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Spatial Risk Factors of Vector-Borne Diseases in Pacific Island Countries & Territories: A Scoping Review

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INTRODUCTION

Review question / Objective This scoping review aims to synthesise the current body of literature examining environ-mental and sociodemographic factors for VBDs across the Pacific region. Specifically, this review synthesises the key variables assessed, map relationships between contextual factors and disease outcomes, and highlights gaps in the evidence base to inform future research and policy.

Background The Pacific Islands Countries and Territories (PICTs) represent a geographically scattered region across the central and southern Pacific Ocean, commonly grouped into Melanesia, Micronesia, and Polynesia. Encompassing nearly one-third of the Earth's surface and home to roughly 11.4 million people, PICTs include some of the world's most remote and least economically developed nations. These islands are largely tropical or subtropical and face heightened vulnerability to infectious disease outbreaks due to their climatic conditions, geographical isolation, and limited public health infrastructure. Climate change further exacerbates risks by intensifying extreme weather events and rising sea levels, with many populations concentrated in low-lying coastal areas. Socioeconomic and demographic factors, including poverty, inequality, and fragile health systems, compound these vulnerabilities and underscore the urgency of comprehensive risk assessments tailored to the region.

Vector-borne diseases (VBDs) such as dengue, malaria, chikungunya, and lymphatic filariasis remain a major public health challenge in PICTs. Globally, VBDs account for approximately 17% of communicable diseases and cause around one million deaths annually. In the Pacific, their transmission is shaped by an interplay of environmental, demographic, and socioeconomic drivers. Climatic conditions influence vector proliferation, while rapid urbanisation and population growth create overcrowded settlements with poor housing, limited sanitation, and

inadequate vector control. Fragile healthcare systems struggle to manage outbreaks, and high poverty rates, coupled with low health literacy, further increase population susceptibility. The combined pressures of climate variability, ecological change, and socioeconomic disadvantage place PICTs at particular risk of recurrent and severe VBD outbreaks.

Spatial risk factors—environmental, demographic, and socioeconomic characteristics that vary across geography—are crucial for understanding the distribution and burden of VBDs. Environmental factors include temperature, rainfall, humidity, vegetation cover, and extreme weather events. Demographic and socioeconomic dimensions encompass housing density, access to healthcare, education, income levels, and employment. These variables interact to influence exposure to vectors, access to preventive measures, and timeliness of diagnosis and treatment. Mapping and analysing spatial risk factors enables the identification of high-risk areas, supporting more efficient resource allocation and the design of geographically targeted interventions. This is particularly relevant for PICTs, where geographic dispersion, ecological diversity, and health system limitations present distinctive challenges to disease control and surveillance.

Despite increasing interest in spatial epidemiology in the Pacific, the evidence base remains fragmented. Studies have explored a variety of environmental and sociodemographic drivers of VBDs, but their scope, methods, and geographic focus vary widely. For example, a study in Papua New Guinea found malaria incidence positively associated with rainfall but not elevation, while research in New Caledonia demonstrated links between dengue incidence, temperature, and relative humidity. Large-scale climate phenomena, such as the El Niño Southern Oscillation, have also been implicated in outbreak dynamics across the Pacific. Fewer studies have examined sociodemographic drivers, but those available highlight important associations. For instance, population density has shown an inverse relationship with dengue incidence, suggesting that housing quality and household-level infrastructure play a protective role. Other studies in New Caledonia found unemployment and low education levels to be significant drivers of dengue transmission.
This scoping review, therefore aims to systematically synthesise the existing literature on environmental and sociodemographic determinants of VBDs in the region. Its objectives are threefold: to identify and categorise the key variables studied, to map the relationships between contextual factors and disease outcomes, and to highlight evidence gaps requiring further research.

Rationale Vector-borne diseases (VBDs), including dengue, malaria, chikungunya, and lymphatic filariasis, represent a major public health concern in the Pacific Island Countries and Territories (PICTs). Globally, VBDs account for nearly 17% of communicable diseases and cause close to one million deaths annually, yet their impact is disproportionately severe in small island nations with fragile health systems. PICTs are characterised by tropical and subtropical climates, limited public health infrastructure, and geographic isolation, conditions that collectively heighten their vulnerability to infectious disease outbreaks.

The risks posed by VBDs are further amplified by climate change, with rising sea levels, increased rainfall variability, and more frequent extreme weather events directly influencing vector ecology and transmission patterns. Demographic and socioeconomic factors, including rapid urbanisation, poverty, overcrowded housing, and low health literacy, compound these vulnerabilities. Consequently, populations in PICTs face recurrent outbreaks that strain already limited health services.

Despite growing recognition of these challenges, evidence on spatial risk factors for VBDs in PICTs remains fragmented across diverse study settings and methodologies. Environmental variables such as temperature, rainfall, and vegetation have been linked to disease incidence, while social and demographic determinants like education, employment, and housing quality are less consistently studied. A consolidated synthesis of this evidence is urgently needed to better understand spatial drivers of VBDs, identify high-risk areas, and inform geographically tailored interventions that can strengthen surveillance and prevention strategies across the Pacific region.

METHODS

Strategy of data synthesis The search combined terms related to vector-borne diseases (e.g., malaria, dengue, lymphatic filariasis), environmental, demographic, and socioeconomic factors (e.g., temperature, rainfall, population density, income), and geographic terms for Pacific Island Countries and Territories (PICTs). Searches were restricted to title and abstract fields, with no year limits applied. The full electronic strategies for PubMed, Scopus, and Web of Science.

Eligibility criteria Studies were included based on the following criteria: a) original research, b) inclusion of at least one spatially relevant factor (environmental, demographic or socioeconomic), c) include any vector-borne disease, d) studies conducted in the Pacific Islands Countries and Territories, e) present quantitative statistical results, and f) studies con-ducted in humans. No restrictions were applied regarding publication year.

Source of evidence screening and selection Information sources:
The literature search was conducted in March 2025 across PubMed, Scopus, and Web of Science. All identified articles were imported into Covidence for screening. Screening was performed at the title, abstract, and full-text levels. Discrepancies in study inclusion or data extraction were resolved through discussion and consensus among all authors to ensure consistency and methodological rigour.

Data extraction process
For each article, the following data were extracted manually: a) title, b) citation details, c) year of publication, d) aim, e) study design, f) geographic scope, g) study location, h) disease studied, i) outcome, j) data sources, k) environmental, demographic or socioeconomic factor, l) key results, and m) main conclusions. The extraction aimed to capture relevant information to enable the thematic synthesis. Data were recorded in a structured spreadsheet to ensure consistency and facilitate subsequent analysis. Discrepancies or ambiguities in the data extraction process were resolved through consensus among the authors.

Data management Data synthesis and analysis
Following data extraction, data were synthesised using a structured tabulation approach to identify relationships across environmental, demographic, and socioeconomic factors influencing disease burden in PICTs. Each study was categorised by factor type, nature of the relationship (positive or negative association), and disease studied. Where available, we also noted whether the associations were derived from bivariate or multivariate-adjusted analyses. The reporting of significance varied across studies, with results ex-pressed through different metrics such as p-values, odds ratios, and credible intervals. By applying this structured tabulation method, we were able to generate a comparative over-view of the evidence, consistent with scoping review methodology, and provide a comprehensive landscape of current research across the region.

Reporting results / Analysis of the evidence The initial database search identified 3008 records. Covidence automatically removed duplicates, and three additional duplicates were identified and removed manually. After deduplication, 1933 unique records remained for screening, of which 1850 were excluded based on title and abstract. Full texts of the remaining 83 articles were retrieved and assessed for eligibility. Following full-text review, 62 articles were excluded due to absence of quantitative results, not being original research, lack of assessment of spatial factors, inaccessibility, absence of VBD outcomes, or focus on non-human subjects or settings outside the Pacific Islands. A total of 21 studies met inclusion criteria. The included studies, published between 1998 and 2025, were unevenly distributed across PICTs, with New Caledonia, Papua New Guinea, and American Samoa most frequently studied. Dengue and malaria were the most investigated diseases, followed by lymphatic filariasis. Ecological mixed with time-series and cross-sectional designs predominated, and twelve studies assessed environmental correlations with lagged association. Data sources included national health surveillance, meteorological records, and survey data.

Among environmental factors, temperature was examined in ten studies (47.62%) and precipitation in seven (33.33%), generally showing positive associations with VBD incidence. Some studies reported non-linear or no significant associations for certain diseases. Land cover, including urbanisation and vegetation density, was linked to higher disease risk, and elevation showed mixed effects, generally with higher altitudes associated with lower prevalence.

Spatial demographic factors, including population density and household human density, had varied associations, often showing negative relationships with disease outcomes. Being born in the Pacific was associated with higher dengue incidence. Genetic factors such as island-level G6PD deficiency were linked to increased malaria incidence. Socioeconomic factors influenced VBD transmission dynamically; lower employment and education were consistently linked to higher dengue incidence, while income level showed a positive correlation with lymphatic filariasis in one study.

Presentation of the results Environmental factors n=34 Disease Measurement Location Associa-tion Outcome Study reference

Temperature Dengue Daily min/max, mean 1-2 months lag New Caledonia Positive Incidence rate Descloux et al.2012 [21]

Dengue Daily maximum 3-month lag New Caledonia Positive NL[1] Outbreak Ochida et al. 2022 [28]

Suspected dengue Weekly mean Min/max No men-tion Fiji Positive Incidence Nelson et al. 2022 [2]

Chikungunya, Zika* Weekly mean 1-month lag French Polynesia Positive NS[2] Outbreak Riou et al. 2017 [26]

Dengue Monthly mean No men-tion New Caledonia Positive Incidence Teurlai et al. 2015 [25]

Malaria Monthly min/max No men-tion Papua New Guinea Positive Incidence Park et al. 2016 [20]

Dengue-like illness Monthly mean 1-month lag Solomon Islands Positive Incidence Andhikaputra et al. 2023 [27]

Malaria Monthly Min/max mean 1-2-months lag Vanuatu Positive Incidence Sorenson et al. 2025 [32]

Malaria Monthly Minimum 3-months lag Papua New Guinea Positive Incidence Imai et al. 2016 [33]

Malaria Monthly mean 3-month lag Vanuatu Positive Incidence rate Chaves et al. 2008 [34]

Rainfall Malaria Mean daily (mm) No mention New Caledonia Positive Incidence Teurlai et al. 2015 [25]

Suspected dengue Mean weekly rainfall (mm) 1-2 months lag Fiji Positive Incidence Nelson et al. 2022 [2]

Malaria Monthly total rainfall (mm) No men-tion Solomon Islands Positive Incidence Smith et al. 2017 [23]

Dengue-like illness Monthly Cumulative rainfall (mm) 1-month lag Solomon Islands Positive Incidence Andhikaputra et al. 2023 [27]

Malaria Annual total rainfall (mm) No men-tion Papua New Guinea Positive Incidence Park et al. 2016 [20]

Precipitation Dengue Cumulative daily (mm) No men-tion New Caledonia Positive Incidence rate Descloux et al. 2012 [21]

Dengue Mean daily (mm/day) 2-3 months lag New Caledonia Positive NL[3] Outbreak Ochida et al. 2022 [28]

Chikungunya, Zika Mean weekly (cm) 1-2 weeks/ 5 weeks lag French Polynesia Negative/ positive Outbreak Riou et al. 2017 [26]

Malaria Mean monthly (mm/month) No men-tion Papua New Guinea (Madang) Positive Incidence Imai et al. 2016 [33]

Zika Mean monthly (mm/month) French Polynesia Negative Outbreak He et al. 2017 [35]

Malaria (P. falcipa-rum) Mean monthly.

Language restriction English.

Country(ies) involved Australia.

Keywords vector-borne diseases, arbovirus, climate change, environmental risk factors, Pacific Island Countries and Territories (PICTs), sociodemographic determinants, climate change, infectious disease.

Contributions of each author

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