Insects and Public Health: A Comprehensive Review

Narasimha Rao .C[1], Srineetha .U[2] and Veera Nagendra Kumar .D[3]

[1]Dept. of Zoology, Govt. Degree College, Mydukur, Kadapa Dist. A.P.-516172
[2]Dept. of Zoology, Govt. Degree College for Women, Pulivendula, Kadapa Dist. A.P.-516390
[3]Dept. of Zoology, Govt. College for Men (A), Kadapa,. A.P.-516004
narasimharao.svu@gmail.com

ABSTRACT

Insects play a pivotal role in global ecosystems, with the Arthropoda phylum alone comprising a staggering 1,242,040 species, making up 80% of the Animalia kingdom. Insects, particularly those within the Insecta class, exhibit a diverse array of roles, from ecosystem maintenance to serving as vectors for various diseases. While insects contribute positively to ecosystems by decomposing nutrients, dispersing seeds, and controlling populations, they also pose threats to human health. WHO reports indicate that over 17% of infectious diseases are vector-borne, resulting in over 700,000 annual deaths. Mosquitoes, sand flies, fleas, ticks, and other blood-feeding parasites are key contributors to the spread of diseases like malaria, Dengue, Zika, and Chikungunya. The transmission of vector-borne diseases is influenced by factors such as breeding environments, population density, and urbanization. The global economic burden of invasive insects, accounting for goods, services, and health costs, exceeds $70.0 billion annually, with health costs alone surpassing $6.9 billion. Preventive measures are crucial, including vaccination, insect repellents, protective clothing, bed nets, tick checks, environmental management, and proper waste disposal. Educational campaigns, community engagement, and vector control programs are essential components of a comprehensive strategy. Prompt healthcare seeking after insect bites is vital for early diagnosis and effective treatment. The National Vector Borne Diseases Control Programme (NVBDCP) in India addresses diseases like Malaria, Japanese Encephalitis, Dengue, Chikungunya, Kala-azar, and Lymphatic Filariasis. The GVCR, endorsed by the World Health Assembly, provides strategic guidance for reinforcing vector control globally, with the WHO Secretariat offering critical support. These initiatives exemplify collaborative efforts to combat and manage vector-borne diseases, safeguarding public health on a global scale.

Key words: Insects, Infectious diseases, Vector borne diseases, Public health.

Introduction

Insects play a multifaceted role in shaping public health dynamics, encompassing both beneficial and detrimental aspects. The Animalia kingdom consists a total of 1,552,319 globally described species distributed among 40 phyla in a recent evolutionary classification. Remarkably, the Arthropoda phylum stands out with a staggering 1,242,040 species, making up approximately 80% of the total species within the kingdom [1]. Estimates suggest around 1.5 million beetle species and 5.5 million total insect species, with 1 million described. E. O. Wilson approximates 10 quintillion insects coexisting at any given time [2]. Insecta is a largest group within the arthropod phylum and they exhibit a distinctive three-part body structure comprising the head, thorax, and abdomen, along with three pairs of jointed legs, compound eyes, and a pair of antennae with a chitinous exoskeleton.

Insects have successfully inhabited nearly every imaginable habitat, establishing the biological underpinning for all terrestrial ecosystems. They play pivotal roles such as decomposing and recycling nutrients, dispersing seeds, upkeeping soil structure and fertility, and exerting control over populations of various organisms in diverse capacities—serving as predators, parasites, parasitoids, disease agents, and vectors. Additionally, insects serve as a significant food source for a wide range of taxa, including amphibians, reptiles, birds, fish, arthropods, other invertebrates, and mammals [3,4]. While insects are thus useful to mankind on one side, on the other hand, they cause many diseases and damaging the health of human beings most severely. Many types of insects are carriers of many disease-causing microorganisms and play a role in the spread of diseases in humans. According to WHO, over 17% of all infectious diseases are vector-borne, and they are responsible for over 700,000 annual deaths [5]. Considering all reported estimates for goods and services, invasive insects incur a minimum annual global cost of US$70.0 billion. Additionally, associated health costs surpass US$6.9 billion per year. While total costs escalate with an increase in the number of estimates, it's noteworthy that a substantial portion of the most severe costs, particularly those linked to human health, has already been estimated [6].

Insects and Human health

Since time immemorial, insects have been spreading many diseases and adversely affecting public health. A well-known aspect of insects related to public health is their role as pathogenic vectors. As pathogenic vectors, insects are spreading bacteria, viruses, protozoans and a variety of parasites, causing a large number of human deaths around the world. Some of

the insects such as cockroaches and flies are usually non-blood-sucking, carry pathogens mechanically, obtain contamination on faces, sewage or other biological fluids, and spread to the environment and food through contact, while mosquitoes, sand flies, fleas, and ticks, are typically blood-feeding parasites [10]. They acquire pathogens during a blood meal from an infected host. Within the vector, the pathogen undergoes multiplication and/or a phase of its development cycle. Subsequently, when the vector organism bites other hosts, it transmits the pathogen to them [4]. Human pathogens transmitted by insects are a global problem, especially those transmitted by mosquitoes; For example, malaria parasites transmitted by Anopheles species and viruses such as Dengue, Zika and Chikungunya, which are transmitted by Aedes mosquitoes [7]. The transmission of vector-borne diseases is influenced by various factors, such as the breeding environment of the vectors, population density in the area, and rapid urbanization. The likelihood of contracting a vector-borne disease increases in regions where vectors flourish, such as stagnant water bodies, dense tall grass, and areas experiencing significant outbreaks [8].

Mosquitos

Diseases transmitted through infected mosquito bites are referred to as mosquito-borne diseases. Mosquito-borne diseases have a global presence, affecting more than 150 countries. These illnesses, transmitted by mosquitoes, afflict over 500 million individuals worldwide and result in approximately 1 million fatalities. In India alone, about 40 million people contract mosquito-borne infections annually [11]. The diseases include Chikungunya, Dengue fever, Malaria, Zika fever, Yellow fever, Filariasis, Rift valley fever and West Nile fever as well as Eastern Equine Encephalitis (EEE), Western Equine Encephalitis (WEE), and St. Louis Encephalitis (SLE) [9,12]. Chikungunya, Dengue fever, Zika fever and Yellow fever can be caused by *Aedes* mosquito. Japanese encephalitis and West Nile fever caused by the *Culex* mosquito and Malaria can be caused by female *Anopheles* mosquito.

Ticks

Ticks are small parasitic organisms inhabiting wooded areas and fields. They depend on blood from humans or animals for sustenance. Ticks are known carriers of a range of serious diseases, which they can transmit to individuals through their bites. The incidence of tick-borne diseases has increased by over twofold in the past 13 years, as indicated by a 2018 report from the Centers for Disease Control and Prevention (CDC) [13]. Crimean-Congo hemorrhagic

fever, Lyme disease, Tick-borne encephalitis, Relapsing fever, Tularaemia and Rickettsial disease are some of diseases caused by ticks [8, 14].

Sandflies

Sand flies, belonging to the family Psychodidae, are dainty, gnat-like insects that feed on a range of mammals and occasionally other vertebrates like reptiles and amphibians. Numerous species of sand flies serve as notable public health nuisances and act as vectors for diseases. Leishmaniasis, bartonellosis, and sandfly fever are the most common diseases transmitted by sandflies [15].

Tse-tse Flies

Human African trypanosomiasis, commonly referred to as sleeping sickness, is a parasitic disease transmitted by vectors. Protozoans belonging to the genus Trypanosoma cause the illness, and it is spread to humans through the bites of tsetse flies (glossina). These flies acquire the parasites from infected humans or animals [16]. Primarily impacting impoverished populations residing in isolated rural areas of Africa, the disease is typically fatal when left untreated. Travelers also face the risk of infection when navigating regions where the insect is prevalent. While the disease is generally absent in urban areas, reported cases have emerged in suburban areas of large cities within certain disease-endemic regions [17].

Lice

Lice are parasitic insects that inhabit various parts of the human body, including the head and body, as well as the pubic area. These parasitic creatures sustain themselves by feeding on human blood. The characteristics of lice found in each body area distinguish them from one another [18]. Typhus, Louse-borne relapsing fever are common diseases caused by Lice. Epidemic typhus, also known as louse-borne typhus, is a rare infectious disease caused by the bacterium *Rickettsia prowazekii*. The transmission of epidemic typhus occurs through contact with body lice carrying the infection. While this disease was once responsible for millions of deaths in past centuries, it is now considered uncommon [19]. Louse-borne relapsing fever (LBRF) is a serious bacterial infection acquired through the bite of a body louse that has fed on the blood of an infected individual. As implied by its name, the predominant symptom of LBRF is the recurrent occurrence of fever [20].

Preventive measures

Preventive measures for insect-borne diseases are paramount for public health. Vaccination against diseases transmitted by insects, like malaria and dengue, is a fundamental strategy. Insect repellents, such as DEET and permethrin, safeguard exposed skin, while wearing protective clothing minimizes the risk of insect bites. Bed nets are effective in areas with prevalent mosquitoes, reducing the transmission of diseases like malaria. Regular tick checks and prompt removal mitigate the risk of tick-borne illnesses. Environmental management, proper waste disposal, and the use of screens on doors and windows contribute to reducing insect habitats. Educational campaigns, community engagement, vector control programs, and animal population management further enhance prevention efforts. Lastly, seeking prompt healthcare after insect bites is vital for early diagnosis and effective treatment, collectively fostering a comprehensive approach to mitigating the impact of insect-borne diseases on public well-being.

The National Vector Borne Diseases Control Programme (NVBDCP) serves as a comprehensive initiative to prevent and control vector-borne diseases, including Malaria, Japanese Encephalitis (JE), Dengue, Chikungunya, Kala-azar, and Lymphatic Filariasis. Among these, the goal is to eliminate Kala-azar and Lymphatic Filariasis by 2015. Implementation of the program rests with the individual states, while the Directorate of NVBDCP in Delhi offers essential technical support, policies, and aid to the states in the form of approved financial and material assistance. This collaborative approach ensures a coordinated effort to combat and manage vector-borne diseases across the country [21].

The World Health Assembly endorsed the "Global Vector Control Response (GVCR) 2017–2030" in 2017. This framework offers strategic guidance to countries and development partners, emphasizing the critical reinforcement of vector control as a foundational strategy for disease prevention and outbreak response. The WHO Secretariat plays a key role by providing countries and development partners with strategic, normative, and technical guidance. This guidance is designed to support the implementation of robust vector control measures in alignment with the GVCR, ensuring an effective and coordinated global effort to prevent diseases and respond to outbreaks [5].

Conclusion

In conclusion, while insects are indispensable to ecosystems, contributing to various ecological processes, their role as vectors poses significant threats to human health. The global

impact of insect-borne diseases, costing billions annually, necessitates robust preventive measures. Vaccination, repellents, protective clothing, and environmental management are crucial components. The collaborative efforts of programs like NVBDCP and global initiatives such as GVCR underscore the importance of a coordinated approach. By prioritizing public awareness, community engagement, and effective vector control, we can mitigate the adverse effects of insect-borne diseases, safeguarding global well-being.

References

1. Nayak, S.B., Elango, K. and Rao, K.S. (2021). Insect biodiversity and their conservation for sustainable ecosystem functioning. In: Biological Diversity: Current Status and Conservation Policies, Volume 1, Eds. Kumar., V., Kumar,S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 304-314, DOI:10.26832/aesa-2021-bdcp-020
2. Wilson, E.O. (1987). The little things that run the world (The importance and conservation of Invertebrates). Conservation Biology, 1:344-346. https://doi.org/10.1111/j.1523-1739.1987.tb00055.x
3. Van Huis (2013). A. Potential of Insects as Food and Feed in Assuring Food Security. Annu. Rev. Entomol. 2013, 58, 563–583. https://doi.org/10.1146/annurev-ento-120811-153704
4. Belluco S, Bertola M., Montarsi F., Di Martino G., Granato A., Stella R., Martinello M., Bordin F. and Mutinelli F. (2023). Insects and Public Health: An Overview. *Insects* , *14*, 240. https://doi.org/10.3390/insects14030240
5. Vector-borne diseases, Key facts. Vector-borne diseases (who.int)
6. Bradshaw CJ, Leroy B, Bellard C, Roiz D, Albert C, Fournier A, Barbet-Massin M, Salles JM, Simard F, Courchamp F. (2016). Massive yet grossly underestimated global costs of invasive insects. *Nat Commun*. Oct 4;7:12986. doi:10.1038/ncomms12986. PMID: 27698460; PMCID: PMC5059451.
7. Nicoletti M. (2020). Past, present, and future of insect-borne diseases. Insect-Borne Diseases in the 21st Century:1–38. doi: 10.1016/B978-0-12-818706-7.00001-2. Epub 2020 Aug 21. PMCID: PMC7442135.
8. Venkat S.R. (2022). Medically Reviewed by Dany P. Baby, MD , What Are Vector-Borne Diseases? What Are Vector-Borne Diseases? (webmd.com)

9. Mosquito-Borne Diseases, Mosquito-Borne Diseases | NIOSH | CDC
10. Vector Borne Diseases (VBD) (Human), Vector Borne Diseases (VBD) (Human) | UNDRR
11. Dr. Arti Prasad, Suman, Sanjay Kumar Meena and Dr. Ashok Kumar, (2022). General Overview of Mosquito Borne Diseases (MBD): A Great Burden on Humanity, In book: Research Trends in Applied Research, Publisher: Weser books, Germany. https://www.researchgate.net/publication/362519799
12. Tina M. Penhollow and Luis Torres (2021). Impact of mosquito-borne diseases on global public health, International Physical Medicine & Rehabilitation Journal, 6(1):19–20. DOI: 10.15406/ipmrj.2021.06.00273
13. ALISA HRUSTIC,(2019). 9 Tick-Borne Diseases That Can Make You Seriously Sick—and How to Spot Them. 9 Tick-Borne Diseases and Their Symptoms - Tick-Borne Illnesses (prevention.com)
14. Medically reviewed by Debra Sullivan, Ph.D., MSN, R.N., CNE, COI — By Darla Burke (2023). Tick Infestations. Tick Infestations: Causes, Signs, and Prevention (healthline.com)
15. Goddard, J. (2018). Sand Fly-Transmitted Diseases. In: Infectious Diseases and Arthropods. Infectious Disease. Humana Press, Cham. https://doi.org/10.1007/978-3-319-75874-9_6
16. WHO, Trypanosomiasis, human African (sleeping sickness (2023). Trypanosomiasis, human African (sleeping sickness) (who.int)
17. WHO, Neglected tropical diseases: Sleeping sickness (human African trypanosomiasis) (2020). Neglected tropical diseases: Sleeping sickness (human African trypanosomiasis) (who.int)
18. Parasitic lice, CDC - Lice
19. Epidemic typhus. Epidemic Typhus | Typhus Fevers | CDC
20. Medically Reviewed by Dany P. Baby, MD on October 18, 2022 Written by Mallika Bhattacharya, What Is Louse-Borne Relapsing Fever (LBRF)? Louse-Borne Relapsing Fever (LBRF): What Is It? (webmd.com)
21. Chapter 6, National Programmes Under NHM, 6_English_AR (mohfw.gov.in)