ANTIMICROBIAL RESISTANCE AND THE CLIMATE CRISIS

Information note of the Global Leaders Group on Antimicrobial Resistance.
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GLOBAL LEADERS GROUP ON ANTIMICROBIAL RESISTANCE

KEY MESSAGES

1. **The climate crisis and antimicrobial resistance - the ability of microbes to resist the drugs designed to inhibit or kill them - are two of the greatest and most complex threats currently facing the world. Both have been exacerbated by, and can be mitigated with, human action.**

2. **The climate crisis is impacting human health, animal health, food, plant and environment eco-systems in numerous ways, and many of these impacts could affect antimicrobial resistance.**

3. **Evidence suggests that changes occurring in the natural environment due to the climate crisis are increasing the spread of infectious disease, including drug-resistant infections.**

4. **High usage of antimicrobial drugs across sectors exacerbates antimicrobial resistance. The increasingly severe impacts of the climate crisis, such as more frequent and severe extreme weather events, will likely result in an increased use of antimicrobial drugs in humans, animals and plants.**

5. **As these two crises continue to grow, the impacts on economies, lives, and livelihoods are expected to be significant and devastating, particularly for low-and middle-income countries and small island developing states.**

6. **More financing, political advocacy and coordinated global action are needed to better understand and respond to the converging threats of antimicrobial resistance and the climate crisis before it is too late.**

7. **The links between antimicrobial resistance and the climate crisis have been neglected and require significantly more attention, including in national action plans on antimicrobial resistance. There is currently no global initiative focused specifically on the intersection of these two crises.**

1. The climate crisis[1] is already affecting patterns of infectious disease and worsening existing health challenges, which may lead to an increase in the use of antimicrobial drugs and antimicrobial resistance.

Many diseases are climate-sensitive and changes in environmental conditions and temperatures may lead to an increase in the spread of many bacterial, viral, parasitic, fungal, and vector-borne diseases in humans, animals and plants. Increased prevalence of disease could result in an increase in the improper use of antimicrobial drugs, which could exacerbate antimicrobial resistance. For example, the climate crisis is a key driver of changes in the spread and distribution of helminths (parasitic worms which can cause severe illness and death in humans and animals) in livestock, with large-scale outbreaks of helminths becoming increasingly common.[2] The climate crisis is also affecting human and animal habitats and ranges, which may increase the risk of human exposure to some vector-borne diseases.[3] In Europe, for example, sand flies (which can transmit the disease *leishmaniasis*) are at present mainly found in the Mediterranean region, but with the climate crisis sand fly species are expected to expand their range into central and northern Europe.[4]

In 2019, nearly half of the world's population was at risk of malaria.[5] Climatic changes, such as more extreme weather events which bring increased rainfall, temperature and humidity may also increase the incidence of malaria in areas where it is already present and lead to it spreading into new areas.[6] As drug resistance for some vector-borne diseases is increasing, climate crisis-associated diseases such as malaria may become harder to contain and treat because the antimicrobial medicines relied on for treatment are becoming less effective. Malaria parasites have already demonstrated resistance to almost every antimalarial drug currently available.[7]

1 The term 'climate crisis' refers to global warming and climate change. Climate change refers to changes that alter the global atmosphere composition and are directly or indirectly attributed to human activity (UNFCCC [1992]. Available here.) The effects of this include increases in global temperatures and in the frequency and intensity of extreme weather events (IPCC [2018]. Available here.)
2 Fox, N et al. (2015). *'Climate-driven tipping-points could lead to sudden, high-intensity parasite outbreaks'.* Royal Society Open Science. Available here.
3 Gonzalez, C et al. (2010.) *'Climate Change and Risk of Leishmaniasis in North America: Predictions from Ecological Niche Models of Vector and Reservoir Species'.* Plos Neglected Tropical Diseases. Available here.
4 Koch, L et al. (2017). *'Modeling the climatic suitability of leishmaniasis vector species in Europe'.* Nature Scientific Reports. Available here.
5 WHO. *'Malaria'.* [webpage]. Available here. (Accessed 24 September 2021)
6 Fernando, S. *'Climate change and malaria: A complex relationship'.* UN Chronicle. Available here.
7 WHO (2001). *'Drug Resistance in Malaria'.* Available here.

2. The climate crisis is altering the natural environment, which is likely making it easier for antimicrobial resistant microbes to develop and spread.

Studies suggest that as global and local temperatures rise due to the climate crisis, antimicrobial resistance and rates of bacterial infection are increasing in humans, animals, plants and the environment.[8,9] For example, fungicide resistance in crops may increase with rising temperatures.[10] Existing data on the global burden of antimicrobial resistance may therefore greatly underestimate the effects that the climate crisis and rising local temperatures are having on the development and spread of drug-resistance.[11]

The climate crisis may also be responsible for the emergence and spread of new and re-emerging threats. For example, *Candida auris,* a deadly fungal pathogen that is often multi-drug-resistant,[12] has long existed in the environment, but evidence suggests that the climate crisis may be responsible for it becoming pathogenic in humans.[13,14] An increasing body of research also suggests that as permafrost (frozen soil) in the Arctic melts due to global warming, it may be releasing ancient, long-dormant pathogens previously trapped in the ice.[15] For example, a 2016 outbreak of anthrax in Siberia is reportedly associated with the thawing of the permafrost and exposure of a reindeer carcass infected with anthrax long ago.[16] New or re-emerging pathogens could be untreatable or harbour new resistance mechanisms that could spread.

3. The frequency and severity of extreme weather events and natural disasters are increasing because of the climate crisis and can damage infrastructure and increase the spread of drug-resistant infections. Water, sanitation and hygiene (WASH) and wastewater management measures across sectors are crucial to reducing this risk.

An increase in extreme weather events and natural disasters such as hurricanes, typhoons, storms, heatwaves, floods and forest fires[17] is causing disruptions and conditions that can increase antimicrobial resistance. For example, natural disasters can cause population displacement, which can increase the spread of drug-resistant infections and disease and place increased pressure on health systems.[18,19,20] Many of the issues faced by displaced people - such as lack of access to proper housing, healthcare and WASH facilities and overcrowding - are also correlated with increased rates of antimicrobial resistance.[21] Natural disasters and extreme weather events can also affect access to health services[22] which could lead to an increase in preventable infectious disease and use of antimicrobial medicines.

Increasing frequency and severity of extreme rainfall and storms can also damage wastewater and sewage infrastructure and increase the risks of flooding, floodwater pollution, sewage overflow and agricultural runoff. Because antimicrobial-resistant microbes can spread via waterways, soil, air and wildlife,[23] this can increase the spread of drug-resistant infections and carry drug-resistant microbes between human populated areas and the environment.[24] In Accra, Ghana, for example, outbreaks of cholera (which is already resistant to several types of antibiotics) are believed to have been triggered by flooding and poor environmental sanitation and wastewater management.[25]

Flooding can also increase the spread of pollutants in the environment, including heavy metals that may increase the development and spread of antibiotic resistance.[26] Other pollutants, including nitrogen fertilizers and farm waste used in agriculture (e.g. manure and wastewater), have also been shown to increase levels of antimicrobial resistance in soil.[27,28] Environmental transmission of antimicrobial resistance can be reduced through proper WASH, sewage, wastewater and waste management and infection prevention and control measures.[29]

Natural disasters may also impact preventive medicine programs, including vaccination, which can lead to increased preventable infectious diseases and increased antimicrobial use and resistance.

8 McGough, S et al. (2020). *'Rates of increase of antibiotic resistance and ambient temperature in Europe: a cross-national analysis of 28 countries between 2000 and 2016'.* Eurosurveillance. Available here.

9 A 2018 study found that a 10°C increase in local temperature was associated with an increase in antibiotic resistance of 2.2 - 4.2% for the common bacterial pathogens *Escherichia. Coli, Klebsiella pneumoniae and Staphylococcus aureus* (MacFadden, D et al. [2018]. Available here), all of which already have high rates of antibiotic resistance (WHO. 'Antimicrobial Resistance'. [webpage]. Available here.)

10 HE, M et al. (2018). *'Slow and temperature-mediated pathogen adaptation to a nonspecific fungicide in agricultural ecosystem'.* Evol Appl. Available here.

11 MacFadden, D. et al. (2018). *'Antibiotic resistance increases with local temperature'.* Nature Climate Change. Available here.

12 Multi-drug-resistant refers to pathogens that are resistant to more than one antimicrobial treatment.

13 Casadevall, A et al. (2019). *'On the Emergence of Candida auris: Climate Change, Azoles, Swamps, and Birds'.* ASM. Available here.

14 Casadevall, A et al. (2021). *'Environmental Candida auris and the Global Warming Emergence Hypothesis'.* ASM. Available here.

15 Revich, B et al. (2011). *'Thawing of permafrost may disturb historic cattle burial grounds in East Siberia'.* Global Health Action. Available here.

16 Stella, E et al. (2020). *'Permafrost dynamics and the risk of anthrax transmission: a modelling study'.* Nature Scientific Reports. Available here.

17 IPCC (2021) *'Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change'.* Available here.

18 Gowrisankar, G et al. (2017) *'Chemical, microbial and antibiotic susceptibility analyses of groundwater after a major flood event in Chennai'.* Nature Scientific Data. Available here.

19 Pingfeng, Y et al. (2018) *'Elevated Levels of Pathogenic Indicator Bacteria and Antibiotic Resistance Genes After Hurricane Harvey's Flooding in Houston'.* Environ.Sci. Technol.Lett. Available here.

20 UNEP (2017). *'Frontiers 2017 Emerging Issues of Environmental Concern'.* Available here. (Pg.14)

21 Collignon, P et al (2018). *'Anthropological and socioeconomic factors contributing to global antimicrobial resistance: a univariate and multivariable analysis.'* The Lancet Planetary Health. Available here.

22 WRI (2021). *'Mainstreaming Climate Adaptation Planning and Action into Health Systems in Fiji, Ghana, and Benin'.* Available here.

23 UNEP. Antimicrobial Resistance: A global threat [webpage] Available here.

24 UNEP (2017). *'Frontiers 2017 Emerging Issues of Environmental Concern'.* Available here. (Pg.14)

25 Ohene-Adjei, K et al (2017). *'Epidemiological link of a major cholera outbreak in Greater Accra region of Ghana, 2014.'* BMC Public Health. Available here.

26 UNEP (2017). *'Frontiers 2017 Emerging Issues of Environmental Concern'.* Available here. (Pg.14)

27 Reardon, S (2014). *'Manure fertilizer increased antibiotic resistance'.* Nature. Available here.

28 Forsberg, K et al. (2014). *'Bacterial phylogeny structures soil resistomes across habitats'.* Nature. Available here.

29 FAO, OIE and WHO (2020). *'Technical brief on water, sanitation, hygiene and wastewater management to prevent infections and reduce the spread of antimicrobial resistance'.* Available here.

4. The climate crisis is placing increased pressure on food production systems, which could lead to increased use of antimicrobial drugs in agriculture to meet global demand for food.

The climate crisis is placing increased pressure on global food security and food systems and could exacerbate plant and animal diseases and associated production losses.[30,31] Historically, farmers and livestock producers have used antimicrobials to both treat and prevent disease in crops and animals, and to promote growth in some types of animals, thereby increasing agricultural yields. As the impacts of the climate crisis increase, farmers and livestock producers may face pressure to rely more heavily on antimicrobial use in plants and animals in order to meet demand and improve production. The use of antibiotics and antifungal agents to treat infection in plants is also expected to increase as older treatments become ineffective.[32] Increased improper use of antimicrobials could fuel a rise in antimicrobial resistance.

Aquaculture (fish farming) is the fastest-growing food production sector globally and is key to food security in many low-and middle-income countries (LMICs). The converging crises of climate change and antimicrobial resistance are expected to have damaging impact on the sustainability of aquaculture. The climate crisis affects global temperatures, sea levels, rainfall patterns, disease spread and algae blooms, all of which impact the aquaculture industry, particularly in coastal regions.[33] Aquaculture environments in most countries already have high levels of antimicrobial resistance and infected aquatic animals are more likely to die at higher temperatures that can increase disease susceptibility. As temperatures rise due to the climate crisis, this could lead to an increase in morbidity and mortality in fish farms, and in response, a likely increase in the use of antimicrobial drugs.[34] Adaptation strategies such as use of vaccinations need to be developed to mitigate the threat that the climate crisis and increasing antimicrobial resistance pose to aquaculture.

5. The dual threat of the climate crisis and antimicrobial resistance will have the most devastating impacts on low-and middle-income countries and small island developing states.

The dual threat of increasing antimicrobial resistance and the climate crisis will have significant impacts on LMICs and Small Island Developing States (SIDS), the majority of which do not yet have funded action plans on antimicrobial resistance.[35] The climate crisis is disproportionately impacting island states that are most vulnerable to the adverse impacts of rising sea levels and temperatures, tropical cyclones and changing rainfall patterns.[36] SIDS stand to be the worst affected as loss of life, damage to infrastructure and buildings, displacement and impacts on key sectors, including tourism, could cripple their economies.[37] Simultaneously, increasing levels of antimicrobial resistance are expected to lead to a rise in extreme poverty and a significant annual reduction in global GDP.[38]

6. More research and surveillance are needed to bolster the evidence base on the effects of the climate crisis on antimicrobial resistance and to galvanize political action.

While clear linkages between the climate crisis, rising temperatures, infection spread and antimicrobial resistance are emerging, the interactions between these two crises are complex and the evidence base is currently relatively small and led by academia. More multidisciplinary research and surveillance are needed to develop a more robust and actionable evidence base on the impacts of the climate crisis on antimicrobial resistance in different scenarios and settings. A key challenge lies in translating the science of these two complex issues into language that resonates with political leaders, policymakers, the media and the general public.

7. To mainstream antimicrobial resistance as a climate crisis issue and build resilience to both, increased political advocacy and financing are urgently needed.

The links between antimicrobial resistance and the climate crisis have been neglected and require significantly more attention, including in national action plans on antimicrobial resistance and climate action plans (Nationally Determined Contributions). There is currently no global initiative focused specifically on the intersection of these two crises. More high-level political advocacy is needed to help draw attention to and mainstream antimicrobial resistance as a climate crisis issue and ensure that the antimicrobial resistance lens is included in high-level discussions on the climate crisis. For both the climate crisis and antimicrobial resistance, the returns on investing in containment and mitigation are expected to far outweigh the costs.[39,40] Additional financing is also needed to better understand and respond to the cross-sectoral linkages between these two crises and to incorporate linkages between them into existing One Health strategies and initiatives.

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30 Mbow, C et al. (2019): Food Security. In *'Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems'.* [Shukla, P et al.] Available here. (Pg. 450)

31 From 1981 to 2019 crop yield potential for maize, winter wheat, soybean, and rice has followed a consistently downward trend, with reductions relative to baseline of 5.6% for maize, 2.1% for winter wheat, 4.8% for soybean, and 1.8% for rice [Watts et al. (2020). *'The 2020 report of the Lancet Countdown on Health and Climate Change: Responding to Converging Crises'.* The Lancet. Available here.]

32 FAO (2018). *'Antimicrobial Resistance and Foods of Plant Origin'.* Available here.

33 Maulu, S et al. (2021). *'Climate Change Effects on Aquaculture Production: Sustainability Implications, Mitigation, and Adaptations'.* Frontiers. Available here.

34 Reverter, M et al. (2020). *'Aquaculture at the crossroads of global warming and antimicrobial resistance'.* Nature Communications. Available here.

35 Global Database for the Tripartite Antimicrobial Resistance Country Self-assessment Survey. [online] .Available here. [Accessed 15 June 2021].

36 Nurse, L et al. (2014): Small islands. In *'Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change'.* [Barros, V et al] Available here. (Pg. 1616)

37 UNFCCC (2005). *'Climate change, small island developing States.'* Available here.

38 World Bank (2017). *'Drug-Resistant Infections: A Threat to Our Economic Future.'* Available here.

39 Ibid.

40 Hallegatte, S et al (2019). *'Lifelines: The Resilient Infrastructure Opportunity. Sustainable Infrastructure'.* World Bank. Available here.