Australian Commission on **Safety and Quality** in Health Care

AURA
Antimicrobial Use and Resistance in Australia

Australian Passive AMR Surveillance: Resistance trends in *Streptococcus pneumoniae* – 2006 to 2025

July 2026

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We recognise that knowledge about healthy Country, community and culture has been developed by Aboriginal and Torres Strait Islander peoples over tens of thousands of years and has been shared for generations. We are committed to partnering with and learning from Aboriginal and Torres Strait Islander peoples through the work that we do.

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Executive summary

Antimicrobial-resistant microorganisms, including bacteria, and the resistance genes they carry can spread readily between people in the community as well as those receiving care in hospitals, aged care homes and primary care services. The spread of antimicrobial resistance (AMR) can occur rapidly and significantly affect patients, the community, health services and the broader health system. Effective surveillance and monitoring are essential to determine the burden and trends of AMR, and to inform infection prevention and control and antimicrobial stewardship (AMS) strategies, and prescribing guidelines. These actions aim to reduce patient harm, minimise healthcare-related environmental impacts, and support the sustainability and resilience of health care.

This report provides analyses of data on AMR in *Streptococcus pneumoniae* from the Australian Passive AMR Surveillance (APAS) system. APAS collects data on antimicrobial susceptibility testing results from public and private pathology services across Australia that voluntarily contribute to APAS. These data are sourced from hospitals, aged care homes and the community. The Australian Commission on Safety and Quality in Health Care (the Commission) established APAS as a key component of the Antimicrobial Use and Resistance in Australia (AURA) surveillance program.

The focus of this report is on trends in resistance to penicillin, macrolides and tetracycline antibiotics in *S. pneumoniae*, primarily for 2016 to 2025, with some analyses extending back to 2006.

Key findings and trends: 2016 to 2025

- Over this 10-year period, resistance rates for *S. pneumoniae* remained relatively stable.
- Resistance to macrolides was the most common in *S. pneumoniae* across all specimen types at an overall average of 23%, followed closely by resistance to tetracyclines.
- Resistance to penicillin was less than 5% across all specimen types, while resistance to ceftriaxone/cefotaxime was the lowest at less than 1%.
- Resistance rates to macrolides and tetracyclines was higher among adults than children.
- Prevalence of resistance varied by patient's location of residence and by antimicrobial agent.

Implications for patient safety

- High and increasing rates of macrolide and tetracycline resistance mean that empirical monotherapy with these agents is more likely to result in treatment failure when *S. pneumoniae* is the causative pathogen.
- Increasing AMR in *S. pneumoniae* may limit available treatment options. This may lead to greater reliance on broader spectrum classes such as fluoroquinolones or carbapenems, which can increase selection pressure for AMR in other bacteria, not only pneumococcus.

What will be done to improve patient safety?

In response to the issues identified in analyses in this report, the Commission will continue to:

- Collaborate with the Australian Centre for Disease Control (CDC) for the monitoring and reporting on AMR data collected by APAS, and communicate APAS and other AURA surveillance data and key findings to states, territories and relevant experts.
- Collaborate with the CDC to prepare and submit data to the World Health Organization (WHO) Global Antimicrobial Resistance and Use Surveillance System (GLASS) including on *S. pneumoniae*.
- Collaborate with the CDC to work with states and territories and the private laboratory sector to encourage consideration of geographic variation of AMR through the use of local antibiograms produced by APAS contributors.
- Work with developers of prescribing guidelines, including Therapeutic Guidelines Limited, to ensure AMR data informs guidelines, including *Therapeutic Guidelines: Antibiotic*[1]; and for these to be promoted to prescribers through clear communications.
- Promote incorporation of concepts of geographical variation in AMR into clinical practice; particularly to support clinicians who work in a range of settings.
- Use APAS and other AURA data to refine and strengthen guidance for surveillance, prevention and control of *S. pneumoniae* and other resistances, and AMR programs.
- Support collaboration and coordination between states and territories, and between hospital and community care settings to explore the drivers of variation and improve local prevention and control efforts to help limit progression of AMR.
- Collaborate with the CDC to work with state and territory health authorities, and private pathology services, to achieve nationwide participation in APAS and enhance recommended national surveillance coverage.
- Promote best practice in the assessment and management of Chronic Obstructive Pulmonary Disease (COPD), including exacerbations in line with the *COPD Clinical Care Standard*.[2]
- Maintain the currency of and promote compliance with the *Australian Guidelines for the Prevention and Control of Infection in Healthcare*[3] as required by the *National Safety and Quality Health Services (NSQHS) Standards*[4] and *National Safety and Quality Primary and Community Healthcare Standards* (*Primary and Community Healthcare Standards*).[5]
- Liaise with the Aged Care Quality and Safety Commission and aged care provider organisations and promote use of *The Aged Care Infection Prevention and Control Guide*[6] to support implementation of infection prevention and control and AMS programs in aged care homes to meet the requirements of the strengthened *Aged Care Quality Standards*[7], particularly the *Aged Care Clinical Standard*.[8]

Introduction

About Australian Passive AMR Surveillance and this report

The Australian Commission on Safety and Quality in Health Care (the Commission) established Australian Passive AMR Surveillance (APAS) in 2015 in collaboration with Queensland Health. APAS forms part of the Antimicrobial Use and Resistance in Australia (AURA) surveillance program, which is coordinated and funded by the Australian Centre for Disease Control (CDC). States and territories and participating private pathology services contribute to APAS through voluntary support and resourcing for the collection and submission of their data, and the maintenance of integrated systems for surveillance of AMR in Australia.

APAS reports on de-identified, patient-level AMR from antimicrobial susceptibility testing results from participating pathology services across Australian healthcare settings. Detailed information about APAS is included in Appendix 1.

This report provides analyses of data on antimicrobial resistance (AMR) in *Streptococcus pneumoniae* from the APAS system. It builds on analyses of *S. pneumoniae* presented in the series of national AURA reports since 2016[9-14], and is complementary to analyses presented in other APAS reports on key or emerging resistances in Australia.[15-17] The methodology and considerations for interpretation of data and analyses presented in this report are included in Appendix 2.

About *Streptococcus pneumoniae*

S. pneumoniae is an important community pathogen often associated with respiratory infections. It can cause both non-invasive and invasive infections and is also known as pneumococcal disease. The capacity of *S. pneumoniae* to cause disease is linked to its polysaccharide capsule, of which there are more than 100 serotypes.[18]

S. pneumoniae is a common cause of non-invasive disease, that is infections found in non-sterile sites, such as otitis media, acute sinusitis and acute exacerbation of chronic obstructive pulmonary disease (COPD). It can also cause serious, invasive disease including pneumonia, bacteraemia and meningitis.

Reports of invasive pneumococcal disease (IPD) are captured by the National Notifiable Disease Surveillance System (NNDSS) due to its serious public health risk.[19] Populations most vulnerable to IPD include young children, the very elderly and Aboriginal and Torres Strait Islander peoples. Other groups at greatest risk are people who are immunocompromised, those with underlying health conditions such as heart or lung disease, and people with a history of smoking.[20] The incidence of IPD varies seasonally with more cases occurring during winter.[21]

S. pneumoniae causes considerable morbidity and mortality in Australia each year. Globally, diseases caused by *S. pneumoniae* remain a leading cause of death in both children and adults.[22]

Vaccination remains the best prevention strategy against IPD. In Australia, infections caused by vaccine-covered serotypes have fallen dramatically since the introduction of pneumococcal vaccines.[23] Three pneumococcal vaccines are included in the National Immunisation Program (NIP).[24] However, not all pneumococcal disease is vaccine-preventable as the available vaccines do not cover all serotypes. Serotype is not captured by APAS, but some data are available from Victoria on serotype distribution and AMR for IPD.[25]

For the subset of patients for whom treatment of non-invasive pneumococcal disease is required, including otitis media and acute sinusitis, amoxicillin is commonly recommended,

while antimicrobial therapy is not routinely recommended for exacerbations of COPD.[1] Benzylpenicillin is commonly recommended for mild to moderate pneumonia, while ceftriaxone is commonly recommended for severe pneumococcal pneumonia and meningitis.[1]

AMR in *S. pneumoniae* is a concern across a range of antimicrobials.[26,27] Penicillin resistance has been identified in Australia over the last 60 years, and resistances to other antimicrobials have emerged since.[28,29]

There are important treatment implications for AMR in *S. pneumoniae*, particularly given variations in laboratory testing and reporting practices, and individual patient factors including disease severity, allergies and contraindications.

In 2024, the World Health Organization (WHO) classified *S. pneumoniae* as a priority pathogen due to the emergence of macrolide-resistant strains.[30] The WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) also collects and reports on data on *S. pneumoniae* from more than 100 countries, including APAS data reported by Australia.[31,32]

Results

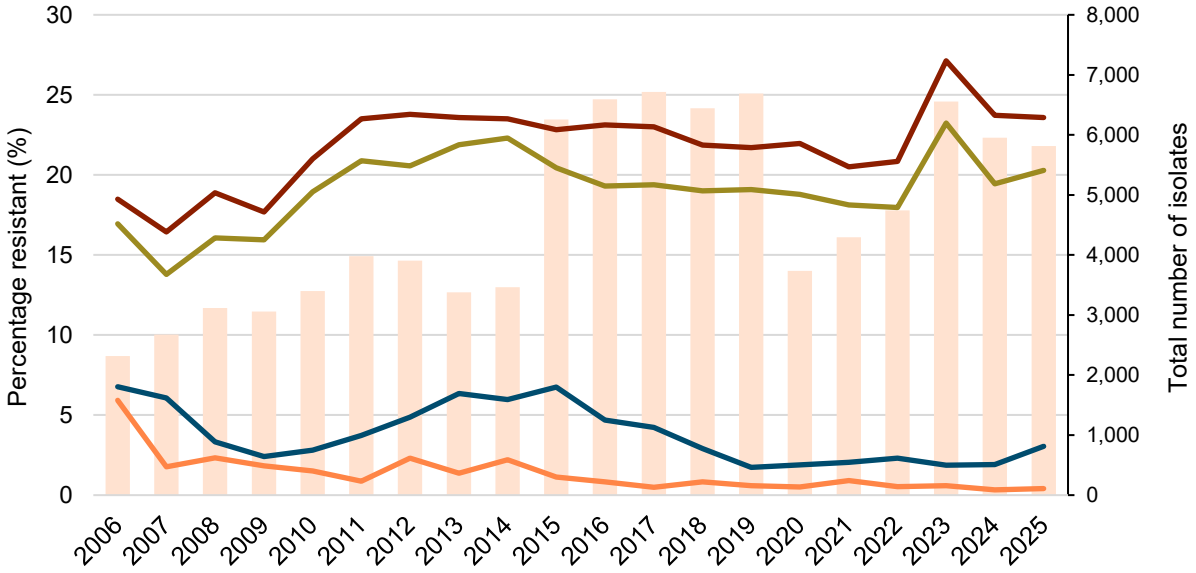
Between 2006 and 2025, there were 93,090 *S. pneumoniae* isolates from all pathology services that contribute data to APAS. Results from 2015 were from all APAS contributors (*n* = 63,792), while results from 2006 data represents historical data collected from four pathology services (see Appendices 1 and 2).

Since 2016, susceptibility test results were available for penicillin for 89.7% of *S. pneumoniae* isolates; macrolides for 91.3%; and tetracyclines for 70.5%. For third-generation cephalosporins (ceftriaxone/cefotaxime), results were only available for 51.7% of isolates noting that this resistance is not commonly tested for in penicillin-susceptible *S. pneumoniae*.

Figure 1 shows the 20-year trends for *S. pneumoniae* with resistance to key antimicrobials reported by all APAS contributors between 2006 and 2025.

In 2025, there were 3,335 *S. pneumoniae* isolates where susceptibility results were reported for penicillin, macrolides, and tetracyclines; these made up 57% of the total number of isolates. One-quarter of these isolates were resistant to one or more antimicrobial class (*n* = 816, 24.5%). The most common combination was resistance to both macrolides and tetracyclines (*n* = 443, 13.3%). Multi-drug resistance (resistance to three or more antimicrobial classes) was identified in 2.1% (*n* = 71) of isolates.

Figure 1 Percentage of *Streptococcus pneumoniae* with resistance to key antimicrobials, APAS contributors, 2006–2025



		Percentage reistant, % (*n*)			
	Total number, *n*	Penicillin	Macrolides	Tetracyclines	Ceftriaxone/ cefotaxime
2006	2,319	6.8 (2,275)	18.5 (2,282)	16.9 (1,789)	5.9 (304)
2007	2,675	6.1 (2,588)	16.4 (2,634)	13.8 (2,031)	1.8 (451)
2008	3,116	3.3 (3,001)	18.9 (3,078)	16.1 (2,273)	2.3 (473)
2009	3,058	2.4 (2,913)	17.7 (3,008)	16.0 (2,307)	1.8 (549)
2010	3,397	2.8 (3,235)	21.0 (3,342)	19.0 (2,680)	1.5 (731)
2011	3,983	3.7 (3,862)	23.5 (3,883)	20.9 (3,136)	0.9 (1,029)
2012	3,908	4.9 (3,805)	23.8 (3,788)	20.6 (3,014)	2.3 (1,168)
2013	3,377	6.4 (3,288)	23.6 (3,244)	21.9 (2,499)	1.4 (1,028)
2014	3,465	6.0 (3,372)	23.5 (3,336)	22.3 (2,561)	2.2 (1,083)
2015	6,255	6.7 (5,694)	22.8 (6,107)	20.4 (4,232)	1.1 (1,937)
2016	6,594	4.7 (5,911)	23.1 (6,416)	19.3 (4,724)	0.8 (2,423)
2017	6,716	4.2 (5,991)	23.0 (6,501)	19.4 (5,027)	0.5 (2,638)
2018	6,443	2.9 (5,860)	21.9 (6,299)	19.0 (4,972)	0.8 (2,664)
2019	6,690	1.7 (6,114)	21.7 (6,129)	19.1 (4,889)	0.6 (3,052)
2020	3,733	1.9 (3,444)	22.0 (3,311)	18.8 (2,651)	0.5 (1,763)
2021	4,295	2.0 (3,958)	20.5 (3,833)	18.1 (2,935)	0.9 (2,216)
2022	4,742	2.3 (4,304)	20.9 (4,163)	18.0 (3,227)	0.5 (2,807)
2023	6,557	1.9 (6,033)	27.1 (5,747)	23.2 (4,234)	0.6 (3,958)
2024	5,954	1.9 (5,061)	23.7 (5,000)	19.5 (4,000)	0.3 (4,250)
2025	5,813	3.0 (4,923)	23.6 (5,121)	20.3 (3,923)	0.4 (3,954)
Total	93,090	85,632	87,520	67,104	38,478

n = denominator for total number of isolates

Notes:

1. Macrolides refer to either erythromycin or azithromycin.
2. Tetracyclines refer to either tetracycline or doxycycline.

Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

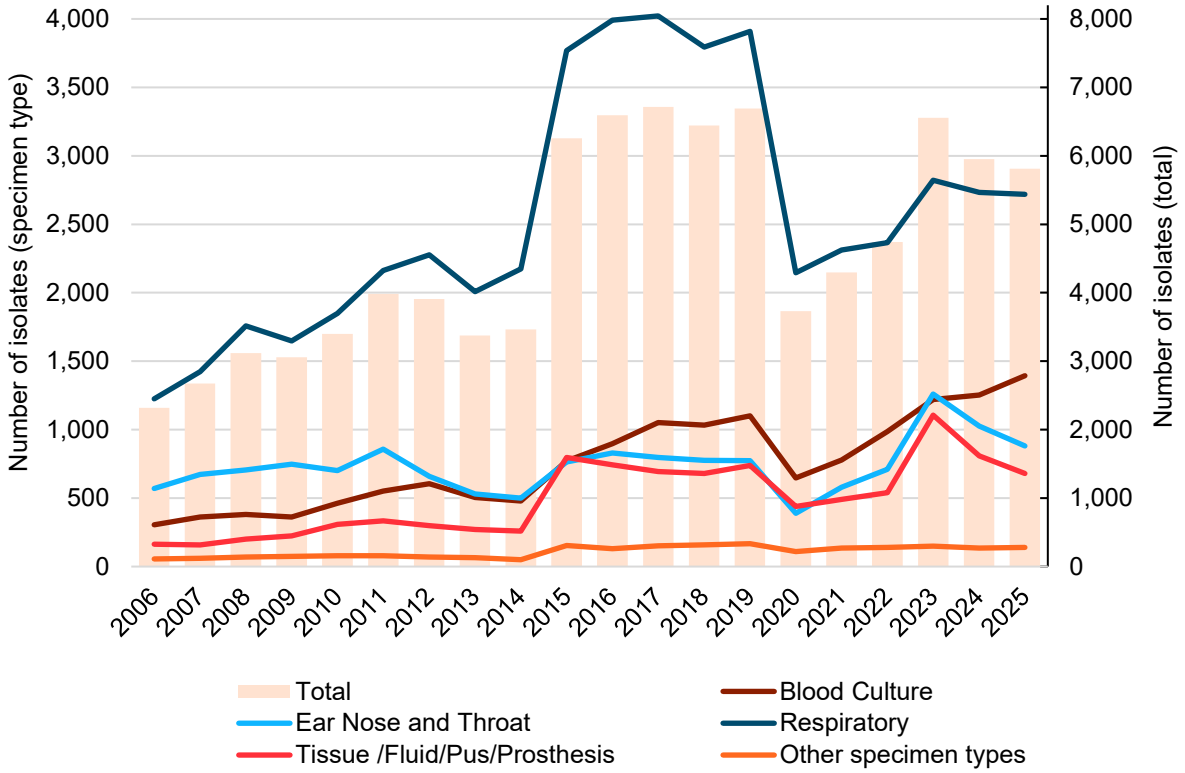
Resistance by specimen type

Figures 2 and 3 show trends by specimen type in *S. pneumoniae* isolates captured by APAS. For more information on specimen types, see Appendix 2.

Of all *S. pneumoniae* isolates since 2006, over 97.7% were collectively from specimens of the respiratory tract (*n* = 51,111, 54.9%), blood culture (*n* = 15,142, 16.3%), ear, nose and throat (*n* = 14,732, 15.8%) or tissue/fluid/pus/prosthesis (*n* = 9,934, 10.7%). Other specimen types include urine (*n* = 928), genital (*n* = 833), and cerebrospinal fluid (*n* = 410) (Figure 2).

Between 2020 and 2025, the number of isolates from blood increased 2-fold, while isolates from other specimen types peaked in 2023, and have since declined or remained steady (Figure 2).

Figure 2 Number of *Streptococcus pneumoniae* isolates by specimen type, APAS contributors, 2006–2025



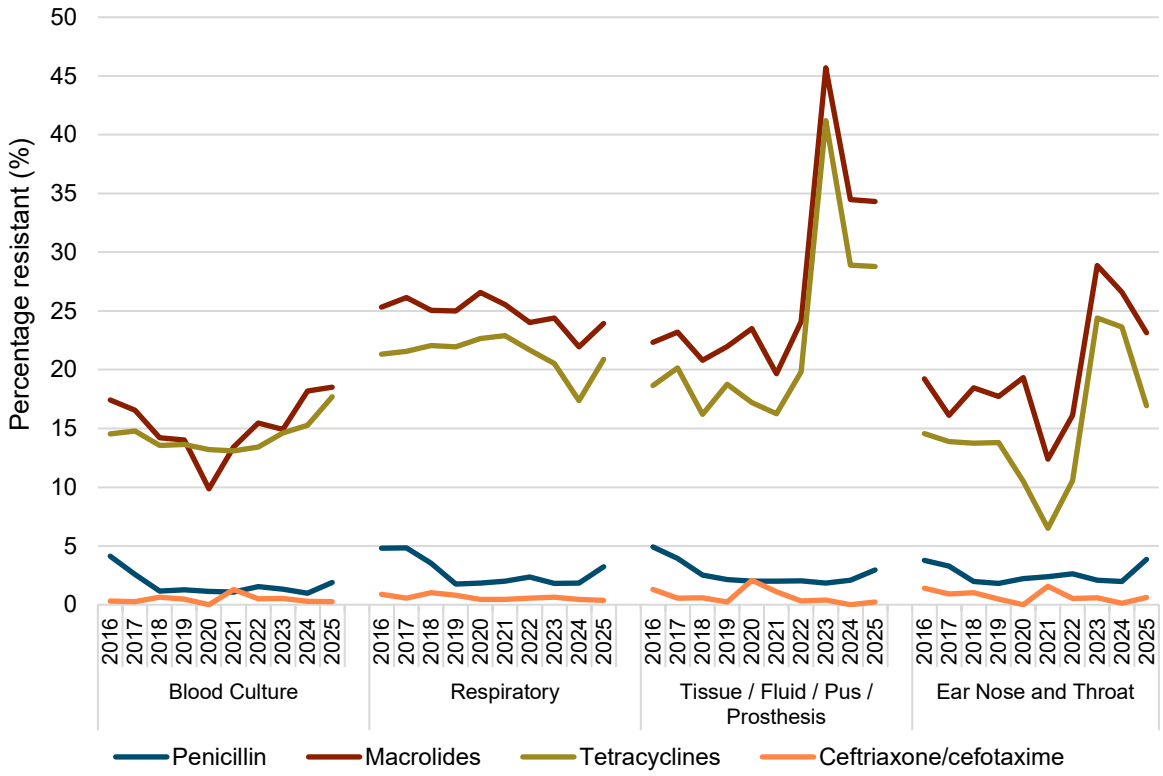
Note: Other specimen types include urine, genital, and cerebrospinal fluid.
Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Figure 3 shows the 10-year trend in resistance in *S. pneumoniae* to key antimicrobials by specimen type.

Resistance to macrolides and tetracyclines was more common than penicillin and third-generation cephalosporins (ceftriaxone/cefotaxime) across all specimen types.

In 2023, there was a sharp increase in macrolide and tetracycline resistance in *S. pneumoniae* isolated from people with tissue/fluid/pus/prosthesis, and ear, nose and throat infections.

Figure 3 Trends in resistance in *Streptococcus pneumoniae* to key antimicrobials by specimen type, APAS contributors, 2016–2025



Notes:
1. Macrolides refer to either erythromycin or azithromycin.
2. Tetracyclines refer to either tetracycline or doxycycline.

Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

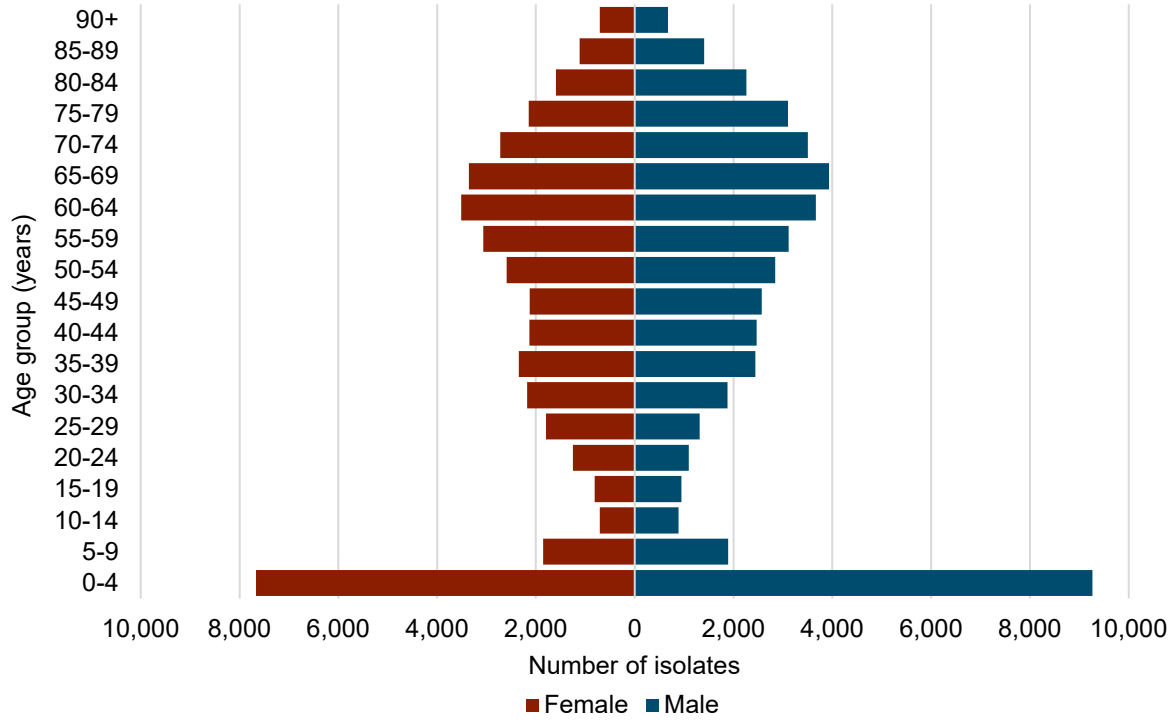
Resistance by age group

Figures 4 and 5 show trends by age group in *S. pneumoniae* isolates captured by APAS. Age was known for all except 83 isolates from 2006 to 2025. For more information on analysis by age, see Appendix 2.

Where age was known, 28.5% (*n* = 26,531) of *S. pneumoniae* isolates over the 20-year period were from people aged 65 years or over and 18.2% (*n* = 16,952) were from children aged less than 5 years. Almost one-half of all isolates were from adults aged 18 years and over with respiratory tract infections (*n* = 46,241).

When grouped by 5-year age groups, incidence of *S. pneumoniae* was higher in males than females except for those aged 5–9, 20–34 and 90 years and over, respectively (Figure 4).

Figure 4 *Streptococcus pneumoniae*, age and sex distribution, APAS contributors, 2006–2025

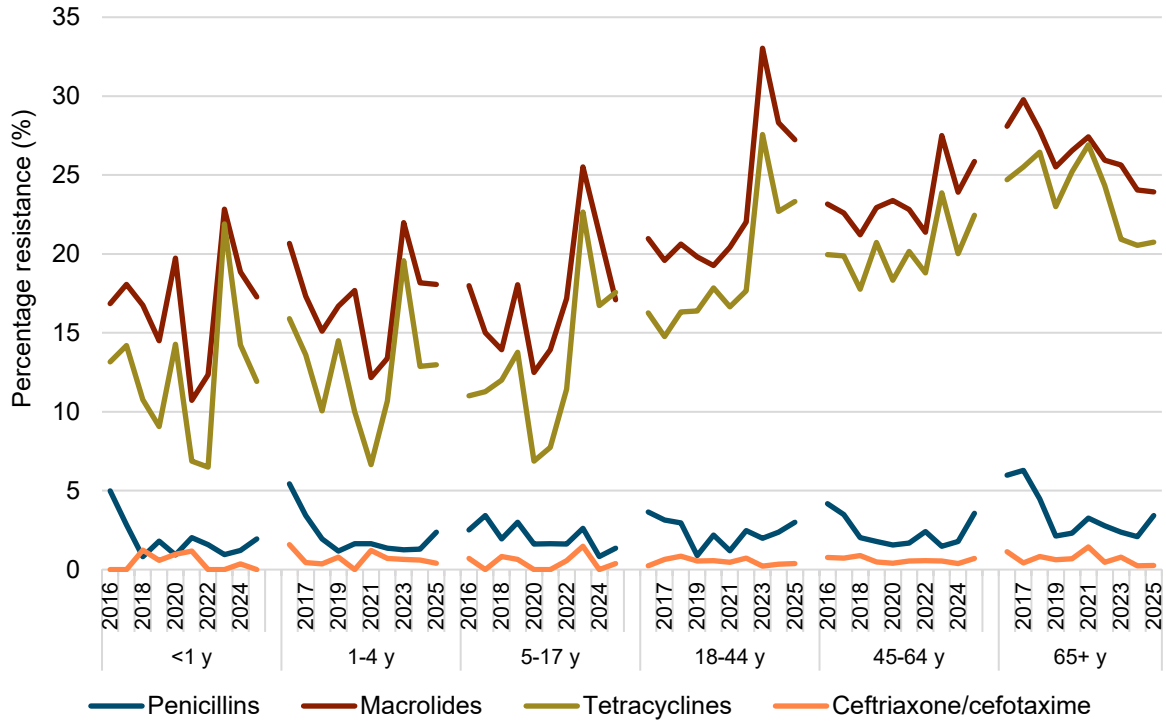


Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Resistance to macrolides and tetracyclines was higher among adults aged 18 years and over than in children. The peak in macrolide and tetracycline resistance in 2023 was not observed in people aged 65 years and over (Figure 5).

There was an increase in penicillin resistance in 2025 across all age groups, while resistance to third-generation cephalosporins (ceftriaxone/cefotaxime) remained very low across all age groups since 2016 (Figure 5).

Figure 5 Trends in resistance in *Streptococcus pneumoniae* to key antimicrobials by age group, APAS contributors, 2016–2025



y = years of age

Notes:

1. Macrolides refer to either erythromycin or azithromycin.
2. Tetracyclines refer to either tetracycline or doxycycline.

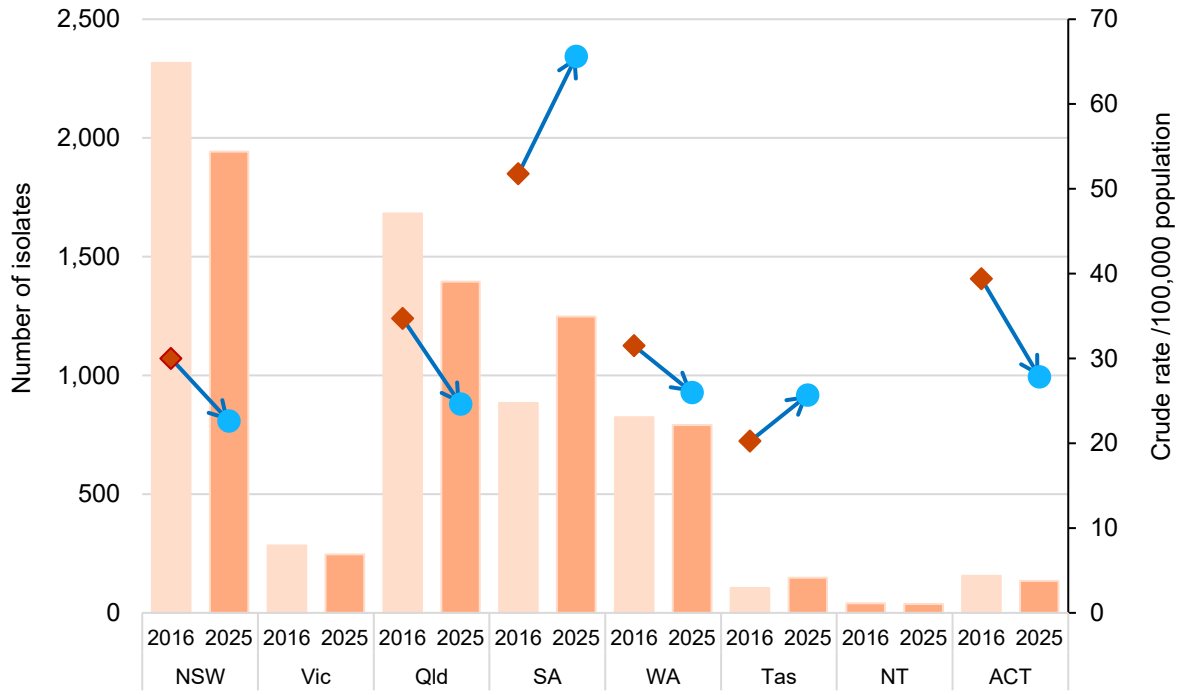
Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Resistance by residence

Figures 6–9 show trends by location in *S. pneumoniae* isolates captured by APAS. Data were analysed based on the known postcode of residence of the person from whom the specimen was taken (see Appendix 2). Postcode of residence was known for 6,291 and 5,943 *S. pneumoniae* isolates in 2016 and 2025, respectively.

The crude rate of *S. pneumoniae* episodes per 100,000 population for 2016 and 2025 is shown in Figure 6. There was a 1.4-fold increase in the number of isolates from South Australia and Tasmania between 2016 and 2025. It is not evident from APAS data why the crude rate is comparatively higher in these two states than all other jurisdictions, where the crude rate decreased over this period.

Figure 6 Crude rate of *Streptococcus pneumoniae* isolates by state and territory, APAS contributors, 2016 versus 2025



Notes:

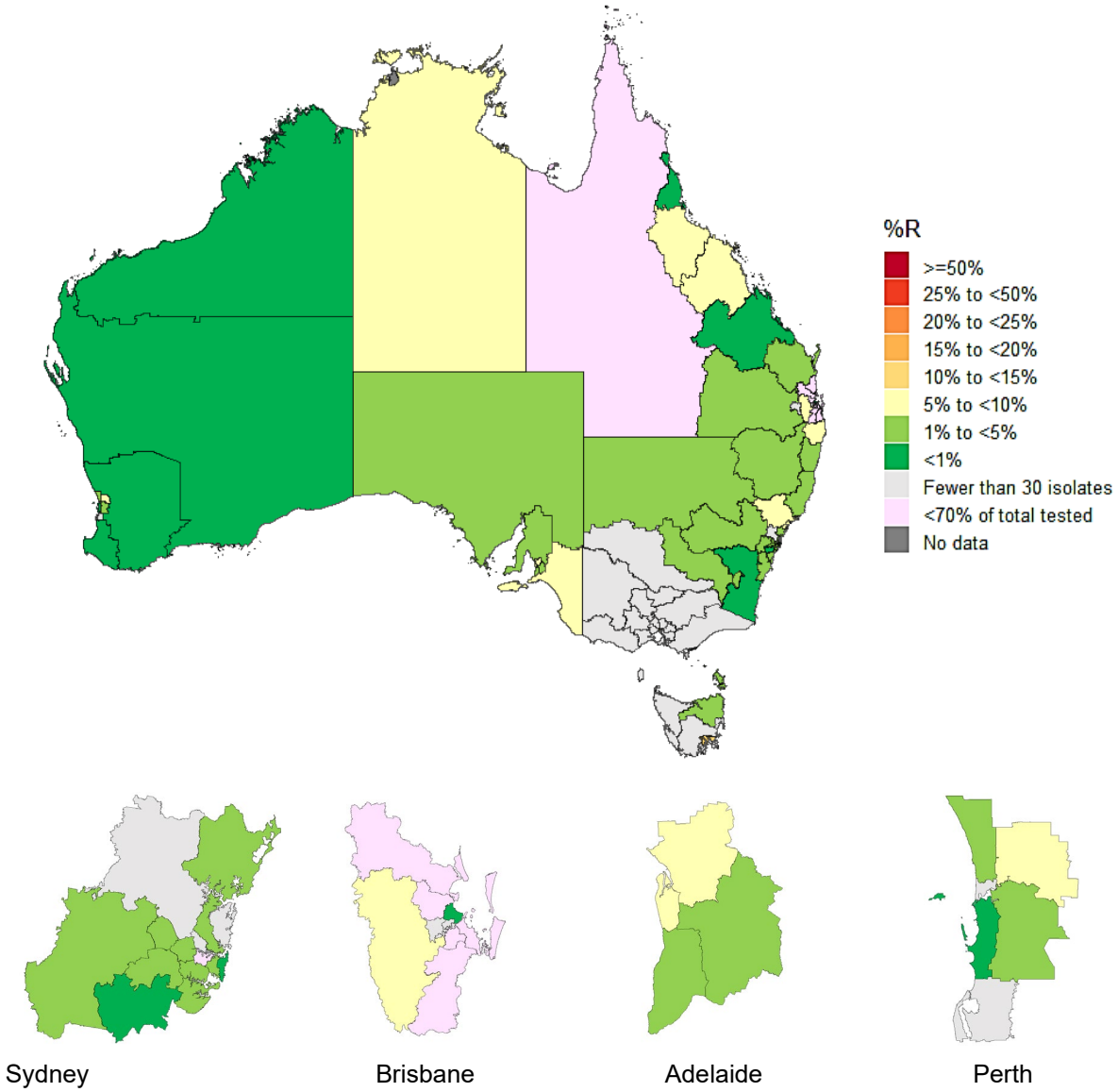
1. Crude rate per 100,000 population (mid-year population) shown by brown diamonds (2016) and blue circles (2025). Crude rates for Victoria and the NT are not applicable as the number of isolates available in the APAS dataset was not representative of the population, respectively.
2. Location is based on postcode of residence (where known). Data available from the NT were from NT residents who received pathology services in another jurisdiction.

Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Figures 7–9 show resistance to penicillin, macrolides, and tetracyclines in *S. pneumoniae*, respectively, with data from 2025 mapped to Australian Statistical Area Level 4 (SA4).

Penicillin resistance was notably lower in Western Australia and some areas of New South Wales (Figure 5). This may reflect that the principal susceptibility test method used in these states, Clinical and Laboratory Standards Institute (CLSI), has higher clinical breakpoints for benzylpenicillin susceptibility test results for *S. pneumoniae* (see Appendix 2).

Figure 7 Penicillin resistance in *Streptococcus pneumoniae*, mapped to Australian SA4 areas, APAS contributors, 2025



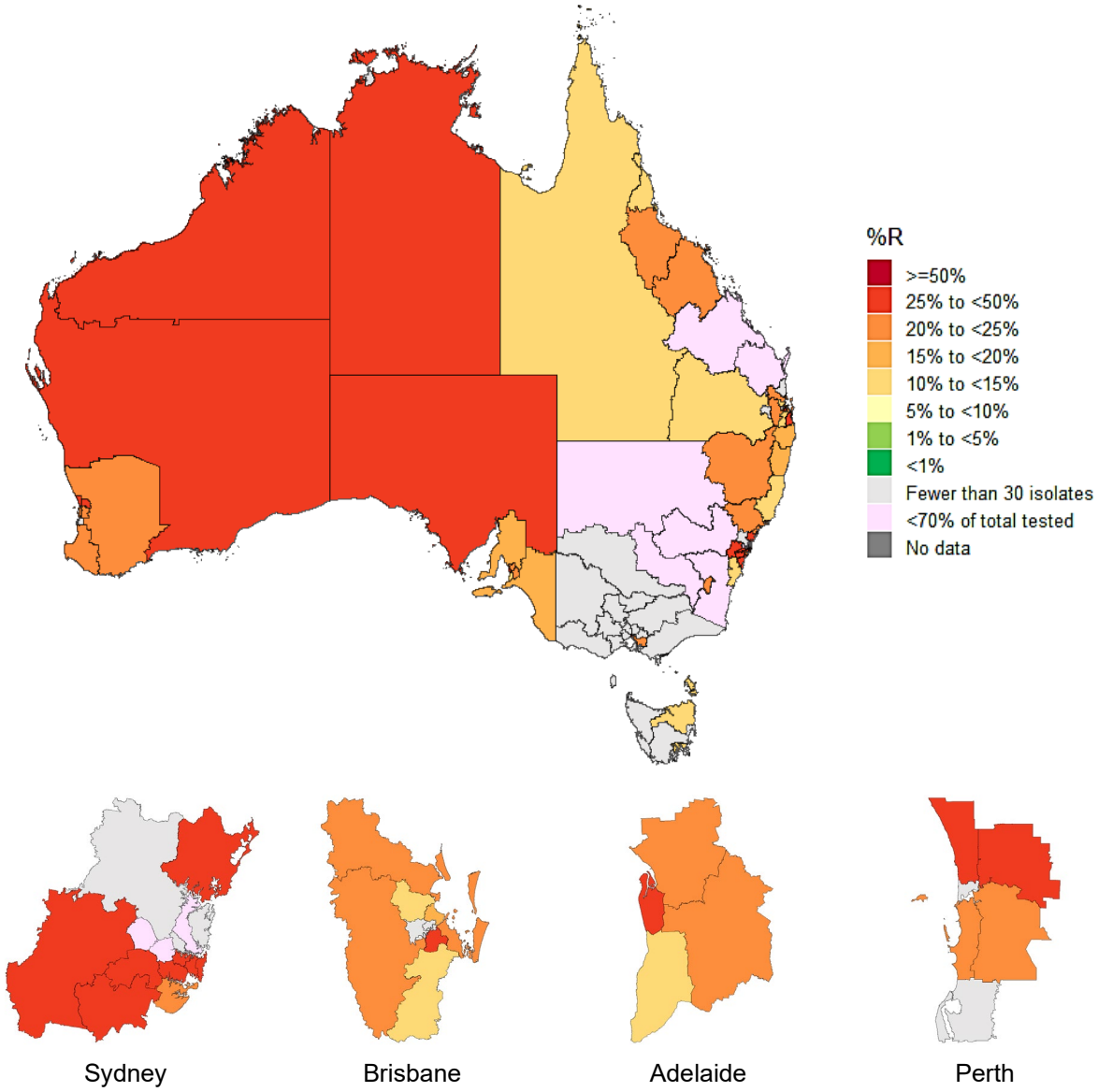
R = resistant; SA4 = Statistical Area Level 4

Notes:

1. Location is based on postcode of residence (where known). Data shown for the NT were from NT residents who received pathology services in another jurisdiction.
2. Screening tests to exclude β-lactam resistance mechanisms are commonly used. If screen test-positive, laboratories report or test ampicillin for indications other than endocarditis and meningitis. The screen test result "(benzyl)penicillin resistant" may not have been reported.

Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Figure 8 Macrolide resistance in *Streptococcus pneumoniae*, mapped to Australian SA4 areas, APAS contributors, 2025



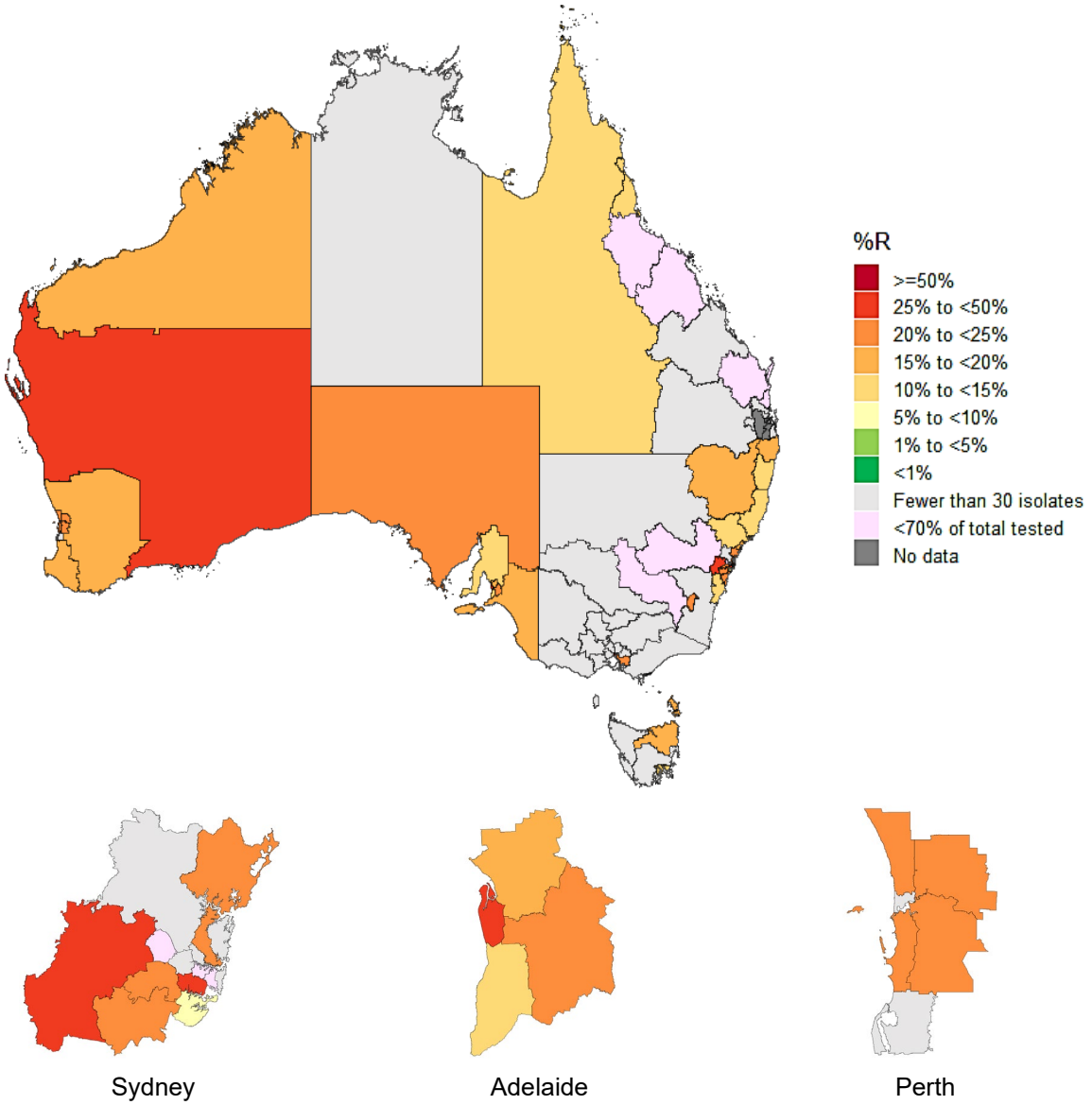
R = resistant; SA4 = Statistical Area Level 4

Notes:

1. Location is based on postcode of residence (where known). Data shown for the NT were from NT residents who received pathology services in another jurisdiction.
2. Macrolides refer to either erythromycin or azithromycin.

Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Figure 9 Tetracycline resistance in *Streptococcus pneumoniae*, mapped to Australian SA4 areas, APAS contributors, 2025



R = resistant; SA4 = Statistical Area Level 4

Notes:

1. Location is based on postcode of residence (where known). Data shown for the NT were from NT residents who received pathology services in another jurisdiction.
2. Tetracyclines refer to either tetracycline or doxycycline.
3. Not all laboratories routinely test for tetracycline resistance.

Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Conclusions

Antimicrobials are an integral component of healthcare delivery and need to be readily available and effective. The emergence and spread of AMR and consequent reduction in the efficacy of antimicrobials continues to be one of the biggest challenges to the provision of safe, high-quality health services in Australia and internationally. AMR is a critical risk to patient safety as it reduces the number of antimicrobials available to treat and prevent infections. There are also cost implications and risks associated with adverse effects from antimicrobial use, including side effects and healthcare-associated related environmental impacts.[33]

S. pneumoniae is an important pathogen that can cause significant morbidity and mortality if infections are not appropriately detected and treated in line with clinical guidelines. Robust surveillance and monitoring of AMR in *S. pneumoniae* are essential to inform effective treatment and optimise prescribing practices. Adherence to prescribing recommendations supports efforts to limit the emergence of AMR and reduce the reliance on broader spectrum antimicrobial classes, such as fluoroquinolones or carbapenems, thereby preserving their effectiveness.

Approximately 6,000 *S. pneumoniae* isolates were captured by APAS each year from 2016 to 2025. This is except for 2020 to 2022, where the number of isolates markedly declined; by 44.2% from 2019 to 2020. This decline coincided with the introduction of COVID-19 restrictions throughout Australia and was especially apparent for isolates from respiratory specimens.

Over this 10-year period, resistance rates for *S. pneumoniae* remained relatively stable. Resistance was less common for penicillins (less than 5%) and ceftriaxone/cefotaxime (less than 1%) across all specimen types from 2016 to 2025.

Resistance to macrolides was most common (range: 20.5% in 2021 to 23.7% in 2024), followed by tetracyclines (range: 18.0% in 2022 to 20.3% in 2025). These ranges exclude the noticeable one-year peak observed for both classes in 2023; 27.1% and 23.2%, respectively. The number of *S. pneumoniae* isolates also increased in 2023 to return to pre-pandemic levels; up 38.3% from 2022.

High and increasing rates of macrolide and tetracycline resistance increase the risk of treatment failure when these antibiotic classes are used for empirical monotherapy and *S. pneumoniae* is the causative pathogen.

Strategies to prevent and control the occurrence of *S. pneumoniae* infections and development of AMR must include prevention through vaccination, ongoing infection prevention and control and antimicrobial stewardship (AMS) programs, surveillance and monitoring programs, and early detection of clinical disease, especially for vulnerable populations.

The Commission will continue to work with developers of antimicrobial prescribing guidelines, including Therapeutic Guidelines and other expert groups, to ensure they are evidence-based and informed by current Australian AMR data. Consideration must also be given to the variability in the geographic distribution of AMR in *S. pneumoniae* and other organisms and differences in local susceptibility testing and reporting practices.

Reporting on APAS data analysis highlights the importance of ongoing surveillance of AMR and infections, and the value of the AURA surveillance program in monitoring the emergence of, and trends in, AMR across Australia. The Commission will continue to collaborate with the CDC to submit AMR data on *S. pneumoniae* and other priority pathogens to WHO GLASS to strengthen global surveillance and strategic efforts.

The Commission will also continue to collaborate with the CDC, state and territory health departments, and private pathology services to enhance national surveillance of AMR and increase utility of AMR data to inform strategies for its prevention and containment.

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Appendices

Appendix 1: About APAS

Australian Passive AMR Surveillance (APAS) was established by the Australian Commission on Safety and Quality in Health Care (the Commission) in collaboration with Queensland Health in 2015 as a component of the Antimicrobial Use and Resistance in Australia (AURA) surveillance program.

Funding for APAS and the Commission's AURA Project is provided by the Australian Centre for Disease Control (CDC). States and territories and participating private pathology services contribute to APAS through voluntary support and resourcing for the collection and submission of their data, and the maintenance of integrated systems for surveillance of AMR in Australia.

Passive antimicrobial resistance (AMR) surveillance involves the extraction of routine susceptibility testing results from laboratory information systems. APAS uses the Queensland Health OrgTRx information technology infrastructure to collect, analyse and report on de-identified patient-level AMR data voluntarily contributed by public and private pathology services across Australia. The laboratories that are part of these pathology services detect AMR in isolates referred from public and private hospitals, aged care homes and community settings. APAS includes more than 142 million records to July 2026. Most data are captured from 2015 and there are some historical data captured from 2006.

In February 2025, the Commission published the APAS Data Explorer dashboard. It is a publicly accessible and interactive data dashboard that offers customised analytics and trends for key antimicrobial resistances across Australia. The APAS Data Explorer is complementary to national reporting undertaken by the Commission.

APAS participants also have timely access to their own data, which enables comprehensive reporting of local AMR in the form of:

- Longitudinal datasets for specified organism–antimicrobial combinations
- Cumulative antibiograms showing rates of resistance for a range of organisms from a specified specimen type in a selected period
- Tabulations showing the resistance profiles of organism strains isolated during a selected period
- Reporting for individual units within hospitals or health services, or at a jurisdiction-wide level
- Statistical Area Geoanalytics dashboard for local data, which is complemented by national data presented in the APAS Data Explorer.

The Commission acknowledges and thanks the pathology services listed in Table A1 that have contributed data to APAS to 2025.

Table A1 APAS contributor pathology services to December 2025

State/Territory	Pathology service	Notes
New South Wales	NSW Health Pathology	All NSW Health Pathology public laboratory services.
Victoria	Alfred Health	Public health service catchment for Alfred Health.
	Monash Health	Public health service catchment for Monash Health.
Queensland	Mater Pathology Queensland	Queensland public and private patients.
	Pathology Queensland	All Queensland Health public hospitals and health services.
South Australia	SA Pathology	Public health catchments for South Australia.
Western Australia	PathWest Laboratory Medicine	All Western Australia public hospitals.
Tasmania	Launceston General Hospital Royal Hobart Hospital	Combined data from these two contributing laboratories capture most public patient data for Tasmania.
Australian Capital Territory	ACT Pathology	All public and some private ACT health services.

Notes:

1. Data were available from 2015, except Launceston General Hospital (Tasmania) from 2021.
2. Data were not available from Mater Pathology Queensland from December 2024.
3. Historical data were available from 2005 for:
   - NSW Health Pathology (South Western Sydney and Sydney; and West from 2010)
   - Mater Pathology Queensland
   - Pathology Queensland
   - SA Pathology.
4. Data were available from the Northern Territory for residents who receive pathology services in another jurisdiction.

Appendix 2: Methodology

Data extraction

Data were extracted from the Australian Passive AMR Surveillance (APAS) system on 16 March 2026. All data analyses for this report were performed using Microsoft Excel 365.

At the time of data extraction, the pathology services listed in Table A1 were contributing data to APAS.

Results from isolates detected in infection control and environmental sampling were excluded because they were not representative of isolates from clinical infections.

Antimicrobial susceptibility testing methods

APAS data report on antimicrobials tested using European Committee on Antimicrobial Susceptibility Testing (EUCAST)[34], Clinical and Laboratory Standards Institute (CLSI)[35,36], or Calibrated Dichotomous Sensitivity (CDS)[37] methods.

Prior to 2012, laboratories in Australia performed antimicrobial susceptibility tests (AST) using either CLSI or CDS methodology. Since 2012, a number of pathology services that contribute to APAS have transitioned to EUCAST methodology. In 2025, all APAS participants use EUCAST methods, except PathWest Laboratory Medicine, which uses CLSI.

APAS provides categorical data (susceptible, intermediate, resistant) based on interpretive criteria. It is acknowledged that there are differences in the interpretation of results obtained by each method and APAS participants use different methodologies, which presents various complexities for analyses of APAS data.

The Australian Commission on Safety and Quality in Health Care (the Commission) continues to work with stakeholders to promote alignment with a single method in Australia.

Analyses of *Streptococcus pneumoniae*

In this report, macrolide resistance in *Streptococcus pneumoniae* refers to resistance to either erythromycin or azithromycin, and tetracycline resistance refers to resistance to either tetracycline or doxycycline.

Reporting benzylpenicillin susceptibility test results for *S. pneumoniae* are challenging. Although the CLSI and EUCAST clinical breakpoints for meningitis are the same, CLSI have significantly higher breakpoints for non-meningitis (Table A2.1).

Laboratories may also use the results of a screen test (oxacillin 1 µg disc) to exclude β-lactam resistance mechanisms. Depending on the zone diameter (9–19 mm), the isolate may be reported as susceptible to ampicillin or amoxicillin without further testing.

How the benzylpenicillin breakpoints are reported and mapped is also dependent on the Laboratory Information System (LIS) that the laboratory uses. Some LIS report 'benzylpenicillin' only, while others have the ability to report on all indications, that is those for both meningitis and non-meningitis.

Another issue is that many laboratories will test and report benzylpenicillin based on gradient tests (Etest™ [bioMérieux] or MTS™ [Liofilchem]), especially for isolates from normally sterile sites. This is known to be problematic and may underestimate the MIC on certain media resulting in false susceptibility.[38,39]

For this report, results reported for non-meningitis indications have been analysed unless the isolate was from cerebrospinal fluid.

Table A2.1 Benzylpenicillin breakpoint changes for *Streptococcus pneumoniae*, 2011–2025

Standard	Year(s)	Site	S (mg/L)	I (mg/L)	R (mg/L)
CLSI	2011–2025	Oral (penicillin V)	≤ 0.064	0.12 – 1	≥ 2
CLSI	2011–2025	Non-meningitis	≤2	4	≥ 8
CLSI	2011–2025	Meningitis	≤ 0.064	-	≥ 0.12
EUCAST	2011	All sites	≤ 0.064	0.12 – 2	>2
EUCAST	2012	Meningitis	≤ 0.064	-	>0.064
EUCAST	2012	Infections other than meningitis	≤ 0.064	0.12 – 2	>2
EUCAST	2013–2024	Meningitis	≤ 0.064	-	>0.064
EUCAST	2013–2024	Infections other than meningitis	≤ 0.064	0.12 – 2	>2
EUCAST	2025	Meningitis, Endocarditis	≤ 0.064	-	>0.064
EUCAST	2025	Non-meningitis, Non-endocarditis	≤ 0.064	0.12 – 1	>1

CLSI = Clinical and Laboratory Standards Institute; EUCAST = European Committee on Antimicrobial Susceptibility Testing; I = intermediate; R = resistant; S = susceptible

Representativeness

All pathology services that participate in APAS are listed in Table A1; most have contributed data from 2015 to APAS. Historical data were available from 2005 for four pathology services: NSW Health Pathology (South Western Sydney and Sydney), Mater Pathology Queensland, Pathology Queensland and SA Pathology, and from 2010 for NSW Health Pathology West.

It is important to note that, for historical data, there may have been changes since 2006 in the number of facilities from which the pathology services have received isolates, and numbers are likely to have varied from year to year, along with laboratory criteria and methods. There have also been breakpoint changes over time.

In addition, several public laboratories have been reconfigured or renamed during the period to which the analyses relate; these changes were not addressed in this report.

All states and the Australian Capital Territory (ACT) participate in APAS. Jurisdictions with state- or territory-wide public pathology services (Queensland, South Australia, Western Australia, New South Wales and the ACT) were most representative. Queensland was comprehensively represented due to the participation in APAS by a private pathology service, Mater Pathology Queensland.

Tasmania was well represented by two pathology services that capture most public patient data for the state.

Data were limited from Victoria as there were only two participating pathology services at the time of data extraction. In 2026, work progressed to integrate two more pathology services with APAS: Northern Pathology and Eastern Health.

Data from Mater Pathology Queensland were not available from December 2024 for analyses for this report following implementation of a new LIS. Data for 2025 onwards will be available when a re-integration project is completed.

Data were not available from the Northern Territory, except where a resident received pathology services in another jurisdiction.

Some public laboratories undertake testing for private facilities and in the community.

Isolates and specimen types

Data were only included where there were at least 30 isolates for each analysis. Analyses were conducted only when the proportion of isolates that were tested against a single antimicrobial was at least 70%.

The results of duplicate testing were included in the data collected for APAS. Duplicate testing means that the same bacterial strain was tested and reported from repeated specimens and similar specimens from a single infection episode. This was appropriate clinical laboratory practice from a patient management perspective. The impact of these duplicates was minimised for analyses of APAS data by using algorithms based on resistance patterns, and selected time periods for which duplicates were not counted. Only the first isolate for the first specimen of each specimen type per year was included in the dataset for analyses. A repeat isolate from the same specimen type was not included.

For this report, specimen types were allocated into eight categories: blood culture; cerebrospinal fluid; ear, nose and throat; enteric; genital; respiratory; tissue/fluid/pus/prosthesis; and urine. Respiratory specimens include sputum, lung aspirates, tracheal aspirates and endotracheal aspirates as well as other specimens of the respiratory tract where the primary site is unspecified.

Figure A.2.1 outlines the number of *S. pneumoniae* isolates by specimen type analysed for this report.

Table A2.2 outlines the number of *S. pneumoniae* isolates by specimen type and patient age group analysed for this report.

Setting

APAS captures data on the setting from which a specimen was collected, which is assigned by the pathology service. Settings captured include aged care, community, multi-purpose service, public hospital and private hospital. Facilities may also be categorised as other, such as correctional services. Analysis by setting was not undertaken for this report.

Residence

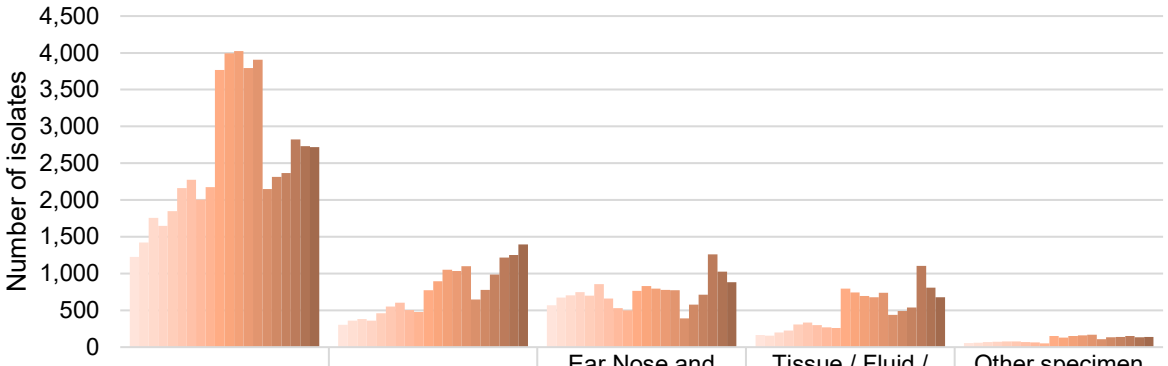
The postcode of residence of the person from whom the specimen was taken, where known, was used to stratify the data in terms of location by state or territory, and local area and remoteness using the Australian Bureau of Statistics Australian Statistical Geography Standard.[40,41]

Main Structure and Greater Capital City Statistical Areas have seven hierarchical levels including states and territories and Statistical Area Levels 4 and 3 (SA4 and SA3).
SA4 creates a standard framework for the analysis of geographical data at a regional level through clustering groups that have similar regional characteristics. SA4s are the largest sub-state/territory regions.

Data Characteristics

APAS data differ from targeted antimicrobial resistance surveillance data in that a smaller range of agents may be tested, there are varied antimicrobial testing and reporting practices, and there are multiple different testing methodologies used in Australia.

Figure A2.1 Number of *Streptococcus pneumoniae* isolates by specimen type, APAS contributors, 2006–2025



	Respiratory	Blood Culture	Ear Nose and Throat	Tissue / Fluid / Pus / Prosthesis	Other specimen types
2006	1,225	305	571	163	56
2007	1,424	362	672	158	60
2008	1,758	381	706	201	70
2009	1,648	362	748	225	75
2010	1,850	462	700	307	78
2011	2,162	551	858	333	79
2012	2,277	604	660	298	69
2013	2,007	504	530	270	66
2014	2,175	479	501	260	50
2015	3,769	772	764	797	153
2016	3,992	897	830	744	131
2017	4,022	1,051	797	695	151
2018	3,795	1,033	776	680	159
2019	3,908	1,102	774	739	167
2020	2,147	647	389	440	110
2021	2,312	779	579	491	134
2022	2,365	986	711	540	140
2023	2,822	1,219	1,260	1,106	150
2024	2,733	1,252	1,025	808	136
2025	2,720	1,394	881	679	139

Note: Other specimen types include urine, genital and cerebrospinal fluid.
Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

Table A2.2 Number of *Streptococcus pneumoniae* isolates by specimen type and patient age group, APAS contributors, 2006–2025

Specimen category	<1y	1–4 y	5–17 y	18–44 y	45–64 y	65+ y	Total
Blood culture	456	1,157	683	2,863	4,385	5,588	15,132
Ear nose and throat	3,776	4,606	2,392	2,320	1,035	599	14,728
Respiratory	755	2,136	1,946	11,140	16,297	18,804	51,078
Tissue/Fluid/Pus/Prosthesis	1,991	1,737	910	2,403	1,513	1,347	9,901
Other specimen types	71	267	353	1,004	280	193	2,170
Total	7,049	9,903	6,284	19,730	23,510	26,531	93,007

y = years of age
Notes:
1. Other specimen types include urine, genital and cerebrospinal fluid.
2. Age was unknown for 83 isolates.
Source: APAS (NSW, Vic, Qld, SA, WA, Tas, ACT) – see Table A1

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