

Perspectives

National Action Plan in Antimicrobial Resistance Using Framework Analysis for China

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INTRODUCTION

The emergence of multi-antibiotic-resistant bacteria has turned bacterial resistance into a pressing global issue. Antibiotics that once effectively treated various infectious diseases are now becoming less efficient against a new class of bacteria known as “Super Bacteria,” including methicillin-resistant *Staphylococcus aureus* (1). It is estimated that one person dies every minute due to drug-resistant strains of disease, and by 2050, drug-resistant bacterial infections could become the leading cause of death in humans (2).

Factors contributing to the antimicrobial resistance (AMR) crisis include insufficient development of new antibiotics, irrational antibiotic use, poor pharmaceutical waste disposal, and a lack of public awareness (3). Addressing AMR necessitates cooperation across public health departments and comprehensive governance solutions, which should involve increased oversight of environmental protection, medication development, drug production, distribution, and application (4).

To confront this critical issue, the World Health Assembly published a global action plan (GAP) in May 2015, which aims to improve awareness and understanding, strengthen surveillance and research, reduce infection incidence, optimize the use of antimicrobial medicines, and promote sustainable financial support (4).

China holds the distinction of being the world’s largest producer and consumer of antibiotics. Per capita antibiotic use in China is approximately ten times higher than in the United States, and the average daily intake of antibiotics per 1,000 individuals is six times greater (5). Since then, AMR management in China has evolved through three major phases: drug control-based management, clinical monitoring-based management, and a comprehensive management strategy involving multiple domains (6). In response to its first National Action Plan (NAP) on AMR (7), China implemented various policies and devoted

significant efforts to enhance AMR monitoring. Following the completion of the first NAP, the NAP for 2022–2025 was released early in 2023.

The Tripartite AMR Country Self-Assessment Survey (TrACSS), administered by the Food and Agriculture Organization (FAO), World Health Organization (WHO), and World Organisation for Animal Health (OIE), aims to monitor country progress in addressing antimicrobial resistance through a questionnaire survey (8). To date, there has been no third-party assessment to systematically review and evaluate the efforts made during the first NAP in China. The purpose of this article is to analyze the governance of AMR-related measures since 2016, including the first and updated NAPs implemented by various ministries in China. This analysis will generate insights from the NAP to inform future policy design recommendations.

METHODS

In 2021, a research team from the National University of Singapore introduced a system for assessing the National Action Plan using line-by-line analysis, which is a method involving grounded theory to identify emerging trends from data line by line and develop a previously non-existent framework (9). Various sub-objectives are evaluated and discussed in each section of Figure 1, encompassing policy design, implementation tools, monitoring and evaluation, sustainability, and One Health engagement. Policy design concentrates on creating policy and action structures from the government to stakeholders. Implementation tools primarily serve to implement the designed policies, reduce AMR, control antibiotic usage, and raise public awareness. Moreover, monitoring and evaluation pertain to the effectiveness of the policies and the feedback after actions have been conducted, while sustainability focuses on the continuation of future planning. We analyzed the relevant departments in China and summarized them

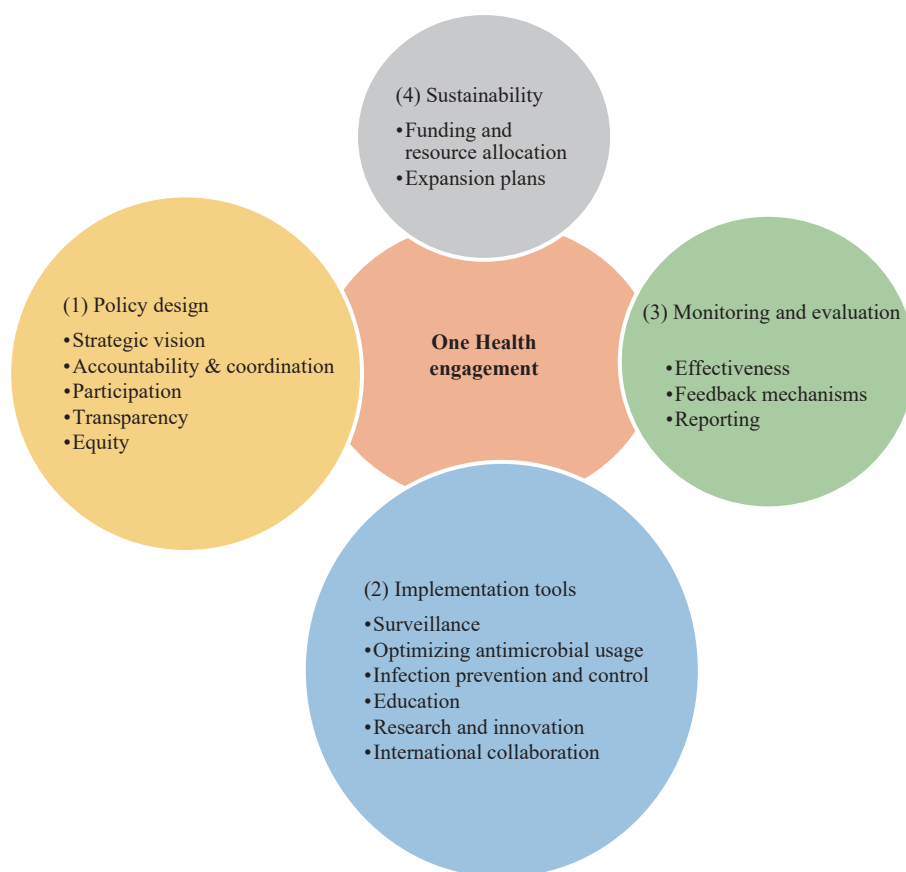


FIGURE 1. The analysis focuses on policy design, implementation tools, monitoring and evaluation, and sustainability toward the goal of One Health engagement.

Note: Analysis framework generated from Chua et al. 2021 (9).

in Figure 2, accompanied by a brief introduction of each department in the annotations.

The successful implementation of the NAP requires collaboration among multiple and cross-sectional departments. The initial stage of our study involved identifying departments involved in AMR control, by analyzing their roles, daily operations, and activity participation. Based on the identified departments, we proceeded to follow the primary objectives of the NAP.

Our research team utilized keywords such as AMR, antibiotic resistance, antibiotics, antimicrobials, and specific antibiotics, as well as references to meetings, to search for news articles, public interviews, and government documents. Two researchers then preprocessed the gathered information according to the relevant departments and validated the data by conducting duplicate determinations within the group.

Subsequently, we categorized the actions and developed a framework for the Chinese action plan to facilitate policy analysis. We also conducted a thorough review of the collected resources. An additional

proofreading and modification process was performed as we transformed the resources into coherent paragraphs for publication.

RESULTS

The major results are listed below and the details are placed in the supplementary materials with the suggestions for further actions.

Policy Design

Strategic vision: National Health Commission (NHC) conducted AMR situation analysis in clinical surveillance and release the annual report with AMR assessment (10).

Accountability & coordination: The Ministry of Agriculture and Rural Affairs (MOA) and the Food Safety Office (FSO) have collaborated on rectification measures to address the issue of excess antibiotic and veterinary drug residues in agriculture (11–12). NHC, National Medical Products Administration (NMPA),

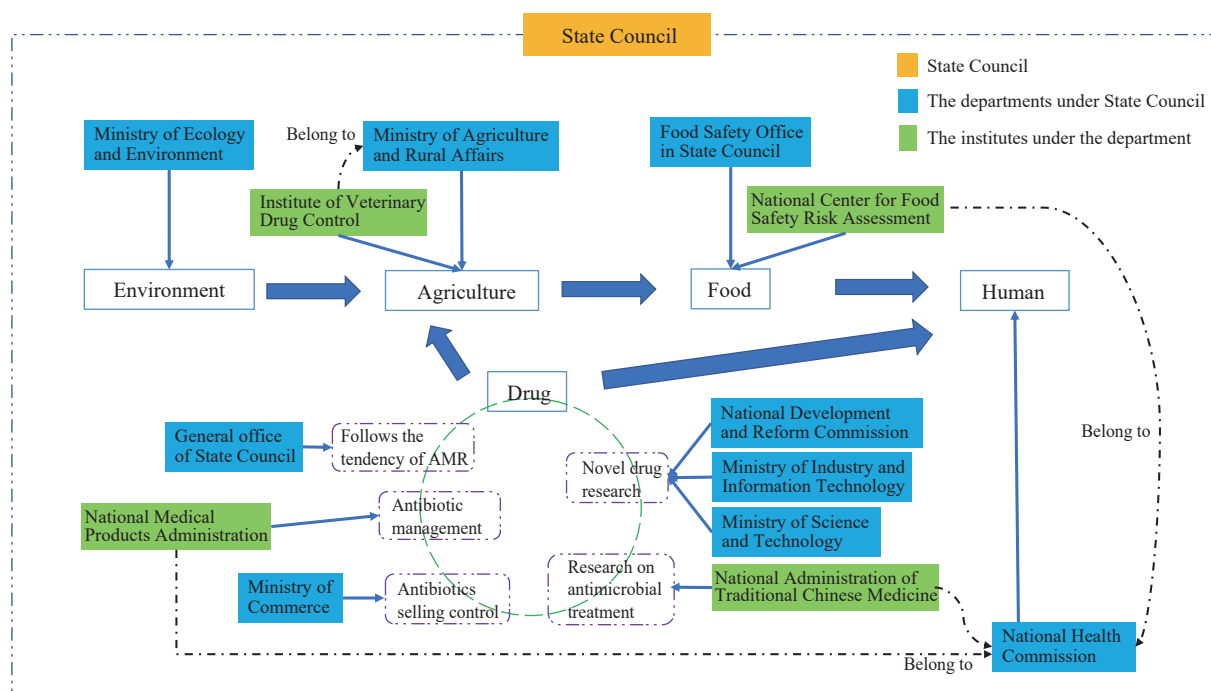


FIGURE 2. Departments chart summarized the involvement based on collected data.

Note: All departments are under the leadership of State Council. MEE takes part in environmental AMR governance. MOA treats AMR problem in breeding, agriculture and graziery. CCVP specifically focuses on the fodder and treatment for animals. FSO in State Council pays part of its attention to AMR as well. CFSA follows the AMR situation in China. NHC develops and organizes the implementation of AMR prevention and control plans. GOSC follows the tendency of AMR domestically. NMPA is in charge of antibiotic management. MOFCOM participates in antibiotics selling control. NATCM has researched on Antibiotics treatment. NDRC focuses on novel drug discovery, MIIT and MOST turn it into practice.

Abbreviation: MEE=Ministry of Ecology and Environment; MOA=Ministry of Agriculture and Rural Affairs; CCVP=Commission of Chinese Veterinary Pharmacopoeia; FSO=Food Safety Office; CFSA=China National Center for Food Safety Risk Assessment; NHC=National Health Commission; GOSC=General Office of State Council; NMPA=National Medical Products Administration; MOFCOM=Ministry of Commerce; NATCM=National Administration of Traditional Chinese Medicine; NDRC=National Development and Reform Commission; MIIT=Ministry of Industry and Information Technology; MOST=Ministry of Science and Technology.

and Ministry of Industry and Information Technology (MIIT) have jointly worked on improving the system for ensuring antibiotic drug supply by enhancing and modernizing the mechanisms associated with antibiotic medication distribution (13–16). Alongside the National Development and Reform Commission (NDRC), the Ministry of Science and Technology (MOST), and the Ministry of Commerce (MOFCOM), they have issued guidelines that aim to promote the improvement of the antibiotics industry in terms of quality, variety, and volume (17).

Participation: NHC improved the management of antibiotics medicine approval, production, and distribution, with a particular focus on antibiotics drug sales in retail (18).

Transparency: Transparency pertains to the accessibility of precise and current data (9). The MOA has established a database, which is centered on the surveillance of veterinary drug residues and the

resistance profile of five key bacterial species (19).

Equity: In addition to the stringent regulation of prescription drugs, the NHC implemented reforms in the medical system, which resulted in increased accessibility and availability of over-the-counter medications for the general public (20).

Implementation Tool

Surveillance: The Ministry of Ecology and Environment (MEE) has conducted a specialized investigation into the levels of antibiotic pollution in drinking water (21). The Global Antimicrobial Resistance and Use Surveillance System (GLASS) offers a standardized methodology for data collection, analysis, and dissemination, as well as supporting capacity building and monitoring the status of national surveillance systems (22). GLASS prioritizes pathogens such as *Acinetobacter* spp., *Klebsiella pneumoniae*, *E.*

coli, *Neisseria gonorrhoeae*, *Shigella* spp., *Streptococcus pneumoniae*, *Staphylococcus aureus*, and *Salmonella* spp. (22). Although China did not participate in GLASS until 2022 (23), the NHC has collaborated in efforts to enhance monitoring of adverse reactions to antibiotic drugs (24) in China.

Optimizing antibiotic usage: MEE has enhanced control over antibiotic discharge by regulating antibiotic manufacturing and pharmaceutical companies (25). MOA has prohibited four antibiotics for use in humans and animals (26). NHC has implemented drug classification management and overseen prescription and over-the-counter medications (27). Antibacterial medication usage in outpatient clinics in China declined from 19.4% in 2010 to 7.7% in 2017, while inpatient usage decreased from 67.3% in 2010 to 36.8% in 2017 (13).

Infection prevention and control: The policies within this section predominantly focus on infection control, with less addressing prevention. The NHC has provided guidance for the clinical use of antibiotic drugs, encompassing both macro-level policies and detailed guidance (28).

Education: NHC implemented educational efforts to address misconceptions regarding antibiotic usage and the risks associated with antibiotic misuse (29). Hospitals provided training on appropriate antibiotic administration for physicians and nurses (7,30).

Research & innovations: MOA aims to develop a series of enhanced feed additives by decreasing the proportion of antibiotics and incorporating non-antibiotic agents that demonstrate efficacy in treating bacterial infections, as well as veterinary drugs and vaccines (31). Since 2018, NHC has been constructing comprehensive databases and traceability networks for drug resistance genes (32), while also promoting medication research and reforming the antibiotic review and approval system. Meanwhile, MOST supports the research and development of novel antibiotics and related technologies (7).

International collaboration: China keeps connection with other countries by jointly funding totally 60 million RMB in the field of AMR (33).

Monitoring and Evaluation

Effectiveness: The evaluation of policies regarding AMR is not publicly accessible. In addition to modern medicine, MOST and associated departments have assessed the effectiveness of Chinese medicine in combating drug-resistant bacterial infections and examined the underlying mechanisms. The National

Administration of Traditional Chinese Medicine (NATCM) has made preliminary progress in promoting innovation and conducting research on antibacterial medications within the realm of traditional Chinese medicine (10).

Feedback mechanism: Although the NAP placed emphasis on generating feedback, it has been observed that the majority of actions and departments lack public and transparent feedback mechanisms (9).

Reporting: NHC published AMR status and report through the national clinic surveillance network for monitoring and evaluation (10).

Sustainability

Fund and resource allocation: MOST established some fund and relevant allocation systems for AMR research (33).

Expansion plans: This section emphasizes the importance of scaling and ensuring future sustainability in the context of expansion plans. The specific details of these plans will not be disclosed to the public until official publication. Prior research has underscored the significance of implementing NAPs in a manner that is both sustainable and yields a substantial impact (34).

ANALYSIS AND DISCUSSION

The NAP analysis framework has demonstrated that in China, the implementation of NAP and the management of AMR-related actions exhibit both horizontal (within each institution) and intersectoral (across institutions) deficiencies in the design, execution, feedback, and regulation of these actions. Furthermore, we incorporated future actions for each governance area, as derived from the NAP analysis framework, into the updated NAP (2022–2025), which can be found in the [Supplementary Tables S1–S4](#) (available in <https://weekly.chinacdc.cn/>) (35).

MOA has placed significant emphasis on monitoring antibiotic usage in growth chemicals or feed and on monitoring resistance in agricultural products ([Supplementary Figure S1](#), available in <https://weekly.chinacdc.cn/>) (36–38). However, limited information from sector actions and publicities reflects MOA's efforts in policy design and subsequent implementation tracking. There is a lack of departmental accountability framework for addressing implementation failures. Another design flaw is related to ensuring equity. This component should be incorporated either in the

department of action or before the majority of government actions to prioritize interests beyond those of the owners. Moreover, increased efforts could be directed towards developing various vaccines with high short-term efficacy, more injection sites, and addressing safety concerns associated with attenuated vaccinations (39). New vaccines should be developed based on the priority of bacterial diseases in each species and integrated with emerging technologies such as adjuvants and delivery (30–40). Annually, NHC publishes a status report detailing the issues identified and providing recommendations for improvement. However, MOA lacks an action plan or agenda for future work. Limited data is available from the food and agriculture section, particularly in aquatic animal health and plant health. These findings were also corroborated by the results in TrACSS's report from China (41).

The management of antibiotic drugs and antibiotic therapy in the medical and healthcare field in China falls under the jurisdiction of the NHC and the NMPA, with a more multi-sectoral approach. The NHC has enhanced its implementation of drug equity, requiring all levels of the healthcare system to adhere to the principle and arrange for professionals to advise patients on appropriate drug usage. Detailed infection treatment methods and medication guidelines have been published to prevent improper utilization and overdoses throughout the infection diagnosis process. The development of new antibiotic medications has been supported and continues to yield positive results, with multinational collaborations being established. Nevertheless, the relevant literature provides limited information on the specifics of interdepartmental cooperation, role assignment, and required accountability.

Intersectoral Analysis of Actions Among Departments Under the State Council: The core principle of One Health involves the cooperation among various government departments and the inclusion of additional stakeholders to achieve an efficient and large-scale impact. AMR governance cannot be addressed by a single sector or country; the essential requirement is the establishment of a coordinating department for cross-departmental collaboration and assigning responsibility and accountability across multiple departments. These aspects pose significant challenges in China's execution of the NAP and remain the objective for the 2022–2025 NAP (35).

There is a lack of intersectoral communication

concerning initiatives related to AMR in China. Each department implements its own measures, leading to inconsistencies in the approaches taken. Our study identified considerable disparities in both the quantity and quality of work performed by various departments. The inconsistent attitudes and abilities of the departments contribute to incongruent deployment and completion of AMR-related actions. As a result, there is a need for an intermediary coordinating department at the national level to facilitate cross-sectoral collaboration, reduce resource waste, and improve governance effectiveness. This issue is also emphasized in the updated NAP.

CONCLUSION

In summary, China has made significant progress in AMR governance over the past five years, as evidenced by the development of a comprehensive surveillance and governance framework. A substantial number of publications have emerged addressing clinical usage of antibiotics, animal breeding, and treatment, with considerable investments allocated to AMR research. Despite these advancements, challenges remain due to inadequate interdepartmental collaboration and insufficient policy sustainability, leading to compromised effectiveness in AMR management. Additional efforts are required to address food safety and environmental concerns.

Drawing from the One Health approach and international experiences, such as those provided by the WHO, future initiatives should prioritize interdepartmental cooperation to enhance the sustainability and effectiveness of national action plans. In 2022, China developed its second NAP for 2022–2025, incorporating contributions from several multisectoral departments (32). The plan encompasses new areas of focus, including vaccination, AMR treatment in environmental settings, and the establishment of an intersectoral collaboration mechanism.

To further address AMR challenges, China should seek to play a more prominent role in international cooperation by joining global networks and adopting standardized laboratory and surveillance methodologies.

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SUPPLEMENTARY MATERIALS

SUPPLEMENTARY TABLE S1. Future actions generated by framework analysis for National Action Plan in China for Governance Area 1: policy design.

Indicator	Result summary	Future actions
Strategic vision	The strategic vision does not include specific, measurable, achievable, relevant, and time-bound (SMART) objectives, which are recommended to be delineated in the ensuing plan.	Make policy and plan consistent with the foreseeability of the global effect
Accountability & coordination	In 2017, MOA introduced a National Action Plan (NAP) with an objective to develop innovative veterinary drugs characterized by low toxicity and minimal residues while simultaneously phasing out high-risk pharmaceuticals. Pursuant to Document No. 194, the production and utilization of feeds containing growth-promoting additives have been prohibited since 2020. A series of guidelines have been established for the development of the pharmaceutical industry, focusing on non-inferior clinical trials for antibiotic drugs, technical requirements for microbiological laboratories involved in clinical trials of antibiotic and anti-TB drugs.	A well-organized coordination and accountability system was absent in the previous NAP, necessitating its implementation in future activities. The updated NAP has recently allocated tasks to specific departments, with the goal of establishing an effective interdepartmental collaboration mechanism.
Participation	The NHC mandated that retail pharmacies, retail companies, and Internet hospitals collaborate in managing antibiotic drug sales under the Measures for Supervision and Administration of Drug Circulation. Unlawful sales of antibacterial medications are subject to penalties, with ongoing policies focused on monitoring antibiotic use and requiring prescriptions for antibiotic sales.	The NAP should focus on promoting public involvement in AMR control efforts. Enhancing public awareness of AMR and emphasizing the importance of combating it through educational initiatives is crucial.
Transparency	MOA built a database based on the surveillance of veterinary drug residues and resistance status of five main bacteria to sixteen veterinary medicines in animal farms housing pigs, poultry, and dairy cows.	The updating process for NAP should be conducted regularly during each specified period, rather than merely providing summary documents in the final stage. It is essential to establish a comprehensive framework and database for AMR in both human and environmental contexts.
Equity	In accordance with the reformation requirements, pharmacists play an essential role in pharmacy settings and are obligated to inform and deliver expert medical advice to customers based on their individual needs.	AMR policy should be more considerate of the real situation in China.

Abbreviation: MARA= Ministry of Agriculture and Rural Affairs; NHC= National Health Commission.

SUPPLEMENTARY TABLE S2. Future actions generated by framework analysis for National Action Plan in China for Governance Area 2: implementation tool.

Indicator	Result summary	Future actions
Surveillance	<p>The MEE primarily focused on two aspects. The first aspect involved antibiotic surveillance and testing. The Eco-Environmental Supervision and Administration Bureau of the MEE conducted antibiotic detection in water bodies within the Haihe River Basin and Beihai Sea Area. The second aspect aimed to bolster antibiotic discharge control and mitigate antibiotic usage. To achieve this, the MEE has strengthened regulations by controlling the approval process for antibiotic manufacturing firms, selecting appropriate locations for pharmaceutical companies, and imposing strict requirements on waste disposal. In terms of controlling the emission to environment from industry, <i>Synergistic control of antibiotics, resistance genes and conventional pollutants in pharmaceutical wastewater</i>, was published by China Pharmaceutical Industry Association. The NHC suggests implementing measures to enhance surveillance of adverse reactions related to antibacterial medications, as outlined in the Administrative Measures for Adverse Drug Reaction Reporting and Monitoring. Additionally, since 2018, the organization has been developing a comprehensive whole-genome database to facilitate national traceability networks for antibiotic-resistant genes found in food-borne pathogenic microorganisms.</p>	<p>Cross-sectoral regulatory collaboration is essential for optimal data sharing at the national level, aimed at facilitating real-time oversight across multiple domains. Interdisciplinary exchange on AMR is promoted within the NAP 2022–2025 framework.</p>
Optimizing antibiotics usage	<p>The MEE has enhanced the management of antibiotic discharge by implementing stringent regulations for granting approvals to antibiotic manufacturing firms. Additionally, the selection of pharmaceutical company locations and the imposition of rigorous waste disposal requirements have been emphasized to further control antibiotic discharge. The MOA has implemented a ban on four antibiotics for both humans and animals, which includes lomefloxacin use in food-producing animals, colistin as a feed ingredient, mycobacterium sulfate as a growth-promoting feed ingredient for food animals, and one veterinary antibiotic for growth promotion. As an example, MOA enforced a series of limitations on antibiotics in feed in 2014, with the regulations becoming effective in the farming process in 2015. As a result, China's cattle, poultry, and aquaculture industries have successfully reduced their antibiotic use per kilogram from 353.8 mg/kg in 2014 to 165 mg/kg in 2020 (25–27). The CCVP aims to halt the use of serial antibiotic veterinary medications, which include arsenic acid, arsine, olaquinox, and others. The NHC prioritized the appropriate use of antibiotics by implementing the Measures for the Classification Management of Prescription and Over-the-Counter Drugs (Trial) in 1999 and establishing a classification management system for prescription and over-the-counter medications through the amended Drug Administration Law in 2001. Throughout the National Drug Safety Twelfth Five-Year Plan, it was mandated that commercial pharmacies employ licensed pharmacists from 2012 onwards, and by 2015, all pharmacists were required to hold a licensed pharmacist certification to provide guidance on antibiotic usage to the public. Furthermore, antibiotic consumption for medical purposes has been subjected to monitoring and regulation via the clinical surveillance network.</p>	<p>Though the clinical research has been finalized, there remains a need to reduce the utilization of drugs in breeding practices. Online pharmaceutical retailers must create stringent policies concerning the prescription of antibiotics. The updated NAP establishes a requirement for all patients to have a prescription prior to purchasing antibiotics. The implementation of fines or sanctions for those who dispense antibiotics without a prescription is essential for compliance.</p>
Inflection prevention and control (IPC)	<p>The NHC has provided guidance for the clinical use of antibiotic drugs through the development and release of the Guiding Principles for the Clinical Application of Antibiotics Drugs (2015 edition). This document offers comprehensive information on the clinical application and management of antibacterial drugs, as well as the treatment of various bacterial infections. It established fundamental guidelines for therapeutic and preventive drug use, and requires medical institutions to create systems for drug classification and management of antibiotic drug applications in clinical settings. Clinical departments are encouraged to establish management teams using real-world examples. Furthermore, the document provides in-depth information on the use of antibacterial agents for numerous bacterial diseases, serving as a reference for the diagnosis and treatment of infectious diseases.</p>	<p>Enhancing preventive measures for humans may be achieved through the development of vaccines for livestock and aquatic animals.</p>

TABLE S2. (Continued)

Indicator	Result summary	Future actions
Education	In 2019, the CFSA prioritized public education through the implementation of foodborne illness and antimicrobial resistance book projects.	Enhancing intra-functional communication regarding AMR governance is crucial for fostering awareness within the department. Advocating for more comprehensive dissemination of information within the community can contribute to this effort. Additionally, professional and continuing education in the One Health approach for stakeholders should be emphasized as a focal point of the educational strategy.
Research & innovations	In July 2018, MOA issued the Notice on Printing and Distributing Technical Guidelines for Agricultural Green Development (2018–2023), which aimed to develop a range of green, efficient feed additives, low-toxicity, low-resistance veterinary drugs, and high-efficiency, safe vaccines. Since 2018, the NHC has been conducting research on the development of whole-genome databases and traceability networks for drug resistance genes in food-borne pathogenic microorganisms on a national scale. The NHC has initiated several actions to promote medicinal research and innovation, such as enhancing the antibiotic drug registration management system to encourage innovation and registration through more clearly defined problem orientation and scientifically grounded regulatory concepts. Furthermore, the NHC has continuously reformed the antibiotics review and approval system, ensuring reviews are conducted in a scientifically standardized manner in compliance with relevant laws and regulations. The MOST actively fosters research and development of novel antibacterial drugs within the National Science and Technology Key Project, specifically focusing on “Key New Drug Creation” during the “13th Five-Year Plan” period. To address the challenges associated with limited resources, the MOST prioritizes the advancement of innovative drugs targeting drug-resistant pathogens and infectious diseases, as well as the establishment of new technology platforms for clinical evaluation of these medications.	The organization of scientific research must be systematically structured, taking into account various factors such as drug categories, distinct diseases, and diverse applications. Furthermore, the transition from research to practical implementation should be expedited.
International collaboration	The National Natural Science Foundation of China and the Royal Society collaborated to fund six joint research projects in the area of AMR, providing a total of 15.1445 million CNY in direct funding. These projects covered a range of topics, including resistance mechanisms and their applications, technological platforms, transmission mechanisms, key factors influencing drug usage behaviors, and path research in China. The National Science and Technology Key Project (NSTKP), through the support of MOST, emphasizes the research and development of innovative antibacterial drugs and concentrates on the advancement of novel pharmaceuticals and cutting-edge technology platforms.	In the context of developing novel antibiotics and managing AMR, international drug development can benefit from multi-partnerships that involve collaboration and shared analysis. Adopting and adapting diverse AMR governance models in such collaborative efforts can prove to be efficient. Moreover, pursuing cooperative AMR governance, such as joint initiatives between bordering countries, can facilitate regional or global control of AMR.

Abbreviation: MEE=Ministry of Ecology and Environment; NHC=National Health Commission; MOA=Ministry of Agriculture and Rural Affairs; NAP=National Action Plan; CCVP=Commission of Chinese Veterinary Pharmacopoeia; CFSA=China National Center for Food Safety Risk Assessment; MOST=Ministry of Science and Technology; CNY=Chinese Yuan; AMR=antimicrobial resistance.

SUPPLEMENTARY TABLE S3. Future actions generated by framework analysis for National Action Plan in China for Governance area 3: monitoring and evaluation Analysis.

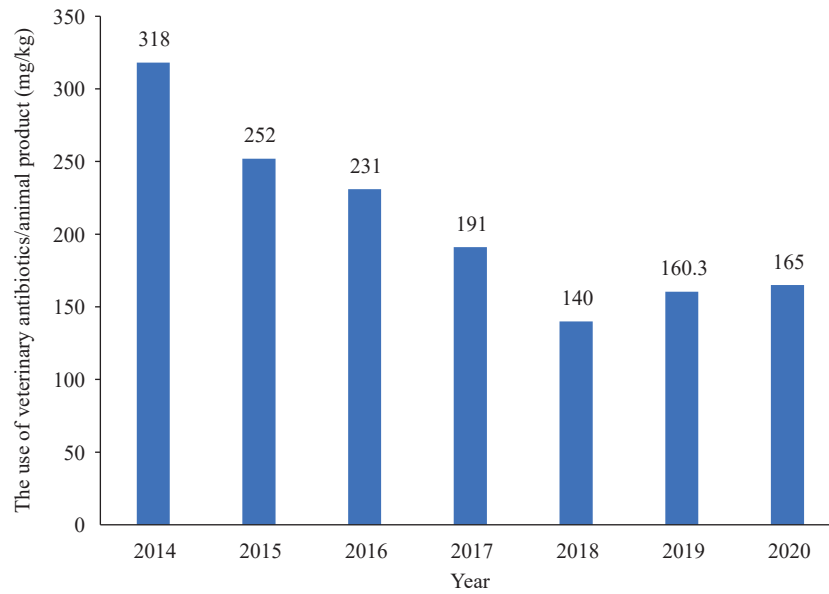
Indicator	Result summary	Future actions
Effectiveness	In 2017, a project was established with a funding of 9.86 million CNY to support teams carrying out a demonstration study on the Application of Antibacterial Drugs in the Reduction of Children's Bacterial Infectious Diseases using Traditional Chinese Medicine. The project aimed to facilitate and conduct exploratory research on innovative Chinese medicine treatments and prescriptions in 2018.	Further methodologies for assessing the efficacy and efficiency of implemented measures must be developed to mitigate potential resource and financial misallocations in subsequent actions. A more comprehensive evaluation mechanism, encompassing objectives, work actions, and system development, is necessary and is also addressed in NAP 2022–2025.
Feedback mechanism		Establishing a feedback mechanism to improve post-action outcomes and strengthen evidence-based governance
Reporting		Currently, only a limited number of departments, such as MOA and NHC, published annual regulatory reports. It is our hope that more departments will release statistical and public reports in a timely manner following the implementation of regulations. Upon establishing interdepartmental collaboration, efforts will be made to generate a comprehensive report aggregating data from diverse sources. This will enable a thorough examination of the national AMR issue and facilitate the identification of macroscopic governance solutions.

Abbreviation: NAP=National Action Plan; MARA=Ministry of Agriculture and Rural Affairs; NHC=National Health Commission; CNY=Chinese Yuan; AMR=antimicrobial resistance.

SUPPLEMENTARY TABLE S4. Future actions generated by framework analysis for National Action Plan in China for Governance area 4: sustainability.

Indicator	Result summary	Future actions
Fund and resource allocation	MOST initiated a project aimed at assisting the pertinent team "Research on the Antibiotics Resistance Mechanism and Transmission Law of Important Foodborne Pathogens", with a funding of 29.8 million CNY.	The allocation of funds and resources could be more transparent and detailed in published documents, clearly indicating the intended purpose or use for significant projects before and after completion. This approach will help ensure the efficient utilization of funds and resources in real-time.
Future expansion of implementation plans		Efforts should be made to identify issues warranting attention and establish annual plans, objectives, and budgets to address these concerns. It is essential to develop robust, locally-driven strategies to determine targeted and sustainable indicators for monitoring antibiotic usage, AMR, and infection prevention and control measures.

Abbreviation: MST=Ministry of Science and Technology; CNY=Chinese Yuan; AMR=antimicrobial resistance.



SUPPLEMENTARY FIGURE S1. Antibiotic usage in animal products in China is getting controlled. Report on the use of veterinary antibiotics in China from MOA published the usage data yearly from 2014 to 2020. Abbreviation: MOA=Ministry of Agriculture and Rural Affairs.