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Vector-Borne Diseases In Humans And Animals: A Review Of Insect-Borne Threats And Control Strategies In Europe And The Middle East

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Abstract :

Vector-borne diseases (VBDs) remain a critical public health issue globally, especially in regions such as Europe and the Middle East, where environmental and climatic shifts, migration, and urbanization have increased vulnerability. This review explores the role of disease-carrying insects in transmitting infections to humans and animals, assessing the impact of climate, ecological factors, and genetic variability on the proliferation of vector populations. It discusses prevention and control strategies, including biological, genetic, chemical, and environmental interventions, and emphasizes the importance of integrated approaches under the One Health framework to mitigate these threats. This systematic review seeks to evaluate the existing information about the effects of climate change on the distribution, incidence, and management options for vector-borne diseases (VBDs), emphasising regional variations in vulnerability worldwide.

Keywords: Vector-borne diseases, zoonoses, insect vectors, environmental control, insecticide resistance, climate change, One Health .

الامراض المنقولة بالنواقل لدى البشر والحيوانات : مراجعة للتهديدات التي تحملها الحشرات واستراتيجيات المكافحة في اوربا والشرق الاوسط

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مستخلص:

لاتزال الامراض المنقولة بالنواقل تشكل مشكلة صحية عامة حرجه على الصعيد العالمي ، لاسيما في مناطق مثل اوربا والشرق الاوسط ، حيث زادت التحولات البيئية والمناخية والهجرة والتحضر من قابلية الاصابه بها ، يستكشف هذا البحث دور الحشرات الحاملة للامراض في نقل العدوى الى البشر والحيوانات ، مقيما تأثير المناخ والعوامل البيئية والتنوع الجيني على انتشار نواقل الامراض. كما يناقش استراتيجيات الوقاية والمكافحة ، بما في ذلك التدخلات البيولوجية والوراثية والكيميائية والبيئية، ويشدد على اهمية اتباع نهج متكاملة في ايطار الصحة الواحدة للتخفيف من حدة هذه التهديدات . ويسعى هذا البحث المنهجي الى تقييم المعلومات المتاحه حول أثار تغيير المناخ على توزيع الامراض المنقولة بالنواقل ومعدلات الاصابة بها وخيارات ادارتها ، مع التركيز على الاختلافات الاقليمية في قابلية الاصابة بها حول العالم.

الكلمات المفتاحية: الامراض المنقولة بالنواقل ، الامراض حيوانية المنشأ ، الحشرات الناقلة للامراض، مكافحة الامراض البيئية ، مقاومة المبيدات الحشرية ، تغير المناخ ، الصحة الواحدة.

Introduction

Insect vectors, such as mosquitoes, and flies, are responsible for transmitting numerous diseases that significantly impact public health. Climate change, globalization, and ecological disruptions have facilitated the expansion of vectors into previously non-endemic areas[1]. This review examines current trends and VBDs across Europe and the Middle East, focusing on disease epidemiology, insect behavior, and vector control methodologies. Human disorders brought on by bacteria, viruses, and parasites that are spread by vectors are known as vector-borne diseases[2]. Diseases include malaria, dengue, schistosomiasis, human African trypanosomiasis, leishmaniasis, Chagas disease, yellow fever, Japanese encephalitis, and onchocerciasis cause about 700,000 deaths annually. The poorest populations are disproportionately affected by these diseases, which are most prevalent in tropical and subtropical regions. Major epidemics of Zika, dengue, malaria, chikungunya, and yellow fever have plagued populations, killed people, and overburdened health systems in numerous nations since 2014. Other illnesses including lymphatic filariasis, leishmaniasis, and chikungunya result in lifelong morbidity, persistent pain, disability, and sporadic stigmatization[3]. The distribution of vector-borne diseases is influenced by a complex array of demographic, environmental, and social factors. The proliferation of vector-borne diseases has been facilitated by global travel and trade, unregulated urbanisation, climate change, and the covert dissemination and adaptation of vectors. Climate change significantly influences pathogens (parasites, viruses, and bacteria), vectors, and reservoir hosts, impacting the transmission of numerous vector-borne diseases[3]. Numerous vectors have broadened their latitudinal and altitudinal ranges, and the duration of their active season is extending. These trends are anticipated to persist as the climate continues to warm. The global influence of vector-borne diseases is exacerbated by the continual appearance of novel, unrecognised outbreaks and the re-emergence of established ones. In recent decades, at least 30 novel in-

fectious pathogens impacting humans have arisen, predominantly zoonotic in nature, with their origins largely linked to socioeconomic, environmental, ecological, and climatic aspects[4].

Vector-borne infectious illnesses present a significant worldwide burden on public health, exacerbating health disparities. The emergence of novel infectious diseases has been well-documented since antiquity. Vector-borne infectious illnesses have been recognised as the most catastrophic pandemics in human history. A notable counterexample of a vector-borne disease that resulted in 25-40 million fatalities is the bubonic/pneumonic plague [5]

The management of vector-borne diseases constitutes a significant challenge within global health initiatives. The rapid and unregulated urbanisation has heightened the urgency to address these issues through the development and execution of structured strategic plans at both global and local levels. The significant prevalence and increasing incidence of endemic vector-borne diseases have concerned stakeholders on the effective control and treatment of affected individuals. The global burden of infectious diseases, including vector-borne illnesses, has significantly decreased over the past decades due to advancements in modern medicine, poverty alleviation strategies, socioeconomic development, and the implementation of more effective intervention and control measures. One of the prevalent and effective vector control methods was the application of chemical pesticides. Notwithstanding the efficacy of chemical insecticides, the emergence of insecticide resistance poses a significant challenge to the control of vector-borne diseases, which mostly relies on targeting vector populations Nonetheless, worldwide advancements encompass notable regional accomplishments[6].

-Vector-Borne Diseases: A Growing Threat

Diseases such as malaria, Chagas disease, dengue, and schistosomiasis continue to pose challenges despite medical advancements. Turkey, acting as a bridge between continents, is particularly vulnerable due to its strategic geography and agricultural de-

pendency[7]. The emergence of West Nile Virus, leishmaniasis, and Crimean-Congo hemorrhagic fever in new zones further exemplifies the growing risks. Vector-borne infectious illnesses impose a significant burden of morbidity and mortality globally, particularly impacting resource-limited and economically disadvantaged populations. Despite their global prevalence, the morbidity and mortality they cause are most pronounced in tropical and subtropical regions. Even within the tropics and subtropics, they disproportionately impose a greater cost on impoverished populations[8]

-Genetic Insights and Insect Behavior

Recent advancements in vector genomics reveal the importance of species differentiation, chromosomal variation, and gene flow in understanding vector biology. Genetic control strategies, including the use of Wolbachia bacteria or genetically modified insects, show promise in reducing disease transmission.[10].

- Control Strategies

1- Chemical Control

The use of insecticides such as organochlorines and pyrethroids remains central to vector control, although resistance is a growing issue. Integrated vector management (IVM) is crucial to reduce pesticide reliance and promote sustainability[11].

2-Biological Control

Predatory fish, copepods, and aquatic plants like azolla have been effective in limiting mosquito larvae. Such ecological interventions are particularly beneficial in agricultural and rural settings[10].

3-Genetic Control

Gene drive technologies and sterile insect techniques aim to suppress vector populations or render them incapable of disease transmission[12].

4-Environmental Management

Insects like moths and mosquitoes display adaptive migratory behavior influenced by wind and temperature. These dynamics impact their capacity to disseminate pathogens across vast regions. Climate-driven factors such as humidity, precipitation, and temperature directly affect breeding, survival, and infection cycles of vectors[9]. Climate change significantly influences pathogens (parasites, viruses, and bac-

teria), vectors, and reservoir hosts, impacting the transmission of numerous vector-borne diseases. Numerous vectors have broadened their latitudinal and altitudinal ranges, and the duration of their active season is extending. These trends are anticipated to persist as the climate continues to warm[3]. Improved waste management, water container design, and urban planning are essential in minimizing breeding grounds for vectors. Access to water and sanitation is a critical determinant in disease prevention and eradication. The WHO collaborates with several governmental sectors to enhance water storage and sanitation, hence aiding in the prevention of diseases at the community level[13].

5-Case Studies of Major Diseases

Chagas Disease: A chronic parasitic illness transmitted by Triatominae, treatable with early administration of benznidazole or nifurtimox.

Schistosomiasis: A parasitic disease linked to freshwater snails, causing intestinal and urinary complications.

Malaria: Primarily transmitted by *Anopheles* mosquitoes, remains a leading cause of death in tropical regions[13].

Dengue: A mosquito-borne viral infection with no specific antiviral treatment, making vector control essential[14].

7-Insecticide Resistance: An Emerging Challenge

The overuse of pyrethroids and organophosphates has accelerated resistance in vector populations, compromising the effectiveness of long-standing control measures. WHO recommends resistance monitoring and the development of localized response plans[4].

8-One Health and Regional Coordination

The One Health approach integrates human, animal. Turkey's national strategy includes the "Turkey Zoonotic Diseases Action Plan 2019–2023," which emphasizes review, public awareness, and intersectoral collaboration to manage zoonotic outbreaks[17].

9-Conclusions

The increase in insects that carry infectious diseases threatens human life and quickly spreads until it becomes an epidemic. Therefore, we must quickly take precautions to prevent the spread

of all diseases and work to increase preventive solutions and face the difficulties of climate change and coexistence with the significantly changing environmental factors and follow the progress of technology to detect vectors to limit or reduce them .The escalation of VBDs, influenced by climate change, vector migration, and ecological pressures, necessitates a comprehensive, multidisciplinary response. Through integrated surveillance, review, and preventive strategies rooted in the One Health framework, Europe and the Middle East can mitigate these growing public health threats. Vector-borne infectious illnesses present a significant global challenge to public health[1]. Over the past few decades, the incidence of vector-borne emerging illnesses has increased, potentially due to various driving factors such as socioeconomic conditions, environmental changes, global warming, and climate change. Collaborative review networks focused on zoonotic and vector-borne emerging and re-emerging infectious diseases are essential for tackling the fundamental issues in long-term planning[5]. In this context, prioritising the empowerment of the One Health approach, which includes public health specialists, veterinarians, entomologists, and parasitologists, is essential. Furthermore, the contributions of international donors and fundraising agencies need significant consideration. Currently, various developing, re-emerging, and established vector-borne infectious illnesses are being effectively handled nevertheless, future initiatives to prevent the establishment of new diseases appear uncertain. This may signal the need for a continuous battle against developing vector-borne infectious illnesses [15] The review revealed a substantial link between climate change variables, including temperature and precipitation, and the distribution of vector-borne diseases (VBDs). Worldwide, diseases such as malaria and dengue have extended their geographical distribution due to elevated temperatures and modified precipitation patterns, resulting in prolonged transmission seasons. Particular regions, especially in tropical and subtropical areas, exhibit increased susceptibility due to socioeconomic conditions and insufficient

public health systems. Climate change intensifies existing health disparities, disproportionately impacting marginalised groups that are least prepared to address vector-borne disease epidemics. Control approaches, such as vector management and community health programs, have demonstrated inconsistent efficacy, frequently constrained by resource availability and regional environmental factors. This analysis highlights the pressing necessity for cohesive climate and health measures to alleviate the effects of climate change on vector-borne diseases (VBDs). Confronting these difficulties necessitates a comprehensive strategy that takes into account local context, fosters fairness in health interventions, and improves readiness for emerging health threats[16].

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