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Vector-borne disease risk assessment in hospitality zones: A case study approach

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Abstract
Vector-borne diseases (VBDs) continue to represent a major global health challenge, especially across tropical and subtropical regions where tourism is a critical economic sector. Hotels, lodges, and restaurants situated in endemic areas frequently offer ideal ecological niches for disease vectors such as mosquitoes and flies. Tourists, travelers, and hospitality workers remain vulnerable to infections such as malaria, dengue, and leishmaniasis. This review article explores vector-borne disease risk assessment in hospitality zones through a case study approach, integrating entomological, environmental, and epidemiological dimensions. It further identifies specific risk factors linked to hospitality infrastructure, evaluates existing preventive mechanisms, and recommends integrated surveillance and management strategies. Emphasis is placed on technological innovation and integrated vector management (IVM) frameworks aligned with WHO's Global Vector Control Response (GVCR) 2017-2030.

Keywords: Vector-borne diseases, tourism health, mosquito surveillance, integrated vector management, hospitality environment, dengue, malaria, leishmaniasis

Introduction
Vector-borne diseases (VBDs) are among the most significant infectious health burdens worldwide. They account for over 17% of all infectious diseases and cause more than 700,000 deaths annually (WHO, 2024). The hospitality industry, encompassing hotels, resorts, and restaurants, represents a dynamic interface between environmental and human health systems. Many of these establishments are located in endemic or semi-endemic areas, where vectors such as *Anopheles*, *Aedes*, and *Phlebotomus* species are abundant.

Tourism contributes substantially to national economies, yet the same environmental features that attract tourists—such as lush gardens, water bodies, and open dining areas—also create favorable habitats for vector breeding. The risk of disease transmission in such hospitality zones extends beyond guests to include staff and local communities. Moreover, tourists visiting from non-endemic countries may lack immunity to local pathogens, increasing both disease susceptibility and the risk of imported infections (Perera *et al*., 2023) [6].

Despite the extensive literature on VBD control in public health and urban settings, there remains limited focus on vector risk within hospitality environments. This review integrates findings from entomological surveys, environmental studies, and case-based investigations to assess the vector ecology surrounding hospitality establishments and provide a framework for risk mitigation.

Background and Significance
Hospitality zones often exhibit micro-ecological and structural features that facilitate vector proliferation. Poorly maintained drainage systems, ornamental pools, garden planters, waste bins, and storage tanks offer breeding sites for *Aedes aegypti* and *Anopheles stephensi*. Similarly, food waste and organic debris attract *Musca domestica* (houseflies), known vectors of enteric pathogens.

The World Health Organization (2023) [10] has emphasized that vector control strategies should extend beyond domestic and community settings to include commercial infrastructures such as hotels and lodges. Tourism-related VBD outbreaks not only pose health risks but also result in economic repercussions due to reduced tourist inflow and reputational damage (Rattanarithikul *et al*., 2022) [7].

In endemic regions such as India, Thailand, and Sri Lanka, hospitality centers frequently coexist with local communities where malaria and dengue are persistent threats. For instance, in coastal Goa, *Anopheles subpictus* populations peak during the tourist season, coinciding with increased water storage and landscaping activities (Naik *et al*., 2023) [5]. Thus, vector surveillance in hospitality premises forms an essential component of integrated disease management.

Objectives

The specific objectives of this review are to: Assess mosquito and fly populations in and around hospitality establishments in vector-endemic regions, Identify environmental and infrastructural determinants of vector proliferation within hospitality premises, Evaluate existing control and preventive strategies implemented by hotels, lodges, and restaurants, Analyze case studies to understand the spatial and ecological dimensions of vector presence, Propose a comprehensive risk assessment model and integrated control framework tailored for hospitality environments.

Vector Ecology in Hospitality Zones

Mosquito Populations

Hospitality sites frequently provide microhabitats conducive to mosquito breeding. Anopheles species: Found breeding in freshwater habitats like overhead tanks, ornamental ponds, and gutters; *An. stephensi* is particularly associated with urban malaria transmission in South Asia and Africa (WHO, 2023) Aedes species: Breed in artificial containers, discarded bottles, flower pots, and air-conditioning drip trays. These are vectors of dengue, chikungunya, and Zika viruses (Rattanarithikul *et al*., 2022) [7]. Culex species: Thrive in septic tanks, drainage channels, and polluted water; they are associated with filariasis and Japanese encephalitis.

A study in hospitality establishments across Goa (Naik *et al*., 2023) [5] recorded an average Breteau Index (BI) of 25, exceeding the WHO threshold, indicating high dengue risk. Similar findings were reported in Zanzibar and Sri Lanka, where hotel zones recorded vector densities two to three times higher than surrounding residential areas.

Fly Populations

Flies, particularly *Musca domestica*, are major mechanical vectors transmitting *Salmonella spp.*, *E. coli*, and *Shigella spp.* (Ali *et al*., 2021) [1]. Improper sanitation and waste management practices in restaurant kitchens, open-air dining, and refuse storage zones enhance fly breeding potential. Flies may travel between waste disposal areas and food service counters, facilitating the spread of food-borne pathogens.

Case Study Insights

Case Study 1: Malaria Risk in Coastal Hotels (Goa, India)

Entomological surveys conducted across 15 hospitality sites revealed the dominance of *Anopheles subpictus* and *Anopheles stephensi*. Major breeding sites included ornamental ponds, broken pipelines, and poorly maintained tanks. Spatial mapping indicated vector clusters within 150-200 meters of kitchen and staff quarters (Naik *et al*., 2023) [5]. This pattern highlights the importance of surveillance in service and maintenance zones, often overlooked during pest control.

Case Study 2: Dengue Transmission in Urban Tourist Hubs (Bangkok, Thailand)

A study by Rattanarithikul *et al*. (2022) [7] investigated 25 hotels across Bangkok, identifying *Aedes aegypti* larvae in rooftop tanks and planters. Hotel premises lacking routine pest control or staff training exhibited higher larval positivity rates. Seasonal variations corresponded to rainfall patterns and tourist occupancy peaks, suggesting a correlation between operational intensity and vector abundance.

Case Study 3: Leishmaniasis in Desert Lodges (Rajasthan, India)

In arid hospitality zones of Rajasthan, Kumar *et al*. (2024) [2] identified *Phlebotomus argentipes* (vector of visceral leishmaniasis) in outdoor dining and accommodation areas. Organic waste near kitchens, dim lighting, and vegetation near walls favored sand fly aggregation. Recommendations included insecticide-treated nets in staff quarters and light management to deter vector attraction.

Methodological Approaches in Vector Risk Assessment

To assess VBD risks in hospitality zones, an integrated methodological framework is essential:

- **Entomological Surveillance:** Adult mosquito collection using CDC light traps and BG-Sentinel traps, Larval surveys using the dipper method and ovitraps, Calculation of indices (Container Index, House Index, Breteau Index) as per WHO (2023) protocols.
- **Environmental & GIS Mapping:** Identification of breeding sites via GPS mapping, Use of GIS to correlate vector distribution with hotel infrastructure (Naik *et al*., 2023) [5].
- **Insecticide Susceptibility Tests:** Periodic monitoring for resistance patterns following WHO protocols to guide insecticide use.
- **Molecular Diagnostics:** PCR and sequencing for species confirmation and detection of Plasmodium or arbovirus presence (ICMR-VCRC, 2024).
- **Sociobehavioral Surveys:** Assessing knowledge, attitudes, and practices (KAP) among hotel staff regarding vector control and prevention.
- **Environmental Indicators:** Measuring temperature, humidity, and vegetation cover to evaluate vector habitat suitability (Magesa *et al*., 2022) [4].

Integrated Vector Management (IVM) Framework for Hospitality

An IVM-based model, adapted from WHO guidelines, can be applied to hospitality settings to ensure sustainable control. Environmental Management Regular cleaning and inspection of water storage containers, gutters, and garden features., Elimination of discarded containers, proper waste segregation, and composting, Maintenance of optimal drainage systems.

Biological and Eco-Friendly Control: Introduction of larvivorous fish (*Gambusia affinis*) in ornamental ponds, Application of *Bacillus thuringiensis israelensis* (Bti) in stagnant water, Encouragement of natural predators like dragonflies in resort landscapes.

Chemical Control: Targeted indoor residual spraying (IRS) in high-risk zones, Space spraying (fogging) during outbreaks following environmental safety guidelines, Use of repellents and insecticide-treated curtains in staff housing.

Structural Modifications: Vector-proof architecture such as screened windows, air curtains, and covered drainage, Placement of ultraviolet light traps in kitchens and waste zones to reduce fly populations.

Capacity Building and Health Education: Training of housekeeping and maintenance staff in larval source reduction and pest control, Display of educational posters for guests on personal protection measures.

Smart Surveillance Technologies: Use of IoT-enabled traps and AI-based identification systems (Singh *et al*., 2024) [8], Integration of digital reporting platforms for real-time entomological data sharing.

Discussion
Hospitality environments serve as unique micro-ecosystems that support vector proliferation due to human activities, water storage practices, and vegetation management. The convergence of high tourist mobility, urbanization, and climate change exacerbates disease transmission dynamics. Vector control within the hospitality industry has historically been limited to chemical interventions, often reactive rather than preventive. However, modern public health approaches advocate proactive surveillance and IVM. Partnerships between hotel associations, municipal health departments, and entomology research institutions can substantially reduce vector density and outbreak potential. Emerging tools such as drone-based habitat mapping, remote sensing, and AI-powered vector identification enable more precise surveillance. Furthermore, the hospitality industry can play a leadership role in promoting eco-health principles by incorporating green pest management and sustainability certifications that include vector control standards (ICMR-VCRC, 2024).

Conclusion
Vector-borne disease risk assessment in hospitality zones is essential for maintaining public health security and ensuring the sustainability of tourism industries in endemic regions. Evidence from case studies demonstrates that hotels and lodges can act as focal points for disease vectors if not properly managed. An integrated vector management approach—combining environmental, biological, chemical, structural, and technological interventions—is vital. Collaboration between the hospitality sector, vector control agencies, and research institutions will enhance preparedness and response mechanisms. Future research should prioritize developing eco-friendly and smart surveillance systems, quantifying vector-host interactions, and evaluating the cost-benefit of vector management programs in hospitality operations.

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