OPINION EDITORIAL

Antimicrobial Resistance: A Bottleneck in the Achievement of the United Nations' Sustainable Development Goals

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INTRODUCTION

Now one of the top ten threats to global health, antimicrobial resistance (AMR), a phenomenon whereby microbes become resistant to therapeutic drugs, may launch humanity to a pre-antibiotic era and hinder treatment of common clinical conditions, leading to broader public health and economic challenges [1,2]. It is estimated that infections caused by drug-resistant microbes will cost the equivalent of $100 trillion USD and cause 10 million deaths per year by 2050 [3,4]. The AMR crisis has been exacerbated by systematic misuse and overuse of antibiotics in clinical, industrial, and agricultural settings [5]. In a society marked by transnational food production systems and trading of goods and services, medical tourism, and frequent human travel, resistant organisms spread rampantly [6–8]. The multi-sectoral, transboundary nature of the AMR crisis mandates urgent, coordinated action from all sectors nationally and internationally. This article outlines the impact of AMR on global development, reviews current barriers to reducing AMR, and suggests critical points of intervention.

AMR IMPEDES ACHIEVEMENT OF THE UN SDGs

Despite the growing threat of AMR on global health and development, it is not mentioned within the current goals, targets, and indicators of the United Nations' (UN) Sustainable Development Goals (SDGs) [9]. Yet, AMR impacts the achievement of SDGs. Most apparently, infections caused by resistant pathogens hamper good health and well-being globally (SDG 3) and result in increased mortality and morbidity. Antibiotics, when used judiciously, are vital to reducing maternal mortality, reducing the under-five child mortality rate, and controlling the spread of communicable diseases [10]. Moreover, antibiotics have made possible the prevention and control of infection during cancer treatment and organ transplantation [11].

The impacts of AMR extend beyond health metrics. AMR hampers sustainable economic growth (SDG 8) and poverty alleviation (SDG 1). One estimate suggests that widespread AMR would cause a 3.8% dip in the global gross domestic product by 2050 and launch an additional 24.1 million people into extreme poverty by 2030 [12]. Unsurprisingly, 18.7 million of those impacted would be from low-income countries, exacerbating current global inequities (SDG 10). AMR will continue to disproportionately impact low- and middle-income countries (LMICs) – especially those burdened with high transmission of communicable diseases, lack of affordable treatment options, and weak hygiene and sanitation systems [1,13].

The overuse and misuse of antibiotics, along with the growing intensification of agricultural practices, raise concerns about the emergence of AMR within the food production sector [14]. The spread of drug-resistant pathogens would not only keep antimicrobial resistant organisms (AMROs) within food chains, but also contribute to loss of livestock and animal protein (SDG 2).

Given these complex interlinkages, we conceptualize AMR as an "SDG bottleneck" as it impedes the achievement of targets across goals

[15]. Therefore, reducing AMR is intricately linked with the progression of the SDGs.

BARRIERS TO ALLEVIATING AMR

AMR continues to spread due to: i) a lack of sufficient research and development (R&D) on new antibiotics [16]; ii) over-prescription of antibiotics [17]; iii) lack of consumer and prescriber awareness [18]; iv) over-the-counter purchase of antibiotics and self-medication [19,20]; v) over-medicated livestock [21]; vi) lack of hygiene and sanitation [13]; and vii) environmental contamination of antimicrobial resistance genes (ARGs) and antibiotic residues [10,13].

The ongoing Coronavirus Disease 2019 (COVID-19) pandemic has drastically altered the global health landscape and represents another barrier to alleviating AMR. It has been suggested that the therapeutic use of antibiotics on COVID-19 patients presenting with respiratory symptoms will exacerbate the AMR crisis [22,23]. The rapid mobilization of global resources towards the COVID-19 pandemic illuminates the effectiveness of coordinated governance and political will [24–26]. Similar global coordination and action has not been achieved in the context of AMR.

Indeed, global governance initiatives on AMR were limited until the World Health Organization (WHO) convened in 2015 to develop a Global Action Plan on AMR [1]. Here, AMR was recognized as a One Health problem and the WHO encouraged an investigation of the intersections between AMR, human and veterinary medicine, agriculture, and environment. Yet, surveillance and regulation of antibiotic consumption have been limited to the human sector, indicating gaps within the animal and environmental sectors [27]. WHO reports this as "an emerging area of concern" where the issues and agenda for action remain unclear [27]. This beckons further inquiry into the role of the environment and water as propagative and protective agents against AMR risks.

RECOMMENDATIONS AND CONCLUSIONS

The AMR crisis will continue to impact global health, poverty, and the economy while exacerbating global inequities. The global community must therefore work to mount an aggressive, equity-centred response to the crisis. Here we outline two critical points of intervention.

1) Strengthened implementation of SDG 6 (Clean Water and Sanitation) interventions in vulnerable settings

Water, sanitation, and hygiene (WASH) practices represent the most cost-effective interventions for reducing the burden of infectious diseases [28,29]. Unclean water carries many infectious pathogens, and water-related diseases abound [30–33]. Basic WASH practices must be adjusted to alleviate the spread of AMR. This need is underpinned by the understanding that unsanitary practices enable environments rich with infective agents, which increases the use of antibiotics [34].

Implementation of SDG 6 must include sustainable innovation and equity. Reducing inequities (SDG 10) in WASH access is key to combating AMR. Clean water access is disproportionately limited to high-income countries (HICs) and 55% of the global population lacks safely managed sanitation [35]. Such inequities in access to WASH among HICs and LMICs increase the risk of AMR emergence in vulnerable settings, which has the potential to spread internationally [36]. Promoting equity in WASH requires understanding of local challenges and collaboration with LMICs to ensure contextually appropriate interventions. Additionally, strengthening innovation and infrastructure (SDG 9) is needed to address the intersection of AMR with WASH. Key efforts include R&D related to the environmental drivers and mitigators of AMR and the development of sustainable technologies to remove AMROs and ARGs from wastewater [37,38]. Innovation and infrastructure should reduce the burden on users and the need for behavioural change to ensure high uptake of interventions, along with training and education [39].

An international commitment towards the provision of WASH services, with an emphasis on equity and innovation, can therefore be conceptualized as an "SDG accelerator" and represents a necessary step towards accelerated progress in the battle against AMR and achievement of multiple SDGs, including SDGs 1, 3, and 6 [15].

2) The inclusion of AMR-specific targets and indicators within the UN SDGs.

The UN SDGs are currently the most prominent internationally accepted framework for global development. While the current SDG indicators are AMR-sensitive and indirectly impact AMR (e.g., infection prevention and control), there are currently no AMR-specific indicators or targets included within the SDG framework [9,11]. We support the inclusion of AMR-specific indicator(s) and believe that such recognition would represent an ambitious and important next step against the global AMR crisis. While the SDGs are not legally binding and recognition of AMR-specific indicator(s) would not be a quick fix solution, UN member-states are expected to uphold the development and execution of frameworks towards the achievement of the 17 goals [40]. Spotlighting AMR as an ongoing threat to the sustainable development of the planet would advance the placement of a truly global crisis onto national agendas.

REFERENCES

1. World Health Organization [WHO]. Global Action Plan on Antimicrobial Resistance [Internet]. 2015 May [cited 2021 Jan 20]. Available from: https://www.who.int/antimicrobial-resistance/global-action-plan/en/

2. WHO. Ten threats to global health in 2019 [Internet]. World Health Organisation. 2019 [cited 2021 Jan 21]. Available from: https://www.who.int/emergencies/ten-threats-to-global-health-in-2019

3. Interagency Coordination Group on Antimicrobial Resistance. No Time to Wait: Securing the Future from Drug-Resistant Infections [Internet]. 2019 [cited 2021 Jan 21]. Available from: https://www.who.int/antimicrobial-resistance/interagency-coordination-group/final-report/en/

4. Review on Antimicrobial Resistance. Tackling Drug-Resistant Infections Globally: Final Report and Recommendations [Internet]. 2016 [cited 2021 Jan 21]. Available from: https://amr-review.org/sites/default/files/160525_Final paper_with cover.pdf

5. Ventola CL. The Antibiotic Resistance Crisis Part 1: Causes and Threats. Pharm Ther [Internet]. 2015 Apr [cited 2021 Jan 21];40(4):277–83.

6. George A. Antimicrobial Resistance (AMR) in the Food Chain: Trade, One Health and Codex. Trop Med Infect Dis [Internet]. 2019 Mar 26 [cited 2021 Jan 21];4(1):54.

7. Langford BJ, Schwartz KL. Bringing home unwelcome souvenirs: Travel and drug-resistant bacteria. Canada Commun Dis Rep [Internet]. 2018 Nov 1 [cited 2021 Jan 21];44(11):277–82.

8. MacPherson DW, Gushulak BD, Baine WB, Bala S, Gubbins PO, Holtom P, et al. Population mobility, globalization, and antimicrobial drug resistance. Emerging Infectious Diseases. 2009 Nov [cited 2021 Jan 23];15(11):1727.

9. United Nations [UN]. Transforming our World: The 2030 Agenda for Sustainable Development [Internet]. 2015 [cited 2021 Jan 21]. Available from: https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981

10. Singer AC, Shaw H, Rhodes V, Hart A. Review of antimicrobial resistance in the environment and its relevance to environmental regulators. Frontiers in Microbiology. 2016 Nov 1 [cited 2021 Jan 21];7:1728.

11. Berthe FCJ, Wadsworth J, Thiebaud A, Marquez P V., Baris E. Pulling Together to Beat Superbugs Knowledge and Implementation Gaps in Addressing Antimicrobial Resistance [Internet]. The World Bank. 2019 [cited 2021 Jan 21]. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/430051570735014540/pulling-together-to-beat-superbugs-knowledge-and-implementation-gaps-in-addressing-antimicrobial-resistance

12. Ahmed SA, Barış E, Go DS, Lofgren H, Osorio-Rodarte I, Thierfelder K. Assessing the global poverty effects of antimicrobial resistance. World Dev. 2018 Nov 1 [cited 2021 Jan 21];111:148-60.

13. WHO. Technical brief on water, sanitation, hygiene and wastewater management to prevent infections and reduce the spread of antimicrobial resistance [Internet]. 2020 [cited 2021 Jan 22]. Available from: https://apps.who.int/iris/bitstream/handle/10665/332243/9789240006416-eng.pdf?ua=1

14. Cheng G, Ning J, Ahmed S, Huang J, Ullah R, An B, et al. Selection and dissemination of antimicrobial resistance in Agri-food production. Antimicrob Resist Infect Control [Internet]. 2019 [cited 2021 Jan 22];8(1):158.

15. United Nations Development Programme. SDG Accelerator and Bottleneck Assessment [Internet]. 2017 [cited 2021 Jan 22]. Available from:

https://www.undp.org/content/dam/undp/library/SDGs/English/SDG_Accelerator_and_Bottleneck_Assessment_Tool.pdf

16. Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: A global multifaceted phenomenon. Pathogens and Global Health. 2015 Oct 3[cited 2021 Jan 22];109(7):309-18.

17. Llor C, Bjerrum L. Antimicrobial resistance: Risk associated with antibiotic overuse and initiatives to reduce the problem. Therapeutic Advances in Drug Safety. 2014 [cited 2021 Jan 22]; 5(6):229-241.

18. Mason T, Trochez C, Thomas R, Babar M, Hesso I, Kayyali R. Knowledge and awareness of the general public and perception of pharmacists about antibiotic resistance. BMC Public Health. 2018 [cited 2021 Jan 22]; 18: 711.

19. Muri-Gama AS, Figueras A, Secoli SR. Inappropriately prescribed and over-the-counter antimicrobials in the Brazilian Amazon basin: We need to promote more rational use even in remote places. PLoS One. 2018 [cited 2021 Jan 22]; 13(8): e0201579

20. Auta A, Hadi MA, Oga E, Adewuyi EO, Abdu-Aguye SN, Adeloye D, et al. Global access to antibiotics without prescription in community pharmacies: A systematic review and meta-analysis. J Infect. 2019 [cited 2021 Jan 22]; 78(1):8-18.

21. Marshall BM, Levy SB. Food animals and antimicrobials: Impacts on human health. Clinical Microbiology Reviews. 2011 [cited 2021 Jan 22]; 24:4.

22. Hsu J. How COVID-19 is accelerating the threat of antimicrobial resistance. BMJ [Internet]. 2020 [cited 2021 Jan 22];369(May):18–9.

23. Rawson TM, Moore LSP, Castro-Sanchez E, Charani E, Davies F, Satta G, et al. COVID-19 and the potential long-term impact on antimicrobial resistance. J Antimicrob Chemother. 2020 [cited 2021 Jan 22];75(7):1681–4.

24. Anderson EJ, Rouphael NG, Widge AT, Jackson LA, Roberts PC, Makhene M, et al. Safety and Immunogenicity of SARS-CoV-2 mRNA-1273 Vaccine in Older Adults. N Engl J Med. 2020 Dec 17 [cited 2021 Jan 22];383(25):2427–38.

25. Polack FP, Thomas SJ, Kitchin N, Absalon J, Gurtman A, Lockhart S, et al. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine. N Engl J Med. 2020 Dec 31 [cited 2021 Jan 22];383(27):2603–15.

26. Ball P. The lightning-fast quest for COVID vaccines - and what it means for other diseases. Nature. NLM (Medline); 2020 [cited 2021 Jan 24]; 589:16-18.

27. WHO. Monitoring Global Progress on Addressing Antimicrobial Resistance [Internet]. 2018 [cited 2021 Jan 22]. Available from: https://www.who.int/publications/i/item/monitoring-global-progress-on-addressing-antimicrobial-resistance

28. WHO/ UNICEF. Poor sanitation threatens public health [Internet]. WHO. World Health Organization; 2011 [cited 2021 Jan 15]. Available from: https://www.who.int/mediacentre/news/releases/2008/pr08/en/

29. World Bank. Drug-Resistant Infections: A Threat to Our Economic Future. [Internet]. Vol. 2, World Bank Report. 2016 [cited 2021 Jan 23]. Available from: https://www.worldbank.org/en/topic/health/publication/drug-resistant-infections-a-threat-to-our-economic-future

30. Aziz RK, Khalifa MM, Sharaf RR. Contaminated water as a source of Helicobacter pylori infection: A review. Journal of Advanced Research. 2015 [cited 2021 Jan 28]; 6(4), 539-547.

31. Rodríguez-Lázaro D, Cook N, Ruggeri FM, Sellwood J, Nasser A, Nascimento MSJ, et al. Virus hazards from food, water and other contaminated environments. FEMS Microbiology Reviews. 2012 [cited 2021 Jan 22]; 36(4): 786-814.

32. Coleman BL, Louie M, Salvadori MI, McEwen SA, Neumann N, Sibley K, et al. Contamination of Canadian private drinking water sources with antimicrobial resistant Escherichia coli. Water Res. 2013 [cited 2021 Jan 22]; 47(9): 3026-3036.

33. Ford TE, Hamner S. A Perspective on the Global Pandemic of Waterborne Disease. Microbial Ecology. 2018 [cited 2021 Jan 22]; 76(1): 2-8.

34. Ministry of Health and Family Wellfare [MoHFW], WHO. Antimicrobial resistance and its containment in India. World Heal Organ Ctry Off India [Internet]. 2016 [cited 2021 Jan 22]; Available from: http://www.searo.who.int/india/topics/antimicrobial_resistance/amr_containment.pdf

35. WHO/UNICEF. Progress on household drinking water, sanitation and hygiene 2000-2017: Special focus on inequalities [Internet]. Launch version July 12 Main report Progress on Drinking Water , Sanitation and Hygiene. 2019 [cited 2021 Jan 22]. 140 p. Available from: https://washdata.org/reports

36. Cars O, Högberg LD, Murray M, Nordberg O, Sivaraman S, Lundborg CS, et al. Meeting the challenge of antibiotic resistance. BMJ. 2008 [cited 2021 Jan 22]; 337.

37. Verburg I, García-Cobos S, Leal LH, Waar K, Friedrich AW, Schmitt H. Abundance and antimicrobial resistance of three bacterial species along a complete wastewater pathway. Microorganisms. 2019 [cited 2021 Jan 22]; 7(9): 312.

38. Perry M, van Bunnik B, McNally L, Wee B, Munk P, Warr A, et al. Antimicrobial resistance in hospital wastewater in Scotland: a cross-sectional metagenomics study. Lancet. 2019 [cited 2021 Jan 27]; 394:S1.

39. Humphrey JH. Reducing the user burden in WASH interventions for low-income countries. The Lancet Global Health. 2019 [cited 2021 Apr 19]; 7(9):e1158-e1159.

40. UN. Sustainable Development Goals [Internet]. United Nations Academic Impact. [cited 2021 Jan 28]. Available from: https://academicimpact.un.org/content/sustainable-development-goals