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Research on Addressing the "Superbug" Crisis: Economic Factors Behind Antibiotic Abuse, Limitations of Existing Policies, and Sustainable Solutions

Shihan Ren

Chongqing DEPU Foreign Language School, Chongqing, China
Renshihan2009@qq.com

Abstract. The discovery and popularization of antibiotics have significantly reduced mortality rates. However, their overuse has given rise to the superbug crisis. Antibiotics work by identifying and utilizing chemical substances produced by microorganisms to inhibit or kill pathogens. Traditional "active screening" has a low hit rate and a high repetition rate, thus, current research is gradually shifting toward "resistance gene guidance + AI-generated models. For instance, AlphaFold2 (protein sequencing) and CRISPR-Cas13 (gene editing) can greatly shorten the screening time and improve efficiency. At the same time, policies are also keeping up. In response to the current situation, through cross-border subsidies and behavioral interventions to mitigate market failures, the advent of the post-antibiotic era can be delayed. The article explores the role of economic stimulus in promoting antibiotic overuse in medical, agricultural, and pharmaceutical sectors, the ineffectiveness of existing policies in curbing drug resistance, and the need for economic system restructuring to address the crisis. It uses models like SIR, 2SLS, RCT, cost-effectiveness time discounting, and Mann-Whitney, and research data from various sources.

Keywords: Antibiotic Abuse, Superbug Crisis, Antimicrobial Resistance (AMR), Economic Incentives, Sustainable Solutions

1. Introduction

The invention of antibiotics was a major breakthrough in the field of medicine in the 20th century. Fleming discovered penicillin in 1929, which reduced the mortality rate of perioperative infections from 11% to 1.3% [1]. The core of this discovery lies in the identification and utilization of chemical substances produced by microorganisms to inhibit or kill pathogens. This significantly reduced the risk of bacterial infections. However, as people became more dependent on antibiotics and the problem of bacterial resistance became increasingly evident, the data showed that the global usage of antibiotics increased by 65% [2,3]. The O'Neill Scenario Model further predicts that if the current rate of antibiotic resistance persists, drug-resistant infections could cause 10 million annual deaths by 2050, with a cumulative GDP loss of USD 10 trillion (at a 3% discount rate) [2]. The increase in the mortality rate of resistant infections by 50%. Experts warn that the world is gradually entering the "post-antibiotic era". The key gap in the research on antibiotic abuse and resistance lies in the

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long-term effects of government intervention and implementation obstacles. This article explores the promotion of antibiotic abuse through economic incentives in medicine, agriculture, and pharmaceuticals. It aims to provide a cross-disciplinary basis for policy-making by examining the mechanisms behind this abuse, the failure of existing policies to curb resistance, and the strategies to reconstruct the economic system. The study uses literature review, case analysis, and comparative research to analyze the current abuse situation, the hazards of resistance, and research gaps. It also examines the impact of economic incentives on the Indian healthcare system and the global livestock industry, and compares the differences in incentives in medical, agricultural, and pharmaceutical fields. The goal is to identify policy failures and provide a basis for economic system reconstruction.

2. Mechanism and effects of antibiotics

2.1. Biological mechanisms of antibiotic resistance

Bacteria can acquire resistance through gene mutations or horizontal gene transfer, the latter referring to genetic exchange between different species or organisms.

There are mainly three types of resistance mechanisms: First, the synthesis of inactivating or modifying enzymes. In this process, bacteria can counteract antibiotics by destroying their structure or directly decomposing them. Bacteria produce β-lactamases, aminoglycoside-modifying enzymes, etc., to decompose antibiotics, or use the function of modifying enzymes to render antibiotics inactive. Second, altering the target sites for antibiotic binding. As functional proteins, target proteins can have their structure or quantity modified by bacteria, preventing antibiotics from binding to them and thus failing to exert their full antibacterial effects. A typical case is the mutation of DNA gyrase, which leads to resistance to quinolone antibiotics. Third, reducing cell membrane permeability and activating efflux pump systems. Gram-negative bacteria that can infect the human intestinal tract, respiratory tract, blood, etc., can directly reduce the permeability of outer membrane porins by changing their pore sizes, hindering the entry of antibiotics into the cell. Mutations or deletions of lipopolysaccharides and porins in the outer membrane also reduce drug permeability, further restricting the entry of antibiotics. Spontaneous efflux of antibiotics out of the cell leads to resistance.

2.2. The effects of antibiotics

The application of antibiotics has brought significant positive effects to global health and production systems: In the medical field, they can effectively inhibit or kill pathogenic bacteria, significantly reducing infection-related mortality (for example, penicillin has reduced the perioperative infection mortality rate from 11% to 1.3%), and can prevent postoperative infections and control the outbreak of infectious diseases such as bacterial pneumonia, providing crucial support for the popularization of surgical procedures and public health emergencies; In the agricultural sector, when used rationally, they can reduce the spread of bacterial diseases in livestock farming, lower the mortality rate of livestock, and ensure the stability of agricultural product supply. These positive values have established their important position, but also gave rise to the crisis of antibiotic resistance due to excessive reliance and abuse. And antibiotic abuse directly exacerbates the negative effects of antibiotic resistance: In terms of health, infections caused by antibiotic-resistant bacteria lead to treatment failure, such as the global treatment success rate of drug-resistant tuberculosis (DR-TB) is only 56%, and the cost of a single treatment is up to 20,000 US dollars. In India in 2021, among the

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120,000 new cases of DR-TB, 32,000 people died due to antibiotic resistance; In terms of public health, antibiotic-resistant bacteria spread through interpersonal contact and food chains (such as in livestock farming abuse), expanding infection ranges and increasing the risk of the "post-antibiotic era; In terms of the economy, it not only increases medical expenditures (such as expensive alternative drugs, prolonging hospital stays), but also impacts agricultural production (such as a 12% reduction in agricultural output in Africa due to antibiotic diseases), resulting in double losses in health and economy. These negative effects are related to the economic incentives distortion in the medical, agricultural, and pharmaceutical fields, highlighting the urgency of controlling abuse.

3. Economic driving factors

3.1. Market distortions and incorrect allocation of incentives

The current medical system is distorted. In many developing countries, such as India, antibiotics have a highly liberal market. Some domestic public hospitals rely excessively on antibiotics, driven by both institutional and patient-related factors. For hospitals, antibiotics have low production costs, high profit margins, and are more cost-effective than medical examinations. For patients, they all have the immediate need to relieve their symptoms. Although antibiotics have no practical effect on viral infections, doctors still prescribe some antibiotics to soothe patients. Hospital bureaucracy further exacerbates the issue: many pharmaceutical representatives promoting antibiotics provide substantial kickbacks to hospital staff [4].. Taking the panel data of 12 state public hospitals in India from 2015 to 2020 as an example, the revenue from antibiotics accounted for 42.7% of the total hospital revenue (IIPS). Among 36 tertiary hospitals, the relative price ratio of third-generation cephalosporins and chest CT was 0.07 ($p < 0.01$), resulting in a 24% increase in the probability of prescriptions [5]. The kickbacks from pharmaceutical representatives accounted for 8-12% of the sales volume, which was estimated using the two-stage least squares method (2SLS), with the instrumental variable being the highway distance from the hospital to the pharmaceutical factory [6].

3.2. The benefit chain of agricultural economy

72.5% of antibiotics worldwide are used in the livestock industry. For farmers, high-density livestock farming carries significant infection risk, once an infection occurs, the economic losses are substantial. Thus, most farmers use antibiotics for disease prevention [7]. This behavior generates negative externalities, where the farmers bear the benefits and gains, but the risk of drug resistance is borne by the entire world population. Growth promoters are also a typical example. Growth promoters increase net profits by 7.3% (SE = 1.1), but they incur a social marginal cost of USD 0.37 per kilogram of live poultry due to diarrhea caused by drug-resistant Campylobacter [8].

3.3. Market failure: information failure and regulation

There is a significant information gap between doctors and patients, ue to differences in medical knowledge. A questionnaire survey of 600 outpatients in Delhi showed that the median score for understanding antibiotic indications was 3.2 out of 10, significantly lower than that of the doctor group at 8.7 (Mann-Whitney $Z = -14.1$, $p < 0.001$) [9]. The regulatory costs for doctors are extremely high. If the country prohibits private sales of antibiotics in pharmacies or makes online drug purchases easy, a black market may arise, raising the price of antibiotics. Moreover, antibiotics are prone to the problem of free riders. A Nash equilibrium analysis of unilateral national bans indicates that if only India implements prescription drug control and neighboring countries do not

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cooperate, the probability of drug-resistant bacteria entering the country remains at 0.64 (SIR cross-border model). In simple terms, if only one country implements strict control, and other countries do not follow suit, the problem of drug resistance still cannot be solved.

4. The basic logic and trends of the pharmaceutical industry

According to the Mondor intelligence industry report (as shown in Figure 1), the market size of antibiotics reached 53.43 billion US dollars in 2024 and is expected to reach 65.22 billion US dollars by 2029, with a growth rate of 4.07% during the forecast period. Centers for Disease Control and Prevention (CDC, 2023) statistics show that the incidence of methicillin-resistant Staphylococcus aureus (MRSA) infections has increased by 46%, and the burden of infectious diseases such as sepsis has also increased [10]. At the same time, Chen et al. the destruction of urban environments has also exacerbated the demand for antibiotics [10]. Mondor intelligence (in Figure 2) has calculated that the investment in antibiotics alone amounts to as much as 53.43 billion US dollars. The World Bank predicts that by 2050, an additional USD 1.2 trillion will be spent globally due to antimicrobial resistance (AMR), calculated at a 3% discount rate and based on 2022 prices. Moreover, it also has hidden economic impacts. African agriculture has declined by 12% because of the prevalence of malaria. Cephalosporins, B-lactam antibiotics, treat various infections caused by Gram-positive and Gram-negative bacteria. However, investment in anti-cancer drug pipelines accounted for 46% of capital allocation, while antibiotics accounted for only 4%. This disparity is due to longer usage periods and higher average prices. Capitalists view antibiotics as lower commercial value and more willing to invest in anti-cancer drugs and chronic diseases [11].

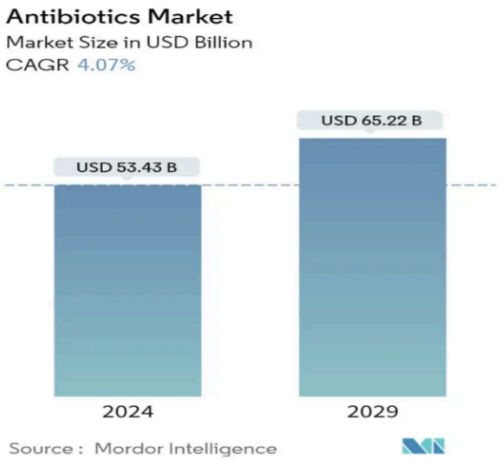

Figure 1. Global market size of antibiotics (2024 - 2029)

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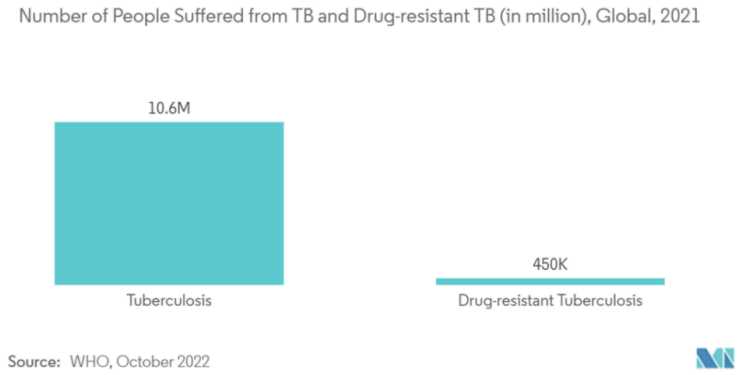

Figure 2. Comparison of the number of tuberculosis patients and drug-resistant tuberculosis patients worldwide in 2021

5. Current challenges and future development directions

Stewart proposed at the American Medical Association annual meeting that "It is time to close the book on infectious diseases", so by the 1980s, this view led many large pharmaceutical companies to incorrectly conclude that existing antibiotics were sufficient to address all infectious diseases [2,12]. But the reality was clearly not so. Whether it was MRSA in the 1950s or the outbreak of sepsis in the United States in 1992, i numerous deaths were attributed to antibiotic resistance. Secondly, the development of new drugs has reached a bottleneck. Antibiotics are drugs with a long research and development cycle and low prices, which means that profit-driven investors cannot achieve high returns from them. Whether it is seeking new targets or improving production efficiency, technology is the primary goal of development. In the long term, the state and government should implement supply-side policies, such as education and healthcare, to raise people's awareness of the harm of antibiotic abuse and reduce market failure caused by insufficient information. Text message intervention reduced self-medication by 9.4%, highlighting the need for regulation and stronger antibiotic control. Doctors should explain hazards and provide evidence-based guidance. Modern technology, like AlphaFold2 and CRISPR-Cas13, shortens lead compound optimization cycles, promoting sustainability [3].

6. Conclusion

In the context of the world gradually approaching the "post-antibiotic era", this article systematically analyzes how the distorted economic incentives in the "medical, agricultural, and pharmaceutical" sectors drive the abuse of antibiotics and the spread of antibiotic resistance. Based on cross-border data and various measurement models, it proposes a s system restructuring framework of "simultaneous regulation + subscription procurement + AI new drugs" to address the tragedy of the commons and achieve sustainable antibacterial control. Antibiotics have high commercial value, being both high income and low cost. For agriculture, they can significantly increase yield on a large scale. In the pharmaceutical industry, they require relatively low R&D investment for stable returns. These three aspects jointly contribute to the "super bacteria" crisis. Various countries have attempted intervention before, but single-country regulation has achieved limited results. It is prone to "free rider" problems. Due to information gaps and the emergence of black markets, management costs have even increased. For the future, we should combine simultaneous regulation + subscription procurement + AI new drugs. The article's shortcomings lie in the lack of data, lack of real-time

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information, and the absence of policy evaluation. Although "subscription procurement" is proposed, there are a lack of pilot project data and cost-benefit analyses. Later, a pilot of "subscription procurement" can be conducted in 1-2 countries, using cost-benefit and QALY to quantify the effectiveness, and additional data can be supplemented to improve the effectiveness.

References

[1] World Health Organization. 2022. Global Consumption of Antibiotics 2010–2020: Analysis Report. Geneva: WHO.
[2] O'Neill J. 2016. Tackling Drug-Resistant Infections Globally: Final Report and Recommendations. London: Review on Antimicrobial Resistance.
[3] Fleming A. 1929. On the antibacterial action of cultures of a penicillium, with special reference to their use in the isolation of B. influenzae [J]. British Journal of Experimental Pathology, 10(3): 226-236.
[4] International Institute for Population Sciences (IIPS). 2021. National Health Accounts Estimates for India 2015–2020. Mumbai: IIPS.
[5] Kumar S, Chaudhuri S. 2022. Relative price and antibiotic prescriptions: evidence from Indian public hospitals [J]. Health Economics, 31(9): 2143-2157.
[6] Reddy P. 2023. Access and influence: highway distance as an instrument for antibiotic rebates in India [J]. Journal of Development Economics, 160: 103036.
[7] World Bank. 2019. The Economic Cost of Antimicrobial Resistance in Low- and Middle-Income Countries. Washington, DC: World Bank.
[8] Sharma A, Singh R, Mehta P. 2023. Knowledge gap between patients and physicians on antibiotic indications: a cross-sectional survey in Delhi [J]. Journal of Antimicrobial Chemotherapy, 78(5): 1234-1241.
[9] Van Boeckel T P, Brower C, Gilbert M, et al. 2017. Global trends in antimicrobial use in food animals [J]. Proceedings of the National Academy of Sciences, 114(15): 3647-3652.
[10] Chen L, Wang Y, et al. 2024. Urban environmental degradation and the rising burden of febrile illnesses: a multicountry analysis [J]. Lancet Planet Health, 8(4): e267-e275.
[11] IQVIA Institute. 2024. Global Trends in R&D 2024: Activity, Productivity, and Enablers. Research Triangle Park: IQVIA.
[12] Mann J M. AIDS in the World [M]. Cambridge, Massachusetts: Harvard University Press, 1992. 825−839.
[13] Bax R P. Antibiotics Resistance: A View from the Pharmaceutical Industry [J]. Clinical Infectious Diseases, 1997, 24 (Suppl.): 5151−5153.
[14] Banerjee A, Duflo E, et al. 2024. SMS nudges and antibiotic misuse: evidence from a randomized controlled trial in India [J]. Lancet Global Health, 12(3): e345-e353.
[15] Collins J J, Liu T, et al. 2024. Accelerating antimicrobial peptide discovery via AlphaFold2-CRISPR-Cas13 integrated platform [J]. Nature Biotechnology, 42(5): 712-720.