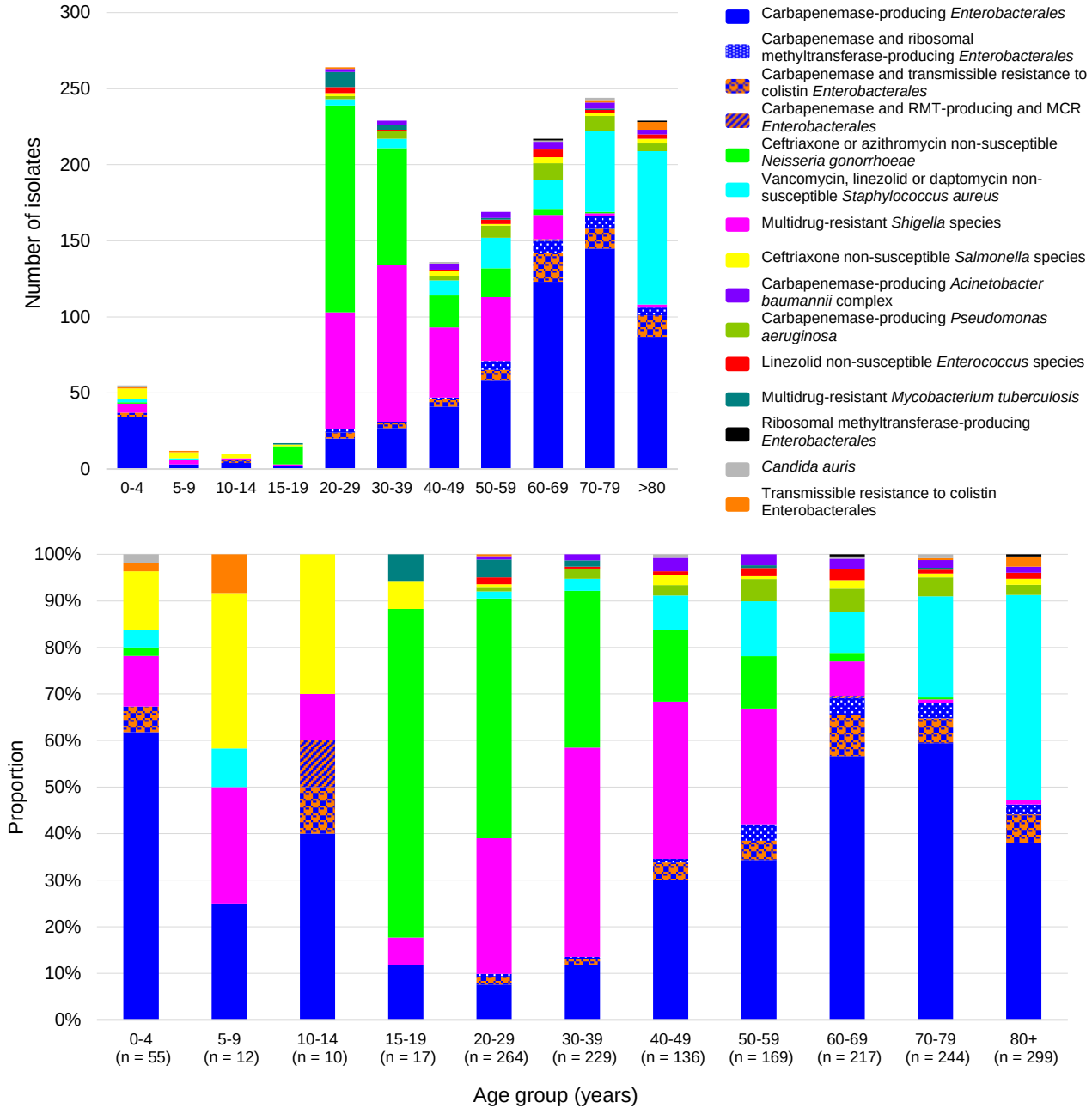
Note: The number of multidrug resistant *Shigella* species for 2019 have been updated to include additional submissions received after previous publication date

Critical antimicrobial resistances by age group

CARs were isolated from patients of all ages; the median age was 50–59 years (Figure 1). Just over three-quarters of CPE were isolated from people aged 50 years and older (76%; 494/646). Azithromycin-nonsusceptible *N. gonorrhoeae* and multidrug-resistant *Shigella* species were the predominant CAR reported for the age groups 20–29 and 30–39 years.

Only 4.9% (77/1,582) of all CARs were reported in children aged less than 15 years; CPE, multidrug-resistant *Shigella* species, and ceftriaxone-nonsusceptible *Salmonella* species were most frequently reported for this age group (91%). For the 0 to 4-year age group, CPE was the most frequently reported CAR (37 reports); followed by ceftriaxone-nonsusceptible *Salmonella* species (*n* = 7), and multidrug-resistant *Shigella* species (*n* = 6).

Figure 1: Critical antimicrobial resistances, by age groups, 2020



Critical antimicrobial resistances by facility type

Excluding azithromycin-nonsusceptible *N. gonorrhoeae*, which is generally isolated in the community, the majority of CARs (854/1,177, 73%) were detected in either hospitalised patients or hospital outpatients. Smaller proportions were isolated in the community (274/1,177, 23%) and in aged care homes (49/1,177, 4%) (Table 2).

Table 2: Number of critical antimicrobial resistance isolates, by setting, national, 2020

Species	Critical resistance	Setting					Total
		Public hospitals	Private hospitals	Aged care homes	Community	Unknown	
Acinetobacter baumannii complex	Carbapenemase-producing	15	0	0	0	0	15
	Carbapenemase and RMT	10	0	0	0	0	10
Candida auris	–	4	0	0	0	1	5
Enterobacterales	Carbapenemase-producing	420	48	8	43	25	544
	Carbapenemase and ribosomal methyltransferase-producing	21	0	2	5	3	31
	Carbapenemase-producing and transmissible colistin resistance	58	6	3	1	1	69
	Carbapenemase and RMT-producing and transmissible resistance to colistin	2	0	0	0	0	2
	Ribosomal methyltransferase-producing	2	0	0	0	0	2
	Transmissible colistin resistance	6	2	0	1	0	9
Enterococcus species	Linezolid non-susceptible	14	0	0	3	2	19
Mycobacterium tuberculosis	Multidrug-resistant – at least rifampicin- and isoniazid-resistant	11	1	0	2	2	16
Neisseria gonorrhoeae	Azithromycin non-susceptible (low-level)	32	0	0	228	7	267
	Azithromycin non-susceptible (high-level)	0	0	0	1	0	1
	Ceftriaxone non-susceptible	0	0	0	3	0	3
	Ceftriaxone non-susceptible and azithromycin non-susceptible	0	0	0	0	0	0
Pseudomonas aeruginosa	Carbapenemase-producing	26	4	1	6	5	42
	Carbapenemase and ribosomal methyltransferase-producing	2	0	0	0	0	2
Salmonella species	Ceftriaxone non-susceptible	14	1	0	8	7	30
Shigella species	Multidrug-resistant	93	1	0	146	59	299
Staphylococcus aureus	Daptomycin non-susceptible	66	27	35	56	29	213
	Daptomycin and vancomycin non-susceptible	0	0	0	1	0	1
	Linezolid non-susceptible	0	0	0	2	0	2
	Vancomycin non-susceptible	0	0	0	0	0	0
Streptococcus pyogenes	Penicillin reduced susceptibility	0	0	0	0	0	0
	Total (reported by 31 January 2021)	**796**	**90**	**49**	**506**	**141**	**1,582**

High-level = azithromycin MIC ≥ 256 mg/L; Low-level = azithromycin MIC < 256 mg/L; RMT = ribosomal methyltransferase

Note: Information on setting for *Neisseria gonorrhoeae* is often not available

CPE accounted for just under two-thirds of all reports from hospitals (555/886, 63%). In the community, almost three-quarters of reports were ceftriaxone- or azithromycin-nonsusceptible *N. gonorrhoeae* (232/506, 46%) or multidrug-resistant *Shigella* species (146/506, 29%). Almost all reports from aged care homes were daptomycin nonsusceptible *S. aureus* (35/49, 71%) or CPE (13/49, 27%).

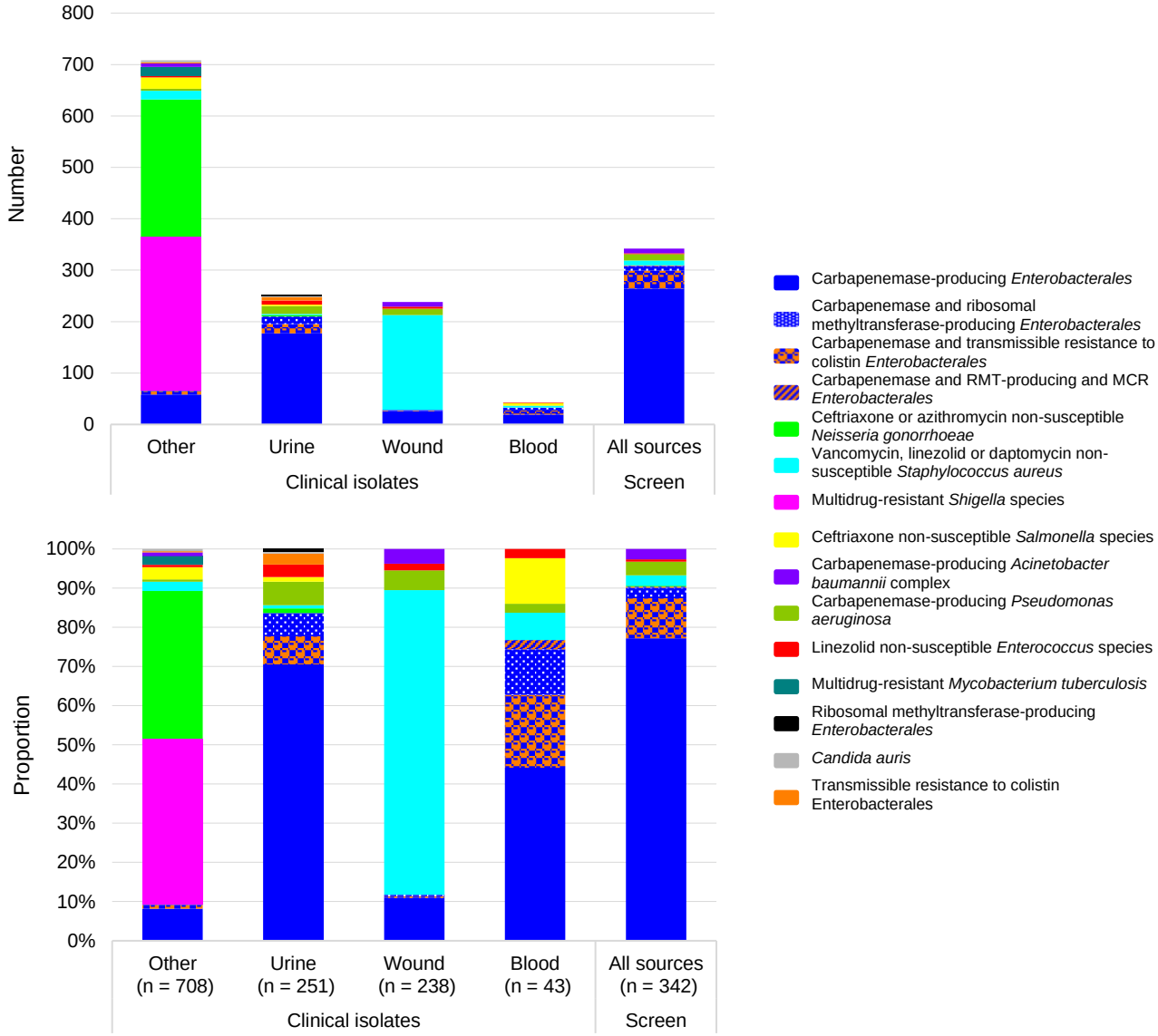
Critical antimicrobial resistances by specimen type

A substantial majority of all CARs reported in 2020 were from clinical specimens (78%), which are specimens collected for diagnostic purposes, rather than for screening. These included urine wound, blood and other (such as genital or respiratory) specimens (Figure 2).

Of CPE reports, more than 52% were from clinical specimens (337/646). Sixty-two percent of isolates from clinical specimens were from urine (210/337), which is to be expected because *Enterobacterales* commonly cause urinary tract infections. Almost 1 in 10 of CPE from clinical specimens were from blood cultures (33/337). CPE comprised 77% of all CARs confirmed from blood specimens, highlighting the clinical spectrum of CPE infections compared with other CARs.

Four other CARs were also reported from blood cultures in 2020: ceftriaxone-nonsusceptible *Salmonella* species (*n* = 5), daptomycin-nonsusceptible *S. aureus* (*n* = 3), carbapenemase-producing *P. aeruginosa* (*n* = 1), and linezolid nonsusceptible *Enterococcus* species (*n* = 1). Urine is an important specimen for certain CARs, such as CPE, because the urinary tract is a common site of infection.

Figure 2: Critical antimicrobial resistances, by specimen type, 2020



Note: 'Other' refers to specimen types other than urine, wound or blood, such as genital, faecal or respiratory tract.

Summary by CAR, with trend data for 2017–2020

Data for each CAR for 2020, nationally and by state and territory, are shown in Figures 3 to 28. Trend data for 2017 to 2020 are also presented, where applicable.

Candida auris

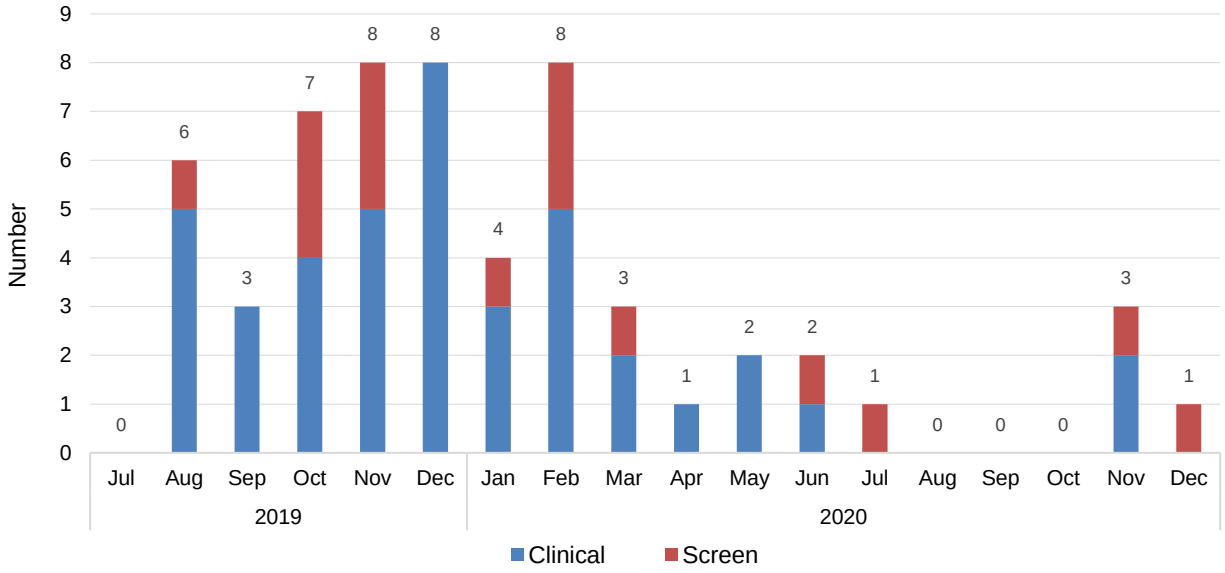
Reporting for *C. auris* began in July 2019. There were three reports in 2019; two from New South Wales and one from Western Australia. Five *C. auris* were reported in 2020: three from Victoria and two from New South Wales.

Acinetobacter baumannii complex

Reporting for carbapenemase-producing *A. baumannii* complex began in July 2019 (Figure 3).

There were 25 reports of carbapenemase-producing *A. baumannii* complex in 2020; 12 from New South Wales, 11 from Victoria, one from Queensland, and one from the Northern Territory (Figures 3 and 4). OXA-23-like types were dominant (*n* = 23, either alone [21] or in combination with NDM [2]). Four NDM types (alone [2] or in combination with OXA-23-like [2]) were reported.

Figure 3: Carbapenemase-producing *Acinetobacter baumannii* complex, number reported by specimen type, 2019–2020, national



Note: New CAR reported from July 2019

Figure 4: Carbapenemase-producing *Acinetobacter baumannii* complex, number reported by carbapenemase type and specimen type, state and territory, 2020

Table 3: Carbapenemase-producing *Acinetobacter baumannii* complex, number reported by setting, state and territory, 2020

	State or territory								
Setting	**NSW**	**Vic**	**Qld**	**SA**	**WA**	**Tas**	**NT**	**ACT**	**Total**
Total	**12**	**11**	**1**	**0**	**0**	**0**	**1**	**0**	**25**
Public hospital	12	11	1	0	0	0	1	0	25
Private hospital	0	0	0	0	0	0	0	0	0
Aged care home	0	0	0	0	0	0	0	0	0
Community	0	0	0	0	0	0	0	0	0

Enterobacterales

There was a decrease in the number of reports of carbapenemase- and/or ribosomal methyltransferase-producing *Enterobacterales* in 2020, compared with 2017–2019, and there were sporadic increases in reports over the four years (Figure 5 and Figure 6). There was no indication of any seasonal variation. The overall number of CPE reports decreased in 2020 (*n* = 646, down 26%) compared with 2019; although there was an increase in numbers reported from Western Australia (Figure 9).

Carbapenemases were found in 25 species (11 genera) of *Enterobacterales*, with eight carbapenemase types reported (Figure 7). Three carbapenemase types, (IMP (59.9%), NDM (24.3%) and OXA-48-like (9.8%) when produced alone, accounted for 94% of all *Enterobacterales* with a confirmed carbapenemase.

IMP types alone accounted for 60% (387/646) of all carbapenemases; they were found in 22 different species (Figure 7). *E. cloacae* complex accounted for 52% (203/387) of all IMP types and 31% (203/646) of all CPE. However, in Queensland, over one-half (72/129, 56%) of all CPE reported were *E. cloacae* complex containing IMP types.

NDM carbapenemase types were found mainly in *E. coli* (54%), and OXA-48-like types in *E. coli* and *K. pneumoniae* (44% for *E. coli*; 43% for *K. pneumoniae*). When both NDM and OXA-48-like types were found together, they were mainly in *E. coli* (64%).

Monthly trends for the top five carbapenemase types (IMP; NDM; OXA-48-like; KPC; NDM-OXA-48-like) reported over four years are shown in Figure 8 (national); and three-year trends by state and territory in Figure 10. The decrease in CPE reported in 2020 was seen across all types when compared with 2019; (IMP: *n* = 387 versus *n* = 504; NDM: *n* = 157 versus *n* = 224; OXA-48-like: *n* = 63 versus *n* = 96; NDM+OXA-48-like: *n* = 11 versus *n* = 22; KPC: *n* = 3 versus *n* = 18).

IMP types decreased by 21% in 2020 compared with 2019, although there was a 64% increase in reports from the Western Australia (Figure 9). No IMP-producing *Enterobacterales* were reported from South Australia. IMP-types accounted for 83% of all CPE reported from Queensland. All the strains that have been genetically sequenced to date (216/397, 54%) were $bla_{\text{IMP-4}}$ (*n* = 215) or $bla_{\text{IMP-26}}$ (*n* = 1).

NDM types, either alone or in combination, were found in all states and territories. There was a 29% decrease in reports of NDM types in 2020 compared with 2019. In South Australia, NDM types accounted for over two-thirds (13/20, 65%) of all CPE reported. Four different genes were found in the strains sequenced (122/174, 70%): bla_{NDM-5} (57/122; 47%), bla_{NDM-1} (43/122; 35%), bla_{NDM-7} (12/122; 10%), and bla_{NDM-4} (10/122; 8%).

Reports of OXA-48-like CPE decreased by 34% in 2020 compared with 2019. Over 72% (56/78) of the isolates with OXA-48-like were sequenced. Four genes were reported; the most common was $bla_{OXA-181}$ (27/56, 48%), followed by bla_{OXA-48} (17/56, 30%), $bla_{OXA-232}$ (8/56, 14%) and $bla_{OXA-244}$ (4/56, 7%).

KPC-producing *Enterobacterales* were only reported from Victoria (*n* = 2), and New South Wales (*n* = 1). The $bla_{\text{KPC-33}}$ gene was detected in a *Klebsiella pneumoniae* isolated from a patient in an aged care home in Victoria.

There were five IMI-producing *Enterobacterales* reported; four *Enterobacter cloacae* complex from New South Wales (*n* = 2), and Victoria (*n* = 2); and one *Serratia marcescens*, from Victoria.

Other carbapenemase types reported were OXA-23-like (*n* = 4), VIM (*n* = 4) and SME (*n* = 2)

Co-production of carbapenemase was seen at low levels (21/646, 3.3%). The co-produced genes in 2020 were NDM+OXA-48-like (*n* = 11), IMP+NDM (*n* = 6), and IMP+OXA-48-like (*n* = 4).

In 2020, there was variation in the proportion of isolates reported from clinical and screening specimens by state and territory (Figure 11). This may be due to differences in local infection control policies or in response to local outbreaks. Relatively fewer reports from screening specimens were identified in the Australian Capital Territory, Western Australia and Queensland.

There were notable regional differences in the distribution of the top five carbapenemases by specimen type (Figure 12) and by setting (Table 4).

CPE were reported from 130 hospitals during 2020, little change from 2019 (*n* = 132). Almost one-quarter (31/130, 24%) of these hospitals did not have a CPE during the period 2016 to 2019. Seventy-five hospitals that had CPE notifications prior to 2020 did not have any reports in 2020.

Ribosomal methyltransferases (RMT) were detected in 33 isolates of *Enterobacterales*, representing five species; 94% (31/33) of these also had a carbapenemase. The RMTs were mostly found among *K. pneumoniae* (15/33, 45%) and *E. coli* (14/33; 42%). Four RMT genes were found: *rmtB* (*n* = 14, 42%), *armA* (*n* = 12; 36%); *rmtC* (4; 12%) and *rmtF* (3, 9%).

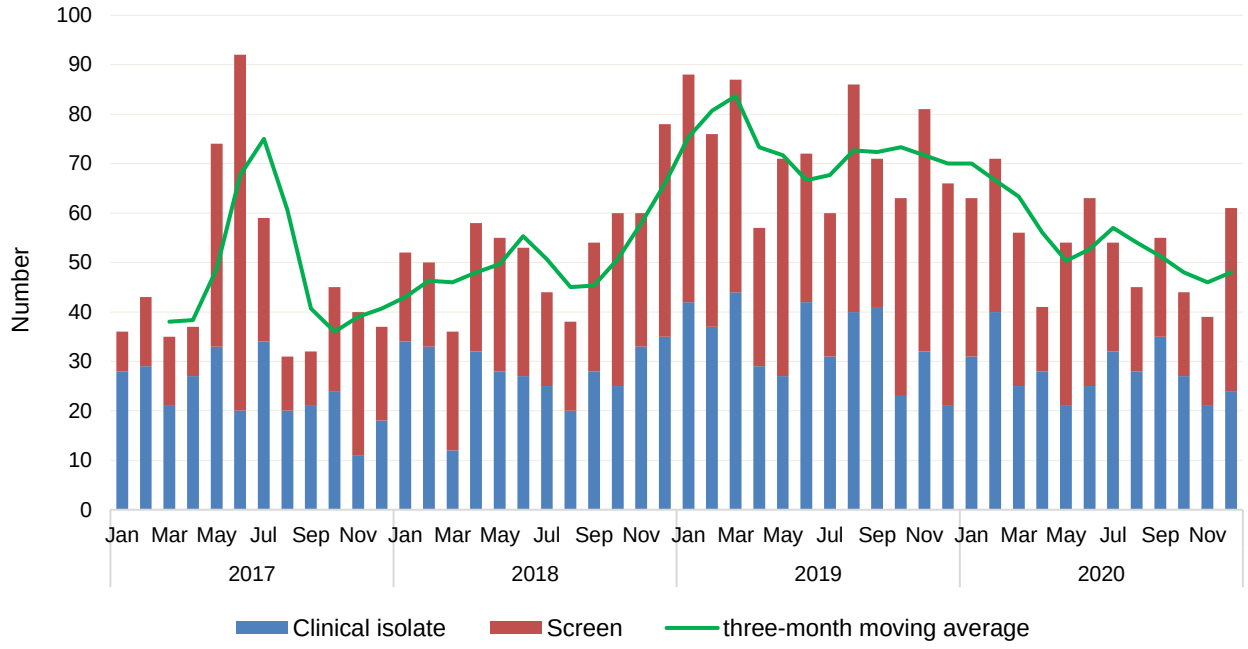
A vast majority of transmissible resistance to colistin (MCR) was reported in isolates that co-produced a carbapenemase (71/80, 89%); $bla_{\text{IMP-4}}$ (*n* = 61), NDM (*n* = 8; $bla_{\text{NDM-1}}$, 6 isolates; $bla_{\text{NDM-7}}$, 2 isolates), $bla_{\text{OXA-48}}$ (*n* = 1), or $bla_{\text{IMP-4}}$+$bla_{\text{NDM-7}}$ (*n* = 1). All isolates co-producing a carbapenemase harboured either *mcr-9.1* (*n* = 69) or *mcr-10.1* (*n* = 2). Co-production of CPE and

MCR was mostly found among *E. cloacae* complex (65/80, 81%), 77% (50/65) of which harboured *bla*$_{IMP-4}$; six other species were reported. *mcr-9* has recently been found among several species of *Enterobacterales*[15] often on an IncHI2 plasmid, and the expression of *mcr-9* was inducible by subinhibitory concentrations of colistin. Preliminary evidence suggests that *mcr-9* is frequently not expressed.[16]

MCR alone was reported in nine *E. cloacae* complex (*mcr-10.1* (*n* = 5) or *mcr-9.1* (*n* = 4). There were no reports of *mcr-1*.

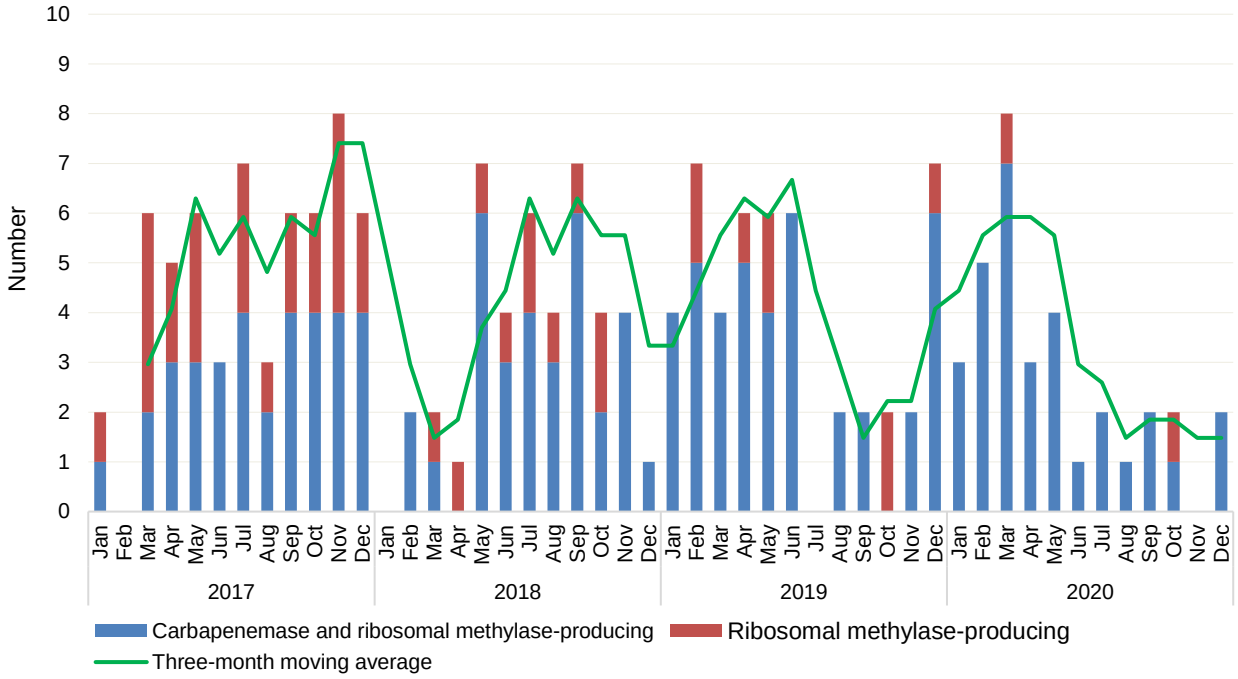
National data

Figure 5: Carbapenemase-producing *Enterobacterales*, number reported by month and specimen type, 2017–2020, national



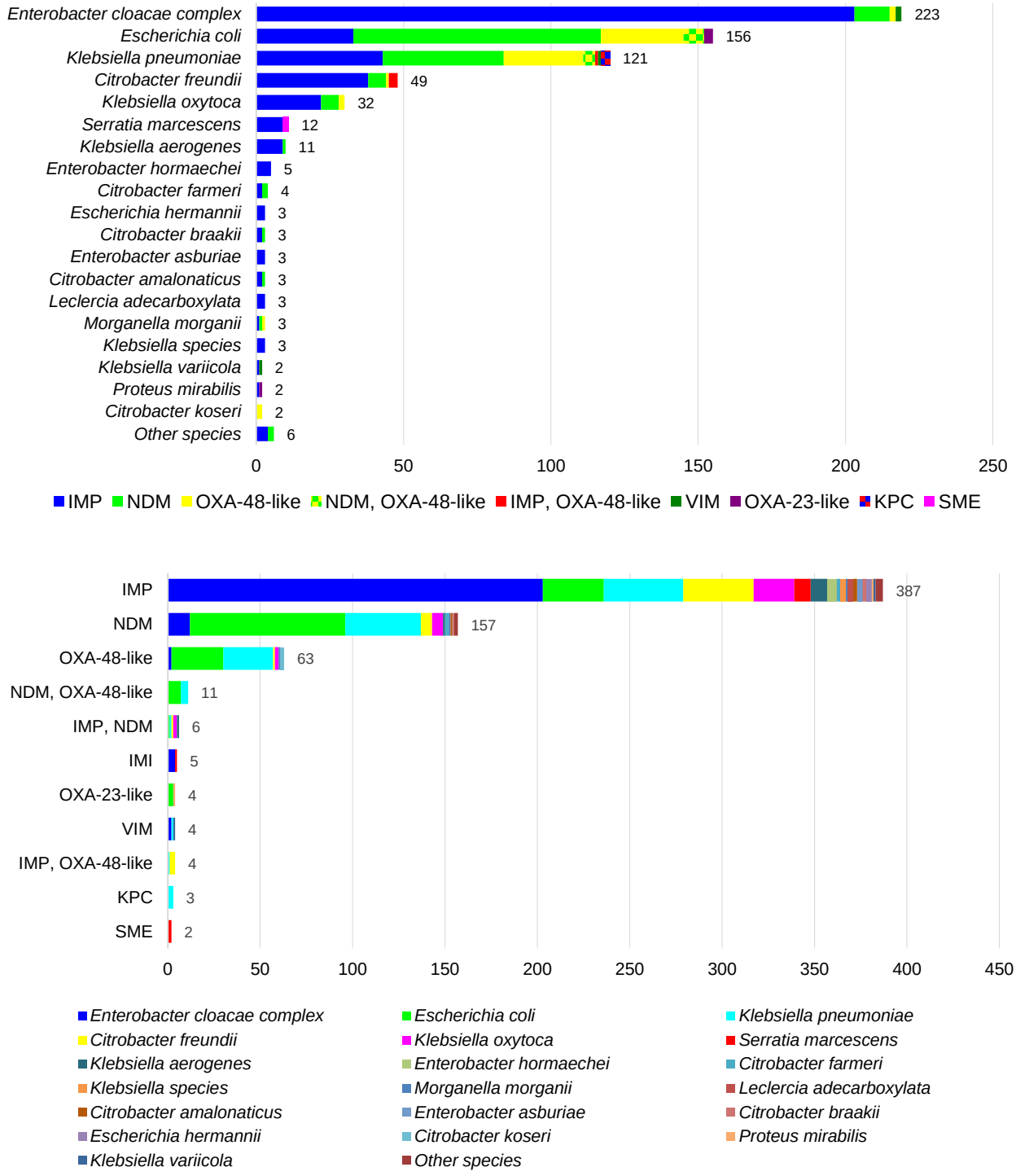
Note: Carbapenemase-producing *Enterobacterales*, including those with ribosomal methyltransferase or transmissible colistin resistance

Figure 6: Ribosomal methyltransferase-producing *Enterobacterales*, number reported by month, 2017–2020, national



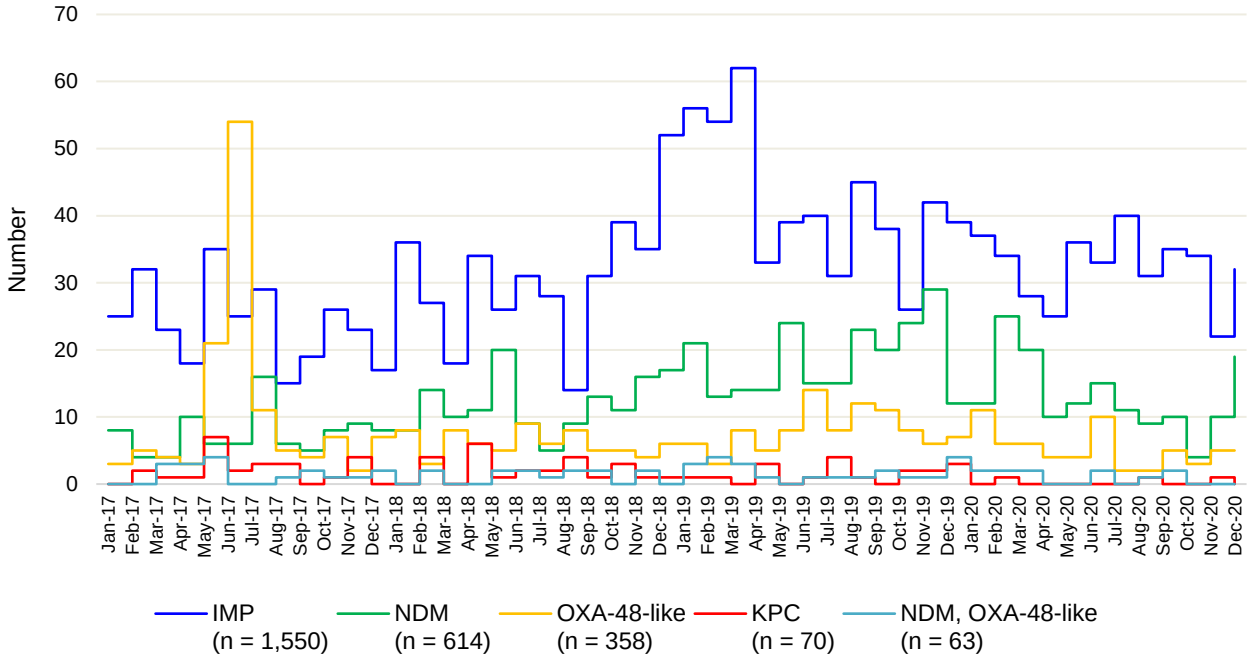
Note: Ribosomal methyltransferase-producing *Enterobacterales*, including those with carbapenemases

Figure 7: Carbapenemase-producing *Enterobacterales**, number reported by species and carbapenemase type, 2020, national



* Carbapenemase-producing (*n* = 544), carbapenemase-producing plus transmissible colistin resistance (*n* = 69), carbapenemase- and ribosomal methyltransferase-producing (*n* = 31), carbapenemase-, ribosomal methyltransferase-producing plus transmissible resistance to colistin (*n* = 2)

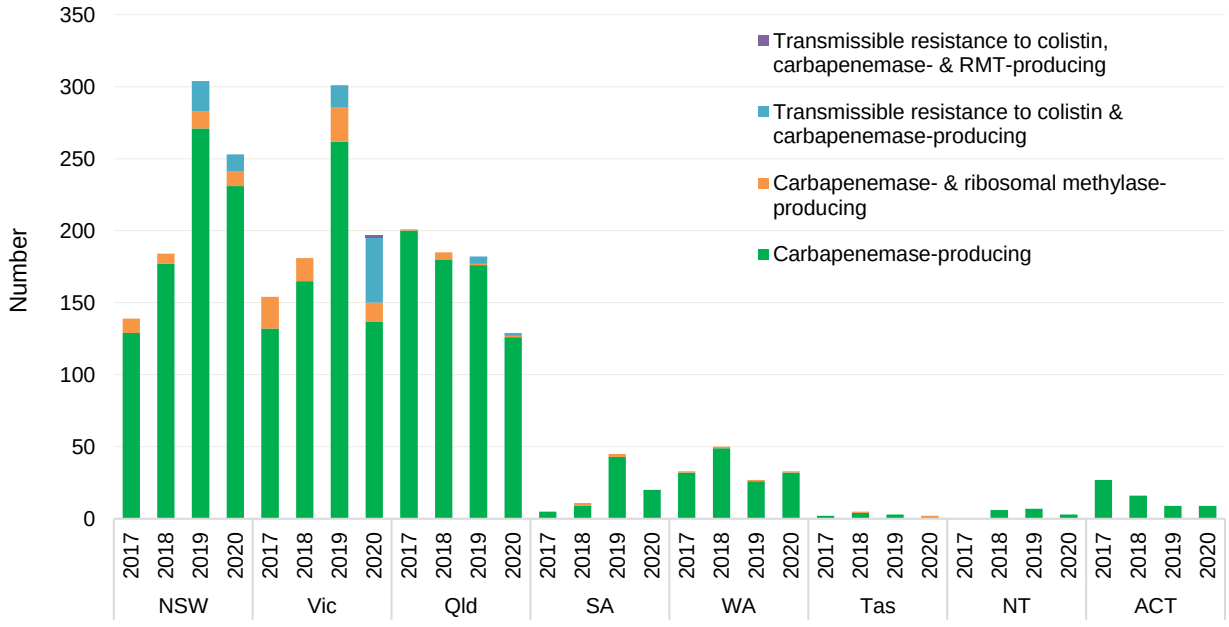
Figure 8: Trend for the top five reported carbapenemase types*, by month, 2017–2020, national



* Alone or in combination with another type for the reporting period indicated

State and territory

Figure 9: Carbapenemase-producing *Enterobacterales,* number reported by state and territory, 2017–2020



Note: Transmissible colistin resistance reported from July 2019

Figure 10: Three-year trend for the top four reported carbapenemase types from *Enterobacterales*, by state and territory and nationally, (three-month moving average), 2018–2020

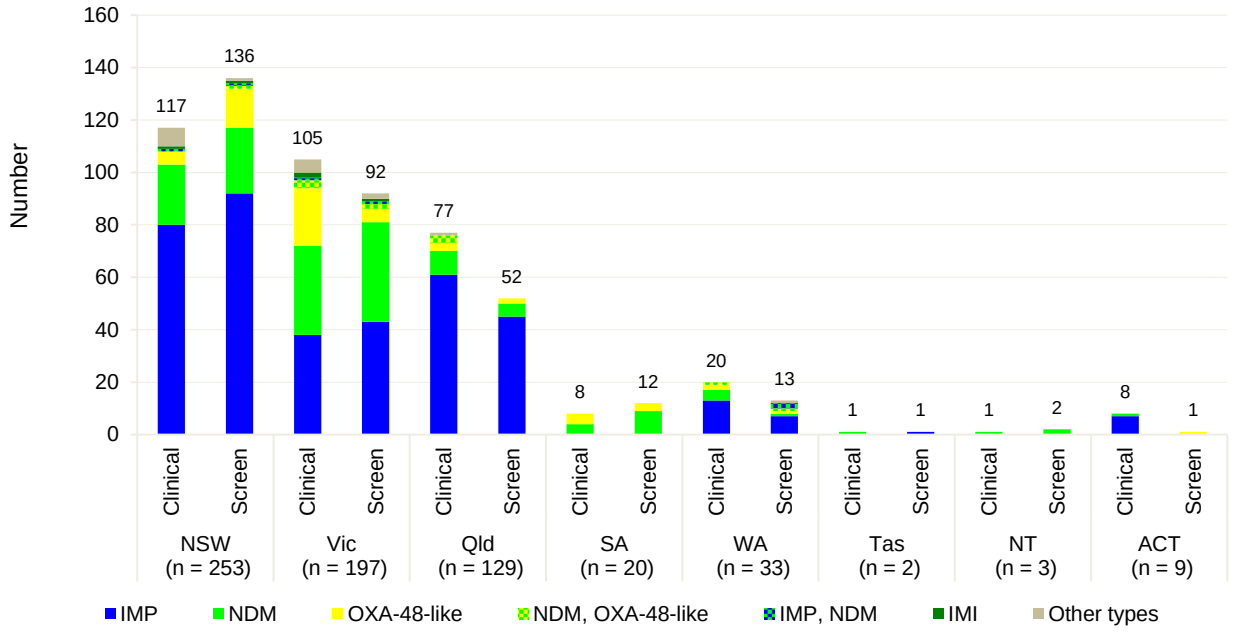
Type	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Australia
IMP	20 8	24 2	17 4	0 0	4 0	0 0	1 0	2 0	57 24
NDM	8 1	9 3	6 0	6 0	2 0	0 0	1 0	1 0	24 8
OXA-48-like	3 1	7 0	2 0	1 0	1 0	0 0	0 0	0 0	11 3
KPC	1 0	3 0	1 0	0 0	0 0	0 0	0 0	0 0	3 0
All types	28 13	35 10	19 5	7 0	6 1	1 0	1 0	2 0	84 43

Line graphs represent three-month moving average for the period 1 January 2018 to 31 December 2020, for each type, where maximum monthly average was greater than one.

Straight green line in cell = no carbapenemase type for that state or territory during the reporting period

Blank cell = maximum monthly average was one or less

Figure 11: Carbapenemase-producing *Enterobacterales**, number reported by carbapenemase type and specimen type, by state and territory, 2020



* Carbapenemase-producing (*n* = 544), carbapenemase-producing plus transmissible colistin resistance (*n* = 69), carbapenemase- and ribosomal methyltransferase-producing (*n* = 31), carbapenemase-, ribosomal methyltransferase-producing plus transmissible resistance to colistin (*n* = 2)

Other types: IMP+OXA-48-like (n = 4: NSW [2], Qld [1], WA [1]); VIM (n = 4: NSW [1], Vic [3]); OXA-23-like (n = 4: NSW [3], Vic [1]); KPC (n = 3: NSW [1], Vic [2]); SME (n = 2: NSW [1], Vic [1])

Figure 12: Top five reported carbapenemase-producing *Enterobacterales* type by specimen type, by state and territory, 2017–2020

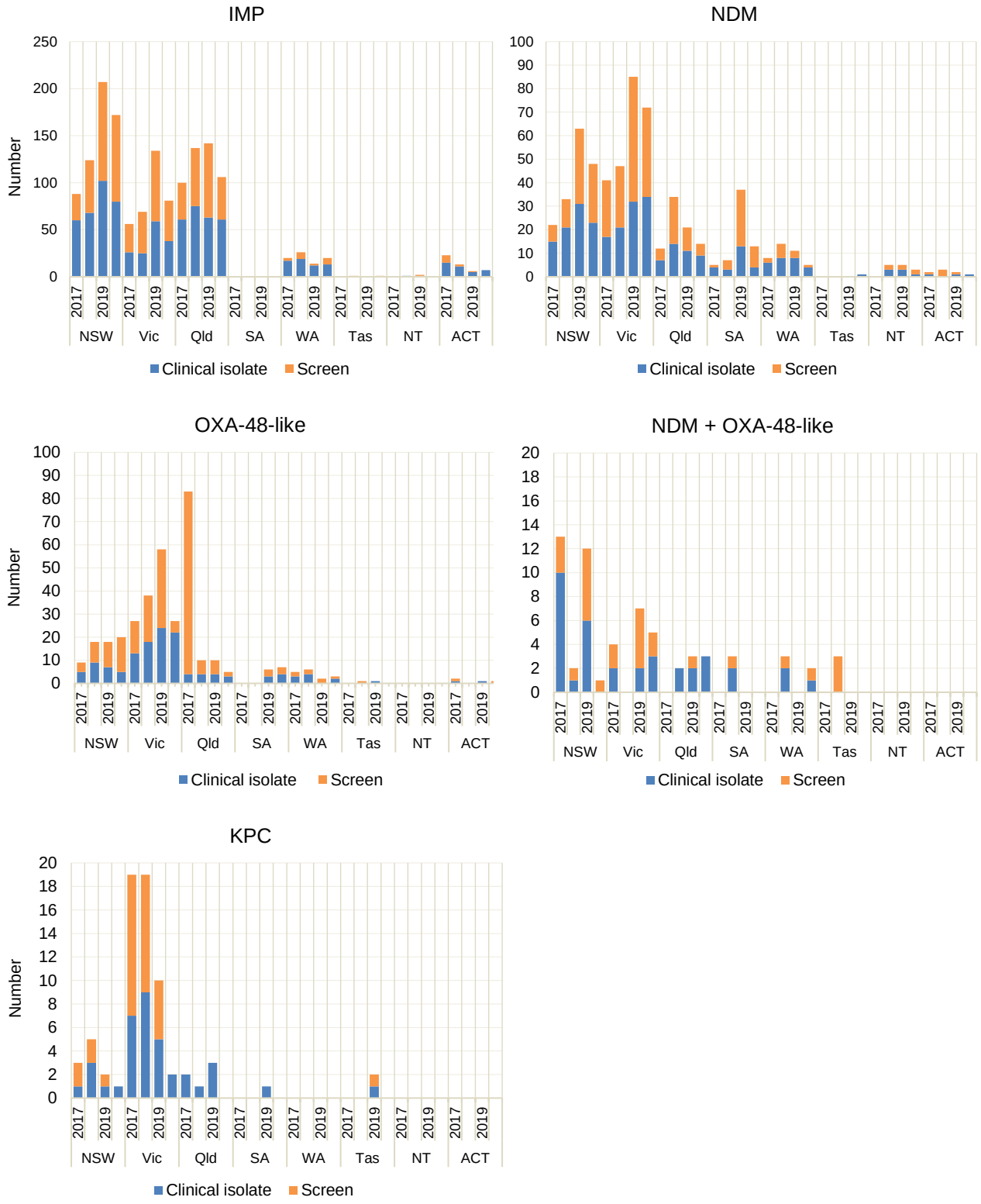


Table 4: Top four carbapenemase types from *Enterobacterales*, number reported by setting, state and territory, 2020

Carbapenemase type[†]	Setting	State or territory								Total
		NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
IMP	**Total**	**172**	**81**	**106**	**0**	**20**	**1**	**0**	**7**	**387**
	Public hospital	157	65	60	0	9	1	0	7	299
	Private hospital	4	9	27	0	3	0	0	0	43
	Aged care home	3	0	4	0	1	0	0	0	8
	Community	5	7	8	0	2	0	0	0	22
	Unknown	3	0	7	0	5	0	0	0	15
NDM	**Total**	**48**	**72**	**14**	**13**	**5**	**1**	**3**	**1**	**157**
	Public hospital	42	53	9	12	0	1	3	1	121
	Private hospital	0	4	2	0	0	0	0	0	6
	Aged care home	1	3	0	0	0	0	0	0	4
	Community	4	9	2	1	2	0	0	0	18
	Unknown	1	3	1	0	3	0	0	0	8
OXA-48-like	**Total**	**20**	**27**	**5**	**7**	**3**	**0**	**0**	**1**	**63**
	Public hospital	20	17	5	5	1	0	0	1	49
	Private hospital	0	2	0	1	0	0	0	0	3
	Aged care home	0	0	0	0	0	0	0	0	0
	Community	0	5	0	1	0	0	0	0	6
	Unknown	0	3	0	0	2	0	0	0	5
NDM, OXA-48-like	**Total**	**1**	**5**	**3**	**0**	**2**	**0**	**0**	**0**	**11**
	Public hospital	1	5	2	0	2	0	0	0	10
	Private hospital	0	0	0	0	0	0	0	0	0
	Aged care home	0	0	0	0	0	0	0	0	0
	Community	0	0	1	0	0	0	0	0	1
	Unknown	0	0	0	0	0	0	0	0	0
IMP, NDM	**Total**	**2**	**2**	**0**	**0**	**2**	**0**	**0**	**0**	**6**
	Public hospital	2	2	0	0	2	0	0	0	6
	Private hospital	0	0	0	0	0	0	0	0	0
	Aged care home	0	0	0	0	0	0	0	0	0
	Community	0	0	0	0	0	0	0	0	0
	Unknown	0	0	0	0	0	0	0	0	0

* Top five carbapenemase types account for 96.6% (624/646) of all carbapenemase-producing *Enterobacterales* reported for this period. Other types were IMI (*n* = 5, NSW, Vic); IMP+OXA-48-like (*n* = 4, NSW, Qld, WA); VIM (*n* = 4, NSW, Vic); OXA-23-like (*n* = 4, NSW, Vic); KPC (*n* = 3, NSW, Vic); and SME (*n* = 2, NSW, Vic)

† Alone or in combination with another type for the reporting period indicated

Enterococcus species

In 2020, reports of linezolid-nonsusceptible *Enterococcus* species remained steady compared to 2019 (*n* = 22 in 2019; *n* = 19 in 2020) (Figure 13).

Reports of linezolid-nonsusceptible *Enterococcccus* species from Western Australia were disproportionate to its population in 2019 and 2020 (Figure 14).

Figure 13: Linezolid-nonsusceptible *Enterococcus* species, number reported by month, 2017–2020, national

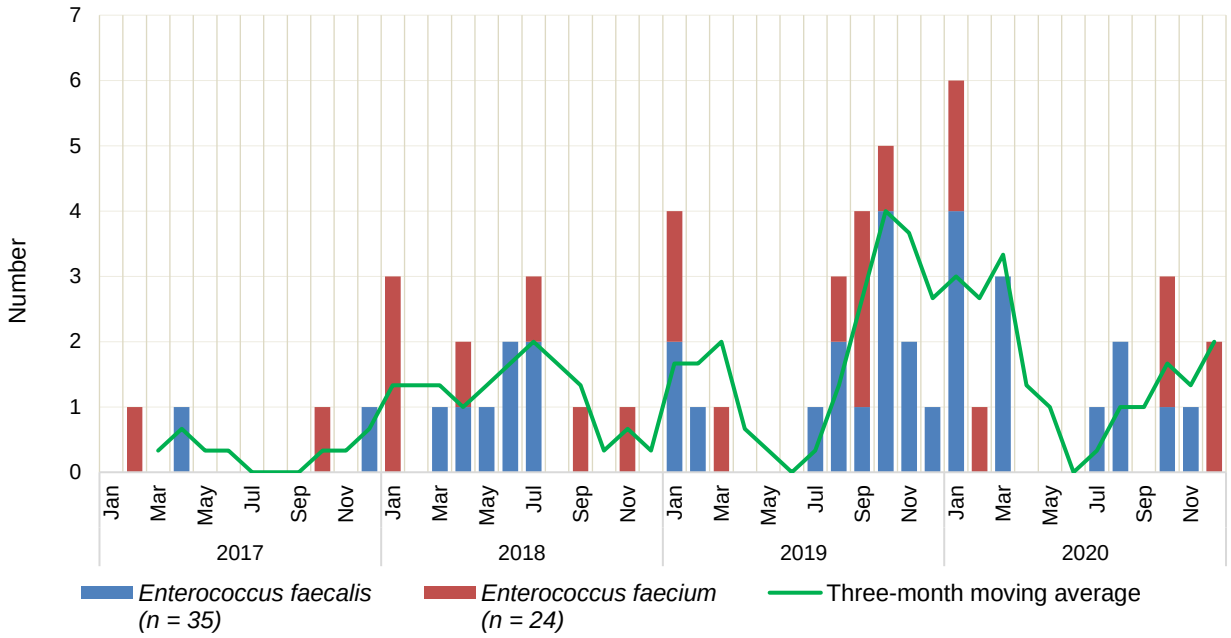
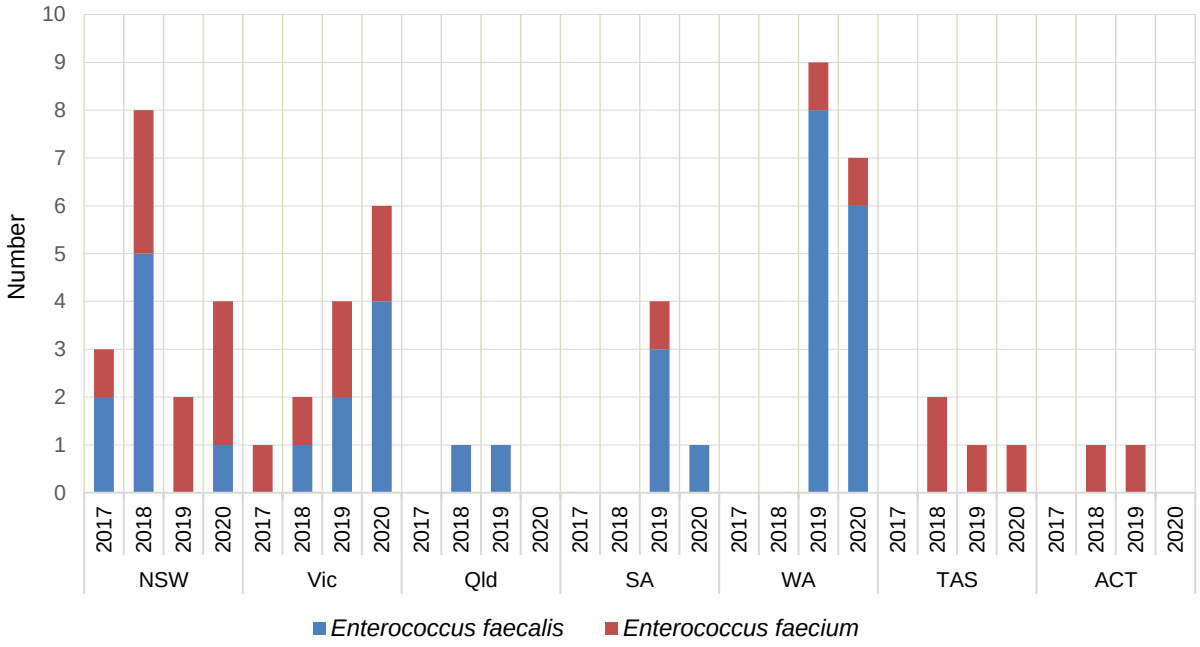


Figure 14: Linezolid-nonsusceptible *Enterococcus* species, number reported by state and territory, 2017–2020



Mycobacterium tuberculosis

Low numbers of multidrug-resistant *Mycobacterium tuberculosis* were reported to CARAlert from 2017 to 2020 (Figure 15). In 2020, half of the multidrug-resistant *M. tuberculosis* reports were from NSW (*n* = 8), followed by Queensland (*n* = 4) (Figure 16).

Figure 15: Multidrug-resistant *Mycobacterium tuberculosis,* number reported by month, 2017–2020, national

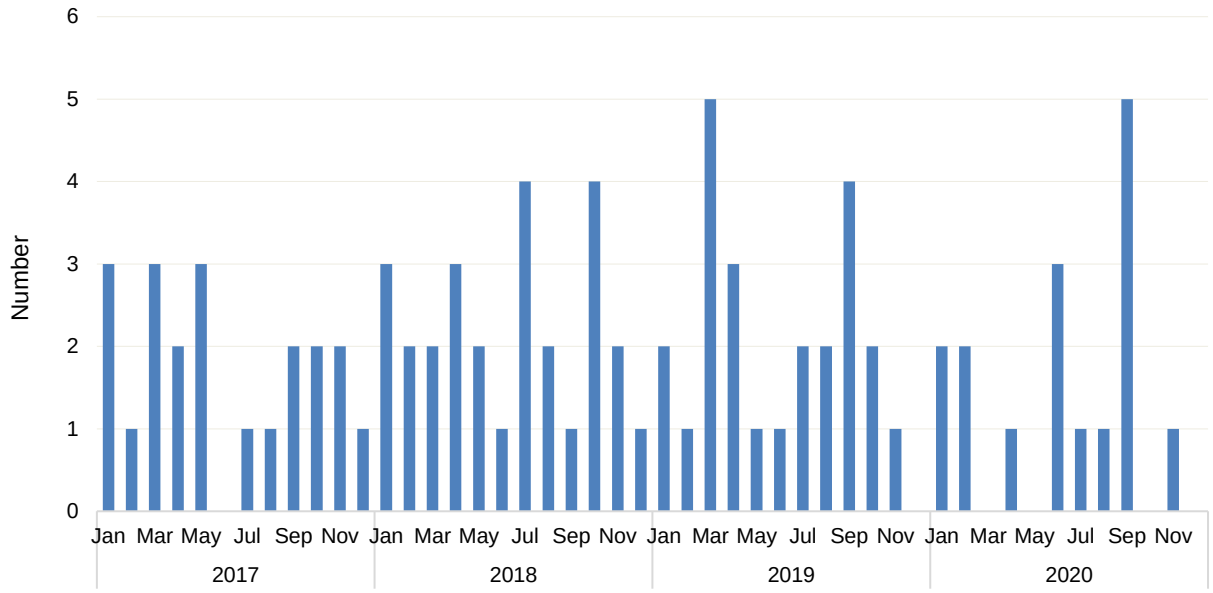
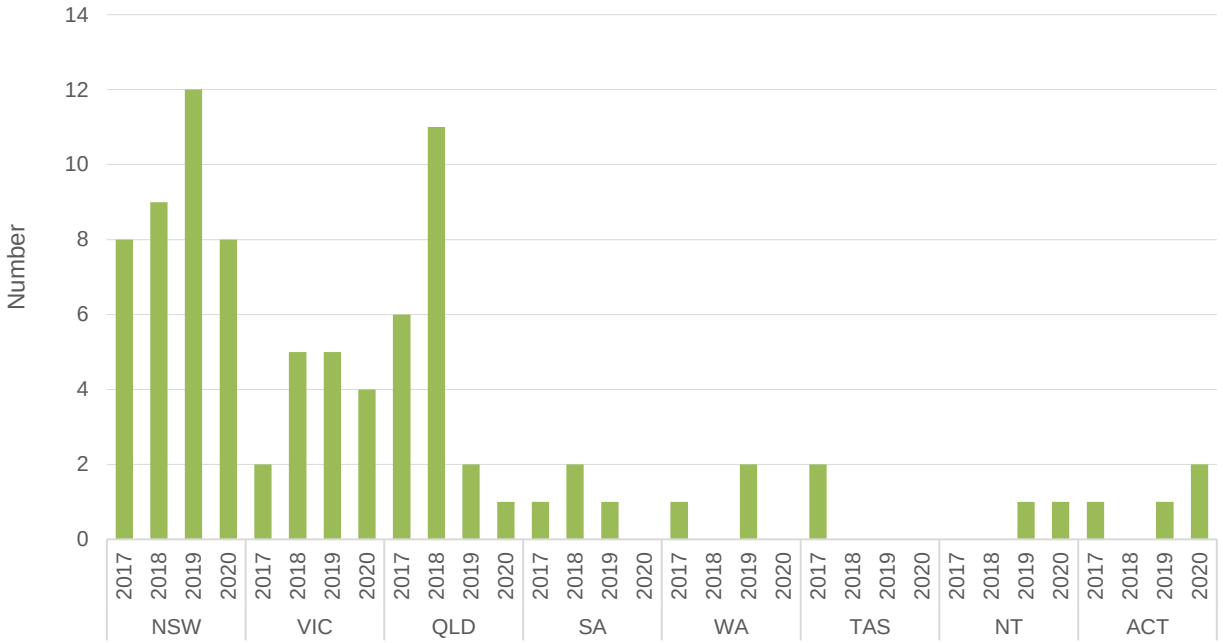


Figure 16: Multidrug-resistant *Mycobacterium tuberculosis*, number reported by state and territory, 2017–2020



Neisseria gonorrhoeae

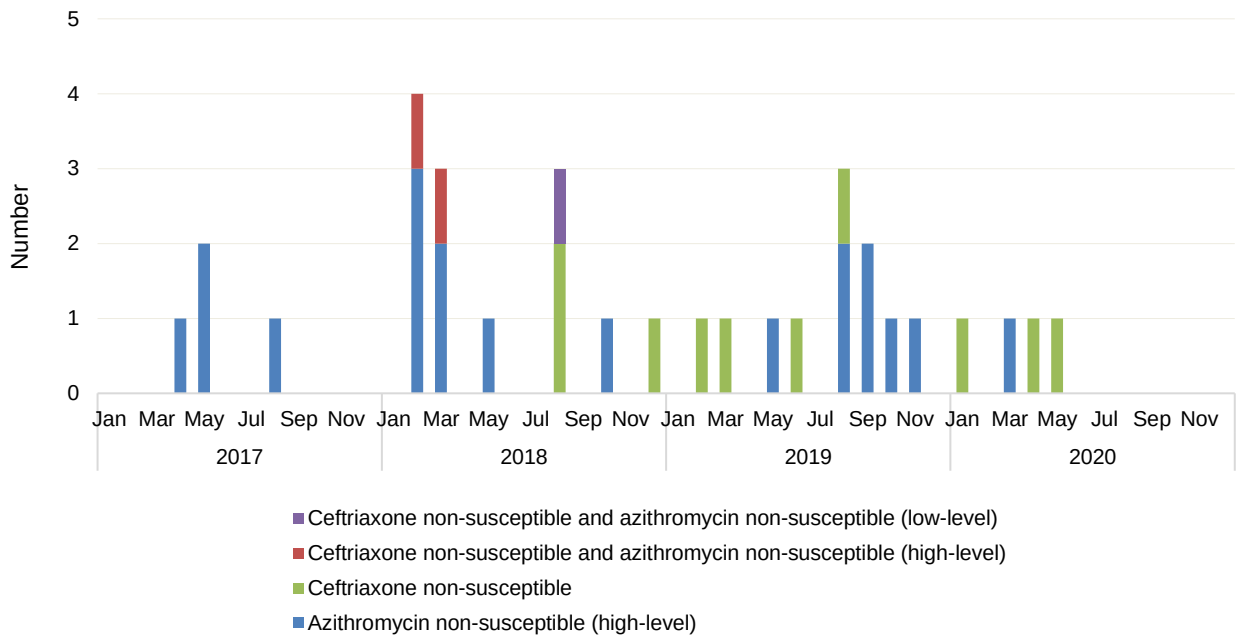
There were sporadic reports of ceftriaxone-nonsusceptible and/or azithromycin-nonsusceptible (high-level) *N. gonorrhoeae* from 2017 to 2020 (Figure 17). Ceftriaxone-nonsusceptible isolates (*n* = 6) were reported for the first time in 2018; there were four reports of this CAR in 2019, and three in 2020, two from Victoria and one from New South Wales.

Reports of azithromycin-nonsusceptible (low-level) *N. gonorrhoeae* decreased from 2017 to 2020 (Figure 18). The majority of reports over the period were from New South Wales and Victoria, and there was a notable decrease in Victoria from 2017 to 2020 (Figure 19).

The total number of reports of this CAR in 2020 decreased by 37% compared to 2019 (*n* = 267 in 2019, *n* = 424 in 2020). There was a six-fold decrease in the number from Victoria (*n* = 25 versus *n* = 156), a decrease in New South Wales (n = 173 versus *n* = 208). There was an increase in the number from Queensland (*n* = 41 versus *n* = 31) and Western Australia (*n* = 19 versus *n* = 16).

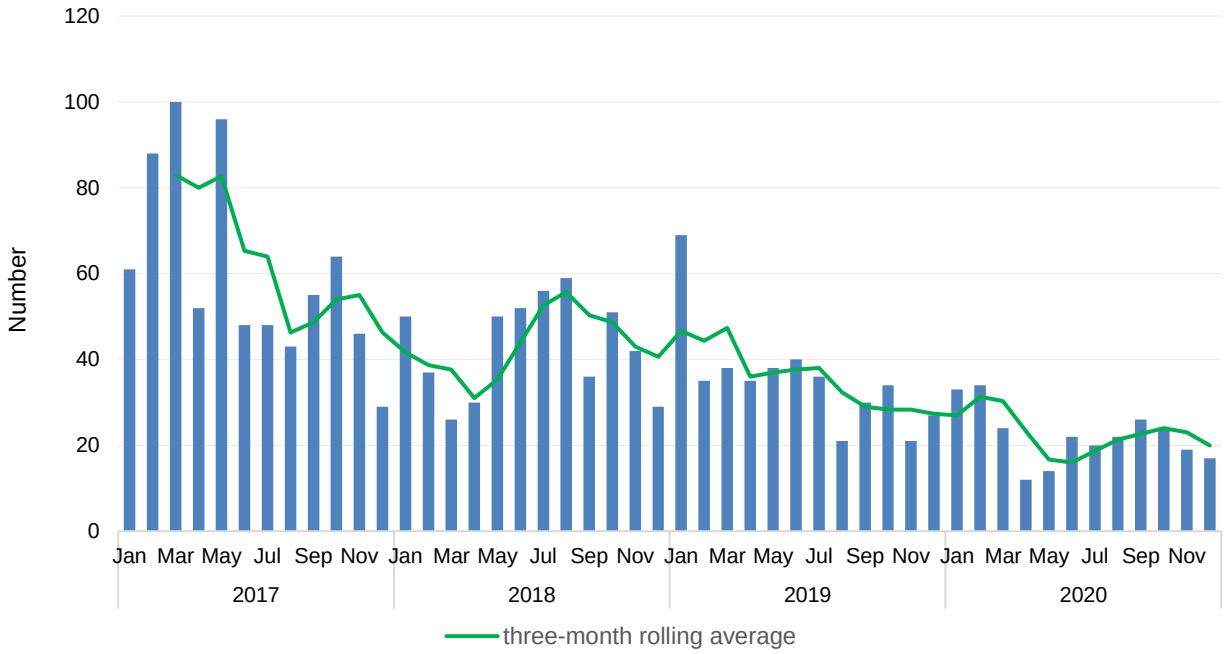
There was one report of an azithromycin non-susceptible (high-level) *N. gonorrhoeae* from Queensland.

Figure 17: Ceftriaxone-nonsusceptible and/or azithromycin-nonsusceptible (high-level) *Neisseria gonorrhoeae,* number reported by month, 2017–2020



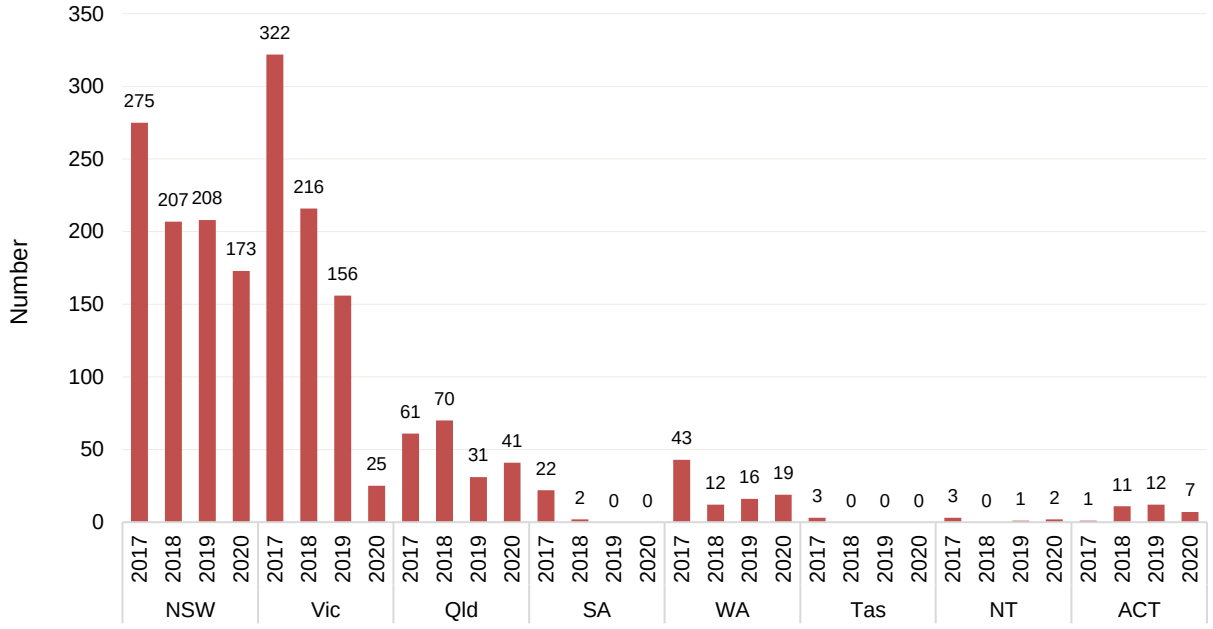
Low-level = azithromycin MIC < 256 mg/L; High-level = azithromycin MIC ≥ 256 mg/L

Figure 18: Azithromycin-nonsusceptible (low-level) *Neisseria gonorrhoeae,* number reported by month, 2017–2020



Low-level = azithromycin MIC < 256 mg/L

Figure 19: Azithromycin-nonsusceptible (low-level) *Neisseria gonorrhoeae,* number reported by state and territory, 2017–2020



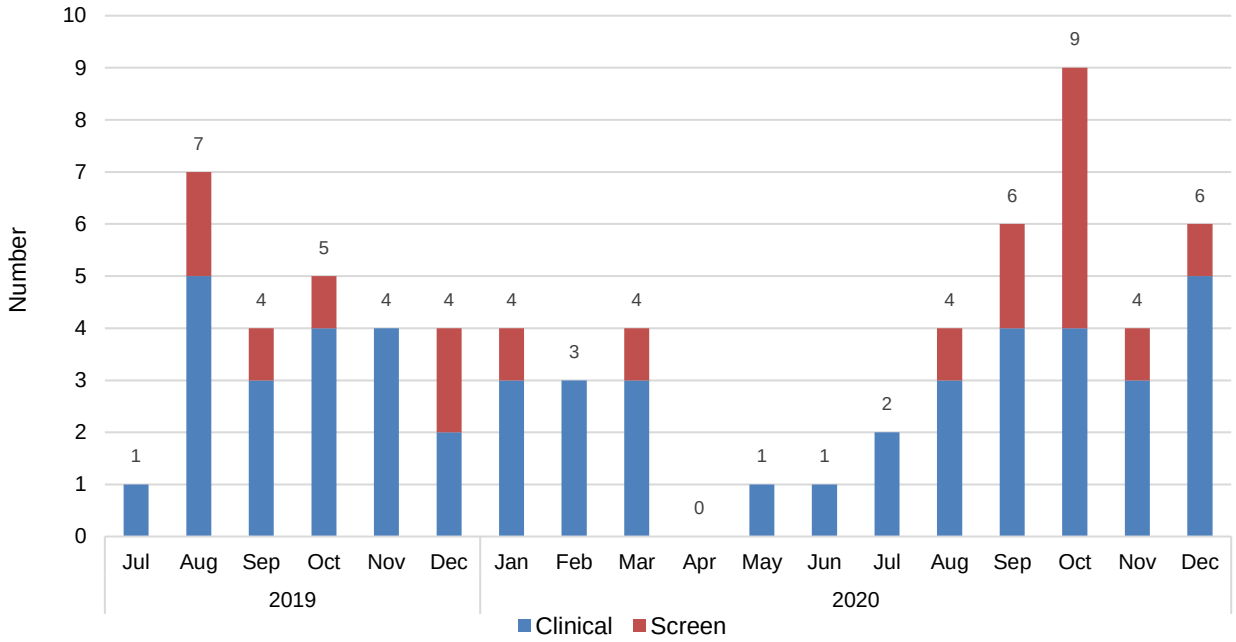
Low-level = azithromycin MIC < 256 mg/L

Pseudomonas aeruginosa

Reporting for carbapenemase-producing *P. aeruginosa* began in July 2019. Forty-four carbapenemase-producing *P. aeruginosa* were reported during 2020 from all jurisdictions except the Northern Territory (Figures 20 and 21). Seventy percent were either GES [*n* = 24] or VIM [*n* = 10] types. VIM-types dominated the reports from Victoria (8/12 (67%), and one AIM-producing *P. aeruginosa* was reported from South Australia.

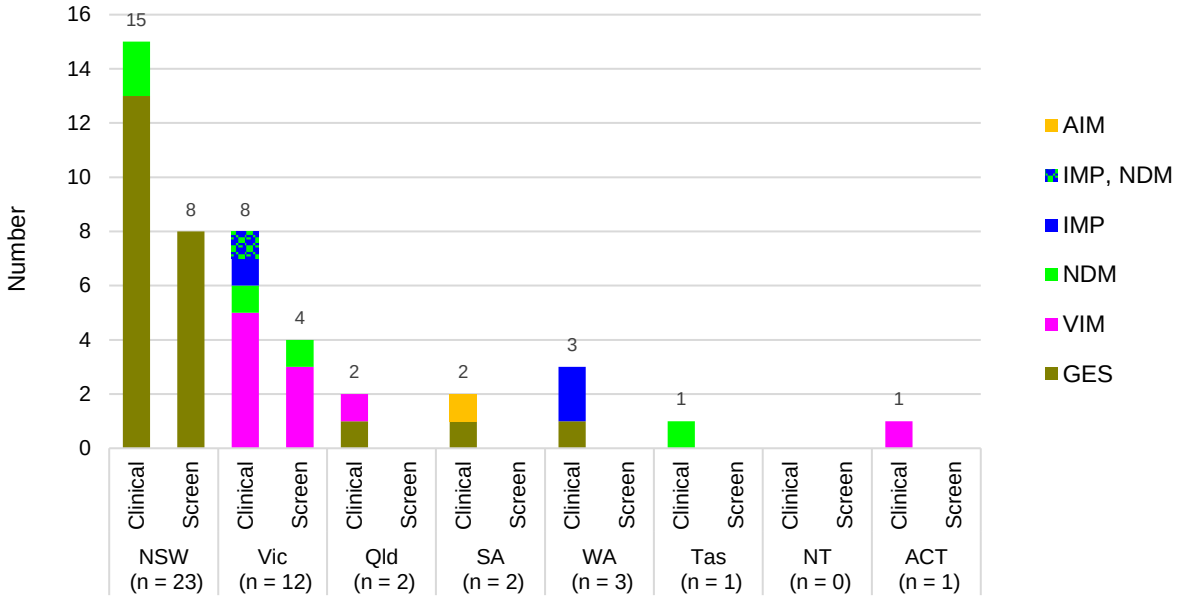
Where setting was known, 82% (32/39) of carbapenemase-producing *P. aeruginosa* were reported from hospitals (Table 5).

Figure 20: Carbapenemase-producing *Pseudomonas aeruginosa*, number reported by specimen type, 2020



Note: New CAR reported from July 2019

Figure 21: Carbapenemase-producing *Pseudomonas aeruginosa*, number reported by carbapenemase type and specimen type, by state and territory, 2020



Note: New CAR reported from July 2019

Table 5: Carbapenemase-producing *Pseudomonas aeruginosa*, number reported by setting and state and territory, 2020

	State or territory								
Setting	**NSW**	**Vic**	**Qld**	**SA**	**WA**	**Tas**	**NT**	**ACT**	**Total**
Total	**23**	**12**	**2**	**2**	**3**	**1**	**0**	**1**	**44**
Public hospitals	16	8	0	2	1	0	0	1	28
Private hospitals	3	1	0	0	0	0	0	0	4
Aged care homes	0	1	0	0	0	0	0	0	1
Community	2	1	1	0	1	1	0	0	6
Unknown	2	1	1	0	1	0	0	0	5

Note: New CAR reported from July 2019

Salmonella species

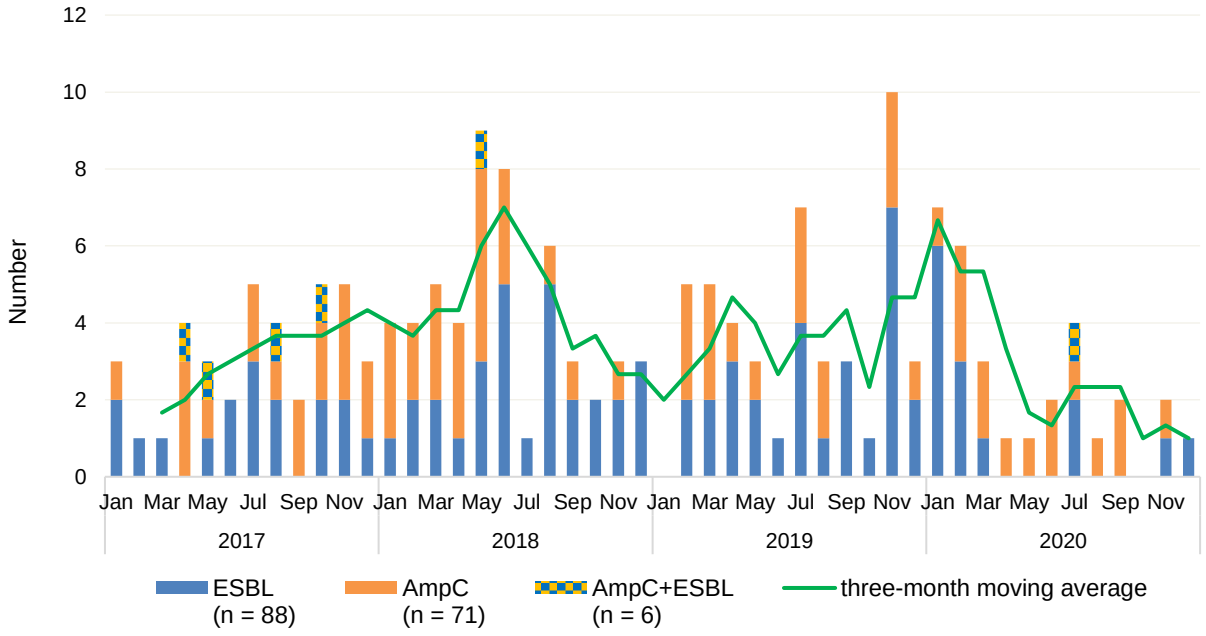
The number of reports of ceftriaxone-nonsusceptible *Salmonella* species decreased in 2020 compared to 2019 (*n* = 30 versus *n* = 45) (Figure 22). These reductions were mainly due to decreases in reports from New South Wales (*n* = 18 versus *n* = 8) and Western Australia *n* = 3 versus *n* = 9) (Figure 23). There were no reports from Tasmania, the Northern Territory, and the Australian Capital Territory.

Over 86% of ceftriaxone non-susceptible *Salmonella* reports were from non-typhoidal species (26/30). Four typhoidal species were reported from New South Wales (from three patients); one patient attended two different institutions.

The ceftriaxone-nonsusceptible *Salmonella* species contained a plasmid-mediated AmpC (pAmpC) (15/30, 50%), ESBL (14/30, 47%), or both ESBL and pAmpC (1/30). ESBL types dominated reports from all jurisdictions except for Queensland, where 75% (9/12) of reports were pAmpC. Where the variant was known, the ESBLs were CTX-M types, and pAmpC were all CMY.

Reports from public hospitals are likely due to admissions associated with severe disease acquired in the community (Table 6).

Figure 22: Ceftriaxone-nonsusceptible *Salmonella* species*, number reported by month, 2017–2020



* Non-typhoidal *Salmonella* species (*n* = 155) and typhoidal *Salmonella* species (*n* = 10)

Figure 23: Ceftriaxone-nonsusceptible *Salmonella* species, number reported by state and territory, 2017–2020

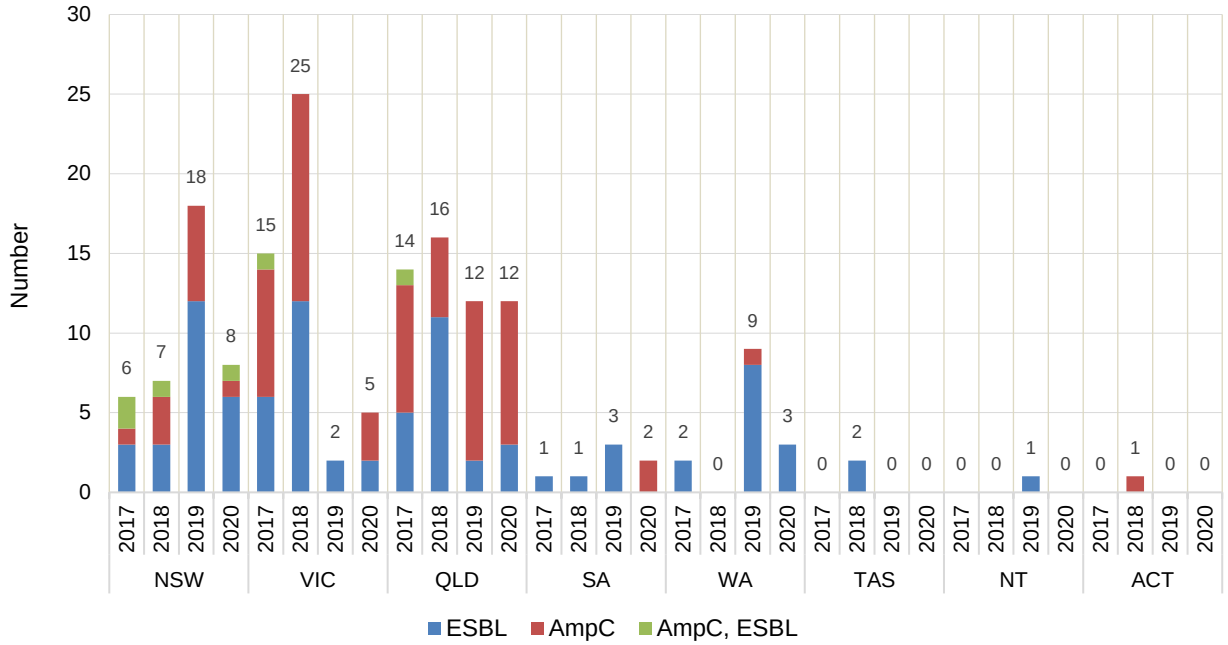


Table 6: Ceftriaxone-nonsusceptible *Salmonella* species, number reported by setting, state and territory, 2020

	State or territory								
Setting	**NSW**	**Vic**	**Qld**	**SA**	**WA**	**Tas**	**NT**	**ACT**	**Total**
Total	**8**	**5**	**12**	**2**	**3**	**0**	**0**	**0**	**30**
Public hospital	6	1	7	0	0	0	0	0	14
Private hospital	0	1	0	0	0	0	0	0	1
Aged care home	0	0	0	0	0	0	0	0	0
Community	2	2	2	2	0	0	0	0	8
Unknown	0	1	3	0	3	0	0	0	7

Shigella species

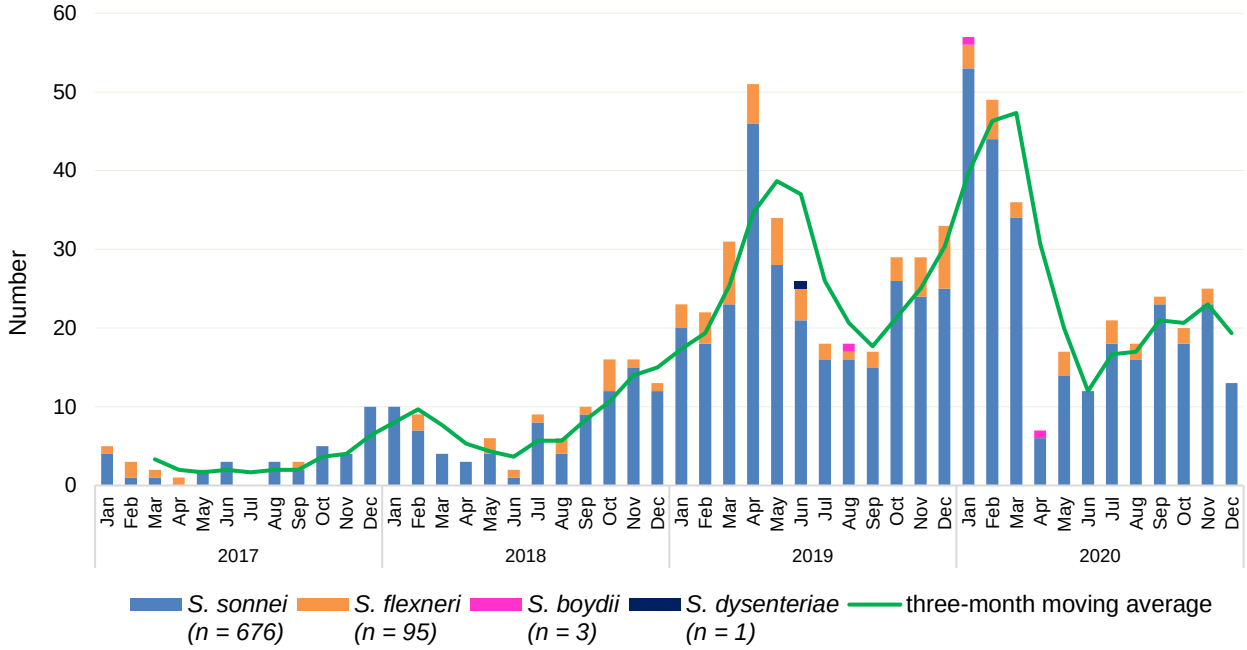
In 2020, the vast majority of multidrug-resistant *Shigella* species were reported from New South Wales (*n* = 171, 57%), Victoria (*n* = 57, 19%), and Queensland (*n* = 47, 16%) (Figure 24 and 25). Most (>86%) were *S. sonnei* in all regions except in Queensland and Western Australia, where *S. flexneri* comprised 1 in 5 of all reports. There were two reports of *S. boydii* from Victoria. There were no reports from Tasmania or the Australian Capital Territory in 2020.

Reports of multidrug-resistant *Shigella* species increased from 2017 to 2019, with a peak in numbers in April 2019 (75% from Victoria), and another in January 2020 (61% from New South Wales). There was a notable decline in reports in April 2020. Reports from New South Wales increased in 2020 compared to 2019 (*n* = 171 versus *n* = 58, up 195%), and from Western Australia (*n* = 20 versus *n* = 7, up 186%). However, there was a decrease in reports from Victoria (57 versus 185, down 69%) and from Queensland (*n* = 47 versus *n* = 65, down 28%) (Figure 25).

The proportion of shigellosis notifications that were MDR increased in 2020 compared to 2019, most notably in New South Wales, Western Australia, and Queensland Figure 26).

National data

Figure 24: Multidrug-resistant *Shigella* species, number reported by month, 2017–2020



State and territory

Figure 25: Multidrug-resistant *Shigella* species, number reported by state and territory, 2017–2020

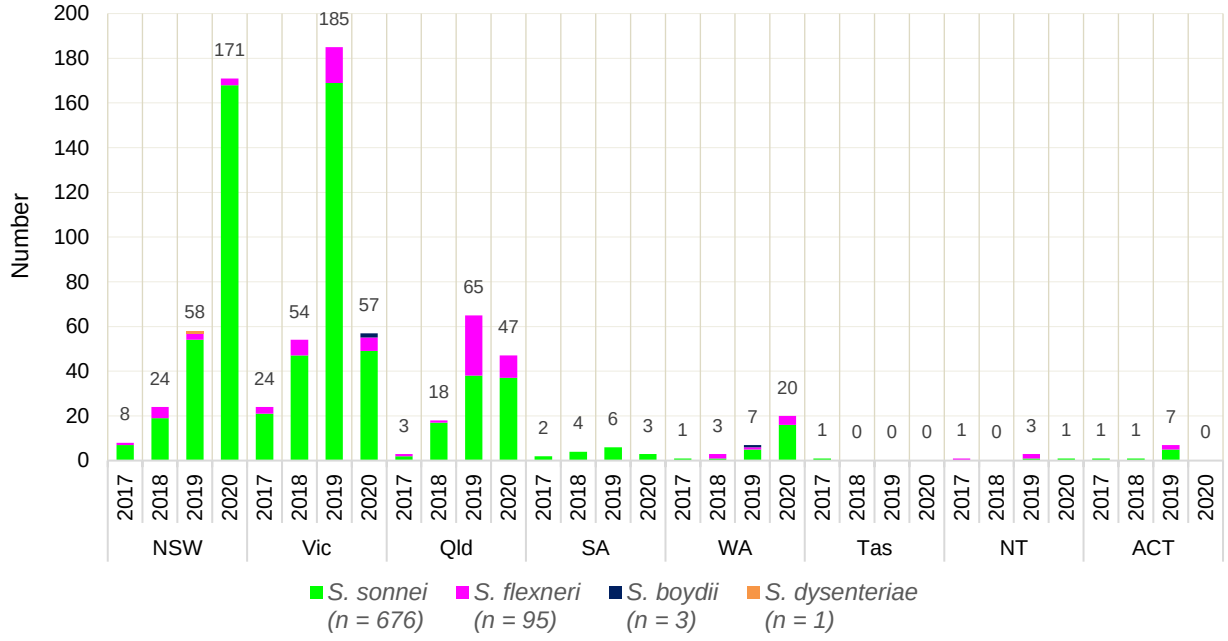
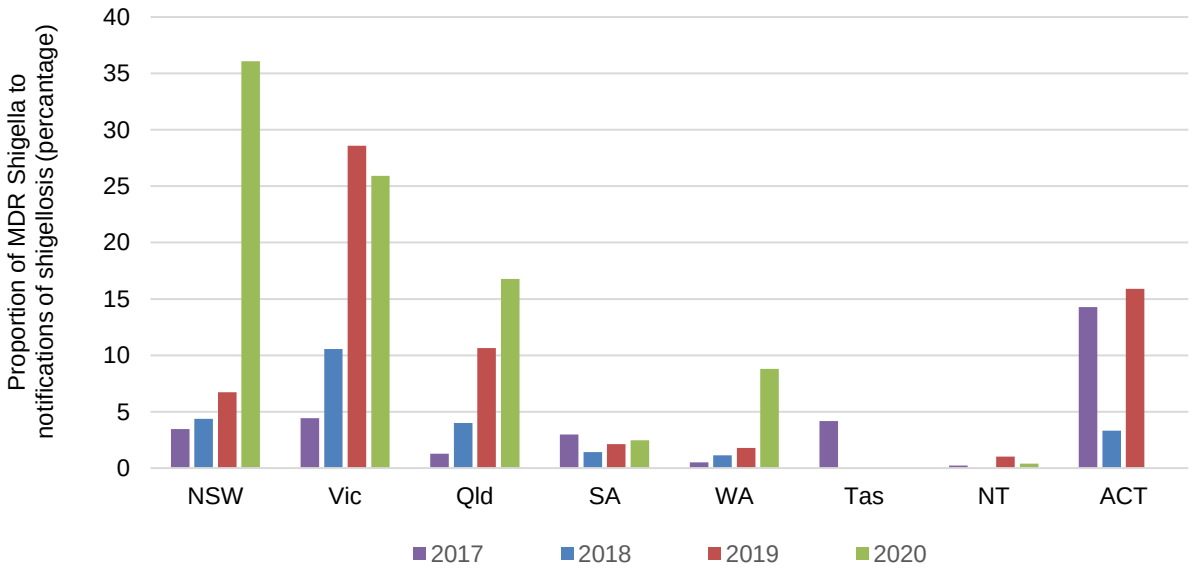


Table 7: Multidrug-resistant *Shigella* species, number reported by setting, state and territory, 2020

Setting	State or territory								Total
	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
Total	**171**	**57**	**47**	**3**	**20**	**0**	**1**	**0**	**299**
Public hospitals	68	17	5	0	3	0	0	0	93
Private hospitals	0	0	1	0	0	0	0	0	1
Aged care homes	0	0	0	0	0	0	0	0	0
Community	98	1	32	3	12	0	0	0	146
Unknown	5	39	9	0	5	0	1	0	59

Figure 26: Multidrug-resistant *Shigella* species and notifications of shigellosis, proportion reported by state and territory, 2017–2020



Note: Notifications of shigellosis may include diagnosis by PCR only

Source: National Notifiable Diseases Surveillance System[7]

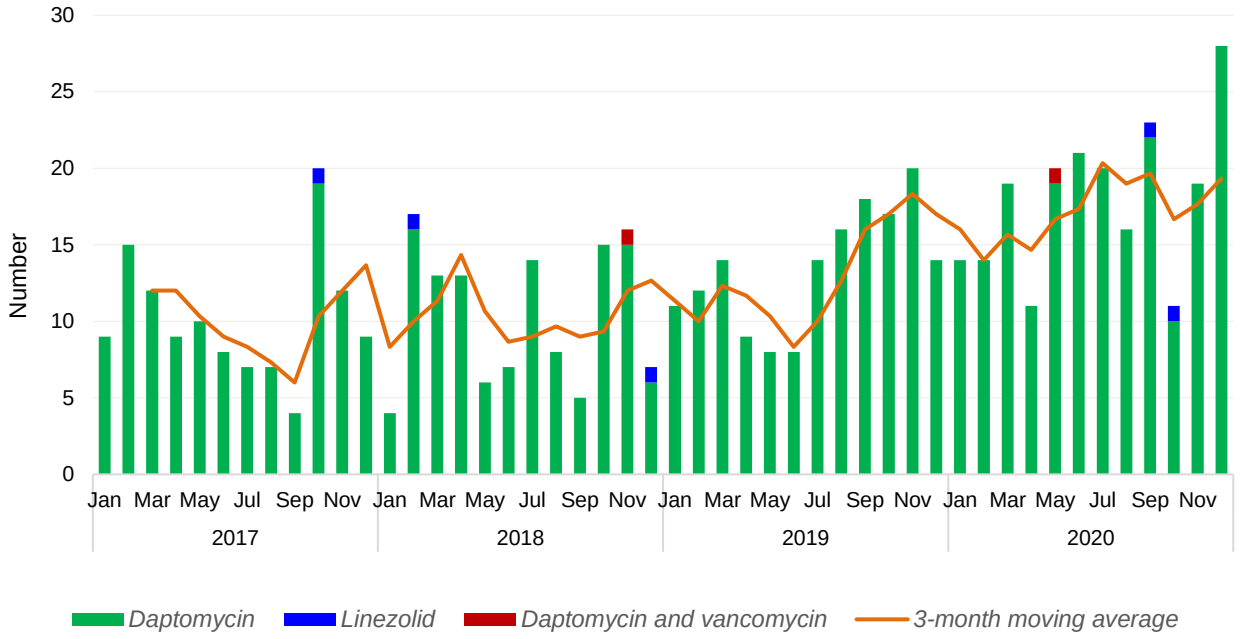
Staphylococcus aureus

From 2017 to 2020, there has been a 1.8-fold increase in the number of vancomycin-, linezolid- or daptomycin-nonsusceptible *S. aureus* (Figure 27). From 2017 to 2019 reports from Victoria dominated (33% in 2017, 43% in 2018, 33% in 2019); however, in 2020, 50% of all reports were from Queensland (Figure 28). Almost all were daptomycin non-susceptible.

The total number of reports of daptomycin non-susceptible *S. aureus* increased in 2020 (*n* = 213, up 32% compared to 2019). There was an increase in the numbers from Queensland (*n* = 106 versus *n* = 42, up 152%) and New South Wales (*n* = 43 versus *n* = 27, up 59%) compared 2019; however, reports from Victoria decreased (*n* = 27 versus *n* = 53, down 49%). In 2020, where setting was known, reports from Queensland were predominantly from the community (34/85, 40%), aged care homes (25/85, 29%), and private hospitals (24/85, 28%) (Table 8). This may be due to differences in routine testing and report practices by originating laboratories for this CAR.

National data

Figure 27: Vancomycin-, linezolid- or daptomycin-nonsusceptible *Staphylococcus aureus,* number reported by month, 2017–2020



Note: No vancomycin-nonsusceptible *S. aureus* were reported from 2017 to 2020

State and territory

Figure 28: Vancomycin-, linezolid- or daptomycin-nonsusceptible *Staphylococcus aureus,* number reported, 2017–2020

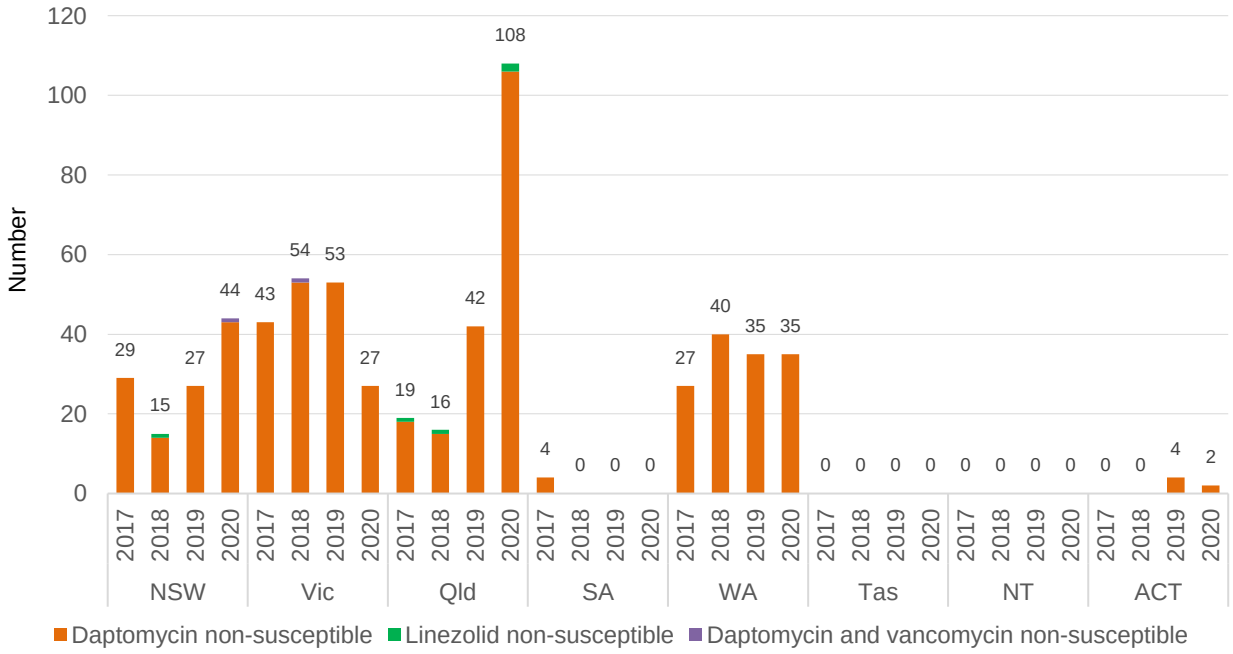


Table 8. Daptomycin-nonsusceptible *Staphylococcus aureus,* number reported by setting and state and territory, 2020

	State or territory								
Setting	**NSW**	**Vic**	**Qld**	**SA**	**WA**	**Tas**	**NT**	**ACT**	**Total**
Total	**43**	**27**	**106**	**0**	**35**	**0**	**0**	**2**	**213**
Public hospital	20	12	2	0	30	0	0	2	66
Private hospital	2	0	24	0	1	0	0	0	27
Aged care home	9	1	25	0	0	0	0	0	35
Community	6	13	34	0	3	0	0	0	56
Unknown	6	1	21	0	1	0	0	0	29

Streptococcus pyogenes

No *S. pyogenes* with reduced susceptibility to penicillin were reported from 2017 to 2020.

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Appendix 1 About CARAlert

CARAlert was established by the Australian Commission on Safety and Quality in Health Care (the Commission) in March 2016 as a component of the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System. Participating confirming laboratories submit data to CARAlert on priority organisms with critical resistance to last-line antimicrobial agents (CARs). No patient-level data are held in the CARAlert system. Funding for AURA is provided by the Australian Government Department of Health, with contributions from the states and territories.

In 2020, 28 confirming laboratories participated in CARAlert. CARAlert generates a weekly summary email alert to report information on confirmed CARs to state and territory health authorities, the Australian Government Department of Health and confirming laboratories. The CARAlert system is based on routine processes used by pathology laboratories for identifying and confirming potential CARs. Information on CARAlert processes is in Appendix 1. Notes on considerations for interpreting CARAlert data are in Appendix 2.

CARAlert data support timely responses to CARs by hospitals, and state and territory health departments. Some states have made selected CARs, such as carbapenemase-producing *Enterobacterales* (CPE) and *Candida auris*, notifiable either using their public health legislation or by policy. Some states and territories have standalone systems for monitoring selected CARs, which complement CARAlert, but these are not widespread. Over time, CARAlert data will become increasingly useful to inform a broader range of safety and quality improvement programs.

The CARs reported under CARAlert are listed in Table 1. These CARs were drawn from the list of high-priority organisms and antimicrobials which are the focus of the AURA Surveillance System.

The AURA National Coordination Unit reviewed CARAlert in 2018, in conjunction with relevant experts, and the states and territories. The review identified four new CARs that were reported to CARAlert from July 2019:

- Transferrable resistance to colistin in *Enterobacterales*
- Carbapenemase-producing *Acinetobacter baumannii* complex
- Carbapenemase-producing *Pseudomonas aeruginosa*
- *Candida auris*, which is a multidrug-resistant yeast that has caused outbreaks in multiple countries.

Table 1: List of critical antimicrobial resistances reported to CARAlert

Species	Critical Resistance
Acinetobacter baumannii complex	Carbapenemase-producing*
*Candida auris**	–
Enterobacterales	Carbapenemase-producing, and/or ribosomal methyltransferase-producing
Enterobacterales	Transmissible colistin resistance*
Enterococcus species	Linezolid resistant
Mycobacterium tuberculosis	Multidrug-resistant – resistant to at least rifampicin and isoniazid
Neisseria gonorrhoeae	Ceftriaxone non-susceptible or azithromycin non-susceptible
Salmonella species	Ceftriaxone non-susceptible
Shigella species	Multidrug-resistant
Staphylococcus aureus†	Vancomycin, linezolid or daptomycin non-susceptible
Streptococcus pyogenes	Penicillin reduced susceptibility
Pseudomonas aeruginosa	Carbapenemase-producing*

* Reported from July 2019

† For CARAlert, *S. aureus* includes *S. argenteus*

Appendix 2 CARAlert reporting processes

All of the following criteria must be met for organisms and resistances to be categorised as a CAR for reporting to CARAlert:

- Inclusion as a priority organism for national reporting as part of the AURA Surveillance System
- A serious threat to last-line antimicrobial agents
- Strongly associated with resistance to other antimicrobial classes
- At low prevalence in, or currently absent from, Australia and potentially containable
- Data not otherwise collected nationally in a timely way.

The CARAlert system is based on the following routine processes used by pathology laboratories for identifying and confirming potential CARs:

- Collection and routine testing – the isolate is collected from the patient and sent to the originating laboratory for routine testing
- Confirmation – if the originating laboratory suspects that the isolate is a CAR, it sends the isolate to a confirming laboratory that has the capacity to confirm the CAR
- Submission to the CARAlert system – the confirming laboratory advises the originating laboratory of the result of the test, and the originating laboratory reports back to the health service that cared for the patient; the confirming laboratory then submits the details of the resistance and organism to the secure CARAlert web portal.

No patient-level data are held in the CARAlert system. Authorised officers in each state and territory health department can access the CARAlert web portal directly for further information about their jurisdiction, including the name of the public hospital where a patient with a confirmed CAR was cared for, and to extract reports on their data.

CARAlert generates a weekly summary email alert to report information on confirmed CARs to state and territory health authorities, the Australian Government Department of Health and confirming laboratories.

Australian public and private laboratories that have the capacity to confirm CARs were identified through consultation with state and territory health authorities, the Public Health Laboratory Network and AGAR. In 2020, 28 confirming laboratories participated in CARAlert, and there was at least one confirming laboratory in each state and territory. The CARs that each of the confirming laboratories are able to confirm are regularly reviewed.

Appendix 3 Data Notes

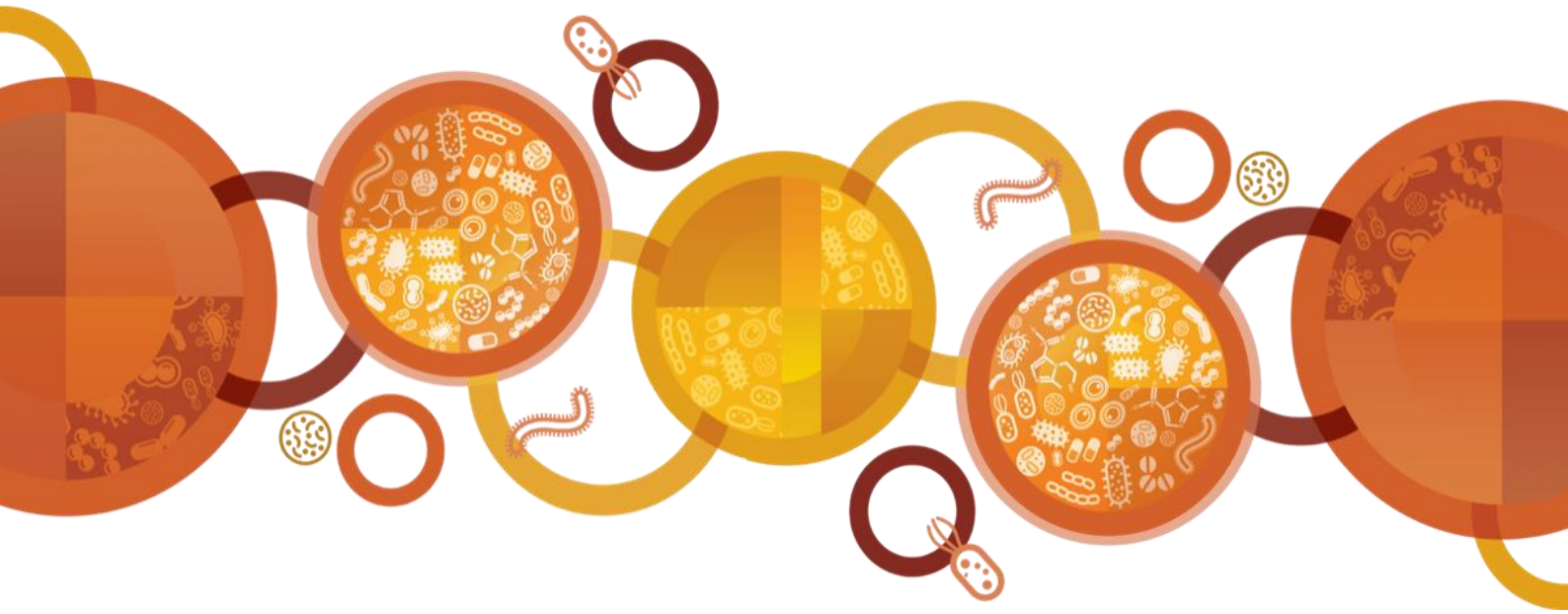
The following are important considerations for interpreting CARAlert data:

1. The data are based on the date that the isolate with the confirmed CAR was collected.
2. States and territories refer to the state or territory where the CAR was detected. If place of residence is unknown or overseas, the state or territory of the originating laboratory is reported.
3. The same CAR/type/species is not submitted where the sample originated from the same patient who had the previous CAR, and the isolate was collected on the same day, or collected in the same admission or within three months.
4. Comparison between reports may be influenced by delayed detection or late submissions of CARs.
5. Number of CARs reported does not always equal the number of patients, as patients may have more than one CAR, or species, detected in a specimen.
6. Cut-off date for data that are included in updates and reports is four weeks after the end of each reporting period.
7. National summary data is provided; comparison across states and territories is provided for organisms where there are large numbers reported and a comparison is meaningful.

Appendix 4 CARAlert confirming laboratories, 2020

The Commission thanks all the originating and confirming laboratories for their support for CARAlert and AURA. The following confirming laboratories contributed to CARAlert in 2020:

State or Territory	Institution
Australian Capital Territory	ACT Pathology, Garran
New South Wales	NSW Health Pathology, Concord Hospital, Concord
	NSW Health Pathology, Liverpool Hospital, Liverpool
	NSW Health Pathology, John Hunter Hospital, New Lambton Heights
	NSW Health Pathology, Royal North Shore Hospital, St Leonards
	NSW Health Pathology, Royal Prince Alfred Hospital, Camperdown
	NSW Health Pathology, St George Hospital, Kogarah
	NSW Health Pathology, The Prince of Wales Hospital, Randwick
	NSW Health Pathology, Westmead Hospital, Westmead
	St Vincent's Pathology (SydPath), Darlinghurst
Northern Territory	Territory Pathology, Tiwi
Queensland	Pathology Queensland, Central laboratory, Royal Brisbane and Women's Hospital, Herston
	Pathology Queensland, Forensic & Scientific Services, Coopers Plains
	QML Pathology, Murarrie
	Sullivan Nicolaides Pathology, Bowen Hills
South Australia	SA Pathology, Royal Adelaide Hospital, Adelaide
Tasmania	Royal Hobart Hospital, Hobart)
Victoria	Alfred Pathology Service, Melbourne
	Austin Pathology, Heidelberg
	Dorevitch Pathology, Heidelberg
	Microbiological Diagnostic Unit Public Health Laboratory, Melbourne
	Victorian Infectious Diseases Reference Laboratory (VIDRL), Melbourne
	Melbourne Pathology, Collingwood
	Monash Pathology, Clayton
	St Vincent's Hospital, Fitzroy
Western Australia	PathWest Laboratory Medicine WA, Fiona Stanley Hospital, Murdoch
	PathWest Laboratory Medicine WA, QEII Medical Centre, Nedlands
	Australian Clinical Labs, Osborne Park



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