BMJ Open

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a qualitative and context analysis

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-082156
Article Type:	Original research
Date Submitted by the Author:	15-Nov-2023
Complete List of Authors:	Allel, Kasim; London School of Hygiene & Tropical Medicine; University of Exeter, Faculty of Health and Life Sciences Fernandez-Miyakawa, Mariano; Instituto Nacional de Tecnología Agropecuaria Gaze, William; University of Exeter, Faculty of Health and Life Sciences Petroni, Alejandro; Instituto Nacional de Enfermedades Infecciosas Corso, Alejandra; Instituto Nacional de Enfermedades Infecciosas Luna, Federico; Independent researcher Barcelona, Laura; Comisión Nacional de Control de la Resistencia Antimicrobiana Argentina, AMR policy research group; Full list of authors provided at the end of the manuscript upon acceptance Boden, Lisa; University of Edinburgh Royal Dick School of Veterinary Studies Pitchforth, Emma; University of Exeter, Faculty of Health and Life Sciences
Keywords:	Public health < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a qualitative and context analysis

Kasim Allel[1,2], Mariano Fernandez-Miyakawa[3], William Gaze[1], Alejandro Petroni[4], Alejandra Corso[4], Laura Barcelona[6], Federico Luna[7], AMR policy research group Argentina†, Lisa Boden[5], Emma Pitchforth[1,*]

[1] Faculty of Health and Life Sciences, University of Exeter, Exeter, UK
[2]Department of Disease Control, London School of Hygiene and Tropical Medicine, London, UK
[3] Instituto Nacional de Tecnología Agropecuaria Castelar, Buenos Aires, Argentina
[4]Servicio Antimicrobianos, Instituto Nacional de Enfermedades Infecciosas, ANLIS "Dr Carlos G. Malbrán", Buenos Aires, Argentina.
[5]Royal School of Veterinary studies, University of Edinburgh, Edinburgh, UK
[6]Comisión Nacional de Control de la Resistencia Antimicrobiana, Buenos Aires, Argentina.
[7] Independent researcher, Buenos Aires, Argentina.
† Full list of authors provided at the end of the manuscript upon acceptance
* Corresponding author: e.pitchforth@exeter.ac.uk. College of Medicine and Health, University of Exeter, Exeter EX1 2HZ, UK.

ABSTRACT

Introduction. Gaps in antimicrobial resistance (AMR) surveillance and control, including implementation of national action plans (NAP), are evident internationally. Countries' capacity to translate political commitment into action is crucial to cope with AMR at the human-animal-environment interface.
Methods. We employed a two-stage process to understand opportunities and challenges related to AMR surveillance and control at the human-animal interface in Argentina. First, we compiled the central AMR policies locally and mapped vital stakeholders around the NAP and the national commission against bacterial resistance. Second, we conducted qualitative interviews using a semi-structured questionnaire covering stakeholders' understanding and progress towards AMR and NAP. We employed a mixed deductive-inductive approach and used the constant comparative analysis method. We created categories and themes to cluster sub-themes and determined crucial relationships among thematic groups.
Results. Crucial AMR policy developments have been made since 1969, including banning colistin in food-producing animals. In 2023, a new government decree prioritises AMR following the 2015 NAP launch. Our qualitative analyses identified six major themes for tackling AMR: (I) Cultural factors and socio-political country context hampering AMR progress, (II) Fragmented governance, (III) Antibiotic access, usage, and dispensing (IV) AMR knowledge and awareness throughout stakeholders, (V) AMR control and surveillance, (VI) NAP, and (VII) External drivers. We identified a fragmented structure of the food production chain, poor cross-coordination between stakeholders, limited surveillance and regulation among food-producing animals, and geographical disparities over access, diagnosis and treatment. The country is moving to integrate animal and food production into its surveillance system, with most hospitals experienced in monitoring AMR through antimicrobial stewardship programs.
Conclusion. AMR accountability should involve underpinning collaboration at different NAP implementation levels and providing adequate resources to safeguard long-term sustainability. Incorporating a multisectoral context-specific approach relying upon different One Health domains is crucial to strengthening local AMR surveillance.
Keywords: Antimicrobial resistance, antibiotic use, Argentina, one health, low-and-middle income countries

What is already known on the topic?
►Stronger administrative structures to ensure the sustainable transition of AMR strategies and identified NAP goals from policy to practice remain a major obstacle to progress, especially in low-and-middle income countries

What this study adds?
► Organisational barriers within stakeholder groups and the wider community—including the complexity of cross-sectoral communication, data access and interpreting information, fragmented routes for collaboration, and population awareness— have resulted in challenges towards establishing better AMR control and surveillance in Argentina
► AMR surveillance and control in food-producing animals outlines puzzled strings; there are limited antimicrobial stewardship programs and highly disintegrated food-production chains among meat production, specifically cattle.
►Potential beneficial opportunities presented, include using agricultural products (e.g., tannins) as an antibiotic replacement and the new law on AMR as an established government priority, should be fostered and capitalised for improvement towards AMR policy.

How this study might affect research, practice, or policy?
► Limited governance structures and system barriers, predominantly affected by political turn and contextual factors, play a central role in progressing towards AMR adaptation, mitigation, and preparedness.
► Effective jointly-designed strategies utilising a One-Health holistic approach to engaging the wider community, including a whole food-chain perspective, are essential to improve conversion to effective implementation of AMR policies

INTRODUCTION

Antimicrobial resistance (AMR) represents a global public health threat driven by interrelated human, animal and environmental factors and requires multidisciplinary and cross-government action(1-3). National and international endeavours have collectively helped reduce AMR over recent years(4). The World Health Organisation (WHO) launched the Global Action Plan on AMR in 2015, soliciting countries to elaborate a National Action Plan (NAP) to confront AMR (5). Similar initiatives have come through the United Nations (UN)(6) and the European Commission (7) to develop multisectoral strategies involving human and animal health to fortify innovation stages and shape the global health agenda towards AMR NAPs. Despite 152 countries having published NAPs(8), challenges exist in implementing NAPs locally, limiting the progress towards addressing AMR(9). Contrasting cultures, policies, incentives and behaviours of relevant sectors and stakeholders have made the implementation of NAPs an arduous process(4). For instance, the lack of surveillance and epidemiological data, the variety of methods used to collect data and the limited understanding of the clinical and social burden of AMR pose challenges for the consummation of NAPs internationally(10). Locally, policy design, including governance and stakeholder involvement and cross-sectoral coordination, are critical to fulfilling the NAP's objectives while adapting the alternating demands of each local subgroup(4, 11).

Recent literature suggests that low- and middle-income countries (LMICs) are likely to face the most significant challenges in NAP implementation(4, 12-20). Among LMICs in Asia, a review found that accountability —a sense of ownership of organisations or people requiring responsibility to other stakeholders— has been omitted in most NAPs(4). Indications of unmet goals and lack of clarity in the stakeholders' role remain significant obstacles to AMR prevention and control (14, 15, 18). In the Americas, 29 countries (89%) have reported developing NAPs to combat AMR since the beginning of 2020 (21).However, most countries including Argentina, have not focussed sufficiently yet on One Health components; active surveillance of human health is not integrated with surveillance in animals or the environment(4, 18). Using a One Health approach is critical for effective NAP implementation because it optimizes the health of different sectors, including natural environments which play a crucial role in AMR evolution and transmission, while preventing zoonotic diseases and improving food safety and security. Argentina implemented a multisectoral NAP strategy in 2015(22), and progress has been made, including regulations prohibiting colistin usage in 2019 and antibiotics as growth promoters among livestock(23, 24). A recent study measuring global response to AMR by employing a governance framework on NAP contents highlighted that Argentina can make improvements in standards to control AMR (18). The study stated Argentina's moderate efforts towards monitoring and evaluating AMR in humans and animals and modest AMR policy design (i.e., lack of accountability). However, the study used the Tripartite Antimicrobial Resistance Country Self-Assessment (TrACSS) survey, which could be influenced by the exclusion of publicly and privately accessible documents relevant for AMR monitoring locally, and it lacked data sources that could invite heterogeneity (e.g., interviews with multiple experts/ stakeholders), all of which are considerably important in LMICs. A more direct way to explore Argentine's response to AMR policy is to obtain current data from the stakeholders involved.

This study aims to better understand the stakeholder and regulatory landscape and the challenges and opportunities Argentina faces in implementing its NAP. We examined Argentina's case because it is one of the first countries to have a NAP and has a vast experience in AMR surveillance in the human sphere, which might indicate a good model for the Latin American region. We use the One Health (25) approach to assess policy priorities in action plans, and the governance framework (26) to evaluate interrelated dynamics between the One Health actors to improve critical areas: policy design, implementation tools, and monitoring and evaluation. The need to provide technical and financial support for implementing One-Health integrated NAPs has been recognised globally through the AMR Multi-Partner Trust Fund. Still, the donor base for this remains a few countries(27, 28). Global action may be based on shared goals, but there is a further need to understand the needs and priorities enabling or hindering those actions at national levels. We explore Argentina as a case-study to understand the complex landscape.

METHODS

Study aims and setting

This article draws on literature and qualitative interview data from a study conducted in Argentina between September 2022 and February 2023. Argentina is an upper-middle income country that is endowed with highly fertile soils and great potential for renewable energy (hydroelectric, wind and solar energy)(29). It is a major food-producing country with an extensive agriculture and livestock industry; however, the country faces a high fiscal deficit with poverty and inflation rates of about39% and 94.8% in 2022, respectively. The project's scope was to comprehend the context of AMR policy locally and among relevant stakeholders towards AMR control

and surveillance, focusing on food-producing animals. Relevant stakeholders included government (those with political/administrative duties and those having scientific-technical functions), academic, international, NGOs, and private (chamber of producers, commercial laboratories and producers) institutions.

Study design

We divided our study into two stages. First, we explored the legal framework within the AMR NAP scope and mapped vital organisations, particularly related to food-producing animals (i.e., cattle, chicken and pigs). We searched the literature, including government documents, academic articles, stakeholder's websites, and grey literature, to capture the most relevant AMR policies and critical actors and their role over time. Expert knowledge was consulted. Second, after identifying and mapping relevant stakeholders, we conducted qualitative semi-structured interviews between September 2022 and January 2023 to gather information on stakeholder's views and experiences of NAP implementation, the role of different organisations and nature of coordination and decision making between organisations. Interviews were held in person or online lasting 45 to 90 minutes and were conducted by a bi-lingual (English-Spanish) social scientist. The stakeholder mapping developed in stage 1 was used to inform recruitment. A range of participants were sought from government, private and academic organisations. Potential participants were sent a formal request letter via email inviting them to take part in the interview study. Semi-structured interviews were performed using an interview topic guide designed to explore five main items, with questions and objectives detailed below (Box 1). Stakeholders were encouraged to discuss their own views openly. After obtaining informed consent, interviews were audio-recorded in Spanish and transcribed and translated to produce English transcripts. Transcripts were checked for accuracy by the interviewer and anonymised. The consent form, participant information sheet, and participants interview topic guide are included in the online supplementary material.

Box 1. Interview's main sections including objectives, items and questions

I. Participant's current role. These questions seek to understand what experiences our participants have and how they might be relevant to implementing the NAP to combat AMR.

<1> What your job/role is, and what tasks do you and your organisation mainly perform?
<2> What are your (or department/organisation) interests and responsibilities concerning AMR?

II. Understanding AMR among stakeholders. This group of questions aim to understand employees' and organisations' views on AMR; its main drivers, change overtime, and priority areas within organisations to help tackle AMR.

<1> How do you feel (or what are your personal and department's concerns) about antimicrobial resistance in humans? Does that differ from antimicrobial-resistance in animals or any other source, including the environment (how)?
<2> Do you think the view about antimicrobial-resistance has changed over the years? How?
<3> What are the priority areas within your organisation to increase AMR awareness and to comply with the NAP? Do you feel your organisation helps to contribute to any of the areas detailed in the national plan (how, which)?
<4> What are the cornerstones for increasing AMR awareness while complying with the NAP within your organisation?
<5> Which cornerstones do you feel are most relevant within your department (organisation)? Why?

III. Information channels and flow within stakeholders/departments. These questions attempt to improve organisations decision making towards better AMR surveillance by identifying how the information is channelled within and between organisations.

<1>How do you feel about AMR-related information and communication flow within your organisation and among all stakeholders?
<2> What do you think about communicational interactions, networking, and educational or getting-to-know instances between your organisation and other stakeholders and within departments of your organisation? Would you believe (and how) that the information pathways vary between specific organisation's fields/disciplines, public/private institutions, or certain other groups?
<3> Could you identify which organisms (organisations), and how, are involved in your organisation's decision making and strategy towards improving AMR surveillance and control?

IV. Challenges in the implementation of the national action plan. These questions attempt to answer what factors or challenges might be key to increasing AMR awareness and improving AMR surveillance in food-producing animals and agriculture.

<1> Do you feel there is any challenge that your organisation faces in complying with the AMR NAP and helping contribute to better animal AMR surveillance? (Political priorities, monetary and non-monetary resources, communication, etc) What are the most important and what can be done to overcome these challenges if your organisation could prioritise resources to contribute more to AMR surveillance in animals?
<2> Who else do you think has a critical role in helping with AMR surveillance in animals from the pool of stakeholders?

V. Future and other considerations. These questions aim to understand future steps to be taken within the industry and different key members to tackle AMR.

<1> How organisations might be helped to enhance cross-sectoral communication and teamwork? How can we ensure organisations make progress and collaborate to meet NAP criteria?
<2> Which organisations, at the national and international levels, do you think are most important to talk to and direct efforts to address AMR knowledge gaps? Does the list differ from that necessary to improve the NAP?
<3> Is there anything else important that you might want to share with us or that we are missing in the current interview?

Data analyses

First, we systematically organised Argentina's main AMR regulations using a timeline frame and drew a map to delineate the main stakeholders directly or indirectly supporting the National Commission for the Control of Antimicrobial Resistance (CoNaCRA, "*Comisión Nacional de Control de la Resistencia Antimicrobiana*") directed by the Coordination on Appropriate Use of Antimicrobials of the Ministry of Health, as the commission articulating the efforts for the implementation of the NAP. Second, we employed a systematic qualitative thematic analysis of the interviews using a mixed deductive-inductive approach(30); deductive because it was guided by interview questions from a general topic to a more specific, but inductive as we draw data-driven conclusions derived from bottom-up reasoning. We followed the constant comparative method(31) to favour participants' comparability. Information and open data were classified into themes and subgroups using a coding scheme. Two investigators independently recorded the interviews (KA, EP) using Dedoose software (V.8.0.35, Los Angeles, California: Socio Cultural Research Consultants, LLC).Researchers frequently met to reconcile differences in code application and distinguish new themes emerging from the data analyses. After consolidating new themes, all interviews were re-coded using an updated scheme (see online supplementary material). Subsequently, we identified interconnections between theme data to ascertain larger categories into which themes were clustered. For quotations, we report descriptive characteristics, such as organisation type (academia, government, private, production system), sex at birth, and assigned a random number to each interviewee. Quotes are reported in the text and Tables as "Q" followed by ordered numbers. We reported descriptive statistics to facilitate reader's understandability from whom quotations were drawn and favour studies' transparency while maintaining the anonymity of participants. Whether themes presented challenges or opportunities for AMR policy, we calculated the proportion of interviews mentioning each theme as a challenge or opportunity. We showed these proportion calculations in six theme-specific squares coloured accordingly to represent 100% of mentions split into challenges and opportunities. Our study analyses followed the consolidated Criteria for Reporting Qualitative Research (COREQ)(32).

Patient and public involvement

Feedback on the study design and research questions employed was provided by members of public health organisations based in Argentina and the UK.

RESULTS

I. First stage: review of policies and mapping key stakeholders

The timeline containing established laws and regulations related to AMR is found in Supplementary material section I. Briefly, antimicrobial regulation started in the early 60's with the first law of medications and enforced prescriptions for antibiotic acquisition. In 2007-9, new decrees were introduced instituting required prescription for antibiotic sale and compliance for dispensation of medicines, including the registration book of veterinary medicines usage in food-producing animals (2009-11, decree number 26514). In 2013, Argentina's

national Food Safety and Quality Service (SENASA) created the traceability system for veterinary medicines, which links sellers and purchasers where entities take full responsibility for antibiotic possession. Consecutively, Argentina's national commission for the control of AMR (CoNaCRA) was established and led the launch of the NAP in 2015 (see Supplementary material section II for a summary).This was concurrent with the abolition of antibiotic usage as an animal growth promoter (2015). The prohibition of colistin usage in any form/ingredient took place in 2019. Recently, there was a new law encompassing an One health AMR agenda in the future (decree number 27680) aiming to foster and promote AMR control, prevention, research, regulation, and awareness (24).

Finally, Figure 1 shows the mapping of key AMR surveillance and control stakeholders. We organised it starting from the CoNaCRA as the commission responsible for the implementation of the NAP and those relevant organisations surrounding them (main governmental divisions in brown boxes).

II. Second stage: qualitative analyses

Descriptive characteristics of study participants

We approached 27 individuals initially (non-response levels=33%), but our final sample consisted of 18 participants (six women, 33%) mostly based in Buenos Aires city (88%) and from diverse institutions including government (N=9), academia (N=3), private (N=2), NGOs (3) and international organisations (N=1).

Thematic categories and codes

Barriers, opportunities, and state-of-art information contributing to human and food-producing animal AMR were clustered into seven thematic categories organised by specificity level (from less and more specific themes towards AMR policy). Themes were established based upon number of mentions and repetitiveness. Two themes emerged from countries embedded values and political context impacting AMR indirectly: (I) Cultural factors and country context and (II) Governance. Four themes were directly associated with AMR: (III) Antibiotics, (IV) AMR knowledge and awareness, (V) AMR control, (VI) National action plan. The remaining theme was linked to external factors indirectly affecting all chain's decision-making: (VII) External drivers. The full definition of themes —ordered from less (more coloured boxes) to more specific (less coloured boxes) except for external drivers, which affects them all— with their respective sub-themes, are shown in Table 1.

Theme I. Cultural factors and socio-political country context

This category involved country characteristics that determine the response to AMR by acknowledging and understanding communities' local context. Interviewees described that country's economic and political shifts, including goods shortages and high inflation rates, had jeopardised the health system, bringing instability over time to AMR control. Most political decisions in a resource-constrained country were said to be difficult to manage but high reliance upon people and relationships was essential. For instance, a participant described frustration and uncertainty but ability to cope with challenges despite the economic circumstances.

> "*Argentina has 30 years of experience on AMR surveillance, we live economic shortages and political shifts fiercely in Argentina; a state of crisis, and we are somewhat used to this dynamic trying to cope with it as best we can. We have developed good coordinating links between teams centralised on good communication skills, but we cannot guarantee sustainability. It will depend on future leader's coordination since monetary resources are limited, a lot relies upon the projects or people's willingness to contribute but we believe it will perpetuate*"—Participant from a public institution (ID=9), female.

Most participants agreed that changing people's attitudes and behaviour, especially among food-producing animal producers, is challenging due to embedded values (Q1, Table 2).

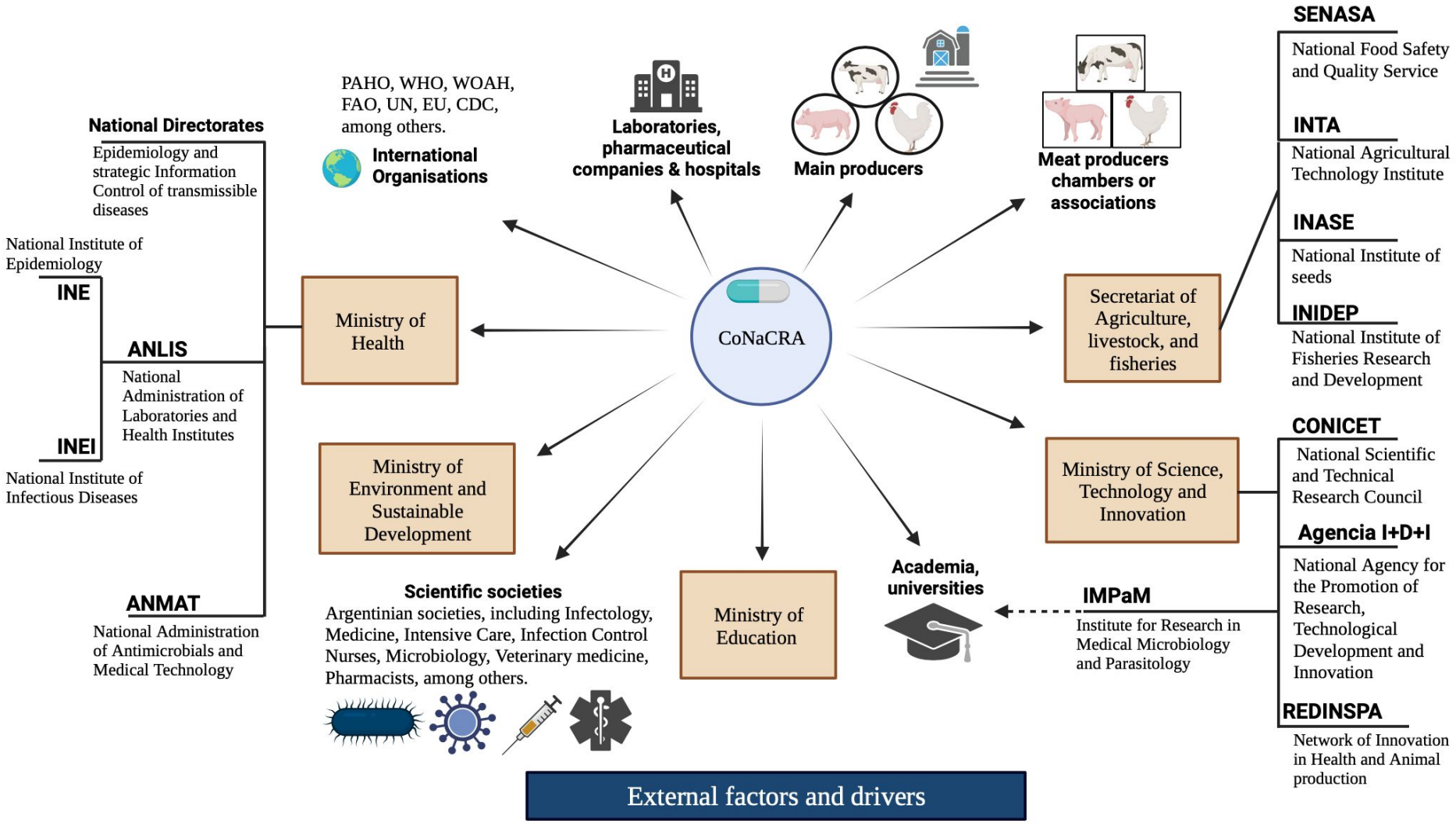
Theme II. Governance

Participants reported constraints in the administration system that limited or enhanced their ability to perform improvements towards tackling AMR. Most participants recognised that SENASA conducts extensive and well-articulated labour; however, they emphasised the lack of auditing and accountability in decentralised administrations (regions) in Argentina, which hampers AMR control due to the inherent variability in the quality of care and health access (Q3, Table 2). Efforts to homogenise quality of care and access to antibiotics in humans and animals are ongoing, but monetary and non-monetary resources are bounded (Q4, Table 2). Although resources were finite, stakeholders' communication was often seen as a local strength and the cornerstone of policy making. Good interpersonal relationships within the public, academic, NGOs and international organisations were reported (Q5, Table 2). However, a demand for more integrated services and decision-making was stated (Q5), translating into the need to foster horizontal information flows with mutually integrated systems and organisations throughout the country (Q6, Table 2).

Regarding the regulation sub-theme, there are positive views towards the new law on antimicrobial use, despite the former law introducing some restrictions but lacking control on usage, prescribing and storage (most frequent among animals) (Q7, Table 2). On top of all previously discussed factors, the political context and

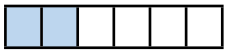
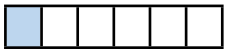
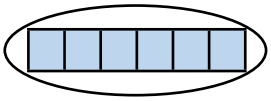
agenda were considered critical for AMR control but conflicting depending on the country's obstacles and people in charge (Q8, Table 2).

Figure 1. Stakeholders within the human and food-producing animal interfaces for the implementation of the NAP for the control of AMR in Argentina



Notes: Organisations abbreviations are provided in the abbreviations subtitle. CoNaCRA= National Commission for the Control of Antimicrobial Resistance. All information on Government's ministries and structures is available in https://www.argentina.gob.ar/organismos.

Table 1. Main themes, definitions and sub-themes identified from the interview analysis (N=18 people)

Themes[†]	Definitions	Sub-Themes	N of times mentioned*
I. Cultural factors and socio-political country context 	Understanding the importance of cultural, country context, including personal relationships	**[1]**Cultural features **[2]**National context and sociodemographic characteristics	**[1]**21 **[2]**18
II. Governance 	Government attributes related to political priorities, federalisation, nature of institutions/groups, accountability, human and economic/budgetary resource available, data systems and capacity, importance of changing political will, regulations and communication between stakeholders.	**[1]**System governance **[2]**Resources **[3]**Stakeholder communication **[4]**Information and data flow **[5]**Regulation and compliance **[6]**Political context and agenda	**[1]**23 **[2]**22 **[3]**39 **[4]**39 **[5]**38 **[6]**11
III. Antibiotics 	Referring to antibiotic consumption and access, prescriptions control and alternatives being developed among animals and humans.	**[1]**Antibiotic access **[2]**Antibiotic consumption **[3]**Antibiotic regulations including prescriptions. **[4]**Alternatives to antibiotics	**[1]**15 **[2]**11 **[3]**14 **[4]**9
IV. AMR knowledge and awareness 	Related to public and professional awareness – the challenge of awareness and steps taken to address it including seminars, conferences, courses, stewardship programs, advertising campaigns using mass media, etc.	**[1]**Challenges related to public and professional awareness. **[2]**Existing training and learning opportunities	**[1]**41 **[2]**15
V. AMR control 	Perceived progress and challenges, inclusive of AMR surveillance. Reference to food production markets including differences by animal species and the role of the veterinary sector on AMR control.	**[1]**AMR surveillance **[2]**Food production systems and specific surveillance **[3]**Veterinary sector, agent of change	**[1]**34 **[2]**35 **[3]**14
VI. National action plan (NAP) 	Implementation of NAP and professional roles, including views on progress over time	**[1]**NAP progress including challenges, barriers, and opportunities	**[1]**22
VII. External drivers 	Referring to external factors contributing to the acceleration of AMR, potential opportunities, and good practice, including international actors and role in/influence on national AMR	**[1]**Context of COVID-19 **[2]**International actors and policies	**[1]**16 **[2]**12

Notes: AMR= Antimicrobial resistance. [†]Themes are ordered from less to more specific levels (except for external drivers which affects them all), see Figure SM2, Supplementary material, for visual hierarchy. *Codes can be mentioned more than once per interview.

241 **Table 2.** Quote examples by themes and sub-themes and identification of challenges and opportunities

Themes†	Sub-theme	Representative quote examples	Challenge/ opportunity
I. Cultural factors and country context	**[1]**	Q1: *"AMR is a cross-cutting issue, but with older-generation low-educated producers living mostly in remote areas (a large quantity), it has been difficult to make them switch their mindset and understand that antibiotics are not necessary for food production, if no bacterial disease is present, and that antibiotic misuse and AMR affect humans and animal well-being."*—Veterinary, public institution(ID=3), male.	Challenge
	[2]	Q2: *"Today, in Argentina, we have 52% poverty and talking about AMR is challenging, considering that 95% of the population is deprived. Telling people to buy cage- and antibiotic-free eggs for a double price seem problematic, considering that overcrowding, hunger, and lack of sewers are constant daily challenges"*—Participant from an NGO (ID=13), male.	Challenge
II. Governance	**[1]**	Q3: *"SENASA is very dynamic but there is lack of accountability from each participating institution when combatting AMR. It is worrisome that SENASA's and other public organisation's labours are highly centralised in the capital, because there is a high heterogeneity in access to treatment, diagnosis, quality standards for animal products, and antibiotic prescribing throughout the country. We know SENASA, for instance, is impeccable but our surveillance system is not punitive, whereas it mostly teaches producers as we do not know where those AMR pathogens came from (reservoirs)"*—Participant from an NGO (ID=12), male.	Challenge and opportunity
	[2]	Q4: *"I think that the most important difficulty is economic and human resources, because especially in public institutions, it is challenging for people to have exclusive and fully compensated dedication"*—Participant from a public institution (ID=11), female.	Challenge
	[3]	Q5: *"We have solid communication channels between governmental institutions (SENASA, INTA, MALBRAN, CoNaCRA) and somewhat with international and academic institutions, but we should employ a strategy of involvement between technical scientific groups, hospital and veterinary leaders, the private industry, including pharmaceutical, and meat producers and related organisations. We need to tell them what our problem is, for them to tell us theirs, and finally come up with integrative solutions that are beneficial for all parties."* —Participant, from a public institution (ID=6), male.	Challenge and opportunity
	[4]	Q6: *"For some diagnostics we report directly to the health informatics system, but we lack perhaps of articulating all the information flows more horizontally facilitating access above all the political decision-makers. Additionally, most systems are not integrated"* —Participant from a public institution (ID=11), female.	Challenge and opportunity
	[5]	Q7: *"Our legislation should regulate and control sales and consumption of antibiotics, including misuse (prohibition, e.g., colistin in veterinary in 2017). Now, it is approved the Antimicrobial Use Law, which legislates on the request of archived prescriptions, and it is stricter than the former law (only monitored required prescriptions and it had poor compliance). We believe antibiotic consumption might decrease. However, regulations are not yet standardised across country regions organically and the informal market is ample."* —Participant from a public institution (ID=6), male.	Challenge and opportunity
	[6]	Q8: *"At the ministerial level, sometimes AMR does not receive the importance and continuity it requires. Today we have a Minister of Health to whom AMR was a priority on their political agenda and most policy attempts entails, and do not omit, reducing AMR and antibiotic misuse. It is helpful to work in favour of that, but it is not frequently the case."* — Participant from an international institution (ID=17), female.	Challenge and opportunity

III. Antibiotics 	**[1]**	Q9: *"Laboratories distribute veterinary products. Laboratories have the approval of SENASA to produce and commercialise the products, as well as the distributors. The commercialisation path is laboratory> distributor> production, through veterinarians, but sometimes is the owner himself selling and applying them due to lack of regulation on access, even over the counter. Among cattle, there is a large part of the production that is still extensive and pharmaceutical companies are often far away from feedlot farms. Hence, they keep first-aid kits, including antibiotics, which are applied to wounds or with no diagnostic or under no veterinary supervision. The law obliges establishments to have a treatment book where animal treatments and antibiotics used are recorded, but in most remote areas is not reliably fulfilled and control is limited"* —Participant from an NGO linked to animals (ID=4), male.	Challenge
	[2]	Q10: *"I work in swine production; our main concern relies upon prophylactic consumption of the antibiotic. Indiscriminate antibiotic consumption is present in two ways within swine production. First, meta-phylactic, when there is a percentage of animals that are indeed sick within the flock, but since they are living with them, it is very likely that others are incubating the disease, hence they are treated. The second is the prophylactic, where there is no sick animal, but there are factors of potential stressors that could make those animals sick. This is our biggest concern, because antibiotic is then incorporated into food, whose biological matrix restricts bioavailability of the active ingredient. Additionally, when antibiotics are applied, withdrawal times are not monitored, which promotes the development of AMR mechanisms further"* —Veterinarian, academia (ID=14), male.	Challenge
	[3]	Q11: *"Laboratories producing medicines for veterinary use must comply with good manufacturing practice 'GMP' standards. They register the product, present all the documentation on waste, among other features. We have traceability in some products, such as ketamine, each bottle is identified and we follow-up until the final user. Laboratory production of medicines is well monitored, but there are limited regulations over usage registration, because products are not often administered by health professionals. For instance, final users do not necessarily respect the restriction period or animal treatment is incomplete, for which regulation is scarce."* —Participant from an NGO (ID=4), male.	Challenge
	[4]	Q12: *"We employ tannins, organic acids, probiotics, and prebiotics instead of antibiotics. We proved their efficacy for Escherichia coli and Salmonella using a mixture of probiotics and prebiotics in sentinel farms, which were boosted animal growth. We have produced alternative to antibiotics for a long-time including animal vaccines against pneumonia, and it was company's initiative."*—Participant from a private company (ID=5), male.	Opportunity
IV. AMR knowledge and awareness 	**[1]**	Q13: *"One of the main challenges is the access to information/ communication, the awareness of responsible antibiotic use, and lack of commitment from the private sector. Technical and general education on antibiotics and AMR should be promoted to help set a change of consciousness in the consumer, prescriber, and sellers by letting them know the actual effects/impacts of AMR on population health and animal businesses (among producers). The profitability of the sector is compromised if producers are not willing to pay a differential for meat production that could produce higher costs in the future if not committed."* —Engineer from an NGO (ID=7), male.	Challenge
	[2]	Q14: *"The Argentine population is much more aware of what human health is and what antibiotics are designed for. For instance, we had the World Week of Awareness in November, and we held the AMR awareness race alongside the Ministry of Health and Sports, which exhibits interrelationships between different groups."* —Participant from an international organisation (ID=17), female	Challenge and opportunity
V. AMR control	**[1]**	Q15: *"We created the infection surveillance program in 2004 for human*	

		*hospitals, which is an essential part of national surveillance reporting the annual prevalence/incidence of most critical pathogens. A ministerial resolution from 2018 recommends establishing hospital prevention and control programs, but adherence is optional. We have more than 200 added institutions reporting the appropriate use of antimicrobials yearly, including whether it was empirical, directed, surgical prophylaxis, community-acquired infection, etc. In-hospital software, part of the National Antimicrobial Resistance Surveillance Network 'WHONET', clinicians load the data, compute the analyses (automatically) and feeds the information to the epidemiology department. However, since 2021 (ministerial resolution), prevention and control programs must be certified depending on international guidelines. We use a federal criterion to enrol national institutions and federal hospitals, but private organisations are poorly represented. Also, some institutions did not have stewardship programs actively functioning. We updated the last referendum to include antimicrobial stewardship as a section for infection control (2021), assigning importance to protected areas for infectious disease specialist and pharmacists within hospitals."* —Participant from a public institution (ID=11), female	Challenge
	[2]	*Q16"We have two main problems. First, we detect and observe a lot of animal cases experiencing neonatal diarrhoea produced by multi-resistant E. coli, even encountering septicaemia, which presents a serious health problem. Secondly, we see multi-resistant bacterial strains more frequently associated with bovine's respiratory complex. We identify bronchopneumonia or pneumonia as the two main infectious syndromes. We receive multiple samples from animal lungs, mainly originated in fattening animals in the pen or outbreaks of pneumonia. Quite predominantly, we observe the presence of bacterial resistance to a large majority of the antibiotics routinely used for treating respiratory conditions. That shows some inefficiency from fragmented production systems lacking vertical structure, reduced biosecurity, and poor vaccination rates, especially among cattle."*—Veterinarian, public organisation (ID=8), male.	Challenge
	[3]	Q17:*"I do believe that veterinarians have a very important multisectoral role to play there as training and awareness agents to contain AMR burden."*— Participant from an NGO (ID=4), male.	Opportunity
VI. National action plan (NAP) 	**[1]**	Q18:*"Progress has been made if we compare it with five years ago. Regulations on the use of antibiotics to prevent their misuse, such as growth promoters, and vast existing (AMR control in animals) and new initiatives to start controlling AMR reservoirs in soil and water demonstrates we are working towards a better integrated system by taking into consideration the One Health approach"*—Veterinarian, public organisation (ID=8), male.	Opportunity
VII. External drivers 	**[1]***	Q19: *"Something the pandemic left us was the effectiveness of virtual meetings, for example, plan out objectives and do training with the veterinarians and farm owners"* —Participant from an NGO (ID=4), male.	Opportunity
	[2]	Q20: *"We performed projects alongside the European Union, WHO and Centre for Disease Control, which supported Argentina through international funding to perform AMR surveillance and control, even in food products and wastewater."* —Participant from a public institution (ID=1), female.	Opportunity

Notes: AMR= Antimicrobial resistance. †Themes coloured box indicates the extent to which codes present more challenges (darker, blue-coloured boxes placed primarily on right side) or opportunities (lighter, blue-coloured boxes placed primarily on left side). Sub-themes descriptions are found in Table 1. NGO= non-governmental organization. *There are challenges associated as well, but we included an opportunity. CoNaCRA= National Commission for the Control of Antimicrobial Resistance. INE= National Institute of Epidemiology. INEI= National Institute of Infectious Diseases. INTA= National Agricultural Technology Institute. SENASA= National Service of Agri-food Health and Quality. WHO= World Health Organization.

Theme III. Antibiotics

Thematic III encompasses efforts to improve antibiotic access, consumption, and regulation, while accounting for potential alternatives. Access to antibiotics was indicated as better regulated in the human side, where hospitals and labs work collaboratively; however, a few participants expressed concerns about the applicability of mandatory prescriptions for sales and a mismatch between prescribed treatments and antibiotic package dosing:

> *"Antibiotics are still sold without a prescription either for human or animal use (more frequent among animals), even if prescriptions are mandatory by law, including keeping track of their usage by health professionals (electronic sales). Another issue is the dosage; antibiotics are usually sold in dosages greater than needed, which incentivises inappropriate utilisation maximising commercial interests."*— Participant, academia (ID=14), female.

In addition, one participant expressed worrying views towards antibiotic access and prophylactic use in animals and its relationship with AMR evolution, including reduced capacity for monitoring usage and withdrawal (Q10, Table 2). On the animal side, the route for antibiotic acquisition could have been more cohesive; vets do not necessarily monitor antibiotic purchase, application, and storage, and limited local regulations are in place (Q9, Table 2). Such practices can be reflected early in the regulation system and antibiotic dispensing from the first stage of the purchasing chain. Most medicines for veterinary use were follow international manufacturing standards, but traceability of compounds and usage is restricted once purchase is made (Q11, Table 2). Finally, some participants working on antibiotic replacement produce alternatives for antibiotic use in food-producing animals. They were optimistic over vaccine production offering an efficacious alternative, tackling respiratory diseases in animals, and using additives and plant-based biomolecules to improve food conversion efficiency and eradicate antibiotic use as growth promoters in animal farms (Q12, Table 2).

Theme IV. AMR knowledge and awareness

Theme IV incorporated progress made towards AMR knowledge and awareness targeting different settings and communities. Participants were inclined to say that awareness has increased, and impacts on human health are acknowledged (Q13, Table 2), primarily among leading institutions including government, but awareness campaigns only have limited reach to the wider population, including meat producers, as they tend to be specific and attend professional needs:

> *"There is a problem with vets' knowledge of antibiotics, specifically in terms of pharmacokinetic and pharmacodynamic aspects, the correct calculation of the dose administration. It is the duration of treatment in the form of clinical criteria and corresponding to specific physiological situations. All these aspects are related to rational antibiotic usage. If you forget these aspects, you can reach a therapeutic failure despite having chosen the correct antibiotic based on what the laboratory said; and this is largely prevalent in the country."*— Veterinarian, academia (ID=14), male.

Notwithstanding, participants reported initiatives to raise human population's awareness generally, including social events and educational seminars, having positive perceived conceptions from participants but their effectiveness remain unclear (Q14, Table 2).

Theme V. AMR control

Theme V comprised all barriers or opportunities that made implementation of surveillance and AMR control overtime arduous or fruitful. Participants expressed that surveillance of AMR has exhibited a lot of progress overtime, especially among humans, and most recently in animals. Antibiotic stewardship and infection surveillance programs in humans, including the regular monitoring of a consolidated network of +200 hospitals, primarily public, are some of the positive views perceived by stakeholders towards implementation (Q15, Table 2). Antibiotic consumption control is a central priority of the government now and a countrywide program is being developed to strengthen AMR surveillance:

> *"We have implemented a national surveillance system for the national consumption of antibiotics in humans, which we did not have until a short time ago. Now, it is time to access the information related to disaggregated statistics on antibiotic sales through collaboration with Pharmacology in human and animal side." —Pharmacist, public organisation (ID=6), female*

However, policies around AMR surveillance and control are moving forward among livestock production systems but at slower rates. One participant indicated that testing for critical animal pathogens is routine and usually comes from public organisations. Still, animal diagnostics are difficult to access sometimes, and surveillance does not yet clearly account for different locations, species, and seasonal components:

> *"INTA monitors some animal production chains, but surveillance is the primary task of SENASA, for example, in dairy, we evaluate animals experiencing a mastitis disease and track AMR and potential environmental reservoirs with technology developed locally. Another example, we detect Salmonella in animals and utilise microbiological analyses, including phenotyping and genotyping to analyse AMR and evolution, as part of surveillance routines hand by hand with SENASA. However, most surveillance comes from the governmental side, sampling seasonality is not often captured due to limited resources, the quantity of livestock farms is*

massively distributed throughout the country, and local producer's veterinary diagnostics are often sent to private labs where traceability is missing."—Veterinarian, public organisation (ID=15), male.

Challenges identified by participants on AMR surveillance among animals are mirrored mainly in the animal industry, which constitutes many producers and actors through the production chain, making it complex to supervise (Figure 2 shows a brief description and example of cattle production based on interview content and additional sources for broader context). As reported by one participant, industry's main challenges rely upon controlling early stages within the production chain, including improved hygiene and sanitation and vaccination strategies before animals are stressed while moving from breeding to fattening stages (Q16, Table 2).

Figure 2. Brief description of some features within the cattle industry in Argentina

Around 52 million head of cattle are kept by livestock farmers in Argentina. The country produced 3.2 million tonnes of beef meat in 2020, of which 900,001 tonnes were exported (75% to China). However, the production chain involves a wide variety of actors and producers (from breeding, fattening, slaughtering, preservation, and sale) and the number of direct beef producers is estimated to be 230,000 with no significant market share among specific companies, compared to chicken or swine industries where three companies concentrate 70% of the market share. Although swine and chicken are amongst food-producing animals species with higher AMR rates for streptomycin, ampicillin and tetracycline resistance, there is still a research gap regarding beef-cattle from feedlots due to reduced AMR monitoring and control, including antibiotic usage. The cattle production chain is highly fragmented, and the movement dynamics of the animals through the production chain are complex, even though their transit must be registered to comply with SENASA guidelines, and all production units should be referenced in a computer database. However, in practicality, controlling thousands of animals at different production stages is challenging, and it is often hard to trace and follow to check if producers follow guidance in antibiotic use. In line with this, cattle vaccination rates against diarrheal or respiratory diseases are relatively low compared to the chicken and swine industry. Most livestock farms are family businesses where there is a partial vet role for antibiotic administration, and antibiotic storage in warehouses is often observed due to reduced control on acquisition.

C

Notes:(A): Feed supplied in the trough for cattle, livestock farm, Buenos Aires, Argentina. (B): Cattle pens, livestock farm, Buenos Aires, Argentina. (C): Characteristics of beef production and relationship with AMR control. AMR= Antimicrobial resistance. NAP= National action plan. Most information was derived from our interviews; exact quotes are shown upon request. References: (33, 34).

Theme VI. National action plan

All participants expressed a positive attitude towards progress made on the NAP even if it is slow. Participants agreed upon improvements, such as, the institutionalisation of CoNaCRA, recently launched law on established AMR network and surveillance (which does not depend on political will), new research centre (IMPaM) for environmental surveillance of AMR reservoirs including water, more control over companion and food-producing animals since 2015 from INTA and SENASA, and that prohibition of some antibiotics has been crucial (Q18, Table 2).

Theme VII. External drivers

Theme VII comprises external factors, identified by participants, that have had a direct or indirect role affecting AMR control and surveillance. Most participants (60%) recognised that COVID-19 limited the progress of AMR control and policy due to reallocation of human, economic and other resources towards the pandemic response. For instance, one participant described it as follows:

"Teams were absolutely overwhelmed during COVID-19, all the artillery was dedicated to diagnosis and containment of COVID. We observed an overuse of antimicrobials during these two

years, which has accelerated the appearance of new AMR mechanisms and their transmissibility. At the microbiological level, pandemic lineages have appeared, which changes local epidemiology"—Infectious disease doctor, public organisation (ID=1), female.

However, positive lessons were drawn from the pandemic, including the effectiveness of virtual meetings as an advantage of multisectoral collaboration (Q19, Table 2). Additionally, prioritisation of personal hygiene and care and hand washing was understood to be improved due to increasing awareness of communicable diseases and human health among citizens, as one participant reflected:

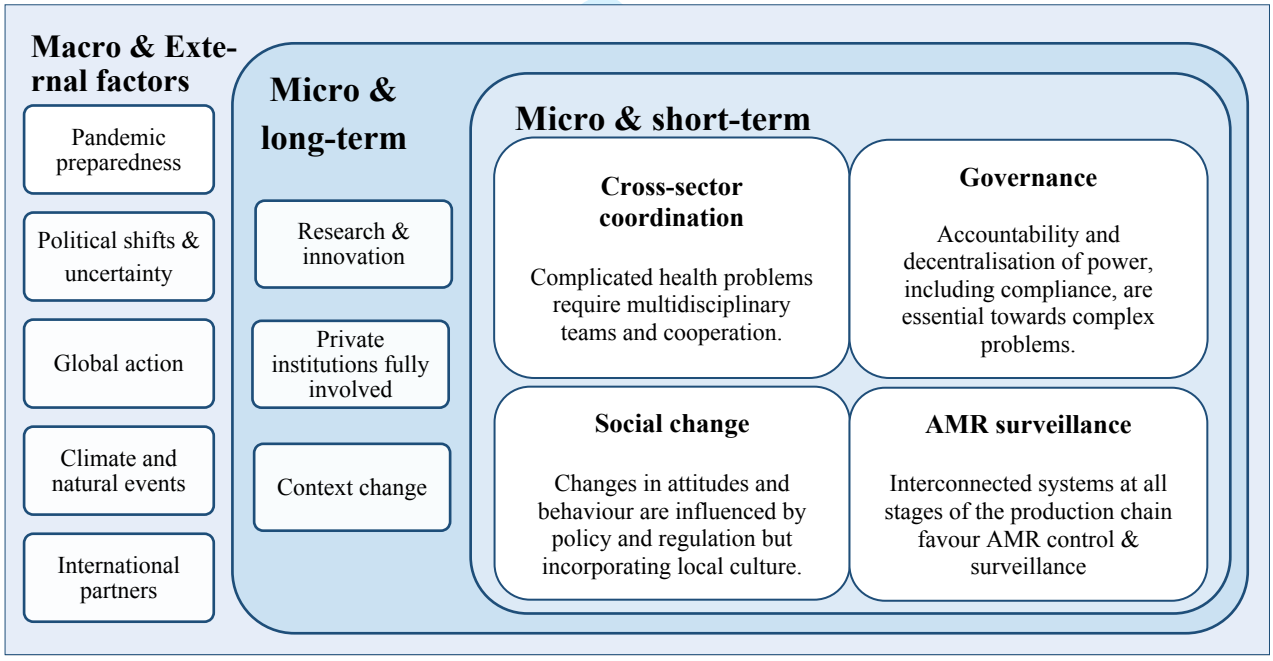
"The pandemic has taught us, it's to prioritize our personal hygiene. Hand washing and personal care help us not get sick from diseases, and if we don't get sick, we do not require antibiotics."—Veterinary, public organisation (ID=3), male.

Finally, the second external factor relies upon international collaborations. Participants described solid relationships with international actors within the Americas and abroad, which has helped fund local projects for improving AMR control and surveillance (Q20, Table 2).

DISCUSSION

We employed a context and qualitative analysis to understand main gaps related to the progress of AMR control in implementing AMR policy and regulation in Argentina. Our findings revealed that overall stakeholders' perceptions towards AMR policy are positive, including development of personal relationships enabling progress, and that the NAP along with current emerging legislation are essential in formalising the first steps to a multisectoral and better integrated AMR surveillance system. Interviewees stated that main challenges on the way forward are related, but not limited to, commitment and accountability, monetary and non-monetary resources, cultural factors implying behaviour change, fragmented food-production systems, and global governance. We have summarised these below in Figure 3 in relation to whether at macro or micro level and short or long-term.

Figure 3. Major challenges and opportunities related to AMR policy in Argentina within a One Health scope in the short and long-term



Notes: AMR= Antimicrobial resistance.

One of the most immediate short-term challenges identified by stakeholders was governance, which implied needing more accountability and resources through different AMR actors. Clearer administration systems for successful improvement and conveying AMR policies are crucial to moving forward in the AMR agenda(26, 35). Argentina's administration system is divided into provinces. Still, political decisions are highly centralised in the capital city, which hampers regulation of antibiotic access, AMR testing, and delivery of consistent access to healthcare and hospital infrastructure in humans and animals. Although the CoNaCRA has province representatives, the AMR agenda had limited alignment with subnational and local governments for NAP

implementation posing significant challenges in rural and remote areas(36). Likewise in Brazil (20), these areas are often highly exposed to AMR risks due to health deprivation. Re-administering monetary and non-monetary resources to meet local needs and capacities and empowering provincial sentinel organisations are crucial to making AMR policies accountable.

Cross-sector coordination including animal, environmental and human sectors was highlighted as crucial by interviewees and constituted an essential element of short-term action towards tackling AMR and improve policy design. Although communication was perceived as positive due to interpersonal relations between colleagues, adequate governance must be established, including mechanisms to link organisations across sectors through formal channels to foster continuity. Literature has focused on countries' need for better engagement and advocacy from various stakeholders (9, 14, 37).Governments, policymakers, and NGOs are essential to AMR control, supported by budgetary commitment and political authority to meet objectives(19). Current interventions in Argentina remain sector-specific, which could be attributed to differences in priorities for AMR or insufficiently well-defined roles in the NAP. Developing a monitoring or evaluation system for all implementation plans is recommended to determine policy effectiveness. Broad cross-field participation is also crucial if no public budget is allocated to address AMR nationally. Insufficient funding provided by the annual national budgets negatively impacts NAP implementation, generating more constraints on AMR action. The COVID-19 pandemic garnered global attention disrupting national resources and health services that were indirectly assigned to AMR control, and reallocating those funds has posed challenges to AMR reduction measures. One Health although theoretically a useful framework, was not considered in NAP implementation—it could have accounted for the co-benefits of addressing both risks concurrently. That is why the United Nations Environment Program (UNEP) established the Multi-partner Trust Fund (MPTF) to help LMICs improve delivery of multisectoral NAPs (28)..

AMR awareness has increased overtime in Argentina. Recent efforts have included various seminars and activities, including a long-distance foot race to spread the word on AMR(38).However, AMR comprises stakeholders with diverse comprehension of the AMR phenomenon, and we evidenced a mismatch between scientific and non-scientific domains, including general public. Social change promoting human health via shifts in society's behaviour should be prioritised to ensure the sustainability of human development and their environments (39). For instance, public engagement is overlooked in Argentina's NAP. Strategies to evaluate attitudes, behaviours, necessities, and practices of socioeconomically and culturally diverging communities, drawing particular attention to those most vulnerable to AMR infections, are crucial to design public health interventions to combat AMR (4).

Strengthening AMR surveillance and control is vital, with different challenges depending on the species spectrum, as highlighted previously in LMICs(4, 19, 20, 40-42). In humans, laboratory surveillance has been based for decades on the connectivity of a well-established hospital networks (e.g., WHONET-Argentina(43)), which has helped monitor AMR locally with institutionalised IPC policies, led by the Antimicrobial Agents Division of INEI-ANLIS, the National and Regional Reference Laboratory for AMR, and the National Hospital Infection Surveillance Program (VIDHA), respectively. However, there are still gaps regarding the effectiveness of preserving antibiotics through stewardship programs, although consumption levels and inappropriate usage rates decreased before COVID-19(44). Yet, quality control among stewardship programs, antimicrobial sales with necessary prescriptions, and targeted local efforts in differing regions are still challenging throughout the country(45).In animals, the main surveillance challenges that were reported were concentrated around the unification of production systems (dispersed via multiple chains and actors potentially favouring the dissemination of AMR), whose current fragmented status hampers regulation, with differing control levels depending upon animal species. Systems' capacity to ensure prescription and consumption data is compromised and policies should coordinate and harmonise AMR surveillance while regulating the usage of antimicrobials in animal production at all production stages(34).Globally, antimicrobial stewardship by farm owners and health professionals (e.g., veterinarians) is relatively weak within agricultural systems; developing efforts towards stewardship programs in veterinary services, bolstering the veterinary role as a critical change agent, and companion animal practice remains crucial (46-48).Argentina's chambers of producers play an active role in agglomerating food producers and understanding their needs (e.g., Camara Argentina de Feedlots); their job should be directed towards better integration and prioritisation of educational services and improved production standards.

A recent WHO report on integrated surveillance of AMR in foodborne diseases indicated that ineffective public health AMR surveillance systems often lack broader regulation and laboratory infrastructure, limited biosecurity, and inadequate data management capacity at government levels(49).We observed reduced capacity for data monitoring and sharing among animal stakeholders, whereby surveillance of antibiotic sales/usage and

AMR rates by animal species could be better reported. Despite limited public control due to fragmentation of the production chain, food producers are perceived to prioritise profitability and local needs, regardless of the effects of AMR on population health. Moreover, creating an integrated One-Health approach combining animal and human systems, including environmental sources, might help reduce the AMR burden and prevent animal infections in farming communities(25, 50), ensuring sustainability over time and lowering the risks associated with political shifts and global uncertainties. The role of the private sector, not only restricted to food producers, in supporting AMR surveillance should be encouraged to provide a holistic whole-system integration, including a whole food-chain approach(51, 52).This should involve data access and optimising contemporary treatments and diagnostics through more research and technology to elucidate the transmission pathways of the most critical microorganisms for animal and human health.

We identified potential opportunities that could help contribute to progressing action to reduce AMR locally. Most stakeholders favoured agricultural non-antimicrobial drug products as an antibiotic replacement for animal growth promoters. Using tannins and natural plant-based medicines could supersede antibiotics, reducing selective pressure and AMR burden(53, 54). Nevertheless, most of these products are difficult to access locally with limited legislation and high reliance on a few international companies. The provision of replacement routes from the government for antibiotic-free additives usage in animals, including appropriate stakeholder education and countrywide support through public pharmacies, is something the authorities should leverage. Furthermore, the new law establishing the AMR agenda as a constituted program, regardless of political change, presents substantial progress towards national recognition of the AMR problem(24). The initiative brings a long-term perspective to AMR policy, which could be used for the creation of an AMR policy database containing information on NAP implementation accountability and cross-species and environment AMR surveillance for policy advisors.

Our study has some shortcomings. First, we were not able to speak to stakeholders from all areas of the stakeholder mapping and cannot generalise the views of participants to others but have confidence in the transferability of findings and common themes that arose among the diverse stakeholders who participated. Nevertheless, common themes arose from speaking to a range of stakeholders and our sample reached saturation with a narrow range of interviews, considered an appropriate sample size for qualitative research (55).Second, we could not represent private hospitals for human AMR, and differences between production chains, including a broader scope of animal species, dairy products, and final animal product providers, which remains a future study. Third, the extent of interviewees' actual involvement in AMR policies differed; however, we ensured respondents best authority through collaborative local work and expert knowledge. Fourth, the authorship group includes people involved in AMR policy in Argentina which could either favour (facilitate information flow) or bias (sampling, selection and confounding) our study results.

Finally, participants' beliefs (interviews held between December 2022 and January 2023) might be subject to change in the forthcoming years due to implementation of the newly introduced national law on AMR prevention and control (August 2022)(24). Tighter measures regarding antibiotic usage and sales (only under-filled prescriptions) and promoting the One Health approach via implementing cross-sector policies while accounting for organisation-specific responsibilities for their listed tasks are examples of the expected outcomes the law might enforce.

CONCLUSION

Our study results draw attention to the main strengths, opportunities, and challenges in the process towards improved AMR awareness, control, and surveillance across the human-animal frontier in Argentina. The country has been one of the leaders in the region with an established AMR surveillance network for human health in the latest 40 years. However, AMR governance requires a multidisciplinary focus to help stakeholders at all levels deal with knowledge uncertainties and resulting differences in framing the AMR problem. We found critical areas that should be strengthened, including accountability, sustainable engagement, integrity and equity, socio-behavioural change, international cooperation, and consolidation of environmental and animal departments. Cross-cutting interventions incorporating these areas through different One Health domains should be accounted for if progressing towards AMR is noted. The recent law on AMR prevention and control serves as a good example, which identifies potential pathways to overcome challenges with direct implications for LMICs in the Latin American region.

Funding: This research is co-funded by the UK Department of Health and Social Care as part of the Global AMR Innovation Fund (GAMRIF)(BB/T004452/1).This is a UK aid programme that supports early-stage innovative research in underfunded areas of antimicrobial resistance (AMR) research and development for the

benefit of those in low- and middle-income countries (LMICs), who bear the greatest burden of AMR. The views expressed in this publication are those of the author(s) and not necessarily those of the UK Department of Health and Social Care.

Role of the funding sources: The funders had no role in the design, conduct, analysis or interpretation of the study.

Acknowledgments: All authors attest they meet the ICMJE criteria for authorship and have reviewed and approved the final article. The authors are grateful to all participants for volunteering time as part of interviews and workshops.

Conflicts of Interest: The authors declare no conflict of interests.

Author Contributions: Conceptualization (KA, EP, WG, MF-M, AP); methodology (KA, EP, LB); formal analysis (KA); writing—original draft preparation (KA); writing—review, editing and commenting (KA, EP, WG, MG-M, AP, LB); supervision (EP, M F-M, AP). All authors have read and approved the final version of the manuscript.

Data availability: The qualitative data underlying this article are available in the article.

Ethics review: Ethical approval was obtained from the Human Ethical Review Committee at University of Edinburgh (Ref: HERC_696_21).

Abbreviations

AMR= Antimicrobial resistance
SENASA= Argentina's National Food Safety and Quality Service
ANLIS= Argentina's National Administration of Laboratories and Institutes of Health
CoNaCRA= Argentina's National Commission for the Control of Antimicrobial Resistance
INTA= Argentina's National Agricultural Technology Institute
IMPaM= Argentina's Institute for Research in Medical Microbiology and Parasitology
UBA= Universidad de Buenos Aires
INE= Argentina's National Institute of Epidemiology
INEI= Argentina's National Institute of Infectious Diseases
ANMAT= Argentina's National Administration of Drugs, Food and Medical Devices
CONICET= Argentina's National Scientific and Technical Research Council
FAO= Food and Agriculture Organization
WOAH= World Organization of Animal Health
WHO= World Health Organization
PAHO= Pan American Health Organization
NAP= National Action Plan

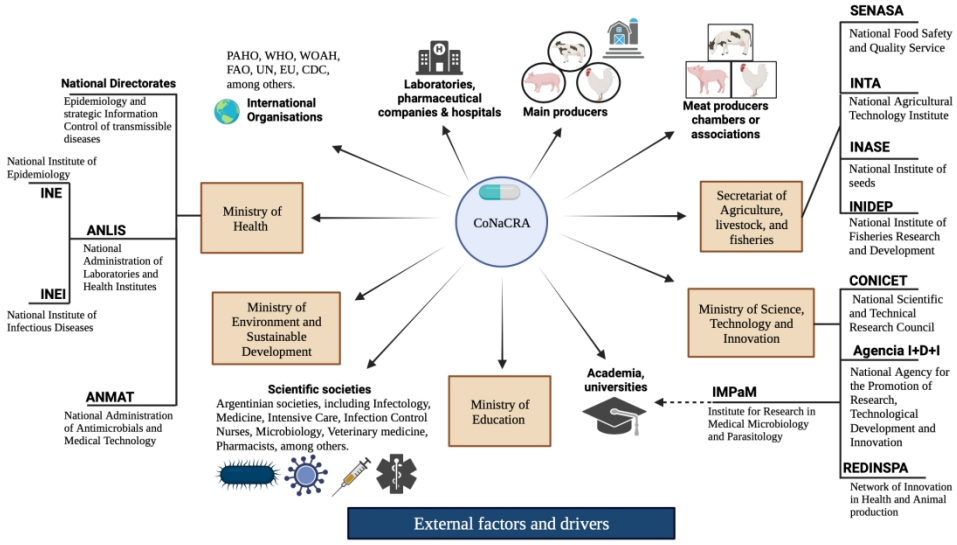
REFERENCES

1. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, et al. Understanding the mechanisms and drivers of antimicrobial resistance. The Lancet. 2016;387(10014):176-87.
2. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet. 2022.
3. Allel K, Day L, Hamilton A, Lin L, Furuya-Kanamori L, Moore CE, et al. Global antimicrobial-resistance drivers: an ecological country-level study at the human–animal interface. The Lancet Planetary Health. 2023;7(4):e291-e303.
4. Charani E, Mendelson M, Pallett SJ, Ahmad R, Mpundu M, Mbamalu O, et al. An analysis of existing national action plans for antimicrobial resistance—gaps and opportunities in strategies optimising antibiotic use in human populations. The Lancet Global Health. 2023;11(3):e466-e74.
5. Mendelson M, Matsoso MP. The World Health Organization global action plan for antimicrobial resistance. SAMJ: South African Medical Journal. 2015;105(5):325-.
6. Humphreys G, Fleck F. United Nations meeting on antimicrobial resistance. World Health Organization Bulletin of the World Health Organization. 2016;94(9):638.

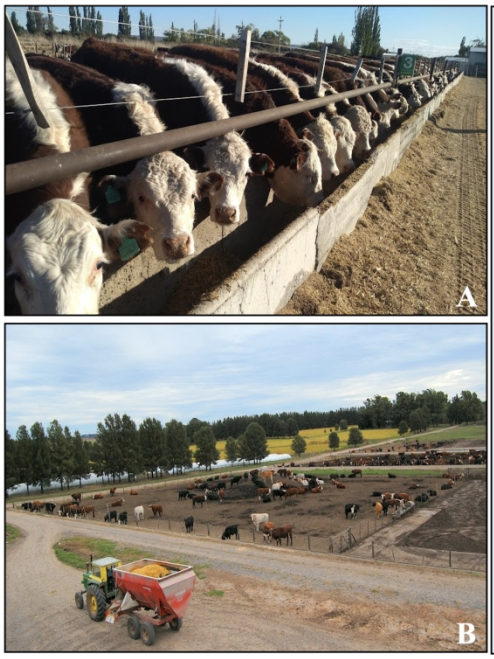
7. Commission E. A European one health action plan against antimicrobial resistance (AMR). European Commission. 2017.
8. World Health Organization. Library of AMR national action plans 2023 [Available from: https://www.who.int/teams/surveillance-prevention-control-AMR/national-action-plan-monitoring-evaluation/library-of-national-action-plans.
9. Frumence G, Mboera LE, Sindato C, Katale BZ, Kimera S, Metta E, et al. The governance and implementation of the National Action Plan on Antimicrobial Resistance in Tanzania: a qualitative study. Antibiotics. 2021;10(3):273.
10. Wernli D, Jørgensen PS, Harbarth S, Carroll SP, Laxminarayan R, Levrat N, et al. Antimicrobial resistance: the complex challenge of measurement to inform policy and the public. PLoS Medicine. 2017;14(8):e1002378.
11. Organization WH. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators. 2019.
12. Jimah T, Ogunseitan O. National Action Plan on Antimicrobial Resistance: stakeholder analysis of implementation in Ghana. Journal of Global Health Reports. 2020;4:e2020067.
13. Khan MS, Durrance-Bagale A, Mateus A, Sultana Z, Hasan R, Hanefeld J. What are the barriers to implementing national antimicrobial resistance action plans? A novel mixed-methods policy analysis in Pakistan. Health policy and planning. 2020;35(8):973-82.
14. Chua AQ, Verma M, Hsu LY, Legido-Quigley H. An analysis of national action plans on antimicrobial resistance in Southeast Asia using a governance framework approach. The Lancet Regional Health-Western Pacific. 2021;7:100084.
15. Harant A. Assessing transparency and accountability of national action plans on antimicrobial resistance in 15 African countries. Antimicrobial Resistance & Infection Control. 2022;11(1):1-15.
16. Nair M, Zeegers M, Varghese G, Burza S. India's National Action Plan on Antimicrobial Resistance: a critical perspective. Journal of Global Antimicrobial Resistance. 2021;27:236-8.
17. Amin ET, Omeichu AA, Shu DM, Ekome SRE, Njumkeng C, van der Sande MAB. Control of antimicrobial resistance in Cameroon: Feasibility of implementing the National Action Plan. Tropical Medicine & International Health. 2021;26(10):1231-9.
18. Patel J, Harant A, Fernandes G, Mwamelo AJ, Hein W, Dekker D, et al. Measuring the global response to antimicrobial resistance, 2020–21: a systematic governance analysis of 114 countries. The Lancet Infectious Diseases. 2023.
19. Shabangu K, Essack SY, Duma SE. Barriers to Implementing National Action Plans on Antimicrobial Resistance using a One Health Approach: Policy-Makers' Perspectives from South Africa and Eswatini. Journal of Global Antimicrobial Resistance. 2023.
20. Juliana Silva Corrêa LFZ, Roberto Rubem Da Silva-Brandão, Sandi Michele de Oliveira, Lislaine Aparecida Fracolli, Maria Clara Padoveze & Gloria Cordoba. The governance of antimicrobial resistance in Brazil: Challenges for developing and implementing a one health agenda. Global Public Health. 2023;18(2190381).
21. da Silva Jr JB, Espinal M, Ramón-Pardo P. Antimicrobial resistance: Time for action. Revista Panamericana de Salud Pública. 2020;44.
22. Ministry of Health. National strategy for the Control of Antimicrobial resistance 2015 [Available from: https://www.boletinoficial.gob.ar/pdf/linkQR/YzB6b2o4Qy9ZRDFycmZ0RFhoUThyQT09.
23. EE 54429573/2018 - Prohibe productos que contengan el principio activo de colistina, (2019).
24. Presidencia de la nacion. Boletin oficial de la republica de Argentina. Ley de prevencion y control de la resistencia a los antimicrobianos, ley 29680. 2022 [Available from: https://www.boletinoficial.gob.ar/detalleAviso/primera/270118/20220824?busqueda=1.
25. Ogyu A, Chan O, Littmann J, Pang HH, Lining X, Liu P, et al. National action to combat AMR: a One-Health approach to assess policy priorities in action plans. BMJ global health. 2020;5(7):e002427.
26. Anderson M, Schulze K, Cassini A, Plachouras D, Mossialos E. A governance framework for development and assessment of national action plans on antimicrobial resistance. The Lancet Infectious Diseases. 2019;19(11):e371-e84.
27. Pitchforth E, Smith E, Taylor J, Davies S, Ali G-C, d'Angelo C. Global action on antimicrobial resistance: lessons from the history of climate change and tobacco control policy. BMJ Global Health. 2022;7(7):e009283.
28. United Nations. Antimicrobial Resistance Multi-Partner Trust Fund Countering antimicrobial resistance with a 'One Health' approach 2022 [Available from: https://mptf.undp.org/fund/amr00.
29. World Bank. World Bank Data 2023 [Available from: https://data.worldbank.org/country/argentina.
30. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative research in psychology. 2006;3(2):77-101.

31. Boeije H. A purposeful approach to the constant comparative method in the analysis of qualitative interviews. Quality and quantity. 2002;36(4):391-409.
32. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care. 2007;19(6):349-57.
33. Instituto de la Promoción de la Carne Vacuna Argentina (IPCVA). Informe de faena y producción 2023 [Available from: http://www.ipcva.com.ar/vertext.php?id=2389).
34. McCormick BP, Quiroga MP, Álvarez VE, Centrón D, Tittonell P. Antimicrobial resistance dissemination associated with intensive animal production practices in Argentina: A systematic review and meta-analysis. Revista Argentina de Microbiología. 2022.
35. Rochford C, Sridhar D, Woods N, Saleh Z, Hartenstein L, Ahlawat H, et al. Global governance of antimicrobial resistance. The Lancet. 2018;391(10134):1976-8.
36. Pokharel S, Raut S, Adhikari B. Tackling antimicrobial resistance in low-income and middle-income countries. BMJ Specialist Journals; 2019. p. e002104.
37. Castro-Sanchez E, Iwami M, Ahmad R, Atun R, Holmes AH. Articulating citizen participation in national anti-microbial resistance plans: A comparison of European countries. European Journal of Public Health. 2018;28(5):928-34.
38. With a massive race, PAHO Argentina spreads the word to prevent antimicrobial resistance [press release]. 2022.
39. Hernando-Amado S, Coque TM, Baquero F, Martínez JL. Antibiotic resistance: moving from individual health norms to social norms in one health and global health. Frontiers in Microbiology. 2020;11:1914.
40. Lota MMM, Chua AQ, Azupardo K, Lumangaya C, Reyes KAV, Villanueva SYAM, et al. A Qualitative Study on the Design and Implementation of the National Action Plan on Antimicrobial Resistance in the Philippines. Antibiotics. 2022;11(6):820.
41. Sirijatuphat R, Chayangsu S, Srisompong J, Ruangkriengsin D, Thamlikitkul V, Tiengrim S, et al. Feasibility, Challenges, and Benefits of Global Antimicrobial Resistance Surveillance System Implementation: Results from a Multicenter Quasi-Experimental Study. Antibiotics. 2022;11(3):348.
42. Sumpradit N, Wongkongkathep S, Poonpolsup S, Janejai N, Paveenkittiporn W, Boonyarit P, et al. New chapter in tackling antimicrobial resistance in Thailand. bmj. 2017;358.
43. Rossi MA, Tokumoto M, Couto E, Di Bella A, Alstchuler M, Gomez N, et al. Survey of the levels of antimicrobial resistance in Argentina: WHONET program-1991 to 1994. International journal of antimicrobial agents. 1995;6(2):103-10.
44. Dapás JI, Quirós RE. Antimicrobial stewardship in low-and middle-income countries. Current Treatment Options in Infectious Diseases. 2018;10:17-27.
45. Boni S, Marin GH, Campaña L, Marin L, Corso A, Risso-Patron S, et al. Disparities in antimicrobial consumption and resistance within a country: the case of beta-lactams in Argentina. Revista Panamericana de Salud Pública. 2021;45:e76.
46. Brodbelt D. Breaking new ground in antimicrobial stewardship in companion animal veterinary practice. Nature Communications. 2021;12(1):2445.
47. Nind L. International trends impacting antimicrobial stewardship in animal health. Australian veterinary journal. 2019;97(9):362-4.
48. Singleton DA, Rayner A, Brant B, Smyth S, Noble P-JM, Radford AD, et al. A randomised controlled trial to reduce highest priority critically important antimicrobial prescription in companion animals. Nature Communications. 2021;12(1):1593.
49. World Health Organization. Integrated surveillance of antimicrobial resistance in foodborne bacteria: application of a one health approach: guidance from the WHO Advisory Group on Integrated Surveillanec of Antimicrobial Resistance (AGISAR). 2017.
50. Jimenez CEP, Keestra SM, Tandon P, Pickering AJ, Moodley A, Cumming O, et al. One Health WASH: an AMR-smart integrative approach to preventing and controlling infection in farming communities. BMJ Global Health. 2023;8(3):e011263.
51. Mendelson M. BSAC Vanguard Series: Inequality and antibiotic resistance. Journal of Antimicrobial Chemotherapy. 2022;77(2):277-8.
52. Blake LJ, Häsler B, Bennani H, Mateus AL, Eastmure E, Mays N, et al. The UK Antimicrobial Resistance Strategy 2013–18: A Qualitative Study of International and Domestic Policy and Action Related to Livestock and the Food Chain. Frontiers in Sustainable Food Systems. 2022;6:102.
53. Huang Q, Liu X, Zhao G, Hu T, Wang Y. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. Animal Nutrition. 2018;4(2):137-50.
54. Farha AK, Yang Q-Q, Kim G, Li H-B, Zhu F, Liu H-Y, et al. Tannins as an alternative to antibiotics. Food Bioscience. 2020;38:100751.

55. Hennink M, Kaiser BN. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. Social Science & Medicine. 2022;292:114523.



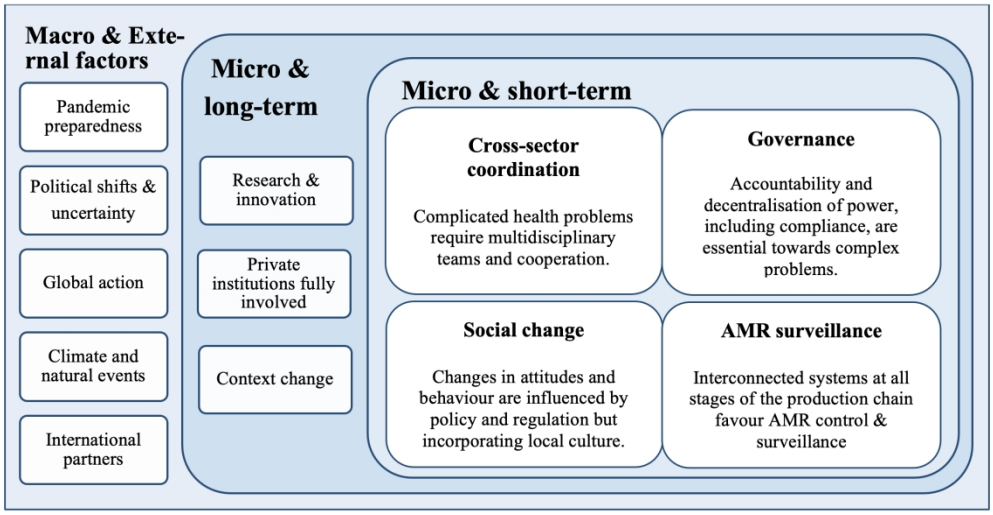
379x210mm (144 x 144 DPI)



Around 52 million head of cattle are kept by livestock farmers in Argentina. The country produced 3.2 million tonnes of beef meat in 2020, of which 900,001 tonnes were exported (75% to China). However, the production chain involves a wide variety of actors and producers (from breeding, fattening, slaughtering, preservation, and sale) and the number of direct beef producers is estimated to be 230,000 with no significant market share among specific companies, compared to chicken or swine industries where three companies concentrate 70% of the market share. Although swine and chicken are amongst food-producing animals species with higher AMR rates for streptomycin, ampicillin and tetracycline resistance, there is still a research gap regarding beef-cattle from feedlots due to reduced AMR monitoring and control, including antibiotic usage. The cattle production chain is highly fragmented, and the movement dynamics of the animals through the production chain are complex, even though their transit must be registered to comply with SENASA guidelines, and all production units should be referenced in a computer database. However, in practicality, controlling thousands of animals at different production stages is challenging, and it is often hard to trace and follow to check if producers follow guidance in antibiotic use. In line with this, cattle vaccination rates against diarrheal or respiratory diseases are relatively low compared to the chicken and swine industry. Most livestock farms are family businesses where there is a partial vet role for antibiotic administration, and antibiotic storage in warehouses is often observed due to reduced control on acquisition.

C

437x291mm (144 x 144 DPI)



441x232mm (144 x 144 DPI)

Supplementary Material

Opportunities and challenges in antimicrobial resistance among animal production systems and humans across stakeholders in Argentina: a qualitative and context analysis

Table of Contents

I. Timeline containing the legislation and policies in place within the AMR spectrum in Argentina 2

II. Summary of the Argentinian National Action Plan to combat AMR 4

III. Consent form for interviewees (participants) 8

IV. Participant information sheet 9

V. Participant interview topic guide 11

VI. Description of main preliminary topic codes applied to the interview analyses and their respective definitions 13

VII. Themes ordered from broader to greater specificity. 14

VIII. Packed code cloud for identified themes/sub-themes 15

I. Timeline containing the legislation and policies in place within the AMR spectrum in Argentina

[1916] Creation of the formerly called Instituto Nacional de Microbiología "Malbran", which is renamed in 1996 (see below).

[1956] Creation of the National Agricultural Technology Institute (INTA)

[1964] Act. 19 of the National Law of Medications No. 16,463. It states that "any form of advertising of products whose sale has not been authorized by prescription is prohibited" (subsection d).

[1967] National law regulating pharmaceutical activity. Also, the Directorate of Registration Inspection and Border Health of the Ministry of Health of the Nation, which upon verifying the violations of the regulations must initiate the corresponding summary actions and may conclude with the sanctions established in art. 45 of Law 17565 on the Exercise of Pharmacy Activity: warning, fine, closure of the establishment, suspension of registration and/or disqualification.

[1969] Decree number 3835/1969 of the Ministry of Public Health established that medicines with antibiotic activity for systemic use must be dispensed under a prescription filed by the dispenser, with penalties for non-compliance with: warning, fine, closure, suspension of registration, disqualification and /or prison of up to three years (Laws 17565/1967 of Practice of Pharmacy and 26524/2009 of the Penal Code)

[1970] Decree number 3835/69 (later modified by decree number 378/70) of the then Ministry of Social Welfare. It established that medicines whose active pharmaceutical ingredients (IFAs) have antibiotic activity for systemic use must be dispensed according to their registration condition of January 1, 1970. Prescriptions must be archived by correlative date and kept for a period of two years, after which the pharmacy can delete them.

[1983] Creation of the National program of epidemiology and control of hospital-acquired infections, which was implemented and monitored by the National Institute of Epidemiology (INE), decree number 2885/83.

[1986] Creation of the National Antimicrobial Resistance Surveillance Network WHONET-Argentina

[1992] Creation of the National Administration of Medicines, Food and Medical Technology (ANMAT)

[1995] Creation of the Intensified National Epidemiological Surveillance System for Hospital Infections (SIVENIH), implemented on a pilot basis and involving 25 public and private hospitals in the country.

[1996] Creation of the National Administration of Laboratories and Institutes of Health (ANLIS), decree number 1628.

[1998] Creation of the National Service of Agri-food Health and Quality (SENASA)

[2001] Creation of the Argentine Beef Promotion Institute (IPCVA), law number 25,507.

[2004] Creation of the National Hospital Infection Surveillance Program (VIHDA) to monitor hospital-acquired infections in participating hospitals.

[2007] Decree number 609 states that antimicrobials must be sold only under prescription.

[2009] Law 26,524. The dispensation of any type of medicinal product without compliance with the legal conditions of sale would be considered as a crime, which can be punished with prison for up to three years.

[2011] Decree number 666/2011 determined that any establishments having food-producing animals must keep a record book for the administration of veterinary products, subject to inspections.

[2011] Decree number 666 determined that the food-producing establishments must keep a record book of treatments subject to inspection by SENASA in which all administration of veterinary products on production animals must be recorded.

[2011] Act. 36 of Decree 7123/68, regulating Law 17,565, defined that: "The acquisition and sales provided by drugstores must be made by invoice and/or separate remittance..., keeping the Documentation filed in an orderly manner, making it available to the inspectors of the Secretary of State for Public Health, at their request.

[2011-2013] ANMAT drug traceability programs (decree number 435, National Ministry of Health) and SENASA phytosanitary and veterinary products (SENASA, decree number 369/2013), will provide data on the commercialization and distribution of antimicrobials in humans and in food-producing animals and agriculture.

[2013] Decree number 369/2013 created the Traceability System for Phytosanitary and Veterinary Products.

[2013] SENASA instituted the National Phytosanitary and Veterinary Products Traceability System, which reports the volume and type of antimicrobials being marketed within the veterinary products framework for commercialization. This online system involves all the parts from the commercial chain; including the manufacturer or importer of the product to the veterinarian who indicates and sells it. In this way, every time a sale is made, the seller must declare what he sold, and the buyer who accepted the sale and who assumes responsibility for the possession of the products purchased.

[2015] Decree number 834/2015 y 391/2015. Creation of the National Action plan for the surveillance, prevention and control of antimicrobial resistance (June) in line with the creation of the national commission for the control of antimicrobial resistance (CoNaCRA).

[2015] Decree number 591. Creation of the National Plan for the surveillance of AMR in food-producing animals (November)

[2015] Decree number 594/2015 prohibited the inclusion of antimicrobials in animal feed. This latest regulation points to the total prohibition (in 2019) of the use of antimicrobials as promoters of animal growth.

[2015] The National Administration of Medicines, Food and Medical Technology (ANMAT) states that the pharmaceutical labelling of antimicrobials must agree with the usual doses and treatments duration (decree number 7,130).

[2019] SENASA states that the manufacture, distribution, import, use and possession of veterinary products containing colistin is banned from veterinary products/medicine (Decree reference: EE 54429573/2018).

[2022] Antimicrobial resistance prevention and control law (number 27680). National statement on establishing the appropriate mechanisms to promote and control antimicrobial resistance in the country. It is remarked as a problem of national interest that perpetuates overtime.

Additional sources

Chapters 6.7 to 6.10 of the WOAH (World Organisation for Animal Health) Terrestrial Animal Health Code, which range from the harmonization of national AMR surveillance programmes to methodologies for monitoring the quantities of antimicrobials used and their patterns of use, the criteria for their prudent and responsible use, and the methodology for applying risk analysis derived from the use of antimicrobials in animals throughout the food chain.

For more details on distribution and marketing of drugs in Argentina, see https://uk.practicallaw.thomsonreuters.com/w-014-7135?transitionType=Default&contextData=(sc.Default)&firstPage=true

II. Summary of the Argentinian National Action Plan to combat AMR

General overview

The national action plan was elaborated and designed by the Ministry of Health in 2015 (16) in partnership with the following organisations:

- The National Administration of Laboratories and Health Institutes (ANLIS)
- National Administration of Medicines, Food and Medical Technology (ANMAT) and the REMEDIAR Program
- Ministry of Agriculture, Livestock and Fisheries:
- National Service of Agri-food Health and Quality (SENASA)
- National Institute of Agricultural Technology (INTA)
- National Universities of La Plata and the Centre of the Province of Buenos Aires
- Representation for the Americas of the World Organization for Animal Health (WOAH)
- Argentinean Society of Infectious Diseases (SADI)
- Argentinean Society of Intensive Care (SATI)

The three main objectives of the national strategy (action plan) are:

a) To prevent the emergence and spread of resistant bacteria through the regulation and supervision of antimicrobial sales, the promotion of their responsible use, and the prevention and control of healthcare-associated infections.
b) To strengthen AMR surveillance and antimicrobial usage policies.
c) To promote innovation, non-antibiotic growth promoters, and diagnostic tests to identify resistant bacteria.

These three main objectives comprise 10 different tasks detailed in the figure below.

Figure SM1. Main tasks of the Argentinian National Action Plan against AMR and their respective subobjectives.

Main 10 tasks to combat AMR in Argentina	Specific actions/sub-objectives
1. Promote leadership for the prevention and control of AMR	To develop and conduct a strategy for the prevention and control of AMR with experts' participation. To fund strategies' activity to enhance participation/awareness.
2. Surveillance of AMR in human and animal health	To develop a national surveillance network coordinated by reference laboratories for human health, animal health and agri-food production.
3. Monitor antimicrobial consumption	To develop a system for monitoring sales, access and appropriate and adequate use of antimicrobials.
4. Regulate and supervise antimicrobials usage and sales	To establish prescription sales requirements and monitor its effective compliance. To regulate the number of antimicrobial units in the pharmaceutical industry. To prohibit the use of antimicrobials as growth promoters in food production.
5. Promote responsible use of antimicrobials	To develop guidelines for diagnosis and treatment of most prevalent infections. To train health professionals on the appropriate and adequate use of antimicrobials and healthcare-associated infection prevention and control measures.
6. Promote community participation	To disseminate the problem AMR might cause in the population and the establishment of education programs on the adequate use of antimicrobials
7. Implementation of antimicrobial usage control mechanisms	To implement antimicrobial management programs in health services
8. Strengthen healthcare-associated infections prevention and control programs	To develop a surveillance strategy for healthcare-associated infections.

	To implement prevention and control programs for healthcare-associated infections in healthcare services
9. Promote antimicrobial research as well as diagnostic methods	To establish the problem of AMR as a priority matter that should be financed and researched. To prioritise the evaluation of new antimicrobials and explore new diagnostic methods.
10. Monitoring and evaluating the achievement of the objectives stated in the national action plan	To create a professional commission to monitor and evaluate the implementation and execution of the strategy (National Action Plan)

Overview of the animal and agri-food related sections

AMR SURVEILLANCE IN ANIMAL AND AGRIFOOD PRODUCTION
[ANIMAL HEALTH SECTION of the national action plan]

Current situation of the AMR surveillance in animal health and agri-food production
Surveillance is necessary for 3 groups of bacteria which have been primarily found in cattle, pigs, and birds: a) "indicator" bacteria, b) zoonotic bacteria, and c) pathogenic bacteria. Indicator bacteria are part of the intestinal microbiota of humans, other mammals, birds, and insects, and their importance lies in their ability to acquire and spread resistance genes that can be transferred to pathogenic or zoonotic bacteria.

Strategic lines of the national action plan for the surveillance of AMR in animal health and agri-food production
a) Development and implementation of the national AMR surveillance program in food-producing animals to determine the presence of resistance to different antimicrobials in at least 2 commensal bacteria: *Escherichia coli* and *Enterococcus spp*, and 2 zoonotic bacteria: *Campylobacter spp* and *Salmonella spp*
b) Harmonization of AMR surveillance strategies in human and animal health
c) Development of communication tools and timely dissemination of information

Specific actions of the national action plan for surveillance of AMR in animal health and agri-food production
a) To isolate commensal and zoonotic bacteria from cattle, pigs and poultry intended for human consumption, and determine their susceptibility profile to different antimicrobials
b) To compare the results with data obtained from previous studies, when possible
c) To determine the prevalence of AMR by animal species and by geographic region
d) To correlate antimicrobial consumption with AMR
e) To characterize and correlate resistance mechanisms between bacteria obtained from animal and human samples
f) To carry out studies on the presence of antimicrobials in different sources (including water, food, etc.) and the impact of their use on the environment and production systems
g) To evaluate alternative therapies for the use of antibiotics as growth factor in intensive production
h) To evaluate the impact of antimicrobial administration in sources on the level of resistance observed in the environmental bacterial population.
Specifically, the National Directorate of Agrochemicals, Veterinary Products and Food of SENASA will be responsible for:
a) Carrying out an annual monitoring of the volume of sales of antibiotics, with the collaboration of professional associations
b) Providing data from the veterinary product traceability system as soon as it is fully operational

REGULATION OF ANTIMICROBIAL CONSUMPTION IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

For more than ten years, SENASA has carried out a Program for the Control of Residuals, Contaminants and Food Hygiene of animal origin. This program seeks to detect the presence of chemical residues and contaminants in foods of animal origin that may affect the health of consumers. Among the residues under control, we find various antimicrobial agents, which can generate antimicrobial resistance when they are present in food.

Strategic lines for the regulation of the use of antimicrobials in animal health and agri-food production
a) Development and updating of regulations on the use of antimicrobials, aimed at preserving bacterial susceptibility as a non-renewable resource
b) To participate in international seminars on regulatory practices to improve animal health

Specific actions to regulate the use of antimicrobials in animal health and agri-food production
a) To compile and analyse the results of the surveillance and traceability systems for veterinary products to carry out risk analyses and therefore create risk profiles
b) To strengthen control protocols on the indiscriminate sales and usage of antibiotics
c) To ensure that all commercialization of antibiotics be carried out by a licensed professional
d) To create a forum for discussion on the use of antimicrobials with the chambers of the veterinary products industry, professional associations, universities and the Ministry of Health

RESPONSIBLE USE OF ANTIMICROBIALS IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

Objectives:
a) To ensure the rational use of antimicrobial agents in animals, with a view to optimizing their efficacy and safety
b) To comply with the ethical obligation and the economic need to keep the animals in good health
c) To prevent or reduce the transfer of resistant microorganisms or resistance determinants within animal populations, their environment and between animals and humans
d) To contribute to maintaining the efficacy and usefulness of antimicrobial agents used in human and veterinary medicine
e) To protect consumer health by ensuring the safety of foods of animal origin in relation to residues of antimicrobial agents

The measures include actions at the level of all stages and actors involved in the antimicrobial usage cycle, from their registration in SENASA to their prescription, marketing and consumption. The regulations generated by SENASA in recent years, have incorporated product traceability and treatment records, which are also in line with the WOAH Code.

Strategic lines for the responsible use of antimicrobials in animal health and agri-food production
a) Development of knowledge, training and information for veterinary professionals on the prudent and responsible use of antibiotics, based on pharmacokinetic, pharmacodynamic and toxicological bases
b) Intensification of marketing controls for antimicrobials usage and dispensing
c) To regulate the use of antimicrobials based on the information obtained from the surveillance program, and the corresponding risk analysis
d) To increase pharmacological knowledge about the behaviour of antibiotic considering its impact on the environment
e) To control the evolution of antibiotic resistance bacteria in clinics of small animals and intensive productions
f) To promote the responsible use of antimicrobials, including their correct prescription and administration by veterinarians

Specific actions for the responsible use of antimicrobials in animal health and food production
a) To prepare a good-practice guide for the prescription and use of antimicrobials and other veterinary products, and in line with international guidelines
b) To organise training courses and workshops for free practice veterinarians and those who work in the marketing chain or are in charge of livestock farms and balanced feed production plants, in conjunction with universities, professional associations and technical groups of exchange of the different productive activities (pigs, poultry, cattle, etc.)
c) To incorporate AMR in the curriculum of veterinary careers, in joint work with the National Council of Veterinary Sciences
d) To sustain and strengthen control in all stages of the distribution process and use of antimicrobials

PREVENTION AND CONTROL OF INFECTIONS IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

There are current international standards highlighting antimicrobials usage, including the Chapters 6.7 to 6.10 of the WOAH Terrestrial Animal Health Code.

Strategic lines for the prevention and control of infections in animal health
a) To develop programs for the management, prevention and control of infectious diseases associated with AMR in veterinary medicine, considering the biosafety of intensive production establishments in terms of infrastructure and adequate equipment for infection prevention and control practices
b) To train technical personnel assigned to intensive animal production for the prevention and control of infectious diseases in production environments; and
c) Implementation of a network of laboratories for the identification of AMR microorganisms

Specific actions for the prevention and control of infections in animal health
a) To develop regulations to enhance infection prevention and control between the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Health, universities and professional associations
b) To carry out training courses for veterinary professionals. Courses would be delivered by the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Health, professional associations and universities
c) To promote biosafety, hygiene and disinfection of personnel, equipment and productive environment compliance.
d) To generate new laboratories equipped with diagnosis tools to determine the levels of AMR bacteria isolated from food animals and the emergence of resistance mechanisms to critical antimicrobials in human and animal health, as well as the proper use of antimicrobials
e) Develop a monitoring and evaluation program to adopt joint strategies between the veterinary and human areas

Also, SENASA, with the cooperation of ANLIS, INTA, and veterinary schools of national universities, implemented a parallel surveillance program for AMR in food-producing animals. The main objective of the plan is to determine and monitor the prevalence of AMR among food-producing animals to avoid the emergence and dissemination and to minimise the damage to the population and animal health (20). The program was designed in partnership with the following institutions: National Directorate of Agrochemicals, Veterinary Products and Food, National Directorate of Food Safety and Quality, National Directorate of Animal Health, General Directorate of Laboratories and Technical Control, and the General Coordination of Regional Management.

III. Consent form for interviewees (participants)

Please initial box

1. I confirm that I have read and understood the Participant Information Sheet for the above study. ☐

2. I have been given the opportunity to consider the information provided, ask questions and have had these questions answered to my satisfaction. ☐

3. I understand that my participation is voluntary and that I can ask to withdraw before or during the interview without giving a reason and without my medical care or legal rights being affected. After the interview has been conducted and/or after data analyses, data will be anonymised and it will not be possible to withdraw. ☐

4. I understand that my anonymised data will be stored for a minimum of 5 years and may be used in future ethically approved research. ☐

5. I consent to this interview being recorded for the purpose of transcription after which the recording will be deleted. ☐

6. I agree to take part in this interview. ☐

Name of person giving consent	Date	Signature
_____	_____	_____

Name of person taking consent	Date	Signature
_____	_____	_____

IV. Participant information sheet

You are being invited to take part in an interview on:
Agricultural antimicrobial supply chains and implementation of Antimicrobial Resistance National Action Plans in Argentina and the United Kingdom

Prof Lisa Boden, Prof Dominic Moran, Dr Emma Pitchforth, Dr Stephen Mackenzie, and Alejandro Petroni at the University of Edinburgh, University of Exeter and Argentinian National Administration of Laboratories and Health Institutes are facilitating these interviews/focus groups. Before you decide to take part, it is important you understand why we are conducting this interview and what it will involve. Please take time to read the following information carefully.

WHAT IS THE PURPOSE OF THIS INTERVIEW?
This interview is intended to gather information about the current communication and interfacing between policy makers, scientific experts and stakeholders in agricultural Antimicrobial resistance and National Action Plan. Our long-term goal is to build relevant expertise to be able to design robust interventions and advice to improve antimicrobial resistance and national action plan implementation outcomes in the policy.

WHY HAVE I BEEN INVITED TO TAKE PART?
You are invited to participate in this study because you have been working on or exposed to agricultural antimicrobial resistance decision-making issues in policy, either in the United Kingdom or Argentina.

DO I HAVE TO TAKE PART?
No – it is entirely up to you whether you choose to take part. If you do decide to take part, please keep this Information Sheet and complete the Informed Consent Form to show that you understand your rights in relation to the meeting and that you are happy to participate. You may withdraw from an interview at any time and without giving a reason.

WHAT WILL HAPPEN IF I DECIDE TO TAKE PART?
You will be invited to participate in a series of interviews and/or focus groups around agricultural antimicrobial resistance, antimicrobial supply and antimicrobial national action plans and how they are perceived and incorporated into policy decision making spaces and processes. Your expertise will allow us to work over the next three years on developing a series of robust suggestions to improve the science policy interface around antimicrobial resistance in both the UK and Argentina.

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?
By participating in this discussion and sharing your experiences with us, you will be helping the research team to engage and participate with local and national policy decision-makers around integration of scientific and policy-making expertise in mitigating the risks of antimicrobial resistance.

ARE THERE ANY RISKS ASSOCIATED WITH TAKING PART?
There are no significant risks associated with participation.

WHAT IF I WANT TO WITHDRAW FROM THE STUDY?
Agreeing to participate in this workshop does not oblige you to remain in the project nor have any further obligation to this project. If you no longer want to be part of the project, please inform Prof Lisa Boden [lisa.boden@ed.ac.uk]. You should note that your ideas may be used in the design and implementation of subsequent projects and interventions. You are advised to contact the research team at the earliest opportunity, preferably before the workshop should you wish to withdraw from the project.

INTERVIEWERS AND INTERVIEW'S DETAILS
The interview will be performed by either our main researchers (detailed in the first paragraph) or Kasim Allel, who is a research fellow at the University of Exeter. The interview will take place at a time and

platform (virtual meeting via Zoom/Microsoft teams or in-person meetings) agreed upon both parties and depending on availability. The interview has five different stages covering participant's current role, understanding antimicrobial-resistance among stakeholders, information channels and flows within stakeholders/departments, challenges in the implementation of the national action plan, and future considerations. The interview has an approximate duration of 30-60 minutes per interview.

DATA PROTECTION AND CONFIDENTIALITY

Any data collected will be processed in accordance with Data Protection Law and GDPR. All information collected about you will be kept strictly confidential. Unless they are anonymised in our records, your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team. Data might be classified by organisation/affiliation only if participants concur. All electronic data and transcripts will be stored on a password-protected computer file within Microsoft teams' shared folders. All paper records will be held in a locked filing cabinet. Your consent information will be kept separately from your responses to minimise risks.

WHAT WILL HAPPEN WITH THE RESULTS OF THIS STUDY?

The outcomes of this meeting may also be summarised in reports and presentations to the funding agency or key stakeholders. The meeting may be video and audio recorded for the purpose of transcription. Quotes or key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name. Information may also be kept for future research.

WHO CAN I CONTACT?

If you have any further questions about the project, please contact Prof. Lisa Boden, lisa.boden@ed.ac.uk

If you wish to make a complaint about the project, please contact:
Lisa Boden (lisa.boden@ed.ac.uk). In your communication, please provide the study title and detail the nature of your complaint.

For general information about how we use your data go to:

https://www.ed.ac.uk/records-management/privacy-notice-research

V. Participant interview topic guide

You are being invited to take part in an interview on:

Agricultural antimicrobial supply chains and implementation of Antimicrobial Resistance National Action Plans in Argentina and the United Kingdom

[Please note this is a topic guide to support the semi-structured interviews. We do not envisage asking every question to every participant, but the questions are illustrative of what we hope to talk about]

Introduction

Thank you for agreeing to take part in this interview.

Can I check that you have had a chance to read the study information sheet?

Do you have any questions about the study?

[if not returned prior to interview go through and complete consent form]

Are you happy for me to begin the interview and to start recording?

[turn on recorder]

Thank you.

The interview is designed to be free-flowing so please talk about anything that you feel is relevant, I have just prepared some questions structured into five broad areas.

Interview's questionnaire

BOX 1. Survey's main sections: objectives and questions

I. Participant's current role. These questions will seek to understand what experiences our participants have and how they might be relevant to implementing the National Actiona Plan to combat AMR.

<1> What your job/role is, and what tasks do you and your organisation mainly perform?
<2> What are your (or department/organisation) interests and responsibilities concerning AMR?

II. Understanding AMR among stakeholders. This group of questions aim to understand employees' and organisations' views on AMR; its main drivers, change overtime, support venues, and priority areas within organisations to help tackle AMR.

<1> How do you feel (or what are your personal and department's concerns) about antimicrobial resistance in humans? Does that differ from antimicrobial-resistance in animals or any other source, including the environment (how)?
<2> Do you think the view about antimicrobial-resistance has changed over the years? How?
<3> What are the priority areas within your organisation to increase AMR awareness and to comply with the national action plan? Do you feel your organisation help contribute to any of the areas detailed in the national plan (how, which)?
<4> What are the cornerstones for increasing AMR awareness while complying with the national action plan within your organisation?
<5> Which cornerstones do you feel are most relevant within your department (organisation)? Why?

III. Information channels and flow within stakeholders/departments. These questions attempt to improve organisations decision making towards better AMR surveillance by identifying how the information is channelled within and between organisations.

<1> how do you feel about AMR-related information and communication flow within your organisation and among all stakeholders?
<2> What do you think about communicational interactions, networking, and educational or getting-to-know instances between your organisation and other stakeholders and within departments of your organisation? Would you believe (and how) that the information pathways vary between specific organisation's fields/disciplines, public/private institutions, or certain other groups?
<3> Could you identify which organisms (organisations), and how, are involved in your organisation's decision making and strategy towards improving AMR surveillance and control?

IV. Challenges in the implementation of the national action plan. These questions attempt to answer what factors or challenges might be key to increasing AMR awareness and improving AMR surveillance among food-producing animals and agriculture.

<1> Do you feel there is any challenge that your organisation faces in complying with the AMR national action plan and helping contribute to better animal surveillance? (Political priorities, monetary and non-monetary resources, communication, etc) What are the most important and what can be done to overcome these challenges if your organisation could prioritise resources to contribute higher to AMR surveillance in animals?
<2> Who else do you think has a critical role in helping with AMR surveillance in animals from the pool of stakeholders?

V. Future and other considerations. These questions aim to understand future steps to be taken within the industry and different key members to tackle AMR

<1> How organisations might be helped to enhance cross-communication and teamwork? How can we ensure organisations make progress and collaborate meeting NAP's criteria?
<2> Which organisations, at the national and international levels, do you think are most important to talk to and direct the efforts to address the gap in knowledge in AMR? Does the list differ for improving the NAP?
<3> Is there anything else important that you might want to share with us or that we are missing in the current interview?

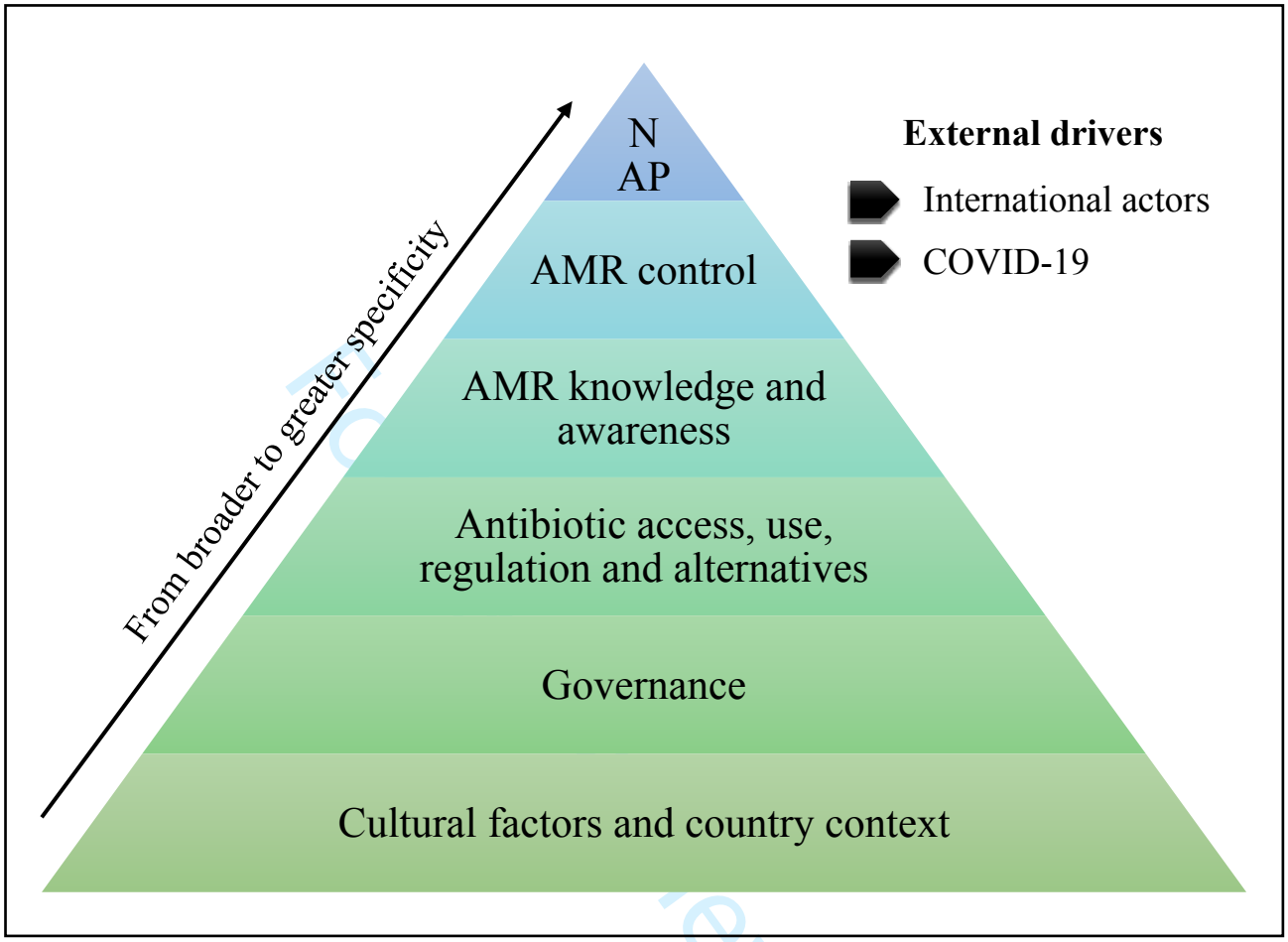
VI. Description of main preliminary topic codes applied to the interview analyses and their respective definitions

Table SM1. Topic codes and their definitions

Code	Definition
Application of NAP	Implementation of NAP and roles, including views on progress
AMR control	Perceived progress and challenges, inclusive of surveillance
Antibiotic access, use and regulation (human and animal)	Referring to antibiotic consumption and access and prescriptions in animals and humans
Alternatives to antibiotics	Discussion of alternatives to antibiotics
Context of Covid	Referring to acceleration of AMR, potential opportunities and good practice, ways of working
Governance	Government priorities, federalisation, vertical vs horizontal, nature of institutions/groups, accountability (lack of)
AMR knowledge/awareness	Referring to public and professional awareness – the challenge of awareness and steps taken to address
Resources	Referring to human and economic/budgetary resource (lack of) available to tackle AMR
Stakeholders	Describing/listing stakeholders involved
Stakeholder communication	Communication (lack of) between stakeholders
Cultural and country context	Understanding of importance of cultural, country context, including personal relationships
International actors and policies	Mention of international actors and role in/influence on national AMR in Argentina
Food production	Reference to food production markets, differences by animal species
Information/data flow	All references, specifically to information/data e.g. capacity/system to share data
Regulation and compliance	Description of different regulation, proposed change and perceived (potential) impact
Political context and agenda //	Importance of (changing) political will
Vet sector	Including role of vet sector, antibiotic in animals
Training and learning opportunities	Including seminars, conferences, courses, stewardship programs, etc.

VII. Themes ordered from broader to greater specificity.

Figure SM2. Structure of the ordered themes



Notes: AMR= Antimicrobial resistance. NAP= National action plan.

VIII. Packed code cloud for identified themes/sub-themes

Figure SM3. Code cloud for identified themes and sub-themes

Notes: AMR= Antimicrobial resistance

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	n/a
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1, page 5-6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-14
		(b) Indicate number of participants with missing data for each variable of interest	5
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*n/a*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*n/a*
		Cross-sectional study—Report numbers of outcome events or summary measures	*5-13*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a qualitative study
		(*b*) Report category boundaries when continuous variables were categorized	n/a qualitative study
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a qualitative study
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely

available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a context and qualitative analysis

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-082156.R1
Article Type:	Original research
Date Submitted by the Author:	08-Apr-2024
Complete List of Authors:	Allel, Kasim; London School of Hygiene & Tropical Medicine; University of Exeter, Faculty of Health and Life Sciences Fernandez-Miyakawa, Mariano; Instituto Nacional de Tecnología Agropecuaria Gaze, William; University of Exeter, Faculty of Health and Life Sciences Petroni, Alejandro; Instituto Nacional de Enfermedades Infecciosas Corso, Alejandra; Instituto Nacional de Enfermedades Infecciosas Luna, Federico; Independent researcher Barcelona, Laura; Comisión Nacional de Control de la Resistencia Antimicrobiana Argentina, AMR policy research group; Full list of authors provided at the end of the manuscript Boden, Lisa; University of Edinburgh Royal Dick School of Veterinary Studies Pitchforth, Emma; University of Exeter, Faculty of Health and Life Sciences
Primary Subject Heading:	Public health
Secondary Subject Heading:	Global health, Communication, Public health
Keywords:	Public health < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a context and qualitative analysis

Kasim Allel[1,2], Mariano Fernandez-Miyakawa[3], William Gaze[1], Alejandro Petroni[4], Alejandra Corso[4], Laura Barcelona[6], Federico Luna[7], AMR policy research group Argentina†, Lisa Boden[5], Emma Pitchforth[1,*]

[1] Faculty of Health and Life Sciences, University of Exeter, Exeter, UK
[2] Department of Disease Control, London School of Hygiene and Tropical Medicine, London, UK
[3] Instituto Nacional de Tecnología Agropecuaria Castelar, Buenos Aires, Argentina
[4]Servicio Antimicrobianos, Instituto Nacional de Enfermedades Infecciosas, ANLIS "Dr Carlos G. Malbrán", Buenos Aires, Argentina.
[5]Royal School of Veterinary studies, University of Edinburgh, Edinburgh, UK
[6]Comisión Nacional de Control de la Resistencia Antimicrobiana, Buenos Aires, Argentina.
[7] Independent researcher, Buenos Aires, Argentina.
† Full list of authors provided at the end of the manuscript
* Corresponding author: e.pitchforth@exeter.ac.uk. University of Exeter Medical School, University of Exeter, Exeter EX1 2LU, UK.

ABSTRACT

Introduction. Gaps in antimicrobial resistance (AMR) surveillance and control, including implementation of national action plans (NAP), are evident internationally. Countries' capacity to translate political commitment into action is crucial to cope with AMR at the human-animal-environment interface.
Methods. We employed a two-stage process to understand opportunities and challenges related to AMR surveillance and control at the human-animal interface in Argentina. First, we compiled the central AMR policies locally and mapped vital stakeholders around the NAP and the national commission against bacterial resistance. Second, we conducted qualitative interviews using a semi-structured questionnaire covering stakeholders' understanding and progress towards AMR and NAP. We employed a mixed deductive-inductive approach and used the constant comparative analysis method. We created categories and themes to cluster sub-themes and determined crucial relationships among thematic groups.
Results. Crucial AMR policy developments have been made since 1969, including gradually banning colistin in food-producing animals. In 2023, a new government decree prioritises AMR following the 2015 NAP launch. Our qualitative analyses identified seven major themes for tackling AMR: (I) Cultural factors and socio-political country context hampering AMR progress, (II) Fragmented governance, (III) Antibiotic access and use (IV) AMR knowledge and awareness throughout stakeholders, (V) AMR surveillance, (VI) NAP efforts, and (VII) External drivers. We identified a fragmented structure of the food production chain, poor cross-coordination between stakeholders, limited surveillance and regulation among food-producing animals, and geographical disparities over access, diagnosis and treatment. The country is moving to integrate animal and food production into its surveillance system, with most hospitals experienced in monitoring AMR through antimicrobial stewardship programs.
Conclusion. AMR accountability should involve underpinning collaboration at different NAP implementation levels and providing adequate resources to safeguard long-term sustainability. Incorporating a multisectoral context-specific approach relying upon different One Health domains is crucial to strengthening local AMR surveillance.

Keywords: Antimicrobial resistance, antibiotic use, Argentina, one health, low-and-middle income countries

Strengths and Limitations

► Organisational barriers within stakeholder groups and the wider community—including the complexity of cross-sectoral communication, data access and interpreting information, fragmented routes for collaboration, and population awareness— have resulted in challenges towards establishing better AMR control and surveillance in Argentina

► AMR surveillance and control in food-producing animals outlines puzzled strings; there are limited antimicrobial stewardship programs and highly disintegrated food-production chains among meat production, specifically cattle.

► Potential beneficial opportunities presented, include using agricultural products (e.g., tannins) as an antibiotic replacement and the new law on AMR as an established government priority, should be fostered and capitalised for improvement towards AMR policy.

► The main limitations of our study are that the extent of interviewees' actual involvement in AMR policies differed, and that the generalisability of results might not apply to less represented sectors, such as the private industry.

Introduction

Antimicrobial resistance (AMR) represents a global public health threat driven by interrelated human, animal and environmental factors and requires multidisciplinary and cross-government action (1-3). National and international endeavours have collectively helped reduce AMR over recent years (4). The World Health Organisation (WHO) launched the Global Action Plan on AMR in 2015, soliciting countries to elaborate a National Action Plan (NAP) to confront AMR (5). Similar initiatives have come through the United Nations (UN)(6) and the European Commission (7) to develop multisectoral strategies involving human and animal health to fortify innovation stages and shape the global health agenda towards AMR NAPs. Despite 152 countries having published NAPs (8), challenges exist in implementing NAPs locally, limiting the progress towards addressing AMR (9). Contrasting cultures, policies, incentives and behaviours of relevant sectors and stakeholders have made the implementation of NAPs an arduous process (4). For instance, the lack of surveillance and epidemiological data, the variety of methods used to collect data and the limited understanding of the clinical and social burden of AMR pose challenges for the consummation of NAPs internationally (10). Locally, policy design, including governance and stakeholder involvement and cross-sectoral coordination, are critical to fulfilling the NAP's objectives while adapting the alternating demands of each local subgroup (4, 11).

Recent literature suggests that low- and middle-income countries (LMICs) are likely to face the most significant challenges in NAP implementation (4, 12-20). Among LMICs in Asia, a review found that accountability —a sense of ownership of organisations or people requiring responsibility to other stakeholders— has been omitted in most NAPs (4). Indications of unmet goals and lack of clarity in the stakeholders' role remain significant obstacles to AMR prevention and control (14, 15, 18). In the Americas, 29 countries (89%) have reported developing NAPs to combat AMR since the beginning of 2020 (21).However, most countries including Argentina, have not focussed sufficiently yet on One Health components; active surveillance of human health is not integrated with surveillance in animals or the environment (4, 18). Using a One Health approach is critical for effective NAP implementation because it optimizes the health of different sectors, including natural environments which play a crucial role in AMR evolution and transmission, while preventing zoonotic diseases and improving food safety and security. Argentina implemented a multisectoral NAP strategy in 2015 (22), and progress has been made, including the prohibition of colistin usage in 2019 and gradual banning of antibiotics as growth promoters among livestock (23, 24). A recent study measuring global response to AMR by employing a governance framework on NAP contents highlighted that Argentina can make improvements in standards to control AMR (18). The study stated Argentina's moderate efforts towards monitoring and evaluating AMR in humans and animals and modest AMR policy design (i.e., lack of accountability). However, the study used the Tripartite Antimicrobial Resistance Country Self-Assessment (TrACSS) survey, which could be influenced by the exclusion of publicly and privately accessible documents relevant for AMR monitoring locally, and it lacked data sources that could invite heterogeneity (e.g., interviews with multiple experts/ stakeholders), all of which are considerably important in LMICs. A more direct way to explore Argentine's response to AMR policy is to obtain current data from the stakeholders involved.

This study aims to better understand the stakeholder and regulatory landscape and the challenges and opportunities Argentina faces in implementing its NAP. We examined Argentina's case because it is one of the first countries to have a NAP and has a vast experience in AMR surveillance in the human sphere, which might indicate a good model for the Latin American region. We use the One Health (25) approach to assess policy priorities in action plans, and the governance framework (26) to evaluate interrelated dynamics between the One Health actors to improve critical areas: policy design, implementation tools, and monitoring and evaluation. The need to provide technical and financial support for implementing One-Health integrated NAPs has been recognised globally through the AMR Multi-Partner Trust Fund. Still, the donor base for this remains a few countries (27, 28). Global action may be based on shared goals, but there is a further need to understand the needs and priorities enabling or hindering those actions at national levels. We explore Argentina as a case-study to understand the complex landscape.

Methods

Study aims and setting

This article draws on literature and qualitative interview data from a study conducted in Argentina between September 2022 and February 2023. Argentina is an upper-middle income country that is endowed with highly fertile soils and great potential for renewable energy (hydroelectric, wind and solar energy) (29). It is a major food-producing country with an extensive agriculture and livestock industry; however, the country faces a high fiscal deficit with poverty and inflation rates of about 39% and 94.8% in 2022, respectively. The project's scope was to comprehend the context of AMR policy locally and among relevant stakeholders towards AMR control

and surveillance, focusing on food-producing animals. Relevant stakeholders included government (those with political/administrative duties and those having scientific-technical functions), academic, international, NGOs, and private (chamber of producers, commercial laboratories and producers) institutions.

Study design

We divided our study into two stages. First, we explored the legal framework within the AMR NAP scope and mapped vital organisations, particularly related to food-producing animals (i.e., cattle, chicken and pigs). We searched the literature, including government documents, academic articles, stakeholder's websites, and grey literature, to capture the most relevant AMR policies and critical actors and their role over time. Most sources were identified from the website of the National Commission for AMR control (CoNaCRA, "*Comisión Nacional de Control de la Resistencia Antimicrobiana*") (30) the National Institute of Infectious Diseases (INEI) (31), and government website for national laws (http://www.infoleg.gob.ar/). A recent systematic literature review was also utilised to support evidence synthesis and mapping (32). Moreover, expert knowledge was consulted for main organisations related to the AMR NAP and food-producing animals, and their interactions with stakeholders. Second, after identifying and mapping relevant stakeholders, we conducted qualitative semi-structured interviews between September 2022 and January 2023 to gather information on stakeholder's views and experiences of NAP implementation, the role of different organisations and nature of coordination and decision making between organisations. Interviews were held in person or online lasting 45 to 90 minutes and were conducted by a bi-lingual (English-Spanish) social scientist. The stakeholder mapping developed in stage 1 was used to inform recruitment. A range of participants were sought from government, private and academic organisations. Potential participants were sent a formal request letter via email inviting them to take part in the interview study. Semi-structured interviews were performed using an interview topic guide designed to explore five main items, with questions and objectives detailed below (Box 1). Stakeholders were encouraged to discuss their own views openly. After obtaining informed consent, interviews were audio-recorded in Spanish and transcribed and translated to produce English and Spanish transcripts. Transcripts were checked for accuracy by the interviewer and anonymised. Translation bias was minimised by analysing both original and translated versions by Spanish native speakers (i.e., KA and a qualified third-party translator from Argentina). Back-translation was performed with a reduced sample (20%) of interviews to validate the accuracy of the initial translation (no discrepancies were found). Special attention was given to cultural references, idiomatic expressions, and regional dialects to ensure that translations were contextually appropriate and culturally sensitive (33). The consent form, participant information sheet, and participants interview topic guide are included in the online supplementary material.

Box 1. Interview's main sections including objectives, items and questions

I. Participant's current role. These questions seek to understand what experiences our participants have and how they might be relevant to implementing the NAP to combat AMR.

<1> What your job/role is, and what tasks do you and your organisation mainly perform?
<2> What are your (or department/organisation) interests and responsibilities concerning AMR?

II. Understanding AMR among stakeholders. This group of questions aim to understand employees' and organisations' views on AMR; its main drivers, change overtime, and priority areas within organisations to help tackle AMR.

<1> How do you feel (or what are your personal and department's concerns) about antimicrobial resistance in humans? Does that differ from antimicrobial-resistance in animals or any other source, including the environment (how)?
<2> Do you think the view about antimicrobial-resistance has changed over the years? How?
<3> What are the priority areas within your organisation to increase AMR awareness and to comply with the NAP? Do you feel your organisation helps to contribute to any of the areas detailed in the national plan (how, which)?
<4> What are the cornerstones for increasing AMR awareness while complying with the NAP within your organisation?
<5> Which cornerstones do you feel are most relevant within your department (organisation)? Why?

III. Information channels and flow within stakeholders/departments. These questions attempt to improve organisations decision making towards better AMR surveillance by identifying how the information is channelled within and between organisations.

<1>How do you feel about AMR-related information and communication flow within your organisation and among all stakeholders?
<2> What do you think about communicational interactions, networking, and educational or getting-to-know instances between your organisation and other stakeholders and within departments of your organisation? Would you believe (and how) that the information pathways vary between specific organisation's fields/disciplines, public/private institutions, or certain other groups?
<3> Could you identify which organisms (organisations), and how, are involved in your organisation's decision making and strategy towards improving AMR surveillance and control?

IV. Challenges in the implementation of the national action plan. These questions attempt to answer what factors or challenges might be key to increasing AMR awareness and improving AMR surveillance in food-producing animals and agriculture.

<1> Do you feel there is any challenge that your organisation faces in complying with the AMR NAP and helping contribute to better animal AMR surveillance? (Political priorities, monetary and non-monetary resources, communication, etc) What are the most important and what can be done to overcome these challenges if your organisation could prioritise resources to contribute more to AMR surveillance in animals?
<2> Who else do you think has a critical role in helping with AMR surveillance in animals from the pool of stakeholders?

V. Future and other considerations. These questions aim to understand future steps to be taken within the industry and different key members to tackle AMR.

<1> How organisations might be helped to enhance cross-sectoral communication and teamwork? How can we ensure organisations make progress and collaborate to meet NAP criteria?
<2> Which organisations, at the national and international levels, do you think are most important to talk to and direct efforts to address AMR knowledge gaps? Does the list differ from that necessary to improve the NAP?
<3> Is there anything else important that you might want to share with us or that we are missing in the current interview?

Data analyses

First, we systematically organised Argentina's main AMR regulations using a timeline frame and drew a map to delineate the main stakeholders directly or indirectly supporting the CoNaCRA directed by the Coordination on appropriate use of antimicrobials of the ministry of health, as the commission articulating the efforts for the implementation of the NAP. Second, we employed a systematic qualitative thematic analysis of the interviews using a mixed deductive-inductive approach (34); deductive because it was guided by interview questions from a general topic to a more specific, but inductive as we draw data-driven conclusions derived from bottom-up reasoning. We followed the constant comparative method (35) to favour participants' comparability. Information and open data were classified into themes and subgroups using a coding scheme. Two investigators independently recorded the interviews (KA, EP) using Dedoose software (V.8.0.35, Los Angeles, California: Socio Cultural Research Consultants, LLC). Researchers frequently met to reconcile differences in code application and distinguish new themes emerging from the data analyses. After consolidating new themes, all interviews were re-coded using an updated scheme (see online supplementary material). Subsequently, we identified interconnections between theme data to ascertain larger categories into which themes were clustered. For quotations, we report descriptive characteristics, such as organisation type (academia, government, private, production system), sex at birth, and assigned a random number to each interviewee. Quotes are reported in the text and Tables as "Q" followed by ordered numbers. We reported descriptive statistics to facilitate reader's understandability from whom quotations were drawn and favour studies' transparency while maintaining the anonymity of participants. We utilised the consolidated Criteria for Reporting Qualitative Research (COREQ) checklist to guide reporting of findings (36).

Patient and public involvement

This study was focused on the views and experiences of professionals. Patient and public involvement was therefore not included but we ensured engagement with the community of interest. Public health experts from

Argentina and the UK contributed feedback on our study design and research questions, ensuring relevance and applicability across diverse settings without direct involvement in the core research process.

Results

I. First stage: review of policies and mapping key stakeholders

The timeline containing established laws and regulations related to AMR is found in Supplementary material section I. Briefly, antimicrobial regulation started in the early 60's with the first law of medications and enforced prescriptions for antibiotic acquisition. In 2007-9, new decrees were introduced instituting required prescription for antibiotic sale and compliance for dispensation of medicines, including the registration book of veterinary medicines usage in food-producing animals (2009-11, decree number 26514). In 2013, Argentina's national Food Safety and Quality Service (SENASA) created the traceability system for veterinary medicines, which links sellers and purchasers where entities take full responsibility for antibiotic possession. Consecutively, Argentina's national commission for the control of AMR (CoNaCRA) was established and led the launch of the NAP in 2015 (see Supplementary material section II for a summary).This was concurrent with the abolition of antibiotic usage as an animal growth promoter (2015). The national law towards gradual prohibition of colistin usage in any form/ingredient took place in 2019. Recently, there was a new law encompassing an One health AMR agenda in the future (decree number 27680) aiming to foster and promote AMR control, prevention, research, regulation, and awareness (24).
Finally, Figure 1 shows the mapping of key AMR surveillance and control stakeholders. We organised it starting from the CoNaCRA as the commission responsible for the implementation of the NAP and those relevant organisations surrounding them (main governmental divisions in brown boxes).

II. Second stage: qualitative analyses

Descriptive characteristics of study participants

We approached 27 individuals initially (non-response levels=33%), but our final sample consisted of 18 participants (six women, 33%) mostly based in Buenos Aires city (88%) and from diverse institutions including government (N=9), academia (N=3), private (N=2), NGOs (3) and international organisations (N=1).

Thematic categories and codes

Barriers, opportunities, and state-of-art information contributing to human and food-producing animal AMR were clustered into seven thematic categories organised by specificity level (from less and more specific themes towards AMR policy). Themes were established based upon number of mentions and repetitiveness. Two themes emerged from Argentina's embedded values and political context impacting AMR indirectly: (I) Cultural factors and country context and (II) Governance. Four themes were directly associated with AMR: (III) Antibiotic access and use, (IV) AMR knowledge and awareness, (V) AMR surveillance, (VI) National action plan efforts. The remaining theme was linked to external factors indirectly affecting all chain's decision-making: (VII) External drivers. The full definition of themes —ordered from less to more specific except for external drivers, which affects them all— with their respective sub-themes, are shown in Table 1.

Theme I. Cultural factors and socio-political country context

This category involved country characteristics that determine the response to AMR. Interviewees described that country's economic and political shifts, including goods shortages and high inflation rates, had jeopardised the health system, bringing instability over time to AMR control. Most political decisions in a resource-constrained country were said to be difficult to manage but high reliance upon people and relationships was essential. For instance, a participant described frustration and uncertainty but ability to cope with challenges despite the economic circumstances.

> "*Argentina has 30 years of experience on AMR surveillance, we live economic shortages and political shifts fiercely in Argentina; a state of crisis, and we are somewhat used to this dynamic trying to cope with it as best we can. We have developed good coordinating links between teams centralised on good communication skills, but we cannot guarantee sustainability. It will depend on future leader's coordination since monetary resources are limited, a lot relies upon the projects or people's willingness to contribute but we believe it will perpetuate*"—Participant from a public institution (ID=9), female.

Most participants agreed that changing people's attitudes and behaviour, especially among food-producing animal producers, is challenging due to embedded values (Q1, Table 2). For instance, a participant described it as follows:

> "*Inappropriate antibiotic use, driven by cultural norms like self-medication and seeking quick remedies is often influenced by limited healthcare access. This extends into food production, where profit motives can override caution. A shift in cultural perspective is crucial, educating on responsible use and the benefits of animal welfare and sustainable practices across the sectors"* —Participant, from a public institution (ID=6), male.

Theme II. Governance

Participants reported constraints in the administration system that limited or enhanced their ability to perform improvements towards tackling AMR. Most participants recognised that SENASA conducts extensive and well-articulated labour; however, they emphasised the lack of auditing and accountability in decentralised administrations (regions) in Argentina, which hampers AMR control due to the inherent variability in the quality of care and health access (Q3, Table 2). Efforts to homogenise quality of care and access to antibiotics in humans and animals are ongoing, but monetary and non-monetary resources are bounded (Q4, Table 2). Although resources were finite, stakeholders' communication was often seen as a local strength and the cornerstone of policy making. Good interpersonal relationships within the public, academic, NGOs and international organisations were reported (Q5, Table 2). However, a demand for more integrated services and decision-making was stated (Q5), translating into the need to foster horizontal information flows with mutually integrated systems and organisations throughout the country (Q6, Table 2).

Regarding the regulation sub-theme, there are positive views towards the new law on antimicrobial use, despite the former law introducing some restrictions but lacking control on usage, prescribing and storage (most frequent among animals) (Q7, Table 2). On top of all previously discussed factors, the political context and agenda were considered critical for AMR control but conflicting depending on the country's obstacles and people in charge (Q8, Table 2).

Table 1. Main themes, definitions and sub-themes identified from the interview analysis (N=18 people)

Themes†	Definitions	Sub-Themes	N of times mentioned*
I. Cultural factors and socio-political country context	Understanding the importance of cultural, country context, including personal relationships	**[1]**Cultural features **[2]**National context and sociodemographic characteristics	**[1]**21 **[2]**18
II. Governance	Government attributes related to political priorities, federalisation, nature of institutions/groups, accountability, human and economic/budgetary resource available, data systems and capacity, importance of changing political will, regulations and communication between stakeholders.	**[1]**System governance **[2]**Resources **[3]**Stakeholder communication **[4]**Information and data flow **[5]**Regulation and compliance **[6]**Political context and agenda	**[1]**23 **[2]**22 **[3]**39 **[4]**39 **[5]**38 **[6]**11
III. Antibiotic access and use	Referring to antibiotic consumption and access, prescriptions control and alternatives being developed among animals and humans.	**[1]**Antibiotic access **[2]**Antibiotic consumption **[3]**Antibiotic regulations including prescriptions. **[4]**Alternatives to antibiotics	**[1]**15 **[2]**11 **[3]**14 **[4]**9
IV. AMR knowledge and awareness	Related to public and professional awareness – the challenge of awareness and steps taken to address it including seminars, conferences, courses, stewardship programs, advertising campaigns using mass media, etc.	**[1]**Challenges related to public and professional awareness. **[2]**Existing training and learning opportunities	**[1]**41 **[2]**15
V. AMR surveillance	Perceived progress and challenges, inclusive of AMR surveillance. Reference to food production markets including differences by animal species	**[1]**AMR surveillance **[2]**Food production systems and specific surveillance **[3]**Veterinary sector, agent of change	**[1]**34 **[2]**35 **[3]**14

	and the role of the veterinary sector on AMR surveillance.		
VI. National action plan (NAP) efforts	Implementation of NAP and professional roles, including views on progress over time	**[1]**NAP progress including challenges, barriers, and opportunities	**[1]**22
VII. External drivers	Referring to external factors contributing to the acceleration of AMR, potential opportunities, and good practice, including international actors and role in/influence on national AMR	**[1]**Context of COVID-19 **[2]**International actors and policies	**[1]**16 **[2]**12

Notes: AMR= Antimicrobial resistance. †Themes are ordered from less to more specific levels (except for external drivers which affects them all), see Figure SM2, Supplementary material, for visual hierarchy. *Codes can be mentioned more than once per interview.

Table 2. Quote examples by themes and sub-themes and identification of challenges and opportunities

Themes†	Sub-theme	Representative quote examples	Challenge/ opportunity
I. Cultural factors and socio-political country context	**[1]**	Q1:*"AMR is a cross-cutting issue, but with older-generation low-educated producers living mostly in remote areas (a large quantity), it has been difficult to make them switch their mindset and understand that antibiotics are not necessary for food production, if no bacterial disease is present, and that antibiotic misuse and AMR affect humans and animal well-being."*—Veterinary, public institution(ID=3), male.	Challenge
	[2]	Q2:*"Today, in Argentina, we have 52% poverty and talking about AMR is challenging, considering that 95% of the population is deprived. Telling people to buy cage- and antibiotic-free eggs for a double price seem problematic, considering that overcrowding, hunger, and lack of sewers are constant daily challenges"*—Participant from an NGO (ID=13), male.	Challenge
II. Governance	**[1]**	Q3: *"SENASA is very dynamic but there is lack of accountability from each participating institution when combatting AMR. It is worrisome that SENASA's and other public organisation's labours are highly centralised in the capital, because there is a high heterogeneity in access to treatment, diagnosis, quality standards for animal products, and antibiotic prescribing throughout the country. We know SENASA, for instance, is impeccable but our surveillance system is not punitive, whereas it mostly teaches producers as we do not know where those AMR pathogens came from (reservoirs)"*—Participant from an NGO (ID=12), male.	Challenge and opportunity
	[2]	Q4: *"I think that the most important difficulty is economic and human resources, because especially in public institutions, it is challenging for people to have exclusive and fully compensated dedication"*—Participant from a public institution (ID=11), female.	Challenge
	[3]	Q5: *"We have solid communication channels between governmental institutions (SENASA, INTA, MALBRAN, CoNaCRA) and somewhat with international and academic institutions, but we should employ a strategy of involvement between technical scientific groups, hospital and veterinary leaders, the private industry, including pharmaceutical, and meat producers and related organisations. We need to tell them what our problem is, for them to tell us theirs, and finally come up with integrative solutions that are beneficial for all parties."* —Participant, from a public institution (ID=6), male.	Challenge and opportunity
	[4]	Q6: *"For some diagnostics we report directly to the health informatics system, but we lack perhaps of articulating all the information flows more horizontally facilitating access above all the political decision-makers. Additionally, most systems are not integrated"* —Participant from a	

		public institution (ID=11), female.	Challenge and opportunity
	[5]	Q7: *"Our legislation should regulate and control sales and consumption of antibiotics, including misuse (prohibition, e.g., colistin in veterinary in 2017). Now, it is approved the Antimicrobial Use Law, which legislates on the request of archived prescriptions, and it is stricter than the former law (only monitored required prescriptions and it had poor compliance). We believe antibiotic consumption might decrease. However, regulations are not yet standardised across country regions organically and the informal market is ample."* —Participant from a public institution (ID=6), male.	Challenge and opportunity
	[6]	Q8: *"At the ministerial level, sometimes AMR does not receive the importance and continuity it requires. Today we have a Minister of Health to whom AMR was a priority on their political agenda and most policy attempts entails, and do not omit, reducing AMR and antibiotic misuse. It is helpful to work in favour of that, but it is not frequently the case."* —Participant from an international institution (ID=17), female.	Challenge and opportunity
III. Antibiotics access and use	**[1]**	Q9: *"Laboratories distribute veterinary products. Laboratories have the approval of SENASA to produce and commercialise the products, as well as the distributors. The commercialisation path is laboratory> distributor> production, through veterinarians, but sometimes is the owner himself selling and applying them due to lack of regulation on access, even over the counter. Among cattle, there is a large part of the production that is still extensive and pharmaceutical companies are often far away from feedlot farms. Hence, they keep first-aid kits, including antibiotics, which are applied to wounds or with no diagnostic or under no veterinary supervision. The law obliges establishments to have a treatment book where animal treatments and antibiotics used are recorded, but in most remote areas is not reliably fulfilled and control is limited"* —Participant from an NGO linked to animals (ID=4), male.	Challenge
	[2]	Q10: *"I work in swine production; our main concern relies upon prophylactic consumption of the antibiotic. Indiscriminate antibiotic consumption is present in two ways within swine production. First, meta-phylactic, when there is a percentage of animals that are indeed sick within the flock, but since they are living with them, it is very likely that others are incubating the disease, hence they are treated. The second is the prophylactic, where there is no sick animal, but there are factors of potential stressors that could make those animals sick. This is our biggest concern, because antibiotic is then incorporated into food, whose biological matrix restricts bioavailability of the active ingredient. Additionally, when antibiotics are applied, withdrawal times are not monitored, which promotes the development of AMR mechanisms further"* —Veterinarian, academia (ID=14), male.	Challenge
	[3]	Q11: *"Laboratories producing medicines for veterinary use must comply with good manufacturing practice 'GMP' standards. They register the product, present all the documentation on waste, among other features. We have traceability in some products, such as ketamine, each bottle is identified and we follow-up until the final user. Laboratory production of medicines is well monitored, but there are limited regulations over usage registration, because products are not often administered by health professionals. For instance, final users do not necessarily respect the restriction period or animal treatment is incomplete, for which regulation is scarce."* —Participant from an NGO (ID=4), male.	Challenge
	[4]	Q12: *"We employ tannins, organic acids, probiotics, and prebiotics instead of antibiotics. We proved their efficacy for Escherichia coli and Salmonella using a mixture of probiotics and prebiotics in sentinel farms, which were boosted animal growth. We have produced alternative to antibiotics for a long-time including animal vaccines against pneumonia, and it was company's initiative."*—Participant from a private company (ID=5), male.	Opportunity

IV. AMR knowledge and awareness	**[1]**	Q13: *"One of the main challenges is the access to information/ communication, the awareness of responsible antibiotic use, and lack of commitment from the private sector. Technical and general education on antibiotics and AMR should be promoted to help set a change of consciousness in the consumer, prescriber, and sellers by letting them know the actual effects/impacts of AMR on population health and animal businesses (among producers). The profitability of the sector is compromised if producers are not willing to pay a differential for meat production that could produce higher costs in the future if not committed."* —Engineer from an NGO (ID=7), male.	Challenge
	[2]	Q14: *"The Argentine population is much more aware of what human health is and what antibiotics are designed for. For instance, we had the World Week of Awareness in November, and we held the AMR awareness race alongside the Ministry of Health and Sports, which exhibits interrelationships between different groups."* —Participant from an international organisation (ID=17), female	Challenge and opportunity
V. AMR surveillance	**[1]**	Q15: *"We created the infection surveillance program in 2004 for human hospitals, which is an essential part of national surveillance reporting the annual prevalence/incidence of most critical pathogens. A ministerial resolution from 2018 recommends establishing hospital prevention and control programs, but adherence is optional. We have more than 200 added institutions reporting the appropriate use of antimicrobials yearly, including whether it was empirical, directed, surgical prophylaxis, community-acquired infection, etc. In-hospital software, part of the National Antimicrobial Resistance Surveillance Network 'WHONET', clinicians load the data, compute the analyses (automatically) and feeds the information to the epidemiology department. However, since 2021 (ministerial resolution), prevention and control programs must be certified depending on international guidelines. We use a federal criterion to enrol national institutions and federal hospitals, but private organisations are poorly represented. Also, some institutions did not have stewardship programs actively functioning. We updated the last referendum to include antimicrobial stewardship as a section for infection control (2021), assigning importance to protected areas for infectious disease specialist and pharmacists within hospitals."* —Participant from a public institution (ID=11), female	Challenge
	[2]	*Q16"We have two main problems. First, we detect and observe a lot of animal cases experiencing neonatal diarrhoea produced by multi-resistant E. coli, even encountering septicaemia, which presents a serious health problem. Secondly, we see multi-resistant bacterial strains more frequently associated with bovine's respiratory complex. We identify bronchopneumonia or pneumonia as the two main infectious syndromes. We receive multiple samples from animal lungs, mainly originated in fattening animals in the pen or outbreaks of pneumonia. Quite predominantly, we observe the presence of bacterial resistance to a large majority of the antibiotics routinely used for treating respiratory conditions. That shows some inefficiency from fragmented production systems lacking vertical structure, reduced biosecurity, and poor vaccination rates, especially among cattle."*—Veterinarian, public organisation (ID=8), male.	Challenge
	[3]	Q17:*"I do believe that veterinarians have a very important multisectoral role to play there as training and awareness agents to contain AMR burden."*— Participant from an NGO (ID=4), male.	Opportunity
VI. National action plan (NAP) efforts	**[1]**	Q18:*"Progress has been made if we compare it with five years ago. Regulations on the use of antibiotics to prevent their misuse, such as growth promoters, and vast existing (AMR control in animals) and new initiatives to start controlling AMR reservoirs in soil and water demonstrates we are working towards a better integrated system by taking*	Opportunity

		into consideration the One Health approach"—Veterinarian, public organisation (ID=8), male.	
VII. External drivers	**[1]***	Q19: *"Something the pandemic left us was the effectiveness of virtual meetings, for example, plan out objectives and do training with the veterinarians and farm owners"* —Participant from an NGO (ID=4), male.	Opportunity
	[2]	Q20: *"We performed projects alongside the European Union, WHO and Centre for Disease Control, which supported Argentina through international funding to perform AMR surveillance and control, even in food products and wastewater."* —Participant from a public institution (ID=1), female.	Opportunity

Notes: AMR= Antimicrobial resistance. ǂ Sub-themes descriptions are found in Table 1. NGO= non-governmental organization. *There are challenges associated as well, but we included an opportunity. CoNaCRA= National Commission for the Control of Antimicrobial Resistance. INE= National Institute of Epidemiology. INEI= National Institute of Infectious Diseases. INTA= National Agricultural Technology Institute. SENASA= National Service of Agri-food Health and Quality. WHO= World Health Organization.

Theme III. Antibiotics

Thematic III encompasses efforts to improve antibiotic access, consumption, and regulation, while accounting for potential alternatives. Access to antibiotics was indicated as better regulated in the human side, where hospitals and labs work collaboratively; however, a few participants expressed concerns about the applicability of mandatory prescriptions for sales and a mismatch between prescribed treatments and antibiotic package dosing:

> *"Antibiotics are still sold without a prescription either for human or animal use (more frequent among animals), even if prescriptions are mandatory by law, including keeping track of their usage by health professionals (electronic sales). Another issue is the dosage; antibiotics are usually sold in dosages greater than needed, which incentivises inappropriate utilisation maximising commercial interests."*— Participant, academia (ID=14), female.

In addition, one participant expressed worrying views towards antibiotic access and prophylactic use in animals and its relationship with AMR evolution, including reduced capacity for monitoring usage and withdrawal (Q10, Table 2). On the animal side, the route for antibiotic acquisition could have been more cohesive; vets do not necessarily monitor antibiotic purchase, application, and storage, and limited local regulations are in place (Q9, Table 2). Such practices can be reflected early in the regulation system and antibiotic dispensing from the first stage of the purchasing chain. Most medicines for veterinary use follow international manufacturing standards, but traceability of compounds and usage is restricted once purchase is made (Q11, Table 2). Finally, some participants working on antibiotic replacement produce alternatives for antibiotic use in food-producing animals. They were optimistic over vaccine production offering an efficacious alternative, tackling respiratory diseases in animals, and using additives and plant-based biomolecules to improve food conversion efficiency and eradicate antibiotic use as growth promoters in animal farms (Q12, Table 2).

Theme IV. AMR knowledge and awareness

Theme IV incorporated progress made towards AMR knowledge and awareness targeting different settings and communities. Participants were inclined to say that awareness has increased, and impacts on human health are acknowledged (Q13, Table 2), primarily among leading institutions including government, but awareness campaigns only have limited reach to the wider population, including meat producers, as they tend to be specific and attend professional needs:

> *"There is a problem with vets' knowledge of antibiotics, specifically in terms of pharmacokinetic and pharmacodynamic aspects, the correct calculation of the dose administration. It is the duration of treatment in the form of clinical criteria and corresponding to specific physiological situations. All these aspects are related to rational antibiotic usage. If you forget these aspects, you can reach a therapeutic failure despite having chosen the correct antibiotic based on what the laboratory said; and this is largely prevalent in the country."*— Veterinarian, academia (ID=14), male.

Notwithstanding, participants reported initiatives to raise the human population's awareness generally, including social events and educational seminars, having positive perceived conceptions from participants but their effectiveness remains unclear (Q14, Table 2).

Theme V. AMR surveillance

Theme V comprised all barriers or opportunities that made implementation of surveillance and AMR control overtime arduous or fruitful. Participants expressed that surveillance of AMR has exhibited a lot of progress overtime, especially among humans, and most recently in animals. Antibiotic stewardship and infection surveillance programs in humans, including the regular monitoring of a consolidated network of +200 hospitals, primarily public, are some of the positive views perceived by stakeholders towards implementation (Q15, Table

2). Antibiotic consumption control is a central priority of the government now and a countrywide program is being developed to strengthen AMR surveillance:

> *"We have implemented a national surveillance system for the national consumption of antibiotics in humans, which we did not have until a short time ago. Now, it is time to access the information related to disaggregated statistics on antibiotic sales through collaboration with Pharmacology in human and animal side." —Pharmacist, public organisation (ID=6), female*

However, policies around AMR surveillance and control are moving forward among livestock production systems but at slower rates. One participant indicated that testing for critical animal pathogens is routine and usually comes from public organisations. Still, animal diagnostics are difficult to access sometimes, and surveillance does not yet clearly account for different locations, species, and seasonal components:

> *"INTA monitors some animal production chains, but surveillance is the primary task of SENASA, for example, in dairy, we evaluate animals experiencing a mastitis disease and track AMR and potential environmental reservoirs with technology developed locally. Another example, we detect Salmonella in animals and utilise microbiological analyses, including phenotyping and genotyping to analyse AMR and evolution, as part of surveillance routines hand by hand with SENASA. However, most surveillance comes from the governmental side, sampling seasonality is not often captured due to limited resources, the quantity of livestock farms is massively distributed throughout the country, and local producer's veterinary diagnostics are often sent to private labs where traceability is missing."*—Veterinarian, public organisation (ID=15), male.

Challenges identified by participants on AMR surveillance among animals are mirrored mainly in the animal industry, which constitutes many producers and actors through the production chain, making it complex to supervise (Figure 2 shows a brief description and example of cattle production based on interview content and additional sources for broader context). As reported by one participant, industry's main challenges rely upon controlling early stages within the production chain, including improved hygiene and sanitation and vaccination strategies before animals are stressed while moving from breeding to fattening stages (Q16, Table 2).

Theme VI. National action plan efforts

All participants expressed a positive attitude towards progress made on the NAP even if it is slow. Participants agreed upon improvements, such as, the institutionalisation of CoNaCRA, recently launched law on established AMR network and surveillance (which does not depend on political will), new research centre (IMPaM) for environmental surveillance of AMR reservoirs including water, more control over companion and food-producing animals since 2015 from INTA and SENASA, and that prohibition of some antibiotics has been crucial (Q18, Table 2). Another participant highlighted its value as a premier platform for interdisciplinary engagement:

> "*The NAP has significantly advanced and enhanced interdisciplinary and interdepartmental cooperation between animal and human health sectors, primarily driven by the CoNaCRA, which has facilitated knowledge sharing. However, the challenge of synchronising NAP initiatives across 24 distinct provinces in a federal system underscores the imperative for more effective inter- and intra-level cooperation*—Participant from a public institution (ID=9), female*."*

Theme VII. External drivers

Theme VII comprises external factors, identified by participants, that have had a direct or indirect role affecting AMR control and surveillance. Most participants (60%) recognised that COVID-19 limited the progress of AMR control and policy due to reallocation of human, economic and other resources towards the pandemic response. For instance, one participant described it as follows:

> *"Teams were absolutely overwhelmed during COVID-19, all the artillery was dedicated to diagnosis and containment of COVID. We observed an overuse of antimicrobials during these two years, which have accelerated the appearance of new AMR mechanisms and their transmissibility. At the microbiological level, pandemic lineages have appeared, which changes local epidemiology"*—Infectious disease doctor, public organisation (ID=1), female.

However, positive lessons were drawn from the pandemic, including the effectiveness of virtual meetings as an advantage of multisectoral collaboration (Q19, Table 2). Additionally, prioritisation of personal hygiene and care and hand washing was understood to be improved due to increasing awareness of communicable diseases and human health among citizens, as one participant reflected:

> *"The pandemic has taught us, it's to prioritize our personal hygiene. Hand washing and personal care help us not get sick from diseases, and if we don't get sick, we do not require antibiotics."*— Veterinary, public organisation (ID=3), male.

Finally, the second external factor relies upon international collaborations. Participants described solid relationships with international actors within the Americas and abroad, which has helped fund local projects for improving AMR control and surveillance (Q20, Table 2).

Discussion

We employed a context and qualitative analysis to understand main gaps related to the progress of AMR control in implementing AMR policy and regulation in Argentina. Our findings revealed that overall stakeholders' perceptions towards AMR policy are positive, including development of personal relationships enabling progress, and that the NAP along with current emerging legislation are essential in formalising the first steps to a multisectoral and better integrated AMR surveillance system. Interviewees stated that main challenges on the way forward are related, but not limited to, commitment and accountability, monetary and non-monetary resources, cultural factors implying behaviour change, fragmented food-production systems, and global governance. We have summarised these below in Figure 3 in relation to whether at macro or micro level and short or long-term.

One of the most immediate short-term challenges identified by stakeholders was governance, which implied needing more accountability and resources through different AMR actors. Clearer administration systems for successful improvement and conveying AMR policies are crucial to moving forward in the AMR agenda (26, 38). Argentina's administration system is divided into provinces. Still, political decisions are highly centralised in the capital city, which hampers regulation of antibiotic access, AMR testing, and delivery of consistent access to healthcare and hospital infrastructure in humans and animals. Although the CoNaCRA has provincial representatives, the AMR agenda had limited alignment with subnational and local governments for NAP implementation posing significant challenges in rural and remote areas (39). Likewise in Brazil (20), these areas are often highly exposed to AMR risks due to health deprivation. Re-administering monetary and non-monetary resources to meet local needs and capacities and empowering provincial sentinel organisations are crucial to making AMR policies accountable.

Cross-sector coordination including animal, environmental and human sectors was highlighted as crucial by interviewees and constituted an essential element of short-term action towards tackling AMR and improve policy design. Although communication was perceived as positive due to interpersonal relations between colleagues, adequate governance must be established, including mechanisms to link organisations across sectors through formal channels to foster continuity. Effectively tackling these challenges is essential for the One Health approach, particularly given the COVID-19 pandemic's revelation of significant complexities and gaps in intersectoral collaboration, underscoring the need for integrated, human-uncentered, policies (40). Literature has focused on countries' need for better engagement and advocacy from various stakeholders (9, 14, 41). Governments, policymakers, and NGOs are essential to AMR control, supported by budgetary commitment and political authority to meet objectives (19). Current interventions in Argentina remain sector-specific, which could be attributed to differences in priorities for AMR or insufficiently well-defined roles in the NAP. Developing a monitoring or evaluation system for all implementation plans is recommended to determine policy effectiveness. Broad cross-field participation is also crucial if no public budget is allocated to address AMR nationally. Insufficient funding provided by the annual national budgets negatively impacts NAP implementation, generating more constraints on AMR action. The COVID-19 pandemic garnered global attention disrupting national resources and health services that were indirectly assigned to AMR control, and reallocating those funds has posed challenges to AMR reduction measures. One Health although theoretically a useful framework, was not considered in NAP implementation— it could have accounted for the co-benefits of addressing both risks concurrently. That is why the United Nations Environment Program (UNEP) established the Multi-partner Trust Fund (MPTF) to help LMICs improve delivery of multisectoral NAPs (28).

AMR awareness has increased overtime in Argentina. Recent efforts have included various seminars and activities, including a long-distance foot race to spread the word on AMR (42).However, AMR comprises stakeholders with diverse comprehension of the AMR phenomenon, and we evidenced a mismatch between scientific and non-scientific domains, including general public. Social change promoting human health via shifts in society's behaviour should be prioritised to ensure the sustainability of human development and their environments (43). For instance, public engagement is overlooked in Argentina's NAP. Strategies to evaluate attitudes, behaviours, necessities, and practices of socioeconomically and culturally diverging communities, drawing particular attention to those most vulnerable to AMR infections, are crucial to design public health interventions to combat AMR (4).

Strengthening AMR surveillance and control is vital, with different challenges depending on the species spectrum, as highlighted previously in LMICs (4, 19, 20, 44-46). In humans, laboratory surveillance has been based for decades on the connectivity of a well-established hospital networks (e.g., WHONET-Argentina (47)), which has helped monitor AMR locally with institutionalised IPC policies, led by the Antimicrobial Agents Division of INEI-ANLIS, the National and Regional Reference Laboratory for AMR, and the National Hospital Infection Surveillance Program (VIDHA), respectively. However, there are still gaps regarding the effectiveness of preserving antibiotics through stewardship programs, although consumption levels and inappropriate usage

rates decreased before COVID-19 (48). Yet, quality control among stewardship programs, antimicrobial sales with necessary prescriptions, and targeted local efforts in differing regions are still challenging throughout the country (49).In animals, the main surveillance challenges that were reported were concentrated around the unification of production systems (dispersed via multiple chains and actors potentially favouring the dissemination of AMR), whose current fragmented status hampers regulation, with differing control levels depending upon animal species. Systems' capacity to ensure prescription and consumption data is compromised and policies should coordinate and harmonise AMR surveillance while regulating the usage of antimicrobials in animal production at all production stages (32).Globally, antimicrobial stewardship by farm owners and health professionals (e.g., veterinarians) is relatively weak within agricultural systems; developing efforts towards stewardship programs in veterinary services, bolstering the veterinary role as a critical change agent, and companion animal practice remains crucial (50-52). Argentina's chambers of producers play an active role in agglomerating food producers and understanding their needs (e.g., Camara Argentina de Feedlots); their job should be directed towards better integration and prioritisation of educational services and improved production standards.

A recent WHO report on integrated surveillance of AMR in foodborne diseases indicated that ineffective public health AMR surveillance systems often lack broader regulation and laboratory infrastructure, limited biosecurity, and inadequate data management capacity at government levels (53).We observed reduced capacity for data monitoring and sharing among animal stakeholders, whereby surveillance of antibiotic sales/usage and AMR rates by animal species could be better reported. Despite limited public control due to fragmentation of the production chain, food producers are perceived to prioritise profitability and local needs, regardless of the effects of AMR on population health. Moreover, creating an integrated One-Health approach combining animal and human systems, including environmental sources, might help reduce the AMR burden and prevent animal infections in farming communities (25, 54), ensuring sustainability over time and lowering the risks associated with political shifts and global uncertainties. The role of the private sector, not only restricted to food producers, in supporting AMR surveillance should be encouraged to provide a holistic whole-system integration, including a whole food-chain approach (55, 56).This should involve data access and optimising contemporary treatments and diagnostics through more research and technology to elucidate the transmission pathways of the most critical microorganisms for animal and human health.

We identified potential opportunities that could help contribute to progressing action to reduce AMR locally. Most stakeholders favoured agricultural non-antimicrobial drug products as an antibiotic replacement for animal growth promoters. Using tannins and natural plant-based medicines could supersede antibiotics, reducing selective pressure and AMR burden (57, 58). Nevertheless, most of these products are difficult to access locally with limited legislation and high reliance on a few international companies. The provision of replacement routes from the government for antibiotic-free additives usage in animals, including appropriate stakeholder education and countrywide support through public pharmacies, is something the authorities should leverage. Furthermore, the new law establishing the AMR agenda as a constituted program, regardless of political change, presents substantial progress towards national recognition of the AMR problem (24). The initiative brings a long-term perspective to AMR policy, which could be used for the creation of an AMR policy database containing information on NAP implementation accountability and cross-species and environment AMR surveillance for policy advisors.

Our study has some shortcomings. First, we were not able to speak to stakeholders from all areas of the stakeholder mapping and cannot generalise the views of participants to others but have confidence in the transferability of findings and common themes that arose among the diverse stakeholders who participated. Nevertheless, common themes arose from speaking to a range of stakeholders and our sample reached saturation with a narrow range of interviews, considered an appropriate sample size for qualitative research (59). Second, we could not represent private hospitals for human AMR, and differences between production chains, including a broader scope of animal species, dairy products, and final animal product providers, which remains a future study. Third, the extent of interviewees' actual involvement in AMR policies differed; however, we ensured respondents best authority through collaborative local work and expert knowledge. Fourth, the authorship group includes people involved in AMR policy in Argentina which could either favour (facilitate information flow) or bias (sampling, selection and confounding) our study results.

Finally, participants' beliefs (interviews held between December 2022 and January 2023) might be subject to change in the forthcoming years due to implementation of the newly introduced national law on AMR prevention and control (August 2022) (24). Tighter measures regarding antibiotic usage and sales (only under-filled prescriptions) and promoting the One Health approach via implementing cross-sector policies while

accounting for organisation-specific responsibilities for their listed tasks are examples of the expected outcomes the law might enforce.

CONCLUSION

Our study results draw attention to the main strengths, opportunities, and challenges in the process towards improved AMR awareness, control, and surveillance across the human-animal frontier in Argentina. The country has been one of the leaders in the region with an established AMR surveillance network for human health in the latest 40 years. However, AMR governance requires a multidisciplinary focus to help stakeholders at all levels deal with knowledge uncertainties and resulting differences in framing the AMR problem. We found critical areas that should be strengthened, including accountability, sustainable engagement, integrity and equity, socio-behavioural change, international cooperation, and consolidation of environmental and animal departments. Cross-cutting interventions incorporating these areas through different One Health domains should be accounted for if progressing towards AMR is noted. The recent law on AMR prevention and control serves as a good example, which identifies potential pathways to overcome challenges with direct implications for LMICs in the Latin American region.

Funding: This research is co-funded by the UK Department of Health and Social Care as part of the Global AMR Innovation Fund (GAMRIF)(BB/T004452/1) and includes funding under the GAMRIF UK:Argentina AMR Pan-Programme Integration Project (PPIP).This is a UK aid programme that supports early-stage innovative research in underfunded areas of antimicrobial resistance (AMR) research and development for the benefit of those in low- and middle-income countries (LMICs), who bear the greatest burden of AMR. The views expressed in this publication are those of the author(s) and not necessarily those of the UK Department of Health and Social Care.

Role of the funding sources: The funders had no role in the design, conduct, analysis or interpretation of the study.

Acknowledgments: All authors attest they meet the ICMJE criteria for authorship and have reviewed and approved the final article. The authors are grateful to all participants for volunteering time as part of interviews and workshops.

Conflicts of Interest: The authors declare no conflict of interests.

Author Contributions: Conceptualization (KA, EP, WG, MF-M, AP); methodology (KA, EP, LBoden); formal analysis (KA); writing—original draft preparation (KA); writing—review, editing and commenting (KA, EP, WG, MF-M, AP, LBoden, LBarcelona, AC, FL); supervision (EP, MF-M, AP); securing funding for the project (RL, SG, SS-B, AP, MF-M, KR, HW, PD, DM, WG). All authors have read and approved the final version of the manuscript.

Data availability: The qualitative data underlying this article are available in the article.

Ethics review: Ethical approval was obtained from the Human Ethical Review Committee at University of Edinburgh (Ref: HERC_696_21, date of approval: 21April 2022).

AMR policy research group Argentina:
Rodolfo Luzbel de la Sota. *Facultad de Ciencias Veterinarias, Unversidad Nacional de la Plata, Argentina.*
Sonia Gómez. *Servicio Antimicrobianos, Instituto Nacional de Enfermedades Infecciosas, ANLIS "Dr Carlos G. Malbrán", Buenos Aires, Argentina.*
Sergio Sánchez Bruni. *Facultad de Ciencias Veterinarias, Universidad Nacional del Centro de la Provincia de Buenos Aires, Argentina*.
Kristen Reyher. *Bristol Veterinary School, University of Bristol, UK.*
Helen West Helen. *University of Nottingham, UK.*
Peers Davies, *Institute of Infection, Veterinary and Ecological Sciences, Liverpool University, UK.*
Dominic Moran. *The Royal (Dick) School of Veterinary Studies, University of Edinburgh, UK.*

Abbreviations
AMR= Antimicrobial resistance
SENASA= Argentina's National Food Safety and Quality Service
ANLIS= Argentina's National Administration of Laboratories and Institutes of Health
CoNaCRA= Argentina's National Commission for the Control of Antimicrobial Resistance
INTA= Argentina's National Agricultural Technology Institute
IMPaM= Argentina's Institute for Research in Medical Microbiology and Parasitology
UBA= Universidad de Buenos Aires
INE= Argentina's National Institute of Epidemiology
INEI= Argentina's National Institute of Infectious Diseases
ANMAT= Argentina's National Administration of Drugs, Food and Medical Devices
CONICET= Argentina's National Scientific and Technical Research Council
FAO= Food and Agriculture Organization
WOAH= World Organization of Animal Health
WHO= World Health Organization
PAHO= Pan American Health Organization
NAP= National Action Plan

Figure 1. Stakeholders within the human and food-producing animal interfaces for the implementation of the NAP for the control of AMR in Argentina *Notes:* Organisations abbreviations are provided in the abbreviations subtitle. CoNaCRA= National Commission for the Control of Antimicrobial Resistance. All information on Government's ministries and structures is available in https://www.argentina.gob.ar/organismos.

Figure 2. Brief description of some features within the cattle industry in Argentina. *Notes:*(A): Feed supplied in the trough for cattle, livestock farm, Buenos Aires, Argentina. (B): Cattle pens, livestock farm, Buenos Aires, Argentina. (C): Characteristics of beef production and relationship with AMR control. AMR= Antimicrobial resistance. NAP= National action plan. Most information was derived from our interviews; exact quotes are shown upon request. References: (32, 37).

Figure 3. Major challenges and opportunities related to AMR policy in Argentina within a One Health scope in the short and long-term. *Notes:* AMR= Antimicrobial resistance.

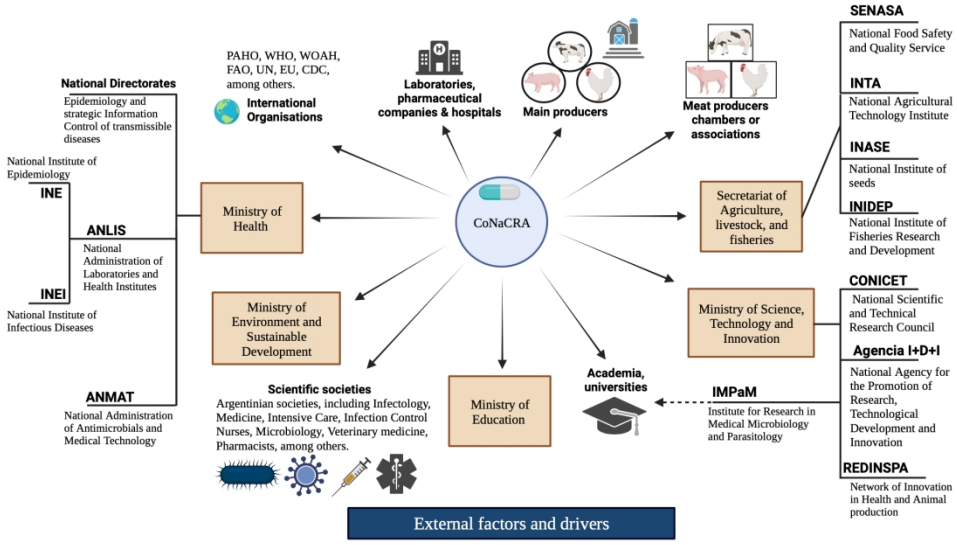
REFERENCES

1. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, et al. Understanding the mechanisms and drivers of antimicrobial resistance. The Lancet. 2016;387(10014):176-87.
2. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet. 2022.
3. Allel K, Day L, Hamilton A, Lin L, Furuya-Kanamori L, Moore CE, et al. Global antimicrobial-resistance drivers: an ecological country-level study at the human–animal interface. The Lancet Planetary Health. 2023;7(4):e291-e303.
4. Charani E, Mendelson M, Pallett SJ, Ahmad R, Mpundu M, Mbamalu O, et al. An analysis of existing national action plans for antimicrobial resistance—gaps and opportunities in strategies optimising antibiotic use in human populations. The Lancet Global Health. 2023;11(3):e466-e74.
5. Mendelson M, Matsoso MP. The World Health Organization global action plan for antimicrobial resistance. SAMJ: South African Medical Journal. 2015;105(5):325-.
6. Humphreys G, Fleck F. United Nations meeting on antimicrobial resistance. World Health Organization Bulletin of the World Health Organization. 2016;94(9):638.
7. Commission E. A European one health action plan against antimicrobial resistance (AMR). European Commission. 2017.
8. World Health Organization. Library of AMR national action plans 2023 [Available from: https://www.who.int/teams/surveillance-prevention-control-AMR/national-action-plan-monitoring-evaluation/library-of-national-action-plans.
9. Frumence G, Mboera LE, Sindato C, Katale BZ, Kimera S, Metta E, et al. The governance and implementation of the National Action Plan on Antimicrobial Resistance in Tanzania: a qualitative study. Antibiotics. 2021;10(3):273.
10. Wernli D, Jørgensen PS, Harbarth S, Carroll SP, Laxminarayan R, Levrat N, et al. Antimicrobial resistance: the complex challenge of measurement to inform policy and the public. PLoS Medicine. 2017;14(8):e1002378.

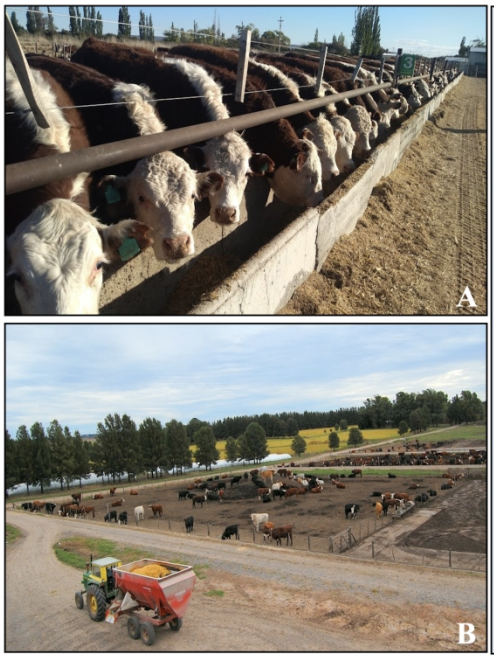
11. Organization WH. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators. 2019.
12. Jimah T, Ogunseitan O. National Action Plan on Antimicrobial Resistance: stakeholder analysis of implementation in Ghana. Journal of Global Health Reports. 2020;4:e2020067.
13. Khan MS, Durrance-Bagale A, Mateus A, Sultana Z, Hasan R, Hanefeld J. What are the barriers to implementing national antimicrobial resistance action plans? A novel mixed-methods policy analysis in Pakistan. Health policy and planning. 2020;35(8):973-82.
14. Chua AQ, Verma M, Hsu LY, Legido-Quigley H. An analysis of national action plans on antimicrobial resistance in Southeast Asia using a governance framework approach. The Lancet Regional Health-Western Pacific. 2021;7:100084.
15. Harant A. Assessing transparency and accountability of national action plans on antimicrobial resistance in 15 African countries. Antimicrobial Resistance & Infection Control. 2022;11(1):1-15.
16. Nair M, Zeegers M, Varghese G, Burza S. India's National Action Plan on Antimicrobial Resistance: a critical perspective. Journal of Global Antimicrobial Resistance. 2021;27:236-8.
17. Amin ET, Omeichu AA, Shu DM, Ekome SRE, Njumkeng C, van der Sande MAB. Control of antimicrobial resistance in Cameroon: Feasibility of implementing the National Action Plan. Tropical Medicine & International Health. 2021;26(10):1231-9.
18. Patel J, Harant A, Fernandes G, Mwamelo AJ, Hein W, Dekker D, et al. Measuring the global response to antimicrobial resistance, 2020–21: a systematic governance analysis of 114 countries. The Lancet Infectious Diseases. 2023.
19. Shabangu K, Essack SY, Duma SE. Barriers to Implementing National Action Plans on Antimicrobial Resistance using a One Health Approach: Policy-Makers' Perspectives from South Africa and Eswatini. Journal of Global Antimicrobial Resistance. 2023.
20. Juliana Silva Corrêa LFZ, Roberto Rubem Da Silva-Brandão, Sandi Michele de Oliveira, Lislaine Aparecida Fracolli, Maria Clara Padoveze & Gloria Cordoba. The governance of antimicrobial resistance in Brazil: Challenges for developing and implementing a one health agenda. Global Public Health. 2023;18(2190381).
21. da Silva Jr JB, Espinal M, Ramón-Pardo P. Antimicrobial resistance: Time for action. Revista Panamericana de Salud Pública. 2020;44.
22. Ministry of Health. National strategy for the Control of Antimicrobial resistance 2015 [Available from: https://www.boletinoficial.gob.ar/pdf/linkQR/YzB6b2o4Qy9ZRDFycmZ0RFhoUThyQT09.
23. República Argentina - Poder Ejecutivo Nacional. Resolución 22/19. Productos veterinarios: prohibición de elaboración, distribución, importación, uso y tenencia 2019 [updated 11 January 2019. Available from: http://www.senasa.gob.ar/sites/default/files/ARBOL_SENASA/INFORMACION/NORMATIVA/RESOL_Y_ANEXOS/2019/r_senasa_22-2019.pdf.
24. Nacion ANCPdl. Boletin oficial de la republica de Argentina. Ley de prevención y control de la resistencia a los antimicrobianos, ley 27680. 2022 [updated August, 2022. Available from: www.boletinoficial.gob.ar/detalleAviso/primera/270118/20220824?busqueda=1).
25. Ogyu A, Chan O, Littmann J, Pang HH, Lining X, Liu P, et al. National action to combat AMR: a One-Health approach to assess policy priorities in action plans. BMJ global health. 2020;5(7):e002427.
26. Anderson M, Schulze K, Cassini A, Plachouras D, Mossialos E. A governance framework for development and assessment of national action plans on antimicrobial resistance. The Lancet Infectious Diseases. 2019;19(11):e371-e84.
27. Pitchforth E, Smith E, Taylor J, Davies S, Ali G-C, d'Angelo C. Global action on antimicrobial resistance: lessons from the history of climate change and tobacco control policy. BMJ Global Health. 2022;7(7):e009283.
28. United Nations. Antimicrobial Resistance Multi-Partner Trust Fund Countering antimicrobial resistance with a 'One Health' approach 2022 [Available from: https://mptf.undp.org/fund/amr00.
29. World Bank. World Bank Data 2023 [Available from: https://data.worldbank.org/country/argentina.
30. Ministry of Health. Comisión Nacional de Control de la Resistencia Antimicrobiana (CoNaCRA) 2024 [Available from: https://www.argentina.gob.ar/salud/epidemiologiaysituacion/conacra.
31. Instituto Nacional de Enfermedades Infecciosas (INEI) – ANLIS "DR. CARLOS G. MALBRAN. Servicio Antimicrobianos 2024 [Available from: http://antimicrobianos.com.ar/servicio-antimicrobianos.
32. McCormick BP, Quiroga MP, Álvarez VE, Centrón D, Tittonell P. Antimicrobial resistance dissemination associated with intensive animal production practices in Argentina: A systematic review and meta-analysis. Revista Argentina de Microbiología. 2022;55(1):25-42.
33. Temple B, Young A. Qualitative research and translation dilemmas. Qualitative research. 2004;4(2):161-78.

34. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative research in psychology. 2006;3(2):77-101.
35. Boeije H. A purposeful approach to the constant comparative method in the analysis of qualitative interviews. Quality and quantity. 2002;36(4):391-409.
36. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care. 2007;19(6):349-57.
37. Instituto de la Promoción de la Carne Vacuna Argentina (IPCVA). Informe de faena y producción 2023 [Available from: http://www.ipcva.com.ar/vertext.php?id=2389).
38. Rochford C, Sridhar D, Woods N, Saleh Z, Hartenstein L, Ahlawat H, et al. Global governance of antimicrobial resistance. The Lancet. 2018;391(10134):1976-8.
39. Pokharel S, Raut S, Adhikari B. Tackling antimicrobial resistance in low-income and middle-income countries. BMJ Specialist Journals; 2019. p. e002104.
40. Chen J, He J, Bergquist R. Challenges and response to pandemics as seen in a One Health perspective. Science in One Health. 2022;1:100010.
41. Castro-Sanchez E, Iwami M, Ahmad R, Atun R, Holmes AH. Articulating citizen participation in national anti-microbial resistance plans: A comparison of European countries. European Journal of Public Health. 2018;28(5):928-34.
42. With a massive race, PAHO Argentina spreads the word to prevent antimicrobial resistance [press release]. 2022.
43. Hernando-Amado S, Coque TM, Baquero F, Martínez JL. Antibiotic resistance: moving from individual health norms to social norms in one health and global health. Frontiers in Microbiology. 2020;11:1914.
44. Lota MMM, Chua AQ, Azupardo K, Lumangaya C, Reyes KAV, Villanueva SYAM, et al. A Qualitative Study on the Design and Implementation of the National Action Plan on Antimicrobial Resistance in the Philippines. Antibiotics. 2022;11(6):820.
45. Sirijatuphat R, Chayangsu S, Srisompong J, Ruangkriengsin D, Thamlikitkul V, Tiengrim S, et al. Feasibility, Challenges, and Benefits of Global Antimicrobial Resistance Surveillance System Implementation: Results from a Multicenter Quasi-Experimental Study. Antibiotics. 2022;11(3):348.
46. Sumpradit N, Wongkongkathep S, Poonpolsup S, Janejai N, Paveenkittiporn W, Boonyarit P, et al. New chapter in tackling antimicrobial resistance in Thailand. bmj. 2017;358.
47. Rossi MA, Tokumoto M, Couto E, Di Bella A, Alstchuler M, Gomez N, et al. Survey of the levels of antimicrobial resistance in Argentina: WHONET program-1991 to 1994. International journal of antimicrobial agents. 1995;6(2):103-10.
48. Dapás JI, Quirós RE. Antimicrobial stewardship in low-and middle-income countries. Current Treatment Options in Infectious Diseases. 2018;10:17-27.
49. Boni S, Marin GH, Campaña L, Marin L, Corso A, Risso-Patron S, et al. Disparities in antimicrobial consumption and resistance within a country: the case of beta-lactams in Argentina. Revista Panamericana de Salud Pública. 2021;45:e76.
50. Brodbelt D. Breaking new ground in antimicrobial stewardship in companion animal veterinary practice. Nature Communications. 2021;12(1):2445.
51. Nind L. International trends impacting antimicrobial stewardship in animal health. Australian veterinary journal. 2019;97(9):362-4.
52. Singleton DA, Rayner A, Brant B, Smyth S, Noble P-JM, Radford AD, et al. A randomised controlled trial to reduce highest priority critically important antimicrobial prescription in companion animals. Nature Communications. 2021;12(1):1593.
53. World Health Organization. Integrated surveillance of antimicrobial resistance in foodborne bacteria: application of a one health approach: guidance from the WHO Advisory Group on Integrated Surveillanec of Antimicrobial Resistance (AGISAR). 2017.
54. Jimenez CEP, Keestra SM, Tandon P, Pickering AJ, Moodley A, Cumming O, et al. One Health WASH: an AMR-smart integrative approach to preventing and controlling infection in farming communities. BMJ Global Health. 2023;8(3):e011263.
55. Mendelson M. BSAC Vanguard Series: Inequality and antibiotic resistance. Journal of Antimicrobial Chemotherapy. 2022;77(2):277-8.
56. Blake LJ, Häsler B, Bennani H, Mateus AL, Eastmure E, Mays N, et al. The UK Antimicrobial Resistance Strategy 2013–18: A Qualitative Study of International and Domestic Policy and Action Related to Livestock and the Food Chain. Frontiers in Sustainable Food Systems. 2022;6:102.
57. Huang Q, Liu X, Zhao G, Hu T, Wang Y. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. Animal Nutrition. 2018;4(2):137-50.

58. Farha AK, Yang Q-Q, Kim G, Li H-B, Zhu F, Liu H-Y, et al. Tannins as an alternative to antibiotics. Food Bioscience. 2020;38:100751.
59. Hennink M, Kaiser BN. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. Social Science & Medicine. 2022;292:114523.



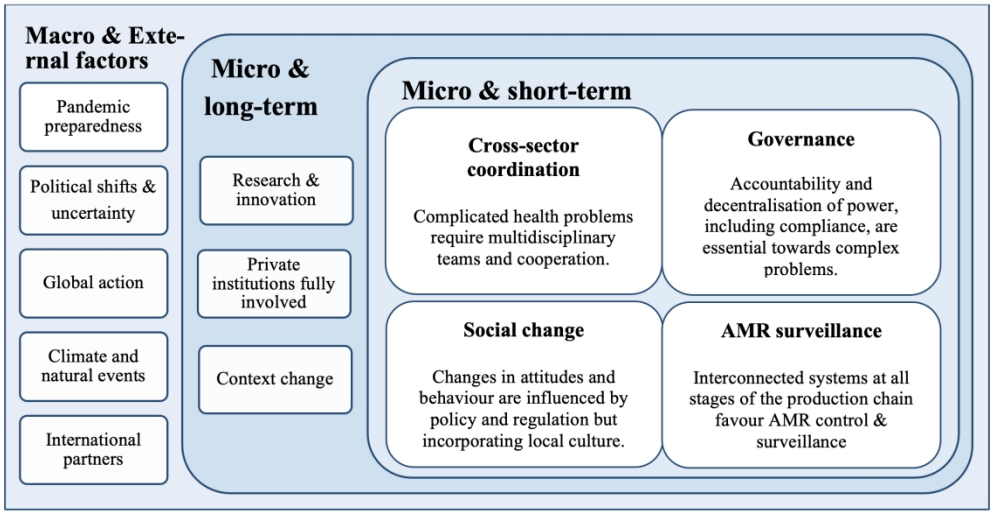
379x210mm (144 x 144 DPI)



Around 52 million head of cattle are kept by livestock farmers in Argentina. The country produced 3.2 million tonnes of beef meat in 2020, of which 900,001 tonnes were exported (75% to China). However, the production chain involves a wide variety of actors and producers (from breeding, fattening, slaughtering, preservation, and sale) and the number of direct beef producers is estimated to be 230,000 with no significant market share among specific companies, compared to chicken or swine industries where three companies concentrate 70% of the market share. Although swine and chicken are amongst food-producing animals species with higher AMR rates for streptomycin, ampicillin and tetracycline resistance, there is still a research gap regarding beef-cattle from feedlots due to reduced AMR monitoring and control, including antibiotic usage. The cattle production chain is highly fragmented, and the movement dynamics of the animals through the production chain are complex, even though their transit must be registered to comply with SENASA guidelines, and all production units should be referenced in a computer database. However, in practicality, controlling thousands of animals at different production stages is challenging, and it is often hard to trace and follow to check if producers follow guidance in antibiotic use. In line with this, cattle vaccination rates against diarrheal or respiratory diseases are relatively low compared to the chicken and swine industry. Most livestock farms are family businesses where there is a partial vet role for antibiotic administration, and antibiotic storage in warehouses is often observed due to reduced control on acquisition.

C

437x291mm (144 x 144 DPI)



441x232mm (144 x 144 DPI)

Supplementary Material

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a context and qualitative analysis

Table of Contents

I. Timeline containing the legislation and policies in place within the AMR spectrum in Argentina....2

II. Summary of the Argentinian National Action Plan to combat AMR....4

III. Consent form for interviewees (participants)....8

IV. Participant information sheet....9

V. Participant interview topic guide....11

VI. Description of main preliminary topic codes applied to the interview analyses and their respective definitions....13

VII. Themes ordered from broader to greater specificity.....14

VIII. Packed code cloud for identified themes/sub-themes....15

I. Timeline containing the legislation and policies in place within the AMR spectrum in Argentina

[1916] Creation of the formerly called Instituto Nacional de Microbiología "Malbran", which is renamed in 1996 (see below).

[1956] Creation of the National Agricultural Technology Institute (INTA)

[1964] Act. 19 of the National Law of Medications No. 16,463. It states that "any form of advertising of products whose sale has not been authorized by prescription is prohibited" (subsection d).

[1967] National law regulating pharmaceutical activity. Also, the Directorate of Registration Inspection and Border Health of the Ministry of Health of the Nation, which upon verifying the violations of the regulations must initiate the corresponding summary actions and may conclude with the sanctions established in art. 45 of Law 17565 on the Exercise of Pharmacy Activity: warning, fine, closure of the establishment, suspension of registration and/or disqualification.

[1969] Decree number 3835/1969 of the Ministry of Public Health established that medicines with antibiotic activity for systemic use must be dispensed under a prescription filed by the dispenser, with penalties for non-compliance with: warning, fine, closure, suspension of registration, disqualification and /or prison of up to three years (Laws 17565/1967 of Practice of Pharmacy and 26524/2009 of the Penal Code)

[1970] Decree number 3835/69 (later modified by decree number 378/70) of the then Ministry of Social Welfare. It established that medicines whose active pharmaceutical ingredients (IFAs) have antibiotic activity for systemic use must be dispensed according to their registration condition of January 1, 1970. Prescriptions must be archived by correlative date and kept for a period of two years, after which the pharmacy can delete them.

[1983] Creation of the National program of epidemiology and control of hospital-acquired infections, which was implemented and monitored by the National Institute of Epidemiology (INE), decree number 2885/83.

[1986] Creation of the National Antimicrobial Resistance Surveillance Network WHONET-Argentina

[1992] Creation of the National Administration of Medicines, Food and Medical Technology (ANMAT)

[1995] Creation of the Intensified National Epidemiological Surveillance System for Hospital Infections (SIVENIH), implemented on a pilot basis and involving 25 public and private hospitals in the country.

[1996] Creation of the National Administration of Laboratories and Institutes of Health (ANLIS), decree number 1628.

[1998] Creation of the National Service of Agri-food Health and Quality (SENASA)

[2001] Creation of the Argentine Beef Promotion Institute (IPCVA), law number 25,507.

[2004] Creation of the National Hospital Infection Surveillance Program (VIHDA) to monitor hospital-acquired infections in participating hospitals.

[2007] Decree number 609 states that antimicrobials must be sold only under prescription.

[2009] Law 26,524. The dispensation of any type of medicinal product without compliance with the legal conditions of sale would be considered as a crime, which can be punished with prison for up to three years.

[2011] Decree number 666/2011 determined that any establishments having food-producing animals must keep a record book for the administration of veterinary products, subject to inspections.

[2011] Decree number 666 determined that the food-producing establishments must keep a record book of treatments subject to inspection by SENASA in which all administration of veterinary products on production animals must be recorded.

[2011] Act. 36 of Decree 7123/68, regulating Law 17,565, defined that: "The acquisition and sales provided by drugstores must be made by invoice and/or separate remittance..., keeping the Documentation filed in an orderly manner, making it available to the inspectors of the Secretary of State for Public Health, at their request.

[2011-2013] ANMAT drug traceability programs (decree number 435, National Ministry of Health) and SENASA phytosanitary and veterinary products (SENASA, decree number 369/2013), will provide data on the commercialization and distribution of antimicrobials in humans and in food-producing animals and agriculture.

[2013] Decree number 369/2013 created the Traceability System for Phytosanitary and Veterinary Products.

[2013] SENASA instituted the National Phytosanitary and Veterinary Products Traceability System, which reports the volume and type of antimicrobials being marketed within the veterinary products framework for commercialization. This online system involves all the parts from the commercial chain; including the manufacturer or importer of the product to the veterinarian who indicates and sells it. In this way, every time a sale is made, the seller must declare what he sold, and the buyer who accepted the sale and who assumes responsibility for the possession of the products purchased.

[2015] Decree number 834/2015 y 391/2015. Creation of the National Action plan for the surveillance, prevention and control of antimicrobial resistance (June) in line with the creation of the national commission for the control of antimicrobial resistance (CoNaCRA).

[2015] Decree number 591. Creation of the National Plan for the surveillance of AMR in food-producing animals (November)

[2015] Decree number 594/2015 prohibited the inclusion of antimicrobials in animal feed. This latest regulation points to the total prohibition (in 2019) of the use of antimicrobials as promoters of animal growth.

[2015] The National Administration of Medicines, Food and Medical Technology (ANMAT) states that the pharmaceutical labelling of antimicrobials must agree with the usual doses and treatments duration (decree number 7,130).

[2019] SENASA states that the manufacture, distribution, import, use and possession of veterinary products containing colistin is banned from veterinary products/medicine (Decree reference: EE 54429573/2018).

[2022] Antimicrobial resistance prevention and control law (number 27680). National statement on establishing the appropriate mechanisms to promote and control antimicrobial resistance in the country. It is remarked as a problem of national interest that perpetuates overtime.

Additional sources

Chapters 6.7 to 6.10 of the WOAH (World Organisation for Animal Health) Terrestrial Animal Health Code, which range from the harmonization of national AMR surveillance programmes to methodologies for monitoring the quantities of antimicrobials used and their patterns of use, the criteria for their prudent and responsible use, and the methodology for applying risk analysis derived from the use of antimicrobials in animals throughout the food chain.

For more details on distribution and marketing of drugs in Argentina, see https://uk.practicallaw.thomsonreuters.com/w-014-7135?transitionType=Default&contextData=(sc.Default)&firstPage=true

II. Summary of the Argentinian National Action Plan to combat AMR

General overview

The national action plan was elaborated and designed by the Ministry of Health in 2015 (16) in partnership with the following organisations:

- The National Administration of Laboratories and Health Institutes (ANLIS)
- National Administration of Medicines, Food and Medical Technology (ANMAT) and the REMEDIAR Program
- Ministry of Agriculture, Livestock and Fisheries:
- National Service of Agri-food Health and Quality (SENASA)
- National Institute of Agricultural Technology (INTA)
- National Universities of La Plata and the Centre of the Province of Buenos Aires
- Representation for the Americas of the World Organization for Animal Health (WOAH)
- Argentinean Society of Infectious Diseases (SADI)
- Argentinean Society of Intensive Care (SATI)

The three main objectives of the national strategy (action plan) are:

a) To prevent the emergence and spread of resistant bacteria through the regulation and supervision of antimicrobial sales, the promotion of their responsible use, and the prevention and control of healthcare-associated infections.
b) To strengthen AMR surveillance and antimicrobial usage policies.
c) To promote innovation, non-antibiotic growth promoters, and diagnostic tests to identify resistant bacteria.

These three main objectives comprise 10 different tasks detailed in the figure below.

Figure SM1. Main tasks of the Argentinian National Action Plan against AMR and their respective subobjectives.

Main 10 tasks to combat AMR in Argentina	Specific actions/sub-objectives
1. Promote leadership for the prevention and control of AMR	To develop and conduct a strategy for the prevention and control of AMR with experts' participation. To fund strategies' activity to enhance participation/awareness.
2. Surveillance of AMR in human and animal health	To develop a national surveillance network coordinated by reference laboratories for human health, animal health and agri-food production.
3. Monitor antimicrobial consumption	To develop a system for monitoring sales, access and appropriate and adequate use of antimicrobials.
4. Regulate and supervise antimicrobials usage and sales	To establish prescription sales requirements and monitor its effective compliance. To regulate the number of antimicrobial units in the pharmaceutical industry. To prohibit the use of antimicrobials as growth promoters in food production.
5. Promote responsible use of antimicrobials	To develop guidelines for diagnosis and treatment of most prevalent infections. To train health professionals on the appropriate and adequate use of antimicrobials and healthcare-associated infection prevention and control measures.
6. Promote community participation	To disseminate the problem AMR might cause in the population and the establishment of education programs on the adequate use of antimicrobials
7. Implementation of antimicrobial usage control mechanisms	To implement antimicrobial management programs in health services
8. Strengthen healthcare-associated infections prevention and control programs	To develop a surveillance strategy for healthcare-associated infections.

	To implement prevention and control programs for healthcare-associated infections in healthcare services
9. Promote antimicrobial research as well as diagnostic methods	To establish the problem of AMR as a priority matter that should be financed and researched. To prioritise the evaluation of new antimicrobials and explore new diagnostic methods.
10. Monitoring and evaluating the achievement of the objectives stated in the national action plan	To create a professional commission to monitor and evaluate the implementation and execution of the strategy (National Action Plan)

Overview of the animal and agri-food related sections

AMR SURVEILLANCE IN ANIMAL AND AGRIFOOD PRODUCTION
[ANIMAL HEALTH SECTION of the national action plan]

Current situation of the AMR surveillance in animal health and agri-food production
Surveillance is necessary for 3 groups of bacteria which have been primarily found in cattle, pigs, and birds: a) "indicator" bacteria, b) zoonotic bacteria, and c) pathogenic bacteria. Indicator bacteria are part of the intestinal microbiota of humans, other mammals, birds, and insects, and their importance lies in their ability to acquire and spread resistance genes that can be transferred to pathogenic or zoonotic bacteria.

Strategic lines of the national action plan for the surveillance of AMR in animal health and agri-food production
a) Development and implementation of the national AMR surveillance program in food-producing animals to determine the presence of resistance to different antimicrobials in at least 2 commensal bacteria: *Escherichia coli* and *Enterococcus spp*, and 2 zoonotic bacteria: *Campylobacter spp* and *Salmonella spp*
b) Harmonization of AMR surveillance strategies in human and animal health
c) Development of communication tools and timely dissemination of information

Specific actions of the national action plan for surveillance of AMR in animal health and agri-food production
a) To isolate commensal and zoonotic bacteria from cattle, pigs and poultry intended for human consumption, and determine their susceptibility profile to different antimicrobials
b) To compare the results with data obtained from previous studies, when possible
c) To determine the prevalence of AMR by animal species and by geographic region
d) To correlate antimicrobial consumption with AMR
e) To characterize and correlate resistance mechanisms between bacteria obtained from animal and human samples
f) To carry out studies on the presence of antimicrobials in different sources (including water, food, etc.) and the impact of their use on the environment and production systems
g) To evaluate alternative therapies for the use of antibiotics as growth factor in intensive production
h) To evaluate the impact of antimicrobial administration in sources on the level of resistance observed in the environmental bacterial population.
Specifically, the National Directorate of Agrochemicals, Veterinary Products and Food of SENASA will be responsible for:
a) Carrying out an annual monitoring of the volume of sales of antibiotics, with the collaboration of professional associations
b) Providing data from the veterinary product traceability system as soon as it is fully operational

REGULATION OF ANTIMICROBIAL CONSUMPTION IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

For more than ten years, SENASA has carried out a Program for the Control of Residuals, Contaminants and Food Hygiene of animal origin. This program seeks to detect the presence of chemical residues and contaminants in foods of animal origin that may affect the health of consumers. Among the residues under control, we find various antimicrobial agents, which can generate antimicrobial resistance when they are present in food.

Strategic lines for the regulation of the use of antimicrobials in animal health and agri-food production
a) Development and updating of regulations on the use of antimicrobials, aimed at preserving bacterial susceptibility as a non-renewable resource
b) To participate in international seminars on regulatory practices to improve animal health

Specific actions to regulate the use of antimicrobials in animal health and agri-food production
a) To compile and analyse the results of the surveillance and traceability systems for veterinary products to carry out risk analyses and therefore create risk profiles
b) To strengthen control protocols on the indiscriminate sales and usage of antibiotics
c) To ensure that all commercialization of antibiotics be carried out by a licensed professional
d) To create a forum for discussion on the use of antimicrobials with the chambers of the veterinary products industry, professional associations, universities and the Ministry of Health

RESPONSIBLE USE OF ANTIMICROBIALS IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

Objectives:
a) To ensure the rational use of antimicrobial agents in animals, with a view to optimizing their efficacy and safety
b) To comply with the ethical obligation and the economic need to keep the animals in good health
c) To prevent or reduce the transfer of resistant microorganisms or resistance determinants within animal populations, their environment and between animals and humans
d) To contribute to maintaining the efficacy and usefulness of antimicrobial agents used in human and veterinary medicine
e) To protect consumer health by ensuring the safety of foods of animal origin in relation to residues of antimicrobial agents

The measures include actions at the level of all stages and actors involved in the antimicrobial usage cycle, from their registration in SENASA to their prescription, marketing and consumption. The regulations generated by SENASA in recent years, have incorporated product traceability and treatment records, which are also in line with the WOAH Code.

Strategic lines for the responsible use of antimicrobials in animal health and agri-food production
a) Development of knowledge, training and information for veterinary professionals on the prudent and responsible use of antibiotics, based on pharmacokinetic, pharmacodynamic and toxicological bases
b) Intensification of marketing controls for antimicrobials usage and dispensing
c) To regulate the use of antimicrobials based on the information obtained from the surveillance program, and the corresponding risk analysis
d) To increase pharmacological knowledge about the behaviour of antibiotic considering its impact on the environment
e) To control the evolution of antibiotic resistance bacteria in clinics of small animals and intensive productions
f) To promote the responsible use of antimicrobials, including their correct prescription and administration by veterinarians

Specific actions for the responsible use of antimicrobials in animal health and food production
a) To prepare a good-practice guide for the prescription and use of antimicrobials and other veterinary products, and in line with international guidelines
b) To organise training courses and workshops for free practice veterinarians and those who work in the marketing chain or are in charge of livestock farms and balanced feed production plants, in conjunction with universities, professional associations and technical groups of exchange of the different productive activities (pigs, poultry, cattle, etc.)
c) To incorporate AMR in the curriculum of veterinary careers, in joint work with the National Council of Veterinary Sciences
d) To sustain and strengthen control in all stages of the distribution process and use of antimicrobials

PREVENTION AND CONTROL OF INFECTIONS IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

There are current international standards highlighting antimicrobials usage, including the Chapters 6.7 to 6.10 of the WOAH Terrestrial Animal Health Code.

Strategic lines for the prevention and control of infections in animal health
a) To develop programs for the management, prevention and control of infectious diseases associated with AMR in veterinary medicine, considering the biosafety of intensive production establishments in terms of infrastructure and adequate equipment for infection prevention and control practices
b) To train technical personnel assigned to intensive animal production for the prevention and control of infectious diseases in production environments; and
c) Implementation of a network of laboratories for the identification of AMR microorganisms

Specific actions for the prevention and control of infections in animal health
a) To develop regulations to enhance infection prevention and control between the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Health, universities and professional associations
b) To carry out training courses for veterinary professionals. Courses would be delivered by the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Health, professional associations and universities
c) To promote biosafety, hygiene and disinfection of personnel, equipment and productive environment compliance.
d) To generate new laboratories equipped with diagnosis tools to determine the levels of AMR bacteria isolated from food animals and the emergence of resistance mechanisms to critical antimicrobials in human and animal health, as well as the proper use of antimicrobials
e) Develop a monitoring and evaluation program to adopt joint strategies between the veterinary and human areas

Also, SENASA, with the cooperation of ANLIS, INTA, and veterinary schools of national universities, implemented a parallel surveillance program for AMR in food-producing animals. The main objective of the plan is to determine and monitor the prevalence of AMR among food-producing animals to avoid the emergence and dissemination and to minimise the damage to the population and animal health (20). The program was designed in partnership with the following institutions: National Directorate of Agrochemicals, Veterinary Products and Food, National Directorate of Food Safety and Quality, National Directorate of Animal Health, General Directorate of Laboratories and Technical Control, and the General Coordination of Regional Management.

III. Consent form for interviewees (participants)

Please initial box

1. I confirm that I have read and understood the Participant Information Sheet for the above study. ☐

2. I have been given the opportunity to consider the information provided, ask questions and have had these questions answered to my satisfaction. ☐

3. I understand that my participation is voluntary and that I can ask to withdraw before or during the interview without giving a reason and without my medical care or legal rights being affected. After the interview has been conducted and/or after data analyses, data will be anonymised and it will not be possible to withdraw. ☐

4. I understand that my anonymised data will be stored for a minimum of 5 years and may be used in future ethically approved research. ☐

5. I consent to this interview being recorded for the purpose of transcription after which the recording will be deleted. ☐

6. I agree to take part in this interview. ☐

Name of person giving consent	Date	Signature
_____	_____	_____

Name of person taking consent	Date	Signature
_____	_____	_____

IV. Participant information sheet

You are being invited to take part in an interview on:
Agricultural antimicrobial supply chains and implementation of Antimicrobial Resistance National Action Plans in Argentina and the United Kingdom

Prof Lisa Boden, Prof Dominic Moran, Dr Emma Pitchforth, Dr Stephen Mackenzie, and Alejandro Petroni at the University of Edinburgh, University of Exeter and Argentinian National Administration of Laboratories and Health Institutes are facilitating these interviews/focus groups. Before you decide to take part, it is important you understand why we are conducting this interview and what it will involve. Please take time to read the following information carefully.

WHAT IS THE PURPOSE OF THIS INTERVIEW?
This interview is intended to gather information about the current communication and interfacing between policy makers, scientific experts and stakeholders in agricultural Antimicrobial resistance and National Action Plan. Our long-term goal is to build relevant expertise to be able to design robust interventions and advice to improve antimicrobial resistance and national action plan implementation outcomes in the policy.

WHY HAVE I BEEN INVITED TO TAKE PART?
You are invited to participate in this study because you have been working on or exposed to agricultural antimicrobial resistance decision-making issues in policy, either in the United Kingdom or Argentina.

DO I HAVE TO TAKE PART?
No – it is entirely up to you whether you choose to take part. If you do decide to take part, please keep this Information Sheet and complete the Informed Consent Form to show that you understand your rights in relation to the meeting and that you are happy to participate. You may withdraw from an interview at any time and without giving a reason.

WHAT WILL HAPPEN IF I DECIDE TO TAKE PART?
You will be invited to participate in a series of interviews and/or focus groups around agricultural antimicrobial resistance, antimicrobial supply and antimicrobial national action plans and how they are perceived and incorporated into policy decision making spaces and processes. Your expertise will allow us to work over the next three years on developing a series of robust suggestions to improve the science policy interface around antimicrobial resistance in both the UK and Argentina.

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?
By participating in this discussion and sharing your experiences with us, you will be helping the research team to engage and participate with local and national policy decision-makers around integration of scientific and policy-making expertise in mitigating the risks of antimicrobial resistance.

ARE THERE ANY RISKS ASSOCIATED WITH TAKING PART?
There are no significant risks associated with participation.

WHAT IF I WANT TO WITHDRAW FROM THE STUDY?
Agreeing to participate in this workshop does not oblige you to remain in the project nor have any further obligation to this project. If you no longer want to be part of the project, please inform Prof Lisa Boden [lisa.boden@ed.ac.uk]. You should note that your ideas may be used in the design and implementation of subsequent projects and interventions. You are advised to contact the research team at the earliest opportunity, preferably before the workshop should you wish to withdraw from the project.

INTERVIEWERS AND INTERVIEW'S DETAILS
The interview will be performed by either our main researchers (detailed in the first paragraph) or Kasim Allel, who is a research fellow at the University of Exeter. The interview will take place at a time and

platform (virtual meeting via Zoom/Microsoft teams or in-person meetings) agreed upon both parties and depending on availability. The interview has five different stages covering participant's current role, understanding antimicrobial-resistance among stakeholders, information channels and flows within stakeholders/departments, challenges in the implementation of the national action plan, and future considerations. The interview has an approximate duration of 30-60 minutes per interview.

DATA PROTECTION AND CONFIDENTIALITY

Any data collected will be processed in accordance with Data Protection Law and GDPR. All information collected about you will be kept strictly confidential. Unless they are anonymised in our records, your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team. Data might be classified by organisation/affiliation only if participants concur. All electronic data and transcripts will be stored on a password-protected computer file within Microsoft teams' shared folders. All paper records will be held in a locked filing cabinet. Your consent information will be kept separately from your responses to minimise risks.

WHAT WILL HAPPEN WITH THE RESULTS OF THIS STUDY?

The outcomes of this meeting may also be summarised in reports and presentations to the funding agency or key stakeholders. The meeting may be video and audio recorded for the purpose of transcription. Quotes or key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name. Information may also be kept for future research.

WHO CAN I CONTACT?

If you have any further questions about the project, please contact Prof. Lisa Boden, lisa.boden@ed.ac.uk

If you wish to make a complaint about the project, please contact:
Lisa Boden (lisa.boden@ed.ac.uk). In your communication, please provide the study title and detail the nature of your complaint.

For general information about how we use your data go to:

https://www.ed.ac.uk/records-management/privacy-notice-research

V. Participant interview topic guide

You are being invited to take part in an interview on:

Agricultural antimicrobial supply chains and implementation of Antimicrobial Resistance National Action Plans in Argentina and the United Kingdom

[Please note this is a topic guide to support the semi-structured interviews. We do not envisage asking every question to every participant, but the questions are illustrative of what we hope to talk about]

Introduction

Thank you for agreeing to take part in this interview.

Can I check that you have had a chance to read the study information sheet?

Do you have any questions about the study?

[if not returned prior to interview go through and complete consent form]

Are you happy for me to begin the interview and to start recording?

[turn on recorder]

Thank you.

The interview is designed to be free-flowing so please talk about anything that you feel is relevant, I have just prepared some questions structured into five broad areas.

Interview's questionnaire

BOX 1. Survey's main sections: objectives and questions

I. Participant's current role. These questions will seek to understand what experiences our participants have and how they might be relevant to implementing the National Actiona Plan to combat AMR.

<1> What your job/role is, and what tasks do you and your organisation mainly perform?
<2> What are your (or department/organisation) interests and responsibilities concerning AMR?

II. Understanding AMR among stakeholders. This group of questions aim to understand employees' and organisations' views on AMR; its main drivers, change overtime, support venues, and priority areas within organisations to help tackle AMR.

<1> How do you feel (or what are your personal and department's concerns) about antimicrobial resistance in humans? Does that differ from antimicrobial-resistance in animals or any other source, including the environment (how)?
<2> Do you think the view about antimicrobial-resistance has changed over the years? How?
<3> What are the priority areas within your organisation to increase AMR awareness and to comply with the national action plan? Do you feel your organisation help contribute to any of the areas detailed in the national plan (how, which)?
<4> What are the cornerstones for increasing AMR awareness while complying with the national action plan within your organisation?
<5> Which cornerstones do you feel are most relevant within your department (organisation)? Why?

III. Information channels and flow within stakeholders/departments. These questions attempt to improve organisations decision making towards better AMR surveillance by identifying how the information is channelled within and between organisations.

<1> how do you feel about AMR-related information and communication flow within your organisation and among all stakeholders?
<2> What do you think about communicational interactions, networking, and educational or getting-to-know instances between your organisation and other stakeholders and within departments of your organisation? Would you believe (and how) that the information pathways vary between specific organisation's fields/disciplines, public/private institutions, or certain other groups?
<3> Could you identify which organisms (organisations), and how, are involved in your organisation's decision making and strategy towards improving AMR surveillance and control?

IV. Challenges in the implementation of the national action plan. These questions attempt to answer what factors or challenges might be key to increasing AMR awareness and improving AMR surveillance among food-producing animals and agriculture.

<1> Do you feel there is any challenge that your organisation faces in complying with the AMR national action plan and helping contribute to better animal surveillance? (Political priorities, monetary and non-monetary resources, communication, etc) What are the most important and what can be done to overcome these challenges if your organisation could prioritise resources to contribute higher to AMR surveillance in animals?
<2> Who else do you think has a critical role in helping with AMR surveillance in animals from the pool of stakeholders?

V. Future and other considerations. These questions aim to understand future steps to be taken within the industry and different key members to tackle AMR

<1> How organisations might be helped to enhance cross-communication and teamwork? How can we ensure organisations make progress and collaborate meeting NAP's criteria?
<2> Which organisations, at the national and international levels, do you think are most important to talk to and direct the efforts to address the gap in knowledge in AMR? Does the list differ for improving the NAP?
<3> Is there anything else important that you might want to share with us or that we are missing in the current interview?

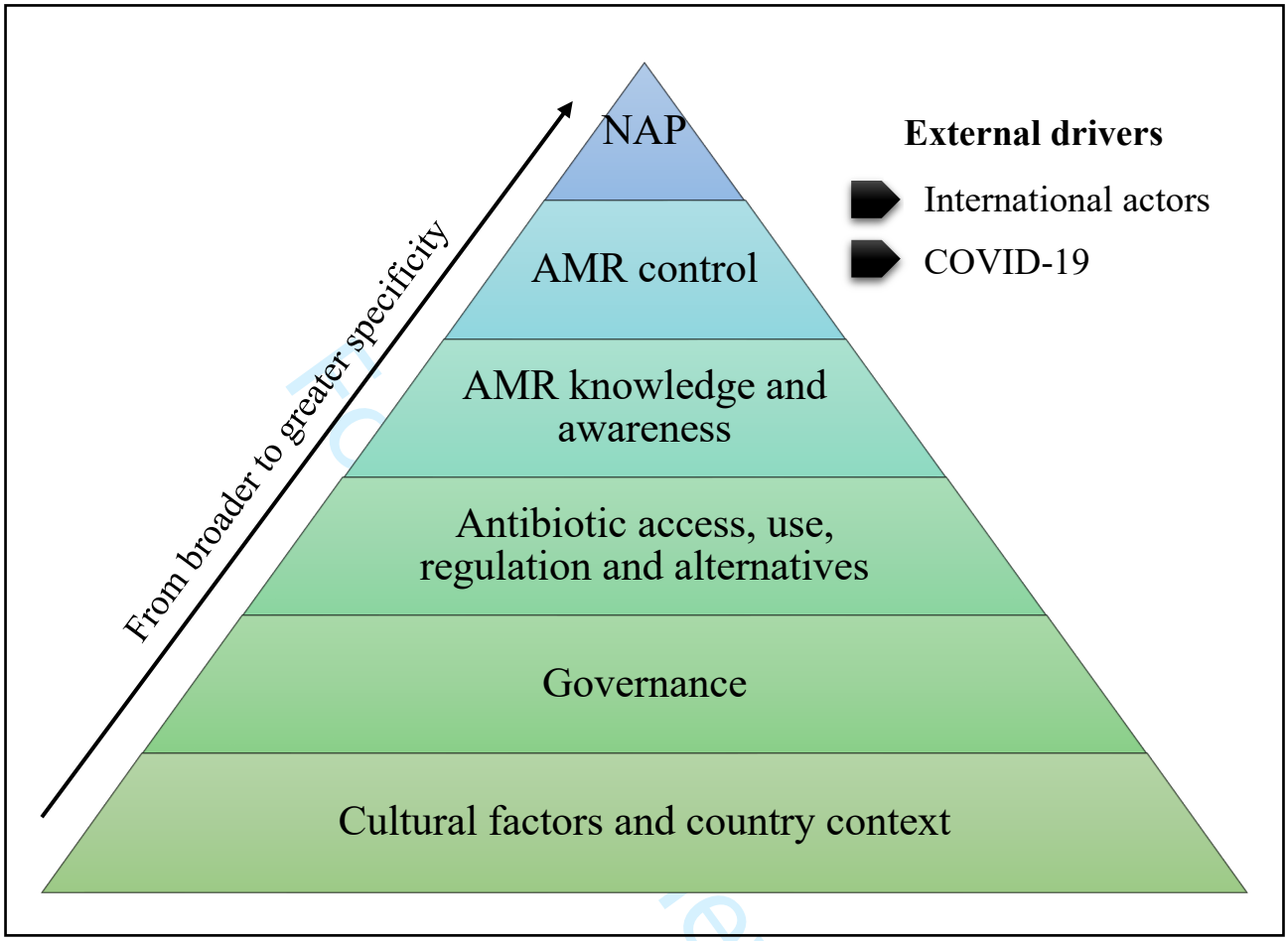
VI. Description of main preliminary topic codes applied to the interview analyses and their respective definitions

Table SM1. Topic codes and their definitions

Code	Definition
Application of NAP	Implementation of NAP and roles, including views on progress
AMR control	Perceived progress and challenges, inclusive of surveillance
Antibiotic access, use and regulation (human and animal)	Referring to antibiotic consumption and access and prescriptions in animals and humans
Alternatives to antibiotics	Discussion of alternatives to antibiotics
Context of Covid	Referring to acceleration of AMR, potential opportunities and good practice, ways of working
Governance	Government priorities, federalisation, vertical vs horizontal, nature of institutions/groups, accountability (lack of)
AMR knowledge/awareness	Referring to public and professional awareness – the challenge of awareness and steps taken to address
Resources	Referring to human and economic/budgetary resource (lack of) available to tackle AMR
Stakeholders	Describing/listing stakeholders involved
Stakeholder communication	Communication (lack of) between stakeholders
Cultural and country context	Understanding of importance of cultural, country context, including personal relationships
International actors and policies	Mention of international actors and role in/influence on national AMR in Argentina
Food production	Reference to food production markets, differences by animal species
Information/data flow	All references, specifically to information/data e.g. capacity/system to share data
Regulation and compliance	Description of different regulation, proposed change and perceived (potential) impact
Political context and agenda //	Importance of (changing) political will
Vet sector	Including role of vet sector, antibiotic in animals
Training and learning opportunities	Including seminars, conferences, courses, stewardship programs, etc.

VII. Themes ordered from broader to greater specificity.

Figure SM2. Structure of the ordered themes



Notes: AMR= Antimicrobial resistance. NAP= National action plan.

VIII. Packed code cloud for identified themes/sub-themes

Figure SM3. Code cloud for identified themes and sub-themes

Notes: AMR= Antimicrobial resistance.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	n/a
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1, page 5-6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-14
		(b) Indicate number of participants with missing data for each variable of interest	5
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*n/a*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*n/a*
		Cross-sectional study—Report numbers of outcome events or summary measures	*5-13*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a qualitative study
		(*b*) Report category boundaries when continuous variables were categorized	n/a qualitative study
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a qualitative study
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely

available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a context and qualitative analysis

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-082156.R2
Article Type:	Original research
Date Submitted by the Author:	29-Apr-2024
Complete List of Authors:	Allel, Kasim; London School of Hygiene & Tropical Medicine; University of Exeter, Faculty of Health and Life Sciences Fernandez-Miyakawa, Mariano; Instituto Nacional de Tecnología Agropecuaria Gaze, William; University of Exeter, Faculty of Health and Life Sciences Petroni, Alejandro; Instituto Nacional de Enfermedades Infecciosas Corso, Alejandra; Instituto Nacional de Enfermedades Infecciosas Luna, Federico; Independent researcher Barcelona, Laura; Comisión Nacional de Control de la Resistencia Antimicrobiana Argentina, AMR policy research group; Full list of authors provided at the end of the manuscript Boden, Lisa; University of Edinburgh Royal Dick School of Veterinary Studies Pitchforth, Emma; University of Exeter, Faculty of Health and Life Sciences
Primary Subject Heading:	Public health
Secondary Subject Heading:	Global health, Communication, Public health
Keywords:	Public health < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a context and qualitative analysis

Kasim Allel[1,2], Mariano Fernandez-Miyakawa[3], William Gaze[1], Alejandro Petroni[4], Alejandra Corso[4], Laura Barcelona[6], Federico Luna[7], AMR policy research group Argentina†, Lisa Boden[5], Emma Pitchforth[1,*]

[1] Faculty of Health and Life Sciences, University of Exeter, Exeter, UK
[2] Department of Disease Control, London School of Hygiene and Tropical Medicine, London, UK
[3] Instituto Nacional de Tecnología Agropecuaria Castelar, Buenos Aires, Argentina
[4]Servicio Antimicrobianos, Instituto Nacional de Enfermedades Infecciosas, ANLIS "Dr Carlos G. Malbrán", Buenos Aires, Argentina.
[5]Royal School of Veterinary studies, University of Edinburgh, Edinburgh, UK
[6]Comisión Nacional de Control de la Resistencia Antimicrobiana, Buenos Aires, Argentina.
[7] Independent researcher, Buenos Aires, Argentina.
† Full list of authors provided at the end of the manuscript
* Corresponding author: e.pitchforth@exeter.ac.uk. University of Exeter Medical School, University of Exeter, Exeter EX1 2LU, UK.

ABSTRACT

Introduction. Gaps in antimicrobial resistance (AMR) surveillance and control, including implementation of national action plans (NAP), are evident internationally. Countries' capacity to translate political commitment into action is crucial to cope with AMR at the human-animal-environment interface.

Methods. We employed a two-stage process to understand opportunities and challenges related to AMR surveillance and control at the human-animal interface in Argentina. First, we compiled the central AMR policies locally and mapped vital stakeholders around the NAP and the national commission against bacterial resistance. Second, we conducted qualitative interviews using a semi-structured questionnaire covering stakeholders' understanding and progress towards AMR and NAP. We employed a mixed deductive-inductive approach and used the constant comparative analysis method. We created categories and themes to cluster sub-themes and determined crucial relationships among thematic groups.

Results. Crucial AMR policy developments have been made since 1969, including gradually banning colistin in food-producing animals. In 2023, a new government decree prioritises AMR following the 2015 NAP launch. Our qualitative analyses identified seven major themes for tackling AMR: (I) Cultural factors and socio-political country context hampering AMR progress, (II) Fragmented governance, (III) Antibiotic access and use (IV) AMR knowledge and awareness throughout stakeholders, (V) AMR surveillance, (VI) NAP efforts, and (VII) External drivers. We identified a fragmented structure of the food production chain, poor cross-coordination between stakeholders, limited surveillance and regulation among food-producing animals, and geographical disparities over access, diagnosis and treatment. The country is moving to integrate animal and food production into its surveillance system, with most hospitals experienced in monitoring AMR through antimicrobial stewardship programs.

Conclusion. AMR accountability should involve underpinning collaboration at different NAP implementation levels and providing adequate resources to safeguard long-term sustainability. Incorporating a multisectoral context-specific approach relying upon different One Health domains is crucial to strengthening local AMR surveillance.

Keywords: Antimicrobial resistance, antibiotic use, Argentina, one health, low-and-middle income countries

Strengths and Limitations

► We utilised a hybrid approach consisting of a historical synthesis of regulations regarding antimicrobial resistance and antibiotic usage across animal and humans, and qualitative analyses of the potential challenges and facilitators towards the national action plan to reduce antimicrobial resistance across key stakeholders.

► We used a mixed deductive-inductive approach alongside the constant comparative analysis method for qualitative analysis, enabling a deep integration and comprehensive understanding of complex datasets through the emergence of new themes and patterns

► The primary limitation of our study includes the varying levels of interviewees' involvement in AMR policies and the underrepresentation of certain sectors, notably the private industry.

Introduction

Antimicrobial resistance (AMR) represents a global public health threat driven by interrelated human, animal and environmental factors and requires multidisciplinary and cross-government action (1-3). National and international endeavours have collectively helped reduce AMR over recent years (4). The World Health Organisation (WHO) launched the Global Action Plan on AMR in 2015, soliciting countries to elaborate a National Action Plan (NAP) to confront AMR (5). Similar initiatives have come through the United Nations (UN)(6) and the European Commission (7) to develop multisectoral strategies involving human and animal health to fortify innovation stages and shape the global health agenda towards AMR NAPs. Despite 152 countries having published NAPs (8), challenges exist in implementing NAPs locally, limiting the progress towards addressing AMR (9). Contrasting cultures, policies, incentives and behaviours of relevant sectors and stakeholders have made the implementation of NAPs an arduous process (4). For instance, the lack of surveillance and epidemiological data, the variety of methods used to collect data and the limited understanding of the clinical and social burden of AMR pose challenges for the consummation of NAPs internationally (10). Locally, policy design, including governance and stakeholder involvement and cross-sectoral coordination, are critical to fulfilling the NAP's objectives while adapting the alternating demands of each local subgroup (4, 11).

Recent literature suggests that low- and middle-income countries (LMICs) are likely to face the most significant challenges in NAP implementation (4, 12-20). Among LMICs in Asia, a review found that accountability —a sense of ownership of organisations or people requiring responsibility to other stakeholders— has been omitted in most NAPs (4). Indications of unmet goals and lack of clarity in the stakeholders' role remain significant obstacles to AMR prevention and control (14, 15, 18). In the Americas, 29 countries (89%) have reported developing NAPs to combat AMR since the beginning of 2020 (21).However, most countries including Argentina, have not focussed sufficiently yet on One Health components; active surveillance of human health is not integrated with surveillance in animals or the environment (4, 18). Using a One Health approach is critical for effective NAP implementation because it optimizes the health of different sectors, including natural environments which play a crucial role in AMR evolution and transmission, while preventing zoonotic diseases and improving food safety and security. Argentina implemented a multisectoral NAP strategy in 2015 (22), and progress has been made, including the prohibition of colistin usage in 2019 and gradual banning of antibiotics as growth promoters among livestock (23, 24). A recent study measuring global response to AMR by employing a governance framework on NAP contents highlighted that Argentina can make improvements in standards to control AMR (18). The study stated Argentina's moderate efforts towards monitoring and evaluating AMR in humans and animals and modest AMR policy design (i.e., lack of accountability). However, the study used the Tripartite Antimicrobial Resistance Country Self-Assessment (TrACSS) survey, which could be influenced by the exclusion of publicly and privately accessible documents relevant for AMR monitoring locally, and it lacked data sources that could invite heterogeneity (e.g., interviews with multiple experts/ stakeholders), all of which are considerably important in LMICs. A more direct way to explore Argentine's response to AMR policy is to obtain current data from the stakeholders involved.

This study aims to better understand the stakeholder and regulatory landscape and the challenges and opportunities Argentina faces in implementing its NAP. We examined Argentina's case because it is one of the first countries to have a NAP and has a vast experience in AMR surveillance in the human sphere, which might indicate a good model for the Latin American region. We use the One Health (25) approach to assess policy priorities in action plans, and the governance framework (26) to evaluate interrelated dynamics between the One Health actors to improve critical areas: policy design, implementation tools, and monitoring and evaluation. The need to provide technical and financial support for implementing One-Health integrated NAPs has been recognised globally through the AMR Multi-Partner Trust Fund. Still, the donor base for this remains a few countries (27, 28). Global action may be based on shared goals, but there is a further need to understand the needs and priorities enabling or hindering those actions at national levels. We explore Argentina as a case-study to understand the complex landscape.

Methods

Study aims and setting

This article draws on literature and qualitative interview data from a study conducted in Argentina between September 2022 and February 2023. Argentina is an upper-middle income country that is endowed with highly fertile soils and great potential for renewable energy (hydroelectric, wind and solar energy) (29). It is a major food-producing country with an extensive agriculture and livestock industry; however, the country faces a high fiscal deficit with poverty and inflation rates of about 39% and 94.8% in 2022, respectively. The project's scope was to comprehend the context of AMR policy locally and among relevant stakeholders towards AMR control

and surveillance, focusing on food-producing animals. Relevant stakeholders included government (those with political/administrative duties and those having scientific-technical functions), academic, international, NGOs, and private (chamber of producers, commercial laboratories and producers) institutions.

Study design

We divided our study into two stages. First, we explored the legal framework within the AMR NAP scope and mapped vital organisations, particularly related to food-producing animals (i.e., cattle, chicken and pigs). We searched the literature, including government documents, academic articles, stakeholder's websites, and grey literature, to capture the most relevant AMR policies and critical actors and their role over time. Most sources were identified from the website of the National Commission for AMR control (CoNaCRA, "*Comisión Nacional de Control de la Resistencia Antimicrobiana*") (30) the National Institute of Infectious Diseases (INEI) (31), and government website for national laws (http://www.infoleg.gob.ar/). A recent systematic literature review was also utilised to support evidence synthesis and mapping (32). Moreover, expert knowledge was consulted for main organisations related to the AMR NAP and food-producing animals, and their interactions with stakeholders. Second, after identifying and mapping relevant stakeholders, we conducted qualitative semi-structured interviews between September 2022 and January 2023 to gather information on stakeholder's views and experiences of NAP implementation, the role of different organisations and nature of coordination and decision making between organisations. Interviews were held in person or online lasting 45 to 90 minutes and were conducted by a bi-lingual (English-Spanish) social scientist. The stakeholder mapping developed in stage 1 was used to inform recruitment. A range of participants were sought from government, private and academic organisations. Potential participants were sent a formal request letter via email inviting them to take part in the interview study. Semi-structured interviews were performed using an interview topic guide designed to explore five main items, with questions and objectives detailed below (Box 1). Stakeholders were encouraged to discuss their own views openly. After obtaining informed consent, interviews were audio-recorded in Spanish and transcribed and translated to produce English and Spanish transcripts. Transcripts were checked for accuracy by the interviewer and anonymised. Translation bias was minimised by analysing both original and translated versions by Spanish native speakers (i.e., KA and a qualified third-party translator from Argentina). Back-translation was performed with a reduced sample (20%) of interviews to validate the accuracy of the initial translation (no discrepancies were found). Special attention was given to cultural references, idiomatic expressions, and regional dialects to ensure that translations were contextually appropriate and culturally sensitive (33). The consent form, participant information sheet, and participants interview topic guide are included in the online supplementary material.

Box 1. Interview's main sections including objectives, items and questions

I. Participant's current role. These questions seek to understand what experiences our participants have and how they might be relevant to implementing the NAP to combat AMR.

<1> What your job/role is, and what tasks do you and your organisation mainly perform?
<2> What are your (or department/organisation) interests and responsibilities concerning AMR?

II. Understanding AMR among stakeholders. This group of questions aim to understand employees' and organisations' views on AMR; its main drivers, change overtime, and priority areas within organisations to help tackle AMR.

<1> How do you feel (or what are your personal and department's concerns) about antimicrobial resistance in humans? Does that differ from antimicrobial-resistance in animals or any other source, including the environment (how)?
<2> Do you think the view about antimicrobial-resistance has changed over the years? How?
<3> What are the priority areas within your organisation to increase AMR awareness and to comply with the NAP? Do you feel your organisation helps to contribute to any of the areas detailed in the national plan (how, which)?
<4> What are the cornerstones for increasing AMR awareness while complying with the NAP within your organisation?
<5> Which cornerstones do you feel are most relevant within your department (organisation)? Why?

III. Information channels and flow within stakeholders/departments. These questions attempt to improve organisations decision making towards better AMR surveillance by identifying how the information is channelled within and between organisations.

<1>How do you feel about AMR-related information and communication flow within your organisation and among all stakeholders?
<2> What do you think about communicational interactions, networking, and educational or getting-to-know instances between your organisation and other stakeholders and within departments of your organisation? Would you believe (and how) that the information pathways vary between specific organisation's fields/disciplines, public/private institutions, or certain other groups?
<3> Could you identify which organisms (organisations), and how, are involved in your organisation's decision making and strategy towards improving AMR surveillance and control?

IV. Challenges in the implementation of the national action plan. These questions attempt to answer what factors or challenges might be key to increasing AMR awareness and improving AMR surveillance in food-producing animals and agriculture.

<1> Do you feel there is any challenge that your organisation faces in complying with the AMR NAP and helping contribute to better animal AMR surveillance? (Political priorities, monetary and non-monetary resources, communication, etc) What are the most important and what can be done to overcome these challenges if your organisation could prioritise resources to contribute more to AMR surveillance in animals?
<2> Who else do you think has a critical role in helping with AMR surveillance in animals from the pool of stakeholders?

V. Future and other considerations. These questions aim to understand future steps to be taken within the industry and different key members to tackle AMR.

<1> How organisations might be helped to enhance cross-sectoral communication and teamwork? How can we ensure organisations make progress and collaborate to meet NAP criteria?
<2> Which organisations, at the national and international levels, do you think are most important to talk to and direct efforts to address AMR knowledge gaps? Does the list differ from that necessary to improve the NAP?
<3> Is there anything else important that you might want to share with us or that we are missing in the current interview?

Data analyses

First, we systematically organised Argentina's main AMR regulations using a timeline frame and drew a map to delineate the main stakeholders directly or indirectly supporting the CoNaCRA directed by the Coordination on appropriate use of antimicrobials of the ministry of health, as the commission articulating the efforts for the implementation of the NAP. Second, we employed a systematic qualitative thematic analysis of the interviews using a mixed deductive-inductive approach (34); deductive because it was guided by interview questions from a general topic to a more specific, but inductive as we draw data-driven conclusions derived from bottom-up reasoning. We followed the constant comparative method (35) to favour participants' comparability. Information and open data were classified into themes and subgroups using a coding scheme. Two investigators independently recorded the interviews (KA, EP) using Dedoose software (V.8.0.35, Los Angeles, California: Socio Cultural Research Consultants, LLC). Researchers frequently met to reconcile differences in code application and distinguish new themes emerging from the data analyses. After consolidating new themes, all interviews were re-coded using an updated scheme (see online supplementary material). Subsequently, we identified interconnections between theme data to ascertain larger categories into which themes were clustered. For quotations, we report descriptive characteristics, such as organisation type (academia, government, private, production system), sex at birth, and assigned a random number to each interviewee. Quotes are reported in the text and Tables as "Q" followed by ordered numbers. We reported descriptive statistics to facilitate reader's understandability from whom quotations were drawn and favour studies' transparency while maintaining the anonymity of participants. We utilised the consolidated Criteria for Reporting Qualitative Research (COREQ) checklist to guide reporting of findings (36).

Patient and public involvement

This study was focused on the views and experiences of professionals. Patient and public involvement was therefore not included but we ensured engagement with the community of interest. Public health experts from

Argentina and the UK contributed feedback on our study design and research questions, ensuring relevance and applicability across diverse settings without direct involvement in the core research process.

Results

I. First stage: review of policies and mapping key stakeholders

The timeline containing established laws and regulations related to AMR is found in Supplementary material section I. Briefly, antimicrobial regulation started in the early 60's with the first law of medications and enforced prescriptions for antibiotic acquisition. In 2007-9, new decrees were introduced instituting required prescription for antibiotic sale and compliance for dispensation of medicines, including the registration book of veterinary medicines usage in food-producing animals (2009-11, decree number 26514). In 2013, Argentina's national Food Safety and Quality Service (SENASA) created the traceability system for veterinary medicines, which links sellers and purchasers where entities take full responsibility for antibiotic possession. Consecutively, Argentina's national commission for the control of AMR (CoNaCRA) was established and led the launch of the NAP in 2015 (see Supplementary material section II for a summary).This was concurrent with the abolition of antibiotic usage as an animal growth promoter (2015). The national law towards gradual prohibition of colistin usage in any form/ingredient took place in 2019. Recently, there was a new law encompassing an One health AMR agenda in the future (decree number 27680) aiming to foster and promote AMR control, prevention, research, regulation, and awareness (24).
Finally, Figure 1 shows the mapping of key AMR surveillance and control stakeholders. We organised it starting from the CoNaCRA as the commission responsible for the implementation of the NAP and those relevant organisations surrounding them (main governmental divisions in brown boxes).

II. Second stage: qualitative analyses

Descriptive characteristics of study participants

We approached 27 individuals initially (non-response levels=33%), but our final sample consisted of 18 participants (six women, 33%) mostly based in Buenos Aires city (88%) and from diverse institutions including government (N=9), academia (N=3), private (N=2), NGOs (3) and international organisations (N=1).

Thematic categories and codes

Barriers, opportunities, and state-of-art information contributing to human and food-producing animal AMR were clustered into seven thematic categories organised by specificity level (from less and more specific themes towards AMR policy). Themes were established based upon number of mentions and repetitiveness. Two themes emerged from Argentina's embedded values and political context impacting AMR indirectly: (I) Cultural factors and country context and (II) Governance. Four themes were directly associated with AMR: (III) Antibiotic access and use, (IV) AMR knowledge and awareness, (V) AMR surveillance, (VI) National action plan efforts. The remaining theme was linked to external factors indirectly affecting all chain's decision-making: (VII) External drivers. The full definition of themes —ordered from less to more specific except for external drivers, which affects them all— with their respective sub-themes, are shown in Table 1.

Theme I. Cultural factors and socio-political country context

This category involved country characteristics that determine the response to AMR. Interviewees described that country's economic and political shifts, including goods shortages and high inflation rates, had jeopardised the health system, bringing instability over time to AMR control. Most political decisions in a resource-constrained country were said to be difficult to manage but high reliance upon people and relationships was essential. For instance, a participant described frustration and uncertainty but ability to cope with challenges despite the economic circumstances.

> "*Argentina has 30 years of experience on AMR surveillance, we live economic shortages and political shifts fiercely in Argentina; a state of crisis, and we are somewhat used to this dynamic trying to cope with it as best we can. We have developed good coordinating links between teams centralised on good communication skills, but we cannot guarantee sustainability. It will depend on future leader's coordination since monetary resources are limited, a lot relies upon the projects or people's willingness to contribute but we believe it will perpetuate*"—Participant from a public institution (ID=9), female.

Most participants agreed that changing people's attitudes and behaviour, especially among food-producing animal producers, is challenging due to embedded values (Q1, Table 2). For instance, a participant described it as follows:

> "*Inappropriate antibiotic use, driven by cultural norms like self-medication and seeking quick remedies is often influenced by limited healthcare access. This extends into food production, where profit motives can override caution. A shift in cultural perspective is crucial, educating on responsible use and the benefits of animal welfare and sustainable practices across the sectors"* —Participant, from a public institution (ID=6), male.

Theme II. Governance

Participants reported constraints in the administration system that limited or enhanced their ability to perform improvements towards tackling AMR. Most participants recognised that SENASA conducts extensive and well-articulated labour; however, they emphasised the lack of auditing and accountability in decentralised administrations (regions) in Argentina, which hampers AMR control due to the inherent variability in the quality of care and health access (Q3, Table 2). Efforts to homogenise quality of care and access to antibiotics in humans and animals are ongoing, but monetary and non-monetary resources are bounded (Q4, Table 2). Although resources were finite, stakeholders' communication was often seen as a local strength and the cornerstone of policy making. Good interpersonal relationships within the public, academic, NGOs and international organisations were reported (Q5, Table 2). However, a demand for more integrated services and decision-making was stated (Q5), translating into the need to foster horizontal information flows with mutually integrated systems and organisations throughout the country (Q6, Table 2).

Regarding the regulation sub-theme, there are positive views towards the new law on antimicrobial use, despite the former law introducing some restrictions but lacking control on usage, prescribing and storage (most frequent among animals) (Q7, Table 2). On top of all previously discussed factors, the political context and agenda were considered critical for AMR control but conflicting depending on the country's obstacles and people in charge (Q8, Table 2).

Table 1. Main themes, definitions and sub-themes identified from the interview analysis (N=18 people)

Themes†	Definitions	Sub-Themes	N of times mentioned*
I. Cultural factors and socio-political country context	Understanding the importance of cultural, country context, including personal relationships	**[1]**Cultural features **[2]**National context and sociodemographic characteristics	**[1]**21 **[2]**18
II. Governance	Government attributes related to political priorities, federalisation, nature of institutions/groups, accountability, human and economic/budgetary resource available, data systems and capacity, importance of changing political will, regulations and communication between stakeholders.	**[1]**System governance **[2]**Resources **[3]**Stakeholder communication **[4]**Information and data flow **[5]**Regulation and compliance **[6]**Political context and agenda	**[1]**23 **[2]**22 **[3]**39 **[4]**39 **[5]**38 **[6]**11
III. Antibiotic access and use	Referring to antibiotic consumption and access, prescriptions control and alternatives being developed among animals and humans.	**[1]**Antibiotic access **[2]**Antibiotic consumption **[3]**Antibiotic regulations including prescriptions. **[4]**Alternatives to antibiotics	**[1]**15 **[2]**11 **[3]**14 **[4]**9
IV. AMR knowledge and awareness	Related to public and professional awareness – the challenge of awareness and steps taken to address it including seminars, conferences, courses, stewardship programs, advertising campaigns using mass media, etc.	**[1]**Challenges related to public and professional awareness. **[2]**Existing training and learning opportunities	**[1]**41 **[2]**15
V. AMR surveillance	Perceived progress and challenges, inclusive of AMR surveillance. Reference to food production markets including differences by animal species	**[1]**AMR surveillance **[2]**Food production systems and specific surveillance **[3]**Veterinary sector, agent of change	**[1]**34 **[2]**35 **[3]**14

	and the role of the veterinary sector on AMR surveillance.		
VI. National action plan (NAP) efforts	Implementation of NAP and professional roles, including views on progress over time	**[1]**NAP progress including challenges, barriers, and opportunities	**[1]**22
VII. External drivers	Referring to external factors contributing to the acceleration of AMR, potential opportunities, and good practice, including international actors and role in/influence on national AMR	**[1]**Context of COVID-19 **[2]**International actors and policies	**[1]**16 **[2]**12

Notes: AMR= Antimicrobial resistance. †Themes are ordered from less to more specific levels (except for external drivers which affects them all), see Figure SM2, Supplementary material, for visual hierarchy. *Codes can be mentioned more than once per interview.

Table 2. Quote examples by themes and sub-themes and identification of challenges and opportunities

Themes†	Sub-theme	Representative quote examples	Challenge/ opportunity
I. Cultural factors and socio-political country context	**[1]**	Q1:*"AMR is a cross-cutting issue, but with older-generation low-educated producers living mostly in remote areas (a large quantity), it has been difficult to make them switch their mindset and understand that antibiotics are not necessary for food production, if no bacterial disease is present, and that antibiotic misuse and AMR affect humans and animal well-being."*—Veterinary, public institution(ID=3), male.	Challenge
	[2]	Q2:*"Today, in Argentina, we have 52% poverty and talking about AMR is challenging, considering that 95% of the population is deprived. Telling people to buy cage- and antibiotic-free eggs for a double price seem problematic, considering that overcrowding, hunger, and lack of sewers are constant daily challenges"*—Participant from an NGO (ID=13), male.	Challenge
II. Governance	**[1]**	Q3: *"SENASA is very dynamic but there is lack of accountability from each participating institution when combatting AMR. It is worrisome that SENASA's and other public organisation's labours are highly centralised in the capital, because there is a high heterogeneity in access to treatment, diagnosis, quality standards for animal products, and antibiotic prescribing throughout the country. We know SENASA, for instance, is impeccable but our surveillance system is not punitive, whereas it mostly teaches producers as we do not know where those AMR pathogens came from (reservoirs)"*—Participant from an NGO (ID=12), male.	Challenge and opportunity
	[2]	Q4: *"I think that the most important difficulty is economic and human resources, because especially in public institutions, it is challenging for people to have exclusive and fully compensated dedication"*—Participant from a public institution (ID=11), female.	Challenge
	[3]	Q5: *"We have solid communication channels between governmental institutions (SENASA, INTA, MALBRAN, CoNaCRA) and somewhat with international and academic institutions, but we should employ a strategy of involvement between technical scientific groups, hospital and veterinary leaders, the private industry, including pharmaceutical, and meat producers and related organisations. We need to tell them what our problem is, for them to tell us theirs, and finally come up with integrative solutions that are beneficial for all parties."* —Participant, from a public institution (ID=6), male.	Challenge and opportunity
	[4]	Q6: *"For some diagnostics we report directly to the health informatics system, but we lack perhaps of articulating all the information flows more horizontally facilitating access above all the political decision-makers. Additionally, most systems are not integrated"* —Participant from a	

		public institution (ID=11), female.	Challenge and opportunity
	[5]	Q7: *"Our legislation should regulate and control sales and consumption of antibiotics, including misuse (prohibition, e.g., colistin in veterinary in 2017). Now, it is approved the Antimicrobial Use Law, which legislates on the request of archived prescriptions, and it is stricter than the former law (only monitored required prescriptions and it had poor compliance). We believe antibiotic consumption might decrease. However, regulations are not yet standardised across country regions organically and the informal market is ample."* —Participant from a public institution (ID=6), male.	Challenge and opportunity
	[6]	Q8: *"At the ministerial level, sometimes AMR does not receive the importance and continuity it requires. Today we have a Minister of Health to whom AMR was a priority on their political agenda and most policy attempts entails, and do not omit, reducing AMR and antibiotic misuse. It is helpful to work in favour of that, but it is not frequently the case."* —Participant from an international institution (ID=17), female.	Challenge and opportunity
III. Antibiotics access and use	**[1]**	Q9: *"Laboratories distribute veterinary products. Laboratories have the approval of SENASA to produce and commercialise the products, as well as the distributors. The commercialisation path is laboratory> distributor> production, through veterinarians, but sometimes is the owner himself selling and applying them due to lack of regulation on access, even over the counter. Among cattle, there is a large part of the production that is still extensive and pharmaceutical companies are often far away from feedlot farms. Hence, they keep first-aid kits, including antibiotics, which are applied to wounds or with no diagnostic or under no veterinary supervision. The law obliges establishments to have a treatment book where animal treatments and antibiotics used are recorded, but in most remote areas is not reliably fulfilled and control is limited"* —Participant from an NGO linked to animals (ID=4), male.	Challenge
	[2]	Q10: *"I work in swine production; our main concern relies upon prophylactic consumption of the antibiotic. Indiscriminate antibiotic consumption is present in two ways within swine production. First, meta-phylactic, when there is a percentage of animals that are indeed sick within the flock, but since they are living with them, it is very likely that others are incubating the disease, hence they are treated. The second is the prophylactic, where there is no sick animal, but there are factors of potential stressors that could make those animals sick. This is our biggest concern, because antibiotic is then incorporated into food, whose biological matrix restricts bioavailability of the active ingredient. Additionally, when antibiotics are applied, withdrawal times are not monitored, which promotes the development of AMR mechanisms further"* —Veterinarian, academia (ID=14), male.	Challenge
	[3]	Q11: *"Laboratories producing medicines for veterinary use must comply with good manufacturing practice 'GMP' standards. They register the product, present all the documentation on waste, among other features. We have traceability in some products, such as ketamine, each bottle is identified and we follow-up until the final user. Laboratory production of medicines is well monitored, but there are limited regulations over usage registration, because products are not often administered by health professionals. For instance, final users do not necessarily respect the restriction period or animal treatment is incomplete, for which regulation is scarce."* —Participant from an NGO (ID=4), male.	Challenge
	[4]	Q12: *"We employ tannins, organic acids, probiotics, and prebiotics instead of antibiotics. We proved their efficacy for Escherichia coli and Salmonella using a mixture of probiotics and prebiotics in sentinel farms, which were boosted animal growth. We have produced alternative to antibiotics for a long-time including animal vaccines against pneumonia, and it was company's initiative."*—Participant from a private company (ID=5), male.	Opportunity

IV. AMR knowledge and awareness	**[1]**	Q13: *"One of the main challenges is the access to information/ communication, the awareness of responsible antibiotic use, and lack of commitment from the private sector. Technical and general education on antibiotics and AMR should be promoted to help set a change of consciousness in the consumer, prescriber, and sellers by letting them know the actual effects/impacts of AMR on population health and animal businesses (among producers). The profitability of the sector is compromised if producers are not willing to pay a differential for meat production that could produce higher costs in the future if not committed."* —Engineer from an NGO (ID=7), male.	Challenge
	[2]	Q14: *"The Argentine population is much more aware of what human health is and what antibiotics are designed for. For instance, we had the World Week of Awareness in November, and we held the AMR awareness race alongside the Ministry of Health and Sports, which exhibits interrelationships between different groups."* —Participant from an international organisation (ID=17), female	Challenge and opportunity
V. AMR surveillance	**[1]**	Q15: *"We created the infection surveillance program in 2004 for human hospitals, which is an essential part of national surveillance reporting the annual prevalence/incidence of most critical pathogens. A ministerial resolution from 2018 recommends establishing hospital prevention and control programs, but adherence is optional. We have more than 200 added institutions reporting the appropriate use of antimicrobials yearly, including whether it was empirical, directed, surgical prophylaxis, community-acquired infection, etc. In-hospital software, part of the National Antimicrobial Resistance Surveillance Network 'WHONET', clinicians load the data, compute the analyses (automatically) and feeds the information to the epidemiology department. However, since 2021 (ministerial resolution), prevention and control programs must be certified depending on international guidelines. We use a federal criterion to enrol national institutions and federal hospitals, but private organisations are poorly represented. Also, some institutions did not have stewardship programs actively functioning. We updated the last referendum to include antimicrobial stewardship as a section for infection control (2021), assigning importance to protected areas for infectious disease specialist and pharmacists within hospitals."* —Participant from a public institution (ID=11), female	Challenge
	[2]	*Q16"We have two main problems. First, we detect and observe a lot of animal cases experiencing neonatal diarrhoea produced by multi-resistant E. coli, even encountering septicaemia, which presents a serious health problem. Secondly, we see multi-resistant bacterial strains more frequently associated with bovine's respiratory complex. We identify bronchopneumonia or pneumonia as the two main infectious syndromes. We receive multiple samples from animal lungs, mainly originated in fattening animals in the pen or outbreaks of pneumonia. Quite predominantly, we observe the presence of bacterial resistance to a large majority of the antibiotics routinely used for treating respiratory conditions. That shows some inefficiency from fragmented production systems lacking vertical structure, reduced biosecurity, and poor vaccination rates, especially among cattle."*—Veterinarian, public organisation (ID=8), male.	Challenge
	[3]	Q17:*"I do believe that veterinarians have a very important multisectoral role to play there as training and awareness agents to contain AMR burden."*— Participant from an NGO (ID=4), male.	Opportunity
VI. National action plan (NAP) efforts	**[1]**	Q18:*"Progress has been made if we compare it with five years ago. Regulations on the use of antibiotics to prevent their misuse, such as growth promoters, and vast existing (AMR control in animals) and new initiatives to start controlling AMR reservoirs in soil and water demonstrates we are working towards a better integrated system by taking*	Opportunity

		into consideration the One Health approach"—Veterinarian, public organisation (ID=8), male.	
VII. External drivers	**[1]***	Q19: *"Something the pandemic left us was the effectiveness of virtual meetings, for example, plan out objectives and do training with the veterinarians and farm owners"* —Participant from an NGO (ID=4), male.	Opportunity
	[2]	Q20: *"We performed projects alongside the European Union, WHO and Centre for Disease Control, which supported Argentina through international funding to perform AMR surveillance and control, even in food products and wastewater."* —Participant from a public institution (ID=1), female.	Opportunity

Notes: AMR= Antimicrobial resistance. ǂ Sub-themes descriptions are found in Table 1. NGO= non-governmental organization. *There are challenges associated as well, but we included an opportunity. CoNaCRA= National Commission for the Control of Antimicrobial Resistance. INE= National Institute of Epidemiology. INEI= National Institute of Infectious Diseases. INTA= National Agricultural Technology Institute. SENASA= National Service of Agri-food Health and Quality. WHO= World Health Organization.

Theme III. Antibiotics

Thematic III encompasses efforts to improve antibiotic access, consumption, and regulation, while accounting for potential alternatives. Access to antibiotics was indicated as better regulated in the human side, where hospitals and labs work collaboratively; however, a few participants expressed concerns about the applicability of mandatory prescriptions for sales and a mismatch between prescribed treatments and antibiotic package dosing:

> *"Antibiotics are still sold without a prescription either for human or animal use (more frequent among animals), even if prescriptions are mandatory by law, including keeping track of their usage by health professionals (electronic sales). Another issue is the dosage; antibiotics are usually sold in dosages greater than needed, which incentivises inappropriate utilisation maximising commercial interests."*— Participant, academia (ID=14), female.

In addition, one participant expressed worrying views towards antibiotic access and prophylactic use in animals and its relationship with AMR evolution, including reduced capacity for monitoring usage and withdrawal (Q10, Table 2). On the animal side, the route for antibiotic acquisition could have been more cohesive; vets do not necessarily monitor antibiotic purchase, application, and storage, and limited local regulations are in place (Q9, Table 2). Such practices can be reflected early in the regulation system and antibiotic dispensing from the first stage of the purchasing chain. Most medicines for veterinary use follow international manufacturing standards, but traceability of compounds and usage is restricted once purchase is made (Q11, Table 2). Finally, some participants working on antibiotic replacement produce alternatives for antibiotic use in food-producing animals. They were optimistic over vaccine production offering an efficacious alternative, tackling respiratory diseases in animals, and using additives and plant-based biomolecules to improve food conversion efficiency and eradicate antibiotic use as growth promoters in animal farms (Q12, Table 2).

Theme IV. AMR knowledge and awareness

Theme IV incorporated progress made towards AMR knowledge and awareness targeting different settings and communities. Participants were inclined to say that awareness has increased, and impacts on human health are acknowledged (Q13, Table 2), primarily among leading institutions including government, but awareness campaigns only have limited reach to the wider population, including meat producers, as they tend to be specific and attend professional needs:

> *"There is a problem with vets' knowledge of antibiotics, specifically in terms of pharmacokinetic and pharmacodynamic aspects, the correct calculation of the dose administration. It is the duration of treatment in the form of clinical criteria and corresponding to specific physiological situations. All these aspects are related to rational antibiotic usage. If you forget these aspects, you can reach a therapeutic failure despite having chosen the correct antibiotic based on what the laboratory said; and this is largely prevalent in the country."*— Veterinarian, academia (ID=14), male.

Notwithstanding, participants reported initiatives to raise the human population's awareness generally, including social events and educational seminars, having positive perceived conceptions from participants but their effectiveness remains unclear (Q14, Table 2).

Theme V. AMR surveillance

Theme V comprised all barriers or opportunities that made implementation of surveillance and AMR control overtime arduous or fruitful. Participants expressed that surveillance of AMR has exhibited a lot of progress overtime, especially among humans, and most recently in animals. Antibiotic stewardship and infection surveillance programs in humans, including the regular monitoring of a consolidated network of +200 hospitals, primarily public, are some of the positive views perceived by stakeholders towards implementation (Q15, Table

2). Antibiotic consumption control is a central priority of the government now and a countrywide program is being developed to strengthen AMR surveillance:

> *"We have implemented a national surveillance system for the national consumption of antibiotics in humans, which we did not have until a short time ago. Now, it is time to access the information related to disaggregated statistics on antibiotic sales through collaboration with Pharmacology in human and animal side." —Pharmacist, public organisation (ID=6), female*

However, policies around AMR surveillance and control are moving forward among livestock production systems but at slower rates. One participant indicated that testing for critical animal pathogens is routine and usually comes from public organisations. Still, animal diagnostics are difficult to access sometimes, and surveillance does not yet clearly account for different locations, species, and seasonal components:

> *"INTA monitors some animal production chains, but surveillance is the primary task of SENASA, for example, in dairy, we evaluate animals experiencing a mastitis disease and track AMR and potential environmental reservoirs with technology developed locally. Another example, we detect Salmonella in animals and utilise microbiological analyses, including phenotyping and genotyping to analyse AMR and evolution, as part of surveillance routines hand by hand with SENASA. However, most surveillance comes from the governmental side, sampling seasonality is not often captured due to limited resources, the quantity of livestock farms is massively distributed throughout the country, and local producer's veterinary diagnostics are often sent to private labs where traceability is missing."*—Veterinarian, public organisation (ID=15), male.

Challenges identified by participants on AMR surveillance among animals are mirrored mainly in the animal industry, which constitutes many producers and actors through the production chain, making it complex to supervise (Figure 2 shows a brief description and example of cattle production based on interview content and additional sources for broader context). As reported by one participant, industry's main challenges rely upon controlling early stages within the production chain, including improved hygiene and sanitation and vaccination strategies before animals are stressed while moving from breeding to fattening stages (Q16, Table 2).

Theme VI. National action plan efforts

All participants expressed a positive attitude towards progress made on the NAP even if it is slow. Participants agreed upon improvements, such as, the institutionalisation of CoNaCRA, recently launched law on established AMR network and surveillance (which does not depend on political will), new research centre (IMPaM) for environmental surveillance of AMR reservoirs including water, more control over companion and food-producing animals since 2015 from INTA and SENASA, and that prohibition of some antibiotics has been crucial (Q18, Table 2). Another participant highlighted its value as a premier platform for interdisciplinary engagement:

> "*The NAP has significantly advanced and enhanced interdisciplinary and interdepartmental cooperation between animal and human health sectors, primarily driven by the CoNaCRA, which has facilitated knowledge sharing. However, the challenge of synchronising NAP initiatives across 24 distinct provinces in a federal system underscores the imperative for more effective inter- and intra-level cooperation*—Participant from a public institution (ID=9), female*."*

Theme VII. External drivers

Theme VII comprises external factors, identified by participants, that have had a direct or indirect role affecting AMR control and surveillance. Most participants (60%) recognised that COVID-19 limited the progress of AMR control and policy due to reallocation of human, economic and other resources towards the pandemic response. For instance, one participant described it as follows:

> *"Teams were absolutely overwhelmed during COVID-19, all the artillery was dedicated to diagnosis and containment of COVID. We observed an overuse of antimicrobials during these two years, which have accelerated the appearance of new AMR mechanisms and their transmissibility. At the microbiological level, pandemic lineages have appeared, which changes local epidemiology"*—Infectious disease doctor, public organisation (ID=1), female.

However, positive lessons were drawn from the pandemic, including the effectiveness of virtual meetings as an advantage of multisectoral collaboration (Q19, Table 2). Additionally, prioritisation of personal hygiene and care and hand washing was understood to be improved due to increasing awareness of communicable diseases and human health among citizens, as one participant reflected:

> *"The pandemic has taught us, it's to prioritize our personal hygiene. Hand washing and personal care help us not get sick from diseases, and if we don't get sick, we do not require antibiotics."*— Veterinary, public organisation (ID=3), male.

Finally, the second external factor relies upon international collaborations. Participants described solid relationships with international actors within the Americas and abroad, which has helped fund local projects for improving AMR control and surveillance (Q20, Table 2).

Discussion

We employed a context and qualitative analysis to understand main gaps related to the progress of AMR control in implementing AMR policy and regulation in Argentina. Our findings revealed that overall stakeholders' perceptions towards AMR policy are positive, including development of personal relationships enabling progress, and that the NAP along with current emerging legislation are essential in formalising the first steps to a multisectoral and better integrated AMR surveillance system. Interviewees stated that main challenges on the way forward are related, but not limited to, commitment and accountability, monetary and non-monetary resources, cultural factors implying behaviour change, fragmented food-production systems, and global governance. We have summarised these below in Figure 3 in relation to whether at macro or micro level and short or long-term.

One of the most immediate short-term challenges identified by stakeholders was governance, which implied needing more accountability and resources through different AMR actors. Clearer administration systems for successful improvement and conveying AMR policies are crucial to moving forward in the AMR agenda (26, 37). Argentina's administration system is divided into provinces. Still, political decisions are highly centralised in the capital city, which hampers regulation of antibiotic access, AMR testing, and delivery of consistent access to healthcare and hospital infrastructure in humans and animals. Although the CoNaCRA has provincial representatives, the AMR agenda had limited alignment with subnational and local governments for NAP implementation posing significant challenges in rural and remote areas (38). Likewise in Brazil (20), these areas are often highly exposed to AMR risks due to health deprivation. Re-administering monetary and non-monetary resources to meet local needs and capacities and empowering provincial sentinel organisations are crucial to making AMR policies accountable.

Cross-sector coordination including animal, environmental and human sectors was highlighted as crucial by interviewees and constituted an essential element of short-term action towards tackling AMR and improve policy design. Although communication was perceived as positive due to interpersonal relations between colleagues, adequate governance must be established, including mechanisms to link organisations across sectors through formal channels to foster continuity. Effectively tackling these challenges is essential for the One Health approach, particularly given the COVID-19 pandemic's revelation of significant complexities and gaps in intersectoral collaboration, underscoring the need for integrated, human-uncentered, policies (39). Literature has focused on countries' need for better engagement and advocacy from various stakeholders (9, 14, 40). Governments, policymakers, and NGOs are essential to AMR control, supported by budgetary commitment and political authority to meet objectives (19). Current interventions in Argentina remain sector-specific, which could be attributed to differences in priorities for AMR or insufficiently well-defined roles in the NAP. Developing a monitoring or evaluation system for all implementation plans is recommended to determine policy effectiveness. Broad cross-field participation is also crucial if no public budget is allocated to address AMR nationally. Insufficient funding provided by the annual national budgets negatively impacts NAP implementation, generating more constraints on AMR action. The COVID-19 pandemic garnered global attention disrupting national resources and health services that were indirectly assigned to AMR control, and reallocating those funds has posed challenges to AMR reduction measures. One Health although theoretically a useful framework, was not considered in NAP implementation— it could have accounted for the co-benefits of addressing both risks concurrently. That is why the United Nations Environment Program (UNEP) established the Multi-partner Trust Fund (MPTF) to help LMICs improve delivery of multisectoral NAPs (28).

AMR awareness has increased overtime in Argentina. Recent efforts have included various seminars and activities, including a long-distance foot race to spread the word on AMR (41).However, AMR comprises stakeholders with diverse comprehension of the AMR phenomenon, and we evidenced a mismatch between scientific and non-scientific domains, including general public. Social change promoting human health via shifts in society's behaviour should be prioritised to ensure the sustainability of human development and their environments (42). For instance, public engagement is overlooked in Argentina's NAP. Strategies to evaluate attitudes, behaviours, necessities, and practices of socioeconomically and culturally diverging communities, drawing particular attention to those most vulnerable to AMR infections, are crucial to design public health interventions to combat AMR (4).

Strengthening AMR surveillance and control is vital, with different challenges depending on the species spectrum, as highlighted previously in LMICs (4, 19, 20, 43-45). In humans, laboratory surveillance has been based for decades on the connectivity of a well-established hospital networks (e.g., WHONET-Argentina (46)), which has helped monitor AMR locally with institutionalised IPC policies, led by the Antimicrobial Agents Division of INEI-ANLIS, the National and Regional Reference Laboratory for AMR, and the National Hospital Infection Surveillance Program (VIDHA), respectively. However, there are still gaps regarding the effectiveness of preserving antibiotics through stewardship programs, although consumption levels and inappropriate usage

rates decreased before COVID-19 (47). Yet, quality control among stewardship programs, antimicrobial sales with necessary prescriptions, and targeted local efforts in differing regions are still challenging throughout the country (48).In animals, the main surveillance challenges that were reported were concentrated around the unification of production systems (dispersed via multiple chains and actors potentially favouring the dissemination of AMR), whose current fragmented status hampers regulation, with differing control levels depending upon animal species. Systems' capacity to ensure prescription and consumption data is compromised and policies should coordinate and harmonise AMR surveillance while regulating the usage of antimicrobials in animal production at all production stages (32).Globally, antimicrobial stewardship by farm owners and health professionals (e.g., veterinarians) is relatively weak within agricultural systems; developing efforts towards stewardship programs in veterinary services, bolstering the veterinary role as a critical change agent, and companion animal practice remains crucial (49-51). Argentina's chambers of producers play an active role in agglomerating food producers and understanding their needs (e.g., Camara Argentina de Feedlots); their job should be directed towards better integration and prioritisation of educational services and improved production standards.

A recent WHO report on integrated surveillance of AMR in foodborne diseases indicated that ineffective public health AMR surveillance systems often lack broader regulation and laboratory infrastructure, limited biosecurity, and inadequate data management capacity at government levels (52).We observed reduced capacity for data monitoring and sharing among animal stakeholders, whereby surveillance of antibiotic sales/usage and AMR rates by animal species could be better reported. Despite limited public control due to fragmentation of the production chain, food producers are perceived to prioritise profitability and local needs, regardless of the effects of AMR on population health. Moreover, creating an integrated One-Health approach combining animal and human systems, including environmental sources, might help reduce the AMR burden and prevent animal infections in farming communities (25, 53), ensuring sustainability over time and lowering the risks associated with political shifts and global uncertainties. The role of the private sector, not only restricted to food producers, in supporting AMR surveillance should be encouraged to provide a holistic whole-system integration, including a whole food-chain approach (54, 55).This should involve data access and optimising contemporary treatments and diagnostics through more research and technology to elucidate the transmission pathways of the most critical microorganisms for animal and human health.

We identified potential opportunities that could help contribute to progressing action to reduce AMR locally. Most stakeholders favoured agricultural non-antimicrobial drug products as an antibiotic replacement for animal growth promoters. Using tannins and natural plant-based medicines could supersede antibiotics, reducing selective pressure and AMR burden (56, 57). Nevertheless, most of these products are difficult to access locally with limited legislation and high reliance on a few international companies. The provision of replacement routes from the government for antibiotic-free additives usage in animals, including appropriate stakeholder education and countrywide support through public pharmacies, is something the authorities should leverage. Furthermore, the new law establishing the AMR agenda as a constituted program, regardless of political change, presents substantial progress towards national recognition of the AMR problem (24). The initiative brings a long-term perspective to AMR policy, which could be used for the creation of an AMR policy database containing information on NAP implementation accountability and cross-species and environment AMR surveillance for policy advisors.

Our study has some shortcomings. First, we were not able to speak to stakeholders from all areas of the stakeholder mapping and cannot generalise the views of participants to others but have confidence in the transferability of findings and common themes that arose among the diverse stakeholders who participated. Nevertheless, common themes arose from speaking to a range of stakeholders and our sample reached saturation with a narrow range of interviews, considered an appropriate sample size for qualitative research (58). Second, we could not represent private hospitals for human AMR, and differences between production chains, including a broader scope of animal species, dairy products, and final animal product providers, which remains a future study. Third, the extent of interviewees' actual involvement in AMR policies differed; however, we ensured respondents best authority through collaborative local work and expert knowledge. Fourth, the authorship group includes people involved in AMR policy in Argentina which could either favour (facilitate information flow) or bias (sampling, selection and confounding) our study results.

Finally, participants' beliefs (interviews held between December 2022 and January 2023) might be subject to change in the forthcoming years due to implementation of the newly introduced national law on AMR prevention and control (August 2022) (24). Tighter measures regarding antibiotic usage and sales (only under-filled prescriptions) and promoting the One Health approach via implementing cross-sector policies while

accounting for organisation-specific responsibilities for their listed tasks are examples of the expected outcomes the law might enforce.

CONCLUSION

Our study results draw attention to the main strengths, opportunities, and challenges in the process towards improved AMR awareness, control, and surveillance across the human-animal frontier in Argentina. The country has been one of the leaders in the region with an established AMR surveillance network for human health in the latest 40 years. However, AMR governance requires a multidisciplinary focus to help stakeholders at all levels deal with knowledge uncertainties and resulting differences in framing the AMR problem. We found critical areas that should be strengthened, including accountability, sustainable engagement, integrity and equity, socio-behavioural change, international cooperation, and consolidation of environmental and animal departments. Cross-cutting interventions incorporating these areas through different One Health domains should be accounted for if progressing towards AMR is noted. The recent law on AMR prevention and control serves as a good example, which identifies potential pathways to overcome challenges with direct implications for LMICs in the Latin American region.

Funding: This research is co-funded by the UK Department of Health and Social Care as part of the Global AMR Innovation Fund (GAMRIF)(BB/T004452/1) and includes funding under the GAMRIF UK:Argentina AMR Pan-Programme Integration Project (PPIP).This is a UK aid programme that supports early-stage innovative research in underfunded areas of antimicrobial resistance (AMR) research and development for the benefit of those in low- and middle-income countries (LMICs), who bear the greatest burden of AMR. The views expressed in this publication are those of the author(s) and not necessarily those of the UK Department of Health and Social Care.

Role of the funding sources: The funders had no role in the design, conduct, analysis or interpretation of the study.

Acknowledgments: All authors attest they meet the ICMJE criteria for authorship and have reviewed and approved the final article. The authors are grateful to all participants for volunteering time as part of interviews and workshops.

Conflicts of Interest: The authors declare no conflict of interests.

Author Contributions: Conceptualization (KA, EP, WG, MF-M, AP); methodology (KA, EP, LBoden); formal analysis (KA); writing—original draft preparation (KA); writing—review, editing and commenting (KA, EP, WG, MF-M, AP, LBoden, LBarcelona, AC, FL); supervision (EP, MF-M, AP); securing funding for the project (RL, SG, SS-B, AP, MF-M, KR, HW, PD, DM, WG). All authors have read and approved the final version of the manuscript.

Data availability: The qualitative data underlying this article are available in the article.

Ethics review: Ethical approval was obtained from the Human Ethical Review Committee at University of Edinburgh (Ref: HERC_696_21, date of approval: 21April 2022).

AMR policy research group Argentina:
Rodolfo Luzbel de la Sota. *Facultad de Ciencias Veterinarias, Unversidad Nacional de la Plata, Argentina.*
Sonia Gómez. *Servicio Antimicrobianos, Instituto Nacional de Enfermedades Infecciosas, ANLIS "Dr Carlos G. Malbrán", Buenos Aires, Argentina.*
Sergio Sánchez Bruni. *Facultad de Ciencias Veterinarias, Universidad Nacional del Centro de la Provincia de Buenos Aires, Argentina*.
Kristen Reyher. *Bristol Veterinary School, University of Bristol, UK.*
Helen West Helen. *University of Nottingham, UK.*
Peers Davies, *Institute of Infection, Veterinary and Ecological Sciences, Liverpool University, UK.*
Dominic Moran. *The Royal (Dick) School of Veterinary Studies, University of Edinburgh, UK.*

Abbreviations
AMR= Antimicrobial resistance
SENASA= Argentina's National Food Safety and Quality Service
ANLIS= Argentina's National Administration of Laboratories and Institutes of Health
CoNaCRA= Argentina's National Commission for the Control of Antimicrobial Resistance
INTA= Argentina's National Agricultural Technology Institute
IMPaM= Argentina's Institute for Research in Medical Microbiology and Parasitology
UBA= Universidad de Buenos Aires
INE= Argentina's National Institute of Epidemiology
INEI= Argentina's National Institute of Infectious Diseases
ANMAT= Argentina's National Administration of Drugs, Food and Medical Devices
CONICET= Argentina's National Scientific and Technical Research Council
FAO= Food and Agriculture Organization
WOAH= World Organization of Animal Health
WHO= World Health Organization
PAHO= Pan American Health Organization
NAP= National Action Plan

Figure 1. Stakeholders within the human and food-producing animal interfaces for the implementation of the NAP for the control of AMR in Argentina *Notes:* Organisations abbreviations are provided in the abbreviations subtitle. CoNaCRA= National Commission for the Control of Antimicrobial Resistance. All information on Government's ministries and structures is available in https://www.argentina.gob.ar/organismos.

Figure 2. Brief description of some features within the cattle industry in Argentina. *Notes:*(A): Feed supplied in the trough for cattle, livestock farm, Buenos Aires, Argentina. (B): Cattle pens, livestock farm, Buenos Aires, Argentina. (C): Characteristics of beef production and relationship with AMR control. AMR= Antimicrobial resistance. NAP= National action plan. Most information was derived from our interviews; exact quotes are shown upon request.

Figure 3. Major challenges and opportunities related to AMR policy in Argentina within a One Health scope in the short and long-term. *Notes:* AMR= Antimicrobial resistance.

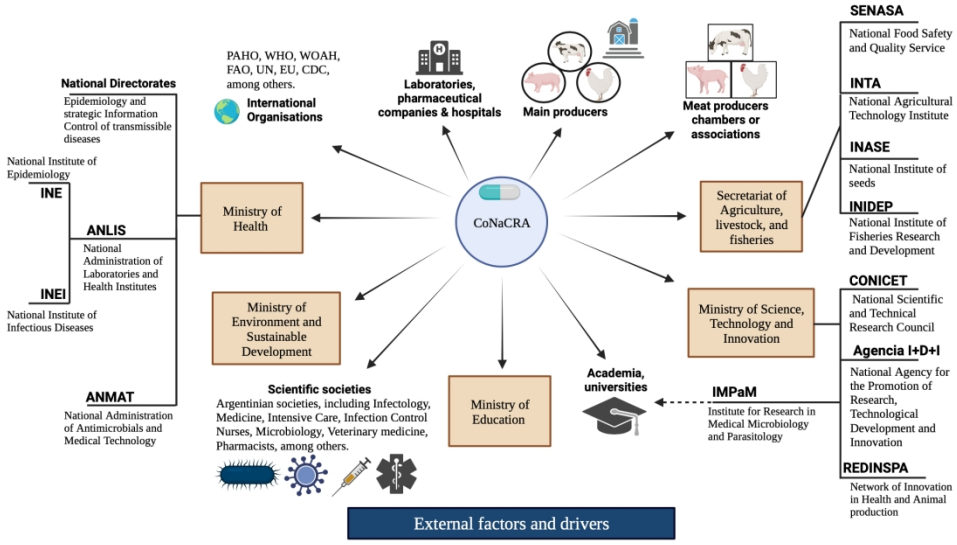
REFERENCES

1. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, et al. Understanding the mechanisms and drivers of antimicrobial resistance. The Lancet. 2016;387(10014):176-87.
2. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet. 2022.
3. Allel K, Day L, Hamilton A, Lin L, Furuya-Kanamori L, Moore CE, et al. Global antimicrobial-resistance drivers: an ecological country-level study at the human–animal interface. The Lancet Planetary Health. 2023;7(4):e291-e303.
4. Charani E, Mendelson M, Pallett SJ, Ahmad R, Mpundu M, Mbamalu O, et al. An analysis of existing national action plans for antimicrobial resistance—gaps and opportunities in strategies optimising antibiotic use in human populations. The Lancet Global Health. 2023;11(3):e466-e74.
5. Mendelson M, Matsoso MP. The World Health Organization global action plan for antimicrobial resistance. SAMJ: South African Medical Journal. 2015;105(5):325-.
6. Humphreys G, Fleck F. United Nations meeting on antimicrobial resistance. World Health Organization Bulletin of the World Health Organization. 2016;94(9):638.
7. Commission E. A European one health action plan against antimicrobial resistance (AMR). European Commission. 2017.
8. World Health Organization. Library of AMR national action plans 2023 [Available from: https://www.who.int/teams/surveillance-prevention-control-AMR/national-action-plan-monitoring-evaluation/library-of-national-action-plans.
9. Frumence G, Mboera LE, Sindato C, Katale BZ, Kimera S, Metta E, et al. The governance and implementation of the National Action Plan on Antimicrobial Resistance in Tanzania: a qualitative study. Antibiotics. 2021;10(3):273.
10. Wernli D, Jørgensen PS, Harbarth S, Carroll SP, Laxminarayan R, Levrat N, et al. Antimicrobial resistance: the complex challenge of measurement to inform policy and the public. PLoS Medicine. 2017;14(8):e1002378.

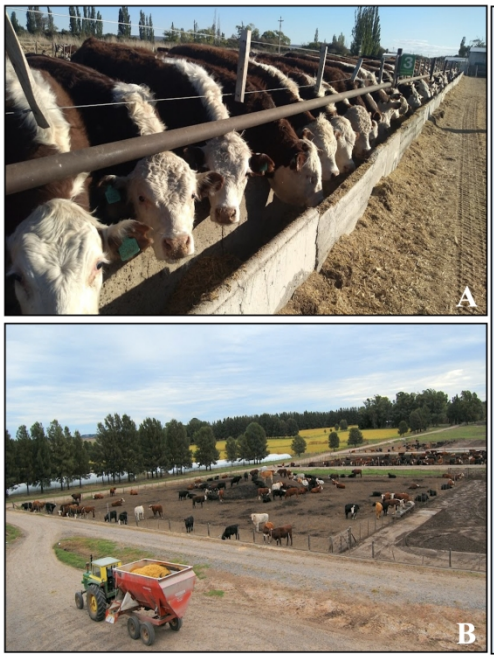
11. Organization WH. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators. 2019.
12. Jimah T, Ogunseitan O. National Action Plan on Antimicrobial Resistance: stakeholder analysis of implementation in Ghana. Journal of Global Health Reports. 2020;4:e2020067.
13. Khan MS, Durrance-Bagale A, Mateus A, Sultana Z, Hasan R, Hanefeld J. What are the barriers to implementing national antimicrobial resistance action plans? A novel mixed-methods policy analysis in Pakistan. Health policy and planning. 2020;35(8):973-82.
14. Chua AQ, Verma M, Hsu LY, Legido-Quigley H. An analysis of national action plans on antimicrobial resistance in Southeast Asia using a governance framework approach. The Lancet Regional Health-Western Pacific. 2021;7:100084.
15. Harant A. Assessing transparency and accountability of national action plans on antimicrobial resistance in 15 African countries. Antimicrobial Resistance & Infection Control. 2022;11(1):1-15.
16. Nair M, Zeegers M, Varghese G, Burza S. India's National Action Plan on Antimicrobial Resistance: a critical perspective. Journal of Global Antimicrobial Resistance. 2021;27:236-8.
17. Amin ET, Omeichu AA, Shu DM, Ekome SRE, Njumkeng C, van der Sande MAB. Control of antimicrobial resistance in Cameroon: Feasibility of implementing the National Action Plan. Tropical Medicine & International Health. 2021;26(10):1231-9.
18. Patel J, Harant A, Fernandes G, Mwamelo AJ, Hein W, Dekker D, et al. Measuring the global response to antimicrobial resistance, 2020–21: a systematic governance analysis of 114 countries. The Lancet Infectious Diseases. 2023.
19. Shabangu K, Essack SY, Duma SE. Barriers to Implementing National Action Plans on Antimicrobial Resistance using a One Health Approach: Policy-Makers' Perspectives from South Africa and Eswatini. Journal of Global Antimicrobial Resistance. 2023.
20. Juliana Silva Corrêa LFZ, Roberto Rubem Da Silva-Brandão, Sandi Michele de Oliveira, Lislaine Aparecida Fracolli, Maria Clara Padoveze & Gloria Cordoba. The governance of antimicrobial resistance in Brazil: Challenges for developing and implementing a one health agenda. Global Public Health. 2023;18(2190381).
21. da Silva Jr JB, Espinal M, Ramón-Pardo P. Antimicrobial resistance: Time for action. Revista Panamericana de Salud Pública. 2020;44.
22. Ministry of Health. National strategy for the Control of Antimicrobial resistance 2015 [Available from: https://www.boletinoficial.gob.ar/pdf/linkQR/YzB6b2o4Qy9ZRDFycmZ0RFhoUThyQT09.
23. República Argentina - Poder Ejecutivo Nacional. Resolución 22/19. Productos veterinarios: prohibición de elaboración, distribución, importación, uso y tenencia 2019 [updated 11 January 2019. Available from: http://www.senasa.gob.ar/sites/default/files/ARBOL_SENASA/INFORMACION/NORMATIVA/RESOL_Y_ANEXOS/2019/r_senasa_22-2019.pdf.
24. Nacion ANCPdl. Boletin oficial de la republica de Argentina. Ley de prevención y control de la resistencia a los antimicrobianos, ley 27680. 2022 [updated August, 2022. Available from: www.boletinoficial.gob.ar/detalleAviso/primera/270118/20220824?busqueda=1).
25. Ogyu A, Chan O, Littmann J, Pang HH, Lining X, Liu P, et al. National action to combat AMR: a One-Health approach to assess policy priorities in action plans. BMJ global health. 2020;5(7):e002427.
26. Anderson M, Schulze K, Cassini A, Plachouras D, Mossialos E. A governance framework for development and assessment of national action plans on antimicrobial resistance. The Lancet Infectious Diseases. 2019;19(11):e371-e84.
27. Pitchforth E, Smith E, Taylor J, Davies S, Ali G-C, d'Angelo C. Global action on antimicrobial resistance: lessons from the history of climate change and tobacco control policy. BMJ Global Health. 2022;7(7):e009283.
28. United Nations. Antimicrobial Resistance Multi-Partner Trust Fund Countering antimicrobial resistance with a 'One Health' approach 2022 [Available from: https://mptf.undp.org/fund/amr00.
29. World Bank. World Bank Data 2023 [Available from: https://data.worldbank.org/country/argentina.
30. Ministry of Health. Comisión Nacional de Control de la Resistencia Antimicrobiana (CoNaCRA) 2024 [Available from: https://www.argentina.gob.ar/salud/epidemiologiaysituacion/conacra.
31. Instituto Nacional de Enfermedades Infecciosas (INEI) – ANLIS "DR. CARLOS G. MALBRAN. Servicio Antimicrobianos 2024 [Available from: http://antimicrobianos.com.ar/servicio-antimicrobianos.
32. McCormick BP, Quiroga MP, Álvarez VE, Centrón D, Tittonell P. Antimicrobial resistance dissemination associated with intensive animal production practices in Argentina: A systematic review and meta-analysis. Revista Argentina de Microbiología. 2022;55(1):25-42.
33. Temple B, Young A. Qualitative research and translation dilemmas. Qualitative research. 2004;4(2):161-78.

34. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative research in psychology. 2006;3(2):77-101.
35. Boeije H. A purposeful approach to the constant comparative method in the analysis of qualitative interviews. Quality and quantity. 2002;36(4):391-409.
36. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care. 2007;19(6):349-57.
37. Rochford C, Sridhar D, Woods N, Saleh Z, Hartenstein L, Ahlawat H, et al. Global governance of antimicrobial resistance. The Lancet. 2018;391(10134):1976-8.
38. Pokharel S, Raut S, Adhikari B. Tackling antimicrobial resistance in low-income and middle-income countries. BMJ Specialist Journals; 2019. p. e002104.
39. Chen J, He J, Bergquist R. Challenges and response to pandemics as seen in a One Health perspective. Science in One Health. 2022;1:100010.
40. Castro-Sanchez E, Iwami M, Ahmad R, Atun R, Holmes AH. Articulating citizen participation in national anti-microbial resistance plans: A comparison of European countries. European Journal of Public Health. 2018;28(5):928-34.
41. With a massive race, PAHO Argentina spreads the word to prevent antimicrobial resistance [press release]. 2022.
42. Hernando-Amado S, Coque TM, Baquero F, Martínez JL. Antibiotic resistance: moving from individual health norms to social norms in one health and global health. Frontiers in Microbiology. 2020;11:1914.
43. Lota MMM, Chua AQ, Azupardo K, Lumangaya C, Reyes KAV, Villanueva SYAM, et al. A Qualitative Study on the Design and Implementation of the National Action Plan on Antimicrobial Resistance in the Philippines. Antibiotics. 2022;11(6):820.
44. Sirijatuphat R, Chayangsu S, Srisompong J, Ruangkriengsin D, Thamlikitkul V, Tiengrim S, et al. Feasibility, Challenges, and Benefits of Global Antimicrobial Resistance Surveillance System Implementation: Results from a Multicenter Quasi-Experimental Study. Antibiotics. 2022;11(3):348.
45. Sumpradit N, Wongkongkathep S, Poonpolsup S, Janejai N, Paveenkittiporn W, Boonyarit P, et al. New chapter in tackling antimicrobial resistance in Thailand. bmj. 2017;358.
46. Rossi MA, Tokumoto M, Couto E, Di Bella A, Alstchuler M, Gomez N, et al. Survey of the levels of antimicrobial resistance in Argentina: WHONET program-1991 to 1994. International journal of antimicrobial agents. 1995;6(2):103-10.
47. Dapás JI, Quirós RE. Antimicrobial stewardship in low-and middle-income countries. Current Treatment Options in Infectious Diseases. 2018;10:17-27.
48. Boni S, Marin GH, Campaña L, Marin L, Corso A, Risso-Patron S, et al. Disparities in antimicrobial consumption and resistance within a country: the case of beta-lactams in Argentina. Revista Panamericana de Salud Pública. 2021;45:e76.
49. Brodbelt D. Breaking new ground in antimicrobial stewardship in companion animal veterinary practice. Nature Communications. 2021;12(1):2445.
50. Nind L. International trends impacting antimicrobial stewardship in animal health. Australian veterinary journal. 2019;97(9):362-4.
51. Singleton DA, Rayner A, Brant B, Smyth S, Noble P-JM, Radford AD, et al. A randomised controlled trial to reduce highest priority critically important antimicrobial prescription in companion animals. Nature Communications. 2021;12(1):1593.
52. World Health Organization. Integrated surveillance of antimicrobial resistance in foodborne bacteria: application of a one health approach: guidance from the WHO Advisory Group on Integrated Surveillanec of Antimicrobial Resistance (AGISAR). 2017.
53. Jimenez CEP, Keestra SM, Tandon P, Pickering AJ, Moodley A, Cumming O, et al. One Health WASH: an AMR-smart integrative approach to preventing and controlling infection in farming communities. BMJ Global Health. 2023;8(3):e011263.
54. Mendelson M. BSAC Vanguard Series: Inequality and antibiotic resistance. Journal of Antimicrobial Chemotherapy. 2022;77(2):277-8.
55. Blake LJ, Häsler B, Bennani H, Mateus AL, Eastmure E, Mays N, et al. The UK Antimicrobial Resistance Strategy 2013–18: A Qualitative Study of International and Domestic Policy and Action Related to Livestock and the Food Chain. Frontiers in Sustainable Food Systems. 2022;6:102.
56. Huang Q, Liu X, Zhao G, Hu T, Wang Y. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. Animal Nutrition. 2018;4(2):137-50.
57. Farha AK, Yang Q-Q, Kim G, Li H-B, Zhu F, Liu H-Y, et al. Tannins as an alternative to antibiotics. Food Bioscience. 2020;38:100751.

716 58. Hennink M, Kaiser BN. Sample sizes for saturation in qualitative research: A systematic review of
717 empirical tests. Social Science & Medicine. 2022;292:114523.
718



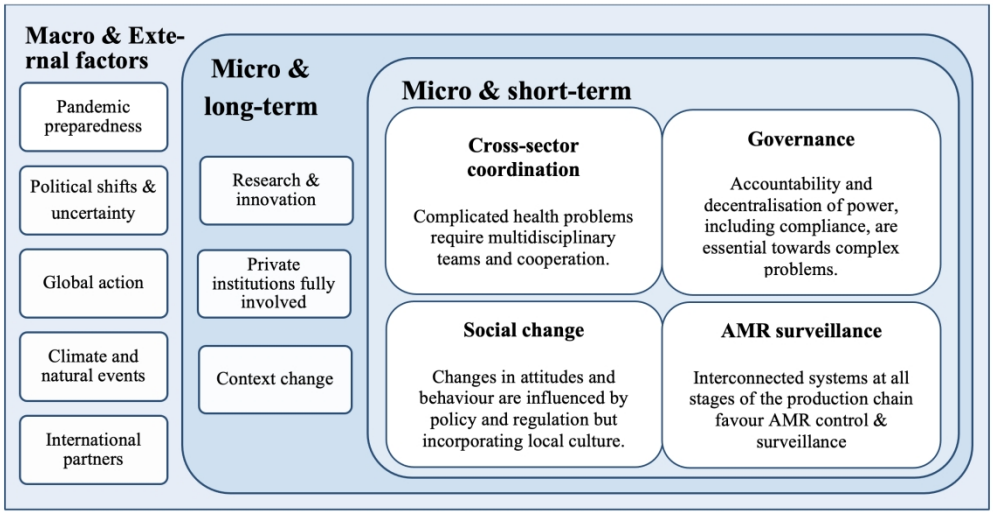
379x210mm (144 x 144 DPI)



Around 52 million head of cattle are kept by livestock farmers in Argentina. The country produced 3.2 million tonnes of beef meat in 2020, of which 900,001 tonnes were exported (75% to China). However, the production chain involves a wide variety of actors and producers (from breeding, fattening, slaughtering, preservation, and sale) and the number of direct beef producers is estimated to be 230,000 with no significant market share among specific companies, compared to chicken or swine industries where three companies concentrate 70% of the market share. Although swine and chicken are amongst food-producing animals species with higher AMR rates for streptomycin, ampicillin and tetracycline resistance, there is still a research gap regarding beef-cattle from feedlots due to reduced AMR monitoring and control, including antibiotic usage. The cattle production chain is highly fragmented, and the movement dynamics of the animals through the production chain are complex, even though their transit must be registered to comply with SENASA guidelines, and all production units should be referenced in a computer database. However, in practicality, controlling thousands of animals at different production stages is challenging, and it is often hard to trace and follow to check if producers follow guidance in antibiotic use. In line with this, cattle vaccination rates against diarrheal or respiratory diseases are relatively low compared to the chicken and swine industry. Most livestock farms are family businesses where there is a partial vet role for antibiotic administration, and antibiotic storage in warehouses is often observed due to reduced control on acquisition.

C

437x291mm (144 x 144 DPI)



441x232mm (144 x 144 DPI)

Supplementary Material

Opportunities and challenges in antimicrobial resistance policy including animal production systems and humans across stakeholders in Argentina: a context and qualitative analysis

Table of Contents

I. Timeline containing the legislation and policies in place within the AMR spectrum in Argentina....2

II. Summary of the Argentinian National Action Plan to combat AMR....4

III. Consent form for interviewees (participants)....8

IV. Participant information sheet....9

V. Participant interview topic guide....11

VI. Description of main preliminary topic codes applied to the interview analyses and their respective definitions....13

VII. Themes ordered from broader to greater specificity.....14

VIII. Packed code cloud for identified themes/sub-themes....15

I. Timeline containing the legislation and policies in place within the AMR spectrum in Argentina

[1916] Creation of the formerly called Instituto Nacional de Microbiología "Malbran", which is renamed in 1996 (see below).

[1956] Creation of the National Agricultural Technology Institute (INTA)

[1964] Act. 19 of the National Law of Medications No. 16,463. It states that "any form of advertising of products whose sale has not been authorized by prescription is prohibited" (subsection d).

[1967] National law regulating pharmaceutical activity. Also, the Directorate of Registration Inspection and Border Health of the Ministry of Health of the Nation, which upon verifying the violations of the regulations must initiate the corresponding summary actions and may conclude with the sanctions established in art. 45 of Law 17565 on the Exercise of Pharmacy Activity: warning, fine, closure of the establishment, suspension of registration and/or disqualification.

[1969] Decree number 3835/1969 of the Ministry of Public Health established that medicines with antibiotic activity for systemic use must be dispensed under a prescription filed by the dispenser, with penalties for non-compliance with: warning, fine, closure, suspension of registration, disqualification and /or prison of up to three years (Laws 17565/1967 of Practice of Pharmacy and 26524/2009 of the Penal Code)

[1970] Decree number 3835/69 (later modified by decree number 378/70) of the then Ministry of Social Welfare. It established that medicines whose active pharmaceutical ingredients (IFAs) have antibiotic activity for systemic use must be dispensed according to their registration condition of January 1, 1970. Prescriptions must be archived by correlative date and kept for a period of two years, after which the pharmacy can delete them.

[1983] Creation of the National program of epidemiology and control of hospital-acquired infections, which was implemented and monitored by the National Institute of Epidemiology (INE), decree number 2885/83.

[1986] Creation of the National Antimicrobial Resistance Surveillance Network WHONET-Argentina

[1992] Creation of the National Administration of Medicines, Food and Medical Technology (ANMAT)

[1995] Creation of the Intensified National Epidemiological Surveillance System for Hospital Infections (SIVENIH), implemented on a pilot basis and involving 25 public and private hospitals in the country.

[1996] Creation of the National Administration of Laboratories and Institutes of Health (ANLIS), decree number 1628.

[1998] Creation of the National Service of Agri-food Health and Quality (SENASA)

[2001] Creation of the Argentine Beef Promotion Institute (IPCVA), law number 25,507.

[2004] Creation of the National Hospital Infection Surveillance Program (VIHDA) to monitor hospital-acquired infections in participating hospitals.

[2007] Decree number 609 states that antimicrobials must be sold only under prescription.

[2009] Law 26,524. The dispensation of any type of medicinal product without compliance with the legal conditions of sale would be considered as a crime, which can be punished with prison for up to three years.

[2011] Decree number 666/2011 determined that any establishments having food-producing animals must keep a record book for the administration of veterinary products, subject to inspections.

[2011] Decree number 666 determined that the food-producing establishments must keep a record book of treatments subject to inspection by SENASA in which all administration of veterinary products on production animals must be recorded.

[2011] Act. 36 of Decree 7123/68, regulating Law 17,565, defined that: "The acquisition and sales provided by drugstores must be made by invoice and/or separate remittance..., keeping the Documentation filed in an orderly manner, making it available to the inspectors of the Secretary of State for Public Health, at their request.

[2011-2013] ANMAT drug traceability programs (decree number 435, National Ministry of Health) and SENASA phytosanitary and veterinary products (SENASA, decree number 369/2013), will provide data on the commercialization and distribution of antimicrobials in humans and in food-producing animals and agriculture.

[2013] Decree number 369/2013 created the Traceability System for Phytosanitary and Veterinary Products.

[2013] SENASA instituted the National Phytosanitary and Veterinary Products Traceability System, which reports the volume and type of antimicrobials being marketed within the veterinary products framework for commercialization. This online system involves all the parts from the commercial chain; including the manufacturer or importer of the product to the veterinarian who indicates and sells it. In this way, every time a sale is made, the seller must declare what he sold, and the buyer who accepted the sale and who assumes responsibility for the possession of the products purchased.

[2015] Decree number 834/2015 y 391/2015. Creation of the National Action plan for the surveillance, prevention and control of antimicrobial resistance (June) in line with the creation of the national commission for the control of antimicrobial resistance (CoNaCRA).

[2015] Decree number 591. Creation of the National Plan for the surveillance of AMR in food-producing animals (November)

[2015] Decree number 594/2015 prohibited the inclusion of antimicrobials in animal feed. This latest regulation points to the total prohibition (in 2019) of the use of antimicrobials as promoters of animal growth.

[2015] The National Administration of Medicines, Food and Medical Technology (ANMAT) states that the pharmaceutical labelling of antimicrobials must agree with the usual doses and treatments duration (decree number 7,130).

[2019] SENASA states that the manufacture, distribution, import, use and possession of veterinary products containing colistin is banned from veterinary products/medicine (Decree reference: EE 54429573/2018).

[2022] Antimicrobial resistance prevention and control law (number 27680). National statement on establishing the appropriate mechanisms to promote and control antimicrobial resistance in the country. It is remarked as a problem of national interest that perpetuates overtime.

Additional sources

Chapters 6.7 to 6.10 of the WOAH (World Organisation for Animal Health) Terrestrial Animal Health Code, which range from the harmonization of national AMR surveillance programmes to methodologies for monitoring the quantities of antimicrobials used and their patterns of use, the criteria for their prudent and responsible use, and the methodology for applying risk analysis derived from the use of antimicrobials in animals throughout the food chain.

For more details on distribution and marketing of drugs in Argentina, see https://uk.practicallaw.thomsonreuters.com/w-014-7135?transitionType=Default&contextData=(sc.Default)&firstPage=true

II. Summary of the Argentinian National Action Plan to combat AMR

General overview

The national action plan was elaborated and designed by the Ministry of Health in 2015 (16) in partnership with the following organisations:

- The National Administration of Laboratories and Health Institutes (ANLIS)
- National Administration of Medicines, Food and Medical Technology (ANMAT) and the REMEDIAR Program
- Ministry of Agriculture, Livestock and Fisheries:
- National Service of Agri-food Health and Quality (SENASA)
- National Institute of Agricultural Technology (INTA)
- National Universities of La Plata and the Centre of the Province of Buenos Aires
- Representation for the Americas of the World Organization for Animal Health (WOAH)
- Argentinean Society of Infectious Diseases (SADI)
- Argentinean Society of Intensive Care (SATI)

The three main objectives of the national strategy (action plan) are:

a) To prevent the emergence and spread of resistant bacteria through the regulation and supervision of antimicrobial sales, the promotion of their responsible use, and the prevention and control of healthcare-associated infections.
b) To strengthen AMR surveillance and antimicrobial usage policies.
c) To promote innovation, non-antibiotic growth promoters, and diagnostic tests to identify resistant bacteria.

These three main objectives comprise 10 different tasks detailed in the figure below.

Figure SM1. Main tasks of the Argentinian National Action Plan against AMR and their respective subobjectives.

Main 10 tasks to combat AMR in Argentina	Specific actions/sub-objectives
1. Promote leadership for the prevention and control of AMR	To develop and conduct a strategy for the prevention and control of AMR with experts' participation. To fund strategies' activity to enhance participation/awareness.
2. Surveillance of AMR in human and animal health	To develop a national surveillance network coordinated by reference laboratories for human health, animal health and agri-food production.
3. Monitor antimicrobial consumption	To develop a system for monitoring sales, access and appropriate and adequate use of antimicrobials.
4. Regulate and supervise antimicrobials usage and sales	To establish prescription sales requirements and monitor its effective compliance. To regulate the number of antimicrobial units in the pharmaceutical industry. To prohibit the use of antimicrobials as growth promoters in food production.
5. Promote responsible use of antimicrobials	To develop guidelines for diagnosis and treatment of most prevalent infections. To train health professionals on the appropriate and adequate use of antimicrobials and healthcare-associated infection prevention and control measures.
6. Promote community participation	To disseminate the problem AMR might cause in the population and the establishment of education programs on the adequate use of antimicrobials
7. Implementation of antimicrobial usage control mechanisms	To implement antimicrobial management programs in health services
8. Strengthen healthcare-associated infections prevention and control programs	To develop a surveillance strategy for healthcare-associated infections.

	To implement prevention and control programs for healthcare-associated infections in healthcare services
9. Promote antimicrobial research as well as diagnostic methods	To establish the problem of AMR as a priority matter that should be financed and researched. To prioritise the evaluation of new antimicrobials and explore new diagnostic methods.
10. Monitoring and evaluating the achievement of the objectives stated in the national action plan	To create a professional commission to monitor and evaluate the implementation and execution of the strategy (National Action Plan)

Overview of the animal and agri-food related sections

AMR SURVEILLANCE IN ANIMAL AND AGRIFOOD PRODUCTION
[ANIMAL HEALTH SECTION of the national action plan]

Current situation of the AMR surveillance in animal health and agri-food production
Surveillance is necessary for 3 groups of bacteria which have been primarily found in cattle, pigs, and birds: a) "indicator" bacteria, b) zoonotic bacteria, and c) pathogenic bacteria. Indicator bacteria are part of the intestinal microbiota of humans, other mammals, birds, and insects, and their importance lies in their ability to acquire and spread resistance genes that can be transferred to pathogenic or zoonotic bacteria.

Strategic lines of the national action plan for the surveillance of AMR in animal health and agri-food production
a) Development and implementation of the national AMR surveillance program in food-producing animals to determine the presence of resistance to different antimicrobials in at least 2 commensal bacteria: *Escherichia coli* and *Enterococcus spp*, and 2 zoonotic bacteria: *Campylobacter spp* and *Salmonella spp*
b) Harmonization of AMR surveillance strategies in human and animal health
c) Development of communication tools and timely dissemination of information

Specific actions of the national action plan for surveillance of AMR in animal health and agri-food production
a) To isolate commensal and zoonotic bacteria from cattle, pigs and poultry intended for human consumption, and determine their susceptibility profile to different antimicrobials
b) To compare the results with data obtained from previous studies, when possible
c) To determine the prevalence of AMR by animal species and by geographic region
d) To correlate antimicrobial consumption with AMR
e) To characterize and correlate resistance mechanisms between bacteria obtained from animal and human samples
f) To carry out studies on the presence of antimicrobials in different sources (including water, food, etc.) and the impact of their use on the environment and production systems
g) To evaluate alternative therapies for the use of antibiotics as growth factor in intensive production
h) To evaluate the impact of antimicrobial administration in sources on the level of resistance observed in the environmental bacterial population.
Specifically, the National Directorate of Agrochemicals, Veterinary Products and Food of SENASA will be responsible for:
a) Carrying out an annual monitoring of the volume of sales of antibiotics, with the collaboration of professional associations
b) Providing data from the veterinary product traceability system as soon as it is fully operational

REGULATION OF ANTIMICROBIAL CONSUMPTION IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

For more than ten years, SENASA has carried out a Program for the Control of Residuals, Contaminants and Food Hygiene of animal origin. This program seeks to detect the presence of chemical residues and contaminants in foods of animal origin that may affect the health of consumers. Among the residues under control, we find various antimicrobial agents, which can generate antimicrobial resistance when they are present in food.

Strategic lines for the regulation of the use of antimicrobials in animal health and agri-food production
a) Development and updating of regulations on the use of antimicrobials, aimed at preserving bacterial susceptibility as a non-renewable resource
b) To participate in international seminars on regulatory practices to improve animal health

Specific actions to regulate the use of antimicrobials in animal health and agri-food production
a) To compile and analyse the results of the surveillance and traceability systems for veterinary products to carry out risk analyses and therefore create risk profiles
b) To strengthen control protocols on the indiscriminate sales and usage of antibiotics
c) To ensure that all commercialization of antibiotics be carried out by a licensed professional
d) To create a forum for discussion on the use of antimicrobials with the chambers of the veterinary products industry, professional associations, universities and the Ministry of Health

RESPONSIBLE USE OF ANTIMICROBIALS IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

Objectives:
a) To ensure the rational use of antimicrobial agents in animals, with a view to optimizing their efficacy and safety
b) To comply with the ethical obligation and the economic need to keep the animals in good health
c) To prevent or reduce the transfer of resistant microorganisms or resistance determinants within animal populations, their environment and between animals and humans
d) To contribute to maintaining the efficacy and usefulness of antimicrobial agents used in human and veterinary medicine
e) To protect consumer health by ensuring the safety of foods of animal origin in relation to residues of antimicrobial agents

The measures include actions at the level of all stages and actors involved in the antimicrobial usage cycle, from their registration in SENASA to their prescription, marketing and consumption. The regulations generated by SENASA in recent years, have incorporated product traceability and treatment records, which are also in line with the WOAH Code.

Strategic lines for the responsible use of antimicrobials in animal health and agri-food production
a) Development of knowledge, training and information for veterinary professionals on the prudent and responsible use of antibiotics, based on pharmacokinetic, pharmacodynamic and toxicological bases
b) Intensification of marketing controls for antimicrobials usage and dispensing
c) To regulate the use of antimicrobials based on the information obtained from the surveillance program, and the corresponding risk analysis
d) To increase pharmacological knowledge about the behaviour of antibiotic considering its impact on the environment
e) To control the evolution of antibiotic resistance bacteria in clinics of small animals and intensive productions
f) To promote the responsible use of antimicrobials, including their correct prescription and administration by veterinarians

Specific actions for the responsible use of antimicrobials in animal health and food production
a) To prepare a good-practice guide for the prescription and use of antimicrobials and other veterinary products, and in line with international guidelines
b) To organise training courses and workshops for free practice veterinarians and those who work in the marketing chain or are in charge of livestock farms and balanced feed production plants, in conjunction with universities, professional associations and technical groups of exchange of the different productive activities (pigs, poultry, cattle, etc.)
c) To incorporate AMR in the curriculum of veterinary careers, in joint work with the National Council of Veterinary Sciences
d) To sustain and strengthen control in all stages of the distribution process and use of antimicrobials

PREVENTION AND CONTROL OF INFECTIONS IN ANIMAL HEALTH AND AGRIFOOD PRODUCTION *[ANIMAL HEALTH SECTION of the national action plan]*

There are current international standards highlighting antimicrobials usage, including the Chapters 6.7 to 6.10 of the WOAH Terrestrial Animal Health Code.

Strategic lines for the prevention and control of infections in animal health
a) To develop programs for the management, prevention and control of infectious diseases associated with AMR in veterinary medicine, considering the biosafety of intensive production establishments in terms of infrastructure and adequate equipment for infection prevention and control practices
b) To train technical personnel assigned to intensive animal production for the prevention and control of infectious diseases in production environments; and
c) Implementation of a network of laboratories for the identification of AMR microorganisms

Specific actions for the prevention and control of infections in animal health
a) To develop regulations to enhance infection prevention and control between the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Health, universities and professional associations
b) To carry out training courses for veterinary professionals. Courses would be delivered by the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Health, professional associations and universities
c) To promote biosafety, hygiene and disinfection of personnel, equipment and productive environment compliance.
d) To generate new laboratories equipped with diagnosis tools to determine the levels of AMR bacteria isolated from food animals and the emergence of resistance mechanisms to critical antimicrobials in human and animal health, as well as the proper use of antimicrobials
e) Develop a monitoring and evaluation program to adopt joint strategies between the veterinary and human areas

Also, SENASA, with the cooperation of ANLIS, INTA, and veterinary schools of national universities, implemented a parallel surveillance program for AMR in food-producing animals. The main objective of the plan is to determine and monitor the prevalence of AMR among food-producing animals to avoid the emergence and dissemination and to minimise the damage to the population and animal health (20). The program was designed in partnership with the following institutions: National Directorate of Agrochemicals, Veterinary Products and Food, National Directorate of Food Safety and Quality, National Directorate of Animal Health, General Directorate of Laboratories and Technical Control, and the General Coordination of Regional Management.

III. Consent form for interviewees (participants)

Please initial box

1. I confirm that I have read and understood the Participant Information Sheet for the above study. ☐

2. I have been given the opportunity to consider the information provided, ask questions and have had these questions answered to my satisfaction. ☐

3. I understand that my participation is voluntary and that I can ask to withdraw before or during the interview without giving a reason and without my medical care or legal rights being affected. After the interview has been conducted and/or after data analyses, data will be anonymised and it will not be possible to withdraw. ☐

4. I understand that my anonymised data will be stored for a minimum of 5 years and may be used in future ethically approved research. ☐

5. I consent to this interview being recorded for the purpose of transcription after which the recording will be deleted. ☐

6. I agree to take part in this interview. ☐

Name of person giving consent	Date	Signature
_____	_____	_____

Name of person taking consent	Date	Signature
_____	_____	_____

IV. Participant information sheet

You are being invited to take part in an interview on:
Agricultural antimicrobial supply chains and implementation of Antimicrobial Resistance National Action Plans in Argentina and the United Kingdom

Prof Lisa Boden, Prof Dominic Moran, Dr Emma Pitchforth, Dr Stephen Mackenzie, and Alejandro Petroni at the University of Edinburgh, University of Exeter and Argentinian National Administration of Laboratories and Health Institutes are facilitating these interviews/focus groups. Before you decide to take part, it is important you understand why we are conducting this interview and what it will involve. Please take time to read the following information carefully.

WHAT IS THE PURPOSE OF THIS INTERVIEW?
This interview is intended to gather information about the current communication and interfacing between policy makers, scientific experts and stakeholders in agricultural Antimicrobial resistance and National Action Plan. Our long-term goal is to build relevant expertise to be able to design robust interventions and advice to improve antimicrobial resistance and national action plan implementation outcomes in the policy.

WHY HAVE I BEEN INVITED TO TAKE PART?
You are invited to participate in this study because you have been working on or exposed to agricultural antimicrobial resistance decision-making issues in policy, either in the United Kingdom or Argentina.

DO I HAVE TO TAKE PART?
No – it is entirely up to you whether you choose to take part. If you do decide to take part, please keep this Information Sheet and complete the Informed Consent Form to show that you understand your rights in relation to the meeting and that you are happy to participate. You may withdraw from an interview at any time and without giving a reason.

WHAT WILL HAPPEN IF I DECIDE TO TAKE PART?
You will be invited to participate in a series of interviews and/or focus groups around agricultural antimicrobial resistance, antimicrobial supply and antimicrobial national action plans and how they are perceived and incorporated into policy decision making spaces and processes. Your expertise will allow us to work over the next three years on developing a series of robust suggestions to improve the science policy interface around antimicrobial resistance in both the UK and Argentina.

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?
By participating in this discussion and sharing your experiences with us, you will be helping the research team to engage and participate with local and national policy decision-makers around integration of scientific and policy-making expertise in mitigating the risks of antimicrobial resistance.

ARE THERE ANY RISKS ASSOCIATED WITH TAKING PART?
There are no significant risks associated with participation.

WHAT IF I WANT TO WITHDRAW FROM THE STUDY?
Agreeing to participate in this workshop does not oblige you to remain in the project nor have any further obligation to this project. If you no longer want to be part of the project, please inform Prof Lisa Boden [lisa.boden@ed.ac.uk]. You should note that your ideas may be used in the design and implementation of subsequent projects and interventions. You are advised to contact the research team at the earliest opportunity, preferably before the workshop should you wish to withdraw from the project.

INTERVIEWERS AND INTERVIEW'S DETAILS
The interview will be performed by either our main researchers (detailed in the first paragraph) or Kasim Allel, who is a research fellow at the University of Exeter. The interview will take place at a time and

platform (virtual meeting via Zoom/Microsoft teams or in-person meetings) agreed upon both parties and depending on availability. The interview has five different stages covering participant's current role, understanding antimicrobial-resistance among stakeholders, information channels and flows within stakeholders/departments, challenges in the implementation of the national action plan, and future considerations. The interview has an approximate duration of 30-60 minutes per interview.

DATA PROTECTION AND CONFIDENTIALITY

Any data collected will be processed in accordance with Data Protection Law and GDPR. All information collected about you will be kept strictly confidential. Unless they are anonymised in our records, your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team. Data might be classified by organisation/affiliation only if participants concur. All electronic data and transcripts will be stored on a password-protected computer file within Microsoft teams' shared folders. All paper records will be held in a locked filing cabinet. Your consent information will be kept separately from your responses to minimise risks.

WHAT WILL HAPPEN WITH THE RESULTS OF THIS STUDY?

The outcomes of this meeting may also be summarised in reports and presentations to the funding agency or key stakeholders. The meeting may be video and audio recorded for the purpose of transcription. Quotes or key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name. Information may also be kept for future research.

WHO CAN I CONTACT?

If you have any further questions about the project, please contact Prof. Lisa Boden, lisa.boden@ed.ac.uk

If you wish to make a complaint about the project, please contact:
Lisa Boden (lisa.boden@ed.ac.uk). In your communication, please provide the study title and detail the nature of your complaint.

For general information about how we use your data go to:

https://www.ed.ac.uk/records-management/privacy-notice-research

V. Participant interview topic guide

You are being invited to take part in an interview on:

Agricultural antimicrobial supply chains and implementation of Antimicrobial Resistance National Action Plans in Argentina and the United Kingdom

[Please note this is a topic guide to support the semi-structured interviews. We do not envisage asking every question to every participant, but the questions are illustrative of what we hope to talk about]

Introduction

Thank you for agreeing to take part in this interview.

Can I check that you have had a chance to read the study information sheet?

Do you have any questions about the study?

[if not returned prior to interview go through and complete consent form]

Are you happy for me to begin the interview and to start recording?

[turn on recorder]

Thank you.

The interview is designed to be free-flowing so please talk about anything that you feel is relevant, I have just prepared some questions structured into five broad areas.

Interview's questionnaire

BOX 1. Survey's main sections: objectives and questions

I. Participant's current role. These questions will seek to understand what experiences our participants have and how they might be relevant to implementing the National Actiona Plan to combat AMR.

<1> What your job/role is, and what tasks do you and your organisation mainly perform?
<2> What are your (or department/organisation) interests and responsibilities concerning AMR?

II. Understanding AMR among stakeholders. This group of questions aim to understand employees' and organisations' views on AMR; its main drivers, change overtime, support venues, and priority areas within organisations to help tackle AMR.

<1> How do you feel (or what are your personal and department's concerns) about antimicrobial resistance in humans? Does that differ from antimicrobial-resistance in animals or any other source, including the environment (how)?
<2> Do you think the view about antimicrobial-resistance has changed over the years? How?
<3> What are the priority areas within your organisation to increase AMR awareness and to comply with the national action plan? Do you feel your organisation help contribute to any of the areas detailed in the national plan (how, which)?
<4> What are the cornerstones for increasing AMR awareness while complying with the national action plan within your organisation?
<5> Which cornerstones do you feel are most relevant within your department (organisation)? Why?

III. Information channels and flow within stakeholders/departments. These questions attempt to improve organisations decision making towards better AMR surveillance by identifying how the information is channelled within and between organisations.

<1> how do you feel about AMR-related information and communication flow within your organisation and among all stakeholders?
<2> What do you think about communicational interactions, networking, and educational or getting-to-know instances between your organisation and other stakeholders and within departments of your organisation? Would you believe (and how) that the information pathways vary between specific organisation's fields/disciplines, public/private institutions, or certain other groups?
<3> Could you identify which organisms (organisations), and how, are involved in your organisation's decision making and strategy towards improving AMR surveillance and control?

IV. Challenges in the implementation of the national action plan. These questions attempt to answer what factors or challenges might be key to increasing AMR awareness and improving AMR surveillance among food-producing animals and agriculture.

<1> Do you feel there is any challenge that your organisation faces in complying with the AMR national action plan and helping contribute to better animal surveillance? (Political priorities, monetary and non-monetary resources, communication, etc) What are the most important and what can be done to overcome these challenges if your organisation could prioritise resources to contribute higher to AMR surveillance in animals?
<2> Who else do you think has a critical role in helping with AMR surveillance in animals from the pool of stakeholders?

V. Future and other considerations. These questions aim to understand future steps to be taken within the industry and different key members to tackle AMR

<1> How organisations might be helped to enhance cross-communication and teamwork? How can we ensure organisations make progress and collaborate meeting NAP's criteria?
<2> Which organisations, at the national and international levels, do you think are most important to talk to and direct the efforts to address the gap in knowledge in AMR? Does the list differ for improving the NAP?
<3> Is there anything else important that you might want to share with us or that we are missing in the current interview?

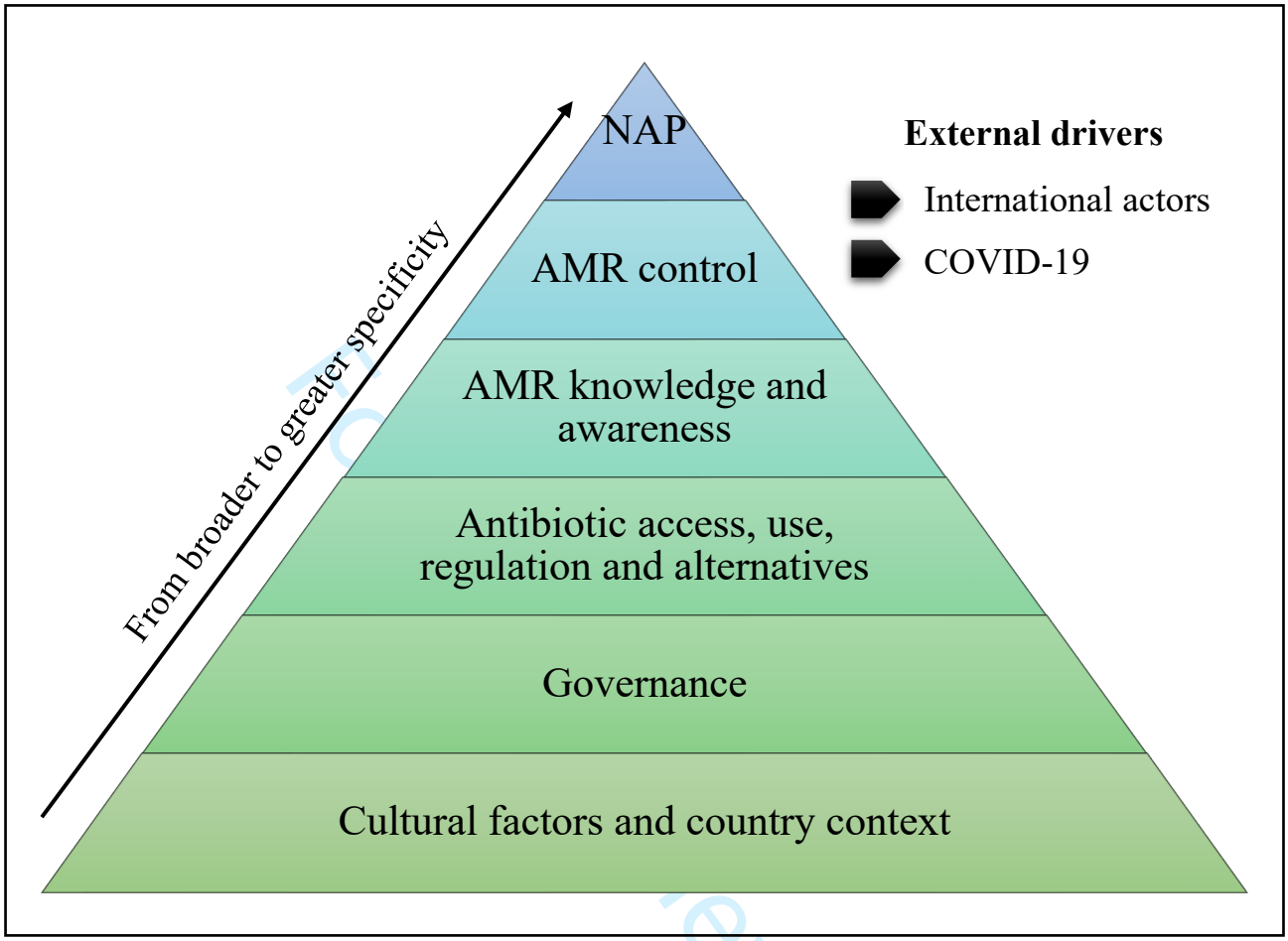
VI. Description of main preliminary topic codes applied to the interview analyses and their respective definitions

Table SM1. Topic codes and their definitions

Code	Definition
Application of NAP	Implementation of NAP and roles, including views on progress
AMR control	Perceived progress and challenges, inclusive of surveillance
Antibiotic access, use and regulation (human and animal)	Referring to antibiotic consumption and access and prescriptions in animals and humans
Alternatives to antibiotics	Discussion of alternatives to antibiotics
Context of Covid	Referring to acceleration of AMR, potential opportunities and good practice, ways of working
Governance	Government priorities, federalisation, vertical vs horizontal, nature of institutions/groups, accountability (lack of)
AMR knowledge/awareness	Referring to public and professional awareness – the challenge of awareness and steps taken to address
Resources	Referring to human and economic/budgetary resource (lack of) available to tackle AMR
Stakeholders	Describing/listing stakeholders involved
Stakeholder communication	Communication (lack of) between stakeholders
Cultural and country context	Understanding of importance of cultural, country context, including personal relationships
International actors and policies	Mention of international actors and role in/influence on national AMR in Argentina
Food production	Reference to food production markets, differences by animal species
Information/data flow	All references, specifically to information/data e.g. capacity/system to share data
Regulation and compliance	Description of different regulation, proposed change and perceived (potential) impact
Political context and agenda //	Importance of (changing) political will
Vet sector	Including role of vet sector, antibiotic in animals
Training and learning opportunities	Including seminars, conferences, courses, stewardship programs, etc.

VII. Themes ordered from broader to greater specificity.

Figure SM2. Structure of the ordered themes



Notes: AMR= Antimicrobial resistance. NAP= National action plan.

VIII. Packed code cloud for identified themes/sub-themes

Figure SM3. Code cloud for identified themes and sub-themes

Notes: AMR= Antimicrobial resistance.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	n/a
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1, page 5-6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-14
		(b) Indicate number of participants with missing data for each variable of interest	5
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*n/a*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*n/a*
		Cross-sectional study—Report numbers of outcome events or summary measures	*5-13*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a qualitative study
		(*b*) Report category boundaries when continuous variables were categorized	n/a qualitative study
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a qualitative study
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely

available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.