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Review Article

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A multi−sectoral approach to antimicrobial resistance containment: Insights from One Health

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ABSTRACT

Antimicrobial resistance (AMR) has become a serious threat to global public health. By 2050, AMR is estimated to cause 1.91 million deaths annually, with related mortality reaching 8.22 million. The challenges posed by AMR extend beyond the healthcare system to include animal health and environmental factors such as livestock farming, urbanization, and climate change. The "One Health" approach, an interdisciplinary and cross-regional collaborative strategy, integrates the management of human, animal, and environmental health. It is considered a crucial framework for addressing complex public health challenges and providing both scientific and preventive strategies to combat AMR. From October 12 to 13, 2024, the Second One Health Conference of Antimicrobial Resistance Containment was successfully held in Hangzhou, Zhejiang Province, China, under the theme "Hand in Hand with One Health to Contain AMR". The conference brought together experts from various fields to engage in in-depth discussions on AMR control, reaching a consensus to take action towards advancing the global health community. This conference strengthened multi-sectoral collaboration, promoted cross-departmental and cross-national cooperation, enhanced public awareness of AMR, explored control mechanisms, and provided both theoretical and practical guidance for mitigating AMR. It also called for increased investment and research and development efforts on AMR containment.

KEYWORDS: One Health; Infectious diseases; Antimicrobial resistance

1. AMR threat and the conference rationales

Antimicrobial resistance (AMR), one of the major threats to global public health and development, has significant implications for patient mortality, healthcare systems and socioeconomy worldwidely. In 2019, AMR directly caused 1.27 million deaths and contributed to an additional 4.95 million relevant deaths[1]. This issue affects countries across all regions and income levels, particularly low- and middle-income countries, where poverty and inequality exacerbate its drivers and consequences.

The causes of AMR are complex, including factors such as expanding populations (both human and animal), globalization, international trade, increasing demand for animal-derived foods, and easy access to antimicrobials. From 2000 to 2015, antibiotic consumption in 76 countries worldwide increased by 65%[2]. Horizontal gene transfer and the evolution of new resistance forms have exacerbated the problem. The lack of new antibiotic development has further intensified the threat posed by drug-resistant pathogens.

By 2050, AMR is projected to reduce the global population by between 11 million and 444 million people[3]. If AMR continues to rise unchecked, critical medical procedures such as cancer chemotherapy, joint replacement, and gastrointestinal surgery may increasingly be associated with higher morbidity due to drug resistance[4]. Countries such as India, Nigeria, Indonesia, and Russia, which already experience high rates of diseases like malaria, HIV, and tuberculosis, are particularly vulnerable as AMR exacerbates resistance to existing treatments[3].

Beyond mortality and disability, AMR incurs substantial economic costs. The World Bank estimates that AMR could result in $1 trillion

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additional healthcare costs by 2050, and $1 trillion to $3.4 trillion GDP losses per year by 2030[5]. Specifically, the economic burden of AMR is estimated to reach approximately $20 billion for the healthcare sector and $35 billion for productivity loss in the United States alone[6]. Moreover, studies indicate that by 2050, global GDP may decrease by about 1%, but for developing countries, this impact could be as high as 5%-7%, exacerbating the economic disparity between developed and developing countries[7]. AMR is not only a result of the healthcare system, but involves multiple components. In addition to the healthcare use of antibiotics, environmental changes such as livestock farming, urbanization, and climate change also have impact on AMR. It has been well evidenced that AMR development is a result of the transfer and evolution of drug-resistant genes among humans, animals, plants, and the environment[8]. Indeed, the environmental AMR resistome consists of more than one million distinct bacterial species, which markedly exceeds the number of species that infect human and animal populations[9]. Globally, approximately 60% of emerging infectious diseases have an animal origin, while 75% of newly discovered human pathogens over the past 30 years have originated from animals[10]. Extended-spectrum β-lactamases (ESBLs) of *Escherichia coli* can be transmitted between different interfaces, and *bla*CTX-M, *bla*NDM, *bla*TEM, *bla*SHV and other resistance genes have been detected in humans, pets, vegetables, meat, soil, water and other media[11–16]. This view is supported by studies of *Klebsiella* (*K.*) *pneumoniae*, *Staphylococcus aureus*, *Clostridioides difficile* and other species[17–19]. Therefore, effective control of AMR requires a multidisciplinary approach that extends beyond the scope of the healthcare system. Contributions from fields such as environmental science, agriculture, aquaculture health, veterinary medicine, and animal husbandry are indispensable.

In 2015, the WHO adopted the Global Action Plan on Antimicrobial Resistance (GAP) at the 68th World Health Assembly, emphasizing multi-sectoral governance within the “One Health” framework[20]. This plan aims to promote the health of humans, animals, and the environment, urging member states to develop and implement national action plans.

To proactively address the challenges posed by AMR, China has implemented the Biosafety Law and 13 departments, including the National Health Commission, have jointly developed the “National Action Plan for Containing Antimicrobial Resistance (2016-2020 & 2022-2025)”(NAP) to enhance public health protection[21]. These plans emphasize the importance of “extensive multi-sectoral and international exchanges and cooperation”.

In alignment with the national call, the Second One Health Conference of Antimicrobial Resistance Containment was held in Hangzhou from October 12 to 13, 2024. The conference was hosted by the Zhejiang Pharmaceutical Society and organized by the Antimicrobial Resistance and Control Committee of the Zhejiang Pharmaceutical Society, the First Affiliated Hospital of Zhejiang University School of Medicine, and the State Key Laboratory of Diagnosis and Treatment of Infectious Diseases. The grand opening of the conference took place in Hangzhou, bringing together leading experts from around the world to engage in in-depth discussions on the pressing and complex issues related to antimicrobial resistance control. The event not only showcased the latest research findings and practical experiences but also served as a significant platform for promoting collaboration in the fight against antimicrobial resistance.

The Conference has strengthened the cooperation among various fields and provided an important platform for cross-sectoral and cross-border cooperation. The contents of this conference were presented in various forms, including academic reports, keynote speeches, symposia and forums, youth forums, excellent paper presentations, poster presentations, and so on. In addition, the reports covered various fields, including AMR control strategies, clinical resistance prevention and control, resistance and drug use monitoring, AMR mechanisms, resistance control technology innovation, and multidisciplinary antimicrobial stewardship, *etc*. Experts from various disciplines discuss how to coordinate the resources and actions of humans, animals and the environment to effectively reduce the risk of transmission of drug resistance, providing a theoretical basis and practical guidance for effective control of AMR.

2. Advancement of the One Health strategy

Currently, human beings are facing a series of complex health challenges, with significant public health crises primarily driven by infectious diseases, an escalating situation of AMR, increasing risks to human health from global environmental changes, and frequent outbreaks of food safety issues.

The One Health concept originated from the “One World, One Health” conference held by the Wildlife Conservation Society in 2004, which systematically highlighted the close relationship between human health, animal health, and the ecological environment[22]. In 2015, the GAP released by the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organization for Animal Health (WOAH) further reinforced this concept, stating that a One Health approach is essential for multi-sectoral governance in addressing the increasingly severe public health challenges posed by AMR[23–25].

At the 2024 UN High-Level Meeting on AMR, parties reiterated their support for the “One Health” framework, proposing that 95% of countries report annually on their AMR national action plans and aim to reduce the 4.95 million deaths related to bacterial resistance by 10% by 2030. Additionally, a $100 million catalytic fund was established to support sustainable national financing, with hopes that by 2030, 60% of countries will provide funding for AMR national action plans[26].

Over the years, One Health has gained significant international influence. The WHO established a One Health Expert Group, and countries agreed to implement the One Health strategy at the G7 and G20 summits. Currently, the European Union has made One Health the core theme of its new action plan, aiming to integrate resources across public health, agriculture, and environmental sectors. Its “Farm to Fork” strategy sets a target to reduce the total sales of antibiotics in EU livestock and aquaculture by 50% by 2030, aiming to enhance food safety and ecological sustainability through controlled antibiotic use[27]. In the UK, AMR governance strategies

are also framed around the One Health approach, with the Public Health England (PHE), Veterinary Medicines Directorate (VMD), and Food Standards Agency (FSA) collaborating to develop and implement relevant policies, publishing a comprehensive One Health monitoring report every two years[28]. The Centers for Disease Control and Prevention (CDC) established a One Health office, signing multiple cooperation agreements to promote monitoring and research on antibiotic use across various sectors, emphasizing the interconnections between antibiotic use in humans, animals, and the environment[29].

However, Chin-Kei Lee, the medical officer at the WHO China Office, pointed out that according to data from the 2023 national action plans and Tracking AMR Country Self-assessment Survey (TrACSS), only 26% of member countries effectively monitor and implement their national action plans, and only 11% allocate budgets for their implementation[30]. Although progress is being made, significant gaps remain in financing and monitoring, necessitating enhanced interdepartmental coordination and cross-sectoral collaboration.

As one of the earliest advocates and implementers of multi-sectoral joint actions, China has made significant progress in advancing the One Health strategy in recent years. In November 2014, the first international forum on One Health research was held in Guangzhou[31]. In 2021, during the 697th Xiangshan Scientific Conference themed "One Health and Human Health", it was decided to establish a One Health professional committee and association, initiating major interdisciplinary research programs based on One Health and establishing new disciplines and research institutions that align with the One Health concept, promoting open sharing mechanisms for joint prevention and control public health data[32].

Professor Jiahai Lu also introduced key technologies and application examples related to One Health, such as vector-borne disease monitoring maps, emerging infectious disease surveillance systems, virus-based VirCapSeqVERT rapid detection technology, serological detection chips (SeroChip), One Health vaccines, and nano-antibody platforms for treatment and diagnostics. The application of these technologies provides a solid foundation for addressing AMR and other public health challenges.

3. AMR control strategies and achievements in China

In response to the United Nations call for the implementation of the One Health approach to antimicrobial resistance control, China has launched the NAP under the One Health framework[21]. Professor Yonghong Xiao reported on the "Current Status of Global One Health Antimicrobial Resistance Control" at the conference, highlighting the core strategies of this plan, which include: 1) prioritizing the prevention and reduction of infection rates; 2) enhancing public health education to raise awareness of drug resistance; 3) strengthening professional training to improve prevention and control capabilities; 4) reinforcing industry regulation to ensure rational use of antimicrobials; 5) improving monitoring and evaluation systems to support evidence-based decision-making; 6) ensuring the supply of relevant drugs and equipment; 7) promoting scientific research and development for AMR prevention; and 8) fostering extensive international cooperation and exchange. It has integrated efforts from multiple sectors such as agriculture, health, and the environment to collaboratively formulate and execute AMR control policies, promoting the rational use of antimicrobials and resistance monitoring.

In alignment with the national AMR control strategy, a comprehensive three-dimensional monitoring network was established during the conference. This network includes the China Antimicrobial Resistance Surveillance System (CARSS), the China Invasive Fungal Monitoring Network, the China Antimicrobial Surveillance Network (CHINET) and the Blood Bacterial Resistant Investigation Collaborative System (BRICS), along with the China Pet Antimicrobial Resistance Monitoring Network[33–37]. These systems, covering medical health, animal husbandry, and environmental resistance, regularly compile and publish reports, providing nationwide monitoring of antibiotic use and ensuring transparent, timely access to information on resistance trends of various bacteria in China.

Legislative measures such as the "Regulations for the Clinical Application of Antimicrobials" issued by the Ministry of Health, emphasize a tiered management system that requires hospitals to strictly control prescription authority and dosage. Mr. Yuanchang Shao stated, "The implementation of antimicrobial stewardship involves collaboration among infectious disease experts, clinical pharmacists, microbiologists, and infection control specialists to oversee the use of antimicrobials, ensuring adherence to clinical guidelines." Guiding documents, such as the "Clinical Application Guidelines for Antimicrobials," provide healthcare professionals with structured approaches for rational antimicrobial use. Expert committees offer guidance for policy and clinical practice, ensuring the sustainability of professional management through education, training, and targeted antimicrobial management programs. After promoting alternative treatments to antibiotics, a downward trend in resistance to various drugs has been observed. At the same time, under the guidance of hospital policies, the use of antibiotics in China has gradually decreased compared to previous levels, and the difference is statistically significant.

In the agricultural sector, Professor Guangguo Ying (South China Normal University, Guangzhou) pointed out that with the improvement of the Ministry of Agriculture's management system, China's veterinary antimicrobial management has entered a new phase. The "Regulations for Veterinary Prescription and Non-Prescription Drugs," implemented in September 2013, brought antimicrobials under prescription control in veterinary practice[33]. According to statistics, since 2013, the use of non-essential veterinary antibiotics has steadily declined year by year, achieving a total reduction of over 50% in drug use over a five-year period. The "National Food Safety Standards for Maximum Residue Limits of Veterinary Drugs in Food," released in September 2019, established residue limits for 2 191 veterinary drugs used in livestock, poultry, aquaculture, and bee products[34]. And the Ministry of Agriculture and Rural Affairs launched a pilot action plan to reduce the use of veterinary antimicrobials in livestock, promoting alternative measures such as vaccination and ecological farming.

Conference Chair Professor Yonghong Xiao stated, "China's regulatory framework for antimicrobial management, along with the responsibilities of professionals and the monitoring network, has established. Through legislation, education, and monitoring, China is gradually eradicating antibiotic misuse and preventing the spread of antimicrobial resistance, achieving promising results." Over the past decade, the number of research papers on resistance under the One Health framework has steadily increased, focusing on exploring resistance mechanisms and the transmission of resistant bacteria in the environment, animals, and human populations. These studies provide a theoretical basis for accurately identifying pathogens, effectively interrupting transmission routes, and mitigating resistance issues. Through government-led multi-sectoral collaboration and cross-field monitoring networks, China has achieved significant results in AMR control within the One Health framework, encompassing policy formulation, antimicrobial management, resistance monitoring, and international research collaboration, thus providing important support for global AMR prevention and control.

4. Research achievements presented in the conference

4.1. Basic research

Carbapenem-resistant bacteria, particularly K. pneumoniae, presents a major global challenge. Professor Fupin Hu (Huashan Hospital, Fudan University, Shanghai) highlighted the rapid global dissemination of carbapenem-resistant bacteria, exacerbated by the emergence of *K. pneumoniae* carbapenemase variants such as *bla*KPC-2 and *bla*KPC-3. Through plasmid and bacterial genome analysis, researchers have identified key mechanisms underlying the spread of these variants. Ongoing global surveillance and multicenter studies will be critical to understanding and addressing the resistance mechanisms. Additionally, carbapenem-resistant hypervirulent K. pneumoniae exhibits both high levels of antimicrobial resistance and significant virulence. Professor Chen Sheng (The Hong Kong Polytechnic University, Hongkong)'s team, through multidisciplinary collaboration, identified key resistance and virulence-related plasmids and analyzed their transmission across different ecological niches and hosts. This research offers valuable insights for controlling multidrug-resistant (MDR) bacteria. Moreover, Professor Beiwen Zheng (Zhejiang University, Hangzhou) pointed out that insertion sequences (IS) and mobile genetic elements (MGEs) are primary facilitators of resistance gene dissemination, enabling horizontal gene transfer between plasmids and bacterial chromosomes.

4.2. Clinical research

Effective AMR management in clinical settings requires comprehensive surveillance and innovative diagnostic technologies. Professor Qiang Sun (School of Public Health, Shandong University, Jinan) emphasized that China, as a major producer and consumer of antibiotics, faces significant AMR challenges, particularly at the grassroots level where limited medical resources and inadequate regulatory frameworks exist. He underscored the necessity of multi-sectoral collaboration, especially in primary healthcare. Professor Xiaoxing Du (Sir Run Run Shaw Hospital, Zhejiang University, Hangzhou) presented molecular epidemiological data on carbapenem-resistant Enterobacteriaceae (CRE), identifying ST11 as the dominant clone in K. pneumoniae and ST410 in drug-resistant E. coli. This research is essential for monitoring the spread of resistance across hospitals and regions. Professor Jian Xu (Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences, Qingdao) introduced single-cell Raman spectroscopy as a rapid diagnostic tool for identifying drug-resistant bacteria and their phenotypes, offering genome-wide tracking. The technology significantly reduces detection time, and combined with high-throughput digital culture, enhances AMR monitoring efficiency. Additionally, Professor Jiang Gu (Army Medical University, Chongqing) stressed the critical role of vaccine development in combating MDR bacteria, such as S. aureus and K. pneumoniae. He noted that China's recombinant S. aureus vaccine, currently in Phase III clinical trials, could significantly reduce the spread of resistance. Finally, Professor Shuyi Si (Institute of Medicinal Biotechnology, Chinese Academy of Medical Sciences, Beijing) highlighted the importance of efficient screening platforms and microbial drug libraries in the discovery of novel antimicrobials, critical to addressing global AMR threats.

4.3. Environmental–clinical dialogue

The interplay between environmental factors and clinical settings is crucial in understanding and controlling the spread of AMR. Professor Xiangdong Li (The Hong Kong Polytechnic University, Hongkong) stressed that antibiotic resistance extends beyond hospitals, with the environment playing a significant role in the evolution and spread of antibiotic resistance genes (ARGs). Human activities, particularly in urban areas, increase the risk of exposure to ARGs and resistant pathogens, making the environment a critical vector. Professor Guangguo Ying pointed out that animal farms are major sources of ARGs, which spread through waste and contaminate air, soil, and water. This exposure is particularly pronounced in rural communities where living conditions contribute to a higher abundance of ARGs in the gut microbiome. Professor Min Yue (Hangzhou Institute for Advanced Study, University of Chinese Academy of Sciences, Hangzhou)'s research, using the One Health framework, focused on cross-species and cross-environmental transmission of pathogens such as Salmonella, using genomics-based risk assessments to guide control strategies. Future efforts should integrate big data and metagenomics for early prediction and risk assessment, facilitating a deeper understanding of ARG evolution.

4.4. Interdisciplinary collaboration

Tackling AMR requires interdisciplinary collaboration, integrating human, animal, and environmental health perspectives. Professor Bing Xie (East China Normal University, Shanghai) discussed the

role of aerosols generated during waste disposal as potential routes for ARG transmission, especially in urban areas. Professor Jianhua Liu (South China Agricultural University, Guangzhou) demonstrated that ARGs like *mcr*-1 and *bla*NDM are transferred across ecological niches between animals and humans, with food chains acting as significant transmission pathways, posing a serious public health risk. Professor Yongzhang Zhu (Shanghai Jiao Tong University, Shanghai) advocated for a comprehensive One Health monitoring system on Chongming Island, integrating human, animal, and environmental data to track AMR development. He highlighted the role of migratory birds, domestic animals, and wildlife as key vectors for ARG dissemination. The Chongming Island model demonstrates the effectiveness of interdisciplinary collaboration in monitoring and controlling AMR, integrating clinical, agricultural, and ecological perspectives under the One Health approach.

5. Expert consensus and action recommendations

Through discussions among experts and scholars, a consensus emerged on the severe situation of AMR. As Professor Chin-kei Lee (WHO China office) pointed out, "AMR is no longer a silent pandemic." By 2050, it is estimated that AMR will result in approximately 1.91 million deaths per year, with related mortality figures reaching 8.22 million[35]. Therefore, combating AMR requires collective efforts across nations and sectors. This conference provided scientific direction and practical experiences for addressing the global challenge of AMR.

5.1. Promoting and implementing One Health approach to combat AMR

One Health is a comprehensive, unified approach aimed at sustainably balancing and optimizing human, animal, and ecosystem health. Professor Yonghong Xiao emphasized that despite existing actions, efforts remain largely confined to individual sectors, failing to form a concerted force. He advocates for a One Health strategy as a necessary and effective method for controlling antimicrobial resistance. The WHO 2025-2035 strategy highlights four key priorities: "preventing infections," "ensuring universal access to affordable quality treatment," "strategic information, science, and innovation," and "effective governance and financing." Strengthening human-centered public health approaches and core interventions is essential for regional and global governance and financing actions.

5.2. Building a comprehensive integrated surveillance network under One Health principle

The One Health principle promotes equity, balance, and interdisciplinary management, addressing disease control from prevention to detection and management. Effective collaboration is needed to establish a shared fate community in One Health, tracking high-risk and latent pathogen evolution and transmission. Surveillance of AMR in human, animal, and environmental sectors is crucial for assessing the development trends of resistance and the public health burden. Through cross-sector collaboration and the establishment of an integrated monitoring network, AMR can be tracked more effectively, and timely interventions can be taken. Additionally, surveillance data helps improve education, policy-making, and antimicrobial stewardship programs.

China has already developed extensive monitoring networks, such as BRICS, CARSS, CHINET. However, laboratory-based surveillance using only clinical samples is not likely to be useful as an early warning system for emerging pathogens and resistance mechanisms. In particular, in the agricultural and animal production sectors, the issue of AMR is closely related to antibiotic use, and it is essential to build a more comprehensive data-sharing platform. Moreover, the environment serves as a crucial reservoir for resistant genes and is a key medium for the transmission of resistance. Therefore, environmental AMR monitoring must be enhanced to detect emerging resistance mechanisms in a timely manner. Surveillance should be extended to include bacterial sample collection from diverse settings, such as human health (*e.g.*, hospitals, extended-care and community settings), animal health (*e.g.*, veterinary clinics, farms, and food production areas), and the environment (*e.g.*, wildlife, soil, water).

Genomic surveillance has become increasingly important in AMR surveillance, complementing traditional phenotypic surveillance. By sequencing and analyzing genetic data from microbial communities across human, animal, and environmental settings, the spread of resistance genes can be monitored more accurately. Genomic data also helps track the movement of antimicrobial resistance genes through mobile genetic elements (MGEs), which can cross between different species and environments. To effectively detect and respond to emerging AMR trends, the surveillance network should focus on real-time data collection. This could be achieved by using modern technologies, such as rapid sequencing, AI-based monitoring tools, and long-read metagenomics, which allow for the early detection of new resistance patterns and the tracking of pathogens.

Surveillance of antimicrobial use involves systematically tracking the use of antimicrobial agents across human, veterinary, and agricultural sectors to better understand usage patterns and identify areas needing intervention. This monitoring should include data collection at national, regional, and institutional levels (such as hospitals, veterinary clinics, and farms), using appropriate denominators (*e.g.*, per capita usage, number of treated animals, or production units) to facilitate cross-country comparisons. Monitoring antimicrobial prescribing and usage behaviors is critical to assess adherence to guidelines and prevent overuse or misuse. The data should be integrated across sectors, analyzed comprehensively, and reported in a timely manner to support policy decisions and antimicrobial stewardship programs. Based on the well-established and sound antimicrobial use and monitoring systems within various departments, a multi-sectoral surveillance network for antimicrobial drugs should be established, covering human, animal, and environmental sectors. This network should report relevant data from the county level to the national level, enabling real-time tracking and traceability of antimicrobial drug usage, with regular publication of the relevant data. The ultimate goal of antimicrobial use surveillance

is to reduce unnecessary or inappropriate use, thereby mitigating the risk of antimicrobial resistance (AMR) and improving treatment outcomes.

AMR is a global problem that requires stronger international cooperation, particularly in areas like data sharing, standardized monitoring methods, and experience exchange. Promoting international cooperation and data sharing can be achieved by joining global AMR monitoring platforms like WHO's Global AMR Surveillance System (GLASS) and establishing cross-country data-sharing agreements to ensure data standardization and comparability. Additionally, supporting international research collaborations, developing open data platforms, and providing technical support and training can help countries share AMR data and expertise, enhancing global efforts to combat antimicrobial resistance. These measures will enable countries to improve monitoring capabilities, coordinate actions, and effectively address the AMR threat.

Effective surveillance requires professionals from various sectors. Therefore, capacity-building programs should be implemented to train healthcare providers, veterinarians, agricultural workers, and environmental experts in AMR detection, monitoring, and prevention. The training should also include how to use surveillance data to guide antibiotic management measures and control strategies.

5.3. Establishing a precise infection control system

Professor Wenhong Zhang (Huashan Hospital, Fudan University, Shanghai) emphasized the close relationship between hospital infections and the spread of superbugs. Environmental factors can serve as transmission mediums for priority pathogens. Strengthening hygiene measures in healthcare settings is critical to preventing superbug outbreaks. For example, isolating beds in intensive care units (ICUs) can help control the spread of resistant bacteria. Additionally, hospital wastewater serves as a significant reservoir for resistant strains, making thorough cleaning and disinfection essential.

The WHO has highlighted that safe drinking water, sanitation, and hygiene (WASH) are crucial to human health and well-being. Evidence suggests that improving service levels towards safely managed drinking water and sanitation, such as regulated piped water or connections to sewers with wastewater treatment, can dramatically reduce deaths from diarrheal diseases. The conference promotes the integration of WASH with other health programs, such as emergency response, quality care, and infection prevention and control. This is especially important in healthcare facilities, nutrition programs, and antimicrobial resistance initiatives.

Beyond hospital settings, veterinary clinics and farms are crucial points for infection control. Although many veterinary clinics lack formal infection control programs, infection prevention in farms, particularly in intensive poultry and swine production, is critical. These programs often focus on preventing the introduction of exotic pathogens and controlling endemic diseases, and they help reduce the need for antimicrobial use in animals. Health management measures, such as vaccination and disease prevention, are essential to reducing reliance on antibiotics in animal production.

To reduce human exposure to antimicrobial resistance from environmental sources, it is crucial to improve the safety of food and drinking water. Ensuring strict hygiene standards in food production, processing, and storage can significantly reduce the spread of foodborne pathogens. Implementing pathogen reduction programs at farms, slaughterhouses, and food processing plants is crucial, especially for controlling enteric bacteria like *Salmonella* and *Campylobacter*. Improving agricultural practices and strengthening biosecurity measures can help reduce pathogen transmission risks.

5.4. Optimizing the use of antimicrobial medicines

Professor David Lye from Singapore shared sustainable achievements in Antimicrobial Stewardship Programs (ASP) over the past decade. Implementing ASP requires a multi-faceted approach, including auditing antibiotic use, providing feedback to prescribers, improving appropriate prescribing rates, and utilizing electronic decision support systems to prevent misuse. Cross-department collaboration is essential, with ASP teams working closely with various departments to update and develop guidelines for the rational use of antibiotics. Training and education are key to raising awareness among healthcare providers. These measures help optimize the use of antimicrobial medicines and control the spread of antimicrobial resistance.

Strengthen the top-level design of the multi-sectoral horizontal and vertical collaboration mechanisms for antimicrobial drug management, ensuring comprehensive coverage both horizontally and vertically. Establish a national-level specialized agency responsible for antimicrobial drug management, coordinating the implementation of China's national action plan to manage antimicrobial drugs and combat bacterial resistance. Additionally, form corresponding multi-sectoral antimicrobial drug management teams at provincial, municipal, county, and township levels, and regularly organize joint meetings for the management of antimicrobial drug use and resistance monitoring.

In the veterinary and agricultural sectors, there is generally a stronger emphasis on national regulatory interventions to control antimicrobial resistance compared to human medicine. The OIE has developed a classification system for antimicrobials critical to animal health. This system helps identify antimicrobials that are essential to human health and should be restricted in animals. Countries like the EU, the United States, and Canada have implemented restrictions on the use of certain antimicrobials that are critically important for human health in animals. For example, carbapenems, glycopeptides, and some other classes are not licensed for use in food animals and are only allowed in companion animals under exceptional circumstances. This strategy reduces the misuse of antimicrobials in animals and helps mitigate the risk of antimicrobial resistance.

5.5. Increasing funding for new drug and techniques development

Experts underscored the importance of funding new antimicrobial drug pipelines to mitigate AMR. Professor David Paterson (The National University of Singapore, Singapore) noted that the AMR crisis is fundamentally an economic issue, with the rapid evolution

of resistant pathogens and the high research costs complicating the development of new drugs. Countries need to invest more in antimicrobial pipelines and personnel to develop new treatments. The WHO's updated list of priority pathogens calls for increased global investment in AMR.

The conference covered advancements in clinical infection diagnosis and treatment, as well as broader agricultural and environmental research. It emphasized interdisciplinary exchange, particularly the integration of One Health across fields. Participants explored various topics, including resistance mechanisms, transmission in different environments, and regional control experiences, fostering academic collaboration and the development of effective One Health strategies for antimicrobial resistance control. On a macro management level, collaboration among sector managers and professionals is vital for coordinated research efforts. Understanding which aspects of resistance emergence and spread are most amenable to intervention is crucial for effective action. One Health Conference of Antimicrobial Resistance Containment is a multi-sectoral collaborative initiative, the Third Conference will be held next October in Hangzhou.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Authors' contributions

Cheng Y, Wang XT, Ma YY, Chen T, Xiong LY, Chen P, Lu P, Zhang EJ wrote the original manuscrpit. Xiao YH reviewed the manuscript and contributed to projectadministration and conceptualization.

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