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Climate Change Disaster and its impact on The Silent Pandemic

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Abstract:

Climate change represents one of the most significant challenges of our time, affecting various ecological and health systems across the globe. As temperatures rise and weather patterns shift, the dynamics of bacterial pathogens are also changing. These changes can have extreme implications for public health, agriculture and biodiversity. Affecting human health, Human pathogenic bacteria resistance (HPBR) infections mediated by the environment are considered a substantial cause of global health losses. However, the biogeography of HPB and their response to climate change remain largely unknown. HPB are widely present in the global environment, and their distribution follows a latitudinal diversity gradient. Climate and anthropogenic factors are identified as major drivers of the global distribution of HPBR. Our predictions indicated that by the end of this century, the richness, abundance, and invasion risk of HPBR will increase globally, with this upward trend becoming more pronounced as development sustainability declines. Therefore, the threat of environmentally mediated HPBR infections to human health may be more severe in a world where anthropogenic activities are intensifying and the global climate is warming. The objective of the study has comprehensive climatic and biological frameworks. This strategy has effectively identified relevant international research information and highlighted areas where further study is needed.

Climate change is likely to affect key aspects of bacterial epidemics in various ways, often exacerbating outbreaks but sometimes having a mitigation impact depending on the pathosystem and other factors.

Keywords: Resistance bacteria, climate change, Silent Pandemic, Pathological consequences

1- Introduction:

Rapid developments in technology, industry, and research are posing serious challenges to planetary ecosystems and global health. Among the most critical of these interconnected threats are climate change and antimicrobial resistance (AMR). Both crises are ultimately driven by anthropogenic choices and lifestyles. The One Health concept, which highlights the intrinsic connections between human health, animal health, and their shared environments, provides a vital framework for addressing these issues and is central to future sustainability [1] [2].

Human and animal health can be influenced by climate variability in different ways: both directly, because of physical impacts that cause Physiologic stress (e.g. temperature) or injury (e.g., floods, storms, fires, and

droughts); or indirectly, because of social and ecological disruptions, like shifting patterns of disease vectors, crop failures, and human migration. The health effects of such impacts tend to reveal shifts in the seasonal and geographic patterns of human infectious diseases, and changes in the severity and frequency of outbreaks. In the current century, the role of climate as a host- and pathogen-related risk factor for infectious RefWorks diseases has gained attention. Some research has focused on how climate change can facilitate the spread of disease vectors to new areas, putting new populations at risk. It is known that weather conditions such as rain, floods, humidity, and heat waves can affect infectious diseases. For example, long periods of rain increase the possibility of the spread of vector-borne diseases[3] [4]. Longer seasons with mild temperatures may also increase the likelihood of vector-borne disease transmission. At warmer temperatures, vectors are more infectious and can transmit pathogens earlier in their lives. While rapid climate change has overshadowed human health by changing the epidemiology of highly pathogenic microorganisms, the models used in this field are still unable to provide accurate predictions. It has been predicted that by 2100, there will be an increase in average precipitation ranging from 1-9% and an average global temperature increase of 1.45.8°C [5] [6]. Some studies have shown a direct relationship between temperature and the number of infectious patients. Therefore, warm and unstable climate as well as prolonged global warming creates suitable conditions for the emergence, spread, and redistribution of infectious diseases in different geographical areas. This study presents a literature review on the scientific evidence for the effect of major climate variables and extreme weather events on human bacterial infectious diseases. To achieve this goal, relevant articles in PubMed and Scopus databases regarding the impact of global climate change on human bacterial infectious diseases were evaluated [7][8].

2- Antimicrobials and Antimicrobial Resistance

Potent antibiotics for bacterial illnesses are one of the basic pillars supporting the efficiency of our modern healthcare system. In the absence of effective antimicrobials, procedures such as caesarean sections, hip replacements, cancer chemotherapy, and organ transplantation could become fatal. Even low-risk procedures taken for granted, from tooth extraction to small skin scratches, would be deadly. According to the World Health Organization (WHO), AMR is one of the twentieth century's most dangerous threats to human health [9]. To clarify, AMR is rising to dangerously high levels worldwide as novel resistance mechanisms develop and spread daily. Treatment of patients with common infectious diseases such as pneumonia has been becoming harder and, in some cases, impossible as drug efficacy declines. Increasing microbial resistance has resulted in superbugs, multi- and pan-drug-resistant bacteria that are not treatable with existing antimicrobial drugs. As all antimicrobial drugs affect pathogens through limited mechanisms, developing other drugs with new mechanisms is impossible. Additionally, prolonged research periods and huge budgets are always needed to develop more antimicrobial drugs. It is worth noting that bacterial pathogens evolve more rapidly than humans can respond, often developing resistance faster than anticipated [10].

3- Pathological consequences for public health

The spread of pathogenic microbes influenced by climate change has direct and indirect pathological consequences for human health. First, the emergence of new infectious diseases or the resurgence of diseases previously under control represents a major challenge for public health systems [11]. Increased prevalence of diseases like malaria, dengue, cholera, and Lyme disease puts pressure on healthcare infrastructure, particularly in low-resource settings. Increased disease transmission can also lead to more severe clinical outcomes. For example, warmer temperatures and increased humidity may facilitate the spread of drug-resistant pathogens, making infections harder to treat. In addition, diseases such as malaria and dengue can place a heavy burden on vulnerable populations, particularly in tropical and subtropical regions, where climate change is having the most pronounced effects [12]. The health disparities exacerbated by climate change are also noteworthy. Marginalized communities, particularly those living in low-lying areas, informal settlements, or areas lacking healthcare infrastructure, are more vulnerable to the effects of climate-driven disease spread [13]. These populations are often at greater risk of exposure to pathogens due to factors such as poor sanitation, overcrowding, and limited access to medical care [14].

4- Selection pressure and transmission mechanisms of ARGs under climate change

Climate change influences ARG transmission patterns in aquatic ecosystems through multiple pathways, including temperature rise, extreme weather events, and pollutant inputs. These environmental changes affect microbial physiology and accelerate ARGs spread by alterations in community structure and gene transfer efficiency. Antibiotics and resistance mechanisms form complex interaction networks involving multiple targets, including cell wall synthesis, protein synthesis, and nucleic acid synthesis [15]. These targets and their corresponding resistance mechanisms show varying responses when environmental temperatures rise. As the most direct environmental pressure, temperature increase affects ARG transmission across multiple levels. When water temperatures exceed 33–35 °C, water physicochemical properties and bacterial physiological states are significantly altered. ARG transmission primarily occurs through HGT [16]. Extreme weather events and pollutant inputs constitute another crucial factor that facilitates ARG transmission. Fig. 2b details how human facilities (wastewater treatment plants, pharmaceutical factories, and hospitals) release ARGs through various pathways [17]. Increased surface runoff from storms and floods carries antibiotic residues and heavy metal pollutants. These pollutants influence ARG enrichment through co-selection mechanisms. This phenomenon is significant because heavy metals and ARGs often co-locate on the same mobile genetic elements [18].

5- Previous Studies

Research Name	Aims of Research	Conclusion of Research
Effect of climate change on bacterial and viral pathogens [1]	evaluate the potential effects of direct and indirect climate-related factors on a wide variety of viral and bacterial pathosystems, which include various vectors, hosts, and pathogens	To protect biodiversity and ensure global food security, significant scientific effort is required to address the growing challenges of managing dangerous plant viral and bacterial outbreaks expected due to future climate instability.
Microbes and Climate Change – Science, People & Impacts [1]	Made several major recommendations for academic, policy, and market partners to promote innovation for microbe-driven climate change solutions that support human well-being.	a strategic step toward the goal of the Academy's scientific portfolio to integrate microbes in broader scientific discussions and contribute to the global efforts to address climate change.
Effects of climate change on plant pathogens and host-pathogen interactions [19]	these insights hold significant promise for bolstering global crop production resilience against mounting environmental challenges.	Effective disease management requires detailed insights at the field scale for specific diseases. Therefore, conducting meticulous assessments and evaluations of the potential impacts of climate change at a granular level is essential to elucidate the critical mechanisms and dynamics driving plant-related diseases and associated epidemics.
Health Effects of Climate Change [20]	The importance of dietary choice for GHG emissions and noted win-wins from dietary changes (for instance, lower animal product consumption reduces both GHG emissions and saturated fat intake.	To improve estimations of the current burden of disease from HABs, and to assess the impact of climate on diseases to understand how incidence may change in future.

Climate change and impact on infectious diseases [21]	The danger posed by climate change's impact on infectious diseases calls for a concerted effort to limit its effects through funding further studies, efforts to limit the extent of global warming, and directs disease mitigation strategies.	Providing mass chemo-prophylaxis, and developing more efficacious vaccines are perhaps more needed than ever and offer yet other ways to combat climate change's pernicious effects.
The Effect of Climate Changes on Human Bacterial Infectious Diseases [3]	The scientific evidence for the effect of major climate variables and extreme weather events on human bacterial infectious diseases.	To develop monitoring systems that will help in predicting the effect of climate changes on the occurrence of these diseases in endemic regions with different social and biological conditions.
The Impact of Climate Change on Infectious Disease Spread [22]	mitigation and adaptation strategies needed to address the public health challenges posed by these environmental changes. mitigation and adaptation strategies needed to address the public health challenges posed by these environmental changes.	addressing these challenges will require a global, interdisciplinary effort that combines climate science, public health, and policy reform
Effects of climate change on plant pathogens and host-pathogen interactions [19]	Relationship between climate change and plant pathogens and carefully provides an analysis of the interplay between climatic shifts and disease dynamics.	Conducting meticulous assessments and evaluations of the potential impacts of climate change at a granular level is essential to elucidate the critical mechanisms and dynamics driving plant-related diseases and associated epidemics.
Climate change and impact on infectious diseases [21]	Efforts to limit the extent of global warming, and direct disease mitigation strategies.	improving access to treatment, controlling vectors, providing mass chemoprophylaxis, and developing more efficacious vaccines
Climate Change and AMR: Interconnected Threats and One Health Solutions [23]	Elucidate not only the connections between AMR and climate change but also how this understanding can inform more effective surveillance, stewardship, and global mitigation strategies.	Addressing the interconnected root causes and implementing integrated strategies for AMR and climate change is not merely an option but a professional and ethical responsibility.

6- Potential Alternative Treatment Options to Combat Antimicrobial-Resistant Pathogens

Although antimicrobial treatment remains the main strategy for managing most infectious diseases, its effectiveness is becoming limited. This limitation has resulted in the evolution of many AMR-producing strains of pathogens, which in turn has become a critical challenge to human health. The problem of AMR emergence is provoked further due to slow-paced inventions in the development of novel antibiotics [24]. Therefore, it appears that finding effective alternative methods to eradicate drug-resistant bacterial organisms is now a necessity rather than a luxury, especially those derived from natural organic materials like plants and animal by-products. The continuously developed non-antimicrobial strategies are safer for humans and livestock and effective against infectious pathogens [25].

7- Global Action Plan on Antimicrobial Resistance (GAP)

During the 2020 World Health Assembly, countries made global commitments to the framework out lined in the 2020 Global Action Plan (GAP) on antimicrobial resistance (AMR), as well as to the

development and implementation of multispectral national action plans[26]. In collaboration with the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), and the World Organization for Animal Health, strategies were established requiring countries to implement these plans across all sectors and secure appropriate financing to ensure sustainable progress [8]. Prior to the endorsement of the GAP in 2020, a key international initiative to combat AMR, was the WHO Global Strategy for the Containment of AMR; it was developed in 2001 and provided a framework of actions to limit AMR emergence and spread [27]. Fig (3) Layout of the basic formulation of disease management strategies as affected by changing climate.

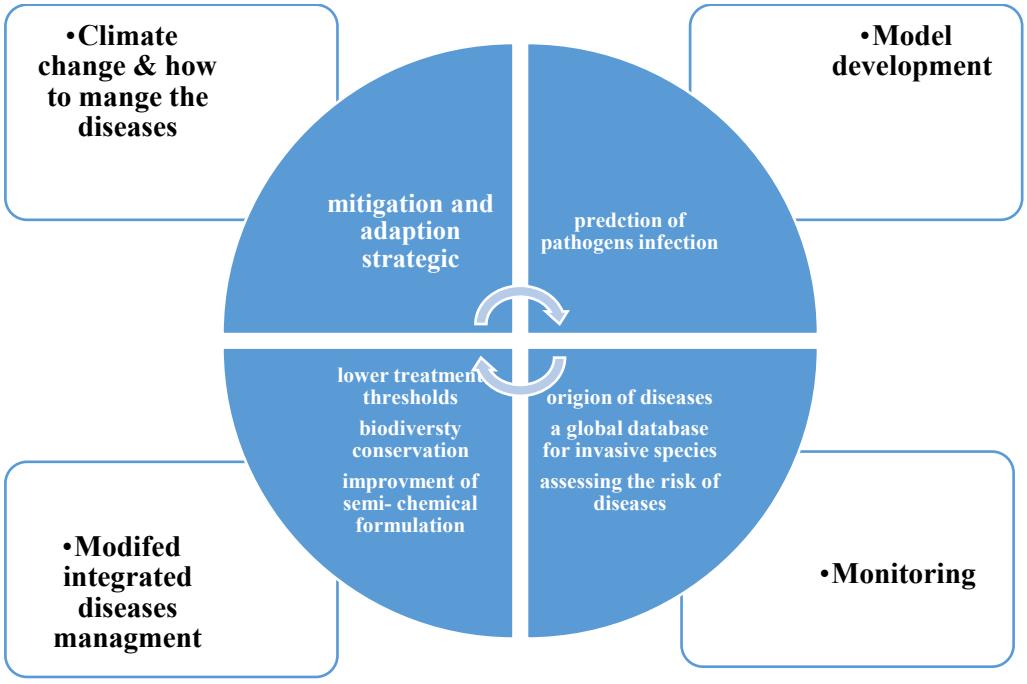

Figure: (3) A Scheme illustrating of the basic formulation of disease management strategies as affected by changing climate

8- Conclusion:

The effects of climate change on infectious diseases are likely to be profound, with over three quarters of the major infectious diseases potentially being impacted. Alarmingly, the published literature suggests a sharp asymmetry to this impact – the vast majority are likely to worsen rather than diminish. Although this may reflect a degree of research and publication bias (more effort is likely to have gone into understanding potential climate risks than benefits), the overall trajectory is nonetheless sobering. A warming climate, and more frequent and extreme climate hazards, is likely to exacerbate infectious diseases, whether spread by vectors, water, air, or food. And climate-driven shifts in the geographical range may mean that diseases which are on the verge of control could shift to geographical regions that are unprepared for the new challenge.

9- Recommendation

• Strengthen international cooperation to combat climate change and antimicrobial resistance.
• Improve oversight of antibiotic use and develop strategies to prevent infections.
• Support research into alternative therapies and vaccines.
• Provide sustainable health solutions in the most vulnerable communities.
• Promote community outreach and health education:
• Launch awareness campaigns to educate about the risks of antimicrobial resistance and the importance of using antibiotics with caution.
• Target groups most vulnerable to the effects of climate change in rural or low-income areas to enhance their understanding of infectious disease prevention and good health practices.

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Data availability statement
The data that support the findings of this study are available.

Conflicts of interest
The authors declare that there is no conflict of interest.

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الخلاصة:

يمثل تغير المناخ أحد أهم التحديات في عصرنا، إذ يؤثر على مختلف النظم البيئية والصحية حول العالم. ومع ارتفاع درجات الحرارة وتغير أنماط الطقس تتغير أيضًا ديناميكيات مسببات الأمراض البكتيرية. وقد يكون لهذه التغيرات آثار بالغة على الصحة العامة والزراعة والتنوع البيولوجي. وتُعد عدوى البكتيريا الممرضة للإنسان التي تنتقل عبر البيئة، سببًا رئيسيًا للخسائر الصحية العالمية. ومع ذلك، لا تزال الجغرافيا الحيوية لهذه البكتيريا واستجابتها لتغير المناخ غير معروفة إلى حد كبير. وتنتشر هذه البكتيريا على نطاق واسع في البيئات العالمية، ويتبع توزيعها تدرجًا في انماط التنوع مع خطوط العرض. وقد تم تحديد العوامل المناخية والبشرية كعوامل رئيسية في التوزيع العالمي لهذه البكتيريا. وتشير توقعاتنا إلى أنه بحلول نهاية هذا القرن، سيزداد تنوع ومقاومة البكتيريا الممرضة للإنسان ووفرتها وخطر غزوها عالميًا، وسيصبح هذا الاتجاه التصاعدي أكثر وضوحًا مع تراجع استدامة التنمية. لذلك، قد يكون خطر عدوى البكتيريا الممرضة للإنسان، التي تنتقل عبر البيئة، على صحة الإنسان أشد وطأة في عالم تتزايد فيه الأنشطة البشرية ويرتفع فيه المناخ العالمي. يهدف هذا المقال إلى وضع أطر شاملة للمناخ والبيولوجيا. وقد نجحت هذه الاستراتيجية في تحديد المعلومات البحثية الدولية ذات الصلة، وسلطت الضوء على المجالات التي تتطلب مزيدًا من الدراسة. من المرجح أن يؤثر تغير المناخ على جوانب رئيسية من الأوبئة البكتيرية بطرق مختلفة، فغالبًا ما يؤدي إلى تفاقم تفشي المرض، بينما قد يكون له أحيانًا تأثير مخفف، وذلك تبعًا للنظام الممرض وعوامل أخرى.