Appendix

1 Antimicrobial usage: monitoring and analysis


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Key points

• Monitoring and analysis of antimicrobial usage is critical to understanding antimicrobial resistance and to monitoring effects of containment strategies.

• Methods of antimicrobial data collection differ, but most institutions provide population surveillance data obtained from computerised pharmacy records.

• Surveillance data can be used to identify changes in usage that may be linked to development of resistance and to measure the impact of antimicrobial stewardship programs.

• Antimicrobial stewardship programs have been shown to reduce resistance rates, morbidity, mortality and cost.

• Comprehensive, integrated surveillance programs operate in the United States and Europe, where programs include the European Surveillance of Antimicrobial Consumption, the Danish Integrated Antimicrobial Resistance Monitoring and Research Program, a surveillance program for antimicrobial consumption and resistance in the Netherlands, and the Swedish Antimicrobial Utilisation and Resistance in Human Medicine report. In Europe, reports on antimicrobial consumption and resistance are published annually.
• In Australia, the National Antimicrobial Utilisation Surveillance Program provides monthly reports on hospital inpatient antimicrobial usage to contributing hospitals, and bi-monthly reports to the Australian Department of Health and Ageing. Data are contributed by 50% of principal referral hospitals from six states.

• Comparison with international data shows that Australian usage rates in hospitals are high for some antimicrobial classes. The total use of antimicrobials in the Australian community falls in the middle of the range recorded in European countries.

• The Drug Usage Subcommittee of the Pharmaceutical Benefits Advisory Committee reports on antimicrobial use in the community sector to the Expert Advisory Group on Antimicrobial Resistance, the Australian Institute of Health and Welfare and the World Health Organization International Committee on Drug Statistics Methodology. Antimicrobial usage data are also published in The Australian Statistics on Medicines. The data are used by the National Prescribing Service to inform program planning.

• Australian antimicrobial usage data are incomplete and not linked with resistance surveillance data, which limits their potential use.

**A1.1 Recommendations on antimicrobial usage: monitoring and analysis**

1. Monitoring of national antimicrobial usage and resistance surveillance data, resistance management, and intervention strategies requires a comprehensive integrated surveillance program.

2. National antimicrobial stewardship guidelines are required for all health-care settings; surveillance data should guide the development and updating of prescribing guidelines, decision support systems (including computerised approval systems), clinical guidelines and education.

3. Antimicrobial resistance and usage data should be made available at clinical service, hospital and national levels.
Appendixes — Antimicrobial usage: monitoring and analysis

Antimicrobial stewardship in Australian hospitals

A1.2 Background

The World Health Organization (WHO) and other international bodies have nominated antimicrobial resistance as a major public health concern. Surveillance of antimicrobial usage and resistance in human and animal populations is widely recommended as part of ongoing management and containment plans.

There is a well-documented causal relationship between prior antimicrobial usage and the emergence of bacterial resistance.\(^1\) The use of particular antimicrobial classes is linked with the emergence of specific pathogens. Chapter 7\(^7\) examines the relationship between prior antimicrobial use and the development of antimicrobial-associated diarrhoea or colitis due to *Clostridium difficile*. Similarly, Chapter 6\(^6\) considers risk factors associated with antimicrobial use for methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE) and multiresistant gram-negative organisms.

Monnet proposed three levels of evidence for a link between prior antimicrobial use and resistance,\(^2\) based on an earlier publication by McGowan:\(^1\)

- patient-level data on exposure to antimicrobials, with infection or colonisation by resistant bacteria as the outcome (i.e. case–control analyses)\(^3-5\)
- aggregated, nonlongitudinal data, at one point in time, for a large number of similar and independent settings\(^6-8\)
- aggregated, longitudinal data for a long period of time but for a single ward, hospital, region or country.\(^9-10\)

Multivariate time series analysis is now used to show how month-to-month variation in use of specific antimicrobial classes correlates closely with subsequent variation in antimicrobial resistance (e.g. changes in hospital MRSA incidence).\(^11\) The most instructive example of this method of analysis is the study by Monnet and colleagues,\(^12\) which examined antimicrobial use and the emergence of two particular clones of MRSA in the Aberdeen Royal Infirmary in 1996–2000. Dynamic, temporal relationships were found between monthly prevalence of MRSA in hospitalised patients and MRSA prevalence, and the use of macrolides, third-generation cephalosporins and fluoroquinolones in previous months. Figure A1.1 shows the summed monthly use of macrolides, third-generation cephalosporins and fluoroquinolones (taking into account their respective lags for direct effects) plotted against monthly MRSA prevalence. The parallel nature of the relationship between the lagged use of these specific antimicrobial classes and MRSA prevalence is striking.

The seriousness of the antimicrobial resistance problem in Australia came into national focus in 1998 when the Australian health and agriculture ministers established the Joint Expert Technical Advisory Committee on Antibiotic Resistance.

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Figure A1.1  Evolution of the monthly per cent methicillin-resistant *Staphylococcus aureus* (MRSA) and monthly sum of lagged antimicrobial use as identified in a polynomial distributed lag model: macrolides (lags of 1–3 months), third-generation cephalosporins (lags of 4–7 months) and fluoroquinolones (lags of 4 and 5 months), Aberdeen Royal Infirmary, January 1996–December 2000

(JETACAR), which includes experts from the health, veterinary and agricultural areas. JETACAR reviewed antimicrobial resistance in Australia; in particular, the evidence that antimicrobial use in food animal production may be contributing to the emergence and spread of resistant bacteria in Australia.\textsuperscript{12} The committee recommended an integrated management plan for antimicrobial resistance in Australia including research, monitoring and surveillance, education, infection control, and regulation.

In 2000, in response to the JETACAR report, the Australian Government established an Expert Advisory Group on Antimicrobial Resistance (EAGAR). One of the terms of reference for EAGAR was to provide expert advice on 'the monitoring of antimicrobial use'. Recently, EAGAR commissioned a report to develop the rationale for a comprehensive integrated surveillance program to improve Australia’s response to antimicrobial resistance.\textsuperscript{14} In line with the previous JETACAR recommendations, EAGAR proposed an integrated surveillance program.
coordinating efforts to measure antimicrobial use and resistance in both animal and human settings. Such surveillance data might then drive significant and beneficial change, similar to that seen as a result of the Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP). The proposed surveillance program would be cross-disciplinary and nationally coordinated, and would consolidate and build on existing surveillance systems and initiatives. Key components of the proposed program for Australia are development and implementation of national surveillance systems for antimicrobials in hospitals and the community. Section A1.4.2 discusses the current status of this program.

Surveillance data on antimicrobial usage provide data that are needed for determining the impact of usage patterns on bacterial resistance. Such data are also important for supporting containment strategies, such as antimicrobial stewardship programs (see Case study 1).

The density of antimicrobial use within specialised units such as intensive care units (ICUs), haematology and oncology units, and solid-organ transplant units is several-fold higher than in other hospital settings. This increased use has been shown to generate high rates of antimicrobial resistance; therefore, these areas should be a particular focus for surveillance and intervention.

**Case study 1 Use of ceftriaxone at a South Australian hospital**

High usage of third-generation cephalosporins in South Australian metropolitan hospitals was noted in 2002 through data collection and analysis by the South Australian Antimicrobial Usage Surveillance Program. One hospital implemented an antimicrobial restriction policy in January 2003, with a focus on community-acquired pneumonia treatment protocols, which had been identified through pharmacy audit as an area of inappropriate use of ceftriaxone.

Figure A1.2 shows that usage of ceftriaxone decreased significantly following the implementation of the new policy and that this level of use was sustained for about four years. However, ceftriaxone use appears to again be on the rise. This has been at least partly attributed to the lack of input from specialist antibiotic pharmacists in recent years; a followup intervention is being considered.

This case study demonstrates the usefulness of surveillance of antimicrobial use. Surveillance allowed the detection of high usage of a specific group of agents; this stimulated investigation and the implementation of a targeted intervention, which was followed by monitoring of the effect of the intervention.

**A1.3 Antimicrobial stewardship programs**

**A1.3.1 Hospital programs**

Antimicrobial stewardship has been defined as ‘an ongoing effort by a healthcare institution to optimise antimicrobial use among hospital patients in order to improve patient outcomes, ensure cost-effective therapy and reduce adverse sequelae of antimicrobial use (including antimicrobial resistance)’. Stewardship programs aim to change antibiotic prescribing to reduce unnecessary use and promote the use of agents less likely to select resistant bacteria, in line with
guidelines and demonstrated incidence of antibiotic resistance (as shown by antibiograms, an antibiogram being the result of laboratory testing on an isolated pathogen to find out what treatments the pathogen is resistant to). Successful programs have been shown to reduce institutional resistance rates as well as morbidity, mortality and cost.\textsuperscript{17}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure.png}
\caption{The usage of ceftriaxone at a South Australian hospital}
\end{figure}

Minimum requirements for hospital antimicrobial stewardship programs have been set down by the European Society of Clinical Microbiology and Infectious Disease (ESCMID) Study Group for Antibiotic Policies (ESGAP). They detail the responsibilities of clinicians, clinical governance, hospital managers and health-care executives, pharmacies, microbiology laboratories, and pharmaceutical industry members.\textsuperscript{18}

Key requirements of an antimicrobial stewardship program include:

- provision of appropriate administrative support for programs
- provision of effective medical education about antibiotic usage and resistance, and responsible prescribing
- implementation of effective clinical guidelines for common infections and promotion of compliance with accepted standards such as \textit{Therapeutic Guidelines: Antibiotic}\textsuperscript{a}
- use of clinical decision-support systems — including computerised systems — to promote best evidence-based practice (e.g. Australian systems such as Guidance DS\textsuperscript{®} and IDEA3S\textsuperscript{®})
- active processes to restrict prescribing of broad-spectrum antimicrobials to those

\textsuperscript{a} etg.tg.com.au/complete
patients where use is clinically indicated

- active regular clinical liaison between clinical microbiologists, infectious disease physicians and pharmacists to improve individual patient management in intensive care and other settings
- close cooperation between microbiology or infectious diseases departments and pharmacy departments to ensure best use of antibiotics
- regular drug usage evaluations (DUEs) under the auspices of each institution’s drug and therapeutics committee.

Intervention programs that restrict use of broad-spectrum antibiotics have shown dramatic effects on antibiotic prescribing, as shown, for example, by Case study 1. Some Australian hospitals with antimicrobial stewardship programs have demonstrated significant cost savings through reduction in drug costs; an example is shown in Case study 2.

Computerised decision support systems have been developed and are in use in several Australian hospitals. These systems can reduce the consultation burden for infectious diseases physicians, but it is not clear whether they produce positive patient outcomes overall.

**Community programs**

In the 1990s, community antibiotic use in Australia was high compared with other developed nations. Today, multiresistant bacteria, such as community strains of MRSA and extended-spectrum beta-lactamase-producing gram-negative bacteria, are causing increasing human morbidity and there is concern that past excessive antibiotic use in the community or in animal production systems (or both) is responsible.

The National Prescribing Service (NPS) delivers programs across Australia that promote judicious antibiotic prescribing in general practice through educational visiting, guideline dissemination, prescribing practice reviews and public education programs. NPS targeting of antibiotic prescribing contributed to a significant decline in antibiotic prescribing over the five year period 1999–2004. In addition, the use of amoxycillin as a proportion of total antibiotic use increased, while use of cefaclor decreased. These changes are consistent with a shift in prescribing towards guideline recommendations.

Comparable programs in veterinary practice are poorly developed.

The NPS also supports drug-usage evaluation programs in hospitals in collaboration with state DUE groups. One such program was Community-Acquired Pneumonia: Towards Improving Outcomes Nationally (CAPTION). This study was a multicentre cross-sectional audit to assess compliance with Therapeutic Guidelines:Antibiotic for treatment of community-acquired pneumonia in Australian emergency departments, and

occurred between April 2003 and February 2005. Compared with the baseline audit, a 1.5-fold increase in the rate of guideline-compliant antibiotic prescribing was seen.²⁴

### Case study 2  Effect of active antimicrobial stewardship program in a large tertiary hospital in New South Wales

A large tertiary teaching hospital in New South Wales has had an active approach to antimicrobial stewardship for many years, underpinned by locally relevant antibiotic guidelines and enthusiastic staff in the areas of pharmacy, infectious diseases and microbiology. Clinical teams are regularly engaged in guideline review, development and implementation at local and national levels. Specific discussions about patients are prompted by an online anti-infective registration (approval) system, where clinicians who prescribe broad-spectrum agents register the indication for use and are advised on correct dosage. Twice-weekly infectious diseases and microbiology patient rounds take place in intensive care units (ICUs). These frequently lead to changes in antibiotic therapy, generally to early cessation.

A drug usage evaluation pharmacist regularly audits antibiotic use for particular agents (e.g. meropenem) or clinical syndromes or situations, mainly community-acquired pneumonia and surgical prophylaxis. These audit data are used to provide feedback to clinicians to encourage more appropriate use.

Monthly data on usage are supplied to the National Antimicrobial Utilisation Surveillance Program. This allows for benchmarking of ICU and non-ICU usage against 22 other large Australian hospitals. A study of usage of selected high-cost (predominantly broad-spectrum) antibiotics in 2006 indicated that, for most agents, use in ICU and non-ICU situations in this hospital was far lower than the national average. Based on purchase cost alone, the net cost difference in 2006 was $278,000 ($59,000 of this was for ICU use).

### A1.4 Impact on the health-care system

The emergence and selection of resistant bacteria and other organisms driven by inappropriate antimicrobial use and subsequent transmission among hospital patients has a significant impact on morbidity, mortality and treatment costs. This applies to both current and future hospital patients due to changes in hospital microbial ecology resulting from this emergence and selection.

Additional costs of infections caused by resistant organisms include:

- the need for more expensive antibiotics to treat the infections
- the need to isolate patients colonised with resistant organisms in order to prevent cross-infection.

Another cost is through inappropriate prescribing of expensive broad-spectrum antibiotics. The existing NAUSP demonstrates unexplained wide variation in usage rates for these agents.²⁵ While this variation may be due to a difference in patient-mix and acuity, the degree of variation seen across 23 large tertiary hospitals
suggests that different approaches to antibiotic restriction are also responsible. Case study 2 is a good example of the costs and benefits of a successful antimicrobial stewardship program.

If unchecked, high levels of antimicrobial usage increase the pool of patients who are colonised or infected with resistant organisms both in the community and in hospitals. This situation is an important externality that has not yet been captured in economic evaluations of healthcare associated infection (HAI).

A1.5 Surveillance methods

A1.5.1 Measurement

There are two main methods of antimicrobial data collection: patient-level surveillance and population surveillance.

Patient-level surveillance involves collecting data about the dose, dosage interval and duration of therapy for individual patients. This approach gives the most accurate information, particularly if the aim is to link excessive antimicrobial use with development of resistance in a particular area of practice. Such information is usually only available through labour-intensive reviews of drug usage. Electronic prescribing and recording of drug administration will make patient-level surveillance a possibility in the future.

Population-surveillance data refer to aggregate antibiotic use data, and most hospitals supply such data from pharmacy reports, summarised at the level of a hospital or unit. Although possibly not as accurate as patient-level surveillance, population-level surveillance is the only realistic alternative for ongoing and systematic monitoring of antibiotic use. The data are generally derived from the volume of antimicrobial medications issued to wards and clinical units or from individual patient prescription data. The latter method is preferred because it provides a more accurate measure of the quantity used during the data collection period. However, in most hospitals in Australia, comprehensive data at the individual patient level are not available and aggregate data from issues to wards combined with individual patient dispensing records are used. Another data collection method is to use pharmacy purchase data; however, this is less representative than aggregation of ward issues and individual inpatient supplies.

Measurement of community antibiotic use is generally based on prescription data. In Australia, this is collected from two sources: Medicare Australia records of prescriptions submitted for payment under the Pharmaceutical Benefits Scheme (PBS) and Repatriation Pharmaceutical Benefits Scheme; and an estimate of nonsubsidised medicines obtained from an ongoing survey of a representative sample of community pharmacies. These data also include antimicrobials dispensed to outpatients and discharged patients in three states (Queensland, Western Australia and Victoria).
A1.5.2 Definitions
The anatomical therapeutic chemical (ATC) classification system is the international drug classification system recommended by WHO. The ATC code enables reporting at the levels of anatomical group, therapeutic subgroup, pharmacological subgroup, chemical subgroup and chemical substance. The ATC code for antimicrobials is JO 1.

A defined daily dose (DDD) is the international unit for comparing drug use, as defined by WHO, and corresponds to the assumed average maintenance dose per day for the main indication of a drug in adults.

Use of this internationally accepted standard enables:
• comparison of the usage of antimicrobial agents with differing doses
• aggregation of data to assess usage of antimicrobial classes
• comparison with data from other surveillance programs or studies.

Because DDDs are based on adult dosing, this parameter cannot be used to measure antimicrobial usage in paediatric populations. Age-group specific DDDs are being investigated as a potential standard measure for children.

A1.5.3 Validation
Information about validation of antibiotic usage data collection is scarce. The South Australian program and NAUSP, based in South Australia, implement a system of semi-automated data validation steps before loading contributor data. This database can data map synonymous drug terminology and filter out exclusions such as topical antibiotics.

A1.5.4 Reporting

Hospitals
Usage in DDDs is calculated from the quantity of antimicrobial used and reported by antibiotic type or class (ATC subgroup). These data are used to produce an aggregate measure of total usage. Intensive care usage is generally reported separately.

To facilitate comparisons, DDD data are normalised into usage density rates, which are calculated as follows, where OBDs are occupied bed-days:

\[
\text{Usage density rate} = \frac{\text{No of DDDs/time period}}{\text{OBDs/time period}} \times 1000
\]

OBD has been widely accepted as the most appropriate denominator in the non-ambulatory (hospital) setting and has been adopted by most international programs. Antimicrobial usage data for outpatient areas, including hospital-in-the-home, day-treatment centres, day surgery and dialysis clinics, are variably excluded from some surveillance programs to ensure that data correspond to OBDs.
Standard methods for reporting usage in paediatric groups have not been established. In neonatal intensive care, measures (stratified by birthweight or gestational age cohorts) that have been reported include the proportion of:

- admitted patients who receive an antibiotic course
- patient days that the patient receives antibiotics
- patient days that the patient receives a specific antibiotic (e.g. vancomycin).

**Community**

In Australia, the Drug Usage Subcommittee of the Pharmaceutical Benefits Advisory Committee (PBAC) uses number of prescriptions and DDD per 1000 population per day as units of drug usage measurement.\(^\text{32}\)

**Future report formats**

Statistical analysis of variation over time through use of control charts or time series analysis is advisable. This enables detection of potentially significant changes in usage rates. Morton and Looke\(^\text{33}\) discuss the use of generalised additive models for the production of antibiotic use control charts. These enable better identification of out-of-control usage at a facility level. It is not known how useful aggregated reporting is at a national level.

Use of time series analysis with transfer-function analysis enables statistical examination of seasonal and other variations as a prelude to correlation of usage with antibiotic resistance\(^\text{10}\) (see Figure A1.1\(^\text{a}\)).

**A1.6 Current surveillance systems and data**

**A1.6.1 International**

**Europe**

A number of surveillance programs have been initiated in Europe during the past decade with an increasing focus on detailed descriptions of patterns of:

- antimicrobial consumption in both hospital and community settings
- resistance in
  - zoonotic bacteria
  - specific (targeted) human pathogens
  - bacteria from diagnostic samples (human and animal).

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Many of these programs have been developed since the European Union conference, *The Microbial Threat*, held in Copenhagen in 1998, where it was agreed that antimicrobial resistance was an international issue and required a common European strategy. A progress report was submitted in June 2001 summarising the status of various activities, obstacles encountered and considerations for the future. A further report detailing progress and proposals for future action was submitted in late 2005.

The European Surveillance of Antimicrobial Consumption program (ESAC) was launched in November 2001 to establish a system for standardised collection, analysis and interpretation of data on antibiotic consumption. The ESAC program includes data from 34 countries, including European Union states and other central and Eastern European countries. The initial phase of the ESAC project includes data on human antibiotic consumption and resistance only and reports rates representing total community use for each region, with aggregate hospital usage data also generated where available. A database accessed via a web site is planned to allow continuous and standardised updates and exchange of internationally comparable data for benchmarking between contributors and other countries. Future initiatives include:

- agreement on evidence-based guidelines for therapeutic and prophylactic human use
- agreement on threshold resistance levels for total cessation of use of particular antimicrobial agents
- development and assessment of intervention strategies to improve antimicrobial prescribing in hospitals and the community
- improved patient education on antimicrobial use.

A corresponding program — European Antimicrobial Resistance Surveillance System (EARSS) — coordinates surveillance of antimicrobial resistance.

The ARPAC (Antibiotic Resistance; Prevention and Control) project established a network of European hospitals and recommended collation of data on antibiotic use. The project ran from January 2002 to June 2005, with work being carried out by four study groups under the auspices of ESCMID. ARPAC recommended that whole-hospital antibiotic usage data, categorised by class, should be recorded quarterly using the WHO-defined unit of DDD per 1000 patient days and the ATC classification system.

The project CARE-ICU (Controlling Antibiotic Resistance in ICUs) was piloted in 2005 through funding from the European Commission. This project enabled the continuous monitoring of antibiotic use and resistance with automatic feedback through a web site. Antibiotic usage was expressed as DDD/1000 bed-days.
Denmark

DANMAP is a collaborative, ongoing program involving the Danish Veterinary Laboratory, Danish Veterinary and Food Administration, Statens Serum Institute and the Danish Medicines Agency. It is the best long-standing example of an integrated country-wide approach to surveillance. DANMAP was established in 1995 to collect data and report trends in resistance in pathogenic bacteria and in the use of antimicrobial agents in food animals and humans. The Danish Medicines Agency has legal responsibility for monitoring consumption of all human medicines; it receives data on all antimicrobial issues from community pharmacies (since 1994) and hospital pharmacies (since 1997). Consumption data from monthly reports from all Danish pharmacies, including hospital pharmacies, is provided to the Danish Medicines Agency. Annual reports have been produced since 1996.9,15

Other European countries

The Netherlands, Sweden and Germany have established antimicrobial surveillance programs in response to increases in antibiotic resistance. All programs collect data on human antimicrobial consumption and resistance rates. In the Dutch program, NethMap (surveillance program for antimicrobial resistance in the Netherlands), in-hospital usage data are provided for antibiotics used systemically; data are provided by ATC classification in DDD per 1000 patient days and DDD per 1000 admissions.38

The Swedish Strategic Program for Rational Use of Antibiotics (STRAMA) was established in 1995. It produces an annual report — Swedish Antibiotic Utilisation and Resistance in Human Medicine (SWEDRES) — that includes data on total antibiotic use in terms of DDD per 1000 population per day and prescriptions per 1000 per day, and hospital use as DDD per 100 patient days and DDD per 100 admissions. ICU data are collected separately. Data from 2001 to 2006 are available.39 STRAMA provides the web site application for the European Union CARE-ICU project.

In Germany, the SARI project (Surveillance of Antimicrobial Use and Antimicrobial Resistance in ICUs) collected data on the use of antimicrobials in ICUs from 2001 to 2004. Consumption was expressed as DDD per 1000 patient days.40

United States

Project ICARE (Intensive Care Antimicrobial Resistance Epidemiology) started in 1996. It provides data on the prevalence of antimicrobial resistance, and use, in a subset of hospitals participating in the United States National Healthcare Safety Network (formerly the National Nosocomial Infections Surveillance System) system of the United States Centers for Disease Control and Prevention.41 A DDD was designated and usage density rates were provided as number of DDD per 1000 patient days. Unfortunately, the DDDs used were not consistent with the WHO definitions.
A1.6.2 Australia

Hospital usage

South Australia

A state-wide antimicrobial usage surveillance program was established in November 2001 as an initiative of the Infection Control Service, Communicable Disease Control Branch and the Pharmaceutical Services Branch of the South Australian Department of Health in response to recommendations arising from the JETACAR report. This program now collects in-hospital antimicrobial usage data from metropolitan and country hospitals and private and public hospitals.

Complete usage data from November 2001 are available for eight metropolitan hospitals. Four additional metropolitan hospitals have provided data since 2002 and one more since 2003, making a total of 13 metropolitan contributors. This group includes seven public and six private hospitals, ranging in size from about 100 to 650 beds. Stratification by hospital type or size has been avoided due to the limited number of contributors. ICU usage rates are reported for five hospitals (three public and two private). Accurate ICU data are not available for a number of small units and total hospital usage is reported for these hospitals.

Contributing hospitals submit antimicrobial consumption and bed occupancy data on a monthly basis. Each hospital is sent monthly reports detailing antimicrobial usage density rates within that hospital. DDDs, as defined by WHO, are used for all rate calculations. Usage rates for six antibiotic classes, and for individual agents within those classes, are routinely reported to each contributor. Reports are presented as time series graphs, generated automatically by a custom-built database. Corresponding ‘state-wide’ rates, calculated from aggregate data, are also supplied for comparison. Usage rates for other classes or agents can be extracted from the purpose-built database as required. Specific usage rates for ICUs are also supplied where data are provided. Routine monthly reports are distributed to hospital executive officers, specialist antimicrobial or drug committees, infection control committees and pharmacy directors. Separate reports detailing monthly usage rates within ICUs are supplied to unit directors on a quarterly basis.

Several country hospitals submit data, and individual reports are generated, but the data are not aggregated due to the diversity among these hospitals and the lack of a suitable benchmark for smaller hospitals.

State-wide aggregate reports are publicly available from the Infection Control Service web site.

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a www.health.sa.gov.au/infectioncontrol
Queensland

The Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP) provides Queensland Health, and other interested organisations, with information on the epidemiology, economics and prevention of HAIs. CHRISP is developing a program to monitor antimicrobial usage data for all Queensland Health facilities based on data extracted from the state-wide pharmacy database. Monthly state-wide reports will be available on the Queensland Health intranet and detailed reports from the database will be available to Queensland Health infectious diseases physicians, microbiologists, pharmacists and infection control practitioners. The reports will provide evidence to better support local antimicrobial stewardship programs.

The main emphasis of the reporting is longitudinal analysis of data within a facility or district. Improvement of the existing antibiogram system is also planned to provide clinicians with efficient access to state-wide and local antibiograms and antibiotic resistance data. CHRISP intends to correlate antimicrobial usage with antibiograms by extracting data from pharmacy and pathology systems. The aim is to identify and quantify the effects of antimicrobial prescribing habits on antibiotic resistance.

Other states

There are no other state-based antibiotic usage monitoring programs in Australia.

National

NAUSP, which was based on the South Australian program, started in July 2004. It is funded on an annual basis by the Australian Government Department of Health and Ageing. Data are processed using the South Australian database, which is currently being redeveloped to be able to accept a larger number of contributors and provide improved reporting capabilities, including statistical analysis.

In-hospital antimicrobial usage data are collected from 23 tertiary referral hospitals from all states except Queensland. This represents 50% of Australian principal referral hospitals. Hospitals range in size from about 300 to 700 adult acute-care beds. Monthly reports, as described earlier for South Australia, are provided electronically to nominated infectious diseases physicians, clinical microbiologists and pharmacy representatives at these hospitals. ICU usage rates are currently reported for 21 level 3 units (i.e. tertiary ICUs). Where ICU data cannot be supplied, total hospital usage is reported. Corresponding ‘national’ rates, calculated from aggregate data, are included for comparison.

Analysis of usage data for NAUSP from July 2004 to June 2007 shows a slight decrease in total aggregate antibiotic consumption. However, there are both upward and downward trends in usage of individual antibiotic classes and agents within classes. Increasing usage has been demonstrated in some hospitals, providing targets for possible intervention programs.

The data on national antibiotic use surveillance also highlight priorities for change and the potential to document the effect of future multicentre interventions.25
Quinolone usage is a risk factor for hospital MRSA\textsuperscript{12,40,42-43} as well as antimicrobial resistance in various gram-negative organisms.\textsuperscript{44-45} Figure A1.3 shows increasing use of the quinolone ciprofloxacin in Australian hospitals between July 2004 and June 2007. Increases in total ciprofloxacin use between 2005–06 and 2006–07 have been demonstrated at 10 of 21 sites, with increases of greater than 30% at two sites.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{ciprofloxacin_usage.png}
\caption{Usage of ciprofloxacin between July 2004 and June 2007 by National Antimicrobial Utilisation Surveillance Program contributors}
\end{figure}

The aggregate rate for total antibiotic usage for 2006–07 was 916 DDDs/1000 OBDs compared to 928 for 2005–06 and 939 for 2004–05. For ICUs, the aggregate rate was 1658 DDDs/1000 OBDs in 2006–07, a slight decrease from the figure of 1684 in 2005–06.

Comparison with international data demonstrates that Australian usage rates in the contributing hospitals remain high for some antibiotic classes (see Figure A1.4\textsuperscript{a}). This may be related to the incidence of particular infections, prescribing policies and drug availability. Total aggregate antibiotic usage rates for the 23 Australian hospitals for which data have been analysed were 916 DDDs/1000 OBDs compared with 649 DDDs per 1000 OBDs for Denmark,\textsuperscript{9} 583 DDDs per 1000 OBDs for the Netherlands\textsuperscript{46} and 589 DDDs per 1000 OBDs for Sweden.\textsuperscript{47}

Although the current national data collection is limited to 50% of tertiary referral hospitals, it has laid the groundwork for the establishment of a comprehensive national surveillance program for hospital antimicrobial drug use.

\textsuperscript{a} In: Reducing harm to patients from health care associated infection: the role of surveillance. Eds Cruickshank M, Ferguson J. Australian Commission on Safety and Quality in Health Care, July 2008.
The 2006 EAGAR report specified the requirements of a comprehensive national surveillance system for hospitals as follows:\textsuperscript{14}

- a generic computer program capable of accepting antimicrobial usage data from individual hospitals from all states and territories
- automated analysis of the data with production of reports and charts that provide individual hospital, state and national usage rates.

Data generated from the system would be used to:

- enable examination of trends in hospital antimicrobial use at state and national levels as the basis for larger-scale interventions to rationalise hospital antimicrobial prescribing
- evaluate the impact of interventions in the hospital setting at local, state and national levels
- produce longitudinal antimicrobial usage data that could be used to demonstrate a link between antimicrobial use and future development of resistance, both at local hospital and national levels
- provide an Australian peer group benchmark for comparison and enable comparison with international data
- inform antimicrobial stewardship programs and monitor intervention strategies.

NAUSP currently fulfils most of these requirements. However, it needs to be expanded, with appropriate resourcing, to include data from all tertiary hospitals and selected smaller hospitals and to include reporting by hospital peer group with appropriate case-mix adjustment. Reporting should also be expanded to include usage by specific clinical specialties and within area health regions.
Antimicrobial usage: monitoring and analysis

Aust = Australia; DANMAP = Danish Integrated Antimicrobial Resistance Monitoring and Research Program; DDD = defined daily dose; NethMap = surveillance program for antimicrobial resistance in the Netherlands; OBD = occupied bed-day; SWEDRES = Swedish Antibiotic Utilisation and Resistance in Human Medicine


Note: NethMap 07 is based on 2005 data. SWEDRES 06 is based on 2005 data.

Figure A1.4  Comparison of aggregate antibiotic usage rates in Australian hospitals with international benchmarks

Community usage

The consumption data on community antibiotic usage collected by the PBAC Drug Usage Subcommittee is reported biennially in Australian Statistics on Medicine. Information on this type of data collection is given in Section A1.3.1. The data are reported at a national level and can be provided at the state level; they can be obtained directly from the Drug Usage Subcommittee. Antibiotic usage data are routinely monitored by the Drug Usage Subcommittee and periodic reports are sent to EAGAR. Annual reports are provided to the Australian Institute of Health and Welfare (AIHW) and to the WHO International Committee on Drug Statistics Methodologies. As explained, these data also include antimicrobials dispensed by hospital pharmacies to outpatients and discharged patients in three Australian states. The volume of data will increase as more states implement the pharmaceutical reforms that allow dispensing of PBS prescriptions for outpatients and on discharge.

The Drug Usage Subcommittee also reports to government on the prescription rate for oral antibiotics most commonly used to treat upper respiratory tract infection. This is reported for individual states and Australia-wide. Due to data restrictions, the report is based only on PBS concession card holders.

The total use of antibiotics in the Australian community falls in the middle of the range recorded in European countries: in 2002, Australian community antibiotic use was 21 DDDs per 1000 population per day. Usage was highest in France at 32 DDDs/1000/day, while the Netherlands had the lowest usage at 10 DDDs/1000/day.

The Bettering the Evaluation and Care of Health project (BEACH) of the Australian General Practice Statistics and Classification Centre collects data on clinical activities in general practice. These data include medications (prescribed, advised and provided), clinical treatments and procedures provided. As of July 2007, there were 90,000 general practitioner encounters in the database. BEACH reports on rates of prescribing; it also contributes to AIHW reports. Data from the BEACH project demonstrated a significant decline in antibiotic prescribing in general practice over the five-year period 1999–2004. No comprehensive resistance data were available to monitor the effect of this decline. Prescribing for upper respiratory tract infections decreased during that period from 42% of patient general practitioner visits for upper respiratory tract infections in 1998–99 to 35% in 2002–03. This change represented a shift towards recommended management as promoted through NPS-targeted interventions.

In 2004, antibiotic prescriptions began to increase again. An increase in doctor visits for respiratory tract infections and the ability of Queensland hospitals to directly access the PBS for outpatient and discharge prescriptions from early 2004 may have contributed to this increase. The increase was mainly in penicillins (amoxicillin), which indicates continuing adherence to NPS recommendations. Rates now appear to have stabilised at a rate less than that of 2001.

Future developments should include integrating the antimicrobial usage data from all care sectors (primary through to tertiary) and linking usage data with resistance patterns in a similar manner to DANMAP.

References


47. STRAMA (Swedish Strategic Programme against Antibiotic Resistance) and SMI (Swedish Institute for Infectious Disease Control) (2006). *A Report on Swedish Antibiotic Utilisation and Resistance in Human Medicine*, STRAMA and the Swedish Institute for Infectious Disease Control, Solna.

