



An analysis of Australia's national action plan on antimicrobial resistance using a governance framework

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Abstract

Aim Antimicrobial resistance is a global health crisis which undermines the effectiveness of current modern therapeutics against microbial infections and demands effective governance at all levels to effectively address the challenge. The aim of the study was to analyse Australia's National Action Plan on antimicrobial resistance using a governance framework to facilitate discussion on the state of implementation.

Methods A governance framework was used to facilitate the systematic analysis of Australia's National Action Plan on antimicrobial resistance through iterative coding of activities listed within the working documents.

Results From the analysis, 1435 codes were created in congruence with the governance framework. The Australian National Action Plan was aligned with the Global Action Plan on antimicrobial resistance in scope of objectives. The most frequent code was research and innovation ($n = 180$, 12.5%). The least frequent theme discussed was equity. No strategic vision or objectives were outlined within any of the documents to measure implementation progress.

Conclusions Overall, Australia's governance on AMR has demonstrated siloed implementation with an absence of strategic objectives to measure progress. Governance structure, surveillance and mechanisms for stakeholder participation have been identified as potential actionable points for AMR strategy refinement that can improve overall accountability towards progress.

Keywords National Action Plan · Antimicrobial resistance · Global Action Plan · NAP · GAP · AMR

Introduction

Antimicrobial resistance and governance

The World Health Organization (WHO) has acknowledged that antimicrobial resistance (AMR) is a global threat to human health and the viability of current therapeutics (Padiyara et al. 2018; Ruckert et al. 2020; IACG 2018b). Multi-drug resistant and pan-drug resistant organisms are complex public health challenges that threaten our ability to treat simple microbial infections (Basak et al. 2016). The emergence of these organisms has been observed across human and animal health, and in the environment (White and Hughes 2019). Historical reliance on the development of novel antibiotic classes to address antibiotic resistance

(AbR) no longer offers a sustainable solution given the development of resistance outpaces the development of new antimicrobial classes (Ruckert et al. 2020; Butler and Paterson 2020). In acknowledgement of the highly interconnected nature of AMR across domains, a tripartite partnership of global leadership was formed with leadership from the WHO, Food and Agricultural Organization of the United Nations (FAO), and the Office International des Epizooties (OIE) (World Animal Health Organization) (WHO 2015). The concerted efforts have resulted in the formation of the Global Action Plan (GAP) for AMR (WHO 2015).

The objectives of the GAP foreground the prioritisation of AMR as a public health issue by calling for engagement of stakeholders, inclusivity of sectors, accountability and capacity building as responses towards AMR (WHO 2015). At the national level, the objectives of the GAP are translated into a National Action Plan (NAP) to better reflect country-specific nuances regarding AMR (IACG 2018a). Australia produced its first AMR strategy in 2015 with supporting

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implementation plans to both meet global objectives as outlined by the GAP and adjust for contextual factors (Department of Health and Department of Agriculture 2015). The Australian NAP stipulates activities in accordance to overarching objectives at a national level for national and subnational actors to achieve (Department of Health and Department of Agriculture 2015). In efforts to ensure viability of governance and efficacy of implemented activities, there is a need for on-going monitoring and evaluation to identify potential barriers and actionable lever points (Moran 2019). The success of the implementation plans is imperative to the realisation of AMR mitigation endeavours (IACG 2018a). However, governance is increasingly complex and realistic engagement remains problematic (IACG 2018a; Hannah and Baekkeskov 2020).

Challenges of antimicrobial resistance

The One Health approach to AMR governance, the recognition of the embedded interconnectedness of human, animal and environmental health sectors (Kahn 2017), presents a fundamental dilemma of conflicting interests at a national level that is compounded by the complexity of maintaining inclusivity of multiple sectors. The polysemous interpretation of the GAP and an absence of comprehensive policy assessment have resulted in inherent discrepancies within the policy and decision-making space (Hannah and Baekkeskov 2020; Naylor et al. 2021). The challenge of congruence amongst decision-makers is further compounded by documented difficulties of coordinating objectives, absence of defined structures, inconsistent political willingness, and inadequate capacity to carry out initiatives (Ruckert et al. 2020). As a resolute approach to address the challenges,

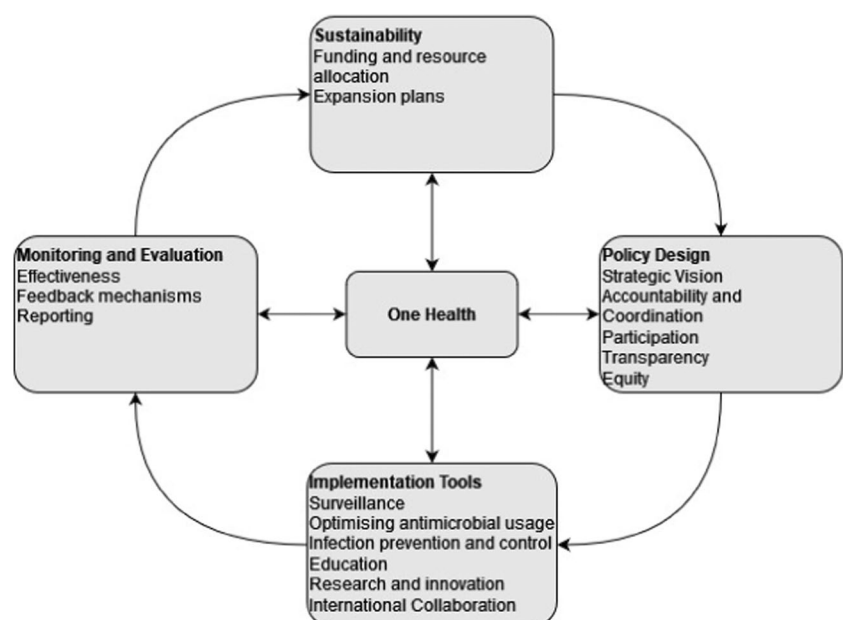
systematically analysing current national actions and facilitating subsequent discussion as to identify the strengths, weaknesses and opportunities can lead to the generation of impactful and feasible interventions.

Antimicrobial resistance governance framework

A framework that sought to classify the interrelated dynamics in the One Health approach to AMR was outlined by Anderson et al. (Anderson et al. 2019). The framework stipulates three main domains for AMR governance in policy design, implementation tools, and mentoring and evaluation as key areas (Anderson et al. 2019). Further work by Chua et al. (2021) advanced the existing framework by consolidating themes with their complementary ideological foundations. The following iteration upheld the essential definitions as previously defined for each component (Chua et al. 2021). Overall, the intention of this framework has been to promote structured discussion in the different domains of governance. A secondary function of the framework can be derived as analysing activities facilitates internal dialogue as to representation and contributors within the NAP. Figure 1 shows the adaptations made by Chua et al. (2021).

A potential case study for facilitated discussion surrounding AMR governance is Australia. Australia's governance of AMR has experience progression as evidenced by the publication of a second NAP that further expands the previous released plan (Department of Health and Department of Agriculture 2015). From the date of publication, Australia has published detailed progress reports (Department of Health and Department of Agriculture Water and the Environment 2021a; Department of Health and Department of Agriculture Water and the Environment 2017) in the activities undertaken

Fig. 1 Adapted antimicrobial resistance governance framework for evaluating National Action Plans. Chua et al. (2021)



and has detailed a new plan for 2020 and beyond (Department of Health and Department of Agriculture Water and Environment 2020). Given the comprehensive progress reports completed for Australia's AMR strategy, an opportunity is provided for insightful commentary to be made over the direction of Australia's AMR governance.

Rationale and aims

Through an analytical framework approach, governance can be objectively discussed based on activities completed. Discussion may be framed surrounding AMR governance to identify encompassing themes and identify the direction of governance. The aim of this study is to: (i) Apply the governance framework detailed by Anderson et al. (Anderson et al. 2019) to Australia's NAPs and evaluate progress and activities. The objectives are to (i) provide structured discussion on the progress and direction of Australia's AMR governance based on the activities identified and (ii) identify potential opportunities to improve the activities in the Australian NAP.

Methodology and methods

Analysis of Australia's National Action Plan implementation

At the time of publication, Australia's published reports have indicated there are two distinct timeframes, 2015 to 2019 and 2020 and beyond. As a result, coded activities were first categorised as past/current (activities completed or still ongoing), or future/planning (proposed activities) documents based on timelines specified within the documents.

To identify past activities undertaken to meet objectives as outlined by the framework, content from the 2015–2019 NAP on AMR was analysed. For current and future planned activities, the 2020 and beyond NAP was analysed. In cases where an activity or priority area was mentioned within two or more documents, the one with the most detail was included to be displayed in the summary results. The documents searched and used for content analysis are found within Table 1.

A comprehensive text-based analysis of governance documents was completed to evaluate the implementation of Australia's NAP by PD. A two-stage approach was employed in the analysis of the relevant governance documents. The first stage looked focused on assessing the compatibility of the objectives of the NAP with the GAP. The second stage employed an iterative detailed content analysis of the working documents using the domains definitions outlined within Anderson et al. (2019). The level of analysis focused on thematic alignment of the contents of the governance documents with the Anderson et al. (2019) domain definitions. If there was ideological similarity, the text was coded according to the domain in which it satisfies. The frequency of codes was recorded to identify prominence of themes throughout the documents. This process was undertaken with the understanding the inclusion of frequency provides an indication of commonality but has insignificant explanatory power with regard to the relative importance of each domain. A diagram illustrating the content analysis procedure can be seen in Fig. 2.

Data collection and storage

Content was analysed and iteratively coded using NVivo (Version 12, QSR International) by identifying

Table 1 Australian National Action Plan working documents categorised by past/current or future/planning based on the timeline specified within the documents

Past/current documents	Future/planning documents
Australia's First National Antimicrobial Resistance Strategy 2015–2019 (Department of Health and Department of Agriculture 2015)	Australia's National Antimicrobial Resistance Strategy 2020 and Beyond (Department of Health and Department of Agriculture Water and Environment 2020)
Australia's First National Antimicrobial Resistance Strategy 2015–2019: Progress report (Department of Health and Department of Agriculture Water and the Environment 2017)	One Health Master Plan for Australia's National Antimicrobial Resistance Strategy 2020 and Beyond (Department of Health and Department of Agriculture Water and the Environment 2021b)
Final Progress Report: Australia's First National Antimicrobial Resistance Strategy 2015–2019 (Department of Health and Department of Agriculture Water and the Environment 2021a)	
Implementation Plan: National Antimicrobial Resistance Strategy 2015–2019 (Department of Health and Department of Agriculture Water and the Environment 2016)	
Responding to Antimicrobial Resistance: Australian Animal Sector National Antimicrobial Resistance Plan 2018 (Department of Agriculture and Water Resources 2019)	

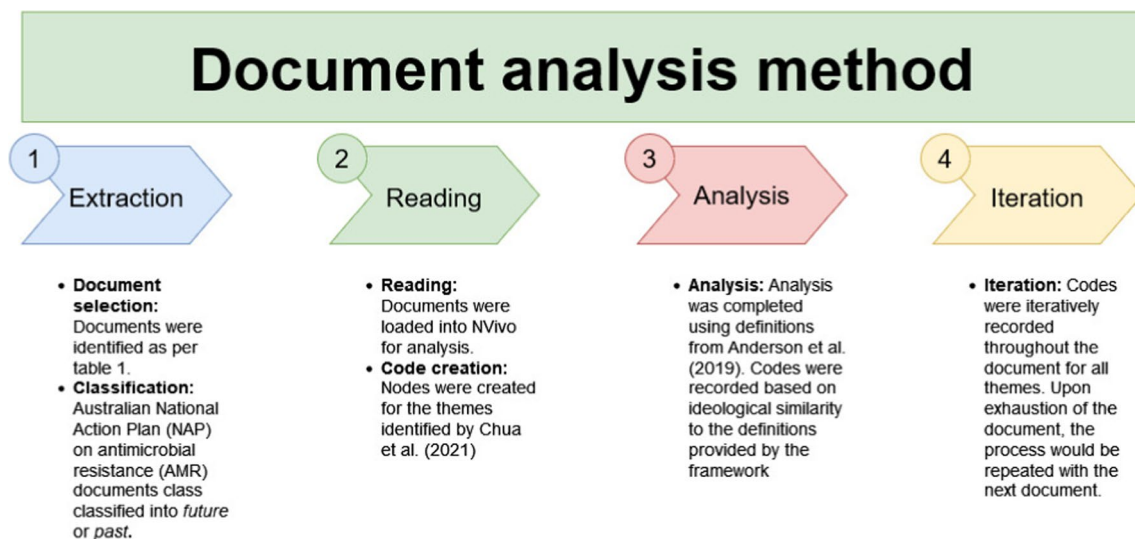


Fig. 2 Flowchart demonstrating the coding process using the framework definitions for each document

congruencies between the item described and the definition outlined within Anderson et al.'s (2019) governance framework. Nodes were created in alignment with headings detailed by Chua et al. (2021). Documents were then reviewed and coded through an iterative procedure whereby coding was conducted theme by theme.

Results

Results of document analysis using the governance framework

Overall, a total of 1435 codes were produced following the analysis of relevant AMR governance documents. The final progress report on Australia's first national antimicrobial resistance strategy represented the largest proportion of items coded ($n = 515$, 35.9%). This was followed by Australia's First national antimicrobial resistance strategy 2015–2019 progress report ($n = 286$, 19.9%). The least coded document was Australia's national antimicrobial resistance strategy 2020 and beyond ($n = 33$, 2.3%). Figure 3 presents the results of coding for all documents. Stratifying by theme, the most prominent category throughout the working documents was research and innovation ($n = 180$, 12.5%) followed by surveillance ($n = 165$, 11.5%). The least present theme was equity ($n = 14$, 0.9%) followed by future expansion and implementation ($n = 24$, 1.67%). The frequency of all codes is presented in Fig. 4.

Alignment of Global Action Plan and Australia's National Action Plan on antimicrobial resistance strategic objectives

The content analysis of priorities and strategic objectives within Australia's NAP is seen to be congruent with the GAP strategic objectives as summarised in Table 2. Whilst the GAP expresses five strategic objectives to mitigate AMR, Australia has seven. There were no absent domains not covered by the NAP. An additional priority included in Australia's NAP was the strengthening of global collaboration and regional partnerships in AMR efforts.

Alignment with antimicrobial resistance governance framework

Key activities within Australia's National Action Plan on AMR were aligned with Anderson et al. (2019) framework definitions. As a general trend, activities were continued with additions from the prior activities to future priorities. There was often repetition of activities throughout various working documents. Table 3 presents the main findings from the analysis using the governance framework. Full contents from the document analysis using the governance framework have been provided in supplementary file 1.

Policy design

Overall, 323 codes (22.5%) for items within the Australian NAP documents were categorised to policy and

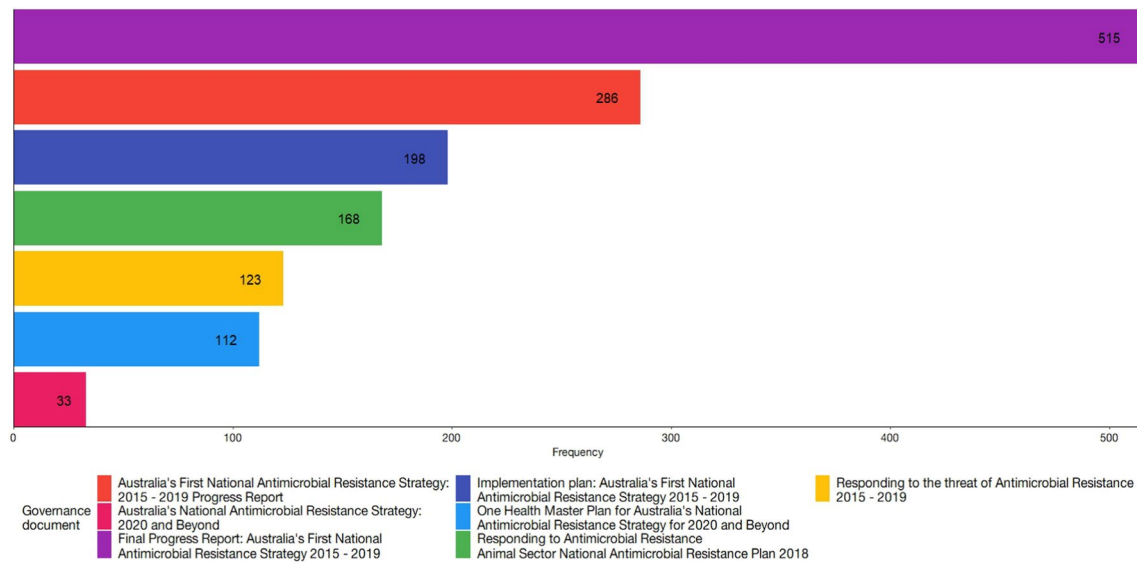


Fig. 3 Total cumulative count of codes identified within each document

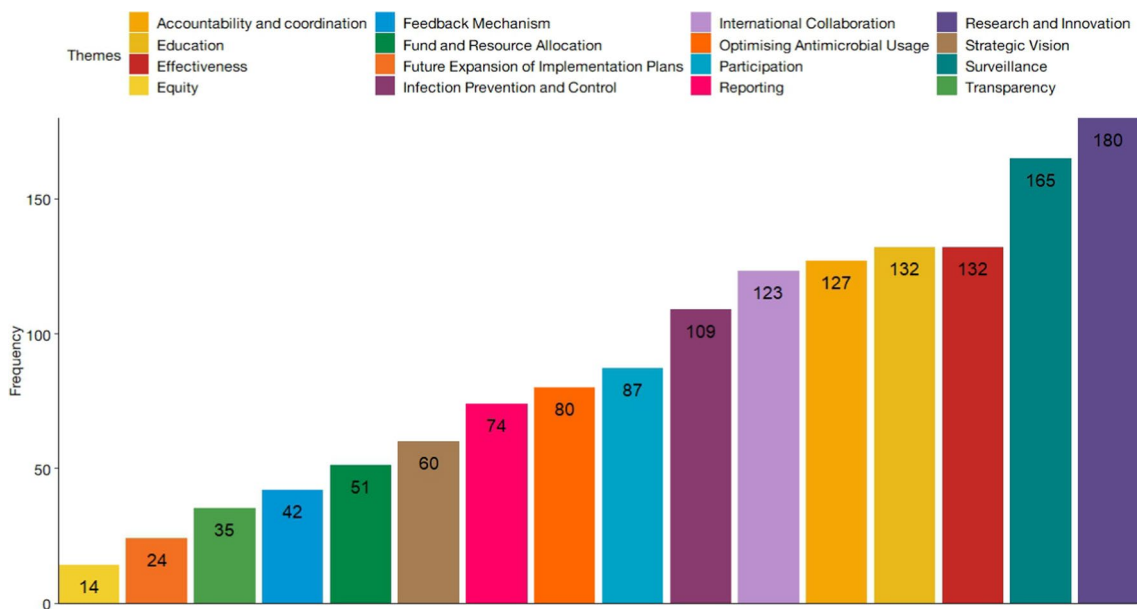


Fig. 4 The frequency distribution of themes across the Australian national plan documents using the framework definitions provided by Anderson et al. (2019)

design. There was a change in goals that were reflective of achievements made from previous activities. All the individual elements of strategic vision, accountability and coordination, participation, transparency, and equity were detailed throughout the working documents in some capacity.

Strategic vision

No numerical goal was stipulated throughout any iteration of the working documents. Strategic goals have been qualitatively described and allocation of responsibility has been delegated to relevant stakeholders. The changes noted

Table 2 Alignment of Global Action Plan strategic objectives with Australia's National Action Plan on antimicrobial resistance

GAP strategic objectives ^a	Australian NAP ^b
Improve awareness and understanding of AMR through effective communication, education and training	<ul style="list-style-type: none"> • Clear governance for antimicrobial resistant initiatives
Strengthen the knowledge and evidence base through surveillance and research	<ul style="list-style-type: none"> • A strong collaborative research agenda across all sectors • Integrated surveillance and response to resistance and usage
Reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures	<ul style="list-style-type: none"> • Greater engagement in the combat against resistance • Prevention and control of infections and the spread of resistance
Optimise the use of antimicrobial medicines in human and animal health	<ul style="list-style-type: none"> • Appropriate usage and stewardship practices
Develop the economic case for sustainable investment that takes account of the needs of all countries and increase investment in new medicines, diagnostic tools, vaccines and other inventions	<ul style="list-style-type: none"> • A strong collaborative research agenda across all sectors
Objectives not included in GAP	<ul style="list-style-type: none"> • Strengthen global collaboration and partnerships

^aGAP strategic objectives are found within the Global Action Plan on Antimicrobial Resistance by the World Health Organization (WHO 2015)

^bThe 2020 and beyond NAP for Australia (Department of Health and Department of Agriculture Water and the Environment 2021b)

GAP Global Action Plan, NAP National Action Plan

between the two documents have been detailed to reflect the growing scope of AMR with the future priority highlighting the need to encompass more classes of antimicrobials as an area of concern (Department of Health and Department of Agriculture Water and Environment 2020).

Accountability and coordination

Accountability and coordination of relevant stakeholders in AMR mitigation efforts is clearly defined by the plans. The implementation plan of 2015–2019 (Department of Health and Department of Agriculture Water and the Environment 2016) and NAP of 2020 and beyond (Department of Health and Department of Agriculture Water and Environment 2020) detail the actors that are responsible for their respective priority area. The multi-sectorial input is managed by representatives in the AMRPC Steering group with technical support given by ASTAG (Department of Health and Department of Agriculture Water and the Environment 2016).

Participation

Participation in the overall strategies have been multi-sectorial. The plans detail the engagement of animal and human health domains. Evidence of collaboration appears in AAW which endeavours to increase the public profile of AMR and relevance to society (Department of Health and Department of Agriculture Water and the Environment 2016). Furthermore, participation is still growing as reflected by the development of greater animal health stewardship groups within the food industry.

Transparency

Transparency for AMR objectives and guidelines has been highlighted to be a priority. In both AMR strategies there is an emphasis on creating and maintaining the integrity of readily available resources for all relevant clinical and non-clinical stakeholders. Data and objectives used to inform decisions are also publicly available through the establishment of the One Health AMR website.

Equity

Equity in the plans is acknowledged to encompass the capacity for which the public can receive quality therapeutics. The priorities reflected within the 2015–2019 NAP highlight the need to improve incentives to vaccinations provision and the review of antibiotic supplies in the community (Department of Health and Department of Agriculture Water and the Environment 2017). The subsequent 2020 and beyond plan consolidates the priorities by aiming to boost regulatory capacity to ensure the supply of quality antimicrobials for usage within the community (Department of Health and Department of Agriculture Water and Environment 2020).

Implementation tools

Implementation tools were the most frequent category of codes assigned to items within the NAP documents ($n=789$, 54.98%). Implementation tools are the means in which the AMR objectives are to be achieved. This includes surveillance, optimisation of antimicrobial usage, infection prevention and control, education, research and innovation, and international collaboration. Past and future priorities within the NAP highlight a commitment to building and

Table 3 Key activities of Australia's National Plan by Governance Framework Objectives grouped by Chua et al. (Chua et al. 2021) and categorised by past and future priorities

	Current and prior activities	Future priorities
Governance framework objectives		
Policy Design		
Strategic vision	<p>Progress Report 2015–2019:</p> <ul style="list-style-type: none"> • 7 focus areas with goals • Priority areas detailed with activities and timeframes for completion • No specified, numerical target for decrease in AMR • No national AMR research agenda to identify agreed research and development priorities <p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> • Detailed objectives and relevant stakeholders <p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • One Health group, Antimicrobial Resistance Prevention and Containment (AMRPC) Steering group developed for provide leadership between sectors • ASTAG bi-annual meeting to highlight emerging issues and research priorities • Coordination between larger governmental bodies: Department of Health and Department of Agriculture, Water and Resources <p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> • Stakeholders outlined in animal and human health sectors • Participation in Antimicrobial Awareness Week (AAW) to increase profile of AMR • Development of animal health stewardship groups in food and live-stock industries (Chicken meat federation, Meat & Livestock Australia, Australia Pork Limited, and Australian Chicken Eggs Limited) <p>Public access to data and reports on AMR available</p> <p>Implementation plan 2015 – 2019:</p> <ul style="list-style-type: none"> • OneHealth website for access to reliable sources on antimicrobials and AMR 	<p>Australia's NAP 2020 and Beyond:</p> <ul style="list-style-type: none"> • 20-year plan. No specified target goals for AMR or specific species • Goals to increase AMR strategy to encompass antifungals, antivirals, food, and the environment <p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Coordination of food, environment, agricultural, animal health and human health stakeholders in AMR priorities • Antimicrobial Resistance Governance Group includes Chief Medical Officer and Chief Veterinary Officer provides coordination between sectors <p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Stakeholder groups must make short-medium term goals to mitigate AMR
Participation		
Transparency		
Equity		
Implementation Tools		
Surveillance	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • Incentives to improve access to vaccines • Review supply of antimicrobials in the community • Maintain access to antimicrobials for animal health via strengthening of animal industry strategies • Promotion of research to understand economic burden of AMR <p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • AURA surveillance developed for human health to monitor trends • Proof-of-concept model for food animals developed • AGAR group for resistant isolates in human health • NAUSP/NAPS to measure AMU usage <p>Progress Report 2015 – 2019</p> <ul style="list-style-type: none"> • Pig, Chicken Meat and Chicken Egg AMR surveillance established 	<p>Australia's NAP 2020 and Beyond:</p> <ul style="list-style-type: none"> • Boost regulatory capacity to ensure access to quality antimicrobials • Easy access to guidelines for animal and human health practitioners <p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Develop national surveillance plan with potential use of genomics and sector-specific objectives to support a One Health surveillance system • Increase understanding for transmission modalities present in food chain • Opportunity to use AURA surveillance as a model for nationally coordinated surveillance system for which other sectors can add data as its available

Table 3 (continued)

Governance framework objectives	Current and prior activities	Future priorities
Optimising antimicrobial usage	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • Participation of hospitals in prescribing surveys (NAPS/NAUSP) to demonstrate compliance with National Safety and Quality Health Service Standards (NSQHS) Standard 3 • Adaptation to local stewardship programmes <p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> • Ensuring adequate access to Therapeutic Guidelines:Antimicrobials 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Strengthening appropriate authority, restriction, and access arrangements for antimicrobials • Development and promotion of resources supporting antimicrobial use in human and animal health • Build monitoring, auditing, and feedback processes into existing frameworks across relevant sectors
Infection prevention and control	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • Mandatory compliance with National Safety and Quality Health Service Standards (NSQHS) Standard 3: Preventing and controlling healthcare associated infections <p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> • Ensure adequate access to infection-specific guidelines • Improving biowaste management 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Develop, implement, and update national biosecurity management standards and ensure resources for education • Sector specific goals implemented • Continue developing biowaste management with relevant stakeholders
Education	<p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> • Increased support for human and animal health professionals in reinforcing messages with patients and clients • Ensure curriculum outcomes and competencies for AMR emphasis in training of health and veterinary professionals <p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • NPS MedicineWise MedicineInsight program to audit antimicrobial usage and assist GPs in prescribing practices • National Centre for Antimicrobial Stewardship (NCAS) conducts AMR education and training activities with annual forum for research and clinical perspectives 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Increase animal and human health professional knowledge with national standards and policies • Promotion of current resources to support appropriate use of antimicrobials • Support development of a One Health communication strategy, monitoring and evaluation, to support behavioural change
Research and innovation	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • Call for AMR research with funding with NHMRC and MRFF grants for the development of diagnostic tools, surveillance, stewardship programs, and novel therapeutics • Investment into product development partnerships (PDP) within region • National Research Agenda established to identify gaps and map current state of AMR <p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> • Identify and monitor behavioural determinants in antimicrobial usage • Improvement of current health services to optimise AMU 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Set a flexible national antimicrobial resistance research and development agenda • Coordination of shared research and development activities • Maintenance and gathering of funding for further research

Table 3 (continued)

Governance framework objectives	Current and prior activities	Future priorities
International collaboration	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> Assurance Australian surveillance is compatible and can contribute to the WHO GLASS program and OIE global database in animals International research collaboration initiatives including Regional contribution to animal health, stewardship, and PDP initiatives within the Asia–pacific region <p>Implementation plan 2015–2019:</p> <ul style="list-style-type: none"> Assistance in development of tools and resources for the Asia–pacific region Support upskilling within the region Support control efforts in malaria, tuberculosis, food safety and animal health Financial and physical contributions contribution to global AMR efforts 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> Contribution to knowledge of AMR in animal health in Southeast Asia and Pacific region Support control efforts in Southeast Asia and Pacific regions Support food safety initiatives Participation in global initiatives for mitigate AMR Continue contributing to GLASS and OIE global databases
Monitoring and Evaluation Effectiveness	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> Monitoring of AMU and AMR resistance using AURA surveillance Monitoring of AMU in representative sample feedlots Regular review of AMS system and AMS programs Centre of Research Excellence (CRE) in Reducing Healthcare Associated Infection (RHAI) examines cost-effectiveness of IPC programs Regulatory arrangements need to be improved and there is a current need to map regulatory framework against the antibiotic supply chain and AMR trends in human and animal health 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> Review current list of priority organisms and associated antimicrobials for human and animal health surveillance Continuation of current initiatives
Feedback Mechanism	<p>Australia's NAP 2015 – 2019:</p> <ul style="list-style-type: none"> Australian Government (Department of Health, Department of Agriculture, Water and Resources) One Health AMR website allows for stakeholders can ask questions and provide feedback regarding projects NPS MedicineWise <i>Reducing Antibiotic Resistance Program</i> allows for clinician feedback AURA surveillance also highlights trends with changes with AMR interventions <p>Implementation plan 2015 – 2019:</p> <ul style="list-style-type: none"> ASTAG provides quality scientific and clinical advice based on evidence AMRPC Steering group engages in monitoring of progress of activities 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> Creation of monitoring, auditing, and feedback processes into existing frameworks across relevant sectors
Reporting	<p>Australia's NAP 2015 – 2019:</p> <ul style="list-style-type: none"> AURA Surveillance with constituent data repositories (only human health) 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> AURA Surveillance with constituent data repositories

Table 3 (continued)

Governance framework objectives	Current and prior activities	Future priorities
Sustainability		
Fund and resource allocation	<p>Australia's NAP 2015–2019:</p> <ul style="list-style-type: none"> • Targeted call for research under Medical Research Future Fund • Human health has over \$90 million in active NHMRC grants 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Investigate ways to improve funding for research and development including private and co-funding opportunities • Publish reports on AMU and AMR to measure societal costs and benefits
Future expansion of implementation plans	<p>Australia's NAP 2015–2019</p> <ul style="list-style-type: none"> • Creation of One Health surveillance system with the inclusion of companion animals, that monitors AMU and AMR • Development of future targets and indicators based on maturation of surveillance system and data • Expansion of understanding of AMR in the environment 	<p>One Health Master Action Plan – 2020 and Beyond:</p> <ul style="list-style-type: none"> • Currently on-going

Current and Prior Activities = Completed objectives or on-going initiatives. Future priorities = Priorities listed within the 2020 and beyond National Action Plan on antimicrobial resistance.

AAW = Antimicrobial Awareness Week. AGAR = Australian Group on Antimicrobial Resistance. AMR = Antimicrobial Resistance. AMRPRC = Antimicrobial Resistance Prevention and Containment, AMU = Antimicrobial Use. ASTAG = Australian Strategic and Technical Advisory Group. AURA = Antimicrobial Use and Resistance. GLASS = Global Antimicrobial Resistance and Use Surveillance System. GP = General Practitioner. NAP = National Action Plan. NAPS = National Antimicrobial Prescribing Survey. NAUPS = National Antimicrobial Utilisation Surveillance Program. NPS = National Prescribing Service. NSQHS = National Safety and Quality Health Service. OIE = Office International des Epizooties. WHO = World Health Organization

maintaining capacity to address AMR through surveillance, education and research (Department of Health and Department of Agriculture Water and the Environment 2016, Department of Health and Department of Agriculture Water and Environment 2020).

Surveillance

Surveillance aims at gathering and evaluating the current evidence of antimicrobial usage and AMR within Australia. Past activities have established AURA surveillance to monitor AMR in human health (Department of Health and Department of Agriculture Water and the Environment 2016). The surveillance system is supported by established data repositories with AGAR and NAUSP/NAPS. Furthermore, there is opportunity for the expansion of AMR surveillance capacity in non-human domains with the formation of animal health surveillance in food animals. Future priorities have expressed desire for expansion into non-human health domains and further refine surveillance methodology and its continued use as a monitoring and evaluative tool.

Optimising antimicrobial usage and infection prevention and control

The recognition of poor hygiene, sanitation and inappropriate antimicrobial usage, as drivers of AMR has been similarly expressed through the stewardship priorities detailed within both plans. Past priorities have been centred around assuring compliance with national health service standards and adequate dissemination of relevant guidelines. Future priorities in both reflect a growing need to increase regulatory power in both antimicrobial usage and biosecurity management standards.

Education

Education has been emphasised in both documents to be centred around support for animal and human health practitioners. This includes support in reinforcing messages with patients and clients, increasing knowledge of national standards and policies, and the modifying educational curriculum competencies to emphasise AMR. Initiatives within this area include analysis of general practitioner prescribing patterns and training activities and forums for research and clinical perspectives.

Research and innovation and international collaboration

The emphasis of research and innovation in the context of AMR has been identified as a priority throughout the documents as evidenced by the minimal variation in priorities over time. Initial priorities and objectives were centred

around obtaining funding for research in the development of diagnostic tools and novel therapeutics, improvement of surveillance, and evaluation of stewardship programs. Subsequent priorities have reflected the notion for research in the need for coordination of research and development activities, flexible national AMR research and development agenda, and sustainability of funding. International collaboration builds upon the national research generated. The priorities included within this domain are to disseminate and contribute to overall AMR understanding within the South-east Asia and Pacific regions. Other areas encompassed by international collaboration include the continued assurance for national surveillance data to be used by global surveillance programs.

Monitoring and evaluation

Categorisation of monitoring evaluation codes were less common ($n = 248$, 17.2%). Monitoring and evaluation focused on mechanisms to gather evidence from implementation processes and inform decision-making procedures. AURA surveillance was commonly referred to as the mechanism to relay feedback back to constituents.

Effectiveness, reporting and feedback mechanisms

Effectiveness and feedback mechanisms are important to inform the decision-making processes within AMR strategies. The 2015–2019 NAP focused on establishing mechanisms for feedback which allowed for service evaluation and monitoring of trends in AMU and AMR. The main source of data is that of the AURA surveillance system. Future priorities are centred around the consolidation of such practices into relevant frameworks and review of current evidence.

Sustainability

Sustainability represented the least frequent category of codes assigned to items ($n = 75$, 5.22%). The domain for sustainability describes mechanisms to maintain current stewardship efforts. The domains measured by sustainability are funding and resource allocation and expansion plans.

Funding, resource allocation and expansion plans

The allocation of funds and resources has been briefly mentioned through the initial NAP (Department of Health and Department of Agriculture 2015). Initial funding for AMR activities and objectives were funded by research call and grants. There was emphasis for greater financial sustainability as mentioned by the 2020 and beyond NAP (Department of Health and Department of Agriculture Water and Environment 2020). Expansion plans have focused on

understanding the determinants of AMR in the environmental, plant and food sectors and integrating animal and human health surveillance systems.

Discussion

The purpose of this study was to assess the past and future priorities of Australia's NAP on AMR using a governance framework provided by Anderson et al. (Anderson et al. 2019). The framework has provided a structural guide to assess NAP contents and facilitate the identification of opportunities and general trends in governance. The analysis has highlighted research and innovation as a top priority within the AMR strategy. As the most mentioned theme, the prominence of research and innovation as a theme suggests there has been a concerted focus on understanding AMR. The implication of the theme's prominence indicates progress may be constrained by the absence of a consolidated evidence base for strategic objectives to be constructed from. The use of progress reports has also been demonstrated to be effective in facilitating discussion to ascertain the current state and direction of governance and identify potential levers for improvement.

The absence of strategic vision and objectives

As an overall trend, there is evidence to argue that general political apathy has been exercised towards AMR within Australia resulting in the absence of strategic objectives. Although the priorities outlined within the NAP (Department of Health and Department of Agriculture 2015) are congruent with the objectives of the GAP (WHO 2015), there is considerable questionability in Australia's progress. The absence of strategic vision and objectives prohibits any insightful commentary to be made towards stewardship and initiative efficacy. The activities listed within the working documents superficially cover a considerable breath but lack any sector-specific accountability through the delegation of objectives. The superficiality is evidenced by the dichotomous nature of activities such as creating proof-of-concept models and program implementation (Department of Health and Department of Agriculture Water and the Environment 2016) without associated feedback mechanisms to evaluate effectiveness. Ideally with political willingness and depth, AMR stewardship mimics Hannah and Baekkeskov's (2020) observation of the United Kingdom's NAP where the authors detail clear dissemination and delegation of measurable, sector-specific goals. The absence of strategic vision limits insight regarding the current direction of AMR governance within Australia and requires urgent attention.

A noteworthy point of discussion from the analysis is Australia's organic approach to AMR governance and

surveillance. Within the elements of policy design, there is an absence of legally binding agreements between stakeholders. Instead, the mechanisms identified suggest a greater emphasis on voluntary participation and partnerships between groups as evidenced by the formation of AMRPC and ASTAG (Department of Agriculture and Water Resources 2019; Department of Health and Department of Agriculture 2015; Department of Health and Department of Agriculture Water and the Environment 2017; Department of Health and Department of Agriculture Water and the Environment 2021a; Department of Health and Department of Agriculture Water and the Environment 2016; Department of Health and Department of Agriculture Water and the Environment 2021b; Department of Health and Department of Agriculture Water and Environment 2020). The contrast to the voluntary nature is active governance outlined by the goal-orientated and legislation supported approach found within Europe (Birgand et al. 2018). To demonstrate, a commonality between the German (Birgand et al. 2018) and Australian NAP (Department of Health and Department of Agriculture 2015) is the creation of AMR surveillance systems. Within the Australian context, AURA has been established through voluntary contributions by participating hospitals (ACSQHC 2021). In Germany, legal power provided by the Protection Against Infection Act (IfSG) necessitates mandatory surveillance by all hospitals (Birgand et al. 2018). The difference in governance draws discussion surrounding the efficacy of the respective approaches. As an interesting point of contention, the macroscopic structure of governance and outcomes of NAPs have yet to be thoroughly examined throughout literature. A potential implication of this finding may necessitate further discourse surrounding the benefits and feasibility of constructing legislation as a foundation for AMR stewardship within Australia.

The need for mechanisms in coordinating and holding accountability in Australia's antimicrobial resistance strategy

Accountability and coordination have been emphasised as foundational elements of Australia's AMR strategy by the frequency of mentions within the NAP documents. However, further examination of activities documented in the working documents using the governance framework reveal the macroscopic focus of programs are generally self-contained (Department of Health and Department of Agriculture 2015; Department of Health and Department of Agriculture Water and the Environment 2017; Department of Health and Department of Agriculture Water and the Environment 2021a; Department of Health and Department of Agriculture Water and the Environment 2016; Department of Health and Department of Agriculture Water and the Environment 2021b; Department of Health

and Department of Agriculture Water and Environment 2020). Fundamentally, this suggests policy and AMR stewardship activity implementation have been done in a siloed manner. The implications of the isolated approach detracts from expressed objectives of the GAP for a One Health approach (WHO 2015) and contradict expressed interests for concerted action encompassing multiple sectors within the working documents (Department of Health and Department of Agriculture 2015; Department of Health and Department of Agriculture Water and the Environment 2021b). A pragmatic explanation for the contradiction is the absence of an interfacing mechanism between stakeholders. Currently, there is no overarching governing body or working group with the capability to contend with the varying interests of stakeholders and set common objectives. This finding reinforces the need to develop cross-sector communication mechanisms for facilitating connections between stakeholders.

An intriguing observation derived from the analysis of NAP documents posits that the paucity of sectoral interfaces could be attributed to the adoption of a non-binding governance approach. An illustrative example is the isolation AMR and AMU data necessary to develop a One Health surveillance system. AMR and AMU data from the animal health sector is a necessary component to achieve the NAP objective for One Health surveillance (Department of Health 2019; Department of Agriculture and Water Resources 2019; Department of Health and Department of Agriculture 2015; Department of Health and Department of Agriculture Water and the Environment 2017; Department of Health and Department of Agriculture Water and the Environment 2021a; Department of Health and Department of Agriculture Water and the Environment 2016; Department of Health and Department of Agriculture Water and the Environment 2021b; Department of Health and Department of Agriculture Water and Environment 2020). As it remains, integration of data sources has not been attempted and no tangible One Health system has been conceptualised. Wider literature provides explanations of financial incentives associated with agricultural antibiotic use (Mitchell et al. 2020) or ambivalence to the subject matter (Golding et al. 2019) as barriers to data sharing. From a governance perspective, the development of an organisation with legislative endorsement to rigidly define and disseminate common goals across the different sectors may act as impetus to overcome the barriers. In a theoretical capacity, this organisation should be capable of deliberating through sector-specific interests, delegating accountability to stakeholders, and act as a facilitator towards One Health surveillance. Through this example, the benefit of binding governance should be explored as an avenue to improve progress in the overall AMR mitigation strategy.

Antimicrobial resistance surveillance: the key for strategic vision

The enhancement of AMR surveillance is crucial to facilitating improved political engagement by delineating strategic objectives. Surveillance of AMR has been emphasised within the working documents as a fundamental element of governance. Through its function, public health surveillance systems provide data to identify trends and monitor progress to generate action and inform refinement procedures (Wolicki et al. 2016). Improving AURA will strengthen AMR enumeration endeavours and provide a foundation for action to be generated. However, the materialisation of goals has yet to be demonstrated in any capacity suggesting the absence of improvement processes. Indeed, the enumeration of AMR as impetus for action has been acknowledged by AURA annual reports (ACSQHC 2021; ACSQHC 2016). Explanations offered by AURA reports suggest the naivety in surveillance structure and the construction of goals being contingent on further improvement of the system (ACSQHC 2021; ACSQHC 2016). By strengthening surveillance efforts through addressing the concerns, the potential benefit will facilitate the generation of strategic vision and potentially allow for lesser discussed themes such as equity to be targeted. This promotion of strengthened surveillance has a cascading effect whereby it may potentially incite heightened political willingness with progress being measurable.

Potential opportunities for implementation in the National Action Plan

Under-representation of sectors presents a difficult challenge to implementing a holistic AMR strategy. There exists a disconnect between the desired interconnectedness between health sectors and discernible outputs from implementation of the NAP. The results of the analysis indicate there is an absence of activities which demonstrate any significant level of integration beyond speculative conceptualisation. For example, amongst NAP governance documents there exists a unanimous sentiment to emphasise a One Health approach in surveillance (Department of Agriculture and Water Resources 2019; Department of Health and Department of Agriculture 2015; Department of Health and Department of Agriculture Water and the Environment 2017; Department of Health and Department of Agriculture Water and the Environment 2021a; Department of Health and Department of Agriculture Water and the Environment 2016; Department of Health and Department of Agriculture Water and the Environment 2021b; Department of Health and Department of Agriculture Water and Environment 2020). The private healthcare sector and animal health AMR data remains to be integrated despite being crucial elements to monitoring AMR through a One Health paradigm (Department of

Health and Department of Agriculture 2015; Department of Health and Department of Agriculture Water and Environment 2020; Department of Health and Department of Agriculture Water and the Environment 2021a; ACSQHC 2021). The difficulty in engaging stakeholders in consolidation efforts of data, and the sectors in general, may be a consequence of the current governance structure possessing inadequate legislative remit to facilitate integration. A solution to enable remit over these sectors requires strategic objectives to be established. With strategic objectives established, auxiliary systems and processes can be implemented to achieve the desired interconnectedness through procedures that are structured in a manner that deliberates stakeholder accountability. Indeed, the solution is simplistic but, requires political willingness to commit and the refinement of current monitoring and evaluation systems to enumerate goals.

Strengths and limitations

The research completed has its own strengths and weaknesses. A strength of the research is the use of Anderson et al.'s (2019) framework to analyse Australia's NAP on AMR. The framework has two innate benefits. The first is it allows for elements within the working documents to be systematically analysed against definitions. Secondly, the framework was specifically developed for AMR governance, so the usage of the framework facilitates a holistic view of the status of AMR governance.

The limitations of the study lie within the text-based analysis. The coding of activities is dependent on the interpretation of the researcher which has the potential to produce bias. However, the use of the framework allows for a foundation for activities to be coded and as such limit the bias. Another limitation of the work completed is the exclusion of academic literature. As the work was primarily focused on the analysis of governance documents, it is possible for other academic literature surrounding Australia's AMR governance to be excluded. Despite the limitations, this study serves to facilitate discussion surrounding Australia's AMR strategy.

Conclusions and further work

The Australian NAP on AMR has been found to be in alignment with the GAP through the analysis using Anderson et al.'s (2019) framework. The discussion facilitated by the framework has identified the misalignment of the desired, idealistic One Health approach with what is presently actioned. Noteworthy findings from the study suggest there is an inherent need for strategic indicators and objectives to be materialised to truly

measure progress in AMR mitigation efforts. Whilst the conceptualisation of strategic vision is necessary, in the current state it is an idealistic hypothetical. There exists further complexity in the need for the development of mechanisms which aim to overall coordinate stakeholders and facilitate deliberation, refinement of AURA surveillance and agreement on the responsibilities of One Health. Furthermore, there are inherent opportunities to explore overall governance and understand if current political structures are adequate for delegating accountability and improving coordination amongst relevant stakeholders.

The study's findings can be translated into actionable recommendations to strengthen Australia's AMR governance. The recommendations are to:

- Develop strategic objectives and goals that are a necessity for evaluating and monitoring the current direction and effectiveness of current and future actions.
- Further refine and develop Australia's AMR surveillance system needs to materialise objectives under the premise of One Health.
- Develop cross-sector interfacing mechanisms for which stakeholders deliberate on responsibilities and accountability.
- Examine the political and governance structures that enable capacity for initiatives and action.

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Declarations

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