AUSTRALIAN COMMISSION
ON SAFETY AND QUALITY IN HEALTH CARE

Specification for a Hospital Cumulative Antibiogram

December 2019

Published by the Australian Commission on Safety and Quality in Health Care
Level 5, 255 Elizabeth Street, Sydney NSW 2001

Phone: (02) 9126 3600
Fax: (02) 9126 3613

Email: mail@safetyandquality.gov.au
Website: www.safetyandquality.gov.au

ISBN: 978-1-925665-87-1

© Australian Commission on Safety and Quality in Health Care 2019

All material and work produced by the Australian Commission on Safety and Quality in Health Care is protected by copyright. The Commission reserves the right to set out the terms and conditions for the use of such material.

As far as practicable, material for which the copyright is owned by a third party will be clearly labelled. The Australian Commission on Safety and Quality in Health Care has made all reasonable efforts to ensure that this material has been reproduced in this publication with the full consent of the copyright owners.

With the exception of any material protected by a trademark, any content provided by third parties, and where otherwise noted, all material presented in this publication is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Licence.

Enquiries regarding the licence and any use of this publication are welcome and can be sent to communications@safetyandquality.gov.au.

The Commission's preference is that you attribute this publication (and any material sourced from it) using the following citation:

> Australian Commission on Safety and Quality in Health Care: Specification for a Hospital Cumulative Antibiogram: Sydney: ACSQHC; 2019

Disclaimer

The content of this document is published in good faith by Australian Commission on Safety and Quality in Health Care (the Commission) for information purposes. The document is not intended to provide guidance on particular health care choices. You should contact your health care provider on particular health care choices.

The Commission does not accept any legal liability for any injury, loss or damage incurred by the use of, or reliance on, this document.

CONTENTS

1 INTRODUCTION

1.1 Purpose

This document provides an update to the *Specification for a Hospital Cumulative Antibiogram 2013.*[1] Timely cumulative antibiograms support health services in achieving compliance with the National Safety and Quality Health Service (NSQHS) Standard, Preventing and Controlling Healthcare-Associated Infection, specifically Action 3.16. This action requires hospitals to use surveillance data on antimicrobial resistance (AMR) and antimicrobial use (AU) to support appropriate prescribing. Updates to the first specification were made in consultation with the previous specification expert roundtable chair, the Commission's Antimicrobial Stewardship Advisory Committee, the states and territories representatives and members of the Australian Passive Antimicrobial Surveillance User Advisory Group, which includes public and private laboratories stakeholders.

Summary antimicrobial susceptibility tables, known as cumulative antibiograms, are used for various purposes. This specification provides a guide for health service organisations to develop their local cumulative antibiograms. The use of cumulative antibiograms is intended to aid antimicrobial stewardship (AMS) programs in the development of local antimicrobial prescribing guidelines and formulary management. The detail in the specification is not intended for use by clinicians without appropriate microbiology, infectious diseases or antimicrobial stewardship support in its interpretation.

Tabulated cumulative antibiograms will ideally be produced for hospitals each calendar year, or at a frequency that suits each institution. They should summarise susceptibilities of the first isolate for a particular organism per patient, per annum for urine, blood and non-urine/non-blood (i.e.: other body site) isolates, where there are sufficient numbers to provide statistically reliable data.

Specifically antibiograms are recommended:

- For non-urine isolates, to report susceptibilities for at least the five most commonly isolated species, regardless of numbers isolated, and to report all isolates where the number tested is greater than 30
- For urine isolates, to report at least the three most commonly isolated species with their susceptibilities, regardless of numbers isolated, and to report all isolates where the number tested is greater than 30
- To report susceptibilities for any species isolated more than 30 times in blood cultures.
- It is also recommended that the frequency of certain specified microorganism–antimicrobial susceptibility combinations ("signal resistances") be reported on an annual basis (Section 3.3).

The cumulative antibiogram may include isolates from inpatient wards, emergency departments and outpatients' clinics. Where the expected organism distributions are likely to be different in terms of frequency or resistance in different settings, separate identification of these patient populations may be possible if threshold volumes are sufficient (for example, haematology patients).

Whilst this document retains the title of Specification, it is recognised that the guidance provided will be used by local expert teams to produce antibiograms of greatest value to their health service organisations.

1.2 Relationship with CLSI M39-A4 guideline

This specification is based largely on the *Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data; Approved Guideline – Fourth Edition*, otherwise known as CLSI M39-A4.[2] The Clinical and Laboratory Standards Institute (CLSI) is an international, educational organisation based in the United States, which promotes the development and use of standards and guidelines within the health care community.
CLSI M39-A4 provides:

- Guidelines for clinical laboratories and their data analysis software providers for the routine generation and storage of susceptibility data and for the compilation of susceptibility statistics
- Suggestions to clinical laboratories for effective use of their cumulative susceptibility statistics.
- This specification differs from CLSI M39-A4 by recommending:
- Combined tables of gram-positive and gram-negative bacteria
- Primary presentation by specimen site (non-urine/non-blood, urine, blood) rather than as a supplemental mode
- The publication of data when there may be fewer than 30 isolates
- Using the terminology of antimicrobials from the *Australian Medicines Handbook*[3]
- Compliance with *Australian Guidelines for the Prevention and Control of Infection in Healthcare* (2019)[4] for standard precautions.

This specification also varies from CLSI M39-A4 in that it does not discourage the presentation of supplemental antimicrobial resistance data, provided that the number of isolates actually tested against the antimicrobial is included, and does not advise presenting overall estimated percentage susceptibility in these circumstances.

More detailed technical information can be found in the relevant sections of CLSI M39-A4 for the following:

- Laboratory information system design
- Data verification and validation procedures
- The reason for including only the first isolate from each individual for the year
- The limitations of these types of data and their statistical analysis

2 CONTEXT

2.1 Antimicrobial stewardship

The inappropriate use of antimicrobials leads to the emergence of resistant microorganisms; an increase in the risk of patient harm from avoidable adverse reactions and interactions with other drugs; infection with multidrug-resistant microorganisms, including *Clostridioides difficile*; and, unnecessary costs. Patients with infections due to resistant bacteria experience delayed recovery, treatment failure and potentially death.

Approximately 1 in 4 antimicrobial regimens prescribed in Australian hospitals are considered inappropriate. Antimicrobial stewardship is an effective approach to improving antimicrobial use in hospitals[5], AMS is a systematic approach to optimising the use of antimicrobials.

Hospital AMS programs have been shown to decrease antimicrobial use and improve patient care.[5-7] These programs are essential to local and national efforts to prevent the emergence of antimicrobial resistance and decrease preventable healthcare associated infection. Action 3.16 of the Preventing and Controlling Healthcare-Associated Infection Standard requires health service organisations to use AMR surveillance data to support appropriate prescribing. The provision of cumulative antibiograms supports this action.

The development of a standard approach to antimicrobial susceptibility testing, cumulative analysis and reporting of antibiograms requires agreement and implementation by clinical microbiology services to achieve effective AMS, from a local to a national level.

At a local level, regular analyses of AMR should be provided to groups and individuals with responsibility for local antimicrobial guidelines (such as an AMS committee or drug and therapeutics committee) to inform local empirical therapy recommendations and formulary management. To avoid misinterpretation of antibiograms, clinical requests for access to antibiograms should be supported by concurrent consultation with an infectious diseases specialist or microbiologist to inform response to enquiries.

2.2 AMR surveillance in Australia

The 2013 edition of this specification for acute hospital-level cumulative antibiograms was an initial step toward achieving detailed, accurate and efficient national antimicrobial resistance (AMR) surveillance. The Commission subsequently established the Antimicrobial Use and Resistance in Australia (AURA) Surveillance System to provide a nationally coordinated system for surveillance of AMR and AU for human health. AURA collects data from hospital and community settings to provide a comprehensive national and regional picture of AMR and AU.

Elements of the specification informed the Australian Passive AMR Surveillance (APAS) system. APAS was established in collaboration with Queensland Health, and uses the OrgTRx system to collect, analyse and report on AMR data from hospitals and private pathology services across Australia. Participation in APAS also allows laboratories to produce their own local cumulative antibiogram via access to the data portal. Where local resistance data are not available, national surveillance data provides a broader picture of antimicrobial resistance in Australia. However, while national data are informative, local data may differ due to service provision demographic differences in local populations and the nature of service provision. As a result, local data are the preferred reference for local AMR surveillance.

3 ANTIBIOGRAM SPECIFICATIONS

3.1 Terminology

Within this specification:

- Generic antimicrobial names should be used, preferably following the terminology of the *Australian Medicines Handbook*[3]
- The antimicrobial-organism combinations reported should be in accordance with those recommendations for treatments in *Therapeutic Guidelines: Antibiotic*[8]
- It is recommended that the terminology for bacteria generally follow the terminology of the Royal College of Pathologists of Australasia[9], although this is at the discretion of the AMS participants who will use the data
- For the purposes of the antibiogram, any organism tested with the EUCAST antimicrobial susceptibility method should be considered susceptible if it meets the definitions of the susceptibility categorises of either ‘susceptible, standard dosing regimen (S)’ or ‘susceptible, increased exposure (I)[10]. Any organisms tested with the CLSI method should be considered susceptible if it meets the definitions of the ‘susceptible (S)’ category.[11]

3.2 Threshold volumes and statistical considerations

The structure of the antibiogram will be affected by local epidemiology and laboratory practices. However, in general:

- Only the first clinical isolate for a particular organism per patient, per annum should be included. The use of multiple isolates from the same patient would bias results to reflect the susceptibility data. Isolates performed as part of surveillance programs should not be included. This does not preclude the separate analysis of sequential patient isolates to determine resistance trends
- Fewer than 30 isolates of any grouping of bacteria do not provide statistically significant information. When data from fewer than 30 isolates are presented, a comment should be included to reflect this and, to provide context. In these cases, it is desirable to provide confidence intervals (as per CLSI M39-A4) for the point estimate of percentage susceptibility. This may apply to the total organism group or only specific antimicrobial-organism combinations within the total organism group
- When there are fewer than 30 isolates, an AMS group may refer to regional, jurisdictional, or national data. However, it is still essential that each institutional AMS group review its own resistance data in the recommended format, rather than depending uncritically on regional, jurisdictional or national data.
- In general percentages should only be reported where 90% of isolates are tested for each organism. However, there may be circumstances for certain subsets where a lower value would be acceptable. The percentage of isolates tested should always be included in the antibiogram notes.

3.3 Sentinel resistances

The occurrence of particular antimicrobial resistances in certain species, at any frequency, may be critical for determining stewardship policies. These antimicrobial-resistant microorganisms are:

- Vancomycin-resistant *Enterococcus faecalis or E. faecium* (VRE)
- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Vancomycin-intermediate and vancomycin resistant *S. aureus* (VISA, VRSA); note that the method used for identifying VRSA should be reported
- Carbapenem-resistant Enterobacterales, or other plasmid-mediated carbapenemase-producing gram-negative organisms (such as carbapenemase-producing Enterobacterales (CPE), *Acinetobacter* species and *Pseudomonas aeruginosa*)
- *Streptococcus pneumoniae* with a penicillin MIC ≥0.06mg/L; these should be categorised as I and R (MIC >2 mg/L) making reference in the commentary to the fact that breakpoints for meningitis differ
- Enterobacterales resistant to third- or later generation cephalosporins; where the mechanism for this resistance has been confirmed, such as with extended spectrum beta-lactamase (ESBL), this should be reported as listed at Section 4.2.

3.4 Presentation of certain classes of antimicrobials

The following principles should be considered in the preparation and presentation of the hospital antibiogram:

- Tetracycline and fluoroquinolone antimicrobials should not be administered to children except on specialist advice. Specific commentary may be appropriate for an antibiogram of a facility that cares for children. This can be emphasised in cumulative antibiograms by means such as a highlighted background colour, different font colour or key. See examples in Section 4 - Structure of the Antibiogram.
- It can be indicated that certain antimicrobials should be reserved for specific purposes. The publication of susceptibility data for carbapenems and fluoroquinolones does not imply they are first-line antimicrobials for empiric treatment, yet presenting those susceptibility data may trigger prescribing by clinicians. In practice in Australia, except for the few indications recommended by *Therapeutic Guidelines: Antibiotic*,[8] these classes of antimicrobials should almost never be used as empirical therapy. They should be reserved for infections with organisms with laboratory-confirmed resistance to alternative antimicrobials or where the patient has a significant allergy to narrower spectrum antimicrobials that would otherwise be appropriate.
- Combinations of antimicrobial–microorganisms are routinely included in laboratory test panels that are known to be ineffective for treatment of infections in clinical practice (such as sulfamethoxazole/trimethoprim for *P. aeruginosa*). In particular certain species may test as apparently susceptible to antimicrobial agents *in vitro* (such as first and second generation cephalosporins and aminoglycosides for *Salmonella* and *Shigella*). These antimicrobial–microorganism combinations should not be reported in the antibiogram.[12, 13]

4. STRUCTURE OF THE ANTIBIOGRAM

The structure of the antibiogram should be a table format, as shown in the examples in the Appendix. Colour coding can be used to identify organisms and antimicrobials and distinguish between gram-positive and gram negative organisms, and their susceptibility percentage.

4.1 Antibiogram tables within the specification

Tabulated cumulative antibiograms should be produced for blood cultures, urine isolates, non-blood/non-urine isolates, and if there are more than 30 isolates of a genus, species or other grouping over one calendar year.

Each cumulative antibiogram table should be annotated with the name of the institution that the isolates reported were derived from, the time period over which the isolates were collected and the standard used by the laboratory to determine antimicrobial susceptibility. These may include calibrated dichotomous susceptibility (CDS)[14], CLSI[15, 16], or European Committee on Antimicrobial Susceptibility Testing (EUCAST).[17] If multiple or non-standardised methods were used, this should be stated.

If the breakpoints for any antimicrobial–organism pair have changed since the last publication of a cumulative antibiogram for a health service organisation, then the date when the change was implemented could be indicated in a footnote to the table.

Only the antimicrobial susceptibility data from the first isolate of a bacterial species from each individual each year should be included. Multiples should be eliminated by including only the initial microbial isolate of a particular species recovered from a patient during the time period analysed, regardless of antimicrobial susceptibility profile. Where the analysis is performed on a subset of isolates (for example isolates from urine or blood cultures) 'first isolate' would refer to the first isolate in that particular subset (that is the patient's first urine or blood isolate). If the same microorganism is isolated from urine, a non-urine site or blood from an individual, then the susceptibility data from the first isolate from each site should be included in their respective antibiogram.

Only finalised, validated test results are included. Unusual antimicrobial resistances or genotypes should be verified before inclusion. Refer to CLSI, EUCAST and CARAlert Handbook reference guides where relevant.[2, 13, 18]

In general, only "percentage susceptible" data should be reported. Exceptions to this are the following antimicrobial–organism combinations for CLSI methods only: VISA and percentage penicillin intermediate susceptibility for *S. pneumoniae* and viridans group *Streptococcus,* if these species are reported. For laboratories using EUCAST methods, all "susceptible–increased exposure" results should be included in "percentage susceptible".

For each genus, species or other grouping, the number of isolates (the denominator) used in determining the percentage can be noted on the antibiogram report (see example antibiograms in the Appendix). Ideally grand totals of all organisms included in the antibiogram should be noted in the antibiogram. Alternatively, include the proportion of the total isolates that each species contributes to the antibiogram. This enables quantification of those organisms that do not meet the required thresholds for inclusion in the antibiogram.
The antibiogram should report antimicrobial susceptibilities for the antimicrobials in actual current clinical use, not the susceptibility to any surrogate antimicrobial used in the laboratory. For example, in laboratories using CLSI methods, the antibiogram for *S. aureus* should report as percentage susceptible to flucloxacillin, and not percentage susceptible to cefoxitin.

The antibiogram should only report antimicrobial susceptibilities for a microorganism where they are clinically relevant for that microorganism. For example, the antibiogram should not report trimethoprim for *P. aeruginosa* or first- and second-generation cephalosporins and aminoglycosides for *Salmonella* and *Shigella*.

For a cumulative antibiogram, the percentage susceptibility for all clinically relevant antimicrobials tested on an isolate should be reported. It should not be restricted to susceptibilities to the narrow-spectrum, first-line antimicrobials that might be included in routine individual patient reports to clinicians. It is useful to highlight in the antibiogram which antimicrobials are restricted.

Laboratories frequently only test susceptibility to second-line, broader spectrum antimicrobials when an isolate has tested non-susceptible to antimicrobials in a first-line, narrower spectrum panel. This results in a smaller denominator number of isolates tested. Where this occurs, or there is any other systematic cause for a difference in the number of isolates of the same type tested against different antimicrobials, this should be annotated at each occurrence and explained in the presentation of the cumulative antibiogram.

Including susceptibility data from isolates which are most often contaminants or normal flora (such as coagulase-negative *Staphylococcus* species*, Corynebacterium* species and viridans group *Streptococcus*) is discouraged. Ordinarily these would not be included in a cumulative antibiogram even if there are more than 30 isolates. However, for particular circumstances (such as a hospital having a neonatal intensive care unit with 30 or more individual blood isolates of coagulase negative *Staphylococcus* species in a year), these data may be included at the discretion of the microbiology laboratory and the AMS group. In this circumstance it is recommended that the data be presented by species (for example *S. haemolyticus*, *S. epidermidis*, not coagulase-negative *Staphylococcus* species) and not accumulated into genus.

When the antimicrobial data from less than 30 isolates is presented, it is recommended it be annotated with the advice that these results may not have attained an accurate measure of susceptibility in that microbial population.

With subsequent antibiograms, graphs and charts for trends that are monitored from year to year are useful to highlight significant changes. Such graphs and charts can be used to highlight changes in susceptibility (See CLSI M39-A4 Appendix F and Appendix H).

Signal resistances that occur at greater than 30 isolates should be included as a separate entry in the main antibiogram. If these occur at a frequency too low to appear in either the urinary, non-urinary or blood culture antibiograms, then the numbers that occur could be reported in a text report or as tabulated data (see Figure A2, Appendix). Although this is not strictly part of a cumulative antibiogram, it is necessary to know the numbers of these organisms in order to direct AMS programs. Zero occurrences of these organisms should also be reported. The ability to detect these resistances is, to a variable degree, dependent on molecular methods, and whether or not these methods have been applied should be noted in the report.

All antibiograms should be clearly labelled with details of the date of issue, author, details of completed approval processes, document control and/or version numbers.

4.2 Specification for non-urine isolates

In relation to non-urine isolates:

- **Required**: for each calendar year, the antibiogram should report susceptibilities for at least the five most commonly isolated species, regardless of numbers isolated, and to report all isolates where the number tested is greater than 30 (Figure A3 Appendix)
- **Desirable**: if there are less than 30 isolates of any of the five most commonly isolated species, then accumulated antimicrobial susceptibility data should be reported. This can be done first by genus, then by grouping Enterobacterales into groups that do or do not usually carry inducible or de-repressed chromosomal β-lactamases. Refer to the *Manual of Clinical Microbiology, 12th Edition.*[19]
- Do not combine data from *S. aureus* with data from coagulase-negative *Staphylococcus* species.

4.3 Specification for urine isolates

In relation to urine isolates:

- **Required**: the antibiogram should report all isolates with more than 30 in number or at least the three most commonly isolated species with their susceptibilities, regardless of numbers isolated or all isolates where the number tested is greater than thirty (Figure A4, Appendix)
- **Desirable:** if there are less than 30 isolates of any of the three most commonly isolated species, then accumulated antimicrobial susceptibility data should be reported. This can be done first by genus, then by grouping *Enterobacterales* into groups that do or do not usually carry inducible or de-repressed chromosomal β-lactamases. Refer to the *Manual of Clinical Microbiology, 12th Edition.*[19]
- Other than *S. saprophyticus*, coagulase-negative *Staphylococcus* species should not be included. Data from *S. aureus* should not be combined with data from *S. saprophyticus.*

5 REFERENCES

1. Australian Commission on Safety and Quality in Health Care. Specification for a Hospital Cumulative Antibiogram. Sydney: ACSQHC; 2013.
2. Clinical and Laboratory Standards Institute (CLSI). Guideline for Analysis and Presentation of Cumulative Antimicrobial Susceptibility (M39-A4). Pennsylvania: CLSI; 2014.
3. Rossi S. Australian Medicines Handbook Online Adelaide: Australian Medicines Handbook Pty Ltd. Available from: shop.amh.net.au/products/digital.
4. The National Health and Medical Research Council. Australian Guidelines for the Prevention and Control of Infection in Healthcare (2010) Commonwealth of Australia: NHMRC; 2010. Available from: nhmrc.gov.au/about-us/publications/australian-guidelines-prevention-and-control-infection-healthcare-2010.
5. Australian Commission on Safety and Quality in Health Care. Antimicrobial Stewardship in Australian Health Care. Sydney: ACSQHC; 2018.
6. Dellit TH, Owens RC, McGowan JE, Jr., Gerding DN, Weinstein RA, Burke JP, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis. 2007;44(2):159-77.
7. Cruickshank M, Ferguson J. Reducing Harm to Pateints from Health Care Associated Infection: the Role of Surveillance. Sydney: ACSQHC; 2008. www.safetyandquality.gov.au/wp-content/uploads/2008/01/Reducing-Harm-to-Patient-Role-of-Surveillance1.pdf
8. Antibiotic Expert Group. Therapeutic Guidelines: antibiotic. Version 16. Ltd TG, editor. Melbourne: Therapeutic Guidelines Limited; 2019.
9. The Royal College of Pathologists of Australasia. Standards for Pathology Informatics in Australia (SPIA) Reporting Terminology and Codes Microbiology Sydney: RCPA; 2017. www.rcpa.edu.au/getattachment/4bb8b4e5-5ddd-4f0e-b576-49788c0565be/SPIA-Microbiology-Reporting-Terminology-and-Codes.aspx
10. European Committee on Antimicrobial Susceptibility Testing. The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters 2019. Available from: www.eucast.org/fileadmin/src/media/PDFs/EUCAST_files/Breakpoint_tables/v_9.0_Breakpoint_Tables.pdf.
11. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing CLSI document M100. 29th ed. Wayne, PA: CLSI; 2019.
12. The European Committee on Antimicrobial Susceptibility Testing (EUCAST). Intrinsic Resistance and Exceptional Phenotypes Tables: EUCAST; 2011. Available from: www.eucast.org/fileadmin/src/media/PDFs/EUCAST_files/Expert_Rules/Expert_rules_intrinsic_exceptional_V3.1.pdf.
13. Leclercq R, Canton R, Brown DF, Giske CG, Heisig P, MacGowan AP, et al. EUCAST expert rules in antimicrobial susceptibility testing. Clin Microbiol Infect. 2013;19(2):141-60.
14. Bell SM, Pham JN, Rafferty DL, Allerton JK, James PM. Antibiotic Susceptibility Testing by the CDS Method. A Manual for Medical and Veterinary Laboratories 2018. Ninth edition:[Available from: cdstest.net/manual/.
15. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Disk Susceptibility Tests. CLSI document M02. 13th ed. Wayne, PA.: CLSI; 2018.
16. Clinical and Laboratory Standards Institute (CLSI). Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria that Grow Aerobically. CLSI document M07. 11th ed. Wayne, PA: CLSI; 2018.
17. The European Committee on Antimicrobial Susceptibility Testing (EUCAST). Antimicrobial susceptibility testing: EUCAST; 2019. Available from: www.eucast.org/ast_of_bacteria/.
18. Australian Commission on Safety and Quality in Health Care. National Alert System for Critical Antimicrobial Resistances (CARAlert): Laboratory Handwork Sydney: ACSQHC; 2019.
19. Carroll KC, Pfaller MA, Landry ML, McAdam AJ, Patel R, Richter SS, et al. Manual of clinical microbiology. Washington: ASM Press; 2019.

6 APPENDIX – ANTIBIOGRAM EXAMPLES

This appendix contains a number of examples of local antibiograms. It is noted that not all antibiograms may be entirely consistent with this Specification due to local circumstances. These antibiograms are included to provide a range of examples of the variety of formats that may best suit local requirements, as part of effective antimicrobial stewardship. The Commission acknowledges the contribution of the laboratories that provided these de-identified examples.

Figure A1: Example of a cumulative antibiogram and signal resistances for blood culture isolates

This document contains the yearly cumulative blood culture antibiogram for all hospitals combined serviced by *Pathology Service*.

Notes:

- Organisms are listed in descending order of frequency
- Organisms are colour coded according to whether they are Gram Positive or Gram Negative organisms
- Only the first isolate of a given species per patient per year per subtype (e.g urine, non-urine, blood cultures) is included.
- Screening isolates collected for infection control purposes have been removed.
- Since 2012, susceptibility testing to produce these antibiograms is performed using EUCAST microbroth dilution and disc diffusion methods
- Expert EUCAST rules in Antimicrobial Susceptibility testing have been applied
- Where the total number of isolates tested is < 30, results are considered statistically invalid in accordance with CLSI M39-A4
- Where only a subset (< 95%) of isolates from a particular organism group have been tested, reported susceptibilities are usually not indicative of the true susceptibility because of the selective nature of testing only more resistant isolates. These occasions are marked with an * and susceptibility results should be interpreted with caution.

Signal resistances: signal resistances are summarised even if the organism occurs at a frequency too low (< 30) to appear in either the urinary, non-urinary or blood culture antibiograms. These organisms include

- Enterobacterales resistant to third or fourth generation cephalosporins due to the presence of Extended Spectrum Beta Lactamases (ESBLs)
- Enterobacterales resistant to third or fourth generation cephalosporins due to the presence of Plasmid mediated AMPC production (PAMPs)
- Enterobacterales resistant to carbapenems due to the presence of a plasmid mediated carbapenemase (CPE)
- Non Enterobacterales (e.g Acinetobacter spp; Pseudomonas aeruginosa) resistant to carbapenems due to the presence of a plasmid mediated carbapenemase (CPNE)
- Vancomycin resistant Enterococci (VRE)
- Methicillin resistant Staphylococcus aureus (MRSA)
- Vancomycin heteroresistant, intermediate and resistant Staphylococcus aureus (hVISA, VISA, VRSA)
- Penicillin intermediate and resistant Streptococcus pneumoniae noting that breakpoints differ according to clinical condition (meningitis, pneumonia, other) and mode of administration
- Penicillin intermediate and resistant viridans Streptococci

Figure A1 (continued)

All Hospitals Antibiogram Jan – Dec 2018

Blood Culture Antibiogram — **All Pathology Service Hospitals Jan – Dec 2018**

Organism Group	No. Organisms	%Total		Penicillin	Amoxicillin	Flucloxacillin	Amoxicillin-clavulanate	Piperacillin-tazobactam	Cefalotin	Cefazolin	Ceftriaxone	Ceftazidime	Cefepime	Meropenem	Gentamicin	Amikacin	Sulpha-trimethoprim	Ciprofloxacin	Fusidic Acid	Rifampicin	Gentamicin (High Level)	Erythromycin/Clarithromycin	Clindamycin	Tetracyclines	Quinupristin-dalfopristin	Vancomycin
All isolates	**2142**	**100.0**																								
Coagulase negative Staphylococci	637	29.7	%	11		41	40		40			R					59	79	79	98		44	64	68		100
			n	627		621	621		621								629	609	623	626		626	625	628		632
Escherichia spp	407	19.0	%		43		79	92		77	90		93	100	91	99	69	86								
			n		407		407	406		407	407		406	407	407	*329	407	407								
Staphylococcus aureus (ALL)	211	9.9	%	26		89	89		89			R					95	92	95	100		86	87	95		100
			n	211		211	211		211								211	*185	*186	*186		211	211	211		211
Klebsiella spp	147	6.9	%		R		94	92		84	93		95	100	99	100	86	93								
			n				147	147		147	147		147	147	147	*119	147	147								
viridans Streptococci	118	5.5	%	85					100		89						68		R		100	50	85	74		100
			n	117					*15		115						*25				*83	117	117	117		116
Pseudomonas aeruginosa	100	4.7	%		R		R	89		R	R	92	94	94	96	96	R	94						R		
			n					100				100	100	100	100	*77		100								
Enterococcus spp	90	4.2	%	77					R	R	R	R					R		R	43	81	R	R	30	33	87
			n	90																*23	*83			90	*76	90
Spore forming GPB	57	2.7	%	17					75								92	97				76	49	78		98
			n	*54					*12								*25	*39				*21	*53	*50		*52
Enterobacter cloacae complex	56	2.6	%		R		R	66		R	71		86	98	93	100	77	93								
			n					56			56		56	56	56	*43	56	56								
B haemolytic Streptococci Group B	30	1.4	%	100					100		100			100			100			30		70	70			100
			n	30					30		29			*26			30			*10		30	30	30		*24

Figure A1 (*continued*)

Colour coding for antibiogram

	Gram Positive Organism		≥90% of isolates susceptible		≥90% of isolates susceptible (where sample size <95% of total isolates tested)
	Gram Negative Organism		70-89% of isolates susceptible		70-89% of isolates susceptible (where sample size <95% of total isolates tested)
	Antibiotic Not recommended to be used in children without specialist advice		<70% of isolates susceptible		<70% of isolates susceptible (where sample size <95% of total isolates tested)
	Restricted or 2nd Line Antibiotics	**R**	Intrinsic Resistance is present with this organism–antibiotic combination	*	Sample size <95% of the total isolates tested
	Restricted or 2nd Line Antibiotics and Antibiotic Not recommended to be used in children without specialist advice	**%**	Percentage of isolates sensitive to this particular antibiotic	**n**	Number of isolates tested with this antibiotic

Signal Resistances: Where the tables below contain no data no multiresistant organisms have been detected.

Blood culture: Extended beta-lactamase producing Enterobacterales (ESBL)			
Organism Group	Organism Name	No. Positive	% of strains
Citrobacter freundii complex n = 9	Citrobacter freundii	1	11.1
Enterobacter cloacae complex n = 56	Enterobacter cloacae	3	5.4
Escherichia spp n = 407	Escherichia coli	38	9.3
Klebsiella spp n = 147	Klebsiella pneumoniae	7	4.8
Serratia spp n = 21	Serratia marcescens	1	4.8
Blood culture: Plasmid mediated APMC producing Enterobacterales (PAMP)			
Organism Group	Organism Name	No. Positive	% of strains
Escherichia spp n = 407	Escherichia coli	8	2.0
Klebsiella spp n = 147	Klebsiella pneumoniae	1	0.7
Citrobacter freundii complex n = 9	Citrobacter freundii	1	11.1
Enterobacter cloacae complex n = 56	Enterobacter cloacae	2	3.6
Blood culture: Plasmid mediated Carbapenemase producing Enterobacterales (CPE)			
Organism Group	Organism Name	No. Positive	% of strains
Citrobacter freundii complex n = 9			
Enterobacter cloacae complex n = 56			
Blood culture: Plasmid mediated Carbapenemase producing Non Enterobacterales (CPNE)			
Organism Group	Organism Name	No. Positive	% of strains

Figure A1 (*Continued*)

Signal Resistances (continued): Where the tables below contain no data no multiresistant organisms have been detected.

Blood culture: Vancomycin Resistant Enterococci (VRE)			
Organism Group	Organism Name	No. Positive	% of strains
Enterococcus spp n = 90	Enterococcus faecium (VRE) VAN A	1	1.1
	Enterococcus faecium (VRE) VAN B	4	4.4
Blood culture: Methicillin Resistant Staphylococcus aureus (MRSA)			
Organism Group	Organism Name	No. Positive	% of strains
Staphylococcus aureus (ALL) n = 211	*S. aureus* (non-multiresistant MRSA)	16	7.6
	Staphylococcus aureus (MRSA)	3	1.4
	Staphylococcus aureus (UK EMRSA-15)	4	1.9
Blood culture: Streptococcus pneumoniae Penicillin Susceptibility (Non-meningitis breakpoints)			
Organism Group	MIC category	No. Positive	% of strains
Streptococcus pneumoniae n = 25	Sensitive ≤ 0.06 mg/L	19	64.0
	Intermediate 0.12 – 2 mg/L	9	36.0
Blood culture: Streptococcus pneumoniae Ceftriaxone Susceptibility			
Organism Group	MIC category	No. Positive	% of strains
Streptococcus pneumoniae n = 25	Sensitive ≤ 0.5 mg/L	23	92.0
	Intermediate 1 – 2 mg/L	2	8.0

Figure A2: Example of a cumulative antibiogram for non-urine isolates

***Hospital name*, Year**

Includes isolates from all samples except urine cultures and infection control screening samples

Non-urinary isolate antibiogram

				Routinely reported antibiotics								Restricted or second line antibiotics					
Organism type		**# strains**	**% total**	**Ampicillin**	**Amoxycillin + clavulanate**	**Cefazolin / cephalexin**	**Flucloxacillin / dicloxacillin**	**Erythromycin / clindamycin**	**Tetracycline**	**Trimethoprim + S'methoxazole**	**Gentamicin (aminoglycoside)**	**Ceftriaxone**	**Piperacillin + tazobactam**	**Ceftazidime**	**Meropenem**	**Ciprofloxacin**	**Vancomycin**
All isolates		8,629	100%	Some miscellaneous/contaminant species excluded.													
Gram negative isolates	*Escherichia coli*	718	8%	58%	**79%**	**77%**	R	R	n/a	**85%**	96%	93%	92%	92%	100%	94%	R
	Klebsiella species	347	4%	R	94%	**71%**	R	R	n/a	97%	97%	95%	91%	97%	100%	97%	R
	Enterobacter -like species*	720	8%	R	R	R	R	R	R	94%	96%	**	**73%**	**89%**	99%	97%	R
	Pseudomonas aeruginosa	2,095	24%	R	R	R	R	R	R	R	94%	R	94%	94%	95%	92%	R
	Haemophilus influenzae	1,674	19%	66%	**89%**	n/a	R	R	99%	**72%**	S	98%	S	S	S	S	R
Gram positive isolates	*Staphylococcus aureus*- ALL	1,692	20%	-	-	-	**84%**	**83%**	95%	99%	n/a						
	Methicillin-susc. S. aureus	1,417	16%	16%	S	S	100%	**87%**	97%	100%	n/a	-	S	-	S	-	100%
	Methicillin-resistant S. aureus	275	3%	R	R	R	R	63%	**85%**	94%	**87%**	R	R	R	R	-	100%
	Streptococcus pyogenes (group A strep)	239	3%	100%	S	S	S	97%	**85%**	n/a	R	S	S	-	S	-	S
	Streptococcus agalactiae (group B strep)	483	6%	100%	S	S	S	**80%**	25%	n/a	R	S	S	-	S	-	S
								79	79								
	Streptococcus dysgalactiae (group C or G strep)	483	6%	100%	S	S	S	**76%**	64%	n/a	R	S	S	-	S	-	S
	Streptococcus pneumoniae	178	2%	**83%**	-	-	-	**77%**	**85%**	n/a	R	S	S	-	S	-	S
				***				99	99								

Figure A2: (Continued)

Antibiogram key

n/a	not available - not routinely tested in this laboratory or no testing standard available
93%	> 90% of isolates susceptible
S	Susceptible by extrapolation or intrinsically susceptible
75%	70-89% of isolates susceptible
45%	< 70% of isolates susceptible
R	Intrinsically resistant
*	*Enterobacter*, *Serratia*, *Citrobacter*, *Providencia*, *Morganella* species (excludes *C. diversus)*
**	Resistance may emerge during therapy and ceftriaxone NOT recommended for these species.
***	Based on oxacillin susceptibility. A majority of oxacillin resistant isolates remain susceptible to benzylpenicillin/amoxicillin used for non-meningeal infection
	Antibiotics shaded yellow are restricted agents. Across HNE Health, the restricted indications specified by the Clinical Excellence Commission are endorsed- see link that is held here- https://aimed.net.au/about/hne-guidelines/

Figure A3: Example of cumulative antibiogram for urine isolates

Cumulative Antibiogram

Susceptibility of Common Urine Isolates – 1 January 2018 to 31 December 2018

Facility name — Pathology service name

Number of unique isolates: **1,683**		Antimicrobials											
		Usually unrestricted								Restricted or Second-line			
Organism	Number of isolates (%)	Ampicillin Penicillin	Flucloxacillin	Doxycycline	Amoxycillin clavulanic acid	Cefalexin	Gentamicin	Nitrofurantoin	Trimethoprim	Meropenem	Ceftriaxone	Norfloxacin	Piperacillin-tazobactam
Escherichia coli	1,053 (62.6)	55% 1,053			84% 1,053	91% 1,053		99% 1,053	76% 1,053		93% 1,053		
Pseudomonas aeruginosa	119 (7.1)			R	R		95% 118		R	94% 117	R	95% 113	90% 118
Klebsiella pneumoniae	90 (5.3)	R			94% 90	89% 90		81% 90	79% 90		91% 90		
Proteus mirabilis	65 (3.9)	83% 65		R	92% 65	94% 64		R	77% 64		97% 65		
Enterococcus faecium	36 (2.1)	8% 36				R	R	31% 36	R				
Klebsiella oxytoca	35 (2.1)	R			86% 35	80% 35		94% 35	94% 35		94% 35		

KEY <70% of isolates susceptible; 70–89% of isolates susceptible; ≥90% of isolates susceptible; Restricted antimicrobials

Antimicrobial not recommended to be used in children without specialist advice

Intrinsic resistance is present with this organism-antimicrobial combination

Notes Only species for which there are 30 or more isolates are reported
Percentages are shown only where more than 90% of isolates were tested for each organism
Susceptibility Testing Method: EUCAST

Date

Figure A4: Example of cumulative antibiogram for non-urine isolates

Cumulative Antibiogram

Susceptibility of Common Non-urine Isolates – 1 January 2018 to 31 December 2018

Facility name — Pathology service name

Number of unique isolates: **1,623** **Organism**	Number of isolates (%)	Antimicrobials															
		Usually unrestricted											Restricted or Second-line				
		Ampicillin Penicillin	Flucloxacillin	Erythromycin	Clindamycin	Doxycycline	Amoxycillin clavulanic acid	Cefazolin	Gentamicin	Vancomycin	Trimethoprim	Trimethoprim-sulphamethoxazole	Meropenem	Ceftriaxone	Ceftazidime	Ciprofloxacin	Piperacillin-tazobactam
Staphylococcus aureus	764 (47.1)	24% 761	100% 760	85% 757	87% 763	97% 745		100% 709				97% 724					
Escherichia coli	264 (16.3)	52% 264					76% 264	71% 255	93% 264		74% 243	76% 248	100% 248	94% 264	94% 251	87% 264	92% 246
Staphylococcus aureus (MRSA)	173 (10.7)	R	R	66% 172	66% 173	94% 173						94% 173					
Pseudomonas aeruginosa	133 (8.2)					R	R		97% 133		R	R	98% 133			94% 133	93% 133
Haemophilus influenzae	117 (7.2)	67% 117				98% 17	79% 117					68% 117					
Streptococcus pyogenes (Group A)	87 (5.4)	100% 87		95% 87	97% 87	84% 87											
Streptococcus pneumoniae	67 (4.1)	79% 66		67% 67	78% 67	72% 67						75% 63					
Staphylococcus epidermidis	62 (3.8)		15% 61	33% 61	54% 61	44% 57		12% 57				44% 57					
Staphylococcus lugdunensis	51 (3.1)	59% 51	92% 50	90% 51	88% 51	98% 51		94% 48									
Klebsiella pneumoniae	49 (3.0)	R					88% 49	85% 46	94% 49			91% 45	100% 45	94% 49	91% 45	88% 49	
Enterococcus faecalis	45 (2.8)	100% 45			R			R	R	100% 45	R	R					

Figure A4 (*continued*)

Cumulative Antibiogram (*continued*)

Susceptibility of Common Non-urine Isolates – 1 January 2018 to 31 December 2018

Facility name — Pathology service name

Number of unique isolates: **1,623** **Organism**	Number of isolates (%)	Antimicrobials															
		Usually unrestricted										Restricted or Second-line					
		Ampicillin Penicillin	Flucloxacillin	Erythromycin	Clindamycin	Doxycycline	Amoxycillin clavulanic acid	Cefazolin	Gentamicin	Vancomycin	Trimethoprim	Trimethoprim-sulphamethoxazole	Meropenem	Ceftriaxone	Ceftazidime	Ciprofloxacin	Piperacillin-tazobactam
Campylobacter jejuni	36 (2.2)		100% 34													100% 36	
Streptococcus agalactiae (Group B)	35 (2.2)		100% 33					100% 34									
Salmonella species (non-typhoidal)	34 (2.1)	82% 33					97% 33					94% 31	100% 31	100% 31	100% 31		100% 31
Streptococcus dysgalactiae	31 (1.9)	100% 31						96% 31									
Proteus mirabilis	30 (1.8)	83% 30				R	93% 30	75%	90% 30			83%		100% 30		100% 30	

KEY

- <70% of isolates susceptible
- 70–89% of isolates susceptible
- ≥90% of isolates susceptible
- Restricted antimicrobials
- Antimicrobial not recommended to be used in children without specialist advice
- Intrinsic resistance is present with this organism-antimicrobial combination

Notes Only species for which there are 30 or more isolates are reported
Percentages are shown only where more than 90% of isolates were tested for each organism
Susceptibility Testing Method: EUCAST

Date

ABBREVIATIONS AND ACRONYMS

AAPP	Australian Association of Pathology Practices
ACSQHC	Australian Commission on Safety and Quality in Health Care
AHPPC	Australian Health Protection Principal Committee
AMR	Antimicrobial resistance
AMRSC	Antimicrobial Resistance Standing Committee
AMS	Antimicrobial stewardship
CDS	Calibrated dichotomous susceptibility
CEC	Clinical Excellence Commission
CHRISP	Centre for Healthcare Related Infection Surveillance and Prevention
CLSI	Clinical and Laboratory Standards Institute
CMS	Clinical microbiology services
CPE	Carbapenemase producing Enterobacterales
EDW	Enterprise data warehouse
ESBL	Extended spectrum beta lactamase
EUCAST	European Committee on Antimicrobial Susceptibility Testing
HAI	Healthcare associated infection
MROs	Multidrug-resistant organisms
MRSA	Methicillin resistant *Staphylococcus aureus*
NCOPP	National Coalition of Public Pathology
NATA	National Association of Testing Authorities
NPAAC	National Pathology Accreditation Advisory Council
NSQHSS	National Safety and Quality Health Service Standards
PAQ	Performance Activity and Quality
SDS	Specialist Diagnostic Services
VICNISS	Victorian Infection Control Nosocomial Infection Surveillance
VISA	Vancomycin intermediate *Staphylococcus aureus*
VRSA	Vancomycin-resistant *Staphylococcus aureus*
VRE	Vancomycin-resistant *Enterococcus*

Level 5, 255 Elizabeth Street, Sydney NSW 2000
GPO Box 5480, Sydney NSW 2001

PHONE: (02) 9126 3600
EMAIL: mail@safetyandquality.gov.au

@ACSQHC

safetyandquality.gov.au