AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

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CARAlert THE NATIONAL ALERT SYSTEM FOR CRITICAL ANTIMICROBIAL RESISTANCE

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Note regarding alternative descriptions

No alternative descriptions have been provided. If you need assistance with the structure of any graphs or charts, please email the Australian Commission on Safety and Quality in Health Care at CARAlert@safetyandquality.gov.au.

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Executive 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 2023, and trend data between 2017 and 2023.

There was an overall 85.8% increase in CARs reported between 2022 (*n* = 1,446) and 2023 (*n* = 2,686). Carbapenemase-producing *Enterobacterales* (CPE), which is the most frequently reported CAR to CARAlert, continues to be a concern for 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 very limited, and lengths of stay for hospital admissions may increase.

Implications for health care and patient safety identified by analyses of 2023 CARAlert data include:

- Increasing rates of CPE in Australian hospitals
- Increases in the community-onset CARs, including multidrug-resistant (MDR) *Shigella* species and *Salmonella* species, corresponding with the easing of travel restrictions associated with the COVID-19 pandemic, and changes in resistance patterns for *Neisseria gonorrhoeae*
- Ongoing reports of low levels of CARs in aged care home residents
- Ongoing implications for increased health service demand and complexity of care due to CARs.

What will be done to improve patient safety?

In response to the issues identified in analyses of CARAlert data between 2017 and 2023, the Australian on Safety and Quality in Health Care will continue to:

- Monitor CARs reported to CARAlert, maintain the CARAlert system and communicate CARAlert and other Antimicrobial Use and Resistance in Australia (AURA) surveillance data and key findings to states, territories, the Department of Health and Aged Care and relevant experts
- Maintain the currency of and promote compliance with the *Australian Guidelines for the Prevention and Control of Infection in Healthcare*[1] as required by the National Safety and Quality Health Service (NSQHS) Standards[2], and relevant local guidance for the response to CPE
- Maintain the currency of and promote implementation of guidance for specific organisms, such as the *Recommendations for the control of carbapenemase-producing* Enterobacterales *(CPE): A guide for acute care health service organisations*[3] and promote consistency of screening and infection prevention and control practices, and outbreak responses to improve CPE containment
- Use CARAlert and other AURA data to refine and strengthen approaches to infection prevention and control and antimicrobial stewardship (AMS), and support implementation of the NSQHS Standards[2], the National Safety and Quality Primary and Community Healthcare Standards[4] and the AMS Clinical Care Standard[5]
- Liaise with the Aged Care Quality and Safety Commission and aged care provider organisations and develop resources to support implementation of infection prevention and control programs in aged care homes to meet the requirements of the Aged Care Quality Standards, particularly the strengthened Aged Care Clinical Standard[6]
- Support collaboration between the states and territories and hospital and community care settings to prevent and control CARs
- Prepare analyses of antimicrobial resistance data for and liaise with Therapeutic Guidelines Limited, the organisation that develops guidance on antimicrobial prescribing in Australia.

National overview of key findings: 2023 compared to 2022

- CPE (including those with ribosomal methyltransferase or transmissible colistin resistance) was the most frequently reported CAR (1,205/2,686, 44.9%) in 2023, followed by azithromycin-nonsusceptible *N. gonorrhoeae* (low-level resistance [LLR], minimum inhibitory concentration [MIC] < 256 mg/L) (669/2,686, 24.9%).
- The total number of CPE (either alone or in combination with other CARs) reported in 2023, compared to 2022, increased by 45.4% (*n* = 1,205 in 2023; *n* = 829 in 2022). The increase was mostly seen in Victoria (*n* = 356 in 2023; *n* = 200 in 2022, up 78.0%), New South Wales (NSW) (*n* = 524 in 2023; *n* = 299 in 2022, up 75.3%).
- The total number of *N. gonorrhoeae* reports in 2023 more than quadrupled compared to 2022 (*n* = 713 in 2023; *n* = 159 in 2022, up 448%). Of these reports, 22 were ceftriaxone-nonsusceptible (MIC ≥ 0.125 mg/L) and 27 were azithromycin-nonsusceptible (high-level resistance, MIC ≥ 256 mg/L). The remaining *N. gonorrhoeae* reports were azithromycin-nonsusceptible (LLR, MIC < 256 mg/L).
- The number of reports of carbapenemase-producing *Pseudomonas aeruginosa* (*n* = 75 in 2023; *n* = 57 in 2022) and carbapenemase-producing *Acinetobacter baumannii* complex (*n* = 37 in 2023; *n* = 23 in 2022) increased compared to the numbers reported in 2022.
- There was a 4.7-fold increase in the overall number of reports of MDR *Shigella* species (*n* = 469 in 2023; *n* = 99 in 2022). There was a 10-fold increase in South Australia (*n* = 21 in 2023; *n* = 2 in 2022), and more than 5-fold increases in Victoria (*n* = 202 in 2023; *n* = 37 in 2022), NSW (*n* = 178 in 2023; *n* = 32 in 2022) and Western Australia (*n* = 30 in 2023; *n* = 5 in 2022).
- There was an increase in the number of ceftriaxone-nonsusceptible *Salmonella* species (*n* = 95 in 2023; *n* = 15 in 2022, up 86.3%). There were 13 (13.7%) typhoidal species reported in 2023.
- There were 14 reports of MDR *Mycobacterium tuberculosis* in 2023, compared to 16 reports in 2022.
- There were 17 reports of *Candida auris* in 2023, from five states. In 2022 there were nine reports.
- Where the setting was known, the majority of CARs were reported from hospitals (1,387/2,244, 61.8%). There were 849 (37.8%) CARs reported from community settings, and eight (0.4%) from aged care homes.

Results from CARAlert, 2023

Information about the National Alert System for Critical Antimicrobial Resistances (CARAlert), and methods used for the analyses presented in this report are included in Appendices 1 and 2.

Between 1 January 2023 and 31 December 2023, a total of 2,686 critical antimicrobial resistances (CARs) from 72 originating laboratories across Australia were entered into CARAlert by 23 of the 26 confirming laboratories nationally that participate in CARAlert (Appendix 3). There was an average of 224 entries per month.

Critical antimicrobial resistances by state and territory

Most CARs were reported for patients who lived in the most populous states (New South Wales [NSW], *n* = 958, 35.7%; Victoria, *n* = 1,103, 41.1%; Queensland, *n* = 299, 11.1%). There were fewer than 20 reports from the Northern Territory (NT) and the Australian Capital Territory (ACT) and less than 10 reports from Tasmania (Table 1).

Carbapenemase-producing *Enterobacterales* (CPE) (including those with ribosomal methyltransferase or transmissible resistance to colistin) was the most frequently reported CAR (1,205/2,686, 44.9%) in 2023. Compared to 2022 (*n* = 829), there was a 45.4% increase in overall reports of CPE in 2023; the greatest increase was seen in Victoria (*n* = 356 in 2023; *n* = 200 in 2022, up 78.0%) and NSW (*n* = 524 in 2023; *n* = 299 in 2022, up 75.3%).

In 2023, the number of azithromycin-nonsusceptible *Neisseria gonorrhoeae* (low-level resistance [LLR], minimum inhibitory concentration [MIC] < 256 mg/L) reports increased by almost 6-fold (*n* = 669 in 2023; *n* = 114 in 2022). The greatest increase was seen in NSW (*n* = 157 in 2023; *n* = 9 in 2022, up 17.4-fold). There was an increase in reports of this CAR in SA (*n* = 17 in 2023; *n* = 2 in 2022, up 8.5-fold and Victoria (*n* = 415 in 2023; *n* = 57 in 2022, up 7.3-fold). There were no reports from the NT or the ACT.

Ceftriaxone-nonsusceptible and azithromycin-nonsusceptible (high-level resistance [HLR], MIC ≥ 256 mg/L) *N. gonorrhoeae* were reported for the first time in 2023 (*n* = 5 from Victoria) since 2018 (*n* = 2 from Queensland).

There was a 4.7-fold increase in the number of multidrug-resistant (MDR) *Shigella* species reported in 2023 (*n* = 469 in 2023; *n* = 99 in 2022). Increases were seen across all states and territories, with the greatest increase seen in reports from South Australia (SA), Western Australia (WA), NSW and Victoria.

Carbapenemase-producing *Pseudomonas aeruginosa* were reported predominantly from NSW (33/75, 44.0%).

There was a 1.9-fold increase in the number of ceftriaxone-nonsusceptible *Salmonella* species reported in 2023 (*n* = 95 in 2023; *n* = 51 in 2022). The greatest increase was in reports from Queensland (*n* = 22 in 2023; *n* = 7 in 2022) and Victoria (*n* = 39 in 2023; *n* = 17 in 2022). Less than 1 in 6 (13/95, 13.7%) of all reports were typhoidal species.

Candida auris was reported from five states, with no reports from Tasmania and the mainland territories.

Enterobacterales with transmissible resistance to colistin (*mcr-1.1*) were reported from SA (*n* = 1) and Victoria (*n* = 1); the isolate from Victoria also harboured $bla_{\text{NDM-1}}$.

Table 1: Number of critical antimicrobial resistances reported to CARAlert, by state and territory, 2023 and 2022

Species	Critical resistance	State or territory, 2023								Year		Relative change*
		NSW	Vic	Qld	SA	WA	Tas	NT	ACT	2022	2023	
Acinetobacter baumannii complex	Carbapenemase-producing	14	5	1	0	6	0	0	1	18	27	▲ 50.0%
	Carbapenemase- and ribosomal methyltransferase-producing	0	7	3	0	0	0	0	0	5	10	▲ 100%
Candida auris	–	1	2	1	4	9	0	0	0	9	17	▲ 88.9%
Enterobacterales	Carbapenemase-producing (alone or in combination with other CARs)	524	356	192	52	59	3	7	12	829	1,205	▲ 45.4%
	Carbapenemase-producing	511	300	180	43	51	3	7	8	782	1,103	▲ 41.0%
	Carbapenemase- and ribosomal methyltransferase-producing	13	55	12	9	8	0	0	4	46	101	▲ 120%
	Carbapenemase-producing and transmissible resistance to colistin	0	1	0	0	0	0	0	0	1	1	0.0
	Ribosomal methyltransferase-producing	2	11	0	1	2	0	0	0	10	16	▲ 60.0%
	Transmissible colistin resistance[†]	0	0	0	1	0	0	0	0	1	1	–
Enterococcus species	Linezolid-resistant	8	20	3	1	5	0	1	1	17	39	▲ 129%
Mycobacterium tuberculosis	Multidrug-resistant – at least rifampicin- and isoniazid-resistant strains	6	5	1	0	0	0	1	1	16	14	▼ 12.5%
Neisseria gonorrhoeae	Azithromycin-nonsusceptible (low-level)[§]	157	415	37	17	42	1	0	0	114	669	▲ 487%
	Azithromycin-nonsusceptible (high-level)[#]	11	8	1	0	2	0	0	0	8	22	▲ 175%
	Ceftriaxone-nonsusceptible	7	1	3	1	2	0	0	0	33	14	▼ 57.6%
	Ceftriaxone-nonsusceptible and azithromycin-nonsusceptible (low-level)[§]	0	3	0	0	0	0	0	0	4	3	▼ 25.0%
	Ceftriaxone-nonsusceptible and azithromycin-nonsusceptible (high-level)[#]	0	5	0	0	0	0	0	0	0	5	–
	Gentamicin-resistant**	0	0	0	0	0	0	0	0	–	0	–
Neisseria meningitidis	Ciprofloxacin-nonsusceptible**	0	4	0	0	0	0	0	0	–	4	–

Continued

Table 1: *continued*

Species	Critical resistance	State or territory, 2023								Year		Relative change*
		NSW	Vic	Qld	SA	WA	Tas	NT	ACT	2022	2023	
Pseudomonas aeruginosa	Carbapenemase-producing	32	18	5	3	9	0	0	0	55	67	▲ 21.8%
	Carbapenemase- and ribosomal methyltransferase-producing	1	2	3	2	0	0	0	0	2	8	▲ 300%
Salmonella species	Ceftriaxone-nonsusceptible	17	39	22	2	15	0	0	0	51	95	▲ 86.3%
Shigella species	Multidrug-resistant	178	202	27	21	30	2	5	4	99	469	▲ 374%
Staphylococcus aureus	Daptomycin-nonsusceptible††	–	–	–	–	–	–	–	–	170	–	–
	Daptomycin- and vancomycin-nonsusceptible	–	–	–	–	–	–	–	–	2	–	–
	Linezolid-nonsusceptible	0	0	0	0	0	0	0	0	3	0	▼ 100%
	Vancomycin-nonsusceptible	0	0	0	0	1	0	0	0	0	1	–
Streptococcus pyogenes	Penicillin reduced susceptibility	0	0	0	0	0	0	0	0	0	0	–
	Total (reported by 1 February 2024)	**958**	**1,103**	**299**	**105**	**182**	**6**	**14**	**19**	**1,446**	**2,686**	**▲ 85.8%**

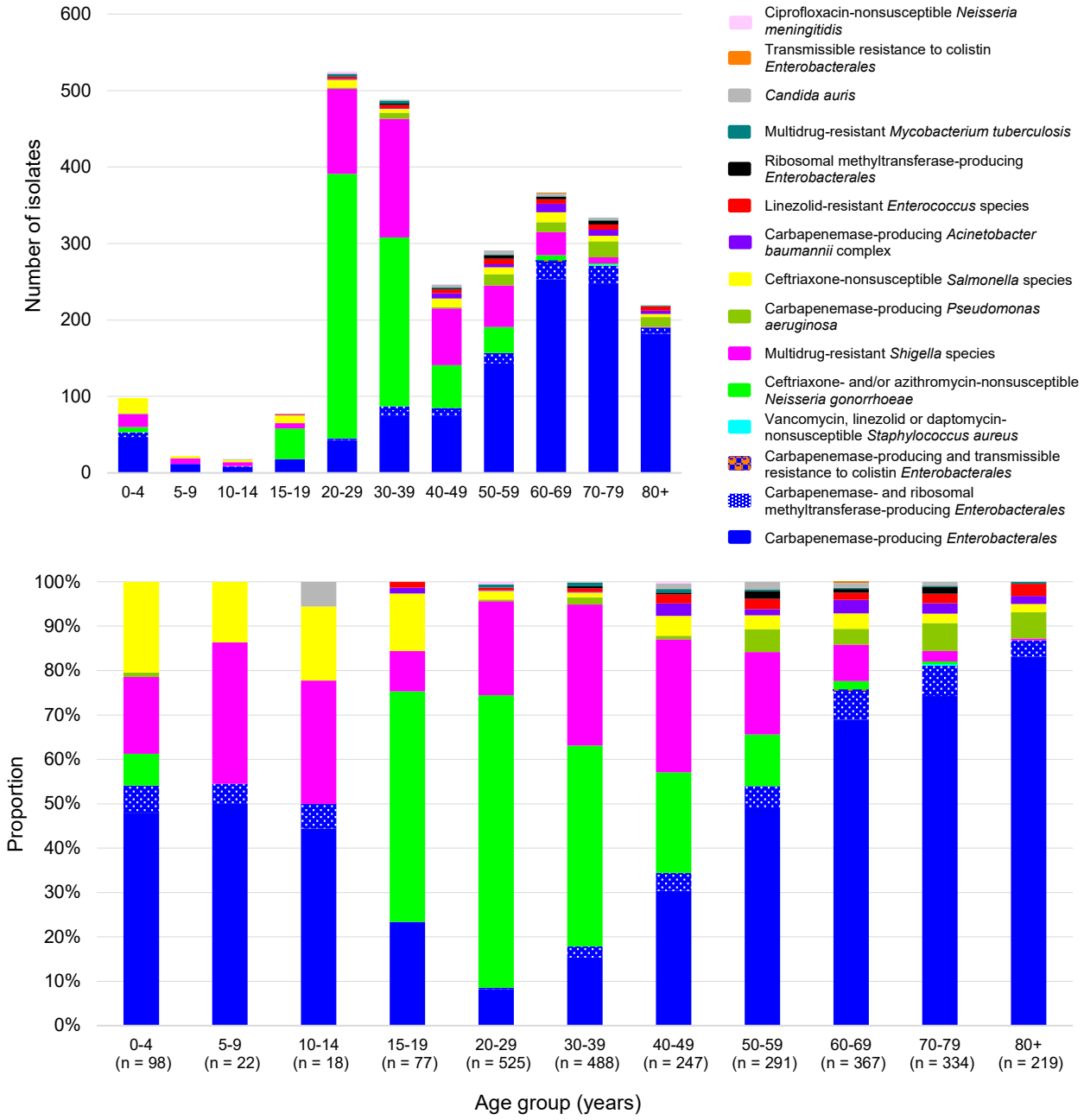
CAR = critical antimicrobial resistance; MIC = minimum inhibitory concentration; ▲ = increase; ▼ = decrease; – = not applicable
* Relative change = absolute change between 2022 and 2023, for each CAR, expressed as a percentage of 2022 base
† When not seen in combination with carbapenemase-producing *Enterobacterales*
§ Azithromycin MIC < 256 mg/L
# Azithromycin MIC ≥ 256 mg/L
** Reported from January 2023
†† Reporting suspended from January 2023

Critical antimicrobial resistances by age group

CARs were isolated from patients of all age groups; the median age was 40–49 years (Figure 1). Almost three-quarters of CPE were isolated from people aged 50 years and older (896/1,205, 74.4%). Most of ceftriaxone- and/or azithromycin-nonsusceptible *N. gonorrhoeae* was reported for people aged 15–59 years (697/713, 97.8%); and 84.0% (394/469) of MDR *Shigella* species were in people aged 20–59 years.

Only 5.1% (138/2,686) of all CARs were reported in children aged less than 15 years; CPE (*n* = 66), MDR *Shigella* species (*n* = 29) and ceftriaxone-nonsusceptible *Salmonella* species (*n* = 26) were most frequently reported for this age group (121/138, 87.7%). For the 0–4-year age group, CPE was the most frequently reported CAR (*n* = 47); followed by ceftriaxone-nonsusceptible *Salmonella* species (*n* = 20), and MDR *Shigella* species (*n* = 17).

Figure 1: Critical antimicrobial resistances reported to CARAlert, by age groups, 2023



Critical antimicrobial resistances by facility type

Where the setting was known, a substantial majority of CARs were detected in either hospitalised patients or hospital outpatients (1,387/2,244, 61.8%). Smaller proportions were isolated in the community (849/2,244, 37.8%) and in aged care homes (8/2,244, 0.4%) (Table 2).

Table 2: Number of critical antimicrobial resistance isolates reported to CARAlert, by setting, national, 2023

Species	Critical resistance	Setting					Total
		Public hospitals	Private hospitals	Aged care homes	Community	Unknown	
Acinetobacter baumannii complex	Carbapenemase-producing	25	1	0	1	0	27
	Carbapenemase- and ribosomal methyltransferase-producing	10	0	0	0	0	10
Candida auris	–	16	1	0	0	0	17
Enterobacterales	Carbapenemase-producing	879	57	7	110	50	1,103
	Carbapenemase and ribosomal methyltransferase-producing	71	2	1	25	2	101
	Carbapenemase-producing and transmissible colistin resistance	0	0	0	0	1	1
	Ribosomal methyltransferase-producing	12	0	0	2	2	16
	Transmissible colistin resistance	1	0	0	0	0	1
Enterococcus species	Linezolid-resistant	30	2	0	3	4	39
Mycobacterium tuberculosis	Multidrug-resistant – at least rifampicin- and isoniazid-resistant	10	0	0	3	1	14
Neisseria gonorrhoeae	Azithromycin-nonsusceptible (low-level)	36	2	0	423	208	669
	Azithromycin-nonsusceptible (high-level)	0	0	0	9	13	22
	Ceftriaxone-nonsusceptible	2	0	0	4	8	14
	Ceftriaxone-nonsusceptible and azithromycin-nonsusceptible (low-level)	0	0	0	1	2	3
	Ceftriaxone-nonsusceptible and azithromycin-nonsusceptible (high-level)	0	0	0	3	2	5
	Gentamicin-resistant	0	0	0	0	0	0
Neisseria meningitidis	Ciprofloxacin-nonsusceptible	0	0	0	4	0	4
Pseudomonas aeruginosa	Carbapenemase-producing	48	3	0	12	4	67
	Carbapenemase- and ribosomal methyltransferase-producing	5	0	0	2	1	8
Salmonella species	Ceftriaxone-nonsusceptible	35	3	0	41	16	95
Shigella species	Multidrug-resistant	127	8	0	206	128	469
*Staphylococcus aureus**	Linezolid-nonsusceptible	0	0	0	0	0	0
	Vancomycin-nonsusceptible	1	0	0	0	0	1
Streptococcus pyogenes	Penicillin reduced susceptibility	0	0	0	0	0	0
Total (reported by 1 February 2024)		**1,308**	**79**	**8**	**849**	**442**	**2,686**

High-level = azithromycin MIC ≥ 256 mg/L; Low-level = azithromycin MIC < 256 mg/L; MIC = minimum inhibitory concentration
* For CARAlert, *S. aureus* complex includes *S. argenteus* and *S. schweitzeri*
Note: Information on setting for *N. gonorrhoeae* is often not available.

CPE accounted for a just over two-thirds of all reports from hospitals (1,009/1,387, 72.7%). In the community, a vast majority of reports were ceftriaxone and/or azithromycin-nonsusceptible *N. gonorrhoeae* (440/849, 51.8%), MDR *Shigella* species (206/849, 24.3%) or CPE (135/849, 15.9%). There were eight reports from aged care homes, all of which were CPE.

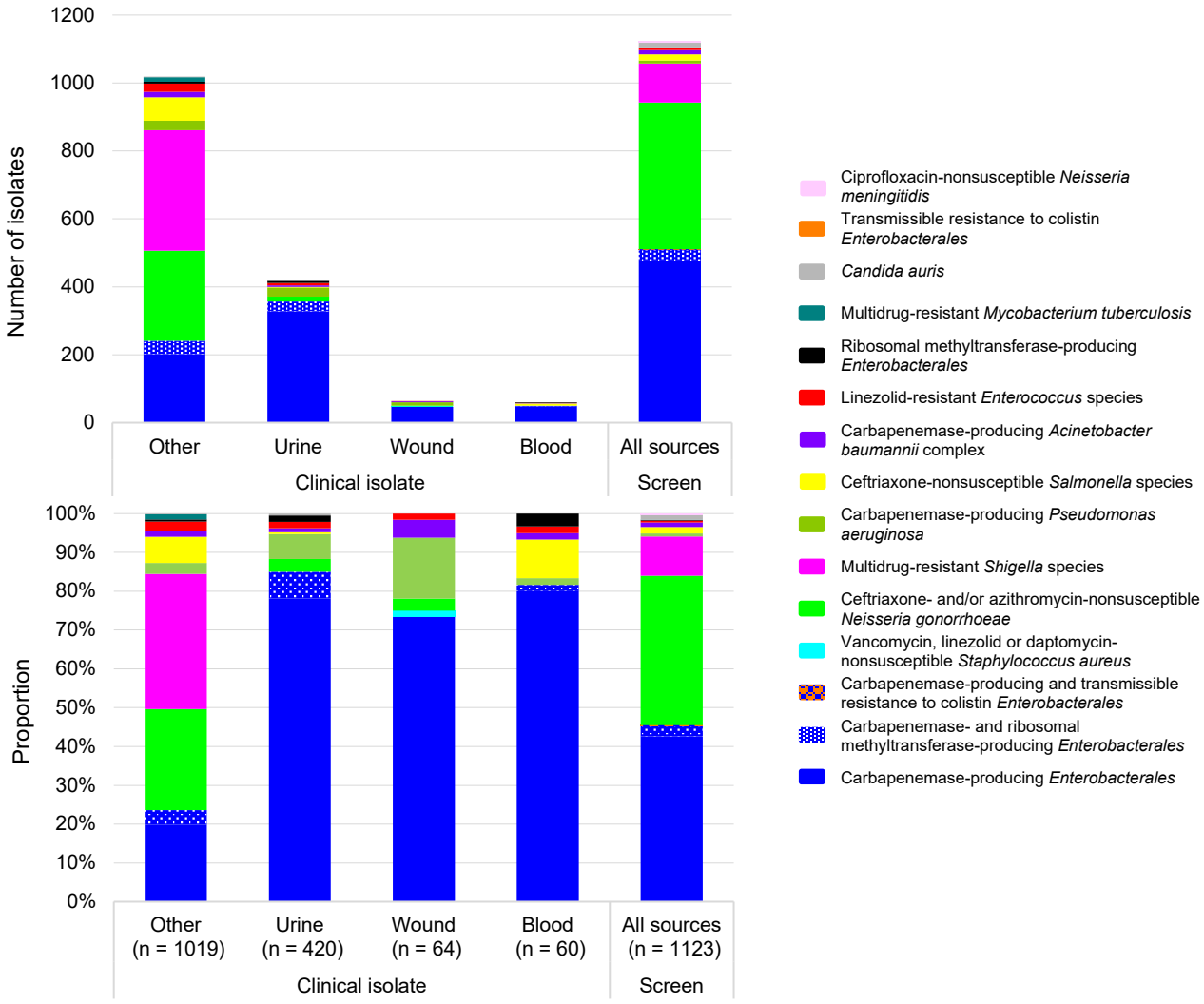
Critical antimicrobial resistances by specimen type

A little over one-half of all CARs reported in 2023 were from clinical specimens (1,563/2,686, 58.2%), which are specimens collected for diagnostic purposes, rather than for screening. These included urine (*n* = 420), wound (*n* = 64), blood (*n* = 60) and other (*n* = 1,019) such as genital or respiratory specimens (Figure 2).

Of CPE reports, 57.6% (694/1,205) were from clinical specimens. Of CPE isolates from clinical specimens, 51.4% (357/694) were from urine – an important specimen for *Enterobacterales* as the urinary tract is a common site of infection. Almost 1 in 15 (49/694, 7.1%) CPE from clinical specimens were from blood cultures. CPE comprised 81.7% (49/60) of all CARs confirmed from blood specimens.

Five other CARs were also reported from blood cultures in 2023: ceftriaxone-nonsusceptible *Salmonella* species (*n* = 6), ribosomal methyltransferase-producing *Enterobacterales* (*n* = 2), carbapenemase-producing *P. aeruginosa* (*n* = 1), carbapenemase-producing *Acinetobacter baumannii* complex (*n* = 1), and linezolid-resistant *Enterococcus* species (*n* = 1).

Figure 2: Critical antimicrobial resistances reported to CARAlert, by specimen type, 2023



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 2017–2023

Data for each CAR for 2023, nationally and by state and territory, are shown in Figures 3 to 29. Trend data for 2017 to 2023 are also presented, where applicable.

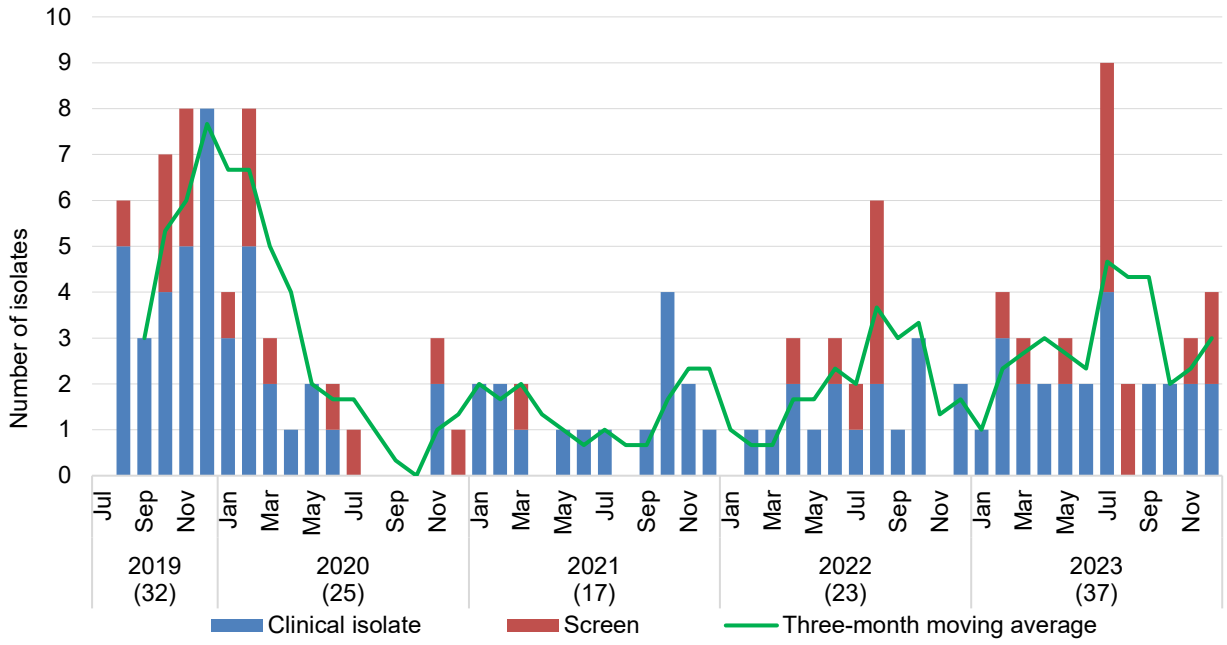
Acinetobacter baumannii complex

A. baumannii complex is a group of environmental organisms that have caused prolonged outbreaks in hospital settings, such as intensive care and severe burns units. *A. baumannii* infections are associated with patients with compromised physical barriers and immunity, most commonly in hospital. The most common infections caused by this species complex are ventilator-associated pneumonia and severe burn infections. Reporting of carbapenemase-producing *A. baumannii* complex to CARAlert began in July 2019.

There were 37 reports of carbapenemase-producing *A. baumannii* complex in 2023, from all states and territories except SA, Tasmania and the NT (Figures 3 and 4). OXA-23-like types were dominant (*n* = 30; alone, *n* = 22). Five NDM types in combination with OXA-23-like and one NDM in combination with GIM were reported. Five OXA-24/40-like types were also reported (alone [4], and in combination with OXA-23-like [1]).

Almost all (36/37, 97.3%) of carbapenemase-producing *A. baumannii* complex were reported from hospitals (Table 3).

Figure 3: Carbapenemase-producing *Acinetobacter baumannii* complex, number reported to CARAlert by specimen type, national, 2019–2023



Note: Reported from July 2019.

Figure 4: Carbapenemase-producing *Acinetobacter baumannii* complex, number reported to CARAlert by carbapenemase type and specimen type, state and territory, 2023

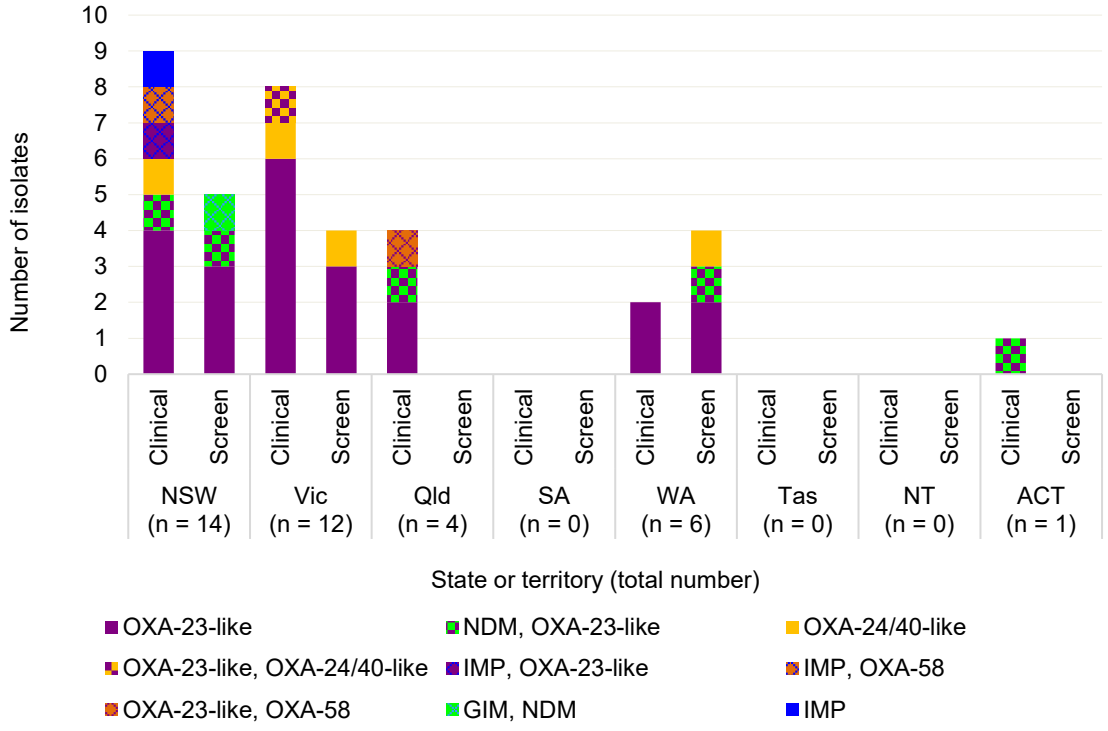


Table 3: Carbapenemase-producing *Acinetobacter baumannii* complex, number reported to CARAlert by setting, state and territory, 2023

Setting	State or territory								Total
	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
Total	**14**	**12**	**4**	**0**	**6**	**0**	**0**	**1**	**37**
Public hospital	14	11	4	0	5	0	0	1	35
Private hospital	0	0	0	0	1	0	0	0	1
Aged care home	0	0	0	0	0	0	0	0	0
Community	0	1	0	0	0	0	0	0	1

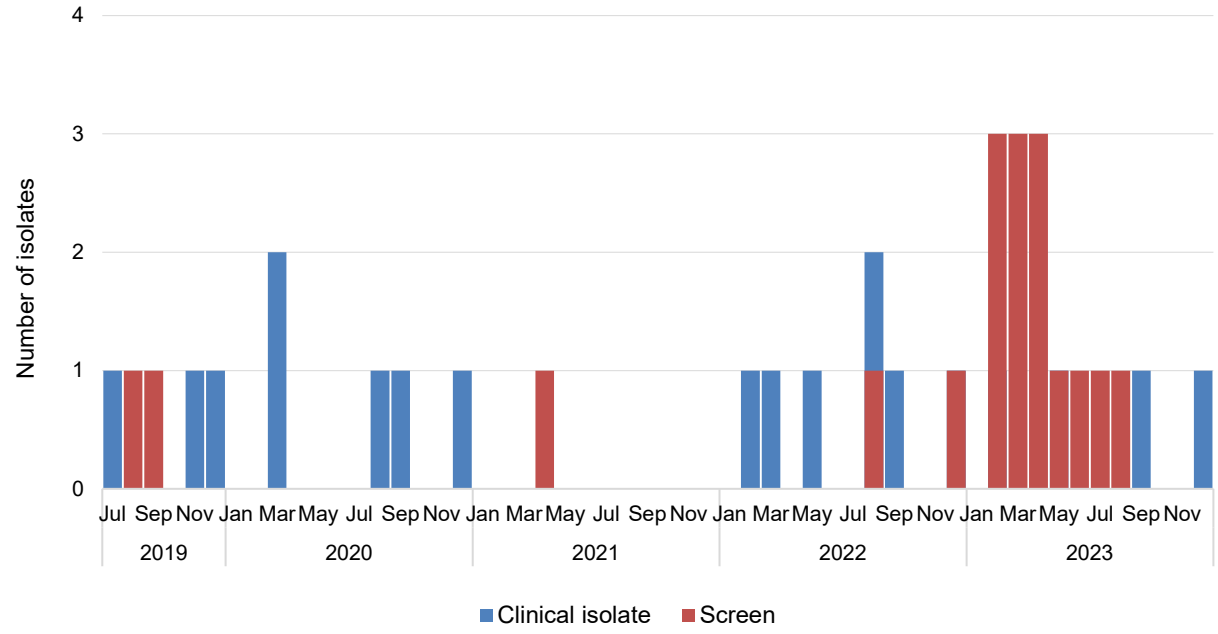
Candida auris

C. auris is an emerging MDR *Candida* species that has been associated with international outbreaks of invasive infections in healthcare facilities. Reporting to CARAlert for *C. auris* began in July 2019.

In 2023, reports of *C. auris* (*n* = 17) increased by 88.9% compared to 2022 (*n* = 9) (Figure 5).

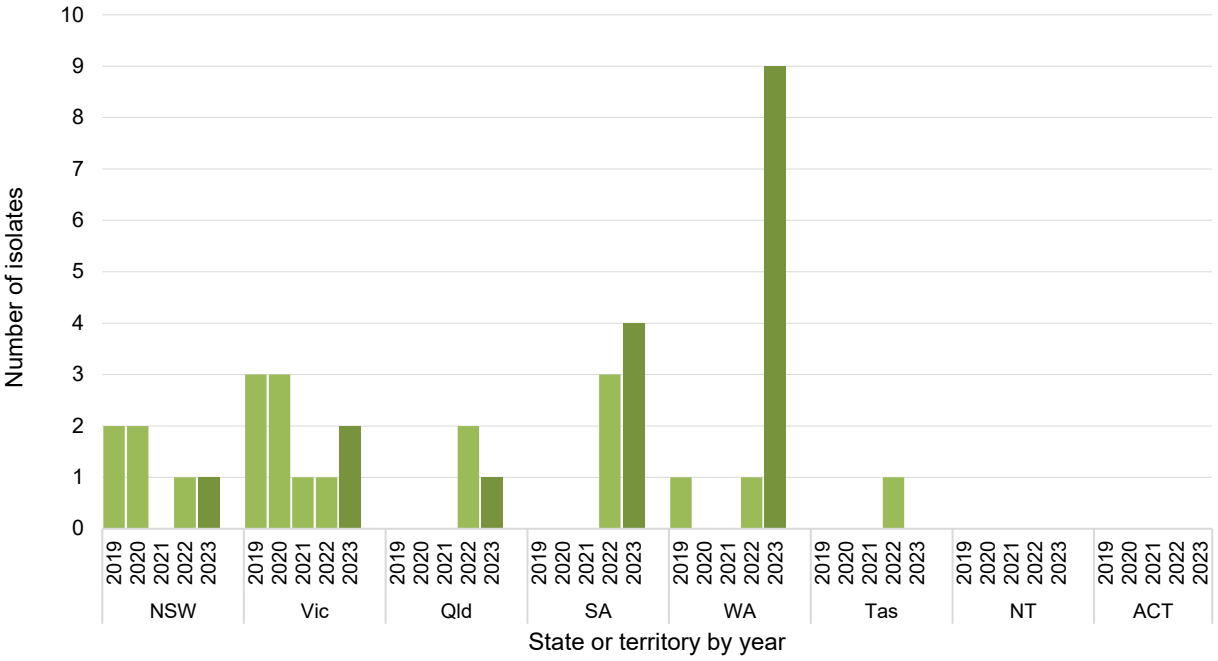
C. auris were reported from all states except Tasmania: nine reports from WA, four reports from SA, two reports from Victoria, and one report each from NSW and Queensland. There were no reports from the ACT or the NT (Figure 6).

Figure 5: *Candida auris,* number reported to CARAlert by month, national, 2019–2023



Note: Reported from July 2019.

Figure 6: *Candida auris*, number reported to CARAlert by state and territory, 2019–2023



Notes:
1. Reported from July 2019.
2. Dark bars indicate values for 2023.

Enterobacterales

Infections of the urinary tract, biliary tract, intra-abdomen, and bloodstream are commonly associated with *Enterobacterales*. Following a gradual decline from 2019 to 2021, there was an increase in the number of reports of carbapenemase- and/or ribosomal methyltransferase-producing *Enterobacterales* in 2022, which continued into 2023 (Figures 7 and 8). There were 1,205 overall reports of CPE in 2023, which was an increase of 45.4% compared to 2022

(*n* = 829); there were 600 reports in 2021. Reports from all states and territories increased or remained stable in 2023 (Figure 11).

Carbapenemases were found in 25 species (12 genera) of *Enterobacterales*, with eight carbapenemase types reported (Figure 9). Three carbapenemase types – IMP (461/1,205, 38.3%), NDM (420/1,205, 34.9%) and OXA-48-like (197/1,205, 16.3%) – when produced alone, accounted for 89.5% (1,078/1,205) of all *Enterobacterales* with a confirmed carbapenemase.

IMP types alone accounted for 38.3% (461/1,205) of all carbapenemases; they were found in 22 different species (Figure 9). *Enterobacter cloacae* complex accounted for 48.2% (222/461) of all IMP types and 18.4% (222/1,205) of all CPE.

NDM carbapenemase types were found mainly in *Escherichia coli* (267/420, 63.6%), and OXA-48-like types in *E. coli* (103/197, 52.3%) and *Klebsiella pneumoniae* (79/197, 40.1%).

Monthly trends for the top five carbapenemase types (IMP, NDM, OXA-48-like, NDM-OXA-48-like, and KPC) reported over five years are shown in Figure 10 (national). Three-year trends by state and territory are shown in Figure 12.

The number of IMP types (alone or co-produced with other types) reported in 2023 (*n* = 472), increased by 7.8% compared to 2022 (*n* = 438). IMP-types accounted for a little over one-half of all CPE reported from Queensland (115/192, 59.9%) and NSW (289/524, 55.2%), and 39.0% (23/59) from WA. In Victoria, 11.0% (39/356) of all CPE were IMP-types, down from 26.0% (52/200) in 2022. Only 1.9% (1/52) of CPE from SA were IMP-types. In Victoria, all the strains that have been genetically sequenced to date (283/472, 60.0%) were either *bla*$_{\text{IMP-4}}$ (*n* = 241), IMP-4-like (*n* = 41), or *bla*$_{\text{IMP-1}}$ (*n* = 1).

The number of NDM types reported in 2023 (alone or co-produced with other types) continued to increase (*n* = 505 in 2023; *n* = 295 in 2022, up 71.2%). NDM types, either alone or in combination, were found in all states and territories. In SA, NDM types accounted for three-quarters (34/52, 65.4%) of all CPE reported, down from 75.6% (31/41) in 2022. In Queensland, NDM types accounted for 31.3% (60/192) of all CPE reported, up from 22.0% (51/232) in 2022. Five different genes were found in the isolates sequenced (384/505, 76.0%): *bla*$_{\text{NDM-5}}$ (244/384; 63.5%), *bla*$_{\text{NDM-1}}$ (108/384; 28.1%), *bla*$_{\text{NDM-7}}$ (21/384; 5.5%), *bla*$_{\text{NDM-4}}$ (10/384; 2.6%), and *bla*$_{\text{NDM-19}}$ (*n* = 1).

Reports of OXA-48-like CPE (alone or co-produced) increased by 141% in 2023 (*n* = 270) compared with 2022 (*n* = 112). The increase was over 3-fold in both Victoria and SA. Seven genes were detected in the isolates that were sequenced (207/270, 76.7%); the most common types were *bla*$_{\text{OXA-181}}$ (112/207, 54.1%), *bla*$_{\text{OXA-48}}$ (36/207, 17.4%), *bla*$_{\text{OXA-232}}$ (29/207, 14.0%), and *bla*$_{\text{OXA-484}}$ (19/207, 9.2%).

Reports of KPC-producing *Enterobacterales* increased in 2023 compared to 2022 (*n* = 27 in 2023; *n* = 14 in 2022). KPC types were predominantly reported from Victoria (*n* = 11) and NSW (*n* = 10) mostly from different hospitals. Two other states reported cases (Queensland [5] and SA [1]). Three KPC variants were detected from the 17 isolates that were sequenced: *bla*$_{\text{KPC-2}}$ (*n* = 11), bla$_{\text{KPC-3}}$ (*n* = 5) and *bla*$_{\text{KPC-4}}$ (*n* = 1). Five KPC-producing *K. pneumoniae* isolates co-produced KPC+NDM+OXA-48-like [NSW [4, from one patient with multiple episodes], Victoria [1]) and two isolates from Victoria co-produced KPC+NDM.

Other carbapenemase types reported were OXA-23-like (*n* = 7), IMI (*n* = 6), VIM (*n* = 5) and SME (*n* = 2).

Co-production of carbapenemase increased to 7.2% in 2023 (87/1,205), up from 5.1% in 2022 (42/829). The majority of co-produced genes in 2023 were NDM+OXA-48-like (*n* = 67, up from *n* = 37 in 2022) and IMP+NDM (*n* = 9, up from *n* = 5 in 2022).

In 2023, there was variation in the proportion of isolates reported from clinical and screening specimens by state and territory (Figure 13). This may be due to differences in local infection prevention and control policies or in response to local outbreaks. Relatively fewer reports from screening specimens were identified in WA and Victoria.

There were notable regional differences in the distribution of the top five carbapenemases by specimen type (Figure 14) and by setting (Table 4).

The CPE crude rate (clinical isolates) per 100,000 population has increased in Victoria, NSW, WA and SA (Figure 15). There was a decrease in the crude rate in the ACT, while the rate in Queensland remained stable.

The clinical impact of each of the CPE types, and the potential impact of co-infection, are not well understood.[7] This aspect of the data provided by CARAlert will be monitored.

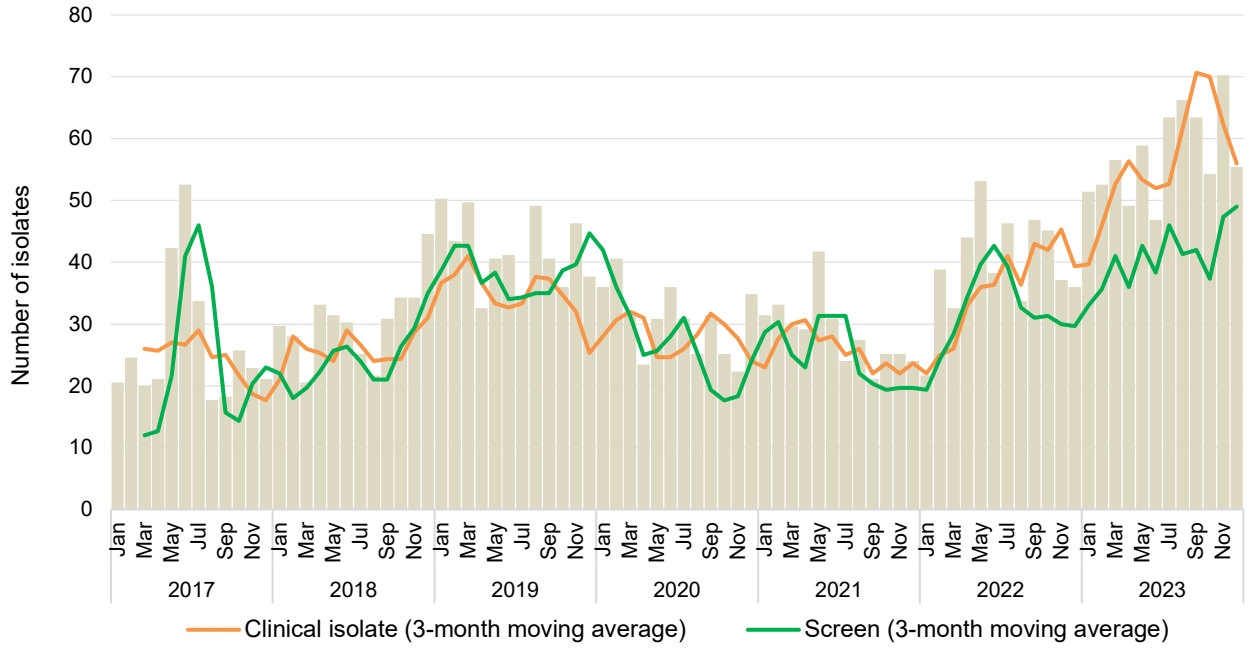
Since 2016, 290 hospitals have reported at least one CPE. CPE were reported from 133 hospitals during 2023. One-eighth (17/133) of these hospitals did not report a CPE during the period 2016 to 2022. Of the hospitals that reported CPE prior to 2022, 157 did not have any reports in 2023.

In 2023, ribosomal methyltransferases were detected in 117 isolates of *Enterobacterales*, representing 10 species; 86.3% (101/117) of these also had a carbapenemase. The ribosomal methyltransferases were mostly found among *K. pneumoniae* (60/117, 51.3%) and *E. coli* (46/117, 39.3%). Four ribosomal methyltransferase genes were found in the isolates sequenced: *rmtB* (68/107, 63.6%), *armA* (17/107, 15.9%), *rmtF* (10/107, 9.3%), *rmtC* (*n* = 7), *rmtB*+*rmtF* (*n* = 4), and *armA*+*rmtF* (*n* = 1).

Transmissible resistance to colistin refers to the presence of *mcr* genes other than *mcr-9*. This variant is not associated with a colistin-resistant phenotype but is typically found on HI2 plasmids which may carry bla_{IMP-4}.[8] Two *E. coli* isolates with *mcr-1.1* were reported from Victoria and SA in 2023. The isolate from Victoria also harboured bla_{NDM-1}. This CAR has been reported to CARAlert since July 2019.

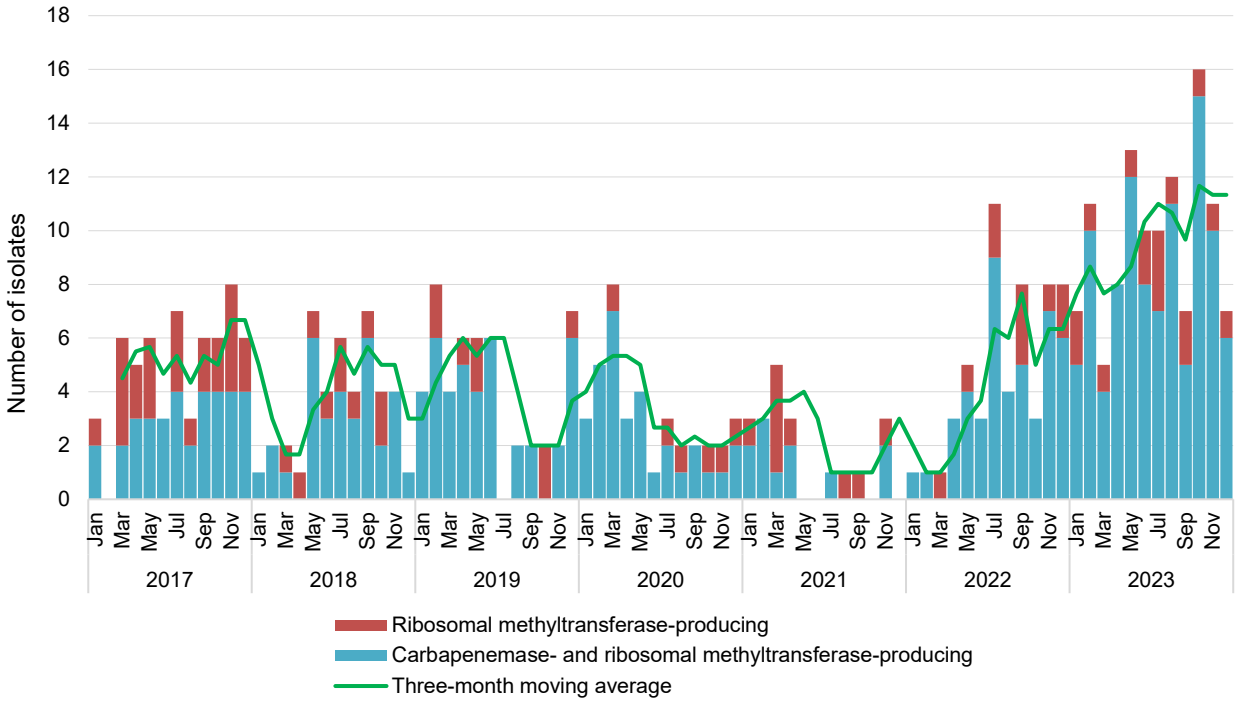
National data

Figure 7: Carbapenemase-producing *Enterobacterales*, number reported to CARAlert by month and specimen type, national, 2017–2023



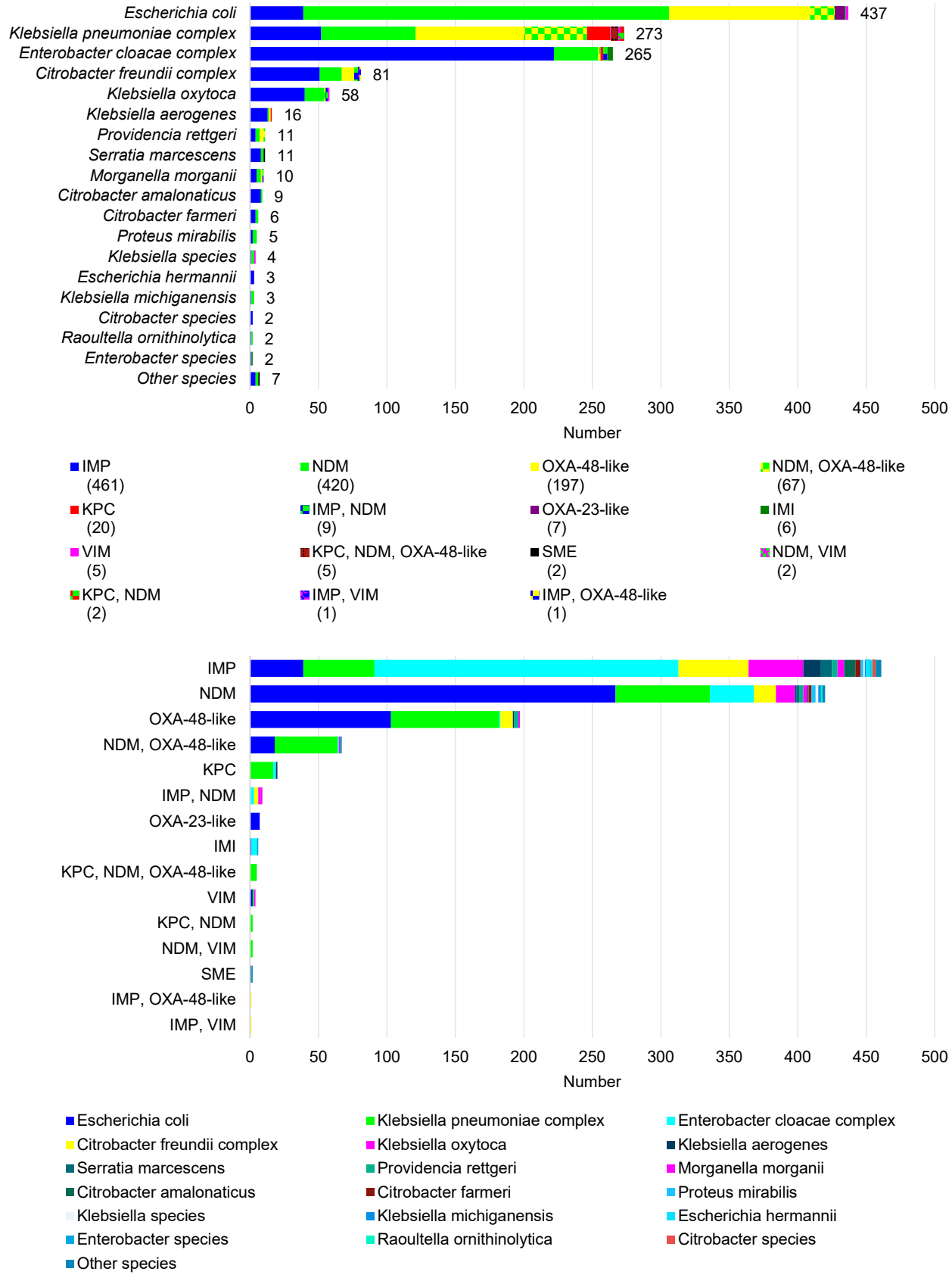
Note: Carbapenemase-producing *Enterobacterales*, includes those co-producing ribosomal methyltransferase and/or transmissible colistin resistance.

Figure 8: Ribosomal methyltransferase-producing *Enterobacterales*, number reported to CARAlert by month, national, 2017–2023



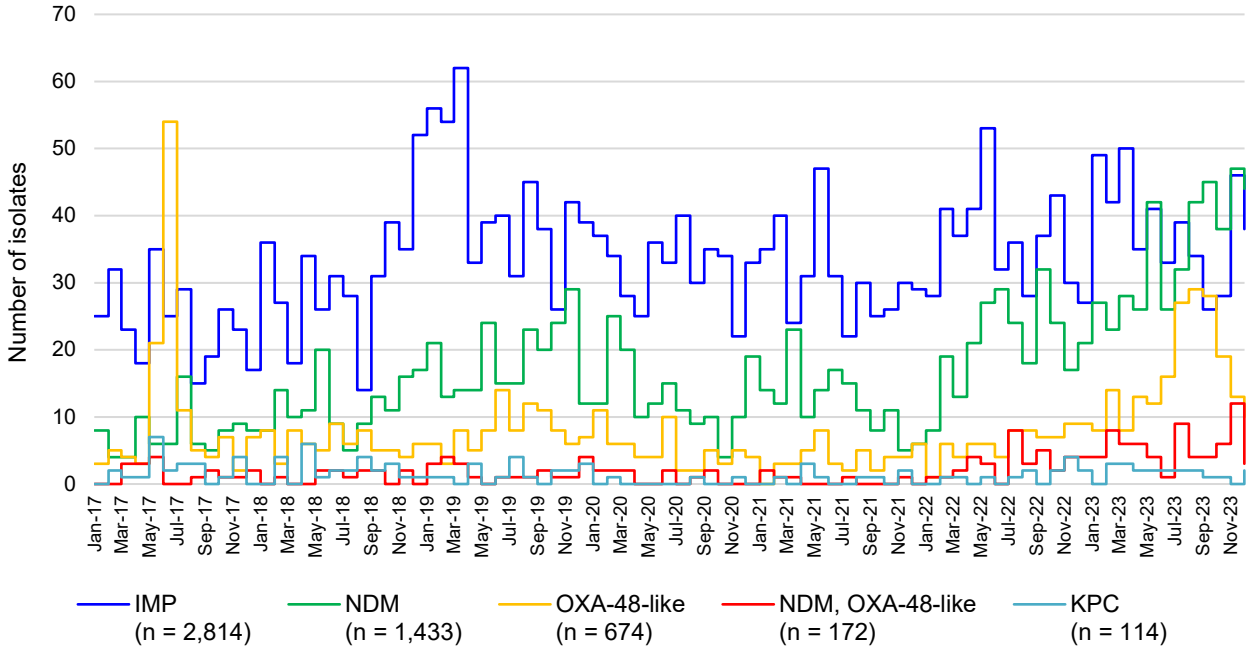
Note: Ribosomal methyltransferase-producing *Enterobacterales*, includes those that also produced carbapenemase.

Figure 9: Carbapenemase-producing *Enterobacterales**, number reported to CARAlert by species and carbapenemase type, national, 2023



* Carbapenemase-producing (n = 1,103), carbapenemase- and ribosomal methyltransferase-producing (n = 101), carbapenemase-producing plus transmissible colistin resistance (n = 1)

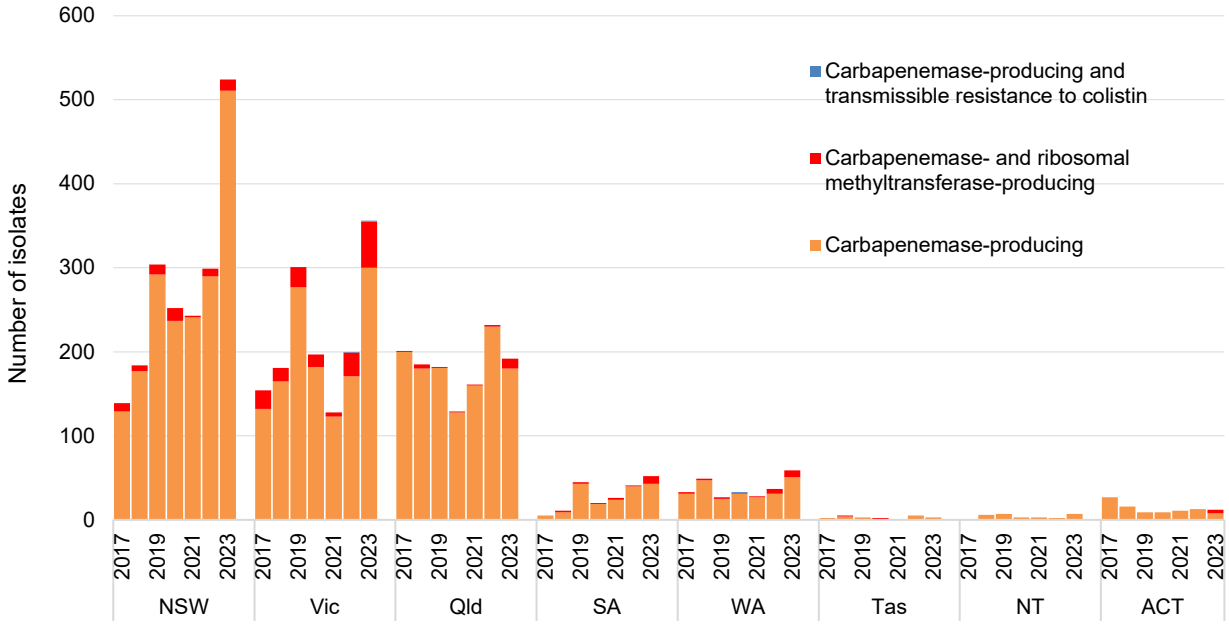
Figure 10: Trend for the top five carbapenemase types* reported to CARAlert, by month, national, 2017–2023



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

State and territory data

Figure 11: Carbapenemase-producing *Enterobacterales,* number reported to CARAlert by state and territory, 2017–2023



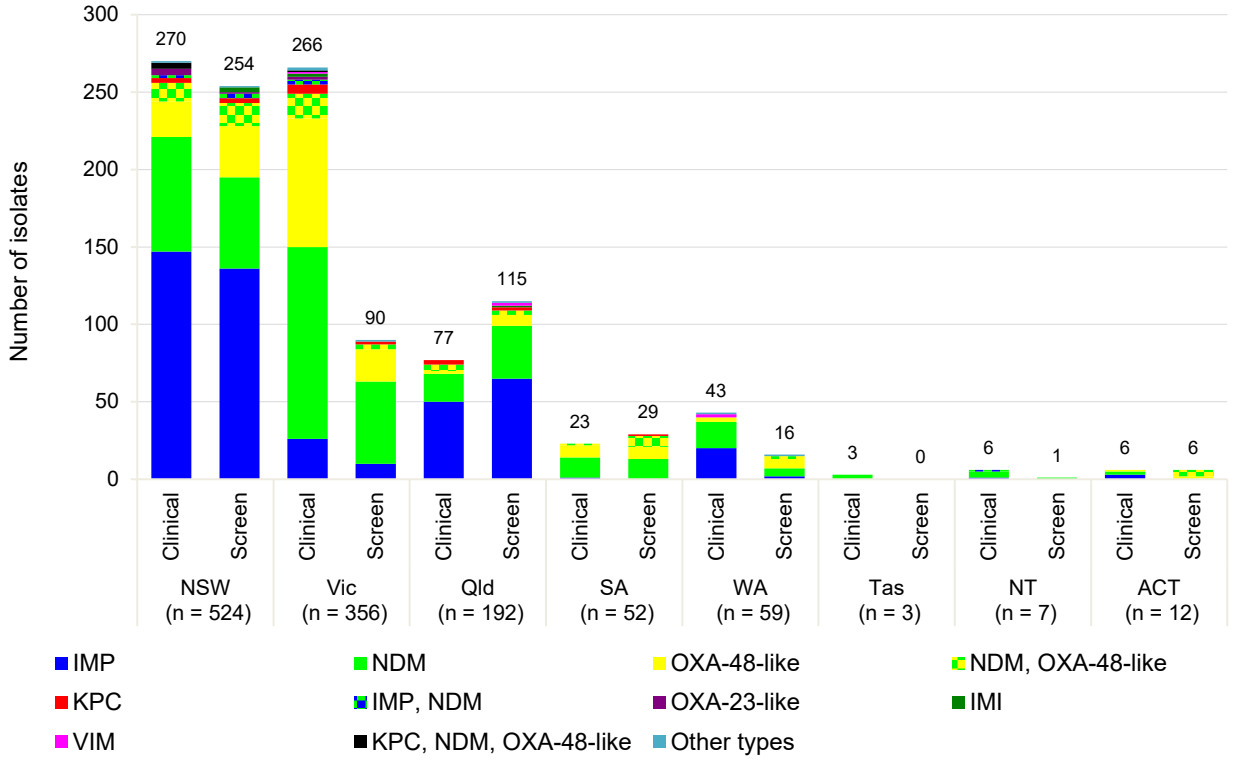
Note: Transmissible colistin resistance reported from July 2019.

Figure 12: Three-year trend for the top five carbapenemase types from *Enterobacterales* reported to CARAlert, by state and territory and nationally, (three-month moving average), 2021–2023

Type	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Australia
IMP	28 10	5 2	19 5	0 0	3 0	0 0	1 0	1 0	47 26
NDM	16 1	21 3	7 1	5 0	3 0	1 0	1 0	1 0	43 6
OXA-48-like	6 0	18 0	2 0	2 0	1 0	0 0	0 0	1 0	28 2
NDM+OXA-48-like	3 0	3 0	1 0	1 0	1 0	0 0	0 0	1 0	7 0
KPC	1 0	2 0	1 0	1 0	0 0	0 0	0 0	0 0	3 0
All types	53 14	43 8	26 9	6 1	7 1	1 0	1 0	2 0	113 41

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
Note: Line graphs represent three-month moving average for the period 1 January 2021 to 31 December 2023, for each type (reported alone or in combination with another type), where maximum monthly average was greater than one.

Figure 13: Carbapenemase-producing *Enterobacterales**, number reported to CARAlert by carbapenemase type and specimen type, by state and territory, 2023



* Carbapenemase-producing (n = 1,103), carbapenemase- and ribosomal methyltransferase-producing (n = 101), carbapenemase-producing plus transmissible colistin resistance (n = 1); Other types: SME (NSW [1], Victoria [1]); NDM, VIM (Queensland [1], WA [1]); KPC, NDM (Victoria [2]); IMP, VIM (WA [1]); IMP, OXA-48-like (NSW [1])

Figure 14: Top five carbapenemase-producing *Enterobacterales* types reported to CARAlert, by state and territory, 2017–2023

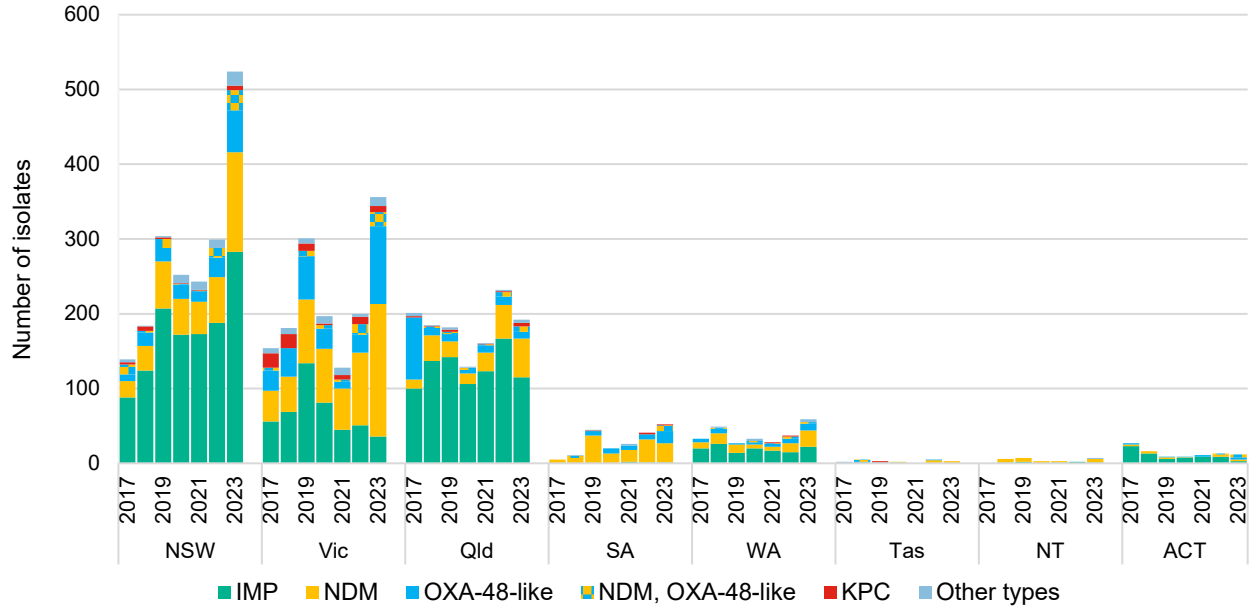


Figure 15: Carbapenemase-producing *Enterobacterales* reported to CARAlert, by specimen type and by state and territory, 2017–2023

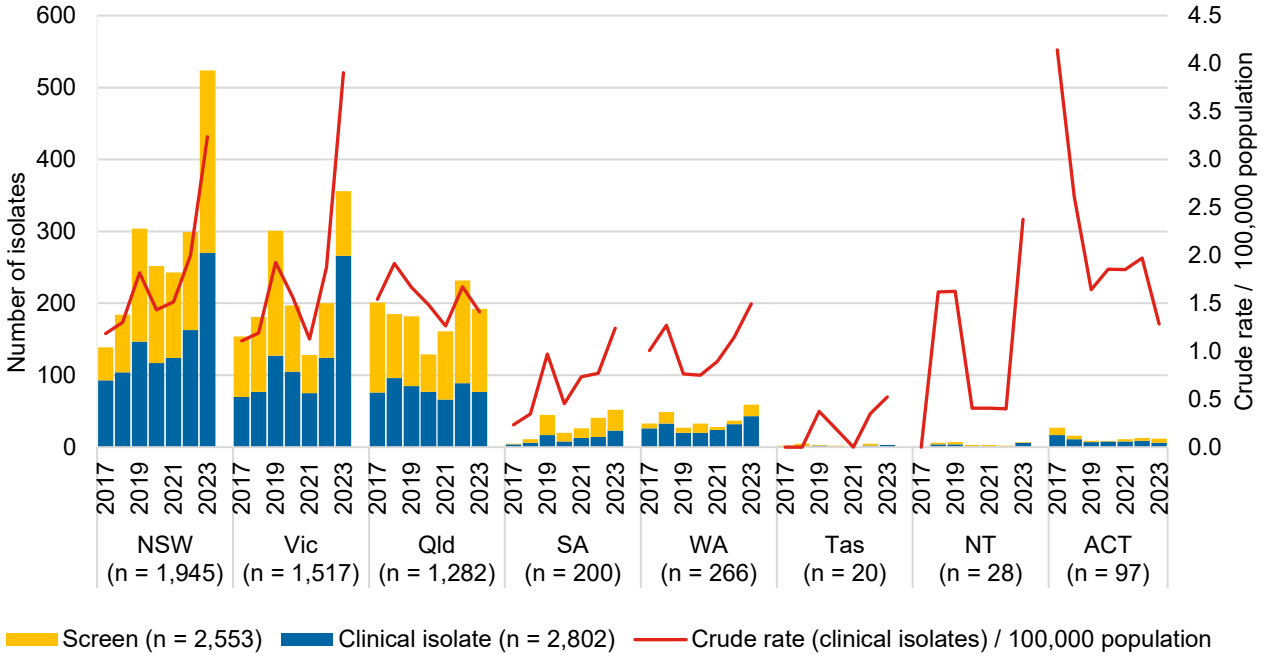


Table 4: Top five carbapenemase types from *Enterobacterales**, number reported to CARAlert by setting, state and territory, 2023

Carbapenemase type†	Setting	State or territory								Total
		NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
IMP	**Total**	**283**	**36**	**115**	**1**	**22**	**0**	**1**	**3**	**461**
	Public hospital	262	31	88	0	13	0	1	3	398
	Private hospital	2	2	19	1	5	0	0	0	29
	Aged care home	0	0	1	0	1	0	0	0	2
	Community	9	3	2	0	3	0	0	0	17
	Unknown	10	0	5	0	0	0	0	0	15
NDM	**Total**	**133**	**177**	**52**	**26**	**22**	**3**	**5**	**2**	**420**
	Public hospital	102	117	39	18	12	1	5	0	294
	Private hospital	3	6	5	1	3	0	0	0	18
	Aged care home	0	2	2	0	1	0	0	0	5
	Community	14	43	4	7	6	2	0	2	78
	Unknown	14	9	2	0	0	0	0	0	25
OXA-48-like	**Total**	**56**	**104**	**9**	**16**	**9**	**0**	**0**	**3**	**197**
	Public hospital	49	79	7	13	6	0	0	2	156
	Private hospital	0	2	0	0	2	0	0	0	4
	Aged care home	0	0	0	0	0	0	0	0	0
	Community	3	17	2	3	1	0	0	1	27
	Unknown	4	6	0	0	0	0	0	0	10
NDM, OXA-48-like	**Total**	**27**	**19**	**7**	**8**	**2**	**0**	**0**	**4**	**67**
	Public hospital	25	15	4	7	2	0	0	4	57
	Private hospital	0	0	1	0	0	0	0	0	1
	Aged care home	0	0	0	0	0	0	0	0	0
	Community	1	4	2	0	0	0	0	0	7
	Unknown	1	0	0	1	0	0	0	0	2
KPC	**Total**	**6**	**8**	**5**	**1**	**0**	**0**	**0**	**0**	**20**
	Public hospital	5	4	4	1	0	0	0	0	14
	Private hospital	1	1	0	0	0	0	0	0	2
	Aged care home	0	0	0	0	0	0	0	0	0
	Community	0	2	1	0	0	0	0	0	3
	Unknown	0	1	0	0	0	0	0	0	1

* The top five carbapenemase types account for 96.7% (1,165/1,205) of all CPE reported for this period. Other types were IMP+NDM (*n* = 9: NSW, Victoria, NT); OXA-23-like (*n* = 7: NSW, Victoria); IMI (*n* = 6: NSW, Victoria, Queensland); VIM (n = *5*: Victoria, Queensland, WA); KPC+NDM+OXA-48-like (*n* = 5: NSW, Victoria);SME (*n* = 2: NSW, Victoria); NDM+VIM (n = *2*: Queensland, WA); KPC+NDM (*n* = 2: Victoria); IMP+VIM (*n* = 1: WA); and IMP+OXA-48-like (*n* = 1: NSW)

† Alone or coproduced with another type for the reporting period indicated

Enterococcus species

Enterococcus species including *E. faecalis* and *E. faecium*, commonly cause urinary tract, biliary tract and other intra-abdominal infections, and bloodstream infections. In 2023, reports of linezolid-resistant *Enterococcus* species (*n* = 39) more than doubled compared to 2022 (*n* = 17) (Figure 16).

Linezolid-resistant *Enterococccus* species were reported from all states except Tasmania in 2023 (Figure 17). Variation in the number of reports from the states and territories may be due to differences in testing and reporting practices by the originating laboratories. Some laboratories may only test linezolid on *Enterococcus* species if other resistances are detected.

Figure 16: Linezolid-resistant *Enterococcus* species, number reported to CARAlert by month, national, 2017–2023

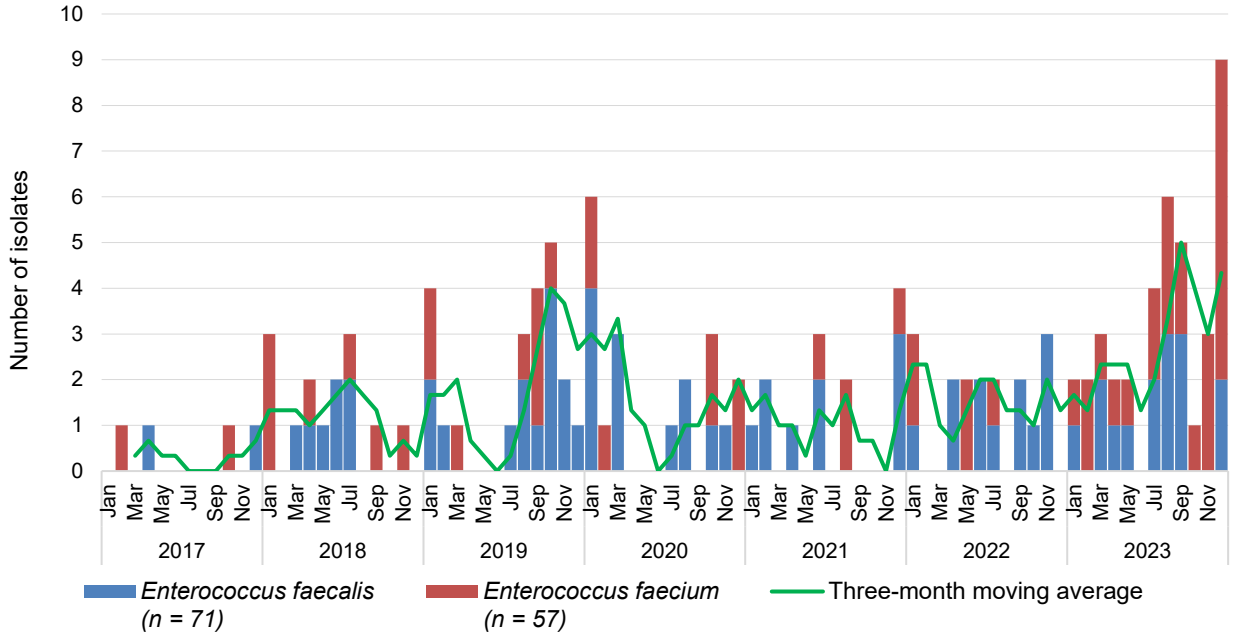
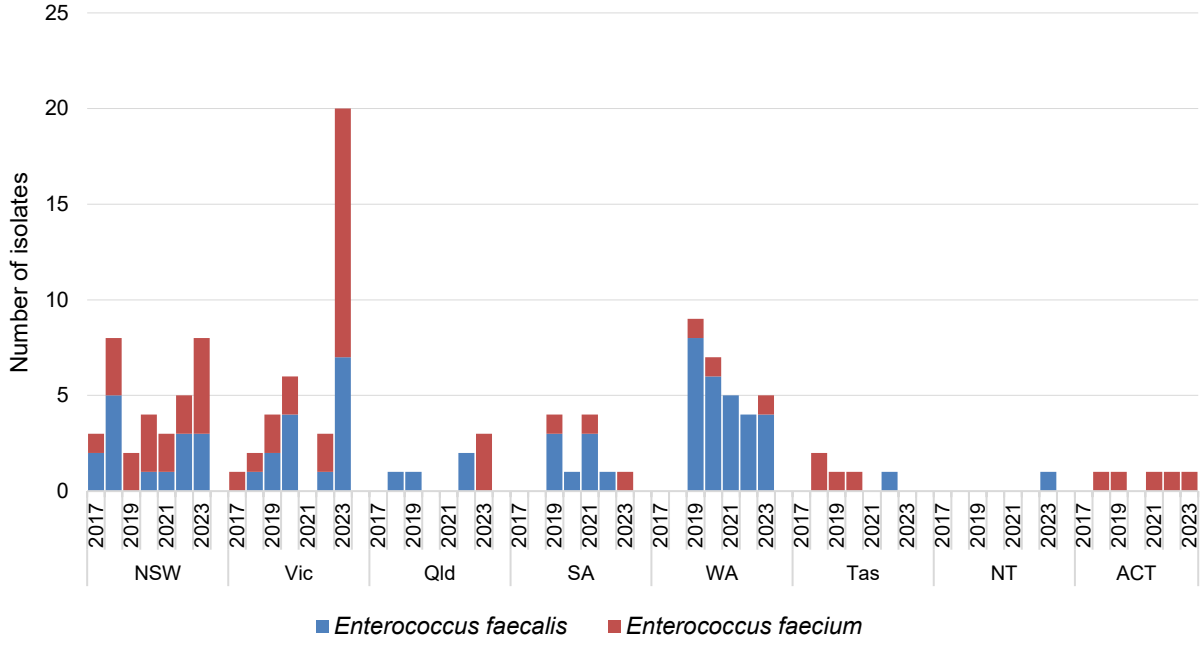


Figure 17: Linezolid-resistant *Enterococcus* species, number reported to CARAlert by state and territory, 2017–2023



Mycobacterium tuberculosis

Mycobacterium tuberculosis causes tuberculosis, which has a variety of clinical manifestations, but most commonly presents as lung disease. Low numbers of MDR *M. tuberculosis* were reported to CARAlert from 2017 to 2023 (Figure 18). In 2023, a little under one-half of the MDR *M. tuberculosis* reports were from NSW (6/14, 42.9%) (Figure 19).

Figure 18: Multidrug-resistant *Mycobacterium tuberculosis,* number reported to CARAlert by month, national, 2017–2023

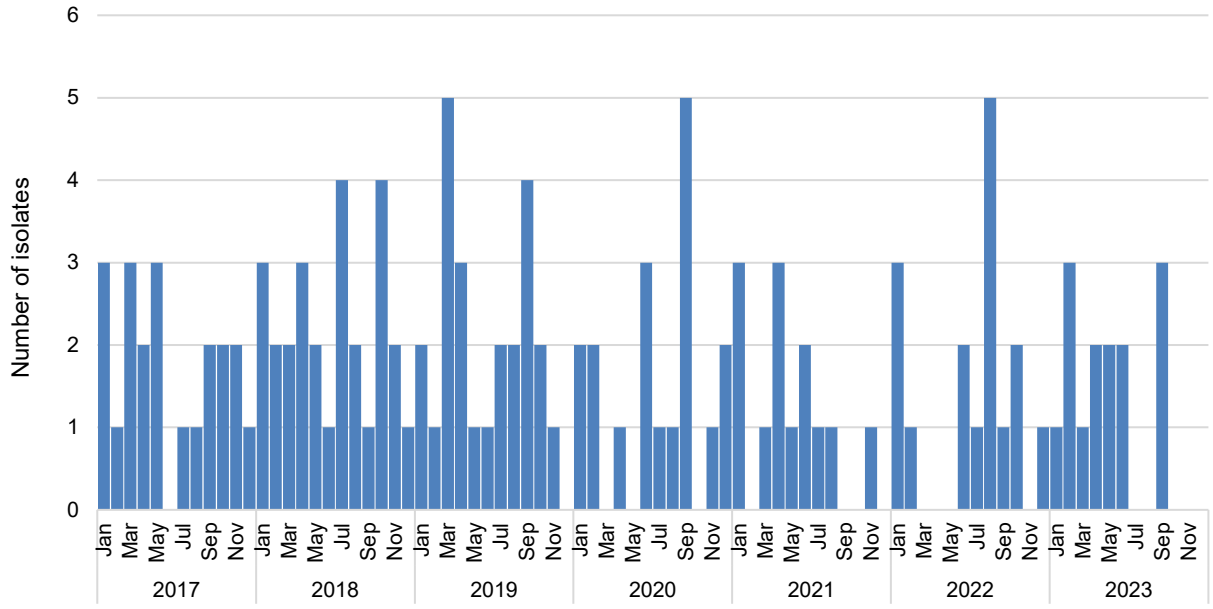
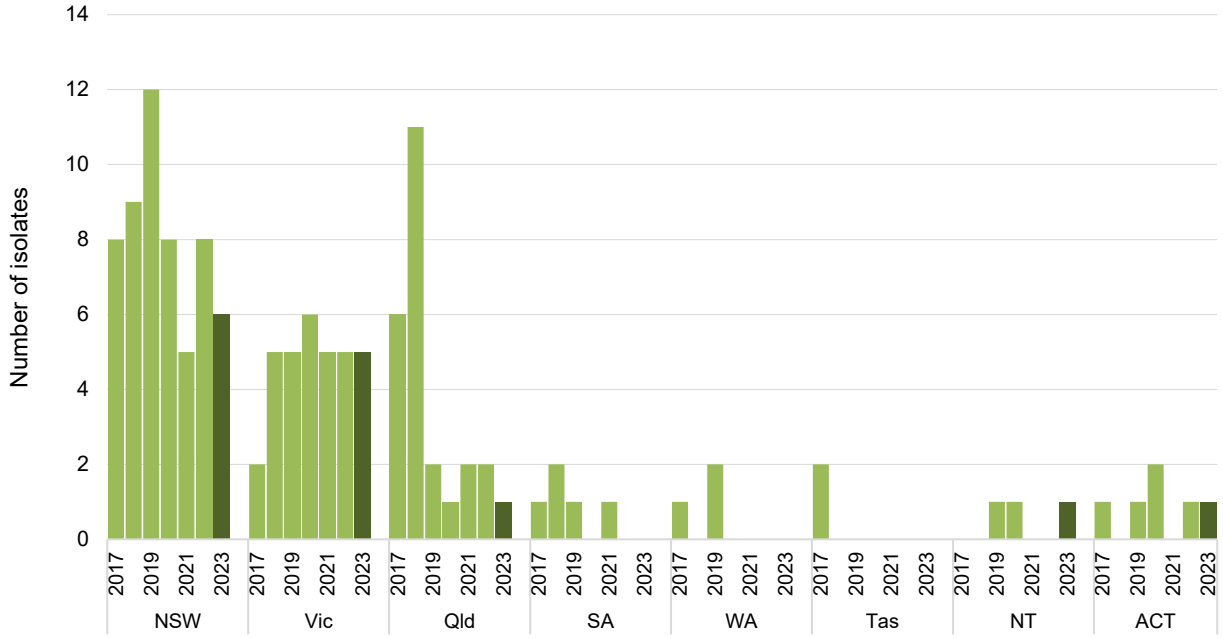


Figure 19: Multidrug-resistant *Mycobacterium tuberculosis*, number reported to CARAlert by state and territory, 2017–2023



Note: Dark bars indicate values for 2023.

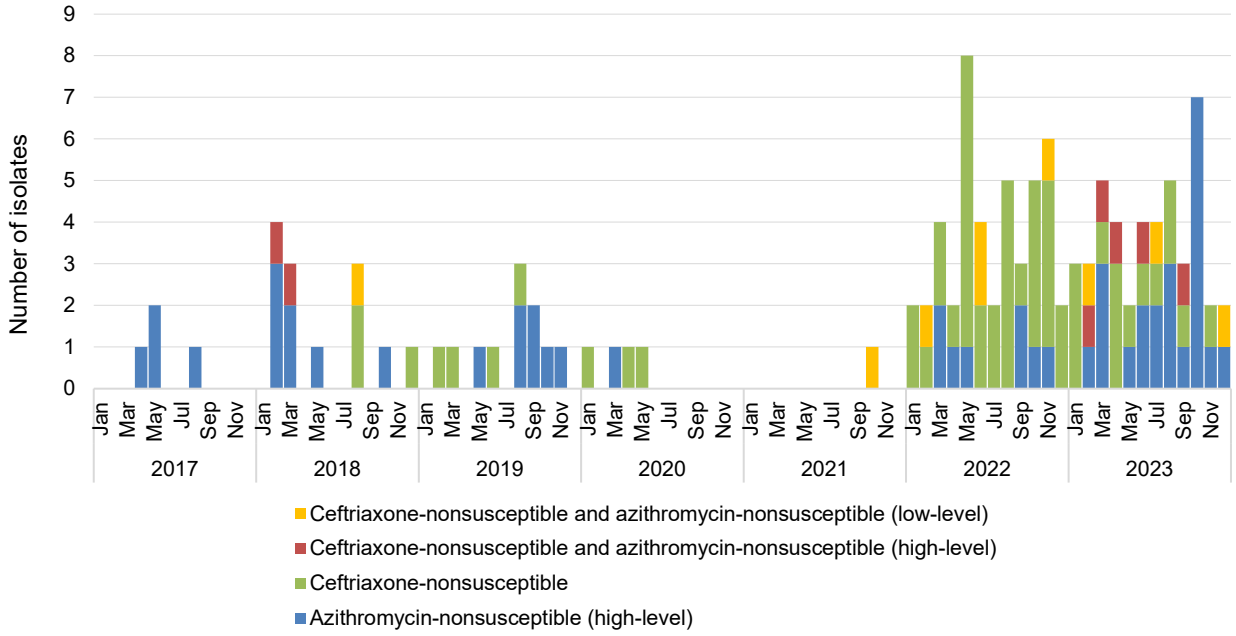
Neisseria gonorrhoeae

N. gonorrhoeae causes gonorrhoea, a largely sexually transmitted infection that most commonly manifests as urethritis in men and cervicitis in women. There were sporadic reports of ceftriaxone-nonsusceptible and/or azithromycin-nonsusceptible (HLR) *N. gonorrhoeae* between 2017 and 2021 (Figure 20).

Ceftriaxone-nonsusceptible isolates were reported to CARAlert for the first time in 2016 (*n* = 4); there were six reports in 2018, four reports in 2019, three in 2020, one in 2021 and 37 reports in 2022. There were 22 reports made to CARAlert in 2023 from Victoria (*n* = 9), NSW (*n* = 7), Queensland (*n* = 3), WA (*n* = 2) and SA (*n* = 1). Of the reports from Victoria, eight were also azithromycin-nonsusceptible (HLR, *n* = 5; LLR, *n* = 3).

Twenty-two azithromycin-nonsusceptible *N. gonorrhoeae* (HLR) were reported in 2023 (NSW [11], Victoria [8], WA [2]), Queensland [1]; there were eight reported in 2022.

Figure 20: Ceftriaxone-nonsusceptible and/or azithromycin-nonsusceptible *Neisseria gonorrhoeae,* number reported to CARAlert by month, national, 2017–2023

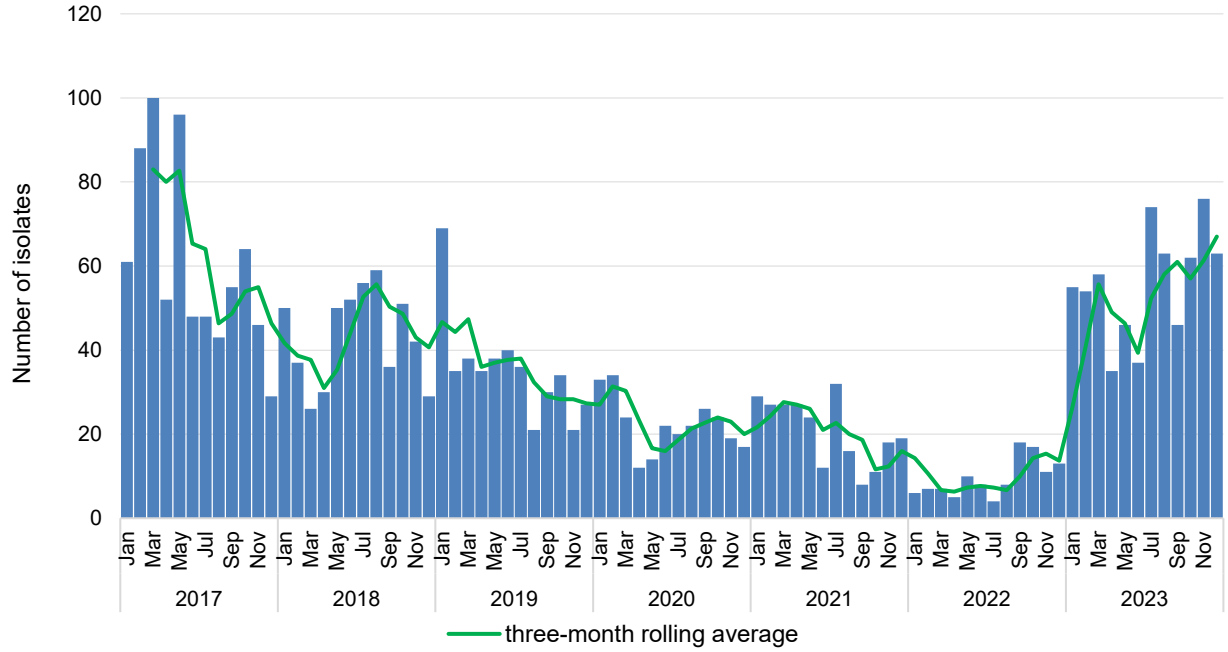


High-level = azithromycin MIC ≥ 256 mg/L; Low-level = azithromycin MIC < 256 mg/L; MIC = minimum inhibitory concentration

In 2023, the number of reports of azithromycin-nonsusceptible *N. gonorrhoeae* (LLR) increased dramatically (5.9-fold) following a declining trend from 2017 to 2022 (Figure 21). However, reports in 2023 (*n* = 669) were not as high as 2017 (*n* = 730). In 2023, a little under two-thirds (415/669, 62.0%) of reports were from Victoria (Figure 22).

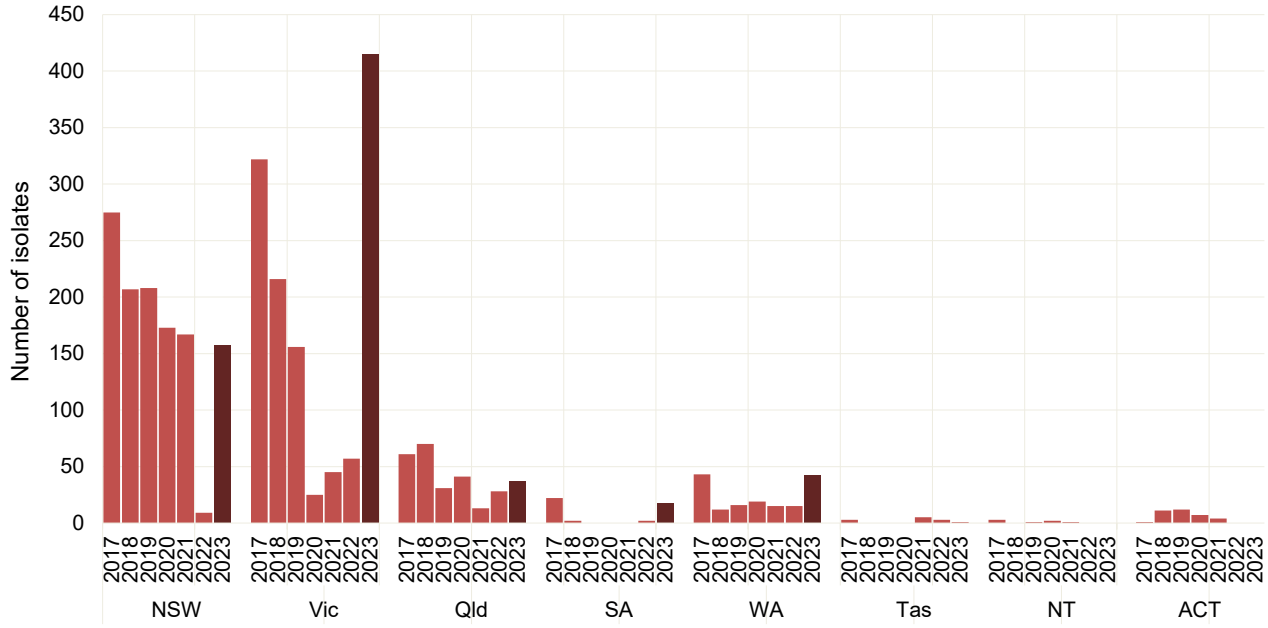
Gentamicin-resistant *N. gonorrhoeae* was added to reporting from 2023. This CAR is yet to be reported to CARAlert.

Figure 21: Azithromycin-nonsusceptible *Neisseria gonorrhoeae* (low-level resistance), number reported to CARAlert by month, national, 2017–2023



Low-level = azithromycin MIC < 256 mg/L; MIC = minimum inhibitory concentration

Figure 22: Azithromycin-nonsusceptible *Neisseria gonorrhoeae* (low-level resistance), number reported to CARAlert by state and territory, 2017–2023



Low-level = azithromycin MIC < 256 mg/L; MIC = minimum inhibitory concentration
Note: Dark bars indicate values for 2023.

Neisseria meningitidis

N. meningitidis causes meningococcal disease, commonly meningitis, which is an infection of the membrane covering of the brain and spinal cord known as the meninges. Ciprofloxacin-nonsusceptible *N. meningitidis* was added to reporting to CARAlert from 2023. There were four reports of this CAR in 2023, all of which were from Victoria.

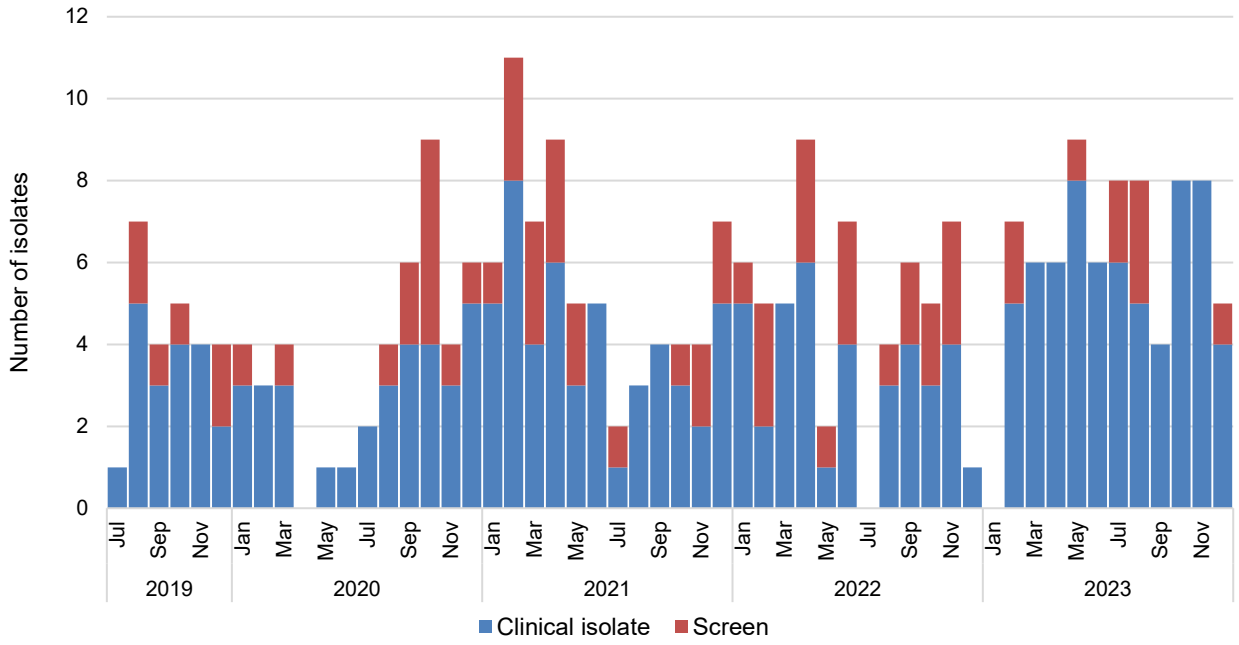
Pseudomonas aeruginosa

P. aeruginosa infections primarily affect hospitalised or immunocompromised patients. Patients with catheters or drains are considered at high risk for carbapenemase acquisition. Reporting for carbapenemase-producing *P. aeruginosa* began in July 2019.

In 2023, 75 carbapenemase-producing *P. aeruginosa* were reported from five states: NSW (*n* = 33), Victoria (*n* = 20), WA (*n* = 9), Queensland (*n* = 8) and SA (*n* = 5). This was an increase from 2022 (*n* = 57, up 31.6%) (Figures 23 and 24). Almost all produced either GES (*n* = 32), NDM (*n* = 18), VIM (*n* = 14), IMP types (*n* = 10), or IMP+NDM (*n* = 1). GES-types dominated the reports from NSW (28/33, 84.8%), while VIM-types were most common in reports from Victoria (9/20, 45.0%). NDM-types were reported from all states except Tasmania.

Where setting was known (70/75, 93.3%), a substantial majority (56/70, 80.0%) of carbapenemase-producing *P. aeruginosa* were reported from hospitals (Table 5).

Figure 23: Carbapenemase-producing *Pseudomonas aeruginosa*, number reported to CARAlert by specimen type, national, 2019–2023



Note: Reported from July 2019.

Figure 24: Carbapenemase-producing *Pseudomonas aeruginosa*, number reported to CARAlert by carbapenemase type and specimen type, by state and territory, 2023

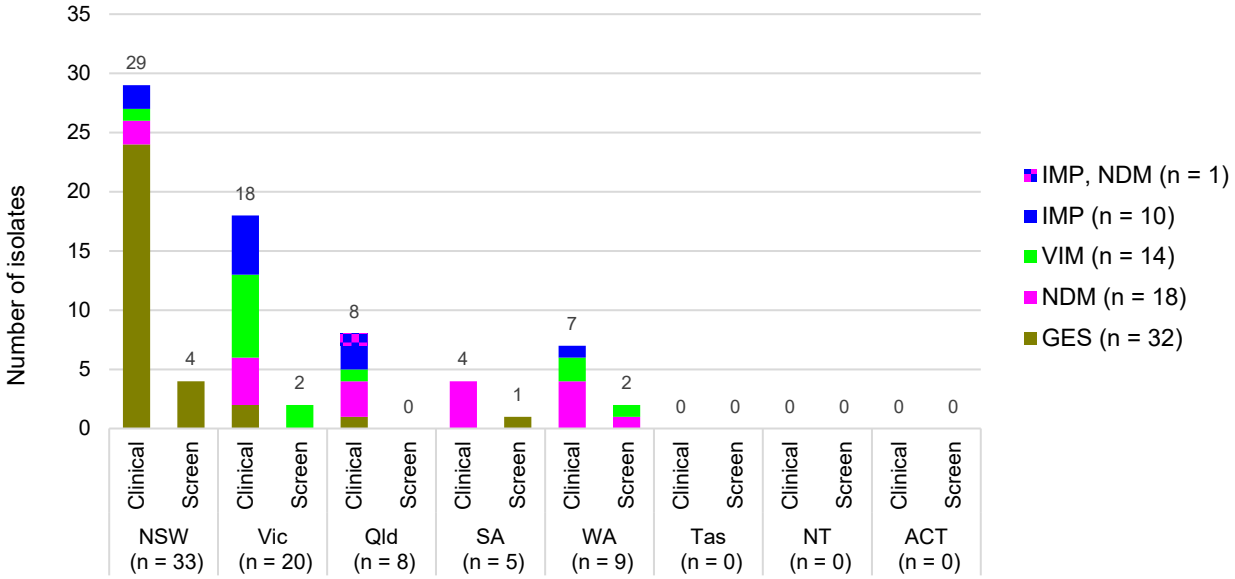


Table 5: Carbapenemase-producing *Pseudomonas aeruginosa*, number reported to CARAlert by setting and state and territory, 2023

Setting	State or territory								Total
	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
Total	**33**	**20**	**8**	**5**	**9**	**0**	**0**	**0**	**75**
Public hospitals	26	13	6	3	5	0	0	0	53
Private hospitals	2	0	0	0	1	0	0	0	3
Aged care homes	0	0	0	0	0	0	0	0	0
Community	2	6	1	2	3	0	0	0	14
Unknown	3	1	1	0	0	0	0	0	5

Salmonella species

Salmonella species are important causes of bacterial gastroenteritis. Most cases are acquired through food-borne transmission. The number of reports of ceftriaxone-nonsusceptible *Salmonella* species nearly doubled from 2022 (*n* = 51) to 2023 (*n* = 95) (Figure 25).

A vast majority of the ceftriaxone-nonsusceptible *Salmonella* reports were from non-typhoidal species (82/95, 86.3%). The non-typhoidal species contained an extended-spectrum β-lactamase (ESBL) (61/82, 74.4%) or a plasmid-mediated AmpC (21/82, 25.6%) (Figure 26).

There were 13 typhoidal species reported in 2023 (from Victoria [8], NSW [4] and WA [1]); the majority (11/13, 84.6%) harboured an ESBL (*bla*$_{\text{CTX-M-15}}$ [9], *bla*$_{\text{CTX-M-14}}$ [1], *bla*$_{\text{CTX-M-65}}$ [1]) and two harboured pAmpC (*bla*$_{\text{CMY-2}}$) (Figure 26). Thirteen typhoidal species were also reported in 2022, and sporadic reports in the preceding five years (*n* = 12). The proportion of ceftriaxone-nonsusceptible typhoidal species, as reported to CARAlert, to the number of paratyphoidal or typhoid fever notifications[9] was 3.2 (13/405) in 2023; it was 5.7 (13/230) in 2022.

Across states and territories, the greatest increase in reports of ceftriaxone-nonsusceptible *Salmonella* in 2023 was in Queensland (*n* = 22 in 2023; *n* = 7 in 2022) and Victoria (*n* = 39 in 2023; *n* = 17 in 2022). There were no reports from Tasmania, the ACT or the NT (Figure 27).

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

National data

Figure 25: Ceftriaxone-nonsusceptible *Salmonella* species, number reported to CARAlert by month, national, 2017–2023

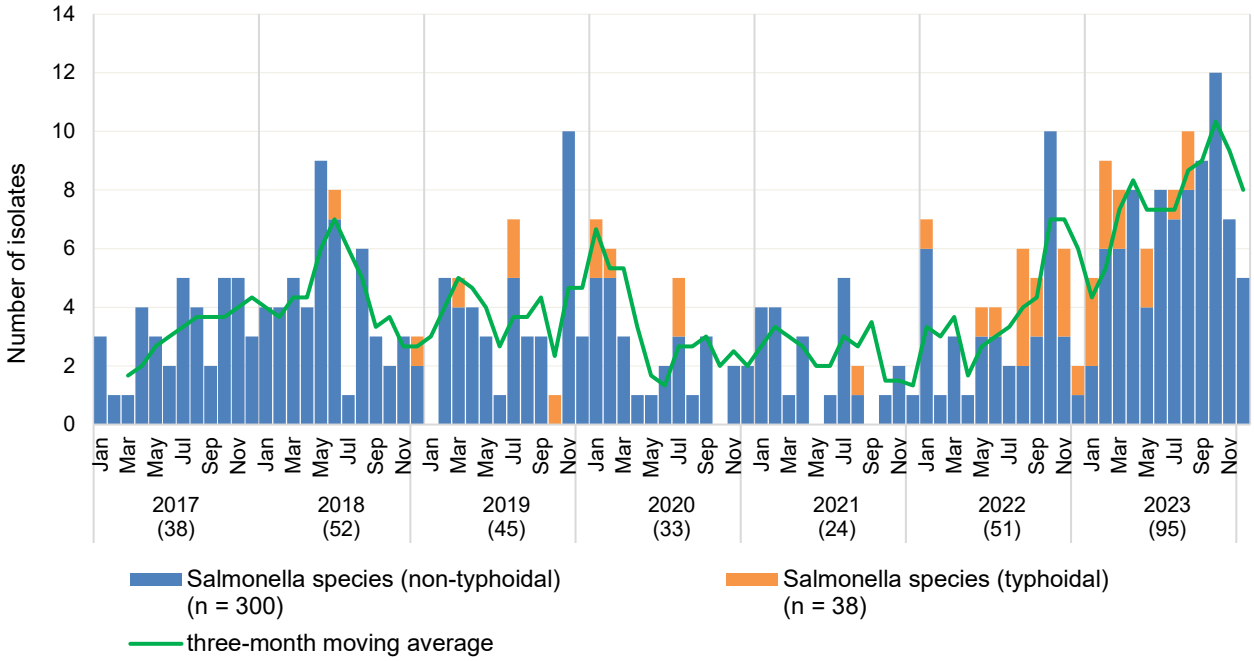
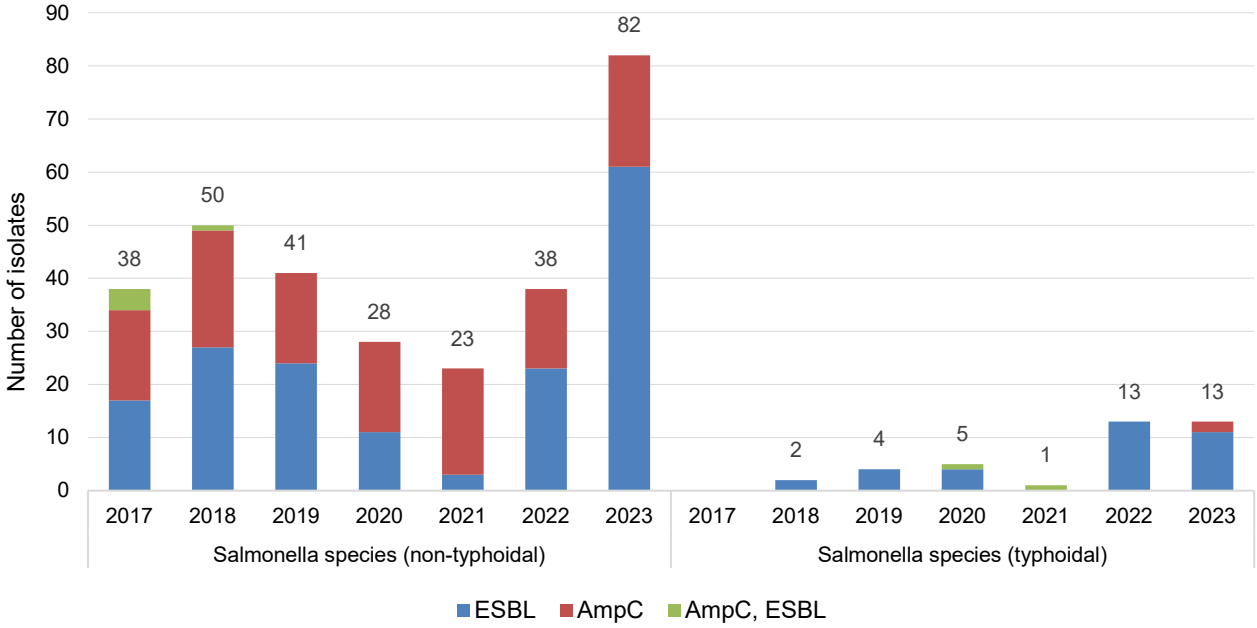


Figure 26: Ceftriaxone-nonsusceptible *Salmonella* species, by resistance phenotype, national, 2017–2023



AmpC = plasmid-mediated AmpC; ESBL = extended-spectrum β-lactamase

State and territory data

Figure 27: Ceftriaxone-nonsusceptible *Salmonella* species, number reported to CARAlert by state and territory, 2017–2023

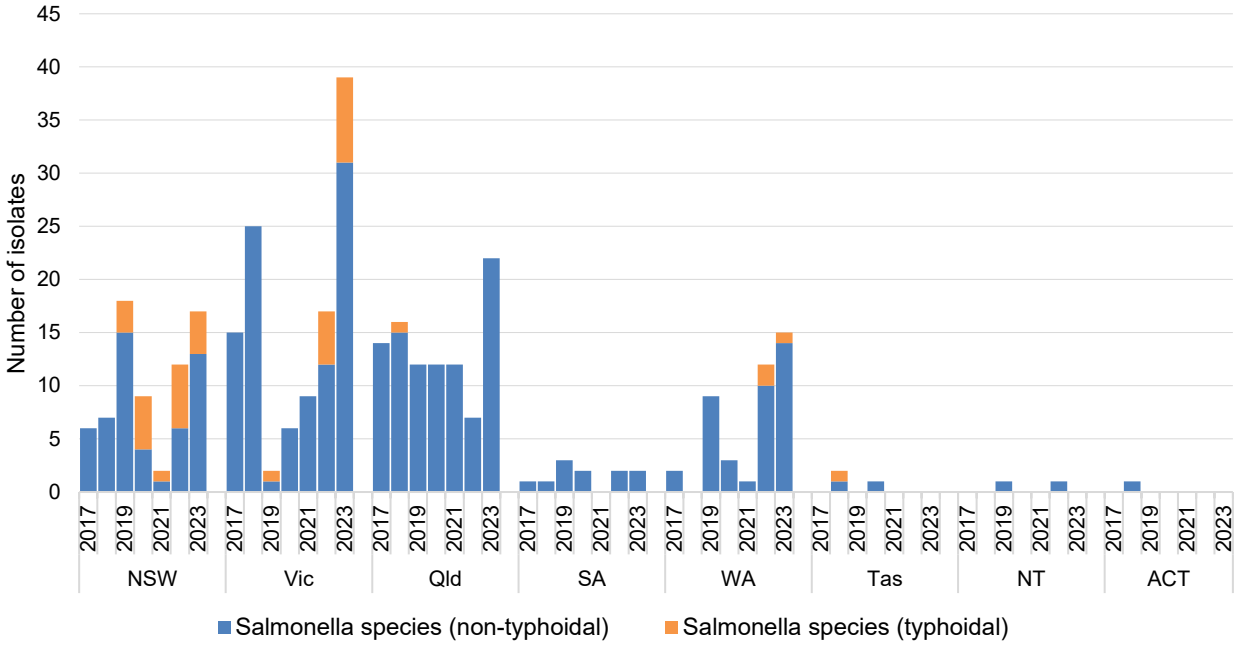


Table 6: Ceftriaxone-nonsusceptible *Salmonella* species, number reported to CARAlert by setting, state and territory, 2023

Setting	State or territory								Total
	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
Total	**17**	**39**	**22**	**2**	**15**	**0**	**0**	**0**	**95**
Public hospital	10	9	12	0	4	0	0	0	35
Private hospital	0	1	0	0	2	0	0	0	3
Aged care home	0	0	0	0	0	0	0	0	0
Community	1	22	8	2	8	0	0	0	41
Unknown	6	7	2	0	1	0	0	0	16

Shigella species

Shigella species infections are commonly food-borne or sexually transmitted. In 2023, there was a 4.7-fold increase in the number of MDR *Shigella* species reports compared to 2022 (*n* = 469 in 2023; *n* = 99 in 2022); there were 42 reports in 2021 (Figure 28). The reports were predominantly from Victoria (202/469, 43.1%) and NSW (178/469, 38.0%). Reports increased across all states and territories, of which, *S. sonnei* was the predominant species (338/469, 72.1%) (Figure 29).

The estimated proportion of shigellosis notifications to the National Notifiable Diseases Surveillance System that were MDR increased from 7.0% (99/1,410) nationally in 2022 to 16.1% in 2023 (469/2,913: range, 2.9% [5/171] in the NT to 30.5% [202/663] in Victoria) (Figure 30). In 2021, the proportion was 9.0% (42/468).

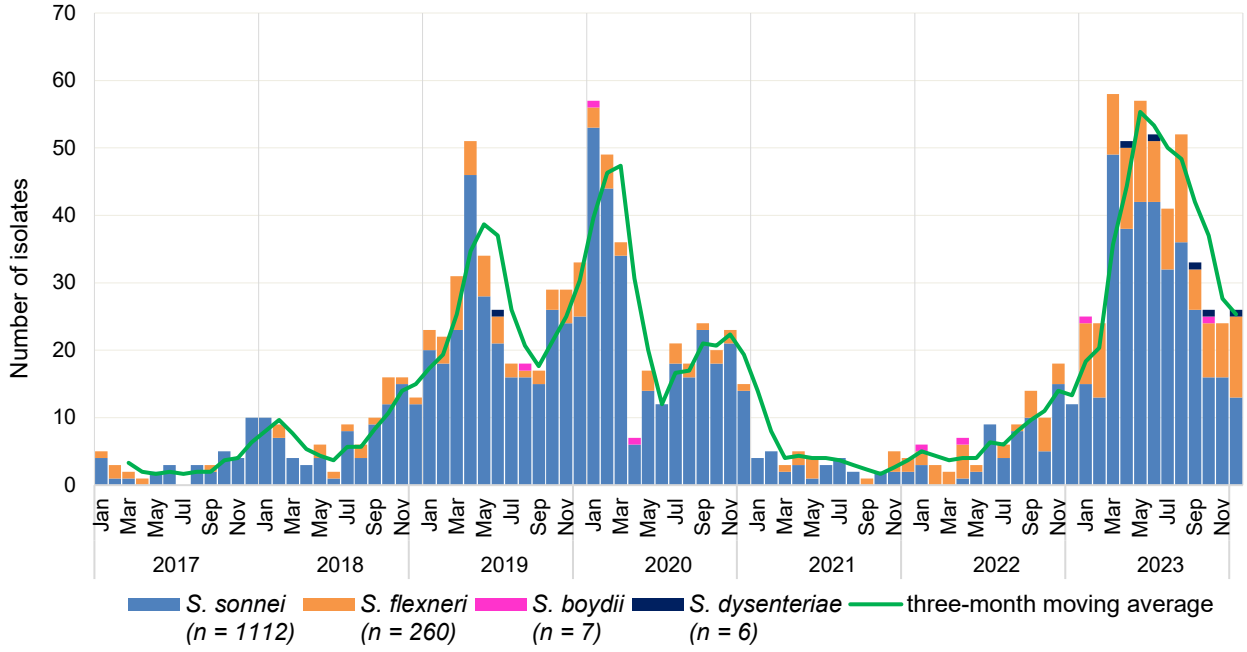
Where setting was known (341/469, 72.7%), a little over one-half (206/341, 60.4%) of the MDR *Shigella* species were reported from community settings (Table 7).

Reports of MDR *Shigella* species increased rapidly from 2018 due to a prolonged clonal outbreak of *S. sonnei* with *bla*$_{CTX-M-27}$ associated with men who have sex with men. There were two large outbreaks across two states, with a peak in numbers in April 2019 (74.5% from Victoria) and another in January 2020 (61.4% from NSW). There was a sharp fall in the monthly number of reports of this CAR from April 2020 onwards, continuing throughout 2021 to reach the lowest level since CARAlert began. This fall coincided with the introduction of COVID-19 restrictions throughout Australia. However, as borders re-opened, the number of reports of ESBL-producing *S. sonnei* has again increased from 17 in 2021 and 62 in 2022 to 321 in 2023. Of isolates that were sequenced, a little over two-thirds of ceftriaxone-nonsusceptible *S. sonnei* in 2023 (198/282, 70.2%) harboured *bla*$_{CTX-M-27}$. In 2022 almost two-thirds (35/55, 63.6%) harboured *bla*$_{CTX-M-27}$; while in 2021, the vast majority harboured *bla*$_{CTX-M-27}$ (15/16, 93.8%).

The majority of MDR *S. flexneri* were ceftriaxone-susceptible (97/124, 78.2% in 2023; 19/28, 67.9% in 2022). However, both ESBL (CTX-M) and pAmpC (*bla*$_{DHA}$) types were detected in low numbers.

National data

Figure 28: Multidrug-resistant *Shigella* species, number reported to CARAlert by month, national, 2017–2023



State and territory data

Figure 29: Multidrug-resistant *Shigella* species, number reported to CARAlert by state and territory, 2017–2023

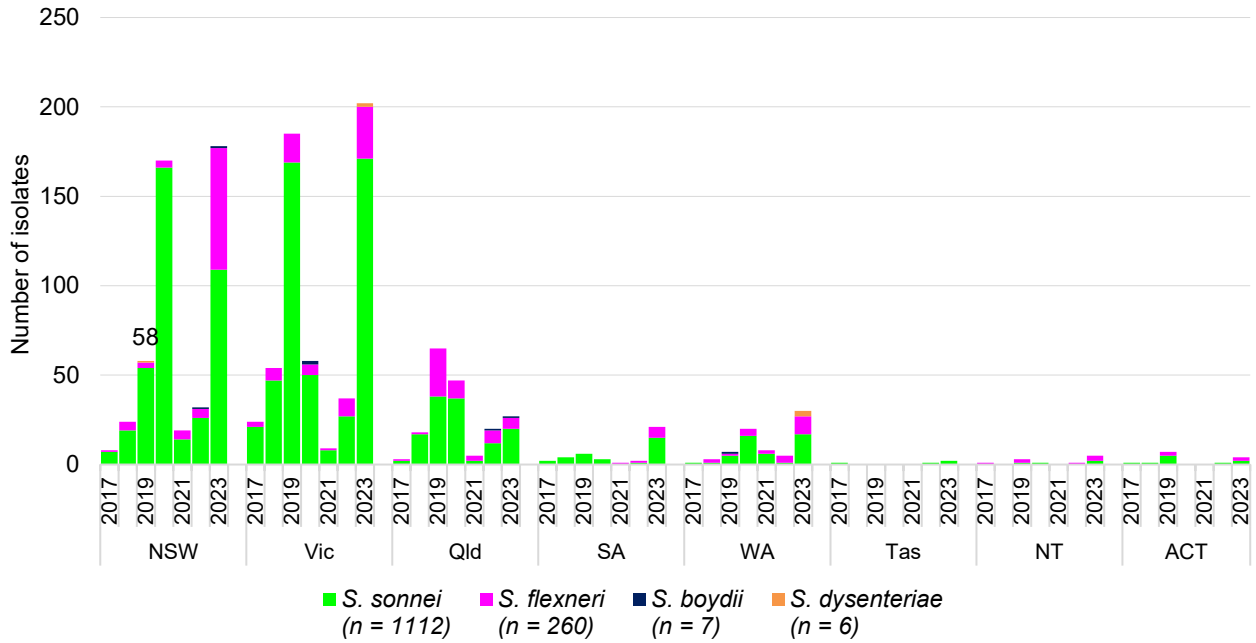
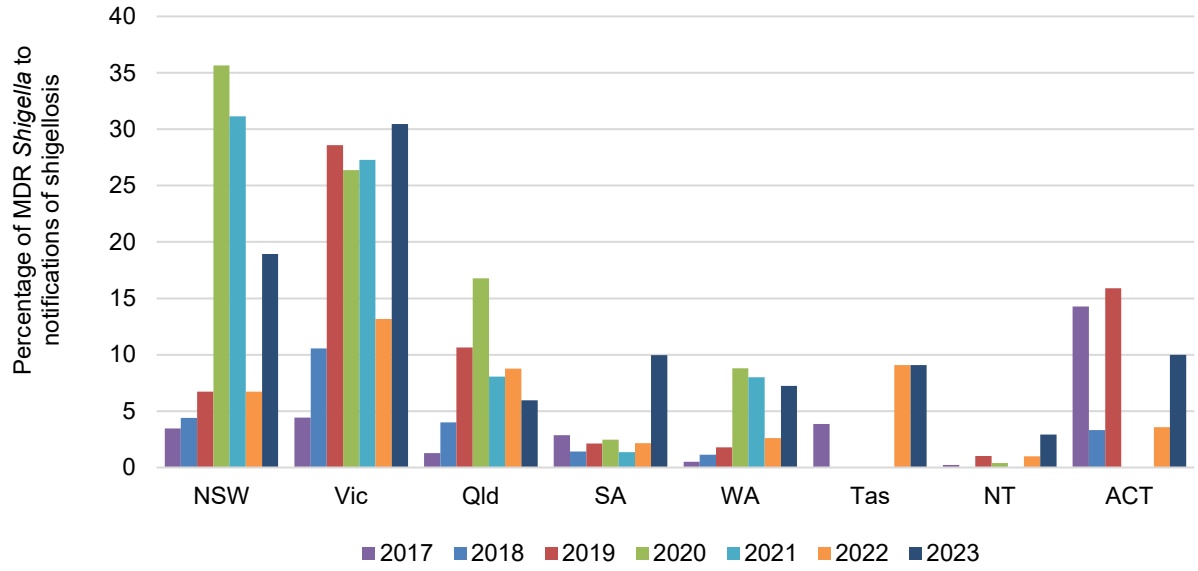


Table 7: Multidrug-resistant *Shigella* species, number reported to CARAlert by setting, state and territory, 2023

Setting	State or territory								Total
	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	
Total	**178**	**202**	**27**	**21**	**30**	**2**	**5**	**4**	**469**
Public hospitals	72	35	3	6	8	1	1	1	127
Private hospitals	1	1	4	1	1	0	0	0	8
Aged care homes	0	0	0	0	0	0	0	0	0
Community	34	116	19	11	19	1	4	2	206
Unknown	71	50	1	3	2	0	0	1	128

Figure 30: Multidrug-resistant *Shigella* species as reported to CARAlert as a percentage of shigellosis notifications, by state and territory, 2017–2023



Note: Notifications of shigellosis may include diagnosis by PCR only.
Source: National Notifiable Diseases Surveillance System[9]

Staphylococcus aureus

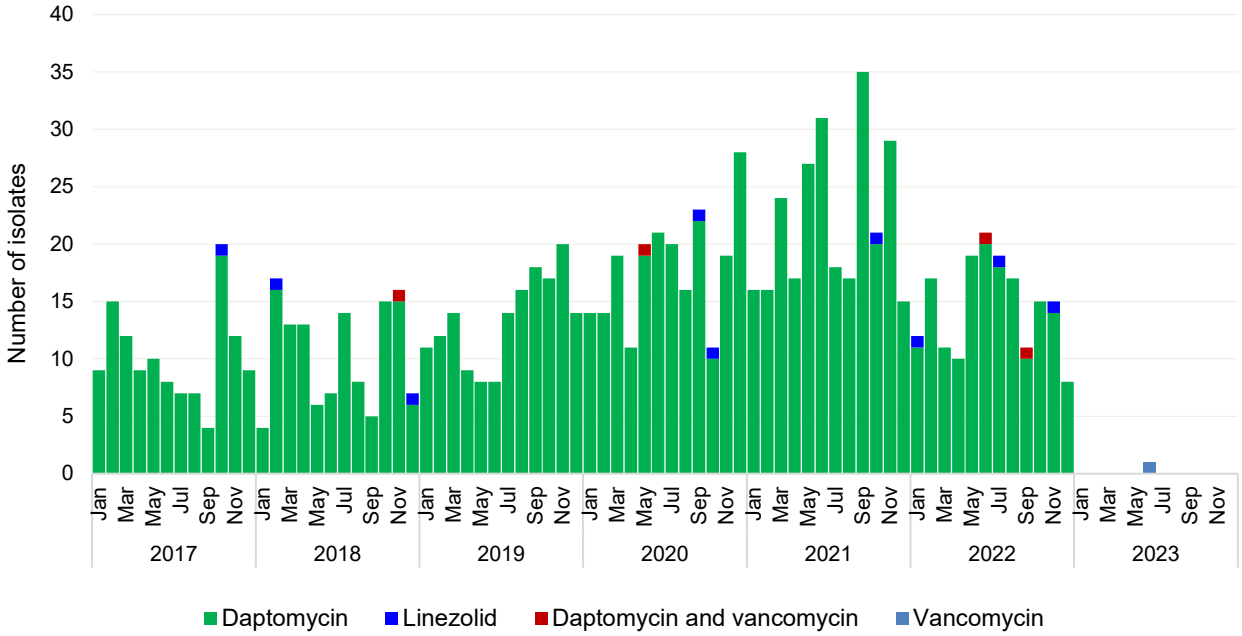
Staphylococcus aureus is a common pathogen causing a wide variety of infections of varying severity.

Reporting of daptomycin-nonsusceptible *Staphylococcus aureus* (DNSA) to CARAlert was suspended from 1 January 2023 given variation in testing and reporting practices by originating laboratories and difficulty in interpreting phenotypic data (Appendix 1).

There was one vancomycin-nonsusceptible *S. aureus* reported in 2023 from a public hospital in WA. This compares to two reports 2022. No linezolid-non-susceptible *S. aureus* were reported in 2023; three were confirmed in 2022 (Figures 31 and 32).

National data

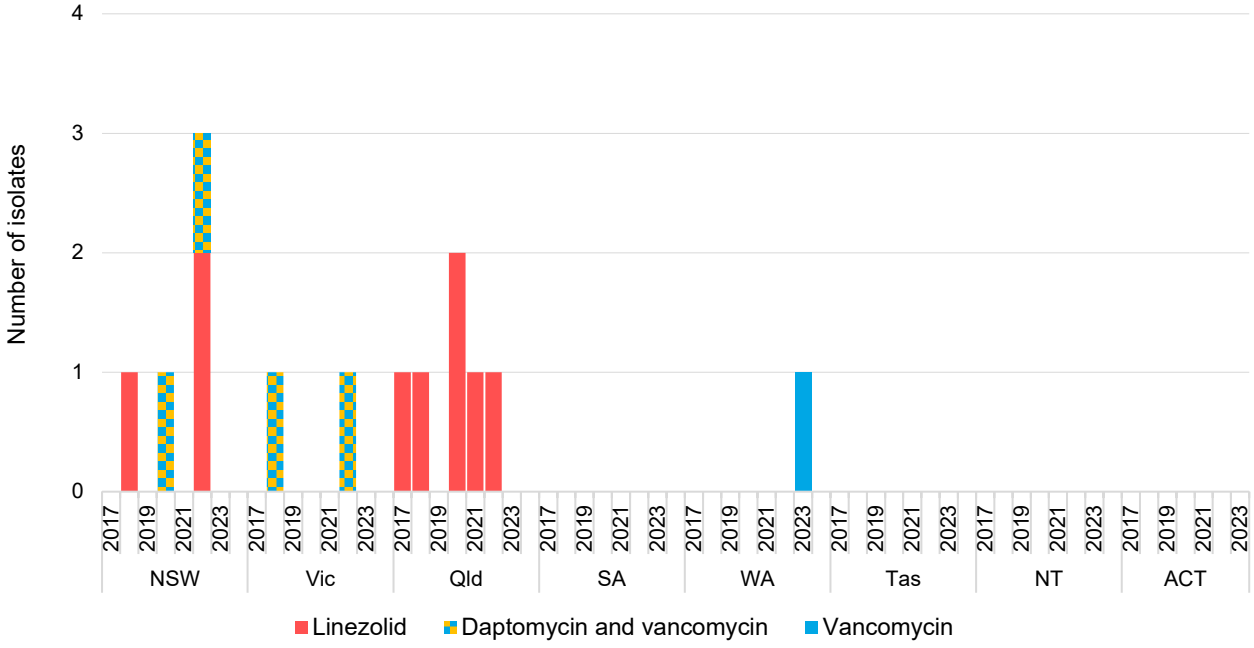
Figure 31: Vancomycin-, linezolid- or daptomycin-nonsusceptible *Staphylococcus aureus,* number reported to CARAlert by month, national, 2017–2023



Notes:
1. For CARAlert, *S. aureus* complex includes *S. argenteus* and *S. schweitzeri*.
2. No *S. argenteus* and *S. schweitzeri* were reported from 2017 to 2023.
3. Daptomycin-nonsusceptible *S. aureus* was suspended from reporting to CARAlert on 1 January 2023.

State and territory data

Figure 32: Vancomycin- or linezolid-nonsusceptible *Staphylococcus aureus,* number reported to CARAlert, national, 2017–2023



Note: Daptomycin-nonsusceptible *S. aureus* was suspended from reporting to CARAlert on 1 January 2023.

Streptococcus pyogenes

Streptococcus pyogenes most commonly causes skin and soft tissue infections, and acute pharyngitis, but may cause serious and life-threatening infections such as scarlet fever, bloodstream infections, bone and joint infections, toxic shock syndrome, necrotising fasciitis and pneumonia.

There have been no reports of *S. pyogenes* with reduced susceptibility to penicillin between 2017 and 2023.

Discussion

Rates of carbapenemase-producing *Enterobacterales* in Australian hospitals

Enterobacterales commonly cause urinary tract, biliary tract and other intra-abdominal infections, and bloodstream infections. Patients are likely to be affected by CPE predominantly where they have been hospitalised.

There was a 45.4% increase in the number of carbapenemase- and/or ribosomal methyltransferase-producing *Enterobacterales* reports from 2022 to 2023. This increase was evident in isolates from hospitals and continues the increasing trend from the beginning of 2022, which followed a decline of CPE reports since 2019. Factors that may have contributed to the decline of CPE reported to CARAlert from 2019 to 2021 include improvements in recognition and infection prevention and control efforts over this period, including the public health measures that were introduced during the COVID-19 epidemic response. It is possible resumption of international travel has contributed to the increase in reports of CPE to CARAlert since 2022. CPE have also become notifiable in some states and territories, which may have contributed to this upward trend.

In 2023, CPE were dominated by IMP-types and NDM-types alone. NDM-producing *Enterobacterales* were reported from all states and territories and showed an increasing trend over 2022 to 2023. By contrast, reporting of IMP-types remained relatively steady over the period 2017 to 2023. Although NDM types are generally thought to be acquired overseas, identification of local transmission and appropriate infection prevention and control actions are important priorities. The range and number of CPE types will continue to evolve because of changing local and global epidemiology. Each carbapenemase type has a slightly different spectrum of activity against different β-lactam antimicrobials. Typing of CPE is important for supporting appropriate antimicrobial prescribing to treat infections caused by CPE.

The differences between states and territories in the proportion of screening isolates may indicate local variations in surveillance, infection prevention and control, and screening practices. Local outbreaks are likely to have required increased infection prevention and control and surveillance resources in affected hospitals over short periods of time. The impact of outbreaks on other aspects of hospital work and patient flows may be substantial in the absence of timely infection prevention and control action. The variation between states and territories in reports of CPE as a proportion of all CARs, and the frequency of reporting of CPE, indicates the need for local decisions about containment priorities.

A total of 4.4% of all CPE reports occurred in the 0–4-year age group. The mode of acquisition of these CARs is not known; however, CPE outbreaks can occur in the neonatal intensive care unit setting. The long-term impact of this type of resistance on neonates is unknown. Education of clinicians on the risks of neonatal acquisition of antimicrobial-resistant organisms, and review of the appropriateness of antimicrobial use and infection prevention and control in the neonatal care setting are encouraged.

Patients are likely to be affected by CPE if they are hospitalised for a prolonged period; 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).

Ongoing reports of CPE albeit at low levels, 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 *(CPE): A guide for acute health service organisations*.[3]

Arrangements for specialist oversight of and access to restricted antimicrobials, such as carbapenems, should continue to be a priority for all Australian hospitals, along with the

implementation of systems that meet the antimicrobial stewardship (AMS) actions of the National Safety and Quality Health Service (NSQHS) Standards.[2]

Changes in community-onset critical antimicrobial resistances

N. gonorrhoeae was the most commonly reported CAR from the community setting for all years since CARAlert commenced, except for 2019 where MDR *Shigella* species dominated. Reports of azithromycin-nonsusceptible *N. gonorrhoeae* (LLR) increased in 2023 following a decline from its peak in 2017. Reports of azithromycin-nonsusceptible *N. gonorrhoeae* (HLR) increased in 2023, while reports of ceftriaxone-nonsusceptible *N. gonorrhoeae* declined. Ceftriaxone-nonsusceptible and azithromycin-nonsusceptible (HLR) *N. gonorrhoeae* was reported for the first time since 2018.

Reports of MDR *Shigella* species more than quadrupled from 2022 to 2023. The proportion of shigellosis notifications that were MDR increased overall in 2023 compared to 2022. The increase was noted in all states and territories where there were five or more reports, except in Queensland, where the proportion decreased.

The ongoing overall increase in reports of these CARs in 2023 corresponds with the increased resumption of usual social interaction and international travel following easing of COVID-19 restrictions from late 2021. These changes indicate that ongoing monitoring of resistance in gonococcal disease and shigellosis is required because of the importance of emerging changes in susceptibility for treatment guidelines.

Increases in reports of MDR *Shigella* suggest that empirical antimicrobial therapy recommendations for shigellosis may need to be reconsidered. Increases also require ongoing close review by states and territories. Public health messaging should continue to highlight the risk of sexual transmission of *Shigella* species, particularly in men who have sex with men, and provide guidance on ways to reduce the risk of transmission.

The emergence of gonococcal antimicrobial resistance (AMR) in Australia has long been influenced by the introduction of MDR strains from overseas.[10, 11] A number of reports from other countries of ceftriaxone-resistant *N. gonorrhoeae* strains have raised global concerns about the effectiveness of current recommended treatments.[12-14] This also prompted the addition of reporting of gentamicin-resistant *N. gonorrhoeae* to CARAlert from 2023. In Australia, the recommended treatment for *N. gonorrhoeae* is ceftriaxone in conjunction with azithromycin. This regimen was introduced in Australia in 2014 to limit further development of resistance to ceftriaxone.[15] The low background rate of azithromycin-nonsusceptible *N. gonorrhoeae* (LLR) in Australia is well established.[16] Reports of this CAR declined from 2019 to 2022, and increased dramatically in 2023, particularly in NSW and Victoria .[9] The clinical implications of this low-level resistance are not clear. Despite low numbers, continuing reports of ceftriaxone-nonsusceptibility are concerning.

Critical antimicrobial resistances in aged care homes

In 2023, there were 8 CARs reported from aged care homes. All reports were CPE from clinical isolates. This is down from 24 in 2022 following the suspension of reporting DNSA to CARAlert. While the number of reports is extremely low, aged care home residents have increased vulnerability to infections, and are at risk of acquiring or transmitting infections due to the frequent movement of aged care home residents between acute settings.

In aged care homes, infections of the skin and soft tissue and urinary tract are the most common reason for antimicrobial prescriptions[17], and are commonly caused by *S. aureus* and *Enterobacterales*, respectively. These organisms may be spread by contact with contaminated surfaces or medical equipment and hands of healthcare workers, visitors and residents. Environmental cleaning and hand hygiene are important prevention and control strategies. In group living situations, infections may also be inadvertently spread from person to person, for example by sharing personal items such as bed linen, towels or clothing.

Specific measures are required in all care settings for CPE. To support the capacity to prevent and control transmission of CPE, aged care homes should comply with the infection prevention and

control requirements of the Aged Care Quality Standards[6], which include compliance with national guidelines.[1]

Health service demand and complexity of care

CARs 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.[18] Patients with MDR infections were also less likely to receive appropriate antimicrobial therapy initially.[18] 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.[19]

Increases in CARs also require ongoing close review by states and territories as there are limited oral antimicrobial options, and intravenous antimicrobials may be required to treat MDR infections. There may also be resource implications for the health system because of increased testing, hospital admissions and transmission in the community.

What will be done to improve patient safety?

In response to the issues identified in analyses of CARAlert data between 2017 and 2023, the Commission will continue to:

- Monitor CARs reported to CARAlert, maintain the CARAlert system and communicate CARAlert and other Antimicrobial Use and Resistance in Australia (AURA) surveillance data and key findings to states, territories, the Department of Health and Aged Care and relevant experts
- Maintain the currency of and promote compliance with the *Australian Guidelines for the Prevention and Control of Infection in Healthcare*[1] as required by the NSQHS Standards[2], and relevant local guidance for the response to CPE
- Maintain the currency of and promote implementation of guidance for specific organisms, such as the *Recommendations for the control of carbapenemase-producing* Enterobacterales *(CPE): A guide for acute care health service organisations*[3] and promote the consistency of screening, infection prevention and control practices, and outbreak responses to improve CPE containment
- Use CARAlert and other AURA data to refine and strengthen approaches to infection prevention and control and AMS, and support implementation of the NSQHS Standards[2], the National Safety and Quality Primary and Community Healthcare Standards[4] and the AMS Clinical Care Standard[5]
- Liaise with the Aged Care Quality and Safety Commission and aged care provider organisations and develop resources to support implementation of infection prevention and control programs in aged care homes to meet the requirements of the Aged Care Quality Standards, particularly the strengthened Aged Care Clinical Standard[6]
- Support collaboration between states and territories and hospital and community care settings to prevent and control CARs
- Prepare analyses of AMR data for, and liaise with Therapeutic Guidelines Limited, the organisation that develops guidance on antimicrobial prescribing in Australia.

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Appendix 1 About CARAlert

The National Alert System for Critical Antimicrobial Resistances (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.

Funding for CARAlert is provided by the Australian Government Department of Health and Aged Care (the Department), with contributions from the states and territories by meeting the costs of confirmatory testing and data submission processes.

CARAlert is based on routine processes used by pathology laboratories for identifying and confirming potential critical antimicrobial resistances (CARs), in which participating confirming laboratories submit data to CARAlert on priority organisms with critical resistance to last-line antimicrobials. Isolates collected from patients are reported to CARAlert as either a clinical isolate, that is a specimen (e.g., from blood, urine, wound) taken to guide clinical diagnosis, or as a screen for infection prevention and control purposes. No patient-level data are held in the CARAlert system.

In 2023, 26 confirming laboratories participated in CARAlert (Appendix 3) and there have been over 12,600 reports to CARAlert since reporting began.

CARAlert data on confirmed cases of CARs can be used to identify seasonal, geographic and national trends. The potential for CARAlert to act as an early warning system for CAR outbreaks to enable timely infection prevention and control responses is dependent on timely reporting of CARs by confirming laboratories.

The CARs reported under CARAlert are listed in Table A1. These CARs were drawn from the list of high-priority organisms and antimicrobials that are the focus of the AURA Surveillance System.

Table A1: List of critical antimicrobial resistances reported to CARAlert, 2023

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

* Reported to CARAlert from July 2019
† Reported to CARAlert from January 2023
§ For CARAlert, *S. aureus* includes *S. argenteus* and *S. schweitzeri*
# Reporting of daptomycin-nonsusceptible *S. aureus* was suspended from January 2023
Note: Low level-azithromycin-nonsusceptible *N. gonorrhoeae* was excluded from the weekly summary following review in 2018.

The CARAlert system generates a weekly summary email to report information on confirmed CARs to state and territory health authorities, the Department and confirming laboratories.

CARAlert data can support timely responses to CARs by hospitals, and state and territory health departments. Some states have made selected CARs, such as carbapenemase-producing *Enterobacterales* 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 has the potential to inform a broad range of safety and quality improvement programs.

The Commission reviewed the CARs reported to CARAlert in 2018, in conjunction with the states and territories and a range of clinical experts. The review identified four new CARs that were reported to CARAlert from July 2019:

- Carbapenemase-producing *Acinetobacter baumannii* complex
- *C. auris*
- Transmissible resistance to colistin in *Enterobacterales*
- Carbapenemase-producing *Pseudomonas aeruginosa*.

The Commission completed another review of the CARs reported to CARAlert in 2022. This review followed a similar process to the 2018 review. The 2022 review identified two new CARs that were reported to CARAlert from January 2023:

- Gentamicin-resistant *Neisseria gonorrhoeae*
- Ciprofloxacin-nonsusceptible *N. meningitidis*.

Reporting of daptomycin-nonsusceptible *Staphylococcus aureus* was suspended from 1 January 2023, as recommended. Reporting of this CAR will be reconsidered when more reliable testing methods are available.

The Department regularly evaluates national surveillance systems to ensure they continue to meet their purpose and objectives. In 2022–2023, the Department conducted an evaluation of CARAlert, which complements the Commission's review of CARs. The purpose of the CARAlert evaluation was to examine:

- How well the system operates to meet its purposes and objectives
- The appropriateness of the system's purposes and objectives
- Improvements to enhance the system's ability to meet these objectives.

The United States Centers for Disease Control and Prevention *Updated Guidelines for Evaluating Public Health Surveillance Systems*[20] was used to evaluate the system's usefulness and performance against system attributes. The Commission will collaborate with the Department, states and territories and confirming laboratories to consider the recommendations of the evaluation and feasibility for implementation.

Information on CARAlert processes and considerations for interpreting CARAlert data is in Appendix 2.

Appendix 2 Methodology

CARAlert reporting processes

All of the following criteria must be met for organisms and resistances to be categorised as a critical antimicrobial resistance (CAR) for reporting to the National Alert System for Critical Antimicrobial Resistances (CARAlert):

- Inclusion as a priority organism for national reporting as part of the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System[21]
- 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.

Candida auris was added as a CAR for reporting to CARAlert in 2019 despite not being an AURA Surveillance System priority organism.[21] This change was in response to feedback from respondents to the 2018 review of CARs, and international concerns for its multi-drug resistance and association with invasive infection outbreaks in healthcare facilities in 2017.[22]

CARAlert 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
- Reporting to clinicians in accordance with usual laboratory processes – the confirming laboratory reports back to the originating laboratory, which in turn reports to the clinician who initially requested the microbiological testing
- Submission to CARAlert – 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 from whom the specimen was collected; the confirming laboratory then submits the details of the resistance and organism to the secure CARAlert web portal.

The results of confirmatory testing are provided to the originating laboratory as soon as possible after confirmation. Generally, confirming laboratories submit a CAR report within seven days of the isolate being confirmed as a CAR.

Information collected in CARAlert includes: the originating and confirmatory laboratory, specimen identifier, specimen collection date, CAR, CAR type or subtype if applicable, organism name, specimen type, facility type, patient age range, patient gender, and state or territory of patient residence and state or territory of record.

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.

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 the Australian Group on Antimicrobial Resistance. In 2023, 26 confirming laboratories submitted data to CARAlert (Appendix 3), 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.

All data analyses for this report were performed using Microsoft Excel 365.

Data considerations

The following are important considerations for interpreting CARAlert data:

- Participation in CARAlert is voluntary
- The data are based on the date that the isolate with the confirmed CAR was collected
- State or territory refers to the jurisdiction within which the hospital is located, or within which the patient resides for isolates from the community. If place of residence is unknown or overseas, the state or territory of the originating laboratory is reported
- The same CAR/type/species is not submitted where the sample originated from the same patient who had the same previous CAR, and the isolate was collected on the same day, or collected in the same admission or within three months
- 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
- Cut-off date for data that are included in updates and reports is four weeks after the end of each reporting period
- Data may vary from that previously published as the reported number of CARs may have been updated to include additional submissions received or removed after the previous publication date; Comparison between reports may be influenced by delays in confirming laboratories reporting CARs to CARAlert due to late submission, which also means that the data analysed for this report may not be complete for the 2023 calendar year at the time of publication
- 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
- Local operating procedures for laboratories may not currently include testing for all the critical resistances included in CARAlert; however, all laboratories are encouraged to actively screen for CARs.

Appendix 3 CARAlert confirming laboratories, 2023

The Commission thanks all originating and confirming laboratories for their support for the National Alert System for Critical Antimicrobial Resistances (CARAlert) and the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System. The following confirming laboratories participated in CARAlert in 2023:

State or Territory	Institution
New South Wales	NSW Health Pathology, Children's Hospital Westmead
	NSW Health Pathology, Concord Hospital, Concord
	NSW Health Pathology, John Hunter Hospital, New Lambton Heights
	NSW Health Pathology, Liverpool Hospital, Liverpool
	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
Victoria	Alfred Pathology Service, Melbourne
	Dorevitch Pathology, Heidelberg
	Melbourne Pathology, Collingwood
	Microbiological Diagnostic Unit Public Health Laboratory, Melbourne
	Monash Pathology, Clayton
	Victorian Infectious Diseases Reference Laboratory (VIDRL), Melbourne
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
Western Australia	PathWest Laboratory Medicine WA, Fiona Stanley Hospital, Murdoch
	PathWest Laboratory Medicine WA, QEII Medical Centre, Nedlands
Tasmania	Royal Hobart Hospital, Hobart
Northern Territory	Territory Pathology, Tiwi
Australian Capital Territory	ACT Pathology, Garran

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