Zhao et al. One Health Advances (2023) 1:29
https://doi.org/10.1186/s44280-023-00029-5

One Health Advances

ARTICLE

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Current status and trends in antimicrobial use in food animals in China, 2018–2020

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Abstract

Antimicrobial resistance poses a significant threat to global public health, and excessive antimicrobial use (AMU) in animals is a major contributing factor. We used national AMU data for food animals to examine the current status and trends for AMU in food animals in China from 2018–2020. In 2020, China used 32,776.30 tons of antimicrobials in food animals, amounting to 165 g of antimicrobials per ton of animal products. AMU in China increased throughout the 2018–2020 study period; however, the data still showed a consistent and notable reduction from those of 2017, coinciding with the implementation of the China National Action Plan for Combating Animal Antimicrobial Resistance. Among the antimicrobials used, tetracyclines, macrolides and β-lactams (including β-lactam inhibitors) were the most commonly used in food animals. Analysis by antimicrobial class revealed shifts in usage patterns, such as decreased tetracycline use and increased macrolide and β-lactam use. Furthermore, the use of antimicrobial growth promoters decreased sharply, from 51.78% in 2018 to 28.7% in 2020. Compared with AMU data from other countries, China used more antimicrobials, but the values were relatively lower when adjusted for population correction units. These findings highlight China's remarkable efforts in combating antimicrobial resistance and promoting antimicrobial stewardship, thus contributing significantly to global initiatives.

Keywords Veterinary antimicrobial use, Quantities, Animal biomass, China

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Introduction

Antimicrobials play critical roles in promoting human and animal health; however, their widespread use has placed a significant burden on antimicrobial resistance (AMR), posing a serious threat to public health [1–3]. Excessive antimicrobial use (AMU) in animals has been extensively documented as a major contributing factor to AMR in animal, human and environmental sectors [4–6], which has become a worldwide concern and led to the development of global action plans against AMR. Global initiatives have been developed to establish surveillance systems for veterinary AMU and recognize the importance of the One Health approach. These systems quantify consumption and estimate trends to inform policymakers in optimizing antimicrobial prescribing and combating AMR. Noteworthy initiatives include the Global Antimicrobial Resistance and Use Surveillance

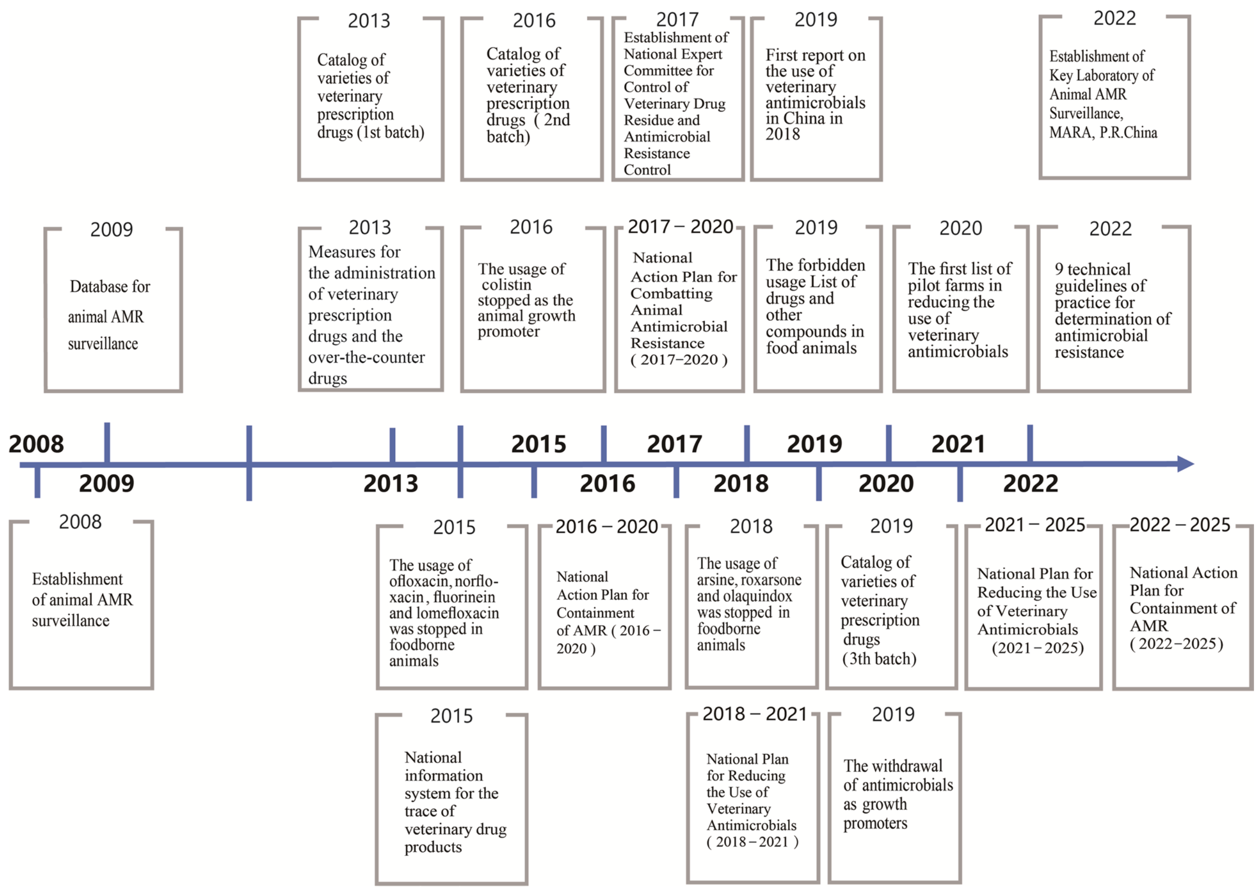

Fig. 1 Timeline of initiatives for AMR prevention, control, and prudent antimicrobial use in animals in China

System of antimicrobial consumption (GLASS-AMC) initiative by the World Health Organization [7], the ANIMUSE program by the World Organization for Animal Health (WOAH) [8], and the European Surveillance of Veterinary Antimicrobial Consumption project by the European Union (EU) [9]. Globally quantified AMU data were mapped and changes could be observed by time and different countries.

In recent decades, China has made significant progress in regulating AMU in animals by implementing multiple policies (Fig. 1) and national AMU data were consistently collected. The Ministry of Agriculture and Rural Affairs (MARA) of the People's Republic of China has published yearly reports on veterinary AMU for 2018–2020 in the official veterinary bulletin [10–12]. Herein, we provide a concise analysis of the current status and trends in AMU in food animals in China from 2018–2020.

Results

Overall AMU in food animals

In 2020, 32,776.30 tons of antimicrobials were used in food animals in China, amounting to 165 g of antimicrobials per ton of animal products. Veterinary AMU increased consistently from 2018 to 2020, with an average increase by 4.93% (Fig. 2a). However, these numbers were reduced from those of 2017, the year that the National Action Plan for Combating Animal Antimicrobial Resistance (2017–2020) was implemented [13], and from 2017 to 2020, the AMU in China dropped 9,190.7 tons (a 21.90% decrease). Furthermore, the AMU adjusted by animal biomass increased from 140 g/t in 2018 to 165 g/t in 2020 (Fig. 2a), which was still a 13.70% decrease from that of 2017. Mixed feeding was the most commonly used administration route in China from 2018–2020, and water feeding increased significantly from 5,702.44 tons in 2018 to 11,208.27 tons in 2020 (Fig. 2b).

AMU classified by antimicrobial class

Tetracyclines were consistently the most used antimicrobial class and exhibited a steady 26.8% reduction from 13,664.82 tons in 2018 to 10,002.73 tons in 2020 (Fig. 3a), owing to the decreased use of antimicrobial growth promoters (AGPs). Conversely, macrolides and

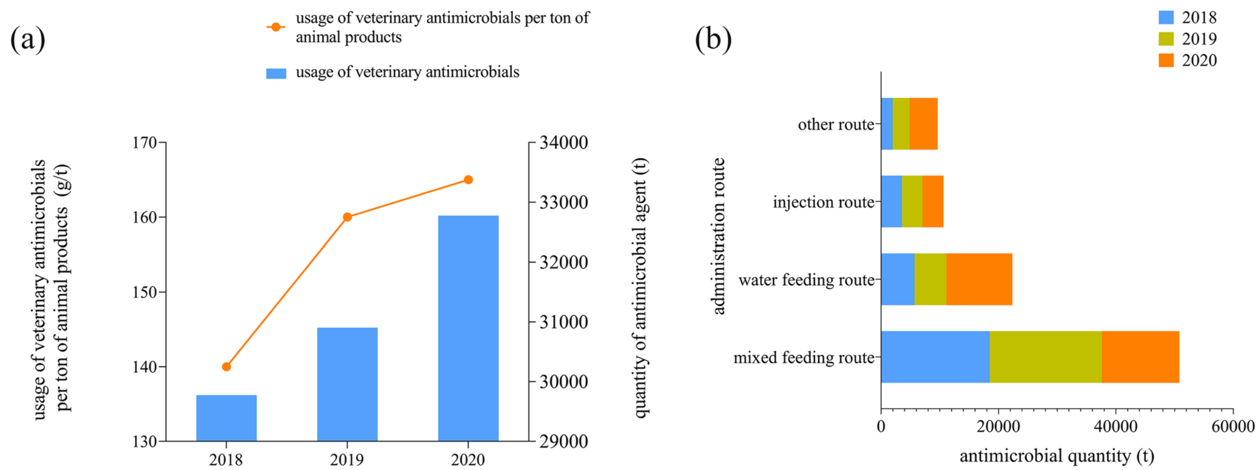

Fig. 2 Trends in antimicrobials used in food animals in China in 2018–2020, categorized by quantity and antimicrobials per ton of animal products (**a**) and administration route (**b**)

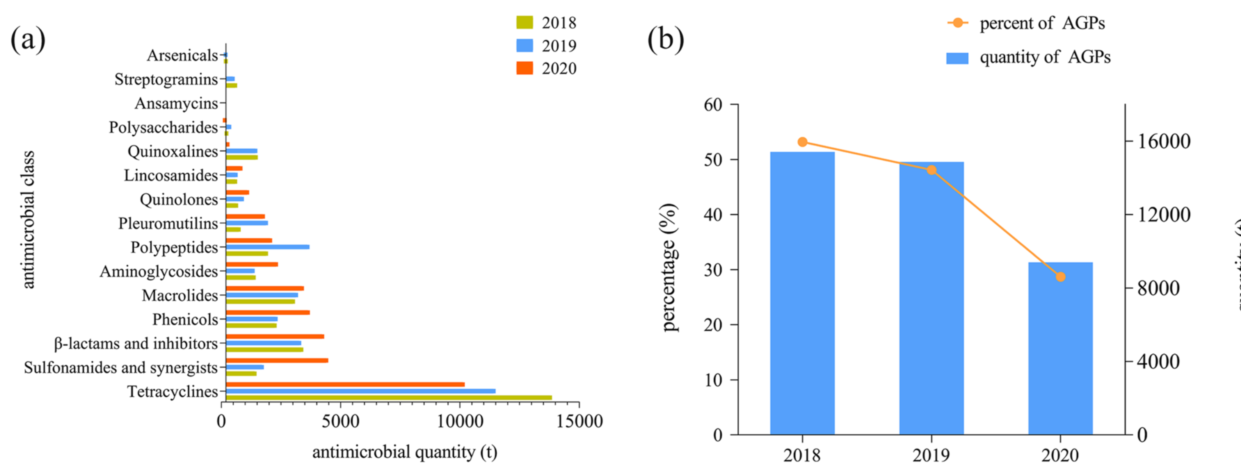

Fig. 3 Trends in antimicrobials used in food animals in China in 2018–2020, categorized by antimicrobial class (**a**) and by AGP quantities (**b**)

β-lactams (including β-lactam inhibitors) showed an opposing trend, with consistent increases of 8.15% and 30.37%, respectively, between 2019 and 2020. Other antimicrobial classes, including phenicols, lincosamides, and quinolones, demonstrated increased usage rates of 65.73%, 48.30%, and 90.16%, respectively. Additionally, aminoglycosides exhibited a substantial 81.01% increase in use between 2019 and 2020. Conversely, quinoxaline use decreased significantly by 88.78% from 1,332.49 tons in 2018 to 149.45 tons in 2020. The official announcement of No. 194 by the MARA in 2019 [14] substantially affected AMU. Consequently, polypeptide and polysaccharide use decreased significantly by 1,564.63 tons (44.69%) and 190.14 tons (86.77%), respectively, in 2020 compared with those of 2019. Streptogramins and arsenicals were completely discontinued from AMU in food animals in China in 2020.

AMU by antimicrobial amount

Between 2018 and 2020, China used five veterinary antimicrobials in quantities consistently exceeding 1000 tons, representing approximately 42.38% of the total annual AMU (Table S1). Overall use of these antimicrobials increased steadily, surpassing 14,963.72 tons in 2020, reflecting a growth rate of 15.87% from 2018 to 2020. This rise could be attributed to the ban on AGPs, which resulted in increased use of other antimicrobials for treatment purposes. Florfenicol exhibited the largest increase, reaching 1,460.8 tons, followed by amoxicillin at 1,029.03 tons. Notably, both tiamulin and tilmicosin exceeded the 1000-ton threshold in 2019, and neomycin and penicillin reached this threshold in 2020. Moreover, penicillin, spectinomycin, and tilmicosin use increased, while ampicillin and ofloxacin use decreased. AGP use decreased by 6,012.74 tons, with AGP proportions dropping from 51.78% in 2018 to 28.69% in 2020 (Fig. 3b). Most of this reduction occurred between 2019 and 2020 (Table S2), evidencing the ban policy's impact on AGP use.

Comparison of AMU in animals between China and other countries

As reported by the EU [9], AMU in animals differed significantly between China and European countries (Fig. 4a). Because of its large animal biomass, China showed higher AMU in food animals compared to European countries. However, in terms of mg/population correction unit (PCU), China exhibited lower AMU than that of Italy, Poland, Cyprus and Hungary.

According to the WOAH report [8, 15], China accounted for 38.82% and 36.62% of the global AMU as well as 66.73% and 69.88% of that of the Asia, Far East, and Oceania region in 2018 and 2019, separately (Fig. 4b and c). Globally, the most widely used antimicrobial class was tetracyclines, which was consistent with China's AMU. However, the overall quantity of tetracyclines used in China was higher than the global (45.90% vs. 40.5%, 36.55% vs. 35.6%) and that of the Asia, Far East, and Oceania region as per the WOAH (45.90% vs. 40.0%, 36.55% vs. 36%) in 2018 and 2019, separately. Conversely, the quantities of penicillins (9.90% vs. 14.1%, 9.43% vs. 13.3%) and fluoroquinolones (1.71% vs. 2.3%, 2.43% vs. 3.4%) used in China were lower than the global in 2018 and 2019, separately. Furthermore, the quantities of AMU per animal biomass were lower in China than in the Asia, Far East, and Oceania region as per the WOAH (140 g/t vs. 161 mg/kg, 160 g/t vs. 166.72 mg/kg), but higher than the global level (140 g/t vs. 96 mg/kg, 160 g/t vs. 108.49 mg/kg) in 2018 and 2019. Other than tetracyclines, streptogramins, macrolides, and polypeptides, which were predominantly used as AGPs in 2018 and 2019, the percentages of most antimicrobial classes used in China were lower than the global averages, indicating the potential for future decreases in AMU in animals in China.

Discussion

In China, the AMU in animals remained high and increased steadily from 2018 to 2020. Several factors may have contributed to this trend. First, fluctuations in animal products could lead to changes in antimicrobial quantities owing to disease epidemics and natural disasters. Second, the withdrawal of many AGPs likely affected the overall AMU amount for preventing and/or treating bacterial infections. Third, the Coronavirus disease 2019 pandemic in 2020 severely affected the export of veterinary antimicrobials, resulting in significantly reduced export quantities compared with those of the previous year. Notably, the similarities in the most widely used antimicrobial classes between China and worldwide may be attributed to the shared prioritization of AMU for medical purposes in animals and the perceived benefits of cost-effectiveness and efficient disease control on a global scale.

Owing to different calculation methods, comparing antimicrobial quantities per animal biomass among countries is challenging. The EU calculates these quantities based on weight at the time of treatment, whereas the WOAH uses the total weight of the live domestic animals in a given population present during a year in a specific area. Conversely, China's calculation is based on animal product weight. The Chinese denominator is the smallest of the three, suggesting that China may have a relatively better situation regarding AMU in animals than our results indicate. Furthermore, fluctuations in AMU are common, particularly during the initial stages of withdrawal, as observed in countries like Denmark that implemented similar bans earlier [16].

China has made significant efforts to reduce AMU in farming, as exemplified by the use of colistin. After reports of the mobile colistin-resistance gene, *mcr-1* [17], the Chinese government banned use of colistin as an AGP in 2017 [18]. Following this ban, production and sales of colistin sulfate premix were markedly reduced, and colistin residue concentrations and relative *mcr-1* abundances decreased significantly [19]. This policy and the subsequent decrease in colistin use led to significantly reduced colistin resistance in animals. China's ban on all growth-promoting antimicrobials, except for traditional Chinese medicines, as feed additives further demonstrates China's commitment to combating AMR. Successful reduction in veterinary AMU relies on collaborative efforts and enforcement of supportive regulations.

While our results provide valuable insight into the AMU situation in China, our study had some limitations. First, we could not directly measure actual usage, and sales data may differ from actual antimicrobial consumption in animals, leading to potential inaccuracies. Second, we used weight-based methods, which are more accessible for national and worldwide AMU surveillance, but may be less accurate than the dose-based metrics that are commonly used in human sectors and at the farm level, especially when different antimicrobial types are used [20]. Third, our study focused on specific indicators of AMU data. Further studies should include additional indicators for a comprehensive risk analysis of veterinary AMU.

In conclusion, our findings indicate that significant quantities of antimicrobials were used in the animal

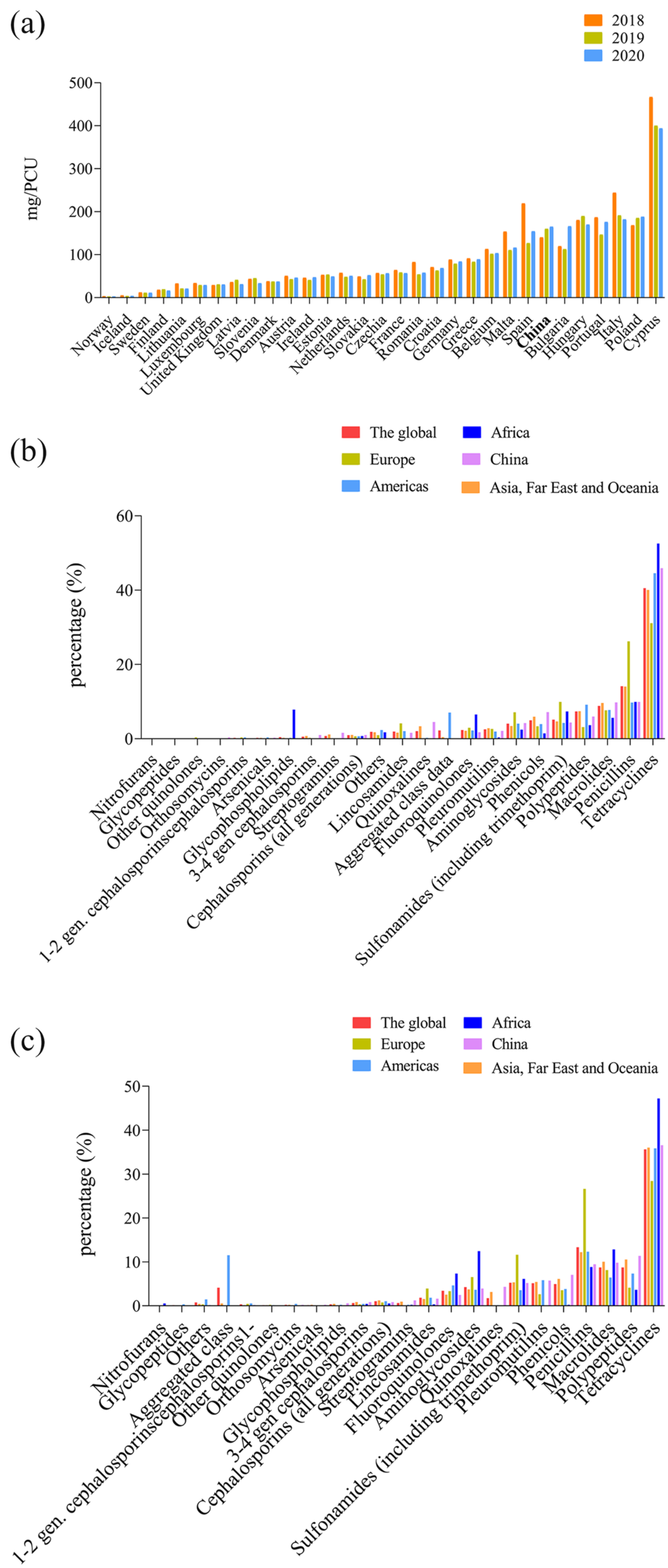

Fig. 4 Comparison of AMU in food animals between China and other countries, categorized by antimicrobial quantities adjusted by animal biomass between China and 31 European countries in 2018–2020 (**a**) and antimicrobial quantities by antimicrobial class between China and some countries in 2018 (**b**) and 2019 (**c**)

production sector in China from 2018–2020. However, these quantities were decreased from those of 2017, when the National Action Plan for Combating Animal AMR was implemented. The notable decrease in AGP use is a positive indication of the effectiveness of this policy. Robust AMU surveillance, including close data collection at the point of use, scientifically sound calculation methodologies, and comprehensive analysis, is crucial. Such national surveillance can provide quantitative information on AMU patterns for analyzing risk, planning AMR surveillance and evaluating the effectiveness of efforts towards prudent use of antimicrobials and mitigation strategies.

Methods

Antimicrobial sales data and product information

China Institute of Veterinary Drug Control (IVDC) and the China Veterinary Drug Association led by MARA provided the veterinary AMU data. We collected sales data from January 2018 to December 2020 that were provided voluntarily with full coverage from both domestic and international veterinary drug manufacturers. Non-overlapping estimations were included in the analysis. The data encompassed terrestrial and aquatic food-producing animals, excluding companion animals. Information on active ingredients and administration route (e.g., powder, bolus, solution, or suspension) was obtained from the IVDC website. Each antimicrobial product's sales data included the license number, antimicrobial class, generic name, administration route, and quantity. AMU data are not classified by species. Total weight of antimicrobial active substances were considered a proxy for AMU on farms.

Animal biomass

To determine animal product weights, we collected animal biomass data from the China Annual Husbandry and Veterinary Yearbook [21–23] and the China Fishery Statical Yearbook [24–26]. These data encompassed pork, beef, mutton, chicken, duck, eggs, milk, and aquaculture. Animal biomass was the denominator when analyzing quantitative AMU data, allowing for comparisons with other national and regional AMU data.

Data analysis

All the calculations were operated by Excel. The quantity of antimicrobial active substance in tons sold for each antimicrobial product presentation was calculated by multiplying the number of packages sold by the strength of the antimicrobial active substance per unit of package, as declared in the corresponding product information. All data were rounded up/down.

Administration routes were categorized into four types. The mixed feeding route included premixes; the water feeding route comprised soluble powders and solutions, and the injection route encompassed injections and powders for injection. Other routes, such as pills, breast infusions, and uterine infusions were classified separately. Antimicrobials such as chlortetracycline, bacitracin, oxytetracycline, kitasamycin, virginiamycin, enramycin, bambermycin, nosiheptide, and avilamycin were prohibited for use as AGPs.

To calculate AMU quantities adjusted by animal biomass in China, we referred to the use of veterinary antimicrobials per ton of animal products in the current year and used the following formula: the total quantity of the antimicrobial agent in grams divided by animal biomass in tons. WOAH's metric was calculated by antimicrobial agents reported (mg) animal biomass (kg) while the indicator applied to express the consumption of veterinary antimicrobials is mg of active substance normalised by the population correction unit in kg (mg/PCU) in EU. Chinese metric can be compared with them to provide a similar order of magnitude as that of other countries. The antimicrobial quantities were classified in the same manner as that of the WOAH for ease of comparison (data for 2018 and 2019).

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s44280-023-00029-5.

Additional file 1: Table S1. Weights of antimicrobials that were consistently used at over 1000 tons in China by year. **Table S2.** Weights of antimicrobials used as AGPs in China (in tons) for 2018–2020.

Acknowledgements

The authors thank the China Veterinary Drug Association and China Agricultural University for their technical and logistical support.

Authors' contributions

Conception and study design: S.X., H.W. and C.W.; Data collection: Q.Z., Z.J.; Statistical analysis: Q.Z., Z.J., T.L., H.S., M.C.; Preparation of first draft: Q.Z., H.W.; Critical review of the manuscript: C. W.; Reading and approval of the final version of the manuscript: all authors.

Funding

This work was supported by a grant from the National Key Research and Development Program of China (grant number 2022YFD1800400).

Declarations

Ethics approval and consent to participate

Not applicable.

Competing interests

The authors have no competing interests to declare regarding the publication of this paper.

Received: 7 July 2023 Revised: 11 October 2023 Accepted: 29 October 2023
Published online: 08 December 2023

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