Candida auris emergence as a consequence of climate change: Impacts on Americas and the need to contain greenhouse gas emissions

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The Lancet Regional Health - Americas 2022;11: 100250
Published online 1 April 2022
https://doi.org/10.1016/j.lana.2022.100250

Anthropogenic climate change has an increasing impact on infectious diseases globally, altering the burden and the geographical distribution of vector-borne diseases, such as malaria and arboviral infections,[1] as well as contributing to the emergence of new zoonotic pathogens.[2] The effects of climate change on infectious diseases are often treated as a future issue, which will increase as climate change intensifies. This is indeed correct; however, the effects of climate change on human infections are already a critical problem, as evidenced by recent disease outbreaks, and these problems have a strong connection with current America's environmental crisis.

The extensive use of fossil fuels and associated greenhouse gas (GHG) emissions play a key role in climate change. Deforestation of tropical forests, such as the Amazon rainforest, also has a fundamental contribution to climate change due to the release of CO_2 into the atmosphere. The Amazon Forest is distributed over the territory of nine South American countries: Bolivia, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, Venezuela, and Brazil, the latter where most of the forest is located. In recent years, deforestation and related land-use changes (e.g. cattle ranching, cash crop plantation, mining) in the Amazon Forest have intensified, leading to an increase in the degradation of the region.[2] The Amazon deforestation aggregates a series of factors that facilitate the emergence of new zoonotic pathogens and the spread of vector-borne diseases in Amazonian countries, affecting Indigenous Peoples and other populations. This occurs due to the association of intensive human activity in a region of high biodiversity and social problems. Furthermore, the loss of ecosystem services as a result of the Amazon degradation, including the loss of carbon stocks and deregulation of water cycling, is already altering the region's climate. Of note, deforestation and deregulation of water cycling also directly affect the so-called Amazon's 'flying rivers', a phenomenon responsible for controlling rainfall regimens of a much wider geographical region, with such deregulation contributing to climate change globally.[2] As a result, the impacts of climate change on emerging infectious diseases are already evident in different world regions.

The emergence of human cases of *Candida auris* infection in America was reported in 2016.[3] *C. auris* is a multidrug-resistant fungus associated with nosocomial infection, especially in critically ill adult and pediatric patients, being a serious problem in intensive care units and other hospital environments.[3,4] The occurrence of *C. auris* outbreaks has grown in various countries of the American continent, such as the USA, Canada, Panama, Colombia, Chile,[4] and Venezuela.[3] In Brazil, *C. auris* infection in COVID-19 patients from an intensive care unit in Salvador city (Bahia state) was recently reported.[5]

The emergence of *C. auris* as a human pathogen may be a consequence of climate change.[6] *C. auris* is a fungus originally found in the environment, specifically in soil of ecosystems with some salinity, such as wetlands. Higher average temperatures resulting from anthropogenic climate change (global warming) may have acted as a selective pressure on *C. auris*, favoring strains adapted to salinity and higher temperatures - similar to the conditions found in the human body - and thus creating favorable conditions for *C. auris* to emerge as a human pathogen.[6] In a broader perspective, global warming may be facilitating the emergence of pathogens more apt to break the 'thermal restriction zone' of the human body.[7] The 'global warming emergence hypothesis'[8] is difficult to prove, and other driving forces for *C. auris* emergence in the human population were suggested.[9] However, the global warming emergence hypothesis is biologically quite plausible[2,4,7,8] and, in our opinion, it does not exclude the possibility that other factors may have acted in combination during the *C. auris* emergence.

Another 'off the radar' example reinforces a climate change hypothesis for disease emergence. The abnormal thawing of the soil (permafrost) in Siberia and the consequent exposure of humans and animals to *Bacillus*

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anthracis spores, resulting in human infection cases and epizooties, is also a potential effect of climate change on disease emergence observed in the present.[10] A relevant question raised by this specific example is: how many other potential human pathogens, including even still unknown microorganisms, are now 'flowing out' of glaciers and so many other regions affected by global warming?

More than a problem increasingly faced in clinical practice, the feasible emergence of *C. auris* in the human population is an additional warning about how climate change is already altering the scenario of infectious diseases (the pathocenosis, as defined by Mirko Grmek), in the present, being not just a threat to human health to be faced in the future. Considering the fundamental role of GHG emission, especially CO_2, as a major driver of climate change, American countries must embrace economic models less dependent on fossil fuels and land-use changes. In this sense, Brazil and other countries of the Amazon region must urgently control the Amazon deforestation. Containing climate change is a fundamental step to reduce the undesirable effects of human activity on disease emergence.

Author contributions

Joel Henrique Ellwanger: Conceptualization, Writing - Original Draft; José Artur Bogo Chies: Writing - Review & Editing. Both authors approved the final manuscript.

Declaration of interests

Joel Henrique Ellwanger is on the editorial board of *Frontiers* and José Artur Bogo Chies is on the editorial board of *Human Immunology*. The authors declare no conflicts of interest regarding this article.

Funding

Joel Henrique Ellwanger receives a postdoctoral fellowship from *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (*Programa Nacional de Pós-Doutorado* — PNPD/CAPES, Brazil). José Artur Bogo Chies receives a research fellowship from *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (*Bolsa de Produtividade em Pesquisa - Nível 1A*, CNPq, Brazil) and has research funded by CAPES (CAPES AUXPE 686/2020; Brazil).

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