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THE INTERPLAY BETWEEN CLIMATE CHANGE, GLOBAL HUMAN HEALTH, AND SUSTAINABILITY: UNRAVELING COMPLEXITIES AND CONSEQUENCES THROUGH A COMPREHENSIVE REVIEW

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Abstract

Climate change is a global threat. Natural and anthropogenic activities both are responsible for climate change. It adversely affects the agricultural system, human beings, and other species existing in this world. In the case of human beings, it affects both internal and external organs. It transmits many diseases, including infectious and vector-borne diseases. Malaria is spread throughout the tropical & subtropical regions by climate change. It impacts 247 million individuals worldwide 619,000 people were killed in 2021, up from 229 million infections and 409,000 decrease in 2019. An increase in temperature, more frequent rainfall, and storms increase the chances of respiratory, cardiac, nervous, and gastrointestinal problems such as diarrhea. The ozone layer is depleted by an increase in temperature and causes skin cancer. As the planet warms, it increases risks from extreme weather conditions, increasing sea altitudes, and altering disease patterns, increasing human health problems and mortality rates. Disaster managers must adapt to these conditions, monitoring trends and adjusting policies accordingly.

INTRODUCTION

"Climate Change" refers to long-term alternations in weather conditions (temperature, precipitation, etc.) that occur over decades or millions of years. The Earth's climate has changed over time, even before human activity played a part in it [1]. However, the UNFCCC [2] describes "Climate modifications caused by Human-induced alterations to the Earth's atmosphere, in addition to natural climate fluctuations." was defined. However, the IPCC defines climate change as changes produced by both natural variability and human activity [3]. Climate change has progressed from a solely scientific worry to a public agenda that is more likely to be an economic problem [2]. The fast temperature rise (0.5 °C) ever since the mid-1970s is mostly caused by manmade greenhouse gas emissions [4, 5]. Climate models in the 1990s accurately simulated atmospheric processes but had limited representations of oceanic, terrestrial, and cryospheric processes and sulfate aerosols. Climate models in the 1990s accurately simulated atmospheric processes but had limited representations of oceanic, terrestrial, and cryospheric processes and sulfate aerosols. Nevertheless, a lot remains to be discovered regarding how the Earth's

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climate system responds to changes in natural and manmade variables such as solar radiation, eruptions of volcanic rocks, airborne particles, diminished ozone layer, and atmospheric greenhouse gas levels. The 2003 European heat wave revealed that even high-income nations may be badly affected [6]. Global temperatures could increase between 1.4°C and 5.8°C by the year 2100, according to climate models [7].

Review of Literature

Climate change causes

Anthropogenic and natural factors both are responsible for climate change. However, a minority of people think that climate change is caused by natural forces [8].In natural factors volcanic eruption, solar radiation and ocean currents cause shift in climate change while in case of anthropogenic factors deforestation, agriculture sectors, industrial activities and vehicles effluents responsible for climate change.

Consequences of climate change on health

The World Health Organization estimated that anthropogenic climate change has caused around 150,000 fatalities per year as a result of heat and precipitation patterns during the last 30 years. Climate change has been linked to many prevalent illnesses in people, ranging from death due to cardiovascular and respiratory disorders caused by heat waves to hunger caused by changed spread of infectious illnesses and crop disasters. Climate change is responsible for the disease's growth and recurrence due to a lack of long-term, high-quality datasets in addition to the considerable effect of changes in socioeconomic issues, immunity, and medication resistance. It remains questionable. The investigators stated that there is emerging information that the climate-health relationship raises concerns regarding health in light of future climate change projections and that warming trends in current times have previously grown globally. We're looking at how this is contributing to rising morbidity and mortality in various places of the world. Temperate latitudes, the Pacific and Indian Oceans, Sub-Saharan Africa, and big urban centers are also potentially vulnerable since urban heat island effects can exacerbate severe weather occurrences [15]. The most relevant sources of disease are anthropogenic methane, nitrous oxides, and emitted carbon dioxide along with chlorofluorocarbons. These GHGs are the main cause of global temperature rise, meteorological events such as droughts and storms, and the spread of allergens and infectious agents. Climate change contributes not only to a rise in respiratory and cardiovascular illnesses but also increases the probability of suffering from infectious diseases (such as malaria, typhus, and cholera), cancer, and other afflictive conditions. It is believed that the negative effects of cold weather on health, which is mainly illnesses associated with excessive cold exposure like the emergence of bronchopneumonia or articular disorders, can be curbed by global warming [16]. Both comparatively low and high temperatures are linked to diabetes. People with diabetes are more susceptible to heat-related diseases [17].

Impact on skin

Due to climate change ozone layer is depleted, and holes form in the ozone layer allowing UV radiation to reach on earth and directly affect human skin by causing skin cancer, acne, aging, and rashes. It also increases skin sensitization as shown in Figure 1.

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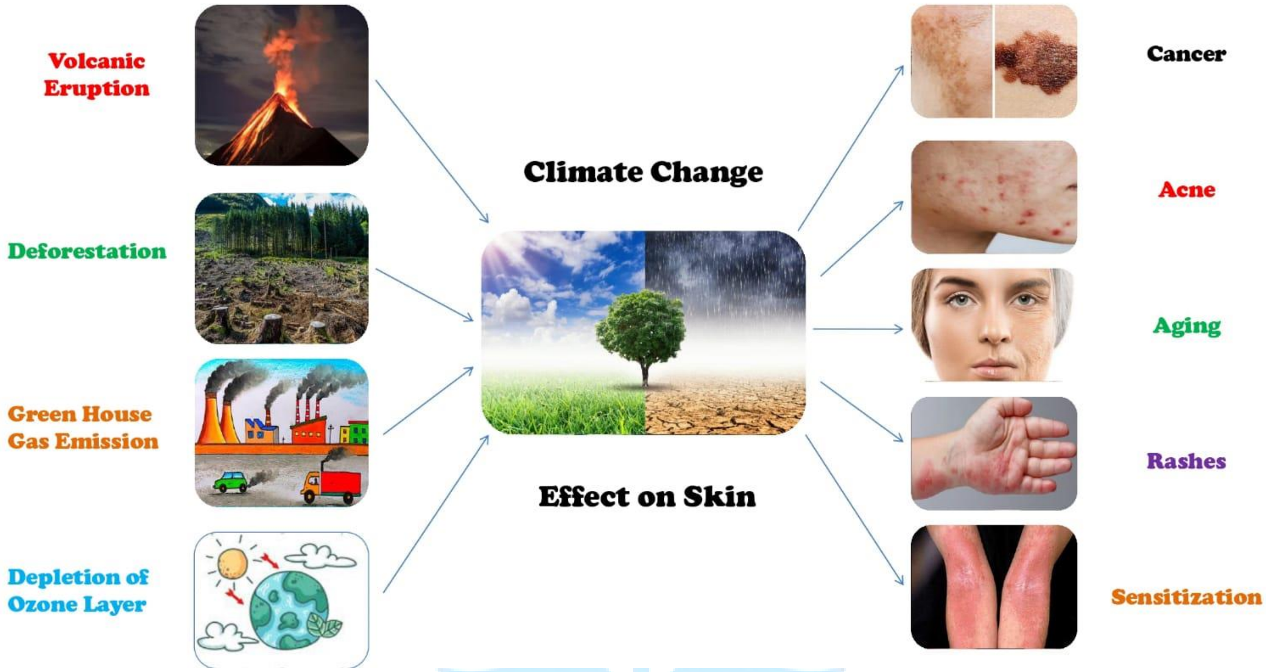

Figure 1 Skin problems caused by climate changes

Impact on cardiopulmonary health

Climate change adversely affects the respiratory and cardiac systems as shown in Figure 2.The World Health Organization's analysis of climate change and well-being forecasts that, from 2030 to 2050, alterations in the global climate will likely contribute to roughly a quarter of a million extra fatalities annually [18]. The impact of climate change on breathing health occurs through both direct shifts in meteorological conditions and ecosystems, and indirectly by elevating risk factors. These indirect factors encompass heightened air contamination, variations in airborne allergen distribution, spread of respiratory pathogens, land degradation, climate-driven disasters like cyclones, inundations, tempests, and blazes, along with the societal and economic susceptibility of populations. The consequences for breathing health involve worsening of long-term lung disorders, onset of immediate respiratory illnesses including contagions, intensified allergic reactions, and untimely deaths [19]

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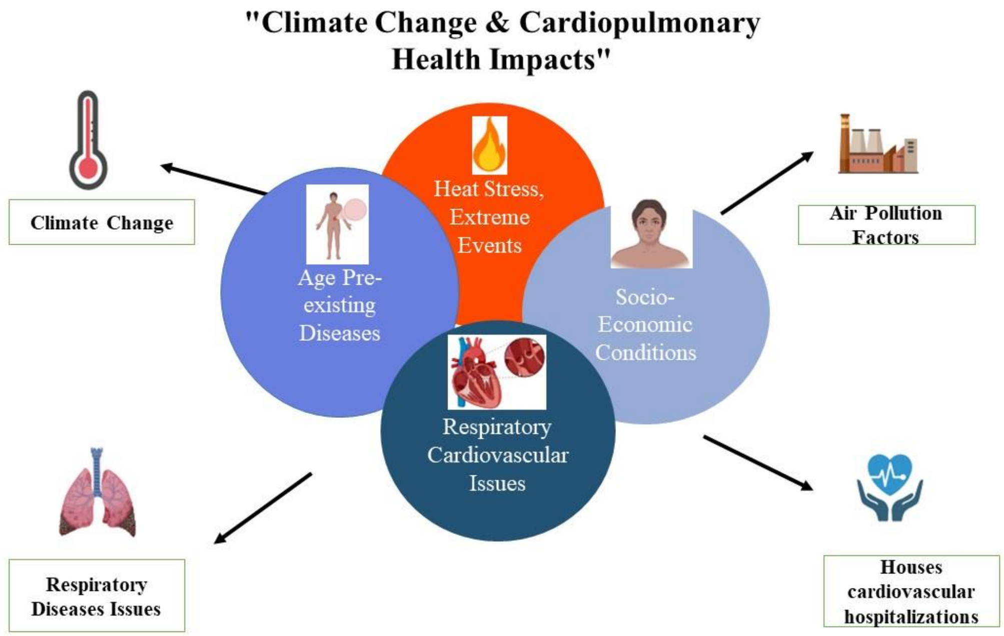

Figure 2 Climate and Cardiopulmonary Problem

Impacts of Climate Change on Mental Health

Climate change is expected to have a detrimental influence on substantial portions of the population's psychological well-being [21]. In the present day, one of the most pressing issues is climate change. Most of the scientific community is concerned about the impacts of climate change on vulnerable life forms as well as society. Increased temperature, heat waves, floods, tornadoes, hurricanes, droughts, fires, loss of forests and glaciers, decreased rivers and streams, and deserts can negatively affect the physical and mental health of human beings. Still, there is a noticeable lack of psychiatric research on psych-political concerns of climate change. Climate change impacts are immediate and can be unforeseen, as well as distant in time. Sudden extreme events can trigger phenomena comparable to traumatic stress which leads to obviously defined psychopathology symptoms. In addition, the effects of being increasingly exposed to harsh or lengthy weather phenomena may be deferrable leading to post-traumatic stress disorder in some or to future generations [22].

Climate Change & Transmission of Diseases

Climate change has broad implications for human health, although the majority of these consequences remain negative. Climate change has been connected to many prevalent human ailments, ranging from cardiovascular mortality and respiratory disorders brought on by heat waves to hunger caused by changed transmission of infectious diseases and crop failures. The climate-health relationship is an increasing health issue in light of future climate change forecasts, with warming patterns over recent decades already contributing to increased morbidity and death in numerous areas of the globe [15].

Infectious Diseases

Climate change is increasing the worldwide incidence of infectious illnesses and endangering health security [23]. Climate change and unusual weather conditions have an important impact on infectious illnesses. Because infectious pathogens (protozoa, bacteria, and viruses) and their transporters (mosquitoes, ticks, and sandflies) lack thermoregulatory systems, temperature changes have a substantial influence on reproductive and rates of survival.

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Climate change and Malaria transmission

Climate influences the distribution and seasonal transmission of malaria because both the vector and the pathogen are temperature-sensitive [24]. Malaria is one of the most common parasite illnesses produced by Plasmodium spp., endangering billions of people in hot and temperate regions. The illness impacted 247 million individuals worldwide and killed 619,000 people in 2021, up from 229 million infections and 409,000 fatalities in 2019 [25, 26]. Climate change's influence on human health has garnered more attention in recent years, with the potential effects of vector-borne illnesses just now becoming clear. Malaria, the most severe vector-borne illness, was responsible for one million fatalities worldwide in 2006 and is anticipated to be particularly vulnerable to climate change because of the sensitivity of its transmission dynamics to climatic circumstances. The biological activity and geographic spread of the malaria parasite and its vector are susceptible to climatic factors, particularly temperature and precipitation [27]. A simple mathematical model is initially used to investigate how temperature affects Anopheles maculipennis' capacity to spread vivax malaria. This suggests that even minor temperature rises at low temperatures might significantly enhance the chance of transmission. This is significant because vulnerable people who are underserved by health care and live in regions with unstable or no malaria are more likely to have subsequent outbreaks. In contrast, locations with steady transmission may be unaffected by rising temperatures. Global warming is thought to produce floods along the coast, changes in precipitation, and, subsequently, changes in land usage. To comprehend how these changes, affect transmission at the local level, one must first understand the ecology of the regional vectors. These are essentially environmental factors that increase the spread of malaria in one mosquito species and can reduce transmission in another [28].

Climate Change and Transmission of Dengue Disease

Dengue fever (DF) is a viral illness that has become a major community well-being concern due to a significant increase in incidence worldwide over the past few decades [12, 31]. Population growth, unplanned urbanization, and inadequate mosquito control in urban areas all contribute to the spread of dengue fever [32]. The World Health Organization (WHO) predicts that 2.5 billion individuals are at risk of contamination internationally[33]. Recently updated studies revealed that the burden has increased by up to three times compared to previous WHO estimates [34, 35]. Based on Halstead (2007), female Aedes aegypti is the primary spreader of the dengue fever virus (DENV). It is a member of the Flaviviridae family and, like most viruses, has four serotypes that cause DF, dengue shock syndrome, and, dengue hemorrhagic fever (DENV 1-4) [36]. A dengue preventative vaccine (Sanofi Pasteur's Dengvaxia (CYD-TDV)) was evaluated and registered in several countries, however, the WHO deemed it unsafe for seronegative individuals[37, 38]. Because vaccinations are not safe, preventative and control strategies are the only viable alternatives for reducing dengue. Climate change may increase the prevalence of dengue disease. Dengue fever rates may rise if improved access to tap water leads to increased home water storage. Climate change might have a significant influence on the success or failure of future dengue control initiatives (2013). Climate change is frequently discussed in terms of its implications 50 or 100 years from now. However, recent occurrences indicate that the damage is already underway, considerably sooner than anticipated. Pakistan is witnessing the harshest consequences of climate change, with severe rains causing catastrophic flooding throughout the country. Since the beginning of 2022, Pakistan has received rainfall equal to 2.9 times the national 30-year average. August 2022 was Pakistan's wettest August since 1961. The worst-hit province of Sindh had 726% more rainfall than the August normal [39]. The resultant floods harmed 33 million people, including 16 million children, killed almost 2,000 people, and wounded 13,000 more. 800,000 houses were demolished, and a further 1.3 million were injured. Over two million individuals become dispossessed [39].

Lyme disease transmission

Lyme disease is caused by the bacterium Borrelia burgdorferi, which is a complicated pathogenic illness. This virus spreads mostly by the bite of an

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infected vector (tick). Several variables contribute to understanding the global spread of Lyme disease. According to epidemiological research, Lyme disease frequently develops in shady and grassy locations with significant tick populations. Ticks transmit B. burgdorferi from asymptomatic hosts (rodents), which then spread to humans. Lyme disease is prevalent in the Arctic, and changes in ecosystems and candies are resulting in public health diseases. Symptoms may include fever, influenza, dermatitis, and, if persistent, inflammation of the heart and nerve system. PCR and serological assays for antibodies against Borrelia burgdorferi can be used to diagnose the illness [43].

Present and future risks due to climate change on human health

Changes in disaster management are crucial, as current disaster vulnerabilities and dangers are frequently unknown. Climatic, Change, and Risk emphasizes that disaster managers must adjust policies to changing climatic circumstances while continuing to monitor trends to detect substantial changes in risk and respond effectively [44]. The scientific community is overwhelmingly in consensus that social-induced greenhouse gas releases are changing the Earth's climate. Anthropogenic emissions have contributed to the recent 0.5°C (global average) warming. Climate change has a wide-ranging and mostly negative influence on human strength. Recently documented changes in the Earth's climate, to which people have made important contributions, are influencing a wide range of health consequences. These include shifts in the distribution of some disease vectors (ticks in high latitudes, malaria mosquitos at high altitudes), as well as trends in extreme weather events and their accompanying increases in deaths, injuries, and other health repercussions. These include shifts in the distribution of some disease vectors (ticks in high latitudes, malaria mosquitos at high altitudes), as well as trends in extreme weather events and the corresponding increases in deaths, injuries, and other health repercussions. Climate change will exacerbate health issues in vulnerable areas, affect infectious disease epidemics, reduce food yields and nutrition, raise the danger of climate-related disasters, and harm mental health. The health industry must assist society in understanding the health dangers and the appropriate actions [45].

Conclusion

Climate change may have altered the distribution and abundance of disease-carrying microorganisms such as mosquitoes and ticks. Rising temperatures and increased precipitation can create favorable conditions for these vectors to breed and spread diseases such as malaria, dengue fever, and Lyme disease. Vulnerable populations are at heightened risk, necessitating urgent action to reduce greenhouse gas emissions, strengthen public health systems, and invest in climate-resilient infrastructure that can control malaria by using insecticide-treated bed grids, indoor enduring spurting, and rapid handling of malaria gears. Additionally, eliminating breeding sites for mosquitoes, such as stagnant water, is crucial. We should protect human health and create a more sustainable future by tackling the underlying causes of climate change and implementing effective adaptation strategies. Climate change can amplify the negative effects of other stressors, leading to more serious health consequences, especially for vulnerable populations. Research needs to examine how climate change interacts with other stressors such as air pollution, poverty, and social inequality to amplify health risks.

Recommendations

On a national level, taxes on pollutant emissions introduced, conservation and purification systems must be introduced in countries, and on the international level alarming system should established.

REFERENCES

1. Change, I.P.O.C., Climate change 2007: the physical science basis. Agenda, 2007. **6**(07): p. 333.
2. Rahman, M.I.-u., Climate change: A theoretical review. Interdisciplinary Description of Complex Systems: INDECS, 2013. **11**(1): p. 1-13.
3. UNFCC, W. Fact Sheet: Climate Change science–the status of climate change science today. in United Nations Framework Convention on Climate Change. 2011.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

4. Smithson, P.A., IPCC, 2001: climate change 2001: the scientific basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change, edited by JT Houghton, Y. Ding, DJ Griggs, M. Noguer, PJ van der Linden, X. Dai, K. Maskell and CA Johnson (eds). Cambridge University Press, Cambridge, UK, and New York, USA, 2001. No. Of pages: 881. Price£ 34.95, US 49.95,ISBN0-521-01495-6(paperback).£90. 00,US 130.00, ISBN 0-521-80767-0 (hardback). 2002, Wiley Online Library.
5. Trenberth, K.E., Climate variability and global warming. Science, 2001. **293**(5527): p. 48-49.
6. Haines, A., et al., Climate change and human health: impacts, vulnerability, and mitigation. The Lancet, 2006. **367**(9528): p. 2101-2109.
7. Change, I.C., The scientific basis. 2001, Cambridge University Press, Cambridge, UK.
8. Nda, M., et al., A review on the causes, effects, and mitigation of climate changes on the environmental aspects. International Journal of Integrated Engineering, 2018. **10**(4).
9. Moore, F.C., Climate change and air pollution: exploring the synergies and potential for mitigation in industrializing countries. Sustainability, 2009. **1**(1): p. 43-54.
10. Jeffry, L., et al., Greenhouse gases utilization: A review. Fuel, 2021. **301**: p. 121017.
11. Leon, M., et al., Effect of deforestation on climate change: A co-integration and causality approach with time series. Sustainability, 2022. **14**(18): p. 11303.
12. Khormi, H.M. and L. Kumar, Modeling dengue fever risk based on socioeconomic parameters, nationality, and age groups: GIS and remote sensing based case study. Science of the Total Environment, 2011. **409**(22): p. 4713-4719.
13. Longobardi, P., et al., Deforestation induced climate change: Effects of spatial scale. PloS one, 2016. **11**(4): p. e0153357.
14. Munsif, R., et al., Industrial air emission pollution: potential sources and sustainable mitigation, in Environmental emissions. 2021, IntechOpen.
15. Patz, J.A., et al., Impact of regional climate change on human health. Nature, 2005. **438**(7066): p. 310-317.
16. Franchini, M. and P.M. Mannucci, Impact on human health of climate changes. European journal of internal medicine, 2015. **26**(1): p. 1-5.
17. Davis, R.E., E.K. Driskill, and W.M. Novicoff, The association between weather and emergency department visitation for diabetes in Roanoke, Virginia. International Journal of Biometeorology, 2022. **66**(8): p. 1589-1597.
18. Organization, W.H., WHO consolidated guidelines on tuberculosis. Module 2: screening-systematic screening for tuberculosis disease. 2021: World Health Organization.
19. Bayram, H., et al., Impact of global climate change on pulmonary health: susceptible and vulnerable populations. Annals of the American Thoracic Society, 2023. **20**(8): p. 1088-1095.
20. Sadeghi, A., D. Leddin, and R. Malekzadeh, Mini review: the impact of climate change on gastrointestinal health. Middle East Journal of Digestive Diseases, 2023. **15**(2): p. 72.
21. Charlson, F., et al., Climate change and mental health: a scoping review. International journal of environmental research and public health, 2021. **18**(9): p. 4486.
22. Cianconi, P., S. Betrò, and L. Janiri, The impact of climate change on mental health: a systematic descriptive review. Frontiers in psychiatry, 2020. **11**: p. 490206.
23. Semenza, J.C., J. Rocklöv, and K.L. Ebi, Climate change and cascading risks from infectious disease. Infectious diseases and therapy, 2022. **11**(4): p. 1371-1390.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

24. Van Lieshout, M., et al., Climate change and malaria: analysis of the SRES climate and socio-economic scenarios. Global environmental change, 2004. **14**(1): p. 87-99.
25. Organization, W.H., WHO Malaria Policy Advisory Group (MPAG) meeting, October 2022. 2022: World Health Organization.
26. Organization, W.H., World malaria report 2023. 2023: World Health Organization.
27. Martens, W., et al., Potential impact of global climate change on malaria risk. Environmental health perspectives, 1995. **103**(5): p. 458-464.
28. Lindsay, S. and M. Birley, Climate change and malaria transmission. Annals of Tropical Medicine & Parasitology, 1996. **90**(5): p. 573-588.
29. Snow, R.W. and K. Marsh, Malaria in Africa: progress and prospects in the decade since the Abuja Declaration. Lancet, 2010. **376**(9735): p. 137.
30. González-Sanz, M., P. Berzosa, and F.F. Norman, Updates on malaria epidemiology and prevention strategies. Current Infectious Disease Reports, 2023. **25**(7): p. 131-139.
31. Shrivastava, S., P. Shrivastava, and J. Ramasamy, Taking major strides in dengue vaccine research: World health organization. Annals of Tropical Medicine and Public Health, 2017. **10**(3): p. 743-743.
32. Pang, T., T.K. Mak, and D.J. Gubler, Prevention and control of dengue—the light at the end of the tunnel. The Lancet Infectious Diseases, 2017. **17**(3): p. e79-e87.
33. Sam, J., T. Gee, and N. Wahab, Fatal intracranial hemorrhage in a patient with severe dengue fever. Asian Journal of Neurosurgery, 2018. **13**(01): p. 56-58.
34. Bhatt, S., et al., The global distribution and burden of dengue. Nature, 2013. **496**(7446): p. 504-507.
35. Runge-Ranzinger, S., Technical handbook for dengue surveillance, dengue outbreak prediction/detection and outbreak response (model contingency plan). 2016, World Health Organization.
36. Li, S., et al., Simultaneous detection and differentiation of dengue virus serotype 1-4, Japanese encephalitis virus, and West Nile virus by a combined reverse-transcription loop-mediated isothermal amplification assay. Virology journal, 2011. **8**: p. 1-9.
37. Olliaro, P., et al., Improved tools and strategies for the prevention and control of arboviral diseases: A research-to-policy forum. PLoS Negl Trop Dis, 2018. **12**(2): p. e0005967.
38. Kayesh, M.E.H., et al., An effective pan-serotype dengue vaccine and enhanced control strategies could help in reducing the severe dengue burden in Bangladesh–A perspective. Frontiers in Microbiology, 2024. **15**.
39. Abid, M.A. and M.B. Abid, Climate change and the increased burden of dengue fever in Pakistan. Lancet Infect Dis, 2023. **23**(1): p. 17-18.
40. Mahmud, M.A.F., et al., The application of environmental management methods in combating dengue: a systematic review. Int J Environ Health Res, 2023. **33**(11): p. 1148-1167.
41. Rather, I.A., et al., Prevention and Control Strategies to Counter Dengue Virus Infection. Front Cell Infect Microbiol, 2017. **7**: p. 336.
42. Achee, N.L., et al., A critical assessment of vector control for dengue prevention. PLoS Negl Trop Dis, 2015. **9**(5): p. e0003655.
43. Saeed, A., et al., A Brief Overview of Lyme disease and One Health Approach for its Control. 2024. **1**: p. 47-74.
44. Ibarraran Viniegra, M.E., et al., Climate Change and Natural Disasters: Macroeconomic Performance and Distributional Impacts. Environment Development and Sustainability, 2009. **11**: p. 549-569.
45. McMichael, A.J. and E. Lindgren, Climate change: present and future risks to health, and necessary responses. J Intern Med, 2011. **270**(5): p. 401-13.