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The Impact of Climate Change on the Transmission of Vector-borne Diseases and Drug Administration: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Climate change continues to be a big threat to humanity, particularly due to its significant impacts on human health. Although there have been some studies on the impacts of climate change on human health, there is a huge gap on its prospective effects on the transmission of vector-borne diseases and drug administration. Therefore this review provides a comprehensive impacts of climate change on the transmission of vector-borne diseases and drug administration It is estimated

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that the global temperature on average will potentially rise by 1.0 – 3.0 ºC, thus increasing the chance of the emergent and increased rate of transmission of vector-borne diseases. Climate change continues to have a significant impact on overly poor and vulnerable populations across tropical and sub-tropical regions across the world. Some studies have established the influence of climate change on the transmission of diseases due to increasing changes in weather patterns such as rainfall and increase in temperature, as a result of global warming. It is believed that climate change will have a long-term effect on the propagation of diseases, and subsequently affect treatment from drug administration. Rising temperatures and global warming due to climate change can alter disease patterns, drug stability and change drug properties, thus potentially increasing drug toxicity and reducing drug efficacy.

Keywords: Climate change; vector-borne diseases; drug administration.

1. INTRODUCTION

Climate change is considered an emerging threat to the health of humans [1]. Climate change occurs as a result of natural and man-made activities that consequently impact the health of humans and the environment through changes in weather conditions and the quality of the environment [2]. Throughout the 21st century, the human population has been challenged with warmer temperatures, changes in rainfall patterns, floods, droughts and other extreme weather conditions which have been predicted to increase in the coming years [3]. In addition to the extremities in seasonal weather change, vectors which are organisms (vertebrates, invertebrates, formite) Wilson et al., [4] that rely on the surrounding temperature for the propagation of disease-causing organisms may carry certain pathogens and necessitate the completion of their lifecycles through their hosts [5]. For the survival, reproduction, distribution and transmission of disease pathogens, the synergy of vectors, or disease hosts, and suitable climatic conditions are needed. Currently, the effects of climate change have a direct influence on the epidemiology of infectious diseases, given the expected consequence of climate change in the transmission of dengue fever [6].

Studies have shown that long-term climate warming tends to favor the geographic expansion of certain infectious diseases, and that extreme weather events can help create opportunities for more frequent outbreaks in untraditional locations (Olmos & Bostik). Changing climatic conditions limit the geographic and seasonal distribution of infectious diseases, and weather has an impact on the timing and strength of outbreaks [7]. The risk from vector-borne diseases is essentially subtle to changes in weather and climate [8]. Overall, vector-borne infections account for more than 17% of all infectious diseases, and thus changes in the environmental conditions predispose the human population to the distribution and spread of diseases [9]. The tropical nature of the African climate is auspicious for the development of vector-borne diseases, and as a result, drives the redistribution and creation of new patterns of diseases. The occurrence of natural or man-made phenomena through environmental change alters the balance in ecological states and the rates at which diseases spread [10].

2. CLIMATE CHANGE AND VECTOR-BORNE DISEASES

The complexity of factors related to climate and disease transmission necessitates the complete synthesis of rigorous systematic approaches to deciphering the role of climate change in addressing practical challenges for effective solutions [11]. Changes in climatic factors influence the pathogenic interaction between vectors and humans or animal hosts [12]. Modifications in climate serve as an avenue for climate-sensitive vector-borne diseases to emerge through variations in annual weather conditions [13].

Ogden suggested that climate change directly affects disease transmission by substituting the vector's terrestrial range, movement, or breeding [14]. Variations in climate influence the epidemiology of vector-borne diseases, predicting an early rise in temperature by 2100. The greatest impact of climate change will be experienced in disease transmission through changes in temperature in extreme regions. Anomalies in climates reported in the El Nino-southern oscillations have been indicative predictors of disease outbreaks which underscore the repercussions of climate change [15]. Climate change may impact the rise of vector-borne diseases in temperate regions however, the transmission mechanics of vector-borne diseases are influenced by a complexity of factors such as climate, social and economic conditions, healthcare capacity, and ecological states. In Denmark, Bygbjerg et al. argued that malaria and leishmaniasis transmission is improbable to become a public health problem while tick-borne diseases may rise [16]. Beermann et al. discussed that human behavior in addition to climate variations play a pivotal role in the distribution of vector-borne infections in Germany [17]. Gage et al. [18] explained that climate change has the potential to marginally affect vector-borne disease transmission, presenting a complex relationship that requires a long-term study for efficient control measures.

Despite these, the probability of vector-borne diseases occurring fundamentally depends on both climatic and non-climatic factors [19]. In Europe, unique changes in vector-borne diseases require a strategy for assessing risks associated with climatic conditions on vector-borne diseases [20,14]. Climate change has the potential to magnify the geographical spread of numerous vector-borne infections to higher altitudes and latitudes in India [21,18]. The transmission prospects of vector-borne diseases are directly proportional to climate changes on broader challenges of areas endemic to climate-sensitive infections at higher altitudes in these regions [22]. The complexity of the impacts of climate change on disease transmission has been affected by non-climatic drivers, which makes it challenging to distinguish the effects of worsening impact of vectors. However, Rocklöv suggested that scenario-based modeling has the potential to predict the prospective effects of non-climatic predictors while improving control and prevention mechanisms [23]. In Africa, climate change has increased the frequency of environmental effects and transmission rates of vector-borne diseases through extreme weather events [24]. Asante & Amuakwa-Mensah [25] proposed that, by 2050, there may be an exponential increase in the spread of infectious diseases and other water-borne diseases as a result of changing and worsening climatic conditions.

3. CLIMATE CHANGE ON ECOLOGY AND VARIABILITY IN TRANSMISSION OF VECTOR-BORNE DISEASES

Vector ecology and transmission of diseases to new geographical locations is significantly influenced by climate change [26]. Climate change controls the transmission of diseases by modifying the ranges in which vectors reproduce. This is largely expressed in tropical climates which consequently impacts the re-emergence of vector-borne diseases [26]. Transmission of vector-borne diseases is related to critical determinants such as host-pathogen interaction in the environment [27]. Despite the progress in eliminating vector-borne diseases, vector-transmitted infections are widely recognized as a public health burden in Africa. However, the spread of diseases to new geographical regions has been recorded in temperate regions through the substantial effects of anthropogenic determinants [28].

The potential for migration of vectors due to climate variations implies a relationship between long-term weather changes and the migratory effects of disease vectors [29]. Hall et al. [29] also discovered that climate change could have a direct contradictory impact by mitigating the transmission if there was a difference in response to the periodic biological phenomenon and spread of important vector species. From an ecological perspective, climate change instigates the spread of vector-borne diseases in the ecosystem. Climatic and non-climatic determinants include the non-linear consequences of local environmental climate, time-lagged impacts of extreme climates, and human interactions through agricultural use of land and motility [30] also suggested the relationship between climatic and non-climatic determinants through land use and movement of human functions as a mediator in the spread of vector-borne infections, taking into consideration the effect of SARS-COV2 which introduces ambiguities in understanding the impacts of climate change on vector-borne infections.

Changing weather patterns in India have favored the spread and reproduction conditions for the growth of vectors particularly species of mosquitoes such as Anopheles mosquitoes, Aedes mosquitoes, thereby increasing the risk of vector-borne diseases [31]. The ecology of vector-borne diseases relies directly on changing weather patterns, temperature, humidity, and precipitation thereby influencing disease transmission [31]. However, Bermudez-Tamayo et al. [32]. contended that variabilities in climate can extend beyond environmental impacts and that socioeconomic factors can influence the transmission of vector-borne diseases and the availability of discrepancies in the quantitative relationship between climate change and the transmission of diseases.

4. IMPACT OF CLIMATE CHANGE ON THE EFFECTIVENESS OF DRUG ADMINISTRATION

The cost-effectiveness of drug administration makes it a reliable means of reaching populated geographical locations, therefore plays a critical role in lessening the burden of neglected tropical diseases. However, climate change is predicted to have an extensive effect on the efficacy of drug administration due to changing patterns of diseases, environmental impacts and usage, especially in the northern hemisphere with a likelihood of a forecasted increase in the incidence of diseases [33]. Climate changes have been projected to affect profiles of diseases and gradually increase pharmaceutical use, subsequently affecting the ecotoxicological properties of drugs [33]. The changing distribution of infectious diseases, pharmaceutical medications and climate change-related abiotic variables have different effects, with harmful effects more pronounced in certain circumstances. Climate change factors induce and introduce different responses to drugs as a result increases higher toxic effects of greater bioconcentration [34]. For example; climate change is now affecting the distribution and activity of allergenic fungi, worsening allergic diseases hence more realistic research is needed to evaluate the impact of pharmacological medications under climate change scenarios [35]. The importance of drug stability in extreme environments is on the verge of declining due to harsh temperatures. Extreme climates may also demand complementary administration routes [36]. Intervention drugs are stable at room temperatures and also at 2-8^{o}C but in terms of climate change of increasing temperature, the stability of drugs and the probable side effects can be altered. A study by Šklebar et al. explained that BCG vaccines are more stable than pertussis vaccines in high-temperature conditions [37]. However, the composition and adapting changes in drug constituents could have diminished effects during heatwaves as a result of global warming or climate change which can impact the health of patients. There may be a potential increase in antibiotic resistance levels of azithromycin in low- and middle-income countries after a mass and systemic administration of antibiotics. The perceived increase in resistance could as a result, be a decline in integrative approaches and consistent surveillance detection, however, in cases where there is no monitoring after administration in harsh climatic conditions, vulnerable populations may be at most risk of drug resistance [38]. Peripheral heating of the body can induce changes in hemodynamics, volume of body fluid and distribution impacting the absorption activity of certain drugs, however there may be less association between the pharmacokinetic relationship and cytotoxicity of drugs [39,40].

5. CONCLUSION

Climate change is a major threat to human health, exacerbated by both natural and human actions, leading to extreme weather events like floods, droughts, and heatwaves, which are expected to worsen. These environmental shifts increase the spread of infectious diseases, particularly vector-borne diseases such as dengue fever, which thrive under warmer temperatures and changing rainfall patterns. In Africa, the tropical climate nurtures the spread of these diseases, while in Europe and other areas, new disease patterns are likely to emerge due to climate change. Tackling climate change requires an integrative approach to the development of climate-health models as well as improvement in disease and environmental surveillance systems, as these will lessen the impacts of climate change on vector-borne diseases. In mitigating the impacts of climate change on drug administration, strategies such as temperature-controlled storage should be implemented to preserve the integrity of drugs. Moreover, reformulation of drugs for stability in changing climates and applying real-time monitoring systems can help preserve drug efficacy while training healthcare professionals on the effects of climate change on drug stability safeguards active and informed care for patients.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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