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The Australian human health antimicrobial use and resistance data landscape

A review of the human health data held and used to understand antimicrobial use and resistance in Australia

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Foreword

In 2019, a team of university and CSIRO researchers, and industry organisations investigated how disparate data sets, including genomics, could inform risk assessments on the likelihood of an antimicrobial-resistant infection. The OUTBREAK project, led by the University of Technology Sydney, was conceptualised as an intelligent surveillance system taking a One Health approach to track, trace and tackle drug-resistant infections in real-time [1].

More recently, CSIRO's Australian e-Health Research Centre (AEHRC) began working with two Queensland hospitals to develop a surveillance and monitoring solution called the Queensland One Health Antimicrobial Resistance Hub (AMR Hub). This scalable data-driven surveillance and decision support platform has the potential to support the development and evaluation of interventions and remediation technologies.

In exploring the data required to support these projects, it became clear that while significant amounts of data are collected, analysed and published about antimicrobial resistance in human health, there is significant variability in quality and accuracy. In addition, there is no single data repository which limits a comprehensive understanding of antimicrobial resistance (AMR) and limits opportunities for new projects and contributes to duplication of efforts.

This report addresses, in part, this lack of information pertaining to antimicrobial use (AU) and resistance data. By establishing a first draft of a human health AU/AMR data landscape in Australia, we hope to assist others working in this space to understand how the data is collected, how it flows through the health system, and the efforts required to analyse, publish, and use this data to improve health outcomes.

1 Introduction

The Australian Government considers antimicrobial resistance (AMR) one of the largest threats to human and animal health [2]. The World Health Organization (WHO) has declared AMR as one of the top 10 global public health threats facing humanity [3]. Drug-resistant infections already undermine the efforts of modern medicine [4]. Inappropriate or overuse of antimicrobials can contribute to the rise of existing and new organisms. Outcomes for patients with antimicrobial-resistant infections include recurrent infections, ineffective or prolonged treatment, delayed recovery, and death [5].

1.1 Understanding antimicrobial use and resistance

The Australian Commission on Safety and Quality in Health Care (ACSQHC) defines antimicrobial stewardship (AMS) as including "the range of activities that promote, and support, optimal antimicrobial prescribing" [5]. Antimicrobial stewardship can decrease inappropriate usage, reduce adverse consequences of antimicrobial use and improve patient outcomes. Combined with other mitigation strategies, antimicrobial stewardship is fundamental to reducing AMR. There are two parts to this work.

1.1.1 Antimicrobial use

The ACSQHC defines antimicrobial use (AU) as "the delivery of medicine that inhibits or destroys bacteria, viruses or fungi". Antimicrobial products include antibiotics, antivirals and antifungals. The effectiveness of antimicrobials is reducing due to the emergence of resistant organisms [6].

Monitoring the overuse and inappropriate use of antimicrobials is critical to understanding AMR and optimising the use of antimicrobial drugs [7]. To address inappropriate use of antimicrobials, coordinated stewardship programs are required.

While AU programs differ in the data collected and analysed, data can also be derived (directly or indirectly) from prescribing records in pharmacy systems or from the resulting health system funding records such as the Pharmaceutical Benefits Scheme (PBS). Longitudinal and standardised usage data may help assess the effectiveness of antimicrobial stewardship programs.

1.1.2 Antimicrobial resistance

AMR occurs when bacteria, viruses, fungi and parasites change over time such that their response to antimicrobial medicines is reduced or eliminated. AMR makes infections harder to treat and increases the risk of disease spread, severe illness and death [3]. Understanding changes in populations of microbes can help understand evolving patterns of resistance to antimicrobials. AMR surveillance programs can be conducted on a global, regional, local country, or healthcare facility basis [8]. Surveillance is important to reducing the increase in AMR as it can:

- provide early warning of emerging threats in specific populations or drugs
- allow decision-makers to intervene before a problem escalates
- guide public health policy and infection prevention and control (IPC) plans
- inform stewardship programs and antimicrobial use.

1.2 The One Health approach

The One Health approach recognises the interdependency between human health, animal health, agriculture, food and the environment. First promoted in 2008, the importance of One Health is recognised by the WHO, the Centre for Disease Control and Prevention (CDC), the World Organization for Animal Health (OIE), and the Food and Agriculture Organization (FAO) [9]. AMR requires a One Health approach to ensure that efforts to monitor AU and AMR considers factors beyond human health and that mitigation strategies take a holistic view [10]. Australia has adopted a One Health strategy to addressing AMR.

The scope of this report is limited to human health. However, the framework for analysing data sources and flows described here should support broader initiatives that adopt a One Health approach.

1.3 Australian responses to AMR

In Australia, the ACSQHC established the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System in 2013. AURA coordinates and reports on data on antimicrobial use and resistance from a wide range of programs [5] and has released national biennial reporting, with the most recent report issued in 2021.

Australia's First National Antimicrobial Resistance Strategy 2015–2019 [11] was released in 2015. It provided a national framework for a coordinated cross-sectoral response to antimicrobial resistance.

In 2020, the Australian Government released *Australia's National Antimicrobial Resistance Strategy – 2020 and beyond* [12]. The seven objectives of this Strategy included the need for appropriate use and stewardship practices, and integrated surveillance and response to resistance and usage.

ACSQHC recognises that monitoring and surveillance to inform clinical policy and practice to improve the safety and quality of health care in Australia. As part of the National Safety and Quality Health Standards Service (NSQHS), the ACSQHC has published the *Preventing and Controlling Infections Standard* [13]. The *Preventing and Controlling Infections Standard* requires health service organisations to monitor patterns of healthcare-associated infections, AU and AMR. Data from such surveillance is then used to inform AMS practices and meet IPC requirements, to comply with the NSQHS Standards.

The AURA Surveillance System uses two broad groups of surveillance programs [14]:

- **Passive surveillance** leverages data collected for purposes other than antimicrobial surveillance, but which can identify patterns and trends in AMR and AU. Examples include the National Antimicrobial Utilisation Surveillance Program (NAUSP) and the Pharmaceutical Benefits Scheme (PBS) datasets for AU, and Australian Passive AMR Surveillance (APAS) and the feed of data from Sullivan & Nicolaides Pathology (SNP) for AMR.
- **Targeted surveillance** is where the primary purpose of collecting data is to identify trends and patterns in AMR and AU. Existing programs that fall into this category include NAPS, AGAR, CARAlert, NNDSS and National Neisseria Network (NNN).

1.4 Why develop an antimicrobial use and resistance data landscape?

There is substantial data held by programs supporting antimicrobial stewardship in Australia. Understanding the processes and flows of data that support antimicrobial use and resistance in Australia, makes it possible to examine how new initiatives can leverage existing investments and avoid unnecessary duplication. While information is publicly available about many individual initiatives, a consolidated view of the data capabilities of antimicrobial activities in Australia is difficult to find. A lack of such a resource can lead to unnecessary duplication of efforts and a reduced potential for learnings when designing AU and AMR programs.

To address this, the CSIRO has commissioned this report to bring together information and analyse existing data flows and processes in Australia. This will be represented in AU/AMR data landscape diagrams and tabular information, which provide a logical view of what data is held and how initiatives collate, transform and report on it. This information can support future programs by providing a single source of information about existing programs.

1.5 Who should read this report?

This report is intended to support the activities of a broad range of stakeholders, including:

- **researchers and clinicians** wishing to understand data collected about human AU and AMR and how it flows through the health system
- **data analysts** who need to identify potential sources of information and the nature and scope of that data
- **organisations** considering the implementation or maintenance of systems that collect or process human antimicrobial use and resistance data, such that they can avoid duplication of efforts
- **existing AMR programs** which may be interested in further development of systems to incorporate more standardised data collection

- **groups interested in digital health standards** and reuse of existing national capabilities
- **governments** who are frequently funding bodies for new AMR programs.

2 Participants in the AU/AMR data landscape

In establishing an Australian AU/AMR data landscape, it is important to understand the participants in that ecosystem. Some of these organisations are primary sources of AU and AMR data, while others aggregate and report at a population level. Reporting also varies from general reporting of AU and AMR to reporting on specific organisms. This chapter outlines the approach to classifying these participants and how the AU/AMR data landscape supports comparison between the roles organisations play.

2.1 Sources of antimicrobial data

While several programs monitor AU or perform AMR surveillance, ultimately, the data is sourced from a few types of organisations.

2.1.1 Antimicrobial use data

Organisations providing or holding AU data such as prescription or dispense data can be grouped as:

- **public hospitals:** The Australian Institute of Health and Welfare (AIHW) reported that in 2017-18, there were 693 public hospitals in Australia [15]
- **private hospitals:** The Australian Bureau of Statistics (ABS) reported that in 2016-17, there were 657 private hospitals in Australia [16]
- **general practice:** According to the Royal Australian College of General Practitioners, there were almost 37,000 general practitioners working in Australia across over 6500 general practices [17]
- **community pharmacy:** There are 5822 community pharmacies in Australia in 2021 [18]
- **aged care:** At 30 June 2020, there were [19]:
  - 845 residential aged care providers across 2722 locations in Australia
  - 920 providers of home care services through 2650 services
  - 2734 outlets for home support services delivered by 1452 providers.

AU data is provided variously through digital extracts from medication management systems, and manually recorded survey data entered in spreadsheets for electronic submission. Not all services participate in reporting of AU.

2.1.2 AMR data

Pathology laboratories across Australia provide AMR data. There are 756 National Association of Testing Authorities (NATA) accredited pathology laboratories in Australia [20], of which over 170 of these are public pathology laboratories [21]. Not all laboratories participate in AMR reporting.

2.2 Organisations reporting on antimicrobials

There are many organisations reporting on the use of and resistance to antimicrobials in Australia. The biennial report by the AURA Surveillance System is probably the most notable and collates data from many of the programs outlined below (these can be seen in Figure 17 on page 42).

2.2.1 Antimicrobial use

Programs specifically monitoring AU include:

- the National Antimicrobial Prescribing Survey (NAPS) – see Appendix A.2 for details
- the National Antimicrobial Utilisation Surveillance Program (NAUSP) – see Appendix A.3 for details.

In addition to the monitoring programs listed, additional data sources of AU include:

- NPS MedicineWise MedicineInsight – see Appendix A.4 for details
- PBS and Repatriation Pharmaceutical Benefits Scheme (RPBS) data – see Appendix A.5 for details.

2.2.2 Antimicrobial resistance

Programs specifically undertaking surveillance of AMR include:

- Australian Group on Antimicrobial Resistance (AGAR) – see Appendix A.6 for details
- National Alert System for Critical Antimicrobial Resistance (CARAlert) – see Appendix A.7 for details
- Australian Passive AMR Surveillance (APAS) – see Appendix A.8 for details
- National Neisseria Network (NNN) – see Appendix A.9 for details
- National Notifiable Diseases Surveillance System (NNDSS) – see Appendix A.10 for details.

In addition to the surveillance programs listed, AURA has recently reported on the HOTspots program – see Appendix A.11 for details.

2.3 Other participants in the landscape

Besides those organisations and programs engaged in AU/AMR monitoring and surveillance, there are many other organisations that exchange data within the broader health system. While not all this data is for AMR, understanding them may provide patterns or ideas for new or enhanced data exchange pathways.

For more detail, refer to Appendix B , which describes participants involved in exchanging data related to medicines, and Appendix C , which covers participants exchanging pathology-related data.

2.4 Comparing the programs

This report presents a collated summary of information about the human health AU/AMR data landscape in Australia to better inform those trying to provide or consume information; it is not intended as an evaluation of the individual programs. However, it's useful to understand the differences between the programs across several metrics and descriptions. This information will allow readers to understand how the data associated with these programs can be compared, the levels of effort required by programs to collect, process and analyse data, and the complexity of the environments in which these programs operate.

2.4.1 Qualitative descriptions

Appendix A describes each program considered for this report. These descriptions include:

- the purpose of the program (for context), generally derived from published materials
- the data collection method, where this is known
- the data processing steps or approach, where this is known
- how the results of the processing and analysis are provided.

2.4.2 Quantitative metrics

When considering the existing programs operating in the Australian AMR landscape, four attributes have been examined. These attributes are supported by several quantitative data points, although the diverse nature of the programs means that not all metrics apply to all programs. The four attributes are:

- **Velocity** – This indicates how often data is collected, processed and reported. This can vary from monthly data collection to biennial reporting. Velocity is important as it affects the speed with which changes in AU and AMR can be identified and acted upon. When examining specific programs, three key metrics for velocity have been identified:
  - how often is data collected?
  - how often is the collected data available for reporting to contributors?
  - how often is the data published for wider consumption (if applicable)?
- **Ubiquity** – This identifies the scope or coverage of data collection and analysis. For some programs, the organisms under study are very targeted, or the breadth of data acquisition sites may be limited. As the data sources can vary widely depending upon the program available, a coverage percentage for each data source is provided where this can be identified. Note that the denominator used for calculating percentages is based on the total number of hospitals or laboratories as listed earlier. For specific programs, a smaller number of data sources may be applicable, and this should be considered when interpreting the calculations.

- **Inclusivity** – Not all programs collect the same range of data points, and this can affect the analysis possible. Where detailed data elements have been identified, these are grouped into logically related categories to provide several data elements per category to allow comparison between programs collecting similar categories of data.
- **Complexity** – The effort required for data collection and analysis depends upon the level of manual intervention required to undertake this work. In a cost-constrained environment such as health care, this can directly affect the velocity of data reporting. For complexity, three metrics are identified:
  - how is data collected?
  - how is data processed?
  - how is data provided for reporting/publication?

2.4.3 The AU/AMR data landscape diagrams

The AU/AMR data landscape diagrams (described more fully in the next section) visualise the flow of AU and AMR data through the data landscape. These diagrams allow a high-level visual comparison of flows, and a view of the complexity as shown by the consolidated landscape diagram.

2.4.4 Tabular summary of the AU/AMR data landscape

Program	Velocity	Ubiquity	Inclusivity	Complexity
AURA	• Collected: Throughout the 2-year period • Reporting: Biennially and intervening reports more frequently. • Published: Biennially and annually	• NA – AURA analyses the supplied data	• AURA implements a strategy to collate a range and representativeness of required data.	• Capture: Data provided • Processing: Unknown • Reporting: Biennial publication
NAPS • **Hospital NAPS**	• Collected: Annually • Reporting: Immediately to participants • Published: Annually	• Public hospitals: 268 -> 38.7% • Private hospitals: 109 -> 16.6% • Total hospitals: 377 -> 27.9% • Prescriptions: 31,424	• Facility: 1 data element • Patient: 11 data elements • Antimicrobial: 26 data elements	• Capture: Manual + file upload (opt) • Processing: Periodic validation • Reporting: Dashboard and export
• **Surgical NAPS**	• Collected: Annually • Reporting: Immediately to participants • Published: Annually	• Public hospitals: 74 -> 10.7% • Private hospitals: 70 -> 10.7% • Total hospitals: 144 -> 10.7% • Surgical episodes: 8,063 • Procedural antimicrobial doses: 6,949 • Post-procedural prophylaxis prescriptions: 2,720	• Facility: N/A • Patient/procedure: 60 data elements • Antimicrobial: 63 data elements	• Capture: Manual + file upload (opt) • Processing: Periodic validation • Reporting: Dashboard and export
• **Aged Care NAPS**	• Collected: Annually • Reporting: Immediately to participants • Published: Annually	• Aged care homes: 568 -> 67.2% • Multipurpose services: 58 -> 1.6% • Total services: 626 -> 13.9% • Residents: 32,347	• Facility: 18 data elements • Resident: 122 data elements • Antimicrobial: 13 data elements	• Capture: Manual + file upload (opt) • Processing: Periodic validation • Reporting: Dashboard and export
NAUSP / MedTRx	• Collected: Monthly • Reporting: Monthly on request • Published: 6 monthly benchmarks	• Public hospitals: 170 -> 24.5% • Private hospitals: 49 -> 7.5%	**Pharmacy dispensing:** • Facility: 5 data elements • Antimicrobial: 5 data elements **Electronic medication administration records:** • Facility: 1 data element • Antimicrobial: 9 data elements	• Capture: Excel spreadsheet file upload via portal • Processing: Monthly • Reporting: Six-monthly. MedTRx has dashboard for QLD only

Program	Velocity	Ubiquity	Inclusivity	Complexity
NPS Medicine Insight	• Collected: Daily from GRHANITE, Weekly from Inca • Processed: Monthly • Reporting: N/A	• 700 general practices -> 10.8% • 2,081,855 patients	• 9 data points per patient • 11 data points per antimicrobial	• Capture: Data extraction tools • Processing: Significant validation effort • Reporting: Individual feedback
PBS/RPBS	• Collected: Monthly • Reporting: N/A • Published: N/A	• Prescriptions: 26,669,561 (antibiotics only) – estimated 90% of antimicrobial prescriptions	• Patient: 3 data elements • Antimicrobial: 15 data elements	• Capture: PBS/RPBS data is captured automatically • Processing: N/A • Reporting: N/A
AGAR	• Collected: Ad hoc or quarterly • Reporting: Annually • Published: Annually	• Institutions: 49 • Laboratories: 30 -> 4.0% • Organisms: 227	• Facility: 1 data element • Patient: Up to 15 data elements • Organism: Up to 20 data elements	• Capture: Spreadsheets or manual entry via portal • Processing: CSV download and inclusion into database • Reporting: Dashboard, publications, reports
CARAlert	• Collected: On confirmation (generally within 5 days) • Reporting: Immediately on submission, after results are provided to the referring clinician. A weekly report is also generated. • Published: Bimonthly and annually on the ACSQHC website	• Confirming laboratories: 28 from 109 originating laboratories • Organisms: 11 organism groups	• Facility: 4 data elements • Patient: 3 data elements • Organism: 10 data elements	• Capture: Online data entry • Processing: Unknown • Reporting: Dashboard, reports and CSV export
APAS / OrgTRx	• Collected: Monthly • Reporting: Monthly to participants • Published: Targeted Reports and in AURA National Reports.	• 13 public and private laboratory information systems from 32 laboratory groups; 112 laboratories representing coverage of all states and the ACT.	• Facility: 3 data elements • Patient: 5 data elements • Organism: 11 data elements	• Capture: Data submitted in XML file format • Processing: Data validated in staging environment • Reporting: On demand post-monthly processing

Program	Velocity	Ubiquity	Inclusivity	Complexity
NNN	• Collected: Quarterly • Reporting: Quarterly • Published: Annually	• All states/territories • Laboratories: 9 (reference laboratories) • Organisms: 2 • AMSP Cases: 278 (of 281 in 2020 [22]) -> 98.9% • AGSP Cases: 7219 (of 29516 reports in 2020 [23]) -> 24%	• AMSP Cases: 5 data elements • AGSP Cases: 6 data elements • AMSP Organism: 4 data elements • AGSP Organism: 2 data elements	• Capture: Electronic • Processing: Unknown • Reporting: Peer-reference report
NNDSS	• Collected: Daily • Reporting: Daily and fortnightly • Published: Quarterly and annually	• All states and territories • Organisms: 50+	• Reporting entity: 3 data elements • Patient: 7 data elements • Organism: 6 data elements	• Capture: Unknown • Processing: Unknown • Reporting: Published on website
HOTspots	• Collected: 6-monthly • Reporting: As processed • Published: As processed	• 100 pathology labs in target area	• Facility: 3 data elements • Patient: 5 data elements • Organism: 4 data elements	• Capture: Data file submitted electronically • Processing: Validated in staging environment • Reporting: Online dashboard

NOTES:

1. Data is based upon the information in the appendices, which is sourced from public websites, interviews and information supplied within the timeframes of this report.
2. Where the number of organisations of a particular type is known, the ubiquity column includes a percentage value representing coverage across Australia.
3. Allocation of data elements across categories has been undertaken by the author and is provided as an indication of data only.
4. Where information was unavailable, the entries in the table above will reflect this as “Unknown”.
5. Acronyms and initialisms have been used in this table for conciseness. See the relevant section for the expanded terms.
6. Data is correct when collected, but may change as programs are added or evolved.

3 Visualising the AU/AMR data landscape

While the information provided in the previous section describes the participants in the AMR landscape in Australia, the relationships between these organisations are less clearly understood without representing this graphically. This section of the report lays out the approach to present these relationships using a visual model.

3.1 Using a classification framework

Like the rest of the health system, there are many organisations and systems involved in the capture, exchange and analysis of antimicrobial data. To allow meaningful analysis of the AU/AMR data landscape, it is important to group these participants into logical categories. In this report, we have classified organisations and programs using three groupings:

- **Sources of antimicrobial data**: To simply classify the source of data, they have been grouped by the level of care generally applicable [24]:
  - primary/community care
  - secondary care
  - tertiary/quaternary care
- **Scope of analysis and reporting**: The scope of reporting generally performed by the program or system:
  - state/territory systems
  - national systems
- **Focus of analysis and reporting**: The primary area of focus for such reporting:
  - antimicrobial use
  - antimicrobial resistance

This structure can be seen in Figure 1 below and described more fully overleaf.

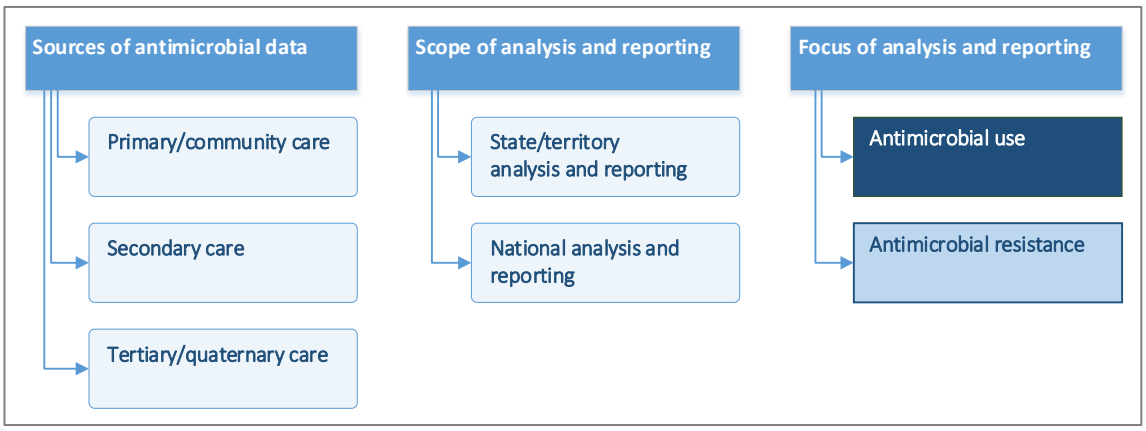

Figure 1: The classification framework adopted

3.1.1 Sources of antimicrobial data

This group of participants provide the original source of data, often as the result of a request-response pattern of interactions (such as the request/report process for diagnostic services). Three broad categories of participants are based largely on increasing levels of care involved:

- **Primary/community care:** Primary care is largely provided in the community and can be divided into broad areas of responsibility [25]:
  - **General practice:** The scope of clinical practice spans prevention and health promotion, early intervention for those at risk, and the management of acute, chronic and complex conditions [26]. General practice is the largest single source of antimicrobial prescribing [27].
  - **Allied health:** University qualified health practitioners other than those in medical, dental or nursing professions are frequently called allied health professionals. They have specialised expertise in preventing, diagnosing and treating a range of conditions and illnesses, often working within a multidisciplinary health team to provide specialised support for different patient needs. Not all allied health professionals can prescribe medications [28].
  - **Community pharmacy:** Community pharmacists provide professional advice and counselling on medications, including their use and effects, and general health care. The provision of prescription medications of proven efficacy is funded through the Australian Government PBS/RPBS via a network of about 5,700 pharmacist-owned community pharmacies [29].
  - **Private pathology:** Pathology is a medical specialty involved in understanding the causes and processes of disease through examining changes in the tissues of the body, blood and other body fluids. These changes can show the causes of disease or how severe a condition is. They can monitor the progress of treatments [30]. Several large private pathology services operate in the community and hospital settings.
  - **Aged care:** Aged care is the support provided to older Australians living either in their own home or in an aged care (nursing) facility, including help with everyday living, health care, accommodation and equipment [31].
- **Secondary care:** Provided by a range of specialist medical services on referral by a primary care practitioner, this includes private hospitals [25].
  - **Private specialist care:** This covers a range of professionals operating in private clinics or private hospitals.
  - **Private hospitals:** Care in private hospitals provides a greater range of choices and may be the only option for those being treated by private specialists [32]. Note that pathology and pharmacy solutions within private hospitals are generally undertaken by private service providers and are considered part of primary/community care. Private hospitals also provide tertiary care.

- **Tertiary/quaternary care:** Public and private hospitals provide the third tier of the Australian healthcare system [25].
  - **Emergency care:** Most public hospitals in Australia have an emergency department providing 24-hour emergency care to patients who need urgent medical attention [33].
  - **Inpatient care:** Inpatient care is provided to those who have been admitted to hospital for medical treatment, either via a hospital's emergency department or through a pre-booked surgery or treatment [34].
  - **Outpatient care:** Outpatient care involved the provision of medical treatment in a surgery, clinic or hospital's emergency room without being admitted to hospital [34].
  - **Public pathology:** Public pathology units provide pathology services in public hospitals and may also service private hospitals or operate community-based collection services [35].
  - **Hospital pharmacy:** Hospital pharmacists often work as part of multidisciplinary healthcare teams to manage the use of medicines in hospitals and may be embedded into medical wards and units [36].

3.1.2 Systems of analysis and reporting

Besides those that provide data, there are those that consume data, by aggregating it, undertaking analysis and/or reporting on the data. This can occur at the level of the state and territory health departments or at a national level. These systems may provide feedback to the sources of information directly or may provide published papers that inform AMS activities generally. In this report, these groupings have been identified:

- **State/territory analysis and reporting**
  - **OrgTRx** is a system operated by Queensland Health for local AMR objectives, but also provides IT services to the ACQSHC APAS program.
  - **MedTRx** is a system operated by Queensland Health for local AMS objectives, but is also one of the feeds for the NAUSP program.
  - **State/territory public health units** that operate notifiable disease programs. While activities and methods of reporting vary, all feed national programs.
- **National analysis and reporting** are undertaken by these programs and coordinated by AURA:
  - Australian Group on Antimicrobial Resistance
  - National Alert System for Critical Microbial Resistance
  - National Antimicrobial Utilisation Surveillance Program
  - Australian Passive AMR Surveillance
  - National Antimicrobial Prescribing Survey
  - National Notifiable Diseases Surveillance System

- National Neisseria Network
- NPS MedicineWise
- Antimicrobial Use and Resistance in Australia
- HOTspots (while not national, it is cross-jurisdictional)

In addition to those listed above, the PBS/RPBS provide reporting of most medication dispensing in Australia. Although this is not limited to antimicrobials, it is included in a wide range of AURA reports.

3.2 Visualising the Australian AU/AMR data landscape

With so many participants and the range of data flows and points of analysis or reporting, the Australian AU/AMR data landscape is complex and can seem confusing. To simplify it, the landscape is represented as diagrams using a common visual framework. The elements of this framework can be seen in Figure 2 below.

The data landscape diagrams have three common elements:

- a point of origin for the data, grouped by the nature or scope of the care given
- flows of data between the point of origin and systems use to analyse or report data
- the systems that perform the analysis and reporting, grouped by the reporting.

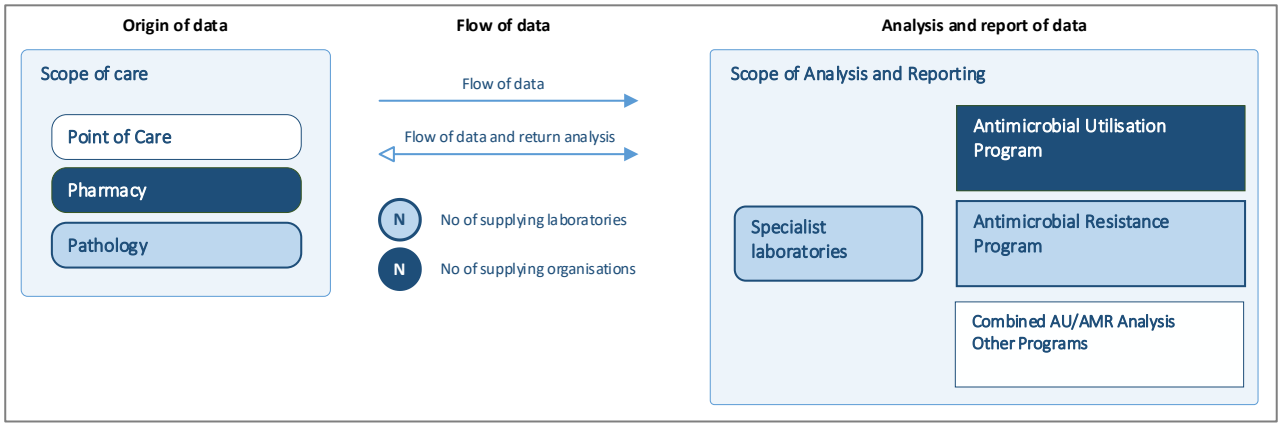

Figure 2: Visual framework elements in the AU/AMR data landscape diagrams

3.2.1 Origin of the data

There are two aspects to the data source that need to be considered:

- **Scope of care:** For this report, we have divided care into three domains:
  - **Primary care** (inclusive of aged care), which generally occurs in the community
  - **Secondary care**, which is largely provided via private specialist practitioners and hospitals
  - **Tertiary care**, which is provided by the public hospital system.
- Within these domains, we have further divided data sources into **three sources**:
  - **Points of care**, in which healthcare providers are providing direct care to patients/residents

– **Pharmacy**, the point at which antimicrobials are being dispensed
– **Pathology**, the point of testing of organisms for resistance

3.2.2 Flow of the data

Flows of data within the landscape are shown using the symbols included in Figure 3 below. These are:

- flows of data from data sources to consumers (a blue line with sold arrow pointing to the consumer)
- flows of data that include direct feedback to the data sources through some reporting or query mechanism (like above but with a hollow arrowhead indicating the return of information).

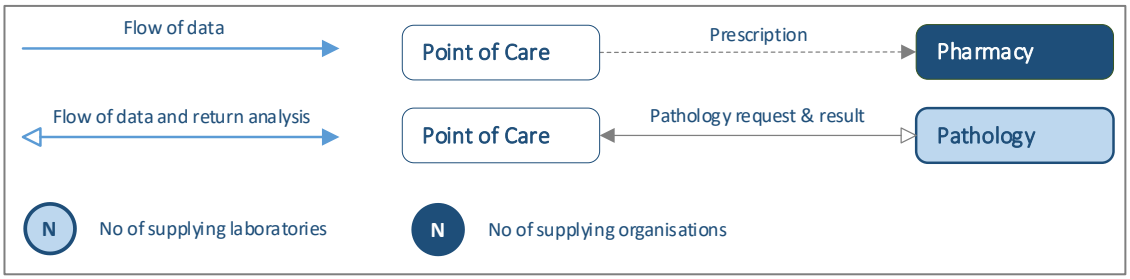

Figure 3: Symbols used to illustrate the flow of data within the AMR landscape

There is significant interaction between some of the data sources, and in the landscape diagrams these are indicated through grey lines on the left of the diagrams. These are:

- prescriptions which flow from the prescriber to the dispenser (a dotted grey line)
- pathology requests which also produce a result back to the requestor (a sold grey line with a solid arrowhead representing the returning result).

Where the number of data sources is known (individually by type or in aggregate), this is also indicated by a number in a circle. The colour of the circle will reflect if it is from an AU data source, or an AMR data source.

3.2.3 Analysis and reporting of data

The AU/AMR data landscape involves many organisations undertaking analysis and reporting of the data provided from one or more data sources. In the landscape diagrams, these have been divided into logically related groups:

- those undertaking analysis and report of **antimicrobial use (AU)**
- those undertaking analysis and report of **antimicrobial resistance (AMR)**.

The nature of the data source or consumer is indicated by a dark blue symbol of AU and a light blue symbol for AMR. The AURA Surveillance System and other points of care are shown as a white symbol, as they may supply or bring together data for analysis from both categories.

The Australian AU/AMR data landscape (without data flows) can be seen in Figure 4.

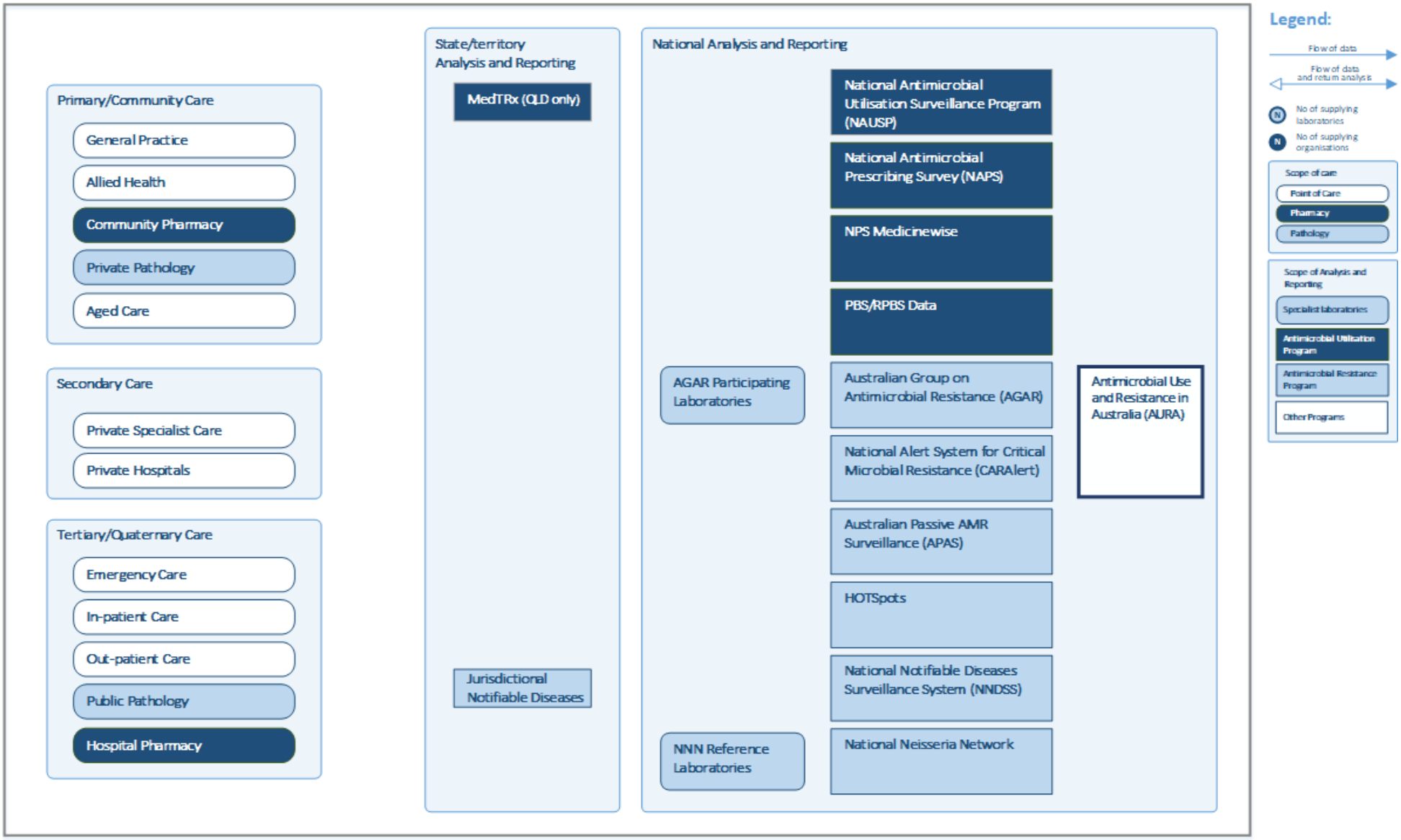

Figure 4: The structural elements of the AU/AMR data landscape

3.2.4 Individual AU/AMR data landscape diagrams

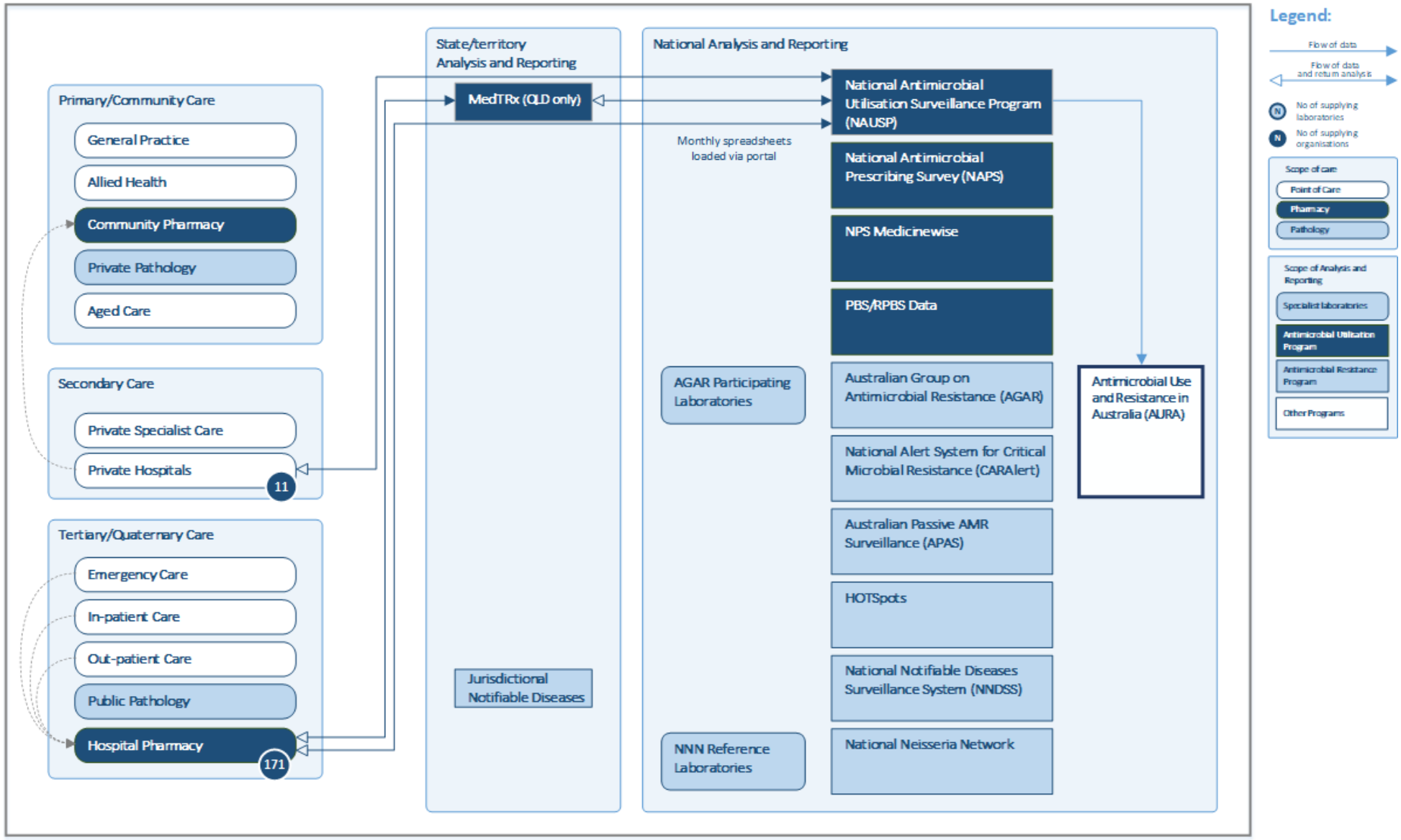

Figure 5: The AU/AMR data landscape for NAUSP

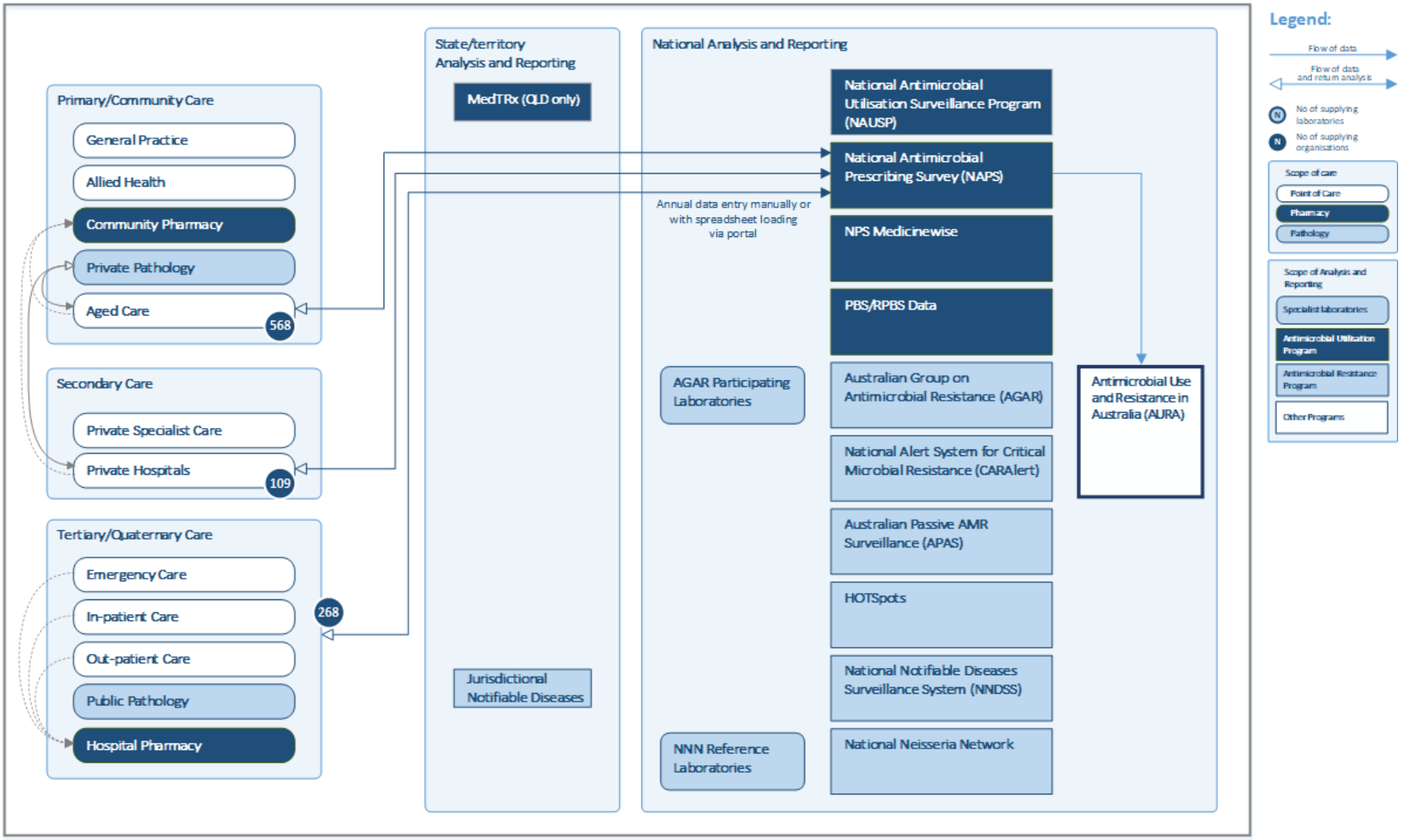

Figure 6: The AU/AMR data landscape for NAPS

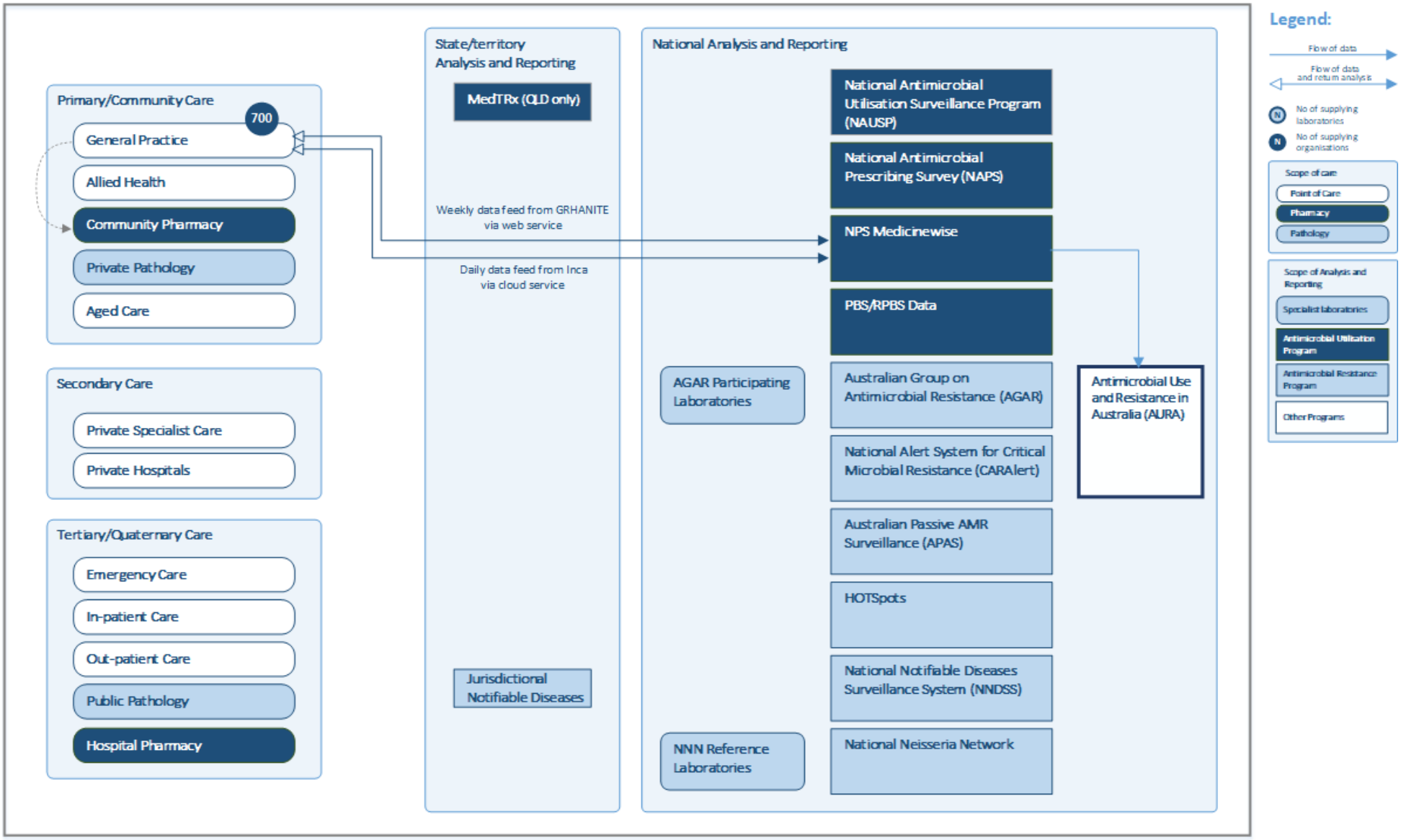

Figure 7: The AU/AMR data landscape for NPS Medicinewise

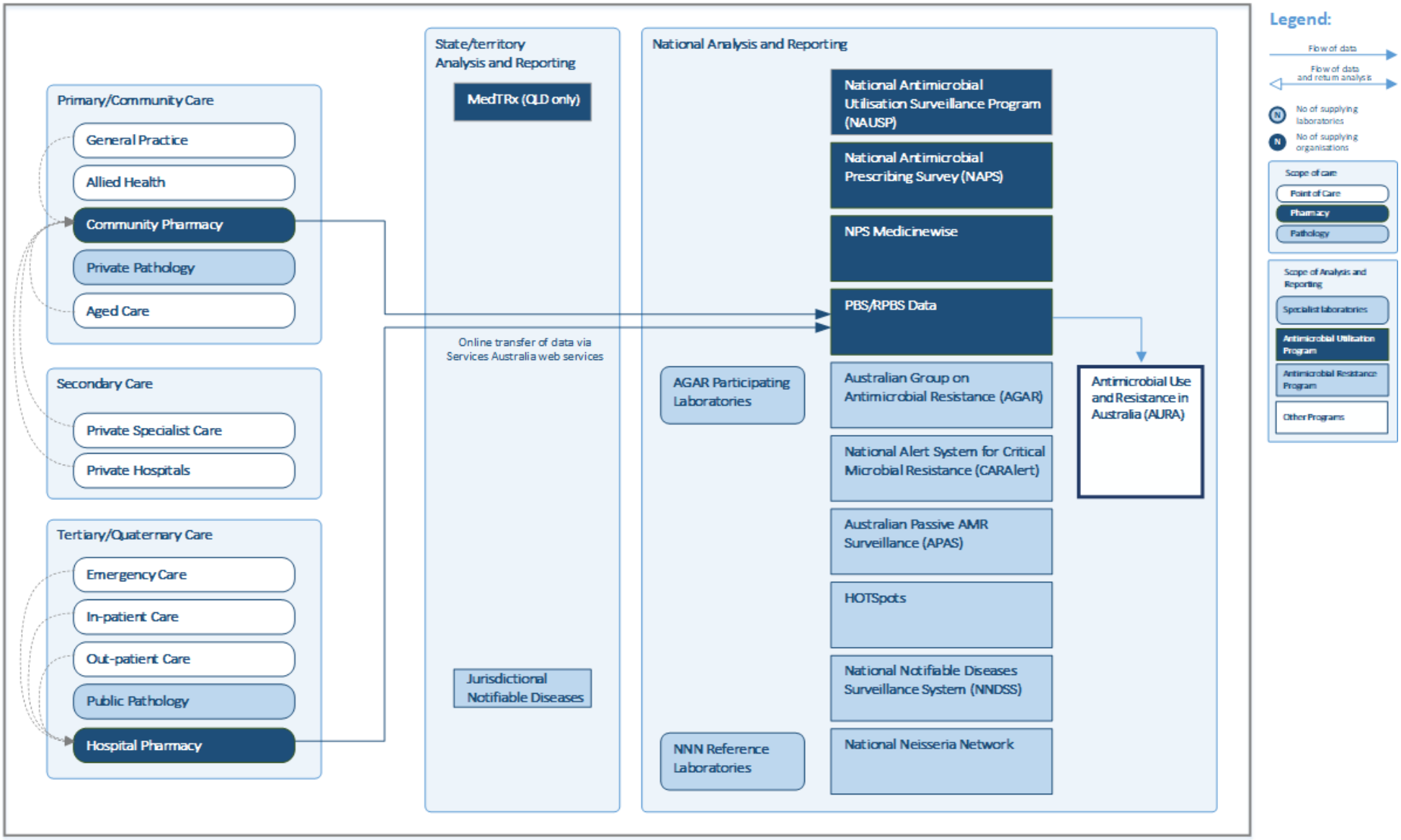

Figure 8: The AU/AMR data landscape for PBS/RPBS

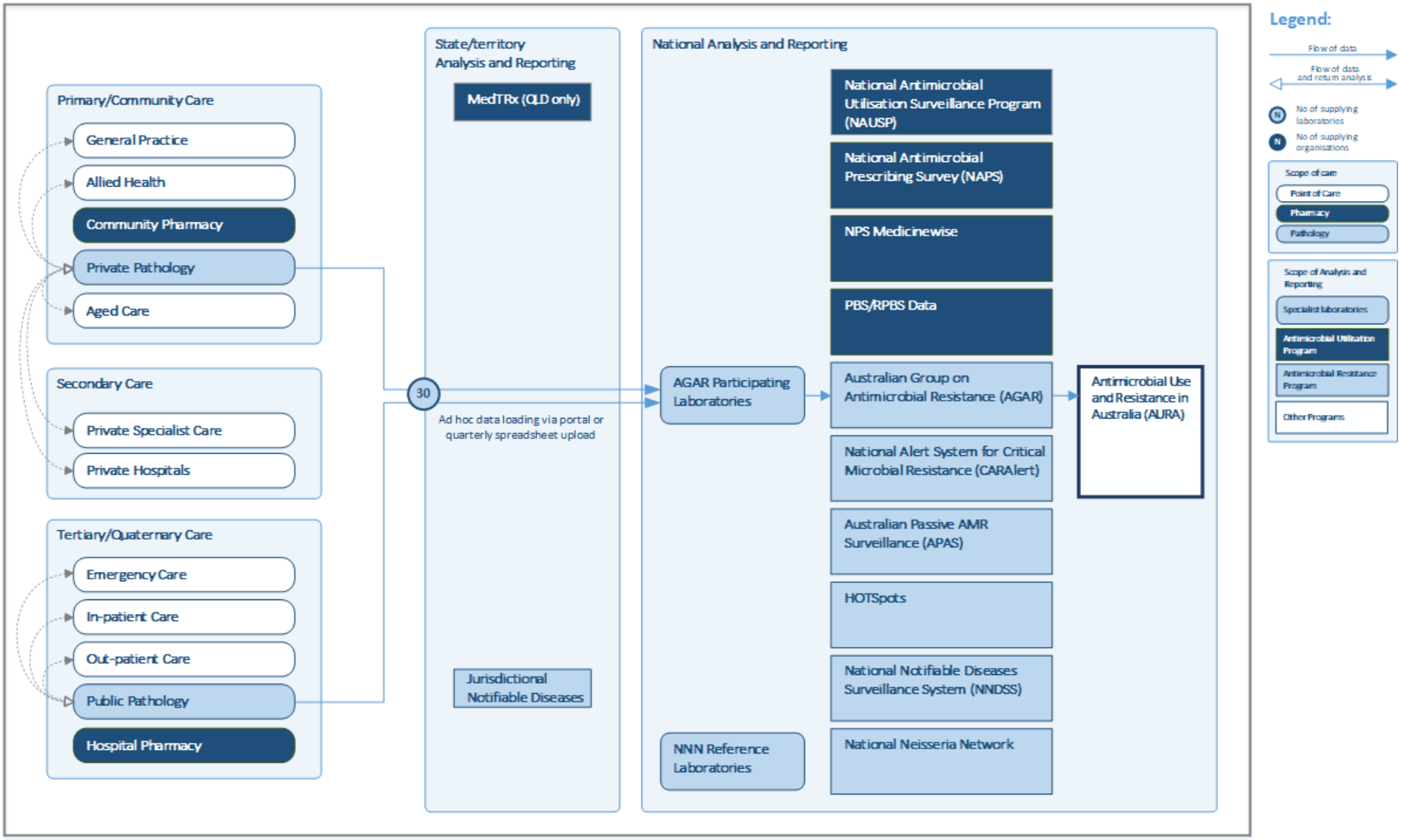

Figure 9: The AU/AMR data landscape for AGAR

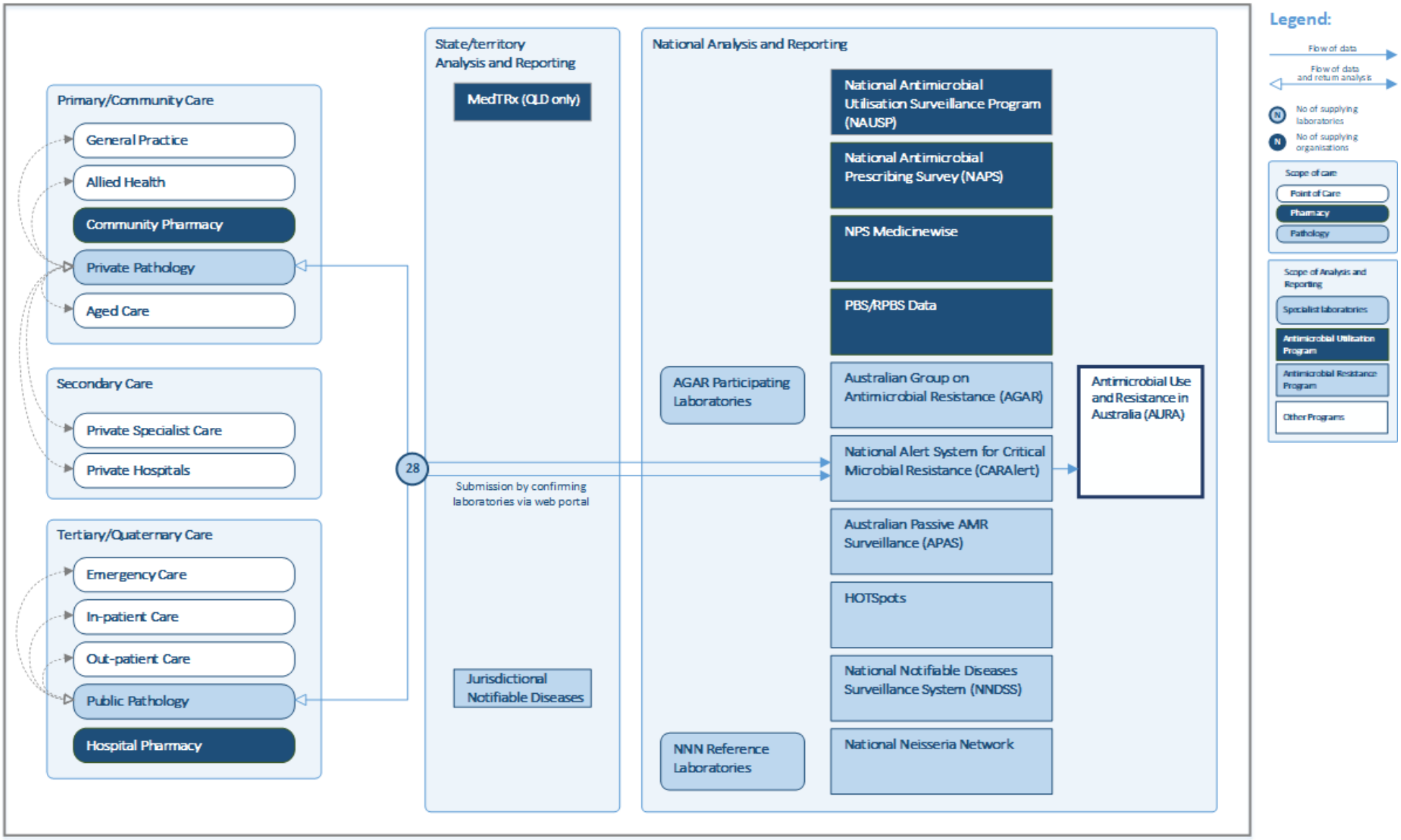

Figure 10: The AU/AMR data landscape for CARAlert

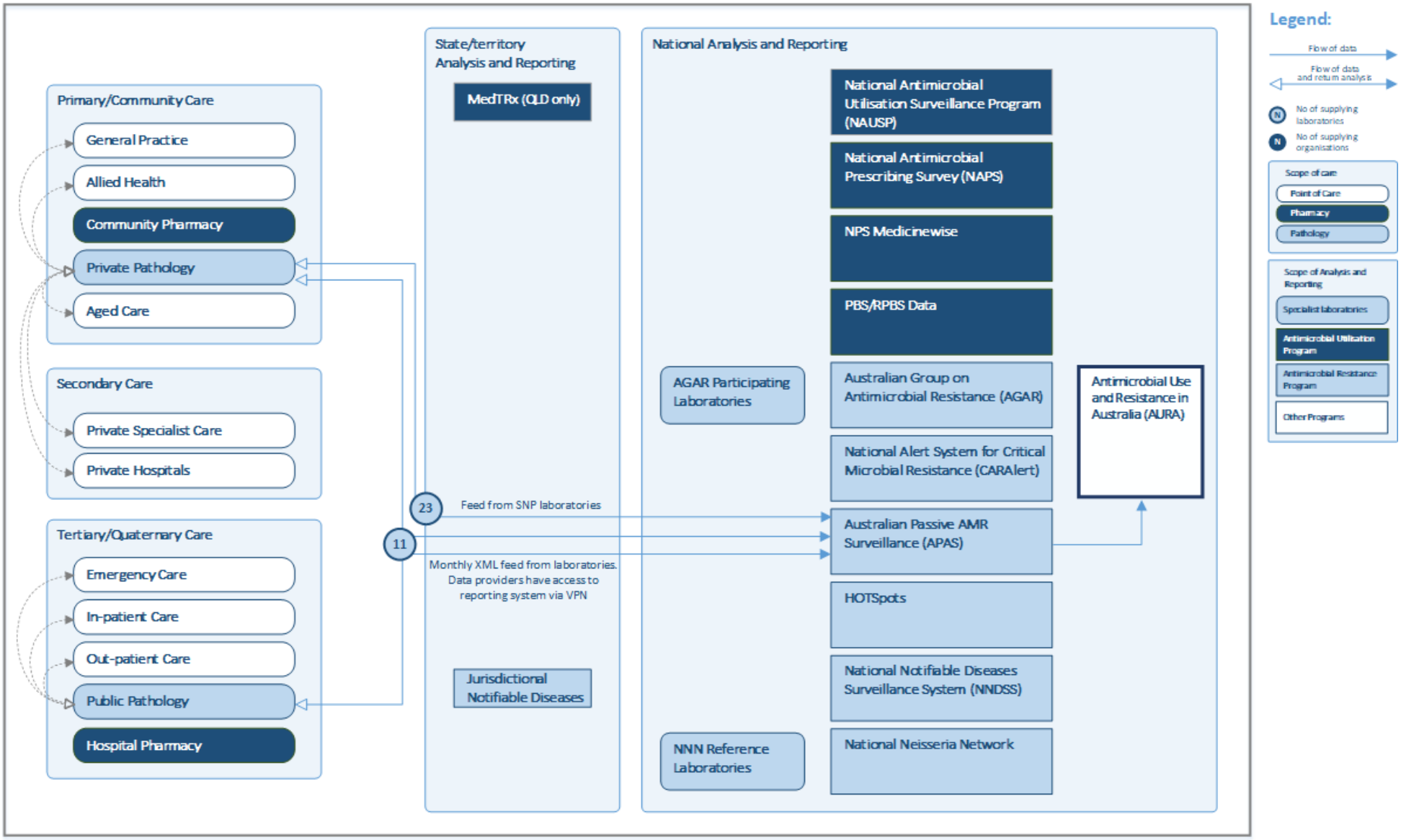

Figure 11: The AU/AMR data landscape for APAS

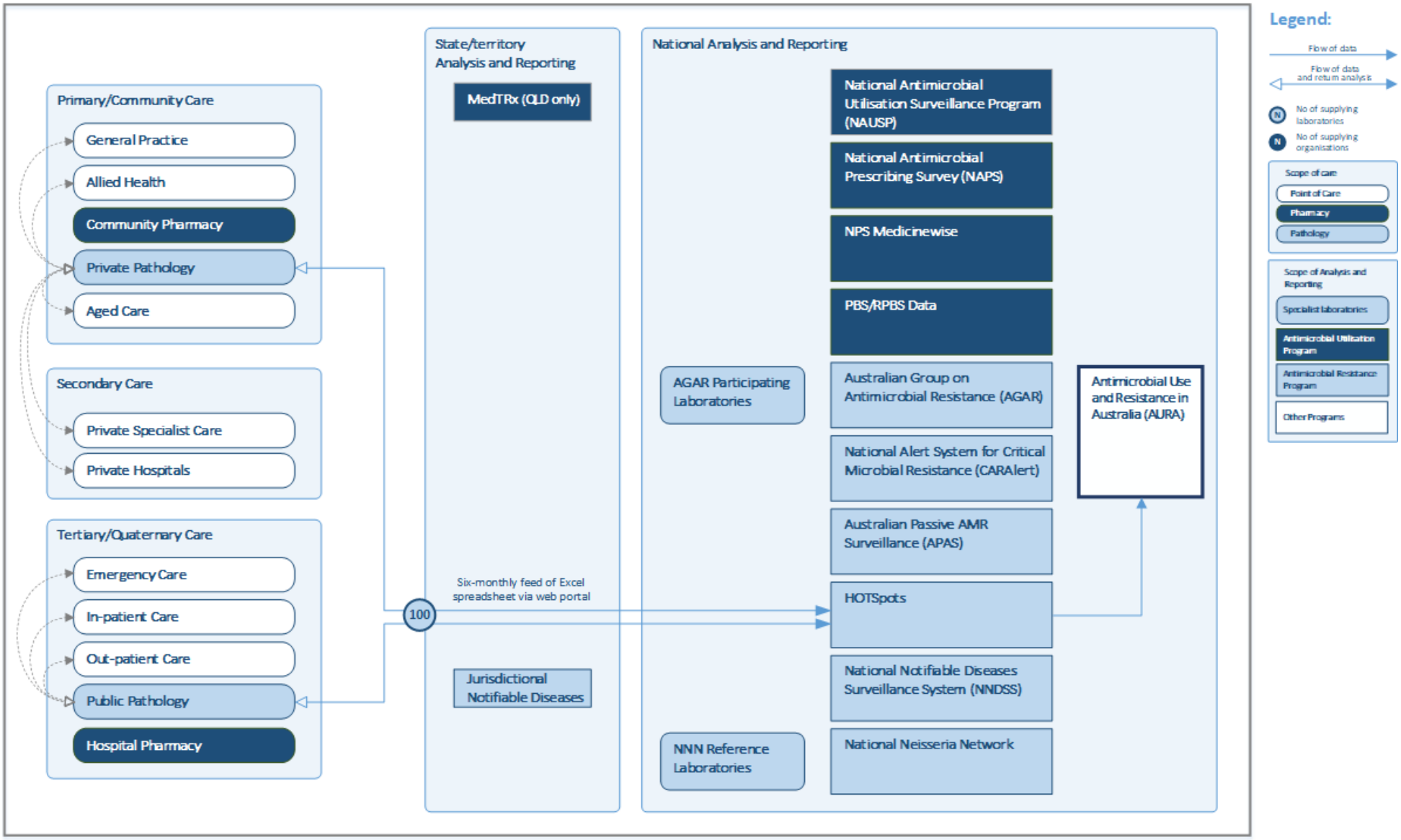

Figure 12: The AU/AMR data landscape for HOTSpots

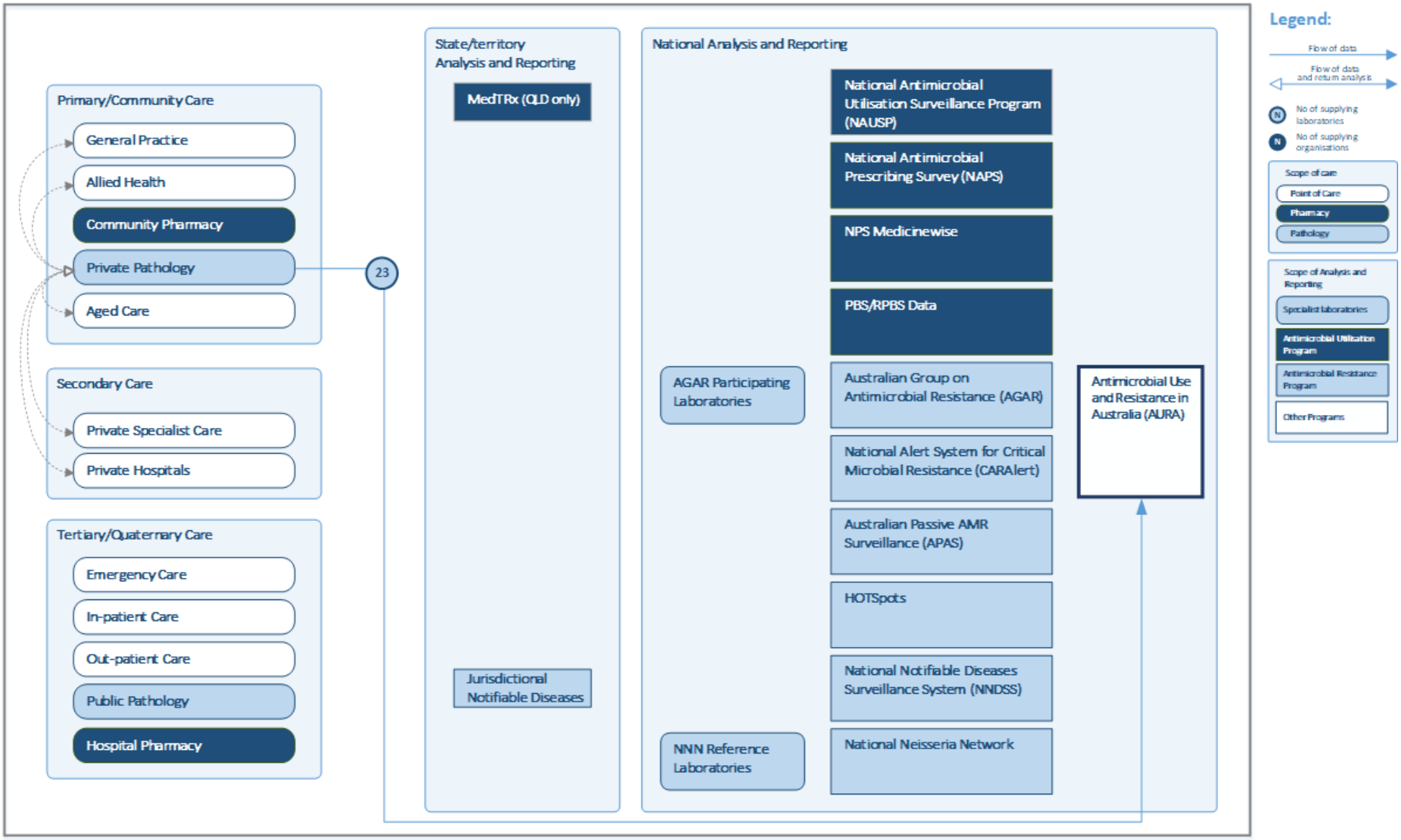

Figure 13: The AU/AMR data landscape for SNP

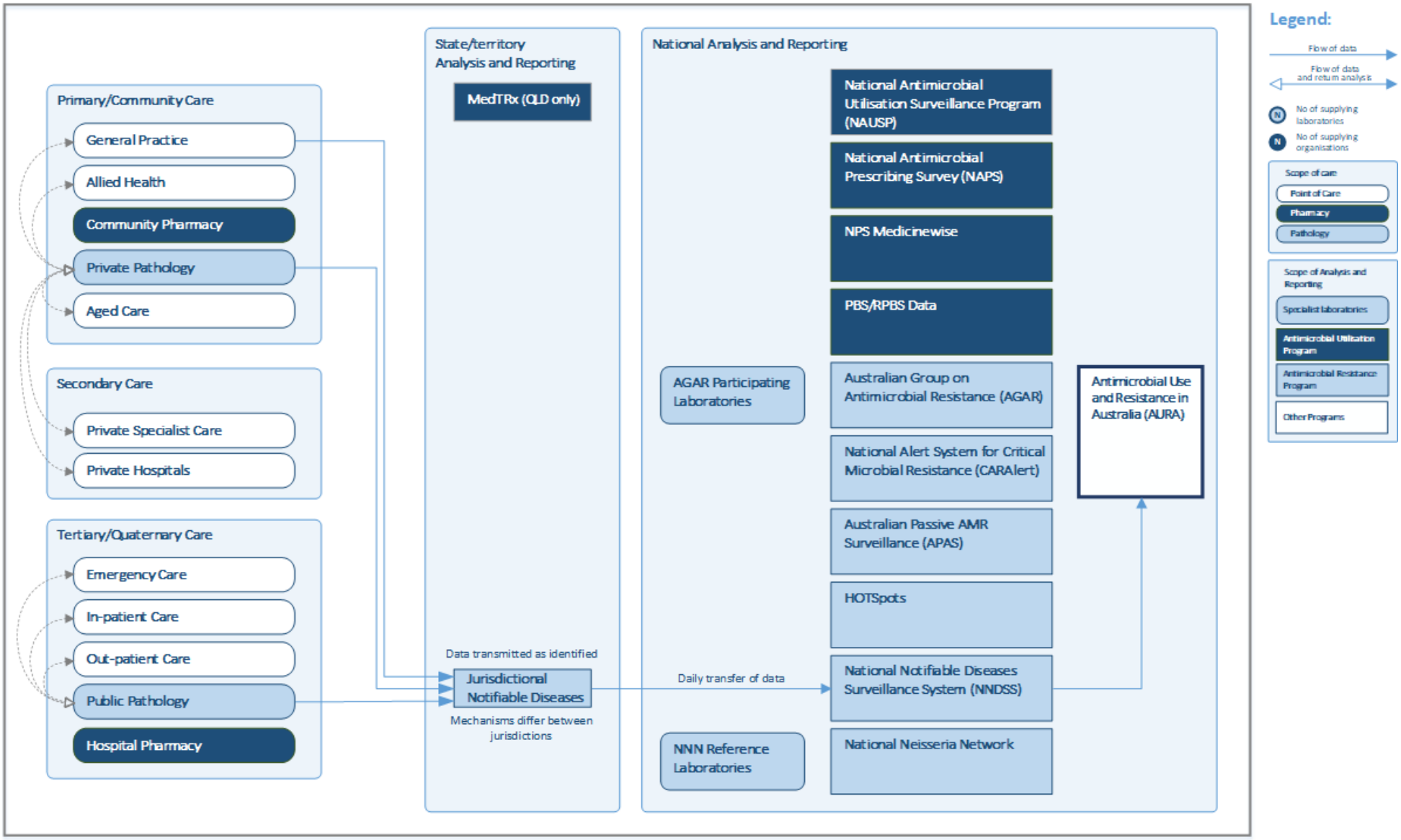

Figure 14: The AU/AMR data landscape for NNDSS

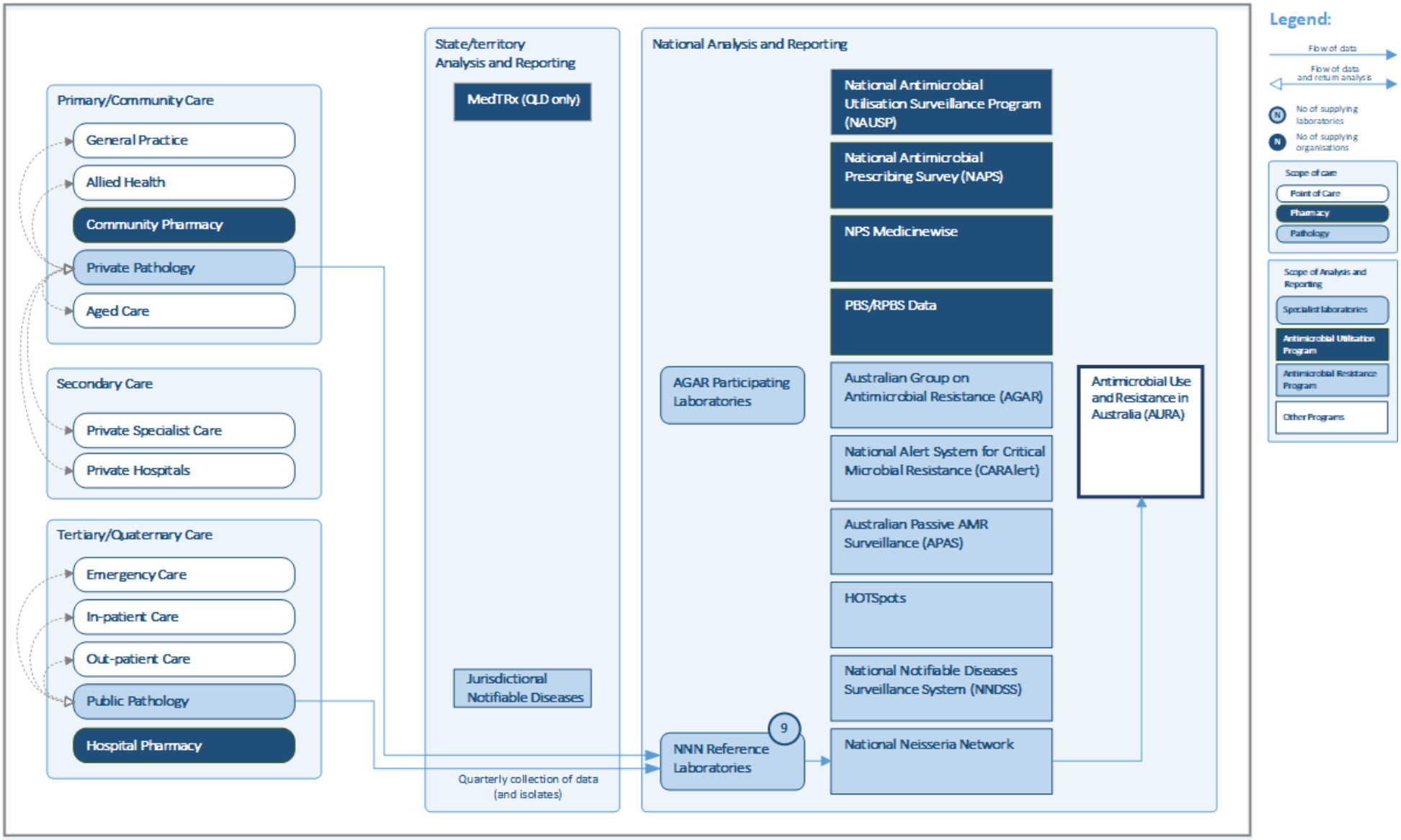

Figure 15: The AU/AMR data landscape for NNN

3.2.5 Combining the AU/AMR data landscape diagrams

The representation of the flows in the individual AU/AMR data landscape diagrams helps to understand the role each program plays in the overall Australian AU/AMR data landscape. However, this comes with the risk of oversimplifying the data landscape in its entirety.

Figure 16 (shown on the next page) combines all the data flows into a single diagram. This view has required some simplification of the representation due to the many flows included. Despite this simplification, it is clear from the diagram when taken as a whole, that the AU/AMR data landscape is complex and includes significant levels of duplication, especially regarding data flowing from pathology laboratories.

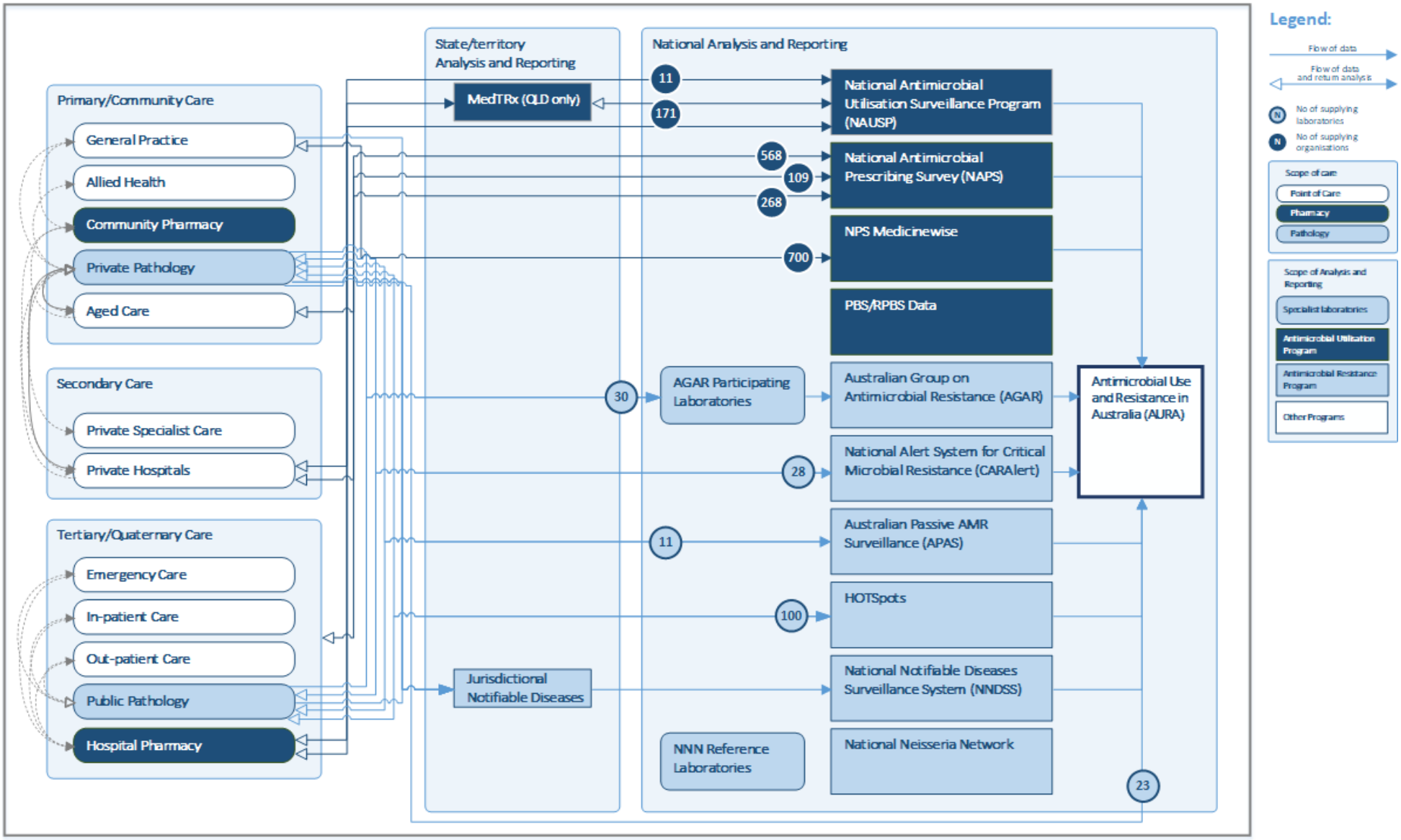

Figure 16: Combining the AU/AMR data landscape for all programs

4 Challenges and opportunities

Like other parts of the health system, data flows within the AMR community are complex. In many cases, the targeted programs were designed as stand-alone initiatives. This presents several compatibility challenges when considering their incorporation into a national data reporting system. This section explores some of these considerations and presents opportunities for unified action.

4.1 Data formats and processing methods

The format of AU and AMR data transfers is typical of those throughout health generally because they are based on a limited set of tools available to those involved in the program design. Several file formats have been identified:

- Comma separated value files (CSV)
- Microsoft Excel spreadsheets (XLS or XLSX)
- Extensible Markup Language (XML)

In addition, some data transfers require manual entry via online portals. While the online portals provide flexibility of access, manual data collation also increases the level of effort required to undertake data transfers and the likelihood of error (when compared with automated electronic transfers).

Having different data exchange formats limits the opportunities for reuse and standardisation of systems.

4.2 Terminologies used

The codification of some data elements through defined terminologies supports greater portability and interpretability of data. In the analysis of individual programs, validation against predefined values is relatively common.

However, such predefined lists have been largely defined within the context of the program providing or collecting the data, rather than based on more generalised terminology sets such as SNOMED CT-AU, LOINC or the like. Given the targeted nature of many programs, and sometimes the time over which they have been operating, it is understandable that more contemporary approaches to using defined terminologies may not have been adopted.

The variety of terminologies used limits the opportunities for reuse and standardisation of systems.

4.3 Standardisation

Using recognised standards for data exchange can help address the issues outlined above. As an example, the pathology sector has typically adopted HL7's V2 messaging standards and the LOINC terminology.

However, the adoption of standards within the healthcare sector is a vexed issue, even with HL7 V2, where many variations and generations of standards exist. As many of the data transfers described across the programs are specific to the area of study, they rarely lend themselves to more generalised data transfer standards.

The recent introduction of HL7's Fast Healthcare Interoperability Resources (FHIR) standard is gaining much support across the health sector. It may present an opportunity to leverage the flexibility of FHIR to provide standardised data transfers.

4.4 Duplication of efforts

There is a significant level of overlap or duplication in the data transfers undertaken in the AU/AMR data landscape.

For instance, pathology laboratories provide data to the APAS, CARAlert, AGAR, HOTspots, NNDSS and NNN programs, reflecting the varying data requirements for different isolates and purposes. Except for reportable organisms, this is based on voluntary participation by laboratories.

While not every laboratory will engage in all these programs and the data sent frequently targets different organisms, this potentially represents additional work for laboratory staff and IT systems and potentially an opportunity for streamlining. Similar duplication exists across pharmacy and other points of care.

4.5 Visualisation and reporting

Unsurprisingly, there is a high variation of reporting and visualisation. Eight of the programs provide an interactive dashboard or reporting tool, while others rely on publication of analysis in journals, websites or bulletins. This reflects the intention of the program – some are targeting immediate feedback to change behaviours or inform AMS, while others are providing long-term trend analysis or benchmarking information.

Reporting timeframes and methods also vary widely. Sometimes, analysis of data is available to data providers in near-real time, whereas for programs reporting of the analysis of data occurs months or years after initial data collection. These last examples are commonly associated with delays in getting access to complete data (e.g., the AGAR program includes survival outcomes within 30 days) or the necessity to collate or aggregate over time to provide trend analysis critical to antimicrobial stewardship.

4.6 Activities in other fields of reporting

While the focus of this report has been on the AU/AMR data landscape, it is apparent that there are similarities with other non-AMR data flows within the health system. These have been examined to assess opportunities or learnings that may be applied to the AU/AMR data landscape.

4.6.1 National screening activities

The National Cancer Screening Register (NCSR) comprises two programs: one testing for bowel cancer and another for cervical cancer. Pathology organisations involved in the diagnosis of these cancers already provide standardised reporting to NCSR. This data can be submitted either using the online portal or via a HL7 messaging interface.

This model of standardised data exchange with a national platform may apply to AMR reporting from the pathology sector.

4.6.2 Notifiable disease reporting

Pathology organisations (and others) also comply with existing state/territory reporting requirements for notifiable disease reporting. The processes and diseases included varies between jurisdictions, limiting the usefulness in a standardised approach. Pathology organisations interviewed suggested they addressed this requirement through reporting capabilities that could be adapted to the target group.

4.6.3 Controlled medicines surveillance

The governments of Australia are rolling out a national Real-Time Prescription Monitoring (RTPM) system that informs doctors (prescribers) and pharmacists (dispensers) about a patient's use of controlled medicines.

The RTPM system consists of two components:

- a **National Data Exchange** (NDE) which captures information from state and territory regulatory systems, prescribing and dispensing software, and a range of external data sources.
- **regulatory systems** within each state or territory, which manage the authorities or permits for controlled medicines in each state and territory.

The NDE was developed and released in December 2018. State/territory health authorities are integrating the NDE into their regulatory systems [37]. Vendors of prescribing software (such as general practice clinical information systems) and dispensing systems have integrated their software with the RTPM system.

While the RTPM does not yet cover all prescribing situations, the model of a nationally standardised submission and advice service based on capture of a filtered list of medications could be applied to AU monitoring by extension of the list of filtered

medications. This could also provide real-time advice to prescribers and dispensers about localised AMR and best practice prescribing guidelines.

Appendix A Key antimicrobial programs

This appendix provides a more detailed description of key programs associated with the AURA system discussed in Section 2, including data captured. Note that information about specific factors such as data validation rules may not have been available for all systems.

A.1 Antimicrobial Use and Resistance in Australia (AURA)

The AURA Surveillance System was established by the AURA National Coordination Unit at the ACSQHC [38]. The system coordinates data from a range of sources to provide patterns and trends of antimicrobial use and resistance in human health across Australia [39].

The AURA Surveillance System was founded on three long-term surveillance programs:

- Australian Group on Antimicrobial Resistance
- National Antimicrobial Prescribing Survey
- National Antimicrobial Utilisation Surveillance Program

ACSQHC have developed two further systems:

- Australia Passive AMR Surveillance
- National Alert System for Critical Antimicrobial Resistances

Additional data and reports are gathered from:

- National Neisseria Network
- National Notifiable Diseases Surveillance System
- Pharmaceutical Benefits Scheme and Repatriation Pharmaceutical Benefits Scheme
- NPS MedicineWise MedicineInsight program
- Rates of AMR from the community and private hospital settings provided by Sullivan Nicolaides Pathology
- HOTspots.

AURA published national reports in 2016, 2017, 2019 and 2021 and multiple other reports. See [38] for more information.

A.1.1 System description

The AURA system was implemented through partnership with existing AMR and AU surveillance programs. Additional programs have been established as required to address specific areas of interest. AURA continued to collaborate with a variety of stakeholders to build and improve surveillance infrastructure, and to coordinate data collection, analysis and reporting on AMR and AU.

A.1.2 Data collection

As AURA is not the primary custodian of the data, it relies on the supplying programs to manage:

- access to and use of data collections
- protection of data collections from unauthorised access, alteration or loss
- advice to data users on the data, including any caveats
- compliance with legislation and policies regarding administration, quality assurance, and data access and release.

A.1.3 Data processing

As many of the datasets have been available to AURA over a long period, trend analysis is available for some programs, such as NAUSP and APAS.

A.1.4 Data access

The AURA reports, including commentary on analyses of data, are used by clinicians, policy and program developers, health service managers and executives, state and territory governments, and the Australian Government to inform policy and clinical practice, and support containment of AMR. The Commission also uses AURA data to identify priorities for quality improvement programs, develops resources for IPC and AMS.

A.1.5 Landscape view

As the AURA Surveillance System leverages the data from other programs described in the remainder of this appendix, an end-to-end trace of the AU/AMR data landscape is of less value.

Figure 17 below [14] provides the AURA Surveillance System overview. The elements of AURA were strategically determined to provide a comprehensive approach to developing the system, and to inform interventions.

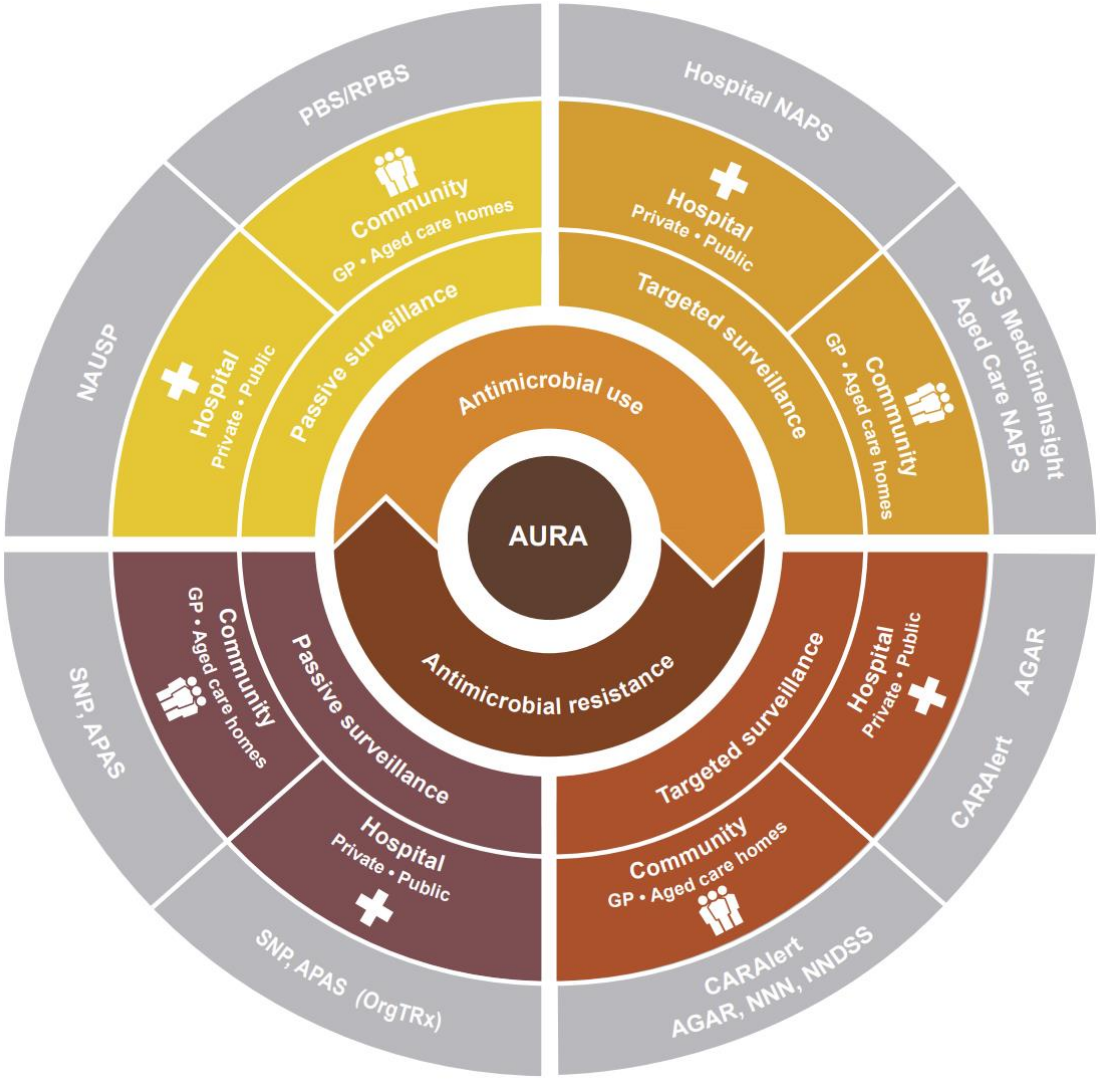

Figure 17: The AURA Surveillance System combines data from multiple programs

A.2 National Antimicrobial Prescribing Survey (NAPS)

The NAPS is coordinated by a multidisciplinary team at the National Centre for Antimicrobial Stewardship and is delivered by the Guidance Group. The survey has been in use since 2011 and helps Australian health care facilities (including aged care) to assess their antimicrobial prescribing practice. It provides information on the utilisation of antimicrobials as part of the AURA Surveillance System [40].

There are three publicly available reports produced annually:

- **Hospital NAPS** (covering public and private hospitals, although participation varies by type and state/territory) provides auditing of many infections and captures aspects of antimicrobial prescribing at a broad level.
- **Surgical NAPS** is designed for surgical (and non-surgical) procedures and captures more comprehensive data on the quantity and quality of antimicrobial prescribing than is covered in the Hospital NAPS survey.
- **Aged Care NAPS** (undertaken in partnership with the VICNISS Coordinating Centre at Melbourne Health)

The Hospital and Surgical surveys are undertaken as either retrospective or prospective audits.

A fourth report, Quality Improvement NAPS, is a quick audit tool designed to be conducted frequently on small numbers of patients and which does not include appropriateness assessment. This complements the Hospital NAPS survey and is targeted at hospitals undertaking targeted reviews rather than for national reporting or benchmarking.

Additional reports that have been trialled or are in development include:

- General Practice NAPS
- Hospital-in-the-Home NAPS
- Veterinary NAPS

The NAPS survey operates in four countries: Australia, New Zealand, Fiji and Canada.

A.2.1 System description

Data submission for the Hospital, Surgical and Aged Care NAPS is via a web-based portal available to registered participants. This has been in development by the National Centre for Antimicrobial Stewardship for many years, and further improvements are planned. The system is specifically targeted to allow submitted organisations to benchmark themselves against comparable organisations.

The system makes use of a Universal Indications List (UIL) to support appropriateness analysis. The UIL is a cloud-based product built using the SNOMED CT-AU terminology and developed with support from the Australian Digital Health Agency. The UIL also incorporates a SNOMED-coded antimicrobial list, is mapped against therapeutic

guidelines and supports aliases. The UIL was a component of the GP NAPS trial. It is available separately for use by systems under a commercial licence.

A.2.2 Data collection

Each facility ensures their data is complete and accurate. Data for the surveys is collected as follows:

- **Hospital NAPS** is generally run yearly, before AMR Awareness Week in November [41]. In 2019, 268 Public hospitals and 109 private hospitals participated [42]. Data collected can be seen in Table 1.
- **Surgical NAPS** is generally run retrospectively each year at a time that considers surgical activity levels, although it can also be run to address requirements for specific procedures or specialties [43]. In 2019, 74 Public hospitals and 70 private hospitals participated [44]. Data collected can be seen in Table 2.
- **Aged Care NAPS** is generally run yearly [45]. In 2019, data was collected for 256 aged care services and 32,347 residents[46]. Data collected can be seen in Table 3 (Facility), and Table 4 (Resident).

Data can be entered into the portal system in one of two ways:

- data can be manually transferred using the portal functionality
- data related to patient and AU can be loaded from spreadsheets extracted from medical record systems, with additional data (such as indications) being loaded manually - this reportedly saves about 60% of the effort to load data using the manual process.

This is the only program specifically capturing appropriateness data. Data for the GP NAPS trail was extracted from GP systems using GRHANITE. Details of the data selected can be seen in Table 5.

Table 1: Patient level data collected for Hospital NAPS

Data element (Hospital NAPS)	Data type	Comments / validation
Audit date	Date	
Patient identification	Text	
Date of birth/age	Date	
Gender	Text	Validated against predefined list (M/F/O)
Specialty	Text	Validated against predefined list of specialties
Currently in ICU/NICU	Text	
Ward	Text	
Weight	Number	
eGFR/CrCl	Number	
Birth weight	Number	For NICU patients
Gestational age	Number	For NICU patients
Antimicrobials	Table	

Data element (Hospital NAPS)	Data type	Comments / validation
Start date	Date	
Antimicrobial	Text	
Route	Text	
Dose	Text	
Frequency	Text	
Indication documented	Yes/No	
Specify documented or presumed indication	Yes/No	
Review/stop date documented	Yes/No	
Guideline compliance	Number	Value 1-6 from predefined list
Surgical prophylaxis > 24 hours	Yes/No	
Allergy mismatch	Yes/No	
Microbiology mismatch	Yes/No	
Indication does not require any antimicrobials	Yes/No	
Incorrect route	Yes/No	
Incorrect dose / frequency	Yes/No	
Incorrect duration	Yes/No	
Spectrum too broad	Yes/No	
If restricted, approval given	Yes/No	
Appropriateness	Number	Value 1-5 from predefined list
Allergies and adverse drug reactions to antimicrobials	Selection	Options: Nil known, not documented, present
Antimicrobial and reaction	Text	Only supplied if “present” selected above
Microbiology	Selection	
Microbiology specimen type, organism and susceptibilities	Text	Only supplied if “collected” selected above
Clinical notes or comments	Text	
Renal replacement therapy given within the previous 24 hours	Yes/No	
Surgical procedure if performed	Text	

Table 2: Patient level data collected for Surgical NAPS

Data element (Surgical NAPS)	Data type	Comments / validation
Patient identification	Text	
Date of birth/age	Date	
Gender	Text	Validated against predefined list (M/F/O)
Date of admission	Date	
Date of discharge	Date	
Specialty	Text	Validated against predefined list of specialties
Height	Number	
Weight	Number	
eGFR/CrCl	Number	
Currently in ICU/NICU	Text	
Surgical details		
Surgery date	Date	
Surgery this admission	Selection	Options: Initial / subsequent
Procedures		
Nature	Selection	Emergency, Elective, Not assessable
Description of procedures	Text	
Trauma	Yes/No	
Removal/insertion of prosthetic material	Yes/No	
Excessive blood loss	Yes/No	
Surgeon code	Text	
Anaesthetist code	Text	
Time of first incision	Time	Options: not documented / not applicable
End time (or estimated)	Time	
Wound classification	Selection	Options: clean / clean-contaminated / dirty / unknown / not applicable
ASA Score	Selection	Options: 1-6 / unknown
Surgical or clinical notes, microbiology, radiology	Text	
Risk factors		
None identified	Yes/No	
Current smoker	Yes/No	
Diabetes	Yes/No	
Peritoneal or haemodialysis	Yes/No	
Obesity (BMI > 30)	Yes/No	
Pregnancy	Yes/No	
Rheumatoid arthritis	Yes/No	
Current malignancy	Yes/No	
Previous radiation therapy	Yes/No	
Immunocompromised	Yes/No	

Data element (Surgical NAPS)	Data type	Comments / validation
Systemic corticosteroids	Yes/No	
Other immunosuppressive treatments	Yes/No	
Presence of prosthesis	Yes/No	
MRSA colonisation	Yes/No	
MDR gram-negative colonisation	Yes/No	
One or more of (defined list)	Yes/No	
Transrectal prostatic biopsy		
Quinolone therapy in preceding 3 months	Yes/No	
Recent travel to Asia/Sth Europe in preceding 6 months	Yes/No	
Gastroduodenal or oesophageal procedures		
Reduced gastric acidity or motility	Yes/No	
Gastrointestinal bleeding	Yes/No	
Gastric outlet obstruction	Yes/No	
Perforation	Yes/No	
Biliary surgery		
Acute cholecystitis	Yes/No	
Obstructive jaundice	Yes/No	
Common bile duct stones	Yes/No	
Non-functioning gallbladder	Yes/No	
Allergies and adverse drug reactions to antimicrobials		
Nil known	Yes/No	
Not documented	Yes/No	
Present	Yes/No	
Drug and nature if present	Text	
Existing antimicrobial therapy		
None prescribed	Yes/No	
Not assessable	Yes/No	
Specify if present		
Antimicrobial	Text	Antimicrobial
Route	Text	Route
Dose	Text	Dose
Date and time of last dose	Date/time	Date and time of last dose
Peri-operative doses		
Antimicrobial	Text	
Route	Text	
Dose	Text	
Documented administration time		
Not assessable	Yes/No	
Accuracy indicator	(section)	
Nearest 15 minutes	Yes/No	
Exact time	Yes/No	

Data element (Surgical NAPS)	Data type	Comments / validation
Start time	Time	
End time	Time	Optional?
Was this a repeat dose?	Yes/No	
Guideline compliance	Number	Options: 1-6
Allergy mismatch	Yes/No	
Microbiology mismatch	Yes/No	
Incorrect dose	Yes/No	
Incorrect route	Yes/No	
Incorrect timing	Yes/No	
Spectrum too broad	Yes/No	
Spectrum too narrow	Yes/No	
Peri-operative antimicrobials not required	Yes/No	
Appropriateness	Number	Options: 1-5
Repeat dose required but not given	Yes/No	
Guideline compliance	Number	Fixed value = 4
Appropriateness	Number	Fixed value = 4
No antimicrobial prescribed	Yes/No	
Guideline compliance	Number	Options: 1-6
Procedure requires antimicrobials	Yes/No	
Appropriateness	Number	Options: 1-5
Post-operative doses		
Start date and time	Datetime	
End date and time	Datetime	
Antimicrobial	Text	
Route	Text	
Dose	Text	
Freq	Text	
Indication		
For prophylaxis only	Yes/No	
For treatment of infection related to procedure	Yes/No	
Not assessable	Yes/No	
Guideline compliance	Number	Options: 1-6
Allergy mismatch	Yes/No	
Microbiology mismatch	Yes/No	
Incorrect dose	Yes/No	
Incorrect route	Yes/No	
Incorrect timing	Yes/No	
Spectrum too broad	Yes/No	
Spectrum too narrow	Yes/No	
Peri-operative antimicrobials not required	Yes/No	
Appropriateness	Number	Options: 1-5

Data element (Surgical NAPS)	Data type	Comments / validation
Repeat dose required but not given	Yes/No	
Guideline compliance	Number	Fixed value = 4
Appropriateness	Number	Fixed value = 4
No antimicrobial prescribed	Yes/No	
Guideline compliance	Number	Options: 1-6
Procedure requires antimicrobials	Yes/No	
Appropriateness	Number	Options: 1-5
30 day follow up		
Surgical site infection	Selection	Options: None identified / Not accessible / Identified
Type of infection	Selection	Options: Superficial / Deep incisional / Organ space / Prosthesis
Microbiology	Text	
Clostridium infection	Selection	Options: Yes / No / Unknown
MDR organism	Selection	Options: Yes / No / Unknown
Unplanned ICU admission	Selection	Options: Yes / No / Unknown
Unplanned hospital readmission	Selection	Options: Yes / No / Unknown
Death	Selection	Options: Yes / No / Unknown
Other morbidity	Selection	Options: Yes / No / Unknown
Other morbidity (specified)	Text	

Table 3: Existing antimicrobials level data collected for Aged Care NAPS (per facility)

Data element (Aged Care NAPS facility)	Data type	Comments / validation
Facility name	Text	
Survey date	Date	
Aged care provider group name	Text	
RAC number	Text	
Facility data		
Infection Prevention and Control (IPC)		
Multidisciplinary team/committee established	Yes/No	
IPC program lead employed	Yes/No	
IC Coordinator has dedicated time for assigned tasks	Yes/No	
IPC policies and procedures detail requirements	Yes/No	
Antimicrobial stewardship (AMS)		
AMS program lead employed	Yes/No	
AMS policies and procedures detail requirements	Yes/No	
Prescribing staff have access to:		
Therapeutic Guidelines: Antibiotic	Yes/No	
Australian Medicines Handbook: Aged Care Comparison	Yes/No	
Demographic data		
No of residents present	Number	

Data element (Aged Care NAPS facility)	Data type	Comments / validation
No of residents aged > 85 years	Number	
No of male residents	Number	
No of residents admitted to hospital in previous 30 days	Number	
No of residents transferred with suspected or confirmed infection	Number	
No of residents with urinary catheter present	Number	

Table 4: Existing antimicrobials level data collected for Aged Care NAPS (per resident)

Data element (Aged Care NAPS patient)	Data type	Comments / validation
Does resident have an antimicrobial prescription	Yes/No	
Does resident have signs/symptoms of infection	Yes/No	
Identification number	Text	
Date of birth or age	Date	
Gender	Text	Option: M/F/O
Admitted to hospital within last 30 days	Yes/No	
Antimicrobials		
Start date	Date	
Started at this facility	Yes/No	
Still prescribed today	Yes/No	
Antimicrobial	Text	
Dose	Text	
Route	Text	
Freq	Text	
PRN	Text	
Administered on survey day or 6 days prior	Yes/No	
Indication documented by prescriber	Yes/No	
Documented or presumed indicator	Text	
Was this for prophylaxis?	Yes/No	
Review/stop date documented?	Yes/No	
Adverse drug reactions to antimicrobials		
Reaction	Selection	Options: nil known/not documented/yes
Antimicrobial	Text	
Anaphylaxis/angioedema	Yes/No	
Rash/urticaria	Yes/No	
Other	Yes/No	
Side effects	Yes/No	
Unknown reaction	Yes/No	
Microbiology		
None collected	Yes/No	
Skin/wound swab	Yes/No	
Urine	Yes/No	

Data element (Aged Care NAPS patient)	Data type	Comments / validation
Sputum	Yes/No	
Respiratory swab	Yes/No	
Other	Yes/No	
Constitutional criteria		
No constitutional criteria identified	Yes/No	
Fever		
Single oral temp > 37.8°C	Yes/No	
Repeated oral > 37.2°C or rectal > 37.5°C	Yes/No	
Single temp > 1.1°C over baseline	Yes/No	
Chills or rigors	Yes/No	
Full blood exam		
WBC elevated	Yes/No	
Left shift documented	Yes/No	
Changed in mental status		
Acute onset	Yes/No	
Fluctuating course	Yes/No	
Inattention	Yes/No	
Disorganised thinking/altered state	Yes/No	
Acute functional decline		
Bad mobility	Yes/No	
Transfer	Yes/No	
Locomotion within facility	Yes/No	
Dressing	Yes/No	
Toilet use	Yes/No	
Personal hygiene	Yes/No	
Eating	Yes/No	
System criteria		
Urinary tract		
Association	Selection	Options: Facility associated / Non-facility associated
Acute pain on urination	Yes/No	
Acute pain, swelling or tenderness of testes, epididymis or prostate	Yes/No	
Back pain or tenderness	Yes/No	
Blood in urine	Yes/No	
Frequency	Yes/No	
Incontinence	Yes/No	
Low blood pressure with no alternate site of infection	Yes/No	
Pus discharging from urethra or around catheter	Yes/No	
Suprapubic pain	Yes/No	
Urgency	Yes/No	

Data element (Aged Care NAPS patient)	Data type	Comments / validation
Urinary retention	Yes/No	
Other signs/symptoms	Yes/No	
Urinary catheter		
None	Yes/No	
Intermittent	Yes/No	
Indwelling	Yes/No	
Suprapubic	Yes/No	
External	Yes/No	
Nephrostomy tube	Yes/No	
Urine dipstick		
Not performed	Yes/No	
Performed	Yes/No	
Date performed	Date	
Nitrite	Selection	Options: Negative / Positive / Not recorded
Leucocyte esterase	Selection	Options: Negative / 1+ / 2+ / 3+ / Not recorded
Urine specimen		
Not collected	Yes/No	
Collected	Yes/No	
Date collected	Date	
Final report attached	Yes/No	
Respiratory tract		
Association	Selection	Options: Facility associated / Non-facility associated
Chest wall pain	Yes/No	
Chest X-Ray (recent, normal)	Yes/No	
Chest X-Ray showing pneumonia or new infiltrate (recent)	Yes/No	
Cough (new or increased)	Yes/No	
Headache or eye pain (new)	Yes/No	
Hoarseness	Yes/No	
Loss of appetite	Yes/No	
Lung abnormalities (new of increased)	Yes/No	
Malaise	Yes/No	
Myalgia or muscle pain	Yes/No	
Oxygen saturation < 94% or reduction or > 3% on baseline	Yes/No	
Pain on swallowing	Yes/No	
Respiratory rate >= 25 breaths per minute	Yes/No	
Runny nose or sneezing	Yes/No	
Sore throat	Yes/No	
Sputum (new or increased)	Yes/No	
Stuffy nose	Yes/No	

Data element (Aged Care NAPS patient)	Data type	Comments / validation
Swollen or tender neck glands	Yes/No	
Sputum specimen		
Not collected	Yes/No	
Collected	Yes/No	
Date collected	Date	
Final report attached	Yes/No	
Respiratory virus test		
Not collected	Yes/No	
Collected	Yes/No	
Date collected	Date	
Final report attached	Yes/No	
Oral		
Association	Selection	Options: Facility associated / Non-facility associated
Doctor or dental provider confirmation	Yes/No	
Presence of raise white patches or plaques in mouth	Yes/No	
Other signs or symptoms not listed above	Yes/No	
Skin or soft tissue		
Association	Selection	Options: Facility associated / Non-facility associated
Heat	Yes/No	
Pus present at wound, skin or soft tissue site	Yes/No	
Redness	Yes/No	
Serous discharge	Yes/No	
Swelling	Yes/No	
Tenderness or pain	Yes/No	
Rash		
Rach or lesions characteristic of a fungal skin infection	Yes/No	
Maculopapular rash and/or itching rash	Yes/No	
Vesicular rash	Yes/No	
Doctor or laboratory confirmation for		
Fungal skin infection	Yes/No	
Herpes simplex or zoster	Yes/No	
Scabies	Yes/No	
Linkage to laboratory confirmed case of scabies	Yes/No	
Other signs or symptoms not listed above	Yes/No	
Swab		
Not collected	Yes/No	
Collected	Yes/No	
Date collected	Date	
Final report attached	Yes/No	
Eye		

Data element (Aged Care NAPS patient)	Data type	Comments / validation
Association	Selection	Options: Facility associated / Non-facility associated
Itching or pain > 24 hours	Yes/No	
New or increased conjunctival redness	Yes/No	
Pus from one/both eyes present for >= 24 hrs	Yes/No	
Other signs or symptoms not listed above	Yes/No	
Other infection(s) not listed		
Association	Selection	Options: Facility associated / Non-facility associated
Comments and clinical notes	Text	

Table 5: Data collected for GP NAPS

Data element (GP NAPS)	Data type	Comments / validation
Event ID	Text	
Visit ID	Text	
Practitioner Number	Text	
Consultation Date	Date	
Visit Reason	Text	
Patient Gender	Text	
Patient Age	Number	
Patient Ethnicity	Text	
Patient Smoking Status	Text	
Patient Height	Number	
Patient Weight	Number	
Height Registered Date	Date	
Weight Registered Date	Date	
Script ID	Text	
Drug Name	Text	
Strength	Text	
Dose	Text	
Quantity	Number	
Repeats	Number	
Script Type	Text	
Long-Term	Yes/No	
Last Script	Date	
Approval Number	Text	
Substitution Allowed	Yes/No	
Regulation 24 indicator	Text	
First Script	Text	
Reason for prescription	Text	
Product ID	Text	

Data element (GP NAPS)	Data type	Comments / validation
ATC Code	Text	
Allergies		
Item Name	Text	
Reaction	Text	
Severity	Text	
Pathology Request		
Request ID	Text	
Pathology Report		
Result Name	Text	
LOINC Code	Text	
Result Value	Text	
Past History	Text	

A.2.3 Data processing

Data is processed soon after the end of each month for reporting back to contributors. As data submissions progress through the year, this reporting becomes more comprehensive. National and state/territory reports are prepared yearly [47].

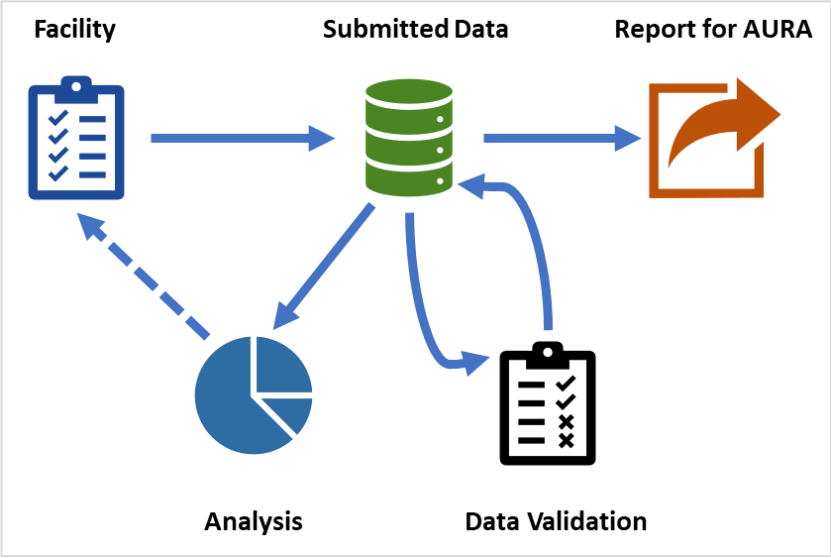

Figure 18: High-level process flow for NAPS

A.2.4 Data access

Reports are automated and can be generated through the website by any user registered for the facility.

The reports available include:

- **dashboard report** – a summary of the major key indicators, displayed in a graphical format
- **detailed report** – enables a focus on a particular antimicrobial, specialty or procedure(s)

- **benchmarking report** – allows comparison of surgical prophylaxis between a particular facility's data and a group of benchmarked facilities
- **data export** – allows export of facility data into an Excel spreadsheet or CSV format.

Deidentified pooled data is used for general reports and publications. Personal or patient-specific information is not provided to any external body or third party without prior consent and is collected solely to report on the provision of services.

The reports provided by NAUSP to AURA as per contract requirements are then reviewed for trends, clinical impact and actions required, to be included in various AURA reports.

A.2.5 Comparative analysis

Attribute	Hospital NAPS	Surgical NAPS	Aged Care NAPS
Velocity	• Collected: Typically, annually • Reporting: Immediately • Published: 1 year	• Collected: Typically, annually • Reporting: Immediately • Published: 1 year	• Collected: Typically, annually • Reporting: Immediately • Published: 1 year
Ubiquity[1]	• Public hospitals: 268 -> 38.6% • Private hospitals: 109 -> 16.6% • Total hospitals: 377 -> 27.9% • Prescriptions: 31,424	• Public hospitals: 74 -> 10.7% • Private hospitals: 70 -> 10.7% • Total hospitals: 144 -> 10.7% • Surgical episodes: 8,063 • Procedural antimicrobial doses: 6,949 • Post-procedural prophylaxis prescriptions: 2,720	• Aged care homes: 568 -> 67.2% • Multipurpose services: 58 -> 1.6% • Total services: 626 -> 13.9% • Residents: 32,347
Inclusivity	• Patient: 11 data elements • Antimicrobial: 26 data elements	• Patient/procedure: 60 data elements • Antimicrobial: 63 data elements	• Facility: 18 data elements • Resident: 122 data elements • Antimicrobial: 13 data elements
Complexity	• Capture: Manual + file upload (opt) • Processing: Periodic validation • Reporting: Dashboard and export	• Capture: Manual + file upload (opt) • Processing: Periodic validation • Reporting: Dashboard and export	• Capture: Manual + file upload (opt) • Processing: Periodic validation • Reporting: Dashboard and export

[1] Statistics taken from AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health [14]

A.3 National Antimicrobial Utilisation Surveillance Program (NAUSP)

The NAUSP was established to monitor the consumption of antimicrobials in public and private hospitals. NAUSP provides annual report on usage trends to identify overprescribing or unexpected changes in prescribing in hospitals [48].

NAUSP is funded by the Australian Government Department of Health to contribute antimicrobial use data to the AURA Surveillance System. NAUSP is operated by the Antimicrobial Programs section, Communicable Disease Control Branch, Department for Health and Wellbeing, South Australia [49].

A.3.1 System description

The program uses a web-based portal that enables contributors from 250 hospitals across Australia to load their usage data in spreadsheet format, together with hospital activity data, and gain access to standardised usage rates to help identify areas requiring improvement or to evaluate the impact of AMS strategies. Data submitted to NAUSP are benchmarked against peer hospitals across Australia. The antimicrobial dispensing and pharmacy distribution data is combined with bed occupancy data (occupied bed days (OBDs)) to provide usage reports using a standardised consumption rate (Defined Daily Doses / 1,000 OBDs).

A note on Queensland's MedTRx system

Queensland Health has a system called MedTRx used to collate data for NAUSP (and its own reporting requirements). MedTRx is a Queensland Health IT system designed to monitor AU for all Queensland Health public hospitals. MedTRx data are reported to the NAUSP.

Both MedTRx and NAUSP data are available to the AMS team in Queensland hospitals. The hospital used its MedTRx and NAUSP data to promote the benefits of infectious diseases specialists. MedTRx data are also used to provide feedback to hospital clinicians about variations in practices, and to explore options for more prudent use of fluoroquinolones [50].

A.3.2 Data collection

The pharmacy dispensing / distribution dataset provides monthly usage of antimicrobials for adult inpatient wards, expressed as number of defined daily doses (DDDs)

In 2022, the Electronic Medical Administration Data (eMAR) data stream will be implemented. This dataset provides monthly usage of antimicrobials by route for all inpatients by admission specialty, expressed as sum of Days of Therapy (DOTs).

Data files are uploaded via the portal monthly in an Excel spreadsheet file format matching the data being loaded. The data provided is detailed in Table 6 and Table 7.

Table 6: Pharmacy dispensing and distribution data

Data element	Data type	Comments
Hospital/facility	Text	Validated against data previously supplied by NAUSP during registration
Year	Number	
Month	Text	Selected from/validated against predefined format
Ward description	Text	
Ward/location	Text	Validated against predefined list of specialties
Product description	Text	Name of drug, strength, formulation and pack size
Quantity	Number	Number of units dispensed (not volume)
Occupied bed days	Number	Used as denominator in analysis
Emergency department presentations	Number	Used as denominator in analysis (ED data only)
Theatre cases	Number	Used as denominator in analysis (theatre data only)

Table 7: Electronic Medical Administration Data (eMAR)

Data element	Data type	Comments
Hospital/facility	Text	Validated against data previously supplied during registration
Year	Number	
Antimicrobial ordered	Text	
Date administered	Date	
Dose administered	Number	
Unit of measurement	Text	
Route	Text	
Days of therapy	Number	
Mapped specialty	Text	Validated against predefined list of specialties
Paediatric / adult	Text	

Note that MEDTRx data is extracted from Queensland Health's iPharmacy system weekly for 150 locations[2] in Queensland. MedTRx collects antimicrobial stock usage information and combines this with bed occupancy data to provide reports on defined daily doses.

[2] As at 10 August 2021

A.3.3 Data processing

Data is processed soon after the end of each month for reporting back to contributors. National and state/territory reports are prepared six-monthly [47].

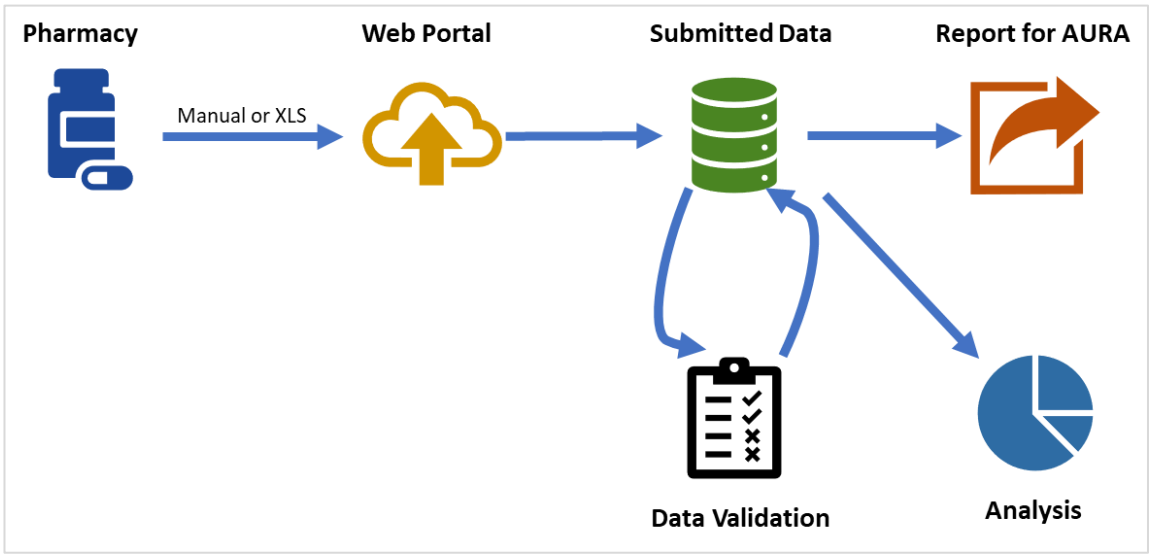

Figure 19: High-level process flow for NAUSP data via portal

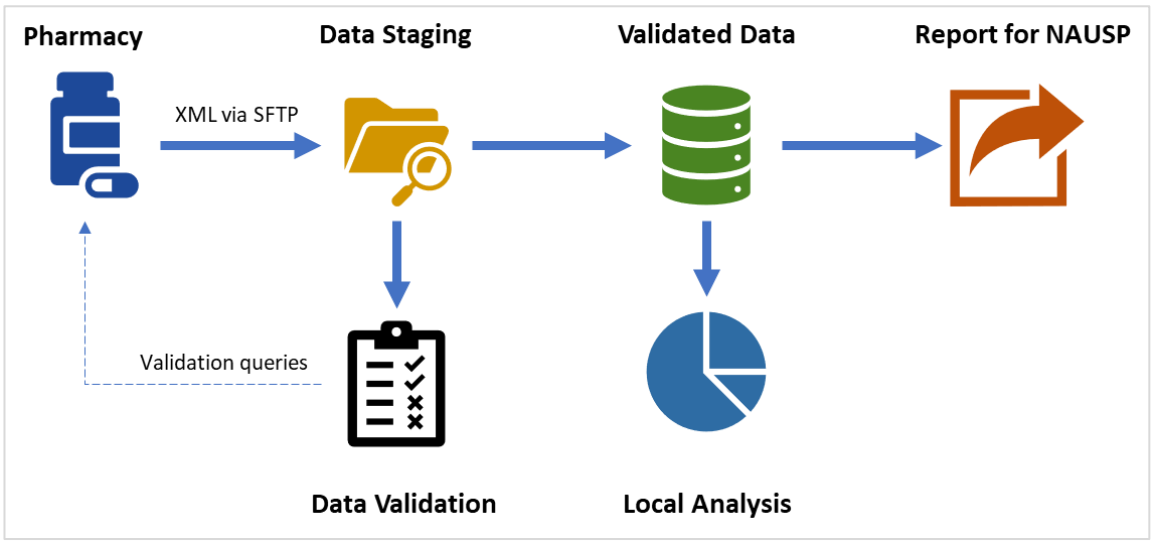

Figure 20: High-level process flow for NAUSP data via MedTRx

For MedTRx, when data is received from the pharmacy systems, it is loaded into a data staging environment. A validation process checks for completeness of data, identifies any new coding elements that need to be incorporated into MedTRx before loading the data into the data cubes and to provide checking against a set of defined rules used to highlight exceptions. Exceptions or queries are reported to the laboratory for correction or analysis.

A.3.4 Data access

Deidentified state/territory and peer group benchmarking reports are published biannually on the NAUSP website. State/territory health departments can use additional information to identify their public hospitals for further analysis.

Comprehensive summary reports of all antimicrobial use are published either annually or biennially and are available on both the NAUSP and AURA websites. Besides national and state/territory reporting, NAUSP reports can serve as a local antimicrobial monitoring tool for participating facilities to provide input to local AMS activities [47].

For MedTRx, once the weekly updates are processed, users can locally analyse the health service data and the production of antibiograms using the tools provided by MedTRx.

A.3.5 Comparative analysis

Attribute	Metrics	
Velocity	• Collected: Monthly • Reporting: Monthly on request • Published: 6 monthly benchmarking reports	
Ubiquity[3]	• Public hospitals: 170 -> 24.5% • Private hospitals: 49 -> 7.5%	
Inclusivity	**Pharmacy dispensing:** • Facility: 5 data elements • Antimicrobial: 5 data elements	**Electronic medication administration records:** • Facility: 1 data element • Antimicrobial: 9 data elements
Complexity	• Capture: Excel spreadsheet file upload via portal • Processing: Monthly • Reporting: Six-monthly. MedTRx has dashboard for QLD only	

[3] Statistics taken from AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health [14]

A.4 NPS MedicineWise MedicineInsight

MedicineInsight was established to support quality improvement in general practice, post-market surveillance of medicines and primary care research. By providing data back to general practice, MedicineInsight allows them to evaluate the use of medicines in the practice compared with benchmarks at local, regional and national levels. Participating practices are also offered customised quality improvement recommendations to support identify key areas for improvement which benefit patients and alignment with best practice [51]. This data has been provided to AURA and has resulted in research into prescribing practices and the relationship to AMR [52].

A.4.1 System description

Developed and managed by NPS MedicineWise with funding from the Australian Government Department of Health, data is extracted from clinical systems such as BestPractice and Medical Director at approximately 700 participating general practices. Individual patients at participating general practices can choose to opt-out, but the number who do so is small.

A.4.2 Data collection

Deidentified data is collected from GP systems using the GRHANITE system from the University of Melbourne [53] and the Inca system from Precedence Health Care [54]. GRHANITE data is collected weekly and Inca data is collected daily.

The data collected by MedicineInsight covers much more than AMR related data, as seen in Figure 21 below extracted from the MedicineInsight Databook 2020 [55].

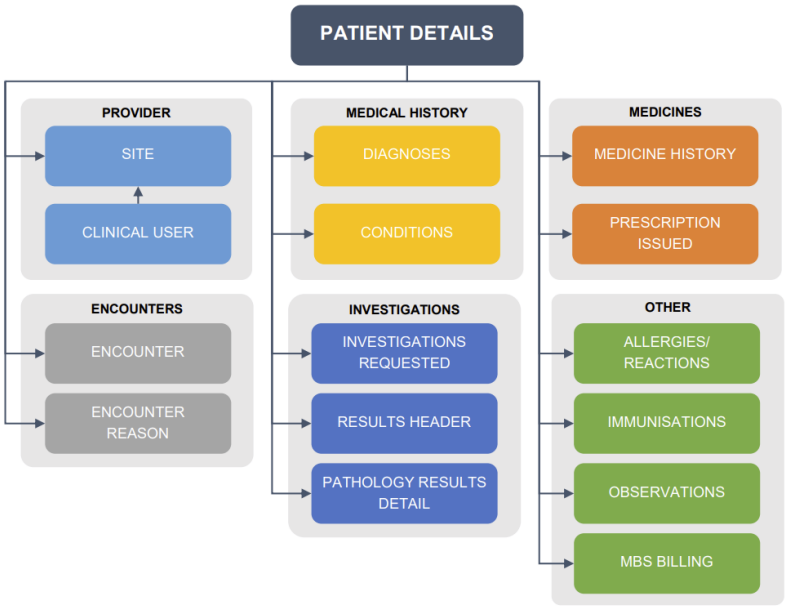

Figure 21: The MedicineInsight data related to patients

A.4.3 Data processing

The collected data is processed monthly and requires a team of over 10 people to ensure quality control. The resulting data warehouse can be queried for specific projects (such as AMR) and provides longitudinal patient data.

A.4.4 Data access

Access to MedicineInsight reports or data must be requested and must be approved by NPS MedicineWise's independent Data Governance Committee, which comprises consumer advisers, privacy and data experts, general practitioners and researchers.

MedicineInsight data was provided to the ACSQHC for further analyses alongside PBS/RPBS data to generate the community prescribing reports for inclusion in the National AURA Reports. This data enabled the integration of clinical data from general practice to evaluate and publish patterns and trends for patients prescribed systemic antimicrobials. It also supported assessing the appropriateness of prescribing for specific conditions such as upper respiratory tract infections and urinary tract infections.

Relevant data elements from the NPS data warehouse used for AMR reporting is outlined in Table 8.

Table 8: AMR data collected via MedicineInsight

Data element	Data type	Comments
Patient ID	Text	
Gender	Text	
Year of birth	Date	
Indigenous status	Text	
Concession/pension status	Text	
Current smoking status	Text	
Remoteness indicator	Text	
SEIFA indicators	Text	
PHN	Text	
Encounter date	Date	
Encounter reasons	Text	
Prescription date	Date	
Medicine name	Text	
Medicine active ingredient	Text	
Dose	Text	
Frequency	Text	
Quantity	Text	
Strength	Text	
Number of repeats	Number	
Restriction code (PBS/RPBS)	Text	

A.4.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: Daily from GRHANITE, Weekly from Inca • Processed: Monthly • Reporting: NA
Ubiquity[4]	• 412 general practices (of 700 in the data collection) -> 10.8% • 2,081,855 patients
Inclusivity	• Patients: 9 data points • Antimicrobials: 11 data points
Complexity	• Capture: Data extraction tools • Processing: Significant validation effort • Reporting: Individual feedback

[4] Statistics taken from AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health [14]

A.5 PBS and RPBS data

The PBS and the RPBS provide subsidised access to medications. Data collected while operating the schemes comprises information about PBS/RPBS scripts and payments, patients, prescribers and dispensing pharmacies, and is available for approved analysis projects.

The dataset does not contain details on any prescriptions supplied privately, as these are not provided under the scheme. This also applies to antibiotics dispensed from some inpatient and outpatient services, some community health services, and some Aboriginal and Torres Strait Islander health services. However, it is estimated that the PBS/RPBS antimicrobial dataset represents 90% of those prescribed [14].

A.5.1 System description

The dataset is owned and managed by the Australian Government Department of Health. Nominated extracts are available for approved research and analysis purposes. The ACSQHC has worked with the University of South Australia to provide reports which are analysed alongside the NPS MedicineWise data to produce a community prescribing section in the national AURA Reports.

A.5.2 Data collection

The Australian Government Department of Health provided an extract of antibiotic prescriptions supplied under the PBS/RPBS for AURA analysis and reporting [14]. The data provided is detailed in Table 9.

Table 9: Data extracted from the PBS/RPBS

Data element	Data type	Comments
Patient identifier (system-generated unique identifier)	Text	
Patient date of birth (MMYYYY)	Date	
Statistical Area Level 3 (SA3) in which the patient resided	Text	
SA3 in which the prescriber's address was located at the date of supply	Text	
Prescriber type	Text	
Specialty group of prescriber	Text	
PBS item code	Text	
ATC code	Text	
Drug name	Text	
Product form and strength	Text	
Quantity of PBS item supplied	Number	
Date of prescribing	Date	
Date of supply	Date	
Prescription count	Number	
Type of prescription – original, repeat, authority	Text	
Number of repeats ordered	Number	

Data element	Data type	Comments
Number of previous supplies	Number	
Regulation 24 indicator	Text	

A.5.3 Data processing

As the data used is a by-product of operating the PBS/RPBS, no specific data processing is considered regarding this report.

A.5.4 Data access

PBS/RPBS data are available in a variety of formats. Aggregated (de-identified) data are available online from Services Australia [24] or the Australian Government Department of Health [25] in fixed or interactive forms, while more detailed, customised reports in aggregated or unit-record formats can be requested. Data related to the RPBS can be requested from the Department of Veterans Affairs.

A.5.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: Monthly • Reporting: N/A • Published: N/A
Ubiquity[5]	• Prescriptions: 26,669,561 (antibiotics only) – estimated 90% of antimicrobial prescriptions
Inclusivity	• Patient: 3 data elements • Antimicrobial: 15 data elements
Complexity	• Capture: PBS/RPBS data is capture automatically • Processing: N/A • Reporting: N/A

[5] Statistics taken from AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health [14]

A.6 Australian Group on Antimicrobial Resistance (AGAR)

The AGAR, which is auspiced by the Australian Society for Antimicrobials (ASA), conducts targeted surveillance of selected pathogens in Australia. AGAR is a longstanding collaboration of clinicians and scientists from major microbiology laboratories across Australia. The group commenced in 1985 with participation from 13 teaching hospitals. It has grown to involve 30 laboratories servicing 49 institutions across Australia, including four private institutions and 11 regional or district hospitals from north-west Western Australia.

AGAR collects demographic, outcome and susceptibility data on bacteria that cause sepsis, and analyses and reports on these as part of the AURA surveillance system.

Established with initial funding from Eli Lilly in 1985 as a snapshot survey of the prevalence of resistance in hospital isolates in *S. aureus*, it has since transitioned to federal government funding focusing on sepsis. The program now provides continuous, active surveillance in line with the European AMR Surveillance Programme [56].

There are three programs under AGAR:

- Gram-negative Sepsis Outcome Program (GNSOP) - Enterobacterales, Pseudomonas aeruginosa and Acinetobacter spp.
- Staphylococcus aureus Sepsis Outcome Program (ASSOP) - Staphylococcus aureus
- Australian Enterococcus Sepsis Outcome Program (AESOP) - Enterococcus spp.

A.6.1 System description

Laboratories provide laboratory data and isolates to the AGAR particiapting laboratories. The AGAR particiapting laboratories collate the data, undertake molecular testing on selected isolates and prepare reports. In the early days, data needed to be transmitted by email, but in recent years this has been replaced with a secure online web portal.

A.6.2 Data collection

Data is submitted to the AGAR participating laboratories via a web portal which allows for manual data entry (largely used by laboratories with smaller volumes) or upload of data held in an Excel spreadsheet (used by laboratories with larger volumes). Data can be provided case-by-case, however, submitting laboratories with larger volumes generally upload spreadsheets on a quarterly basis. The data entry mechanisms include basic validation rules.

Note that besides data captured by the submitting laboratories, raw Vitek®2 or BD Phoenix ™ MIC data is also submitted. This data is provided as a standard process from the instruments, meaning that submitting laboratories do not have additional work to undertake.

The data provided is detailed in Table 10 [56]. Items in both tables marked with "+" indicate additional data provided by the coordinating laboratory.

Table 10: Data collected for AGAR

Data element	Data type	Comments
Blood culture isolate identifier for each patient episode	Text	
Vitek or Phoenix raw data - Excel file uploaded to web portal (MIC required)	-	Linked via the blood culture identifier
Date of blood culture collection	Date	
Laboratory number (for isolate being reported)	Text	
+Genus and species isolated	Text	
Polymicrobial bacteraemia	Text	
Concomitant organisms	Text	
Patient Date of Birth	Date	
Patient Sex	Text	
Patient Postcode	Text	
Patient Date of Admission	Date	
Date of Discharge	Date	
Device-related Infection	Yes/No	
Principal Clinical Manifestation	Text	
Outcome at 7 days	Text	Died/Survived/Unknown
Outcome at 30 days	Text	Died/Survived/Unknown
Date of Death ≤ 30 days if died	Date	

A.6.3 Data processing

Data is downloaded from the portal system in a CSV file format and added to the database by the Scientific Officer. Additional data validation occurs, before analysis and publication of results.

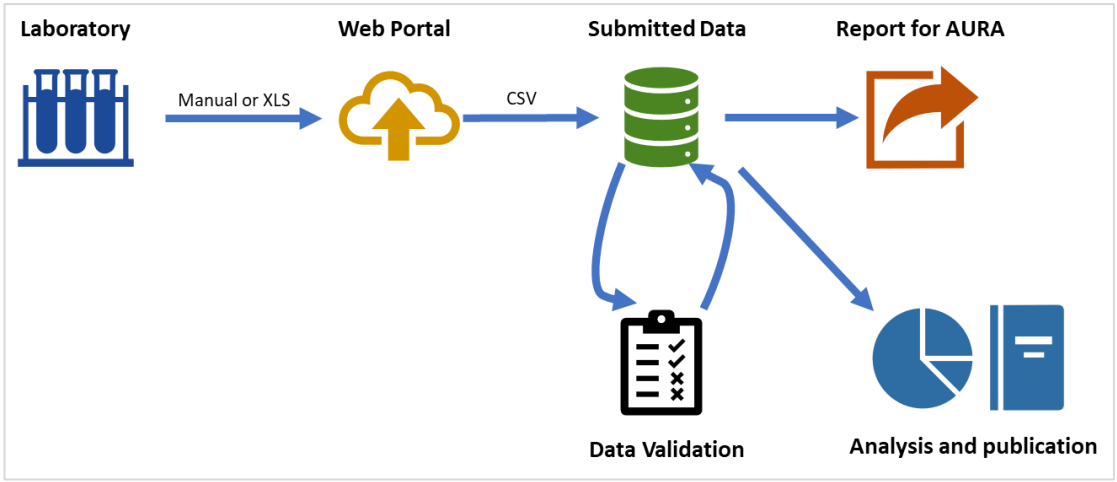

Figure 22: High-level process flow for AGAR

A.6.4 Data access

AGAR publishes annual reports and a range of articles and presentations on findings. Reports are automated and can be generated through the website by any user registered for the facility.

The reports available include:

- **dashboard report** – a summary of the major key indicators, displayed in a graphical format
- **detailed report** – enables a focus on a particular antimicrobial, specialty or procedure(s)
- **benchmarking report** – allows comparison of bacteraemia between a particular facility's data and a group of benchmarked facilities
- **data export** – allows export of facility data into an Excel spreadsheet or CSV format.

Deidentified pooled data is used for general reports and publications. Personal or patient-specific information is not provided to any external body or third party without prior consent and is collected solely to report and the provision of services.

In addition, consolidated analyses of data from the three AGAR SOPs are prepared annually by the ACSQHC, in collaboration with the AGAR Executive. These reports are published on the AGAR and ACSQHC websites.

Periodic detailed technical reports on trends for selected organisms are also prepared by the ACSQHC in collaboration with the AGAR Executive. These reports are published on the AGAR and ACSQHC websites.

A.6.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: Ad hoc or quarterly • Reporting: Annually • Published: Annually
Ubiquity	• Institutions: 49 • Laboratories: 30 [6] • Organisms: 227
Inclusivity	• Facility: 1 data element • Patient: Up to 15 data elements • Organism: Up to 20 data elements
Complexity	• Capture: Spreadsheets or manual entry via portal • Processing: CSV download and inclusion into database • Reporting: Publications, reports

[6] Not all of the laboratories nationally are accredited to perform antimicrobial susceptibility testing

A.7 National Alert System for Critical Antimicrobial Resistances (CARAlert)

The National Alert System for Critical Antimicrobial Resistances (CARAlert) collects data on nationally agreed priority organisms with critical resistance to last-line antimicrobial agents. CARAlert provides timely information and advice to support clinicians, policy makers and health system managers regarding antimicrobial resistance in Australia.

CARAlert was established by the Commission in 2016, as part of the AURA Surveillance System, to collect and report on data on critical antimicrobial resistances (CARs) – these are resistance mechanisms or profiles known to present a serious threat to the effectiveness of last-line antimicrobial agents.

Monitoring and providing regular reports on these critical resistances in Australia helps to inform actions that prevent and contain resistance. The system also provides access to confirmatory results directly to state and territory public health services.

Not all laboratories have the capability to confirm resistance for all organisms.

A.7.1 System description

The CARAlert system is based on routine processes and practices used by pathology laboratories for identifying a potential critically resistant isolate and referring that isolate to a laboratory with the capacity to confirm the CAR.

A.7.2 Data collection

There are 28 public and private pathology laboratories with the capacity to confirm CARs (known as confirming laboratories); from 109 originating laboratories across Australia. Reports of confirmed CARs are submitted to CARAlert via a secure web portal, following their routine processes to analyse isolates and report results to referring clinicians.

Patient date of birth is converted to a 5-year age range prior to inclusion in the CARAlert database.

Table 11: CARAlert data

Data element	Data type	Comments
Originating laboratory	Selection	Validated against list
Confirming laboratory	Selection	Validated against list
Specimen identifier (originating)	Text	
Specimen identifier (confirming)	Text	
Specimen collection date	Date	
Confirmation date	Date	
CAR	Multiple Selection	Type, Subtype, Organism Name
Type	Selection	Validated against list
Subtype	Text	
Organism name	Selection	
Clinical isolate or screen		Clinical isolate or screen
Specimen type	Selection	blood, urine, wound, screen, other
Facility type	Selection	hospital, residential aged care facility, other, unknown
Facility name	Text	If HOSPITAL selected
Patient demographic data		
Patient date of birth	Date	
Patient gender	Text	Female, Male, Unknown
Address postcode	Text	

A.7.3 Data processing

Data is downloaded from the portal system in a CSV file format and added to the database by AURA. Additional data validation occurs, before analysis and publication of results.

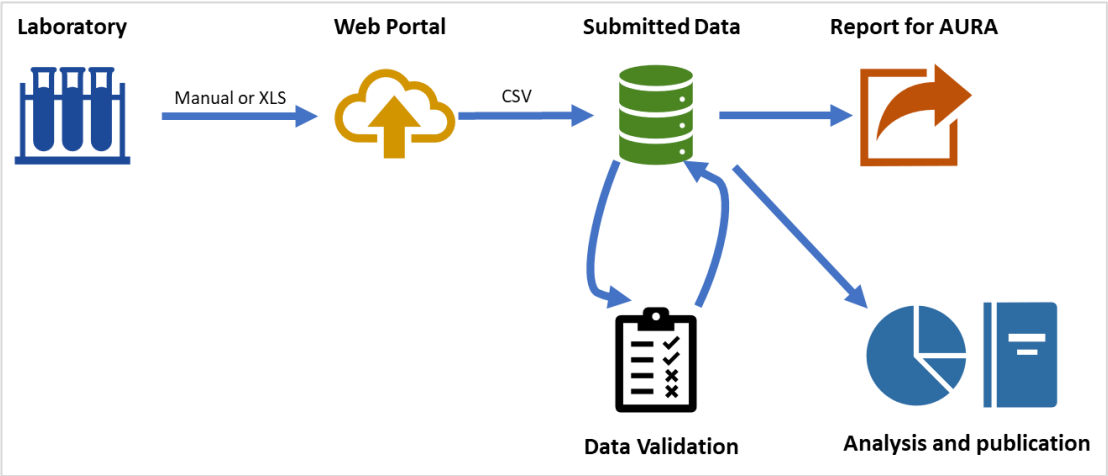

Figure 23: High-level process flow for CARAlert

A.7.4 Data access

The CARAlert system provides immediate access on a 24/7 basis, to local results for the state and territory designated officers. A weekly summary report on confirmed CARs, is

also provided by email to nominated personnel in the states and territories, the Australian Government Department of Health and the confirming laboratories. Bimonthly reports are published that summarise data received and processed by CARAlert. In addition, annual reports are published that provide data and analysis. All reports are available from the CARAlert website.

The CARAlert portal provides preconfigured reports and allows users to export data for their laboratory or state/territory in CSV file format for further analysis.

A.7.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: On confirmation (generally within 5 days) • Reporting: Immediately on submission, after results are provided to the referring clinician. A weekly report is also generated. • Published: Bimonthly and annually on the ACSQHC website
Ubiquity[7]	• Confirming laboratories: 28 from 109 originating laboratories • Organisms: 11 organism groups
Inclusivity	• Facility: 4 data elements • Patient: 3 data elements • Organism: 10 data elements
Complexity	• Capture: Online data entry • Processing: NA • Reporting: Dashboard, reports and CSV export

[7] Statistics taken from AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health [14]

A.8 Australian Passive AMR Surveillance (APAS)

APAS collects, analyses and reports on deidentified patient-level AMR data contributed by 13[8] public and private pathology services across Australia. APAS provides the bulk of resistance surveillance data to AURA, which provides access to geographical and organism related trends in resistance [57]. The system now has access to over 85 million records to analyse and report on the burden of AMR.

APAS was established by the Commission by engaging with states, territories and the private sector in locations across Australia to capture resistance data from public and private hospitals, aged care homes and community settings. The Commission is responsible for the analysis, interpretation and publication of all APAS data. Participants maintain ownership of their data and have immediate access to results and data to use to develop antibiograms.

Participants in the APAS include:

- ACT Pathology (all public and some private Australian Capital Territory health services)
- Pathology Queensland (all Queensland Health public hospitals and health services)
- Monash Health, Victoria
- Royal Hobart Hospital and Launceston General Hospital, Tasmania
- NSW Health Pathology laboratories that provide services to Sydney, South Western Sydney, South Eastern Sydney, Illawarra Shoalhaven, Hunter New England, Mid North Coast and Northern New South Wales Local Health Districts, and the Sydney Children's Hospitals Network (Randwick)
- Mater Pathology Queensland (Queensland public and private patients)
- SA Pathology (public health catchments for South Australia)
- PathWest Laboratory Service (all Western Australian public hospitals)
- The Alfred Hospital, Victoria

The PathWest LIS includes all results from across all of WA analysed by the public system which is a significant coverage of that population. The coverage provided by Monash is a large proportion of the Melbourne population and referral base from Victoria. It should also be noted that not all laboratories have the capability to test for all resistances.

A.8.1 System description

The Commission contracts with Queensland Health to provide access to the OrgTRx system to provide the information technology infrastructure for APAS. Health services have access to their own data within the system to support the antimicrobial

[8] As at 10 August 2021

stewardship and infection prevention efforts of their respective health services. APAS does not hold patient-identified data.

Data (including antibiograms) can be access via the Queensland Health Decision Support System (DSS). Clinicians with responsibility for antimicrobial stewardship have access to the data which they use to inform their local AMS program. Data is imported from laboratory information systems [58].

APAS provides these reporting capabilities:

- antibiograms for local health service analysis and accreditation
- ad hoc and saved queries
- visualisations of queried data
- reports defined on queries
- national reporting on resistance.

A.8.2 Data collection

Data files are sent via secure systems from participating laboratories monthly in an XML file format. The data provided is detailed in Table 12 [59]. Items marked with * are mandatory data elements.

Table 12: Data collected for OrgTRx (APAS)

Data element	Data type	Comments
Jurisdiction code*	Text	Text constant assigned to the Jurisdiction
Patient code*	Text	
Patient category*	Text	
Date of birth	Date	
Sex	Text	Validated against predefined list (M/F/U/I)
Postcode	Text	Patient's postcode
Facility*	Text	Validated against predefined list of facilities
Ward of collection	Text	Validated against predefined list of wards
Date collected	Date	
Testing laboratory*	Text	Validated against predefined list of laboratories
Order number*	Text	
Specimen*	Text	
Primary site	Text	
Specific site	Text	
Test request codes	Text	
Organism*	Text	
Organism number*	Number	
Antimicrobial*	Text	

Data element	Data type	Comments
Sensitivity*	Text	Validated against predefined list (S, R, I, s, i, r, +, -)

A.8.3 Data processing

When data is received from the laboratory, it is loaded into a data staging environment. A validation process checks for completeness of data, identifies any new coding elements that need to be incorporated into OrgTRx before loading the data into the data cubes and to provide checking against a set of defined rules used to highlight exceptions. Exceptions or queries are reported to the laboratory for correction or analysis. A full-time systems and data administrator operates the system and ensures data quality.

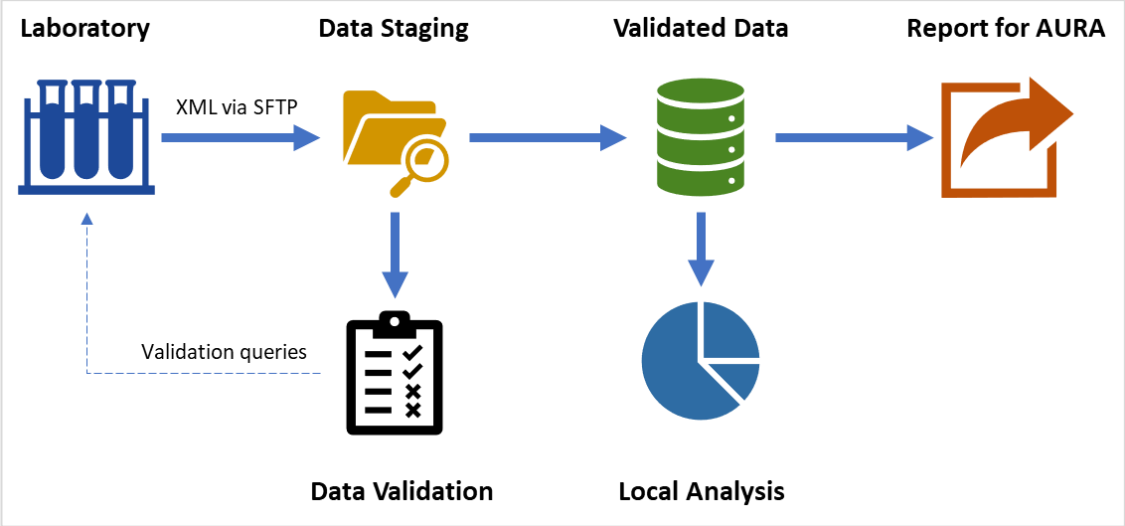

Figure 24: High-level process flow for APAS (OrgTRx) data

A.8.4 Data access

Once the monthly updates are processed, users can locally analyse the health service data and the production of antibiograms using the tools provided by OrgTRx. There is no exchange of data between health services.

Only individuals authorised by the ACSQHC have access to all data for extract data for AURA analysis and reporting. This is done manually.

A.8.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: Monthly • Reporting: Monthly • Published: NA
Ubiquity[9]	• Laboratories: 13 public and private laboratory information systems from 32 laboratory groups; 112 laboratories representing coverage of all states and the ACT. • Organisms: 10 organisms
Inclusivity	• Facility: 3 data elements • Patient: 5 data elements • Organism: 11 data elements
Complexity	• Capture: Data submitted in XML file format • Processing: Data validated in staging environment • Reporting: On demand post-monthly processing

[9] Statistics taken from AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health [14]

A.9 National Neisseria Network (NNN)

The NNN is a collaborative network of nine state/territory Neisseria reference laboratories [60] across Australia that perform testing of clinical isolates of the organismic Neisseria species: *Neisseria gonorrhoeae* and *N. meningitidis*.

Note that confirmed cases of both are also notifiable to the NNDSS under legislation. Isolates tested by the NNN therefore represent a proportion of the total of notified cases [22], [23].

The NNN operates two programs:

- The Australian Gonococcal Surveillance Programme (AGSP) has monitored and reported gonococcal antimicrobial susceptibility since 1981 [23].
- The Australian Meningococcal Surveillance Programme (AMSP) provides a national laboratory-based program for examining invasive meningococcal disease caused by *N. meningitidis* and has operated since 1994. The NNN laboratories supply phenotypic and genotypic data to supplement the notification data from the NNDSS, which includes cases of probable and laboratory confirmed invasive meningococcal disease (IMD) [22].

A.9.1 System description

Details of the system used to manage the data are not available.

A.9.2 Data collection

Infections caused by *N. gonorrhoeae* and *N. meningitidis* are notifiable to the NNDSS via state and territory health authorities under the public health legislation. Computerised, deidentified unit records of notifications are supplied to the Australian Government Department of Health daily [14]. Data collection depends upon the program included:

- **AGSP:** Gonococcal antimicrobial susceptibility testing data from each state/territory are submitted quarterly to the coordinating laboratory (the Neisseria Reference Laboratory and WHO Collaborating Centre Sydney) which collates the data for reporting
- **AMSP:** Meningitidis antimicrobial susceptibility testing, serogroup and genotyping data from each state/territory are submitted quarterly to the coordinating laboratory (the Neisseria Reference Laboratory and WHOCC Sydney) which collates the data for reporting.

The data provided and determined for AMSP is detailed in Table 14 [22]. The data provided and determined for AGSP is detailed in Table 14 [23]. Items in both tables marked with "+" indicate additional data provided by the reference laboratory.

Table 13: Data collected for AMSP

Data element	Data type	Comments
Jurisdiction	Text	
Date	Date	
Site of isolation of isolate	Text	Blood, cerebrospinal fluid, other
Age	Number	Male, female, unknown, other
Sex	Text	
+Method of confirmation	Text	Isolate of meningococci, PCR positive
+Serogroup	Text	B, C, W, Y, E (other), Not grouped, Not determined
+Genotype	Text	
+ Antimicrobial susceptibility testing		
+Antimicrobial	Text	Ceftriaxone, penicillin, ciprofloxacin, rifampicin
+Minimum inhibitory concentration	Number	

Table 14: Data collected for AGSP

Data element	Data type	Comments
Jurisdiction	Text	
Location classification	Text	Urban, remote, non-emote
Date	Date	
Country of acquisition of infection	Text	
Site of isolation of isolate	Text	genital, rectal, pharynx, DGI, other, not specified
Age	Number	Male, female, unknown, other
Sex	Text	
+Antimicrobial susceptibility testing		
+Antimicrobial	Text	Ceftriaxone, azithromycin, penicillin, ciprofloxacin, spectinomycin, tetracycline, gentamicin
+Minimum inhibitory concentration	Number	

A.9.3 Data processing

In the previous section, the reference laboratories undertake additional texting of the supplier isolates to enrich the data provided by submitting laboratories. This includes undertaking genomic sequencing of *N. meningitidis* isolates.

A.9.4 Data access

Data is collated, analysed and published annually in the *Communicable Diseases Intelligence* journal.

A.9.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: Quarterly • Reporting: Quarterly • Published: Annually
Ubiquity	• All states/territories • Laboratories: 9 (reference laboratories) • Organisms: 2 • AMSP Cases: 278 (of 281 in 2020 [22]) -> 98.9% • AGSP Cases: 7219 (of 29516 reports in 2020 [23]) –> 24%
Inclusivity	• AMSP Cases: 5 data elements • AGSP Cases: 6 data elements • AMSP Organism: 4 data elements • AGSP Organism: 2 data elements
Complexity	• Capture: Electronic • Processing: NA • Reporting: Peer-reference report

A.10 National Notifiable Diseases Surveillance System (NNDSS)

The NNDSS was established in 1990 under the auspices of the Communicable Diseases Network Australia. The system coordinates the national surveillance of over 50 communicable diseases or disease groups. Under this scheme, notifications are made to the state or territory health authority under the public health legislation in their jurisdiction [61].

Of particular interest to the AURA program is testing for tuberculosis. Susceptibility data on *M. tuberculosis* isolates are provided by the Australian Mycobacterium Reference Laboratory Network to state and territory public health units to include in the NNDSS [14].

A.10.1 System description

In 2021, a decision was made to decommission the NNDSS and replace it with a new system. Until this has been completed, a web page has been deployed to allow access to the public datasets and alternative reports [62].

A.10.2 Data collection

Depending upon the jurisdiction, notifications may be required from treating clinicians, diagnostic laboratories or hospitals. In addition, the mechanism of notification varies between states and territories and sometimes different diseases are notifiable by different mechanisms. The proportion of cases seen by health care providers which are the subject of notification to health authorities is not known with certainty for any disease, and may vary among diseases, between jurisdictions and over time.

Computerised, deidentified unit records of notifications are supplied to the Australian Government Department of Health daily for collation and analysis. The data provided is detailed in Table 15 [59].

Table 15: Data collected for NNDSS

Data element	Data type	Comments
Unique reference number	Text	
Notifying state or territory	Text	
Disease code	Text	As per the National Notifiable Disease List
Age	Number	
Sex	Text	
Indigenous status	Text	
Postcode of residence	Text	
Date of onset of disease	Date	
Death	Date	
Date of report to state or territory health department	Date	
Outbreak reference	Text	
Species	Text	

Data element	Data type	Comments
Serogroups/subtypes	Text	
Phage types	Text	
Vaccination status	Yes/No	

A.10.3 Data processing

No information on data processing is available.

A.10.4 Data access

Aggregated data were presented on the department's internet site under Communicable Diseases Surveillance and updated daily, with a summary report and data table are also published on the internet each fortnight.

Data were published in the quarterly journal *Communicable Diseases Intelligence* and in an annual report publication and include numbers of notifications for each disease by state and territory, totals for Australia for the period, the year and for the corresponding period of the previous year. A 5 year comparison is also provided [61].

A.10.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: Daily • Reporting: Daily and fortnightly • Published: Quarterly and annually
Ubiquity	• All states and territories • Organisms: 50+
Inclusivity	• Reporting entity: 3 data elements • Patient: 7 data elements • Organism: 6 data elements
Complexity	• Capture: Unknown • Processing: Unknown • Reporting: Published on website

A.11 HOTspots

HOTspots is an analytical platform that delivers synthesised data to clinicians on evolving antimicrobial susceptibility. These data are accurate for local needs, up-to-date and readily available at point of care, which is important in regional Australia. The HOTspots program was developed to address a lack of AMR surveillance in the northern part of Australia, focused on the Northern Territory but also including the northern parts of Western Australia and Queensland. These regions are geographically isolated, have limited infrastructure and have traditionally not been monitored, despite a high use of antimicrobials and a significant disease burden [63].

A.11.1 System description

HOTspots is a digital interactive platform providing a web portal that reports temporal and spatial trends for AMR organisms of public health significance [63]. The initial prototype platform went live in January 2019 and was evaluated in 2020. Following the recommendations from the evaluation, an updated platform was developed into Shiny app and was launched in August 2021.

A.11.2 Data collection

Data is provided from the laboratory information systems in an Excel file format. From 2021, agreements with pathology providers are to supply data on a voluntary, six-monthly basis by over 100 pathology laboratories operating in the target areas[10]. The line-listed patient-level data includes both primary care (private and public pathologies) and public hospital patients. Pathology data from each pathology service is transmitted electronically and a unique identifier is created for each patient within the HOTspots informatics pipeline.

[10] As at 26 October 2021

Table 16: HOTspots data collection

Data element	Data type	Comments
Name of facility where specimen collected	Text	
State of facility	Text	
Postcode of facility	Text	
Aged in years (or DOB)	Text	
Sex	Text	
State of residence	Text	
Postcode of residence	Text	
Patient ID	Text	
Specimen ID	Text	
Sample type	Text	From list of bloodstream, urinary, respiratory, other
Organism	Text	
Antibiotic susceptibility test results	Text	Transmitted as interpreted data (Resistant, Intermediate, Susceptible) OR transmitted as uninterpreted Minimum Inhibitory Concentration (MIC) value

A.11.3 Data processing

The electronic data are stored on a secure, password protected network drive with routine backup procedures. These data are analysed by the team and uploaded onto the HOTspots platform.

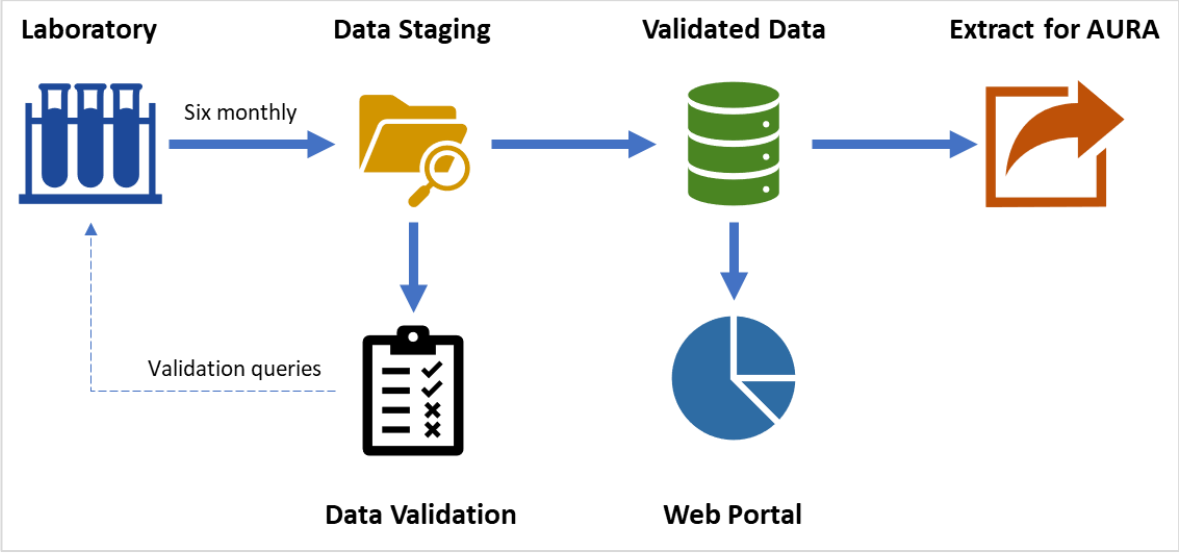

Figure 25: High-level process flow for HOTspots data

A.11.4 Data access

The electronic data are stored on a secure, password protected network drive with routine backup procedures. These data are deduplicated, coded (where data are transmitted as MICs value, laboratory breakpoints are applied) and analysed by the team. This dataset is stored on a secure server at Menzies. Another dataset is

generated which is aggregated by region and is not line-listed, this dataset is uploaded onto the HOTspots Shiny platform.

HOTspots data (%resistance) are validated against the gold standard. The gold standard used to quantify concordance with HOTspots data is the Northern Territory hospital antibiogram.

A.11.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: 6 monthly • Reporting: As processed • Published: As processed
Ubiquity	• Laboratories: 100 pathology labs in target area • Organisms: 8
Inclusivity	• Facility: 3 data elements • Patient: 5 data elements • Organism: 4 data elements
Complexity	• Capture: Data file submitted electronically • Processing: Validated in staging environment • Reporting: Online dashboard

A.12 Sullivan and Nicolaides Pathology (SNP)

SNP is a member of the Sonic Healthcare group, and services communities in Queensland and northern New South Wales.

A.12.1 System description

SNP hold AMR data in a central repository, and can undertake analysis of the analysis to support

A.12.2 Data collection

SNP collect AMR data in the community, acute facilities and aged care homes. Specific details of the data available were not available at time of writing.

A.12.3 Data processing

Details of data processing are not available but are done internally with SNP's laboratory systems.

A.12.4 Data access

SNP can generate and report AMR data in:

- Longitudinal datasets for specified organism–antimicrobial combinations
- Cumulative antibiograms showing rates of resistance for a range of organisms from a specified specimen type within a selected period
- Tabulations showing the resistance profiles of organism strains isolated during a selected period.
- The ACSQHC have a long-standing collaborative relationship with SNP to provide AMR data which is incorporated into various AURA reports.

A.12.5 Comparative analysis

Attribute	Metrics
Velocity	• Collected: As tested • Reporting: NA • Published: NA
Ubiquity	• Laboratories: 23 pathology labs in Queensland and northern New South Wales • Organisms: 10
Inclusivity	• Facility: unknown • Patient: unknown • Organism: unknown
Complexity	• Capture: As part of the SNP system • Processing: As part of the SNP system

Attribute	Metrics
	• Reporting: As part of the SNP system

Appendix B Other medication systems of interest

Besides the AMR specific systems described in Appendix A , other systems record medication data pertinent to AMR analysis or which may provide models for the collection of AMR data. Each of these is discussed in brief below.

B.1 My Health Record – Prescribing and Dispense Record

My Health Record is a secure online summary of an individual's health information and is available to all Australians. Healthcare providers authorised by their healthcare organisation can access My Health Record to view and add patient health information. Through the My Health Record system healthcare providers can access information about their patients such as shared health summaries, discharge summaries, prescription and dispense records, pathology and diagnostic imaging reports, and immunisation information. The My Health Record system also provides access to health information to individuals and their nominated representatives online [64].

Healthcare professionals who use clinical software to prescribe and dispense medications can also upload a copy of this information directly to a patient's My Health Record. Prescription and dispense records contain information about medicines prescribed by a healthcare provider [65]. For information about these systems, see sections B.6 and B.7.

B.1.1 Data

The My Health Record's Prescribing and Dispense Records include the following data:

- medication brand name and strength prescribed
- generic medication name
- dosage instructions
- maximum number of prescription repeats
- the date the medication was prescribed and the prescription expiry date

B.1.2 Considerations

Several factors must be considered about the My Health Record's Prescribe and Dispense records, including:

- not every Australian has a My Health Record, as individuals can choose not to have a record or to have it deleted
- individuals can request that specific prescribe or dispense events are not loaded to their My Health Record
- not all prescribers operate compliant software or participate in the My Health Record.

B.2 My Health Record – PBS Data

The My Health Record can also hold up to two years details of any successful claims made for medications covered under the PBS/RPBS [66]. This data is provided by Services Australia for those individuals who have allowed the data to be transferred. PBS data forms part of the My Health Record Medications View.

B.2.1 Data

The data available is the same as that described in Appendix A.5.

B.2.2 Considerations

Several factors must be considered about the My Health Record's PBS data, including:

- not every Australian has a My Health Record, as individuals can choose not to have a record or to have it deleted
- individuals can determine whether data from the PBS is included in their My Health Record
- PBS/RPBS data does not include details of medications such as:
  - prescriptions not listed on the PBS/RPBS, or 'private' prescriptions
  - prescriptions dispensed in a public hospital for inpatients
  - prescriptions supplied under Section 100 Special Arrangements in the National Health Act 1953, for example, supplies through an Aboriginal Health Service (AHS), IVF/GIFT Program, Botulinum Toxin Program
  - PBS prescriptions priced under the patient co-payment amount before 1 April 2012.

B.3 My Health Record – Pharmacy Shared Medicines Lists (PSML)

The My Health Record and pharmacy software is being upgraded to support a Pharmacist Shared Medicines List. This is a list of medicines that may include those prescribed by a doctor and non-prescription medicines including over the counter or complementary medicines. This list will include details on how and when the medicines are taken when the list was created [67].

Several sources of medicines information may create a PSML. PSMLs might be created based on:

- a hospital discharge medicines list
- a medicines history provided by the consumer
- a dose administration aid medicines list
- a pharmacist professional service for example, a Home Medicines Review.

B.3.1 Data

The PSML is loaded as a PDF document. The PDF will contain a medicines item list in a tabular format that includes the medicine item (brand name and/or active ingredient) and directions for use (including dose of administration and frequency).

B.3.2 Considerations

Several factors must be considered about the My Health Record's PBS data, including:

- not every Australian has a My Health Record, as individuals can choose not to have a record or to have it deleted
- not every pharmacist will have compliant software or use it.

B.4 Electronic Prescribing and Prescription Exchange Services (PES)

An Electronic Transfer of Prescription creates an electronic message (and a legal paper prescription) which is sent to a PES. Pharmacies can then dispense the medications from the paper prescription with support from the prescription details which can be electronically retrieved from the PES to improve efficiency and reduce the opportunity for errors transcribing prescription information from paper [68].

There are two PESs in Australia:

- eRX, which is owned and operated by FRED IT Group, an organisation jointly owned by Telstra Health and the Pharmacy Guild of Australia
- MediSecure, which is owned and operated by MDS, a part of pharmacy software developed Simple Retailer.

These two systems are interoperable, meaning pharmacies can scan barcodes to access data from either PES and download the prescription information regardless of the PES to which the data was originally transmitted.

B.4.1 Data

Data provided using this method includes:

- a barcode or QR code accompanied by the alphanumeric representation
- name of the subject of care (name title, given name, family name)
- name of the prescriber (name title, given name, family name)
- name of the prescriber organisation (optional)
- contact details of the prescriber/organisation (address line 1, line 2, line 3, suburb, state, postcode)
- telephone number
- medicine name and strength
- date prescribed

- number of repeats available.

B.4.2 Considerations

Several factors must be considered about electronic prescribing and prescription exchange services, including:

- not every prescriber will have compliant software or use it
- not every pharmacist will have compliant software or use it.

B.5 Real Time Prescription Monitoring (RTMP)

RTPM monitors the prescribing and dispensing of controlled medicines to reduce their misuse in Australia. Controlled medicines include pain medications such as oxycodone, morphine and fentanyl and other high-risk medicines, including all benzodiazepines such as diazepam. The full list of such medications is determined by each state or territory [37].

The misuse of these medicines is a concern within Australia, with levels of overdose and accidental deaths rising. The RTPM system attempts to address these concerns by:

- identifying patients at risk of harm due to dependence or misuse of controlled medicines
- identifying patients who may be diverting these medicines
- limiting 'doctor shopping' — visiting several doctors for the same prescriptions of a controlled medicine
- providing state and territory regulators with data to detect prescribers who are not complying with regulations.

The RTPM system consists of two components:

- a National Data Exchange, which captures information from state and territory regulatory systems, prescribing and dispensing software, and a range of external data sources
- regulatory systems within each state or territory, which manage the authorities or permits for controlled medicines in each state and territory.

These regulatory systems are being progressively rolled out across the county.

B.5.1 Data

The RTPM system is integrated with prescribing systems (see B.6) and dispensing systems (see B.7) and the prescription exchange services (see B.4).

The system records a range of data, including:

- personal information of a patient relating to the prescribing and dispensing of controlled medicines to that patient
- prescribing data including

  - the drug(s) prescribed
  - the date of prescription
  - amount prescribed
  - details of the prescriber
- drug dispense information including
  - the drug(s) dispensed
  - the date of dispensing
  - amount dispensed
  - details of the dispenser.

B.5.2 Considerations

Several factors must be considered about RTPM, including:

- not all states and territories have current implemented the system
- data recorded is limited to Schedule 8 (controlled drugs) and Schedule 8 (additional medicines)
- the list of medicines differs between states and territories
- while community usage is widely adopted, hospital medication monitoring is not yet in widespread use.

B.6 Prescribing systems

As already noted elsewhere in this report, prescribing systems in both community and hospital settings are a rich source of medication usage data.

In the primary care sector, Best Practice and Medical Director are the two most widely used systems within general practice. Both systems interoperate with national infrastructure for the RTPM, My Health Record and electronic prescribing systems. Other software products are also available and have also supported national infrastructure systems. Some of these products are also available and target the private specialist market.

The tertiary care or hospital sector is also well supported by digital systems, including large international software providers such as Cerner, Epic and Intersystems. While not all hospitals in Australia have yet implemented digital systems, there is a growing trend of implementing electronic health records (EHRs) and other specialist software products in hospitals. Many of these systems are already integrated with national infrastructure such as the My Health Record.

B.6.1 Data

All these systems hold extensive data on patients and medication usage. There are many programs (e.g., NPS MedicineWise MedicineInsight) and tools (e.g., GRHANITE,

PenCS, Inca) that connect to primary care systems to make use of that data; however, this may fall outside the control of the software vendor sometimes.

B.6.2 Considerations

Several factors must be considered about existing systems, including:

- not all hospitals have implemented EHRS
- market penetration of the private specialist community for digital systems is not has high as with the primary care market
- access to data can be complex and expensive to implement.

Organisations engaged during developing this report also noted that while "reason for prescribing" is very helpful for analysing AU, this data item was not necessarily considered clinically relevant by prescribers who had access to broader data that indicated the rationale for a prescription. This can add challenges when interpreting prescription data.

B.7 Dispensing systems

As already noted elsewhere in this report, dispensing systems in both community and hospital settings are a rich source of medication usage data.

While not all hospitals in Australia have yet implemented digital systems, the tertiary care or hospital sector is well supported by digital systems, including large international software providers such as Cerner, Epic and Intersystems. These systems usually have medication management components.

Dispensing systems in community pharmacy are common practice, with systems from FRED IT and Simple Retail having significant market penetration. These systems are already integrated with national infrastructure such as My Health Record, electronic prescribing and the RTPM system.

B.7.1 Data

Dispensing systems hold less data than prescribing systems, and as such have been less frequently targeted for broader data analysis purposes outside AMR.

B.7.2 Considerations

Several factors must be considered about existing systems in both primary and tertiary care, including:

- not all hospitals have implemented EHRS.

Appendix C Other pathology systems of interest

Besides the AMR specific systems described in Appendix A , there are other pathology systems that record data that may be pertinent to AMR analysis, or which may provide models for the collection of AMR data. Each of these is discussed in brief below.

C.1 National Cancer Screening Register (NCSR)

To support delivery of the National Cervical Screening Program (NCSP) and National Bowel Cancer Screening Program (NBCSP), the Australian Government established the NCSR.

The NCSR has delivered a healthcare provider portal and integration with clinical information systems to enable providers (e.g., general practitioners, nurses, and other specialists) to access and submit bowel and cervical screening data electronically in a self-service fashion.

A participant portal allows people doing bowel and cervical screening to update personal details, manage their participation and view screening information.

C.1.1 Data

It enables a single electronic record for each person participating in the programs, and provides a national electronic infrastructure for the collection, storage, analysis and reporting of screening program data. The national register also generates comprehensive data to inform policy and improve program quality and service delivery [68].

Data is provided by pathology laboratories, with many supporting electronic data submissions.

C.1.2 Considerations

The NCSR's capabilities for electronic submission of results to the register may offer insights into methods of gathering other forms of pathology data related to AMR.

C.2 National Integrated Health Services Information (NIHSI)

The Australian Government Department of Health is working with the AIHW and state and territory health authorities to add NIHSI Analysis Asset (AA) data to Health's Enterprise Data Warehouse. It's used to derive insights into a wide variety of situations ranging from health care in the home and management of chronic disease to the use of opioids. The NIHSI AA will contain de-identified data from 2010–11 onwards on admitted patient care services (in public and private hospitals where available), emergency department services and outpatient services in public hospitals for all participating states and territories, along with Medicare Benefits Schedule data, PBS

and RPBS data, Residential Aged Care data and National Deaths Index data. Incorporating data into the NIHSI AA will be staged and will depend on timing of receipt of the required data [69], [70].

C.2.1 Data

Deidentified data will initially be available to selected analysts nominated by the data providers – state and territory health authorities, the Australian Government Department of Health and the AIHW. Other users can apply for access to the NIHSI AA later, or to data extracted from the NIHSI AA, provided their proposed use of the data complies with the ethics processes. Such purposes include:

- patterns of use and effectiveness of health and residential aged care services
- quality and safety of services provided
- health risks for patient cohorts
- chronic disease management — patterns of service provision
- validation of the treatment pathways for chronic disease management and care
- defining patient journeys and assessing efficiency and effectiveness of the health and residential aged care systems
- safety and quality of hospital and other services, such as residential aged care services
- accessibility and effectiveness of services contributing to the management of chronic conditions
- policies and programs designed to reduce the incidence and severity of disease and injury.

C.2.2 Considerations

Access to a richer set of data may be supportive of some AMR programs.

C.3 Communicable Diseases Genomics Network (CDGN)

The CDGN was established with an aim of implementing genomics into clinical and public health microbiology in Australia. The CDGN includes representatives from public health laboratories across all states and territories in Australia, and New Zealand. The CDGN is coordinated by the Microbiological Diagnostic Unit Public Health Laboratory (MDU PHL), the University of Melbourne at The Peter Doherty Institute for Infection and Immunity. The Australian Government Department of Health provides funding support for the coordination and bioinformatics capacity and capability building activities of the network [71].

The CDGN objectives are:

- establish a unified and coordinated public health microbial genomics network to advise and interact with existing laboratory and public health networks, government, policy makers and other relevant stakeholders
- establish consensus on whole-genome sequencing (WGS) and metagenomic platforms and methods
- establish and coordinate jurisdictional capacity and expertise in microbial WGS and metagenomics
- establish consistent, validated national microbial bioinformatics pipelines
- develop procedures and policies allowing rapid national genomic data sharing and analysis, to enhance public health outbreak detection and response
- develop and support teaching and training activities to enhance public health microbial genomics
- align with core functions and enablers proposed in the National Framework for Communicable Disease Control, particularly in areas related to improved surveillance.

C.3.1 Data

CDGN operates the AusTrakka platform, which was developed in response to the need to better facilitate public health genomics data sharing and analysis in Australia. The platform facilitates nationally integrated genomics epidemiology in Australia developed in alignment with the *National Microbial Genomics Framework 2019-2022*. It analyses integrated organism genomic data for public health across Australia. A central, secure and private online location to share, store, analyse and view aggregated national and state/territory data underlies the system [72]. AusTrakka has underpinned Australia's response to the COVID-19 pandemic [73].

C.3.2 Considerations

AusTrakka and other systems operated by the CDGN may guide patterns of data gathering that can be applied to AMR programs, especially those related to genomic studies of resistant organisms.

Appendix D References

[1] OUTBREAK, 'OUTBREAK History', *Outbreak Project*, 2020. https://outbreakproject.com.au/about-us-outbreak-history/our-history/ (accessed Apr. 24, 2021).

[2] Department of Health and Department of Agriculture, Water and the Environment, Australian Government, 'Antimicrobial resistance', *Antimicrobial resistance*, Apr. 12, 2021. https://www.amr.gov.au/front (accessed Apr. 12, 2021).

[3] World Health Organisation, 'Antimicrobial resistance', *World Health Organization*, Oct. 13, 2020. https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance (accessed Apr. 12, 2021).

[4] CSIRO, 'Antimicrobial Resistance', 2015. https://www.csiro.au/en/about/challenges-missions/antimicrobial-resistance (accessed Apr. 24, 2021).

[5] ACSQHC, 'Antimicrobial stewardship', *Australian Commission on Safety and Quality in Health Care*, 2018. https://www.safetyandquality.gov.au/our-work/antimicrobial-stewardship (accessed Jun. 30, 2021).

[6] 'What is AMR and AU?', *Australian Commission on Safety and Quality in Health Care*, 2016. https://www.safetyandquality.gov.au/publications-and-resources/resource-library/what-amr-and-au (accessed Apr. 12, 2021).

[7] K. Thursky and K. Buising, 'Drug resistance: how we keep track of whether antibiotics are being used responsibly', *The Conversation*, Oct. 02, 2017. http://theconversation.com/drug-resistance-how-we-keep-track-of-whether-antibiotics-are-being-used-responsibly-82446 (accessed Mar. 01, 2022).

[8] 'Antimicrobial Surveillance', *Pfizer*. https://www.pfizer.com/science/therapeutic-areas/anti-infectives/antimicrobial-surveillance (accessed Oct. 26, 2021).

[9] E. Muraille and J. Godfroid, 'The "One Health" concept must prevail to allow us to prevent pandemics', *The Conversation*, Oct. 20, 2020. http://theconversation.com/the-one-health-concept-must-prevail-to-allow-us-to-prevent-pandemics-148378 (accessed Mar. 01, 2022).

[10] 'About this initiative', *Antimicrobial resistance*, May 29, 2017. https://www.amr.gov.au/about-us/about-this-initiative (accessed Mar. 01, 2022).

[11] 'Australia's First National Antimicrobial Resistance Strategy 2015–2019', Australian Government, Jun. 2015. Accessed: May 08, 2022. [Online]. Available: https://www.amr.gov.au/resources/national-amr-strategy

[12] 'Australia's National Antimicrobial Resistance Strategy – 2020 and beyond', *Antimicrobial resistance*, Mar. 10, 2020. https://www.amr.gov.au/resources/australias-national-antimicrobial-resistance-strategy-2020-and-beyond (accessed May 20, 2021).

[13] 'National Safety and Quality Health Service Standards (second edition)'. Australian Commission on Safety and Quality in Health Care, May 2021. Accessed: Dec. 12, 2021. [Online]. Available: https://www.safetyandquality.gov.au/publications-and-resources/resource-library/national-safety-and-quality-health-service-standards-second-edition

[14] 'AURA 2021: Fourth Australian report on antimicrobial use and resistance in human health', Australian Commission on Safety and Quality in Health Care, Sydney, 2021.

[15] 'Hospital care', *Australian Institute of Health and Welfare*, Jul. 23, 2020. https://www.aihw.gov.au/reports/australias-health/hospital-care (accessed Dec. 12, 2021).

[16] ‘Private Hospitals, Australia, 2016-17 financial year’, *Australian Bureau of Statistics*, Jun. 29, 2018. https://www.abs.gov.au/statistics/health/health-services/private-hospitals-australia/latest-release (accessed Dec. 12, 2021).

[17] ‘Health of the Nation 2019 Report’, Royal Australian College of General Practitioners, Sep. 2019. Accessed: Dec. 12, 2021. [Online]. Available: https://www.racgp.org.au/FSDEDEV/media/documents/Special%20events/Health-of-the-Nation-2019-Report.pdf

[18] The Pharmacy Guild of Australia, ‘Vital facts on community pharmacy’. The Pharmacy Guild of Australia, Feb. 10, 2021. [Online]. Available: https://www.guild.org.au/__data/assets/pdf_file/0028/91909/PGA_February_2021_infographic.pdf

[19] AIHW, ‘Providers, services and places in aged care’, Apr. 27, 2021. https://www.gen-agedcaredata.gov.au/Topics/Providers,-services-and-places-in-aged-care (accessed Jul. 06, 2021).

[20] The Centre for International Economics, ‘The economic value of pathology: achieving better health, and a better use of health resources’, Pathology Awareness Australia, Jun. 2019. [Online]. Available: https://www.pathologytechnology.org.au/resources/Documents/Economic%20value%20of%20pathology_June%202019%20APPROVED.pdf

[21] Public Pathology Australia, ‘Public Pathology - Values and Opportunities’, Jun. 2020. [Online]. Available: https://publicpathology.org.au/wp-content/uploads/2020/06/Public-Pathology-Values-and-Opportunities-Paper.pdf

[22] M. M. Lahra, R. Enriquez, T. Hogan, and the National Neisseria Network, ‘Australian Meningococcal Surveillance Programme annual report, 2018’, *Commun Dis Intell*, vol. 44, Mar. 2020, doi: 10.33321/cdi.2020.44.10.

[23] M. M. Lahra, R. P. Enriquez, and C. R. R. George, ‘Australian Gonococcal Surveillance Programme Annual Report, 2018’, *Commun Dis Intell*, vol. 44, Feb. 2020, doi: 10.33321/cdi.2020.44.4.

[24] ‘The Australian health system’, *Department of Health, Australian Government*, Aug. 10, 2018. https://www.health.gov.au/about-us/the-australian-health-system (accessed Feb. 08, 2021).

[25] ‘Australia’s health 2016: How does Australia’s health system work?’ Australian Institute of Helath and Welfare, 2016. Accessed: Dec. 12, 2021. [Online]. Available: https://www.aihw.gov.au/getmedia/f2ae1191-bbf2-47b6-a9d4-1b2ca65553a1/ah16-2-1-how-does-australias-health-system-work.pdf.aspx

[26] ‘What is General Practice?’, *RACGP*. https://www.racgp.org.au/education/students/a-career-in-general-practice/what-is-general-practice (accessed Dec. 12, 2021).

[27] ‘For general practice’, *Antimicrobial resistance*, Jul. 14, 2017. https://www.amr.gov.au/what-you-can-do/general-practice (accessed Dec. 12, 2021).

[28] ‘What is allied health?’, *Allied Health Professions Australia*. https://ahpa.com.au/what-is-allied-health/ (accessed Dec. 12, 2021).

[29] ‘Serving Australians: a system of community pharmacy’. The Pharmacy Guild of Australia, Jul. 2018. Accessed: Dec. 12, 2021. [Online]. Available: https://www.guild.org.au/__data/assets/pdf_file/0020/5942/FACTSHEET-Serving-australians-a-system-of-community-pharmacy_JULY-2018.pdf

[30] ‘What is Pathology?’, *RCPA*, Jun. 04, 2019. https://www.rcpa.edu.au/pathology-careers/what-is-pathology (accessed Dec. 12, 2021).

[31] ‘What is aged care?’, *Australian Government Department of Health*, Mar. 18, 2019. https://www.health.gov.au/health-topics/aged-care/about-aged-care/what-is-aged-care (accessed Dec. 12, 2021).

[32] ‘The public and private hospital systems’, Oct. 15, 2021. https://www.healthdirect.gov.au/understanding-the-public-and-private-hospital-systems (accessed Dec. 12, 2021).

[33] ‘Emergency departments’, *Healthdirect Australia*, Jun. 20, 2021. https://www.healthdirect.gov.au/hospital-emergency-departments (accessed Dec. 12, 2021).

[34] ‘Inpatient Vs. Outpatient: What’s the Difference?’, *nib*, Jul. 30, 2018. https://www.nib.com.au/the-checkup/inpatient-vs-outpatient-whats-the-difference (accessed Dec. 12, 2021).

[35] ‘Home - Public Pathology Australia’, *Public Pathology Australia*. https://publicpathology.org.au/ (accessed Dec. 12, 2021).

[36] ‘About hospital pharmacy’, *The Society of Hospital Pharmacists of Australia*. https://www.shpa.org.au/about-hospital-pharmacy (accessed Dec. 12, 2021).

[37] ‘National Real Time Prescription Monitoring (RTPM)’, *Australian Government Department of Health*, Nov. 21, 2019. https://www.health.gov.au/initiatives-and-programs/national-real-time-prescription-monitoring-rtpm (accessed Dec. 07, 2021).

[38] ACSQHC, ‘Antimicrobial Use and Resistance in Australia Surveillance System’, *Australian Commission on Safety and Quality in Health Care*, 2019. https://www.safetyandquality.gov.au/our-work/antimicrobial-resistance/antimicrobial-use-and-resistance-australia-surveillance-system (accessed Jul. 02, 2021).

[39] ACSQHC, ‘About AURA’, *Australian Commission on Safety and Quality in Health Care*, 2019. https://www.safetyandquality.gov.au/our-work/antimicrobial-resistance/antimicrobial-use-and-resistance-australia-surveillance-system/about-aura (accessed May 25, 2021).

[40] National Centre for Antimicrobial Stewardship, ‘NAPS - National Antimicrobial Prescribing Survey’. https://www.naps.org.au/Default.aspx (accessed May 26, 2021).

[41] ‘Hospital NAPS information sheet’. Guidance Group. Accessed: Nov. 05, 2021. [Online]. Available: https://www.naps.org.au/Resources/Hospital_NAPS_information_sheet_for_homepage.pdf

[42] ‘Antimicrobial prescribing practice in Australian hospitals’, Australian Commission on Safety and Quality in Health Care, Feb. 2021. Accessed: Nov. 05, 2021. [Online]. Available: https://irp-cdn.multiscreensite.com/d820f98f/files/uploaded/Hospital%20NAPS%20Report_2019.pdf

[43] ‘Surgical NAPS User Guide’. Guidance Group, 2020. Accessed: Nov. 05, 2021. [Online]. Available: https://www.naps.org.au/Resources/SurgicalNAPS_userguide_2020.pdf

[44] ‘Surgical prophylaxis prescribing in Australian Hospitals’, Australian Commission on Safety and Quality in Health Care, Oct. 2020. Accessed: Nov. 05, 2021. [Online]. Available: https://irp-cdn.multiscreensite.com/d820f98f/files/uploaded/surgical_prophylaxis_prescribing_in_australian_hospitals_results_of_the_2019_surgical_national_antimicrobial_prescribing_survey_002.pdf

[45] ‘Information Sheet Aged Care NAPS’. Guidance Group, 2021. Accessed: Nov. 05, 2021. [Online]. Available: https://www.naps.org.au/Resources/Information_sheet_ACNAPS2021_Updated.pdf

[46] ‘2019 aged care national antimicrobial prescribing survey report’, Australian Commission on Safety and Quality in Health Care, Sep. 2020. Accessed: Nov. 05, 2021. [Online]. Available: https://irp-cdn.multiscreensite.com/d820f98f/files/uploaded/report_2019_ac_naps.pdf

[47] ‘NAUSP Data Principles and Definitions’. Department for Health and Wellbeing, South Australia, Jan. 2021. Accessed: Nov. 01, 2021. [Online]. Available: https://www.sahealth.sa.gov.au/wps/wcm/connect/6160c380498ada628ac08eaa8650257d/NAUSP_Data_Principles_and_Definitions_2021_V7.0+final.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-6160c380498ada628ac08eaa8650257d-nK-g6yu

[48] ‘National Antimicrobial Utilisation Surveillance Program’, *Department for Health and Wellbeing, South Australia*, Sep. 05, 2021. https://www.sahealth.sa.gov.au/wps/wcm/connect/Public+Content/SA+Health+Internet/Clinical+Res

ources/Clinical+Programs+and+Practice+Guidelines/Infection+and+injury+management/Antimicrobial+stewardship/National+Antimicrobial+Utilisation+Surveillance+Program+NAUSP/National+Antimicrobial+Utilisation+Surveillance+Program+NAUSP (accessed Nov. 01, 2021).

[49] 'About the National Antimicrobial Utilisation Surveillance Program (NAUSP)'. https://www.sahealth.sa.gov.au/wps/wcm/connect/Public+Content/SA+Health+Internet/Clinical+Resources/Clinical+Programs+and+Practice+Guidelines/Infection+and+injury+management/Antimicrobial+stewardship/National+Antimicrobial+Utilisation+Surveillance+Program+NAUSP/About+us/About+the+National+Antimicrobial+Utilisation+Surveillance+Program+NAUSP (accessed May 26, 2021).

[50] 'DSS MedTRx - How to Guide'. Queensland Health, Oct. 17, 2016.

[51] 'MedicineInsight', *NPS MedicineWise*. https://www.nps.org.au/medicine-insight (accessed Oct. 28, 2021).

[52] J. Wu *et al.*, 'Relationship between antimicrobial-resistance programs and antibiotic dispensing for upper respiratory tract infection: An analysis of Australian data between 2004 and 2015', *J Int Med Res*, vol. 46, no. 4, pp. 1326–1338, Apr. 2018, doi: 10.1177/0300060517740813.

[53] 'GRHANITE™ Health Informatics Unit', *University of Melbourne*. https://www.grhanite.com/ (accessed Oct. 28, 2021).

[54] 'Developing digital solutions for health care practitioners.', *Precedence Health Care*. https://precedencehealthcare.com (accessed Oct. 28, 2021).

[55] 'MedicineInsight databook 2020'. NPS Medicinewise, Jun. 2020. Accessed: Oct. 28, 2021. [Online]. Available: https://www.nps.org.au/assets/NPS/pdf/MedicineInsight-databook-2020.pdf

[56] G. Coombs, 'The Australian Group on Antimicrobial Resistance (AGAR)', 2019. Accessed: Dec. 07, 2021. [Online]. Available: http://microbiology.publish.csiro.au/?paper=MA19020

[57] 'Antibiotic susceptibility from OrgTrx - Open Data Portal', *Queensland Government*. https://www.data.qld.gov.au/dataset/antibiotic-susceptibility-from-orgtrx (accessed May 26, 2021).

[58] 'OrgTRx User Guide'. Queensland Government, Sep. 2019. Accessed: May 26, 2021. [Online]. Available: https://www.safetyandquality.gov.au/sites/default/files/2019-10/orgtrx_user_guide.pdf

[59] 'OrgTRx Flat File Specification v1.9'. Queensland Government, Nov. 2015.

[60] 'National Neisseria Network (NNN) laboratories'. https://www.health.nsw.gov.au/Infectious/controlguideline/Documents/mening-reference-labs.pdf (accessed Dec. 02, 2021).

[61] 'Surveillance systems reported in Communicable Diseases Intelligence, 2016', *Australian Government Department of Health Office of Health Protection*. https://www1.health.gov.au/internet/main/publishing.nsf/Content/cda-surveil-surv_sys.htm (accessed Dec. 02, 2021).

[62] 'NNDSS Public datasets'. Australian Government Department of Health and Ageing, Aug. 2021. Accessed: Dec. 02, 2021. [Online]. Available: https://www1.health.gov.au/internet/main/publishing.nsf/Content/ohp-pub-datasets.htm

[63] L. Goddard and T. M. Wozniak, 'Antimicrobial Resistance Surveillance to Support Decision-Making in a High-Prevalence Region: An Evaluation', *Frontiers in Tropical Diseases*, vol. 2, p. 38, 2021, doi: 10.3389/fitd.2021.772491.

[64] 'My Health Record', *My Health Record*, 2020. https://www.myhealthrecord.gov.au/ (accessed Jul. 01, 2020).

[65] 'Prescription and dispense records', *My Health Record*, Mar. 28, 2018. https://www.myhealthrecord.gov.au/for-healthcare-professionals/howtos/prescription-dispense-records (accessed Nov. 25, 2021).

[66] ‘Manage Medicare information’, *My Health Record*, Mar. 23, 2018. https://www.myhealthrecord.gov.au/for-you-your-family/howtos/manage-medicare-information (accessed Dec. 13, 2021).

[67] ‘Pharmacist Shared Medicines List (PSML)’, *Australian Digital Health Agency Developer Centre*. https://developer.digitalhealth.gov.au/products/psml?autodownload=true (accessed Dec. 14, 2021).

[68] ‘Electronic Transfer of Prescription’, Mar. 23, 2018. https://developer.digitalhealth.gov.au/products/electronic-transfer-prescription (accessed Dec. 13, 2021).

[69] ‘Approved AIHW linkage projects’, *Australian Institute of Health and Welfare*. https://www.aihw.gov.au/our-services/data-linkage/approved-aihw-linkage-projects (accessed Nov. 25, 2021).

[70] ‘Data Integration Partnership Australia (DIPA)’. Australian Government Department of Health. Accessed: Nov. 25, 2021. [Online]. Available: https://www1.health.gov.au/internet/main/publishing.nsf/Content/Data-Integration-Partnership-Australia

[71] ‘CDGN - Communicable Diseases Genomics Network’, *CDGN*. https://www.cdgn.org.au (accessed Nov. 25, 2021).

[72] ‘AusTrakka’, *CDGN*. https://www.cdgn.org.au/austrakka (accessed Nov. 25, 2021).

[73] G. Conroy, ‘You haven’t heard of AusTrakka — but this team analyses the virus genome from every single positive COVID test’, *Australian Broadcasting Corporation*, Jun. 09, 2021. https://www.abc.net.au/news/health/2021-06-10/how-a-genomic-database-helps-australia-track-covid-19/100197830 (accessed Jul. 22, 2021).

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