

‘Today’s greatest global challenges and health threats are the result of human activity affecting the natural environment. Discuss, with examples relevant to pathology specialties.’

It is hard to imagine a world without the influence of human activity. One of its most profound consequences on the natural environment is perhaps climate change. There is little doubt that we are driving climate change at a staggering rate¹. Increasing greenhouse gas emissions leads to atmospheric warming, causing multiple climate hazards (Figure 1)². The consequences of these present many challenges relevant to pathology specialties. In addition to climate change, our construction of urban environments and use of man-made materials may also detriment our health and that of the environment.

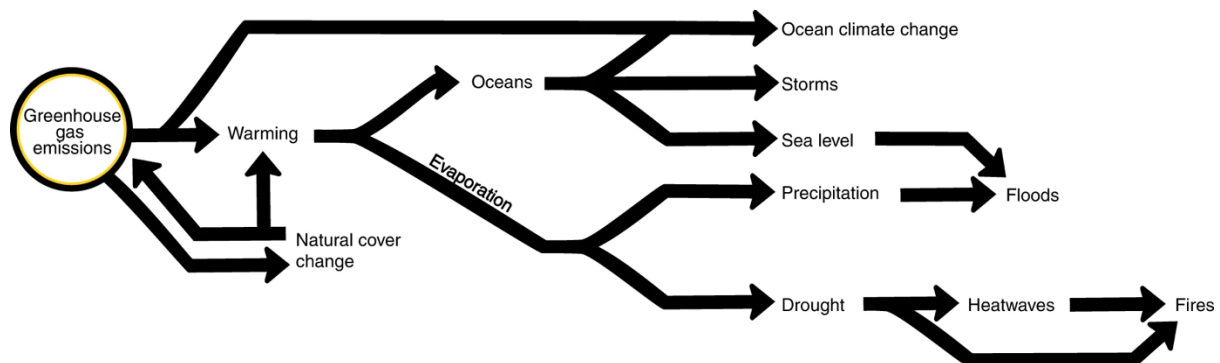


Figure 1 – A summary of the climate hazards which can occur secondary to increased greenhouse gas emissions².

Climate change can increase the transmission of infectious diseases. It can increase interactions between pathogen and human populations^{2,3}; enhance pathogen’s survival, reproductive ability, and virulence²; and increase human’s susceptibility to disease². For example, vector-borne disease transmission is increased when climatic suitability enhances the geographical range or period over which vectors can interact with humans⁴. The malaria-carrying *Anopheles* mosquitoes’ range is predicted to expand due to warming and increased rainy season duration in tropical regions of Africa⁵. This may over-burden current healthcare facilities, expose immunologically naïve populations, and expose healthcare systems which are less developed to respond to these diseases⁴. Additionally, climate change may cause novel pathogen exposures due to the expansion of zoonotic diseases³ and thawing of ice and permafrost². These changes are likely to increase the pressure upon microbiology and virology services. These services will be vital in monitoring for, and rapidly responding to new outbreaks; identifying causative agents; identifying or developing diagnostic tests and treatment; and advising public health strategies⁶. The COVID-19 pandemic highlighted these pressures, and how instrumental pathology services were in responding to global health threats⁷. For example, there was a reliance on lateral flow assays to rapidly identify COVID-19 infected persons⁸. This highlighted our need for innovative technologies to quickly and accurately identify infected persons, to control the spread of disease.

Another health risk posed by climate change is food insecurity and malnutrition. Climate change can impair crop production and the nutritional quality of food^{9,10}, increase food prices¹¹, and disrupt supply chain infrastructure^{9,11}. The effects of malnutrition are widespread. They range from impairing immunocompetence and increasing the risk of infectious diseases in the short-term², to increasing the risk of development of cancer in offspring¹². Consequentially, malnutrition can increase the demand

upon histopathology and haematology services, especially in the context of an already growing and ageing population^{13,14}.

Furthermore, these pressures on food production lead to sub-optimal farming practices for long-term planetary and human health, including a growing reliance on herbicides and pesticides. In 2023, over 50% of fruits and vegetable samples in the United Kingdom were found to contain pesticide residues, with 3% containing levels above the Maximum Residue Level¹⁵. Although consuming a wholefood diet is considered protective of health, exposure to pesticides in fruits and vegetables may offset the benefits of their consumption in relation to all-cause mortality¹⁶. Furthermore, Cavalier et al. detected a causal relationship between pesticide exposure and acute lymphoblastic leukaemia and colorectal cancer¹⁷, of relevance to the histopathology and haematology disciplines. Similarly, the use of antimicrobials in animal farming is likely contributing to antimicrobial resistance¹⁸. Microbiologists are already facing increasing pressures to reduce antimicrobial prescription, and challenges in treating multi-drug resistant bacterial infections¹⁹.

Climate change is also increasing the incidence of severe weather events, such as wildfires and droughts. These increase transmission of infectious diseases² and convey longer-term health threats. For example, wildfires are associated with an increased incidence of asthma²⁰, as particulate matter can penetrate alveoli and bronchioles and induce inflammatory processes²¹.

The manipulation of the natural environment to support human activities, as seen in our construction of urban environments, has also generated challenges aside from climate change. Urban design may promote physical inactivity, poor food choices^{22,23}, and exposure to air and noise pollution²⁶. Urban environments with poor walkability are associated with an increasing burden of obesity^{24,25} and cardiometabolic diseases, including hypertension^{24,25} and type 2 diabetes mellitus²⁵. Similarly, increased exposure to noise and air pollution may increase the risk of developing cardiovascular disease²⁶. These are all long-term diseases with significant sequelae, which rely on pathology services for their diagnosis and monitoring. Additionally, human activity may be a factor in the dramatic increase in allergic disorders seen in recent years²⁷. Many environmental and lifestyle changes have been implicated in this, including air pollution, which may also be related to the severity of presentation²⁷. Of course, urban design may also promote climate change, for example by increasing air pollution, thereby exacerbating the problems previously discussed²⁸.

Another global threat is the widespread use of plastics, leading to accumulation of microplastics in the environment, food chain, and human tissue²⁹. The full extent of the risk that this poses to human health is unknown, but it is thought to potentially contribute to carcinogenesis, metabolic disorders, and immune system dysfunction, all of which would burden pathology services²⁹. Of course, plastics are also heavily used by healthcare services, including pathology services themselves.

Despite all these factors, global life expectancy is generally increasing³⁰, and rates of death from infectious disease are falling³¹. Perhaps this is due to the tremendous efforts by humans to improve the prevention, detection and management of diseases; promote health equity; and mitigate climate change. Urbanicity also improves access to healthcare services, sanitation, education and

employment. It is therefore difficult to label human's effects on the natural environment as purely damaging, despite the challenges it presents.

In conclusion, human activity has profoundly impacted the equilibrium of the natural environment, the consequences of which are now being unmasked. Currently, it appears that we are somewhat compensating for these changes – death rates from infectious diseases are static, for example - but it is unknown whether human activity can continue to buffer these changes. It seems likely that pathology services' workload will increase and will need to be adaptable to meet evolving demands in the context of a rapidly changing health landscape. It remains to be seen whether human activity can evade the so-called tipping point, both in terms of climate stability and healthcare service provision.

References

1. Byg B, Shah AD. Heating up: climate change and the threat to human health. *Current Opinion in Nephrology and Hypertension* [Internet]. 2024 Jan 1;33(1):78–82. Available from: <https://pubmed.ncbi.nlm.nih.gov/37846636/>
2. Mora C, McKenzie T, Gaw IM, Dean JM, von Hammerstein H, Knudson TA, et al. Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Climate Change* [Internet]. 2022 Aug 8;12(12). Available from: <https://www.nature.com/articles/s41558-022-01426-1.pdf>
3. Carlson CJ, Albery GF, Merow C, Trisos CH, Zipfel CM, Eskew EA, et al. Climate change increases cross-species viral transmission risk. *Nature* [Internet]. 2022 Apr 28;607(607):1–1. Available from: https://www.nature.com/articles/s41586-022-04788-w?utm_medium=affiliate&utm_source=commission_junction&utm_campaign=CONR_PF018_ECOM_GL_PHSS_ALWYS_PRODUCT&utm_content=textlink&utm_term=PID100107553&CJ_EVENT=33fde107c7f811ec81ad00890a1c0e12
4. Colón-González FJ, Sewe MO, Tompkins AM, Sjödin H, Casallas A, Rocklöv J, et al. Projecting the risk of mosquito-borne diseases in a warmer and more populated world: a multi-model, multi-scenario intercomparison modelling study. *The Lancet Planetary Health* [Internet]. 2021 Jul 1;5(7):404–14. Available from: [https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196\(21\)00132-7/fulltext](https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(21)00132-7/fulltext)
5. Le PVV, Kumar P, Ruiz MO, Mbogo C, Muturi EJ. Predicting the direct and indirect impacts of climate change on malaria in coastal Kenya. Keller DP, editor. *PLOS ONE*. 2019 Feb 6;14(2):e0211258.
6. Omar RF, Boissinot M, Huletsky A, Bergeron MG. Tackling Infectious Diseases with Rapid Molecular Diagnosis and Innovative Prevention. *Infectious Disease Reports* [Internet]. 2024 Apr 1;16(2):216–27. Available from: <https://www.mdpi.com/2036-7449/16/2/17>
7. Catalán P, Alonso R, Alcalá L, Marín M, Moure Z, Pescador P, et al. The challenge of COVID-19 for a Clinical Microbiology Department. *Diagnostic Microbiology and Infectious Disease*. 2021 Oct;101(2):115426.
8. Performance of lateral flow devices during the COVID-19 pandemic [Internet]. GOV.UK. Department of Health & Social Care; 2023 [cited 2024 May 8]. Available from: <https://www.gov.uk/government/publications/lateral-flow-device-performance-data/performance-of-lateral-flow-devices-during-the-covid-19-pandemic>
9. Ziska L. Rising Carbon Dioxide and Global Nutrition: Evidence and Action Needed. *Plants*. 2022 Apr 6;11(7):1000.
10. Zhu C, Kobayashi K, Loladze I, Zhu J, Jiang Q, Xu X, et al. Carbon dioxide (CO₂) levels this century will alter the protein, micronutrients, and vitamin content of rice grains with potential health consequences for the poorest rice-dependent countries. *Science Advances* [Internet]. 2018 May;4(5):eaq1012. Available from: <https://advances.sciencemag.org/content/4/5/eaq1012>
11. Dasgupta S, Robinson EJZ. Attributing changes in food insecurity to a changing climate. *Scientific Reports*. 2022 Mar 18;12(1).
12. da Cruz RS, Carney EJ, Clarke J, Cao H, Cruz MI, Benitez C, et al. Paternal malnutrition programs breast cancer risk and tumor metabolism in offspring. *Breast Cancer Research*. 2018 Aug 30;20(1).
13. British Society for Haematology Workforce Report 2019 [Internet]. British Society for Haematology; 2019. Available from: <https://b-s-h.org.uk/media/18082/bsh-report-0520.pdf>
14. Histopathology workforce census [Internet]. The Royal College of Pathologists; 2018. Available from: <https://www.rcpath.org/static/952a934d-2ec3-48c9-a8e6e00fcdca700f/Meeting-Pathology-Demand-Histopathology-Workforce-Census-2018.pdf>
15. Pesticide residues in food: quarterly monitoring results for 2023 [Internet]. GOV.UK. Department for Environment, Food & Rural Affairs; 2024 [cited 2024 May 6]. Available from: <https://www.gov.uk/government/publications/pesticide-residues-in-food-quarterly-monitoring-results-for-2023>
16. Sandoval-Insausti H, Chiu YH, Wang YX, Hart JE, Bhupathiraju SN, Mínguez-Alarcón L, et al. Intake of fruits and vegetables according to pesticide residue status in relation to all-cause and

- disease-specific mortality: Results from three prospective cohort studies. *Environment International*. 2022 Jan;159(107024).
17. Cavalier H, Trasande L, Porta M. Exposures to pesticides and risk of cancer: Evaluation of recent epidemiological evidence in humans and paths forward. *International Journal of Cancer*. 2022 Oct 25;152(5):879–912.
 18. Pokharel S, Shrestha P, Adhikari B. Antimicrobial use in food animals and human health: time to implement “One Health” approach. *Antimicrobial Resistance & Infection Control* [Internet]. 2020 Nov 7;9(1). Available from: <https://aricjournal.biomedcentral.com/articles/10.1186/s13756-020-00847-x>
 19. Shrestha J, Zahra F, Cannady J. Antimicrobial Stewardship [Internet]. PubMed. Treasure Island (FL): StatPearls Publishing; 2021. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK572068/>
 20. Alves L. Amazon fires coincide with increased respiratory illnesses in indigenous populations. *The Lancet Respiratory Medicine*. 2020 Nov;8(11):e84.
 21. Bowman WS, Schmidt RJ, Sanghar GK, Thompson GR, Ji H, Zeki AA, et al. “Air That Once Was Breath” Part 1: Wildfire-Smoke-Induced Mechanisms of Airway Inflammation – “Climate Change, Allergy and Immunology” Special IAAI Article Collection: Collegium Internationale Allergologicum Update 2023. *International archives of allergy and immunology*. 2024 Mar 7;7(1):1–17.
 22. Morris TT, Northstone K. Rurality and dietary patterns: associations in a UK cohort study of 10-year-old children. *Public Health Nutrition*. 2014 Sep 5;18(8):1436–43.
 23. Levin KA. Urban–rural differences in adolescent eating behaviour: a multilevel cross-sectional study of 15-year-olds in Scotland. *Public Health Nutrition*. 2013 Aug 18;17(8):1776–85.
 24. Koohsari MJ, Oka K, Nakaya T, Vena J, Williamson T, Quan H, et al. Urban design and cardio-metabolic risk factors. *Preventive Medicine* [Internet]. 2023 Aug 1 [cited 2024 Apr 23];173(107552). Available from: <https://pubmed.ncbi.nlm.nih.gov/37211251/>
 25. Chandrabose M, Rachele JN, Gunn L, Kavanagh A, Owen N, Turrell G, et al. Built environment and cardio-metabolic health: systematic review and meta-analysis of longitudinal studies. *Obesity Reviews*. 2018 Sep 25;20(1):41–54.
 26. Münzel T, Sørensen M, Gori T, Schmidt FP, Rao X, Brook J, et al. Environmental stressors and cardio-metabolic disease: part I—epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies. *European Heart Journal*. 2016 Jul 26;38(8):ehw269.
 27. Aldakheel FM. Allergic Diseases: A Comprehensive Review on Risk Factors, Immunological Mechanisms, Link with COVID-19, Potential Treatments, and Role of Allergen Bioinformatics. *International Journal of Environmental Research and Public Health*. 2021 Nov 18;18(22):12105.
 28. Bikis A. Urban air pollution and greenness in relation to public health. Wang Q, editor. *Journal of Environmental and Public Health*. 2023 Jan 30;2023(8516622):1–18.
 29. Ziani K, Ioniță-Mîndrican CB, Mititelu M, Neacșu SM, Negrei C, Moroșan E, et al. Microplastics: A Real Global Threat for Environment and Food Safety: A State of the Art Review. *Nutrients* [Internet]. 2023 Jan 25;15(3):617. Available from: <https://www.mdpi.com/2072-6643/15/3/617>
 30. World Health Organisation. GHE: Life expectancy and healthy life expectancy [Internet]. www.who.int. World Health Organization; 2019 [cited 2024 May 8]. Available from: <https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-life-expectancy-and-healthy-life-expectancy>
 31. Infectious disease death rates [Internet]. Our World in Data. 2019 [cited 2024 May 8]. Available from: <https://ourworldindata.org/grapher/infectious-disease-death-rates?tab=chart>