

# Antimicrobial stewardship in Australian hospitals: how does compliance with antimicrobial stewardship standards compare across key hospital classifications?

Renee Jones<sup>1</sup>, Kylie Carville<sup>2</sup> and Rodney James <sup>3\*</sup>

<sup>1</sup>University of Melbourne School of Population Global Health (Master of Public Health student project), 207 Bouverie Street, Carlton, VIC 3053, Australia; <sup>2</sup>Victorian Infectious Diseases Reference Laboratory, Doherty Institute, 792 Elizabeth St, Melbourne VIC 3000, Australia; <sup>3</sup>National Centre for Antimicrobial Stewardship, Doherty Institute, 792 Elizabeth St, Melbourne VIC 3000, Australia

\*Corresponding author. E-mail: rodney.james@mh.org.au

Received 14 May 2020; accepted 13 October 2020

**Background:** There is little information on the prevalence and type of antimicrobial stewardship (AMS) activities that are currently occurring in Australian hospitals.

**Objectives:** To determine what AMS activities are currently occurring in Australian hospitals, identify gaps in compliance with the Australian Commission on Safety and Quality in Health Care (ACSQHC) standards and determine perceived barriers and enablers for implementing AMS programmes.

**Methods:** A cross-sectional survey open to all Australian hospitals, conducted online and available to hospitals between November 2016 and July 2017.

**Results:** Responses were received from 254 hospitals. Compliance with ACSQHC AMS essential activities was high, except for essential activity 3 (post-prescription reviews), which was conducted by only 39% of respondent hospitals. Importantly, compliance varied by hospital remoteness classification for all activities except essential activity 1 (availability and endorsement of guidelines) and additional activity 4 (publishing antimicrobial susceptibility data annually), with major city hospitals having the highest compliance across all activities. The three most frequently reported barriers to implementing AMS programmes were a lack of training and education, lack of pharmacy resources and a lack of willingness from medical officers to change.

**Conclusions:** Due to low response rates from certain hospital groups, the survey results are not generalizable to all Australia hospitals. This survey has identified that several gaps in compliance still exist and outlines the need to address lower AMS compliance in hospitals located outside major cities. The key barriers and enablers for AMS programme implementation identified should be used to inform future strategies.

## Introduction

As the pipeline for new antibiotics is running dry and resistance to currently available antimicrobials is increasing, the need to reduce the development and spread of antimicrobial resistance has become a pressing global public health concern.<sup>1</sup> A major factor contributing to the increasing rate of antimicrobial resistance is the overuse and misuse of antibiotics.<sup>2,3</sup> Antimicrobial stewardship (AMS) programmes encourage the appropriate use of antimicrobials and have been shown to decrease antimicrobial consumption as well as reduce infections due to specific antimicrobial pathogens.<sup>4,5</sup> In 2011, the Australian Commission on Safety and Quality in Health Care (ACSQHC) developed guidelines for AMS

programmes in Australian hospitals. These guidelines outline five essential activities (implementing clinical guidelines, antimicrobial formularies, post-prescription reviews, performance monitoring and selective reporting of susceptibility testing) and four additional AMS activities (prescriber education, point-of-care interventions, electronic decision support and publishing antimicrobial susceptibility data annually) (Figure 1).<sup>6</sup> In 2013, these guidelines became part of the accreditation standards for all Australian hospitals.<sup>7</sup>

AMS programmes have been implemented in Australian hospitals to varying degrees.<sup>7</sup> The evidence suggests that, amongst Victorian hospitals, AMS activities are poorly implemented in private hospitals and in public regional and remote hospitals

The five essential Antimicrobial Stewardship strategies are:

1. Implementing clinical guidelines that are consistent with the latest version of Therapeutic Guidelines: Antibiotic, and which take into account local microbiology and antimicrobial susceptibility patterns.
2. Establishing formulary restriction and approval systems that include restricting broad-spectrum and later generation antimicrobials to patients in whom their use is clinically justified.
3. Reviewing antimicrobial prescribing with intervention and direct feedback to the prescriber—this should, at a minimum, include intensive care patients.
4. Monitoring performance of antimicrobial prescribing by collecting and reporting unit or ward-specific use data, auditing antimicrobial use, and using quality use of medicines indicators.
5. Ensuring the clinical microbiology laboratory uses selective reporting of susceptibility testing results that is consistent with hospital antimicrobial treatment guidelines.

The additional stewardship activities according to local priorities and resources include:

1. Educating prescribers, pharmacists and nurses about good antimicrobial prescribing practice and antimicrobial resistance.
2. Using point-of-care interventions, including streamlining or de-escalation of therapy, dose optimisation or parenteral-to-oral conversion.
3. Using information technology such as electronic prescribing with clinical decision-support or online approval systems.
4. Annually publishing facility-specific antimicrobial susceptibility data.

**Figure 1.** The Australian Commission of Safety and Quality in Health Care's Antimicrobial Stewardship strategies for Australian hospitals.<sup>6</sup>

compared with public metropolitan hospitals.<sup>8</sup> These findings align with two similar surveys in the USA, which found that rural hospitals were less likely to have AMS policies and had the lowest rates AMS programme uptake compared with larger urban hospitals.<sup>8–10</sup> Other studies have shown that public hospitals in the state of Queensland and Australian children's hospitals have some key AMS activities implemented; however, additional resources are required to meet all accreditation standards.<sup>11,12</sup> These studies provide some insight into AMS programmes within their specific study settings, outlining that AMS activities vary between different hospital types.

The existing literature suggests that the two most commonly perceived barriers to achieving and implementing a fully compliant AMS programme in Australia are a lack of education and a lack of resources.<sup>8,11–15</sup> These barriers are consistent with studies in the USA, Canada and New Zealand.<sup>9,16,17</sup> In regional and rural settings, a lack of specialist support was found to be a barrier to implementing AMS programs.<sup>13</sup> The literature regarding enablers for implementing AMS programmes in Australian hospitals is more limited. Regional hospitals report that flatter governance structures, a greater sense of pride and good telehealth services are key enablers.<sup>14</sup> Acknowledging the need for assistance and readiness to consult national guidelines were key enablers for Australian tertiary hospitals.<sup>13</sup>

At present, there is no information regarding the prevalence of current AMS activities occurring in hospitals at a national scale across Australia.<sup>7</sup> Moreover, there is insufficient understanding of variation in compliance by key hospital classifications, such as geographical (hospital jurisdiction and remoteness classification) and financial (hospital funding type). Identifying how AMS activities vary across hospital classifications at a national

level is crucial to improving the quality of AMS programme implementation.<sup>7</sup>

The National Centre for Antimicrobial Stewardship (NCAS) conducted a national AMS survey to address this gap. The aims of this study were to: (i) outline AMS activities occurring in Australian hospitals; (ii) identify gaps in compliance across key hospital characteristics; and (iii) identify key barriers and enablers to meeting hospital accreditation standards for AMS.

## Methods

A cross-sectional, point-prevalence survey design was used. The study focused on Australian hospitals and was made available online between November 2016 and July 2017. Jurisdictional AMS leaders (i.e. clinical leads for AMS at the state departments of health) were notified about the survey and helped recruit participants by disseminating the survey to hospitals within their jurisdiction. Participants were also recruited via e-mail [e.g. registrants on the National Antimicrobial Prescribing Survey (NAPS) contact list] and on online discussion groups for infectious diseases physicians, microbiologists and pharmacists. Survey respondents were recruited through multiple platforms to improve response rates. To ensure the appropriate person completed the survey, the information letter specified that the respondent should be the best person at the hospital to respond to a survey regarding AMS practices. Due to the varying resources at different hospitals the 'best person to respond' will differ, thus no one profession could be targeted. Respondents were required to insert their hospital name and answer on behalf of their hospital. All hospitals in Australia, as defined by the Australian Institute for Health and Welfare (AIHW), who utilize antibiotics were eligible to participate and there were no exclusion criteria.<sup>18</sup> The survey was conducted through SurveyMonkey®, and all surveys were completed voluntarily.

The national AMS survey was developed by NCAS and consisted of 36 closed- and 4 open-ended questions; of these, 30 questions were

compulsory and 6 were optional. Questions covered hospital geographic location, funding type, types of AMS activities, governance structures, resources and workplace capacity, as well as perceived barriers and enablers to implementing AMS (the survey is available as [Supplementary data](#) at JAC-AMR Online). The survey was initially designed through an iterative process with end users for a 2013 study of Victorian Hospitals.<sup>8</sup> Following this study, further feedback was received and changes were made accordingly to maximize the surveys validity for its use in this study.

Data cleaning was undertaken to remove respondents who registered for the survey but provided no data, multiple respondents from the same hospital and respondents who represented more than one hospital (a hospital network response). Following cleaning, data were coded to generate a binary variable (compliant and non-compliant) for the majority of ACSQHC AMS activities, using 13 survey questions (Table S1). AMS essential activity 5 and additional activity 2 were not assessed as no questions covered this content. For essential activity 5, information was required from microbiology laboratories. For additional activity 2, this was reliant on essential activity 3 and more in-depth questions relating to this were not asked.

Respondent hospitals were categorized by geographical (hospital jurisdiction and remoteness), financial (hospital funding type) and peer group classification type. Jurisdictions refer to the Australian state or territory in which the hospital is located. Remoteness classifications were derived from the Australian Bureau of Statistics' classification system.<sup>19</sup> Funding type was defined as either public or private, as recorded by the AIHW.<sup>18</sup> Hospital peer groupings refer to a classification system where hospitals with similar characteristics, such as bed number, case mix and funding type, are grouped together.<sup>18</sup> Hospital peer groups were defined in accordance with the AIHW classification system, and hospitals were sorted into 12 peer groupings (public principal referral, public acute A, public acute B, public acute C, public acute D, public other, public women's and children's, private acute A, private acute B, private acute C, private acute D and private other).<sup>18</sup>

Response rate was calculated by dividing the number of respondents by the number of eligible hospitals. Hospital compliance was measured using AMS activities outlined by the ACSQHC. Statistical analyses were conducted to determine if compliance varied by hospital remoteness classification and funding type using Fisher's exact test, with the significance level set at  $P < 0.05$ . Perceived barriers and enablers were calculated using descriptive statistics. This study was approved by the Melbourne School of Population and Global Health Human Ethics Advisory Group (Ethics ID: 1851295.1).

## Results

A total of 357 survey responses were received and 103 were excluded from analysis. Fifty-nine were excluded due to being secondary responses from a responding hospital, 36 were excluded as they represented a hospital network and 8 were excluded as no responses to the survey questions were received, leaving 254 hospitals available for analysis. The survey had a response rate of 27%, with 951 Australian hospitals eligible for the survey. There was large within-group variation in response rates across all hospital classifications; the characteristics of respondents are outlined in Table 1. The most common respondent profession type was AMS/infectious disease pharmacist (36%) (Table S2).

Respondent hospitals' compliance with the essential and additional ACSQHC AMS activities and strategies by funding type and remoteness classification are presented in Table 2. Due to poor response rates from some jurisdictions and peer groups this analysis was not presented in Table 2.

### Compliance with essential activities

Essential AMS activity 1 (availability and endorsement of 'Therapeutic Guidelines: Antibiotic') was undertaken in almost all hospitals (89%) (Table 2). This high level of compliance was consistent across all hospital subgroups.

A large proportion, 77% of respondents, were compliant with AMS essential activity 2 (having an antimicrobial formulary in place that included restrictions on broad-spectrum antimicrobials) (Table 2). Compliance did not vary by hospital funding type ( $P = 0.13$ ) but did vary by remoteness ( $P < 0.001$ ), with the highest compliance being seen in major city hospitals (92%) and lowest in outer regional hospitals (53%).

Compliance with essential AMS activity 3 (post-prescription reviews) was poor: only 39% of respondents reported conducting these reviews. Compliance with this activity varied by hospital remoteness ( $P < 0.001$ ), but not by funding type ( $P$  value near 1) (Table 2). Compliance decreased with increasing remoteness, with only 15% of outer regional and 10% of remote and very remote hospitals conducting post-prescription reviews.

Compliance with essential AMS activity 4 (performance monitoring through regular antimicrobial audits and feedback to prescribers) was high, with this activity occurring in 85% of respondent hospitals (Table 2). This level of compliance was consistent across hospital funding types ( $P = 0.43$ ); however, it did vary by hospital remoteness ( $P = 0.02$ ). Again, compliance with performance monitoring decreased with increasing remoteness.

### Compliance with additional activities

Most hospitals undertook additional AMS activity 1 (education on antimicrobial prescribing to medical officers, pharmacists and nurses), with 60% of hospitals reporting compliance with this activity (Table 2). Compliance varied by hospital funding type ( $P = 0.006$ ) with only 38% of private hospitals conducting education on antimicrobial prescribing compared with 64% of public hospitals. Compliance also varied by remoteness ( $P < 0.001$ ), with the highest compliance being seen in major city hospitals (74%) and the lowest in outer regional hospitals (41%).

Additional activity 3 (electronic decision support) had poor compliance, with only 17% of respondents reporting compliance with this activity (Table 2). Compliance varied by remoteness ( $P < 0.001$ ) with major city hospitals having a much higher compliance compared with hospitals outside major cities. Compliance also varied by funding type ( $P = 0.04$ ) with only 3% of respondent private hospitals having electronic decision support, compared with 19% of public hospitals.

Approximately half of respondents, 53%, were compliant with additional activity 4 (publishing antimicrobial susceptibility data annually) (Table 2). Compliance did not vary by remoteness ( $P = 0.13$ ) but did vary by funding type ( $P = 0.02$ ), with 72% of respondent private hospitals publishing antimicrobial susceptibility data annually, compared with only 50% of public hospitals (Table 2).

### Barriers and enablers

Note that respondents were able to select multiple barriers and enablers. The three most frequently reported barriers were a lack of training and education on antimicrobial use, a lack of willingness

**Table 1.** Characteristics of survey respondents

| Characteristic                            | Number of respondents<br>(% of total respondents) | Response rate (% respondents of<br>all eligible Australian hospitals within subgroup) |
|-------------------------------------------|---------------------------------------------------|---------------------------------------------------------------------------------------|
| Hospitals, by jurisdiction                |                                                   |                                                                                       |
| Australian Capital Territory              | 3 (1)                                             | 33                                                                                    |
| New South Wales                           | 111 (44)                                          | 38                                                                                    |
| Northern Territory                        | 1 (1)                                             | 17                                                                                    |
| Queensland                                | 35 (14)                                           | 19                                                                                    |
| South Australia                           | 6 (2)                                             | 5                                                                                     |
| Tasmania                                  | 4 (2)                                             | 14                                                                                    |
| Victoria                                  | 80 (32)                                           | 38                                                                                    |
| Western Australia                         | 14 (6)                                            | 13                                                                                    |
| Hospitals, by remoteness classification   |                                                   |                                                                                       |
| major city                                | 105 (41)                                          | 30                                                                                    |
| inner regional                            | 79 (31)                                           | 33                                                                                    |
| outer regional                            | 60 (24)                                           | 27                                                                                    |
| remote and very remote                    | 10 (4)                                            | 8                                                                                     |
| Hospitals, by funding type and peer group |                                                   |                                                                                       |
| public                                    |                                                   |                                                                                       |
| principal referral                        | 23 (9)                                            | 79                                                                                    |
| public acute A                            | 40 (16)                                           | 61                                                                                    |
| public acute B                            | 27 (11)                                           | 61                                                                                    |
| public acute C                            | 54 (21)                                           | 38                                                                                    |
| public acute D                            | 33 (13)                                           | 17                                                                                    |
| very small                                | 19 (8)                                            | 14                                                                                    |
| women's and children's <sup>a</sup>       | 6 (2)                                             | 43                                                                                    |
| other <sup>b</sup>                        | 16 (6)                                            | 24                                                                                    |
| all public hospitals                      | 218 (85)                                          | 31                                                                                    |
| private                                   |                                                   |                                                                                       |
| private acute A                           | 8 (3)                                             | 36                                                                                    |
| private acute B                           | 9 (4)                                             | 25                                                                                    |
| private acute C                           | 8 (3)                                             | 16                                                                                    |
| private acute D                           | 4 (2)                                             | 6                                                                                     |
| private other <sup>b</sup>                | 7 (3)                                             | 10                                                                                    |
| all private hospitals                     | 36 (14)                                           | 14                                                                                    |
| Total                                     | 254 (100)                                         | 27                                                                                    |

<sup>a</sup>Women's and children's hospitals include hospitals classified as: combined women's and children's hospitals; women's hospitals; and children's hospitals.

<sup>b</sup>Other hospitals include hospitals classified as: mixed sub-acute and non-acute; other acute specialized hospitals; drug and alcohol hospitals; other acute specialized hospitals; other day procedure hospital; private rehabilitation hospitals; public rehabilitation hospitals; psychiatric hospitals; and mixed day procedure hospitals.

from medical officers to change their prescribing practices and a lack of pharmacy resources, with 60%, 59% and 54% of respondents selecting these barriers, respectively (Table 3).

The three most frequently reported enablers were the availability of 'Therapeutic Guidelines: Antibiotic'; the National Safety and Quality Health Service Standards 2012, Standard 3.14; and the National Antimicrobial Prescribing Survey, with 88%, 69% and 68% of respondents selecting these enablers, respectively (Table 4).

## Discussion

This survey outlined key gaps in AMS programmes across Australian hospitals. Only 39% of respondent hospitals were

identified as conducting post-prescription reviews, essential activity 3. This low compliance should be the focus of future interventions and may be due to a lack of pharmacy resources, which was a frequently reported barrier. An international survey across 67 countries reported similarly low rates of prescription reviews, with 43% conducting outcome reviews at day 3 post prescription.<sup>20</sup> Compliance with additional AMS activities (AMS staff education, electronic decision support and publishing antimicrobial susceptibility) is another key gap. This may be due to hospitals focusing resources towards achieving essential activities. Additional activity 3 had particularly low compliance, with only 17% of hospital having electronic decision support available. This is likely due to the high cost of electronic decision support. An

**Table 2.** Number and percentage of hospitals compliant with Australian Commission of Safety and Quality in Health Care's antimicrobial stewardship guidelines by hospital funding type and remoteness classification<sup>5</sup>

| Hospital classification   | Compliant hospitals, n (%)                                              |                                                   |                                                     |                                                  |                                                |                                                        |                                                              |
|---------------------------|-------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------|--------------------------------------------------|------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------------|
|                           | Essential activity 1<br>(availability and endorsement<br>of guidelines) | Essential activity 2<br>(antimicrobial formulary) | Essential activity 3<br>(post-prescription reviews) | Essential activity 4<br>(performance monitoring) | Additional activity 1<br>(AMS staff education) | Additional activity 3<br>(electronic decision support) | Additional activity 4<br>(antimicrobial susceptibility data) |
| All hospitals             | 218 (89)                                                                | 193 (77)                                          | 95 (39)                                             | 204 (85)                                         | 145 (60)                                       | 40 (17)                                                | 127 (53)                                                     |
| Funding type              |                                                                         |                                                   |                                                     |                                                  |                                                |                                                        |                                                              |
| public                    | 188 (89)                                                                | 171 (79)                                          | 83 (39)                                             | 175 (84)                                         | 133 (64)                                       | 39 (19)                                                | 104 (50)                                                     |
| private                   | 30 (91)                                                                 | 22 (67)                                           | 12 (36)                                             | 29 (91)                                          | 12 (38)                                        | 1 (3)                                                  | 23 (72)                                                      |
| Fisher's exact test       | near 1                                                                  | 0.13                                              | near 1                                              | 0.43                                             | 0.006                                          | 0.04                                                   | 0.02                                                         |
| Remoteness classification |                                                                         |                                                   |                                                     |                                                  |                                                |                                                        |                                                              |
| major city                | 91 (93)                                                                 | 94 (92)                                           | 58 (60)                                             | 86 (90)                                          | 72 (74)                                        | 30 (31)                                                | 59 (61)                                                      |
| inner regional            | 70 (91)                                                                 | 60 (77)                                           | 27 (35)                                             | 65 (86)                                          | 42 (55)                                        | 7 (9)                                                  | 39 (51)                                                      |
| outer regional            | 48 (81)                                                                 | 32 (53)                                           | 9 (15)                                              | 48 (83)                                          | 24 (41)                                        | 2 (3)                                                  | 24 (41)                                                      |
| remote and very remote    | 9 (90)                                                                  | 7 (70)                                            | 1 (10)                                              | 5 (50)                                           | 7 (70)                                         | 1 (10)                                                 | 5 (50)                                                       |
| Fisher's exact test       | 0.14                                                                    | <0.001                                            | <0.001                                              | 0.02                                             | <0.001                                         | <0.001                                                 | 0.13                                                         |

**Table 3.** Perceived barriers to implementing antimicrobial stewardship

| Barriers to implementing AMS                                                    | Respondents selecting barrier (%) |
|---------------------------------------------------------------------------------|-----------------------------------|
| Lack of training and education in antimicrobial use                             | 60                                |
| Lack of willingness from medical officers to change their prescribing practices | 59                                |
| Lack of pharmacy resources                                                      | 54                                |
| Lack of an electronic medication management system                              | 49                                |
| Lack of dedicated funding for an antimicrobial stewardship physician            | 46                                |
| Lack of dedicated funding for an antimicrobial stewardship pharmacist           | 44                                |
| Lack of infectious diseases or microbiology services                            | 37                                |
| Lack of enforcement by facility management / executive                          | 35                                |
| Lack of support from senior clinicians at the facility                          | 34                                |
| High level of transient or seconded staff                                       | 33                                |
| Lack of leadership to promote antimicrobial stewardship at the facility         | 30                                |

international survey across 67 countries identified similar rates of electronic prescribing.<sup>20</sup>

With the exception of essential activity 3 (post-prescription reviews), compliance with essential activities (availability and endorsement of guidelines, antimicrobial formulary and performance monitoring) was high. Importantly, compliance with essential activities 2 and 4 (antimicrobial formulary and performance monitoring) was lower in hospitals outside major cities.

**Table 4.** Perceived enablers to implementing antimicrobial stewardship

| Enablers to implementing AMS                                                  | Respondents selecting enabler (%) |
|-------------------------------------------------------------------------------|-----------------------------------|
| The Therapeutic Guidelines: Antibiotic, Therapeutic Guidelines Limited        | 88                                |
| National Safety and Quality Health Service Standards 2012, Standard 3.14; AMS | 69                                |
| The National Antimicrobial Prescribing Survey (NAPS)                          | 68                                |
| Antibiotic Awareness Week                                                     | 58                                |
| AMS in Australian Hospitals 2011, The ACSQHC                                  | 55                                |
| The Antimicrobial Stewardship Clinical Care Standards 2014, ACSQHC            | 55                                |
| Resources provided by ACSQHC                                                  | 44                                |
| The National Prescribing Service (NPS)                                        | 43                                |
| The National Antimicrobial Utilisation Surveillance Program (NAUSP)           | 41                                |
| The National Centre for Antimicrobial Stewardship (NCAS)                      | 32                                |
| Resources provided by the department of health in your state or territory     | 26                                |
| Discussion forums within your professional group                              | 24                                |
| Resources provided by your professional society                               | 19                                |
| Resources provided by international professional organizations                | 13                                |

Compliance varied by remoteness for measured AMS activities except essential activity 1, availability and endorsement of guidelines ( $P = 0.14$ ) and additional activity 4, publishing antimicrobial susceptibility data annually ( $P = 0.13$ ) (Table 2). For AMS activities



that varied by remoteness classification, compliance was consistently highest in major cities. This finding is consistent with other literature that indicates that more regional hospitals tend to have lower rates of conducting AMS activities compared with metropolitan hospitals.<sup>8–10</sup> Due to the low response rate from remote and very remote hospitals the external validity of results from these hospitals is limited.

Funding type only had an impact on compliance for additional activities (Table 2). These findings are inconsistent with the 2013 Victorian study that found private hospitals had lower compliance across all AMS activities in comparison to public metropolitan hospitals.<sup>8</sup> Due to the limited responses from private hospitals in this study, the comparability of these study results is limited.

When the compliance of Victorian hospitals in this survey (Table S3) was compared with the results of the 2013 Victorian study, it was found that compliance was much higher for essential activity 2 (antimicrobial formulary) and additional activity 4 (antimicrobial susceptibility data published annually). This indicates an improvement on these activities over time, likely due to the incorporation of AMS guidelines into hospital accreditation standards in 2013, which occurred after the Victorian study was completed.<sup>9</sup>

The three most frequently reported barriers—a lack of training and education, lack of pharmacy resources and a lack of willingness from medical officers to change—are consistent with the wider literature.<sup>8,10,12–15</sup> Due to the inconsistency in methodology in the wider literature, the enablers identified in this study were not easily comparable to other literature. Further investigation using consistent methodology should be undertaken to understand enablers, especially in hospital groups with lower compliance.

This survey has several limitations. As with any self-reported survey, the response of one person might not reflect the true nature of what is happening in the hospital. A further limitation is that this survey only captures whether the AMS activity occurs or not and is not able to comment on the quality of the AMS activities occurring in the responding hospitals. Low response rates from private and ‘remote and very remote’ hospitals as well as hospitals from South Australia, Western Australia, Tasmania, Northern Territory and Queensland may limit the generalizability of study results and therefore should not be considered representative of all Australian hospitals. It is likely the low response rates in remote and very remote hospitals reflects a lack of AMS resources or engagement. AMS within these hospitals was a relatively new practice at the time this survey was completed compared with some larger major city hospitals, who have been undertaking some form of AMS for some years allowing for strong relationships with AMS communities and resources to be developed. Future efforts should focus on strengthening the engagement of remote hospitals and other low responding hospital groups to better connect them with appropriate resources. Where variation in response rates was too large and likely marred by confounding, this analysis was not included, such as for hospital jurisdictions and hospital peer groups.

As AMS has only been mandated in Australian hospital accreditation since 2013, it is important to understand how compliance with these standards has changed over time. Similar surveys should be repeated at regular intervals in the future to monitor uptake and to measure compliance with the newly updated 2018 standards. Future national surveys should focus on better engaging ‘hard to reach’ hospitals, including remote, very remote,

smaller and private hospitals as well as aiming to understand the quality of programme and activity implementation.

This survey has identified that while there have been some improvements over time, several gaps in AMS compliance still exist. This survey has also identified a specific need to address and further investigate lower AMS compliance in hospitals located outside major cities. Furthermore, this survey has identified key barriers and enablers for Australian AMS programme implementation, this will assist in informing future improvements to AMS and strategies. Continued research into AMS strategies within all healthcare settings is required to understand the changing nature of how these different strategies are being utilized. Identification of the key gaps in AMS compliance as well as how compliance varies by hospital classification is important for deciding how resources are directed and uptake of AMS activities is improved, so that the use of antimicrobials is optimized.

## Acknowledgements

We thank the Doherty Institute for the assistance from dedicated staff throughout this project. We would also like to sincerely thank all the hospitals across Australia who took part in the survey.

## Funding

This survey was completed as part of the routine work of the National Centre for Antimicrobial Stewardship (NCAS) and as a research project by a Master of Public Health student.

## Transparency declarations

None to declare.

## Supplementary data

The survey and Tables S1 to S3 are available as [Supplementary data](#) at JAC-AMR Online.

## References

- 1 Carlet J, Jarlier V, Harbarth S *et al.* Ready for a world without antibiotics? The Pensières Antibiotic Resistance Call to Action. *Antimicrob Resist Infect Control* 2012; **1**: 11.
- 2 Bell BG, Schellevis F, Stobberingh E *et al.* A systematic review and meta-analysis of the effects of antibiotic consumption on antibiotic resistance. *BMC Infect Dis* 2014; **14**: 13.
- 3 Ingram PR, Seet JM, Budgeon CA *et al.* Point-prevalence study of inappropriate antibiotic use at a tertiary Australian Hospital. *Intern Med J* 2012; **42**: 719–21.
- 4 Owens RC Jr. Antimicrobial stewardship: concepts and strategies in the 21st century. *Diagn Microbiol Infect Dis* 2008; **61**: 110–28.
- 5 Karanika S, Paudel S, Grigoras C *et al.* Systematic review and meta-analysis of clinical and economic outcomes from the implementation of hospital-based antimicrobial stewardship programs. *Antimicrob Agents Chemother* 2016; **60**: 4840–52.
- 6 Australian Commission on Safety and Quality in Healthcare. National Safety and Quality Health Service Standards. 2011. <https://www.safetyandquality.gov.au/standards/nsqhs-standards>.

- 7** Cairns AK, Roberts AJ, Menino O *et al.* Antimicrobial Stewardship in Australian Hospitals and other settings. *Infect Dis Ther* 2015; **4** Suppl 1: S27–38.
- 8** James RS, McIntosh KA, Luu SB *et al.* Antimicrobial stewardship in Victorian hospitals: a state-wide survey to identify current gaps. *Med J Aust* 2013; **199**: 692–5.
- 9** Pogorzelska-Maziarz M, Herzig CT, Larson EL *et al.* Implementation of antimicrobial stewardship policies in U.S. hospitals: findings from a national survey. *Infect Control Hosp Epidemiol* 2015; **36**: 261–4.
- 10** Pollack LA, van Santen KL, Weiner LM *et al.* Antibiotic Stewardship Programs in U.S. Acute Care Hospitals: findings from the 2014 National Healthcare Safety Network Annual Hospital Survey. *Clin Infect Dis* 2016; **63**: 443–9.
- 11** Avent ML, Hall L, Davis L *et al.* Antimicrobial stewardship activities: a survey of Queensland hospitals. *Aust Health Rev* 2014; **38**: 557–63.
- 12** Bryant, PA. Antimicrobial stewardship resources and activities for children in tertiary hospitals in Australasia: a comprehensive survey. *Med J Aust* 2015; **202**: 134–8.
- 13** Chaves NJ, Cheng AC, Runnegar N *et al.* Analysis of knowledge and attitude surveys to identify barriers and enablers of appropriate antimicrobial prescribing in three Australian tertiary hospitals. *J Intern Med* 2014; **44**: 568–74.
- 14** James R, Luu S, Avent M *et al.* A mixed methods study of barriers and enablers in implementing antimicrobial stewardship programmes in Australian regional and rural hospitals. *J Antimicrob Chemother* 2015; **70**: 2665–70.
- 15** Cotta MO, Robertson MS, Marshall C *et al.* Implementing antimicrobial stewardship in the Australian private hospital system: a qualitative study. *Aust Health Rev* 2015; **39**: 315–22.
- 16** Leung V, Wu JH, Langford BJ *et al.* Landscape of antimicrobial stewardship programs in Ontario: a survey of hospitals. *CMAJ Open* 2018; **6**: E71–6.
- 17** Gardiner SJ, Pryer JA, Duffy EJ. Survey of antimicrobial stewardship practices in public hospitals in New Zealand district health boards. *N Z Med J* 2017; **130**: 27–41.
- 18** Australian Institute of Health and Welfare. Australian Hospital Peer Groups: Health Services Series Number 66; Appendix C: Alphabetical Listing of Public and Private Hospitals by Peer Group. 2015. <https://www.aihw.gov.au/reports/hospitals/australian-hospital-peer-groups/contents/table-of-contents>.
- 19** Pink B. Australian Statistical Geography Standard (ASGS): Volume 5—Remoteness Structure. Australian Bureau of Statistics. 2013. [http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/A277D01B6AF25F64CA257B03000D7EED/\\$File/1270055005\\_july%202011.pdf](http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/A277D01B6AF25F64CA257B03000D7EED/$File/1270055005_july%202011.pdf).
- 20** Howard P, Pulcini C, Levy Hara G *et al.* An international cross-sectional survey of antimicrobial stewardship programmes in hospitals. *J Antimicrob Chemother* 2015; **70**: 1245–55.