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Superbugs Unleashed: Is Time Running Out to Stop the Global Infection Crisis?

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The global infection crisis poses a significant threat to public health, with the emergence and spread of antibiotic-resistant bacteria or "superbugs" becoming a major concern. The crisis has been fueled by various factors, including the overuse of antibiotics, inadequate infection prevention and control measures, and the lack of investment in research and development of new treatments. Addressing this issue requires a comprehensive approach that involves improving surveillance and monitoring systems, promoting individual responsibility, and investing in research and development. Collaboration between stakeholders, including governments, healthcare providers, researchers, and the public, is crucial in overcoming the challenges posed by the global infection crisis. Despite promising advances in emerging technologies, sustained investment in research and development is necessary to ensure continued progress in addressing the issue. Failure to take action risks a future where superbugs run rampant and existing treatments become ineffective. It is time to act decisively to halt the spread of superbugs and prevent a global health crisis.

Keywords: Global Infection Crisis, Superbugs, Antibiotic Resistance, Surveillance and Monitoring, Research and Development, Collaboration, Individual Responsibility

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Introduction

Superbugs refer to bacteria that have become resistant to multiple antibiotics and are difficult, if not impossible, to treat with traditional antibiotic therapies.[1] This phenomenon has led to a global infection crisis, where common bacterial infections that were once easily treatable are now becoming increasingly difficult to manage, resulting in higher rates of morbidity and mortality.[2]

The rise of superbugs poses a significant threat to global health and calls for urgent action. In recent years, the number of infections caused by superbugs has been increasing at an alarming rate, with some estimates suggesting that antibiotic-resistant infections could become the leading cause of death worldwide by 2050.[3] The problem is further exacerbated by the lack of new antibiotics being developed, as well as the overuse and misuse of antibiotics, which has contributed to the development of antibiotic-resistant bacteria. [4]

The global infection crisis has far-reaching consequences that extend beyond individual patient outcomes. It has significant economic and social impacts, with increased healthcare costs and lost productivity, as well as potential implications for national security and global health security.[5] The threat of a global pandemic caused by a superbug is also a real concern, as evidenced by the recent COVID-19 pandemic. [6]

In light of these challenges, urgent action is needed to address the global infection crisis and the rise of superbugs. This may involve developing new antibiotics and alternative treatments, promoting responsible use of antibiotics, improving infection prevention and control measures, and increasing public awareness and engagement. Collaboration and partnerships across sectors and national borders will also be crucial in addressing this complex and multifaceted issue. [7]

Therefore, this paper argues that the global infection crisis is a pressing issue that requires immediate attention and collaborative action. Through increased awareness and engagement, investment in research and development, and a coordinated global response, we can work towards mitigating the impacts of superbugs and protecting global health.

Superbugs are bacteria that have developed resistance to multiple antibiotics and are difficult to treat. They are also known as multidrug-resistant organisms (MDROs). [1] These bacteria are different from regular bacteria because they have developed mechanisms that make them resistant to the antibiotics that were once effective in killing them.

The emergence of several factors, including the overuse and misuse of antibiotics, can lead to the development of antibiotic-resistant bacteria. In addition, the lack of new antibiotics being developed has created a situation where bacteria have evolved faster than new drugs can be discovered. [2]

Another factor contributing to the emergence of superbugs is the widespread use of antibiotics in livestock farming. Antibiotics are often used as growth promoters and to prevent infections in animals, but this can lead to the development of antibiotic-resistant bacteria that can spread to humans through the food chain or direct contact with animals. [8]

Examples of superbugs include Methicillin-resistant Staphylococcus aureus (MRSA), which is a type of staph bacteria that is resistant to several antibiotics and can cause serious infections such as pneumonia, bloodstream infections, and skin infections.[9]Another example is Klebsiella pneumoniae, which can cause infections such as pneumonia, bloodstream infections, and urinary tract infections and has become increasingly resistant to antibiotics.[10]

Superbugs have a significant impact on human health, with infections caused by these bacteria leading to increased morbidity and mortality rates. In addition, the treatment of these infections is often more expensive and can result in longer hospital stays. [11] The economic and social impacts of superbugs are also significant, with increased healthcare costs and lost productivity due to illness and death.

The emergence of superbugs is a complex issue with significant consequences for human health and the global economy. Addressing the problem will require a multifaceted approach that includes the responsible use of antibiotics, the development of new antibiotics and alternative treatments, improved infection prevention and control measures, and increased public awareness and engagement.

The Global Infection Crisis

1.1The scale of the problem and its impact on healthcare systems

The rise of superbugs has resulted in a global infection crisis that poses a significant threat to public health. According to the World Health Organization (WHO), antimicrobial resistance (AMR) is a growing public health threat that could cause up to 10 million deaths by 2050 if no action is taken. [1] In addition, the impact of AMR is not limited to human health but also affects animal health, agriculture, and the environment. Superbugs have made it more challenging to treat infectious diseases, leading to increased morbidity and mortality rates, longer hospital stays, and higher healthcare costs. [12]

1.2 The economic and social costs of the infection crisis

The global infection crisis has significant economic and social costs, including increased healthcare costs, lost productivity, and a strain on healthcare systems. The cost of treating infections caused by antibiotic-resistant bacteria is higher than those caused by susceptible bacteria, resulting in increased healthcare spending and a burden on already stretched healthcare systems. [13] In addition, the global economic burden of AMR is estimated to be $2.9 trillion by 2050, with the potential to affect food security and global trade. [14]

1.3 The implications of failing to address the issue

The failure to address the issue of superbugs and AMR could have significant implications for public health, the economy, and global security. The spread of superbugs could make it more challenging to control infectious diseases and could lead to pandemics that could affect global security. [15] In addition, the economic and social costs of AMR could have a significant impact on global development and could lead to increased poverty and inequality.[16]

2. The Need For Urgent Action

2.1The role of governments and policymakers in addressing the issue

Governments and policymakers play a critical role in Addressing the issue of superbugs and AMR. They can implement policies and regulations to reduce the overuse and misuse of antibiotics, improve infection prevention and control measures, and promote the development of new antibiotics and alternative treatments. [17]

2.2 Strategies for tackling the spread of superbugs

Strategies for tackling the spread of superbugs include promoting responsible use of antibiotics, improving infection prevention and control measures, investing in research and development for new antibiotics and alternative treatments, and improving surveillance and monitoring of AMR. [18]

2.3The importance of research and development in finding new antibiotics and alternative treatments

Research and development are crucial in finding new antibiotics and alternative treatments for infectious diseases. The development of new antibiotics has slowed, and there is a need for increased investment in research and development to find new drugs that can combat superbugs.[2] In addition, alternative treatments, such as phage therapy, immunotherapy, and microbiome therapy, have shown promise in treating infectious diseases and should be explored further.[19]

The global infection crisis caused by superbugs and AMR requires urgent action from governments, policymakers, healthcare providers, and the public. Strategies for tackling the issue include promoting responsible use of antibiotics, improving infection prevention and control measures, investing in research and development for new antibiotics and alternative treatments, and improving surveillance and monitoring of AMR.

3. The Role Of Healthcare Workers

The importance of infection control and prevention in healthcare settings cannot be overstated. Healthcare workers play a critical role in preventing the spread of superbugs, and strategies must be implemented to reduce the spread of these infections in hospitals and other healthcare facilities. The World Health Organization has identified hand hygiene, appropriate use of personal protective equipment, and effective environmental cleaning as essential components of infection control and prevention measures in healthcare settings. [20]

Education and training for healthcare workers are crucial in the fight against superbugs. Healthcare workers must be informed about the risks associated with antibiotic overuse and the importance of appropriate antimicrobial stewardship. Studies have shown that education and training programs can significantly reduce the incidence of healthcare-associated infections and antibiotic-resistant infections.[21]

4. The Global Response to Superbugs

International efforts to address the issue of superbugs have gained momentum in recent years. The World Health Organization's Global Action Plan on Antimicrobial Resistance outlines five strategic objectives to tackle the spread of superbugs: improving awareness and understanding of antimicrobial resistance, strengthening surveillance and research, reducing the incidence of infection, optimizing the use of antimicrobial agents, and ensuring sustainable investment in countering antimicrobial resistance.[17]

Collaborations and partnerships are also playing a critical role in developing solutions to the global infection crisis. For example, the Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator (CARB-X) is a global partnership that provides funding and support for the development of new antibiotics and alternative therapies.[22]

Several successful interventions and initiatives have been implemented around the world to address the spread of superbugs. Examples include the UK government's five-year antimicrobial resistance strategy, which includes goals for reducing inappropriate antibiotic prescribing, and Australia's national antimicrobial resistance strategy, which includes measures to improve infection prevention and control, optimize prescribing practices, and promote research and development. [23,24]

5. Public Awareness And Advocacy

Greater public awareness of the threat of superbugs and the infection crisis is essential to driving action on this issue. Efforts to raise awareness and promote advocacy can help engage the public in the fight against superbugs and generate support for policy changes and funding for research and development. Successful public awareness campaigns and advocacy efforts have been implemented in several countries.

For example, the European Antibiotic Awareness Day, which takes place every year on November 18th, aims to raise awareness of the risks associated with antibiotic overuse and promote responsible antibiotic use. [25] In the United States, the Centers for Disease Control and Prevention's Get Smart About Antibiotics Week is an annual observance aimed at promoting the appropriate use of antibiotics. [26]

New technologies and approaches are emerging that hold promise for addressing the problem of superbugs. For example, CRISPR-Cas9 gene editing technology has shown potential for developing new antibiotics and alternative therapies.[27] Other technologies, such as phage therapy and immunotherapy, are also being explored as potential solutions to the global infection crisis. [28]

Continued investment in research and development is essential to the fight against superbugs. This includes investment in basic science research, clinical research, and the development of new antibiotics and alternative therapies. A coordinated, global response to the infection crisis is also critical to ensuring that solutions are developed and implemented effectively.

Overall, the rise of superbugs poses a significant threat to global health and calls for urgent action. The implications of failing to address the issue are profound, and strategies must be implemented at the local, national, and global levels to prevent the spread of these dangerous infections. Through a coordinated, collaborative approach involving healthcare workers, policymakers, researchers, and the public, it is possible to address the global infection crisis and safeguard the health of current and future generations.

7. The Impact On Vulnerable Populations

Superbugs and the infection crisis have a disproportionate impact on vulnerable populations such as the elderly, children, and people with compromised immune systems. For example, older adults are more likely to have weakened immune systems and are often hospitalized, putting them at increased risk for healthcare-associated infections. [29] Similarly, young children are at higher risk for infections and are more likely to receive antibiotics, which can contribute to the development of antibiotic-resistant bacteria.[30]

Strategies for protecting vulnerable populations and improving access to healthcare services include the development and implementation of infection prevention and control measures, appropriate use of antibiotics, and vaccination programs.[31] Additionally, efforts to improve access to healthcare services, particularly in underserved areas, can help to ensure that vulnerable populations receive timely and appropriate care.

8. The Environmental Impact

The environment plays a role in the development and spread of superbugs. Human activities, such as agriculture and waste management, can contribute to the selection and spread of antibiotic-resistant bacteria.[32] For example, the use of antibiotics in livestock and poultry farming can lead to the emergence and spread of antibiotic-resistant bacteria that can be transmitted to humans through the food chain.[33] Similarly, improper disposal of antibiotics and other pharmaceuticals can contribute to the spread of antibiotic-resistant bacteria in the environment.[34]

Strategies for reducing environmental factors that contribute to the spread of superbugs include the implementation of regulations and guidelines for the appropriate use of antibiotics in agriculture and waste management, as well as the development of alternative approaches to these activities that reduce the use of antibiotics.[35]

9. The Economic Implications

The global infection crisis has significant economic costs, including healthcare costs and lost productivity. For example, the direct healthcare costs associated with healthcare-associated infections in the United States alone are estimated to be between $28 billion and $45 billion annually. [36] Additionally, the global economic impact of antibiotic-resistant infections is projected to be as high as $100 trillion by 2050. [37]

Economic incentives can drive investment in research and development of new antibiotics and alternative treatments. For example, public-private partnerships, tax incentives, and patent extensions can encourage pharmaceutical companies to invest in the development of new treatments. [38]

10. Ethical Considerations

The global infection crisis has ethical implications, Such as access to healthcare services and the responsibility of governments and pharmaceutical companies to address the issue. The unequal distribution of healthcare services and resources can result in disparities in access to care, particularly for vulnerable populations.[39] Additionally, the responsibility of governments and pharmaceutical companies to address the issue of superbugs is a matter of ethical consideration. [40]

The importance of ethical considerations in developing policies and strategies for addressing the global infection crisis is critical to ensuring that solutions are equitable and accessible to all populations.

11. Overcoming Barriers To Action

There are several barriers to action on the global infection crisis, such as political and economic factors. For example, the development of new antibiotics and alternative treatments is costly and time-consuming, and the potential profitability of these treatments may not be sufficient to encourage investment by pharmaceutical companies. [2]

Partnerships and collaborations can help to overcome these barriers and drive action on the issue. For example, public-private partnerships can bring together the resources and expertise of governments, pharmaceutical companies, and other stakeholders to address the global infection crisis. [41] Additionally, international collaborations can help to coordinate efforts and promote the sharing of knowledge and resources to address the issue.

12. One Health Approach

The concept of a "One Health" approach recognizes the interconnectedness of human, animal, and environmental health in addressing the global infection crisis.[42] The approach emphasizes collaboration between human and veterinary healthcare providers and the integration of environmental health considerations to promote holistic and effective responses to emerging infectious diseases. One Health has been successfully implemented in several countries, including the United States, where it has been used to address issues such as foodborne illness and zoonotic diseases. [43]Strategies for implementing a One Health approach include the development of interdisciplinary teams and partnerships between

Human and veterinary healthcare providers and the integration of environmental health considerations into healthcare policies and practices. [44]Additionally, One Health initiatives can focus on addressing the root causes of emerging infectious diseases, such as the degradation of natural habitats and changes in land use, which can increase the risk of zoonotic disease transmission. [45]

13. The Importance Of Surveillance And Monitoring

Robust surveillance and monitoring systems are critical for tracking the emergence and spread of superbugs and identifying potential outbreaks.[46] These systems can also help to identify trends in antibiotic resistance, guide the development of effective prevention and control strategies. The Role of data sharing and collaboration in strengthening surveillance and monitoring efforts is also crucial. [47]

Efforts to strengthen surveillance and monitoring systems include the development of national and international surveillance networks, the use of advanced diagnostic technologies, and the establishment of protocols for sharing data between countries and across sectors.[47]

14. Personal Responsibility And Action

Individual actions play a critical role in preventing the spread of superbugs. Strategies for promoting individual responsibility and engagement in addressing the global infection crisis include promoting hand hygiene, responsible use of antibiotics, and vaccination. [48] Additionally, education and awareness campaigns can help to Raise Public Awareness About The Issue And Encourage Behavior Change.

15. Future Challenges And Opportunities

The challenges and opportunities that lie ahead in addressing the global infection crisis include the potential for emerging technologies and the need for sustained investment in research and development. The development of new diagnostic tools, therapies, and vaccines, as well as advances in data analytics and artificial intelligence, offer promising opportunities for addressing the issue.[49]However, sustained investment in research and development is necessary to ensure continued progress in addressing the issue. Ongoing dialogue and collaboration between stakeholders, Including healthcare providers, policymakers, researchers, and the public, will be crucial to identify and address emerging challenges.[7]

Conclusion

In conclusion, the global infection crisis poses a significant threat to public health and requires urgent action at local, national, and international levels. The emergence and spread of superbugs, driven by factors such as overuse of antibiotics and poor infection control practices, highlight the need for a coordinated and multidisciplinary approach to address the issue. The One Health approach, which recognizes the interconnectedness of human, animal, and environmental health, provides a framework for such an approach.

Efforts to address the global infection crisis require sustained investment in research and development, as well as the development of robust surveillance and monitoring systems to track the emergence and spread of superbugs. Partnerships and collaborations between governments, pharmaceutical companies, and other stakeholders can help to overcome barriers to action and drive progress on the issue.

Individual actions, such as hand hygiene, responsible use of antibiotics, and vaccination, play a critical role in preventing the spread of superbugs. Strategies for promoting individual responsibility and engagement in addressing the global infection crisis, including education and awareness campaigns, can help to raise public awareness about the issue and encourage behaviour change.

The challenges and opportunities that lie ahead in addressing the global infection crisis require ongoing dialogue and collaboration between stakeholders. Emerging technologies, such as new diagnostic tools, therapies, and vaccines, as well as advances in data analytics and artificial intelligence, offer promising opportunities for addressing the issue. The continued progress in addressing the global infection crisis depends on sustained investment in research and development and the continued engagement of all stakeholders to identify and address emerging challenges.

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References

1. World Health Organization. Antimicrobial Resistance;2021. Available from: https://www. who. *int/health-topics/antimicrobial-resistance#tab=tab_1. [Last accessed on 2023 Apr18] [Crossref][PubMed][Google Scholar]*

2. Ventola CL. The antibiotic resistance crisis: part 1: causes and threats. P T. 2015;4:277-83. *[Crossref][PubMed][Google Scholar]*

3. Review on Antimicrobial Resistance. Tackling drug-resistant infections globally: final report and recommendations;2016. https://amrreview. org/sites/default/files/160518_Final%20paper_with %20cover. *pdf [Last accessed on 2023 Apr18] [Crossref][PubMed][Google Scholar]*

4. World Health Organization. Antibiotic Resistance. Available from: https://www. who. *int/news-room/fact-sheets/detail/antibiotic-resistance. [Last accessed on 2023 Apr18] [Crossref][PubMed] [Google Scholar]*

5. Centers for Disease Control and Prevention. Antibiotic Resistance Threats in the United States;2019. Available from: https://www. cdc. *gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf. [Last accessed on 2023 Apr18] [Crossref][PubMed][Google Scholar]*

6. World Health Organization. COVID-19 and Antimicrobial Resistance. Available from: https://www. who. *int/health-topics/coronavirus/antimicrobial-resistance. /.[Last accessed on 2023 Apr 14] [Crossref][PubMed] [Google Scholar]*

7. O'Neill J. Tackling drug-resistant infections globally: final report and recommendations. The review on antimicrobial resistance;2016. Available from: https://wellcomecollection. *org/works/thvwsuba/.[Last accessed on 2023 Apr 20] [Crossref][PubMed][Google Scholar]*

8. Food and Agriculture Organization of the United Nations. Antimicrobial Resistance in the Food Chain;2019 Available from: http://www. fao. org/antimicrobial-resistance/key-action-areas/food-chain/en/. *[Last accessed on 2023 Apr 14] [Crossref][PubMed][Google Scholar]*

9. Centers for Disease Control and Prevention. Methicillin-resistant Staphylococcus aureus (MRSA);2023 Available from: https://www. cdc. gov/mrsa/index. *html. /.[Last accessed on 2023 Apr 14] [Crossref][PubMed][Google Scholar]*

10. World Health Organization. Global Priority List of Antibiotic-resistant Bacteria to Guide Research, Discovery, and Development of New Antibiotics. Available from: https://www. who. *int/medicines/publications/global-priority-list-antibiotic-resistant-bacteria/en/.[Last accessed on 2023 Apr 19] [Crossref][PubMed][Google Scholar]*

11. Centers for Disease Control and Prevention. Antibiotic Resistance Threats in the United States;2019. Available from: https://www. cdc. *gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf. [Last accessed on 2023 Apr 24] [Crossref][PubMed][Google Scholar]*

12. Laxminarayan R, Duse A, Wattal C, et al. Antibiotic resistance—the need for global solutions. Lancet Infect Dis. 2013 ;12:1057-98. *[Crossref] [PubMed][Google Scholar]*

13. Howard SJ, Catchpole M, Watson J, et al. Antibiotic resistance: global response needed. Lancet Infect Dis. 2013;12:1001-3. *[Crossref] [PubMed][Google Scholar]*

14. O'Neill J. Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations. Review on Antimicrobial Resistance 2014;1-16. . *[Crossref] [PubMed][Google Scholar]*

15. Morens DM, Folkers GK, Fauci AS. The challenge of emerging and re-emerging infectious diseases. Nature. 2004 ;6996:242-9. *[Crossref][PubMed] [Google Scholar]*

16. Bloom DE, Black S, Rappuoli R. Emerging infectious diseases: a proactive approach. Proc Natl Acad Sci U S A 2017 ;16:4055-9. . *[Crossref] [PubMed][Google Scholar]*

17. World Health Organization. Global Action Plan on Antimicrobial Resistance. Available from: https://www. who.

Int/publications/i/item/9789241509763. [Last accessed on 2023 Apr 24] [Crossref][PubMed] [Google Scholar]

18. Centers for Disease Control and Prevention. Antibiotic Resistance Threats in the United States:2019. Available from: https://www. cdc. *gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf. [Last accessed on 2023 Apr 22] [Crossref][PubMed][Google Scholar]*

19. Pehrsson EC, Tsukayama P, Patel S, et al. Interconnected microbiomes and resistomes in low-income human habitats. Nature 2016 ;7602:212-6. . *[Crossref][PubMed][Google Scholar]*

20. World Health Organization. WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care Is Safer Care. Geneva: World Health Organization; 2009. Available from https://www. *who.int/publications/i/item/9789241597906 [Last accessed on 2023 Apr 22] [Crossref][PubMed] [Google Scholar]*

21. Chen Y, Sheng WH, Wang JT, et al. Effectiveness and limitations of hand hygiene promotion on decreasing healthcare-associated infections. PLoS One 2011;11: e27163. . *[Crossref][PubMed][Google Scholar]*

22. The Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator (CARB-X). . . . *[Crossref][PubMed][Google Scholar] [Crossref] [PubMed][Google Scholar]*

23. org/about/overview/ [Last Accessed on 2023 April 20]. . . . *[Crossref][PubMed][Google Scholar] [Crossref][PubMed][Google Scholar] [Crossref] [PubMed][Google Scholar]*

24. HM Government. UK 5 Year Action Plan for Antimicrobial Resistance 2019 to 2024. London: HM Government; 2019. Available from: https://www. *gov.uk/government/publications/uk-5-year-action-plan-for-antimicrobial-resistance-2019-to-2024. [Last accessed on 2023 Apr 22] [Crossref][PubMed] [Google Scholar]*

25. Australian Government. National Antimicrobial Resistance Strategy 2020 and Beyond. Canberra: Department of Health; 2020. Available from: https://www1. *health.gov.au/internet/main/publishing.nsf/Content/ohp-antimicrobial-2019.htm. [Last Accessedon 2023 April 20] [Crossref][PubMed][Google Scholar]*

26. European Centre for Disease Prevention and Control. European Antibiotic Awareness Day (EAAD). Stockholm: ECDC;2022. Available from: https://www. *ecdc.europa.eu/en/antimicrobial-resistance-and-consumption/european-antibiotic-awareness-day. [Last accessed on 2023 Apr 20] [Crossref][PubMed][Google Scholar]*

27. Centers for Disease Control and Prevention. Get Smart About Antibiotics Week. Atlanta: CDC; 2021. Available from: https://www. *cdc.gov/antibiotic-use/week/index.html. [Last accessed on 2023 Apr 20] [Crossref][PubMed][Google Scholar]*

28. Citorik RJ, Mimee M, Lu TK. Sequence-specific antimicrobials using efficiently delivered RNA-guided nucleases. Nat Biotechnol2014;11:1141-5. . *[Crossref][PubMed][Google Scholar]*

29. Fauconnier A. Phage therapy regulation: from night to dawn. Viruses 2019;4:352. . *[Crossref] [PubMed][Google Scholar]*

30. World Health Organization. Antimicrobial resistance: global report on surveillance 2014. Geneva: World Health Organization; 2014. Available from: https://www. *who.int/antimicrobial-resistance/publications/surveillancereport/en/ [Last accessed on 2023 Apr 24] [Crossref][PubMed] [Google Scholar]*

31. Tängdén T, Cars O, Melhus Å, Löwdin E. Foreign travel is a major risk factor for colonization with Escherichia coli producing CTX-M-type extended-spectrum β-lactamases: a prospective study with Swedish volunteers. Antimicrob Agents Chemother 2010 ;12:3564-8. . *[Crossref][PubMed][Google Scholar]*

32. Graham JP, Boland JJ, Silbergeld E. Growth promoting antibiotics in food animal production: an economic analysis. Public Health Rep 2007 ;1:79-87. . *[Crossref][PubMed][Google Scholar]*

33. Pruden A, Arabi M, Storteboom HN. Correlation between upstream human activities and riverine antibiotic resistance genes. Environ Sci Technol 2012 ;14 :11541-9. . *[Crossref][PubMed][Google Scholar]*

34. Review on Antimicrobial Resistance. Tackling drug-resistant infections globally: final report and recommendations. London: Review on Antimicrobial Resistance; 2016. Available from: https://amrreview.

Org/sites/default/files/160525_Final%20paper_with %20cover.pdf [Last accessed on 2023 Apr 24] [Crossref][PubMed][Google Scholar]

35. World Bank. Drug-resistant infections: a threat to our economic future. Washington, DC: World Bank; 2017. Available from: https://www. *worldbank.org/en/topic/health/brief/drug-resistant-infections-a-threat-to-our-economic-future [Last accessed on 2023 Apr 24] [Crossref][PubMed] [Google Scholar]*

36. Littmann J, Viens AM. The ethical significance of antimicrobial resistance. Public Health Ethics 2015;3: 209-24. . *[Crossref][PubMed][Google Scholar]*

37. Emanuel EJ, Persad G, Upshur R,et al. Fair allocation of scarce medical resources in the time of Covid-19. N Engl J Med 2020 ;21:2049-55. . *[Crossref][PubMed][Google Scholar]*

38. Hoffman SJ, Outterson K. What will it take to address the global threat of antibiotic resistance? J Law Med Ethics 2015;3:363-8. . . *[Crossref] [PubMed][Google Scholar] [Crossref][PubMed] [Google Scholar]*

39. Laxminarayan R, Matsoso P, Pant S, et al. Access to effective antimicrobials: a worldwide challenge. Lancet 2016;10014:168-75. . *[Crossref] [PubMed][Google Scholar]*

40. Pittet D, Donaldson L, Clean Care is Safer Care programme, WHO. Clean care is safer care: a worldwide priority. Lancet. 2005 ;9493:1246-47. *[Crossref][PubMed][Google Scholar]*

41. Hoffman SJ, Outterson K, Røttingen J-A. Towards global collective action on antimicrobial resistance. Lancet Infect Dis 2015;11:1252-58. . *[Crossref][PubMed][Google Scholar]*

42. Outterson K, McDonnell A, Cox E. Clustering strategies for antibiotic conservation. In: VanDeveer S, editor. The Palgrave Handbook of the International Political Economy of Energy. *London: Palgrave Macmillan UK; 2016.1-28 [Crossref] [PubMed][Google Scholar]*

43. One Health Initiative. About the One Health Initiative [Internet]. [place unknown]: One Health Initiative; [date unknown]. Available from: https://www. *onehealthinitiative.com/about.php [Last accessed on 2023 Apr 24] [Crossref][PubMed] [Google Scholar]*

44. American Veterinary Medical Association. One Health: A New Professional Imperative [Internet]. [place unknown]: American Veterinary Medical Association. Available from: https://www. *avma.org/resources-tools/one-health [Last accessed on 2023 Apr 23] [Crossref][PubMed][Google Scholar]*

45. World Health Organization. One Health [Internet]. Geneva: World Health Organization; 2018. Available from: https://www. *who.int/news-room/q-a-detail/one-health. [Last accessed on 2023 Apr 23] [Crossref][PubMed][Google Scholar]*

46. Gibbs EPJ. The evolution of One Health: A decade of progress and challenges for the future. Vet Rec 2014;4:85-91. . *[Crossref][PubMed][Google Scholar]*

47. Centers for Disease Control and Prevention. Antibiotic Resistance & One Health [Internet]. Atlanta (GA): Centers for Disease Control and Prevention; 2022. Available from: https://www. *cdc.gov/drugresistance/one-health.html [Last accessed on 2023 Apr 23] [Crossref][PubMed] [Google Scholar]*

48. World Health Organization. Global Action Plan on Antimicrobial Resistance [Internet]. Geneva: World Health Organization; 2015. Available from: https://www. *who.int/publications/i/item/9789241509763 [Last accessed on 2023 Apr 23] [Crossref][PubMed] [Google Scholar]*

49. Centers for Disease Control and Prevention. Antibiotic resistance threats in the United States, 2019 [Internet]. Atlanta (GA): Centers for Disease Control and Prevention; 2021. Available from: https://www. *cdc.gov/drugresistance/biggest-threats.html [Last accessed on 2023 Apr 23] [Crossref][PubMed][Google Scholar]*

50. World Health Organization. Global antimicrobial resistance surveillance system (GLASS) report: Early implementation 2020 [Internet]. Geneva: World Health Organization; 2019. Available from: https://www. *who.int/publications/i/item/9789240005583 [Last accessed on 2023 Apr 23] [Crossref][PubMed] [Google Scholar]*