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Review Article

Socioeconomic Determinants of Malaria and Dengue Risk Following Extreme Weather Events: A Systematic Review with Narrative Synthesis

Aleena Qaiser[1], Sidra Irfan[2], Saad Naseer[3], Syed Faraz Munir Bukhari[4], Raana Riaz[5], Farman Hussain[6]

[1] Pharm D, Baqai Medical University, Karachi, Pakistan
[2] Senior Registrar, Preventive Medicine, Amiri Hospital, Kuwait City, Kuwait
[3] MBBS, Rai Medical College, Sargodha, Pakistan
[4] Medicolegal Officer, Abbasi Shaheed Hospital, Karachi, Pakistan
[5] Medical Officer, Fatima Jinnah Medical University, Lahore, Pakistan
[6] Medical Officer, Rural Health Center, Uch Sharif, Pakistan

Correspondence: Raana Riaz, Riazraana97@gmail.com

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ABSTRACT

Background: Extreme-weather events influence malaria and dengue transmission, but disease burden varies substantially between populations exposed to similar climatic hazards. Structural socioeconomic conditions may modify this relationship through housing, basic services, displacement, preventive-resource access, and healthcare availability. Objective: To systematically evaluate how socioeconomic vulnerability influences malaria and dengue risk under extreme-weather and climate-sensitive conditions and to characterize the pathways supported by observational evidence. Methods: A systematic review with narrative synthesis was structured according to PRISMA 2020 and PRISMA-S principles. PubMed/MEDLINE, Scopus, Web of Science, Embase, and Cochrane Library were searched using terms for extreme weather, socioeconomic vulnerability, malaria, and dengue. Observational human studies examining relevant structural determinants were eligible. Study characteristics, associations, and methodological limitations were synthesized without meta-analysis because of substantial heterogeneity. Results: Of 1,482 records identified, 312 duplicates were removed, 1,170 records were screened, 56 full texts were assessed, and eight studies contributed to the narrative evidence set. Housing and basic-service deficiencies consistently increased vector-related vulnerability. Post-flood malaria risk was associated with displacement and reduced access to insecticide-treated nets, while socioeconomic conditions modified temperature-associated dengue risk. Healthcare-system vulnerability represented a plausible additional pathway, although direct event-specific evidence was limited. Conclusion: Socioeconomic vulnerability appears to amplify climate-sensitive malaria and dengue risk through interacting structural and healthcare pathways. Climate-resilient disease control should integrate vector surveillance with housing, water, preventive-resource, displacement, and healthcare interventions. *Keywords: Malaria; Dengue; Extreme Weather; Socioeconomic Factors; Floods; Housing; Healthcare Access; Climate Change.*

INTRODUCTION

Malaria and dengue remain major climate-sensitive vector-borne diseases whose transmission is determined by interactions among vector ecology, environmental conditions, population susceptibility, and social context. Climate variability can alter mosquito survival, breeding-site availability, biting activity, pathogen development, and seasonal transmission, but exposure to these hazards is neither socially uniform nor biologically deterministic.

Socioeconomic position influences the capacity of households and communities to prevent mosquito exposure, maintain adequate housing and water infrastructure, access preventive resources, and obtain timely diagnosis and treatment. A systematic review and meta-analysis of socioeconomic markers and arboviral infection identified associations with poverty, education, interrupted water supply, housing conditions, and healthcare coverage, demonstrating that vector-borne disease risk is embedded within broader structural inequalities rather than being attributable to climatic suitability alone (1). Similar evidence for malaria indicates that socioeconomic disparities operate through interconnected pathways involving housing, food security, access to preventive measures, education, livelihoods, and healthcare utilization (2,3).

The influence of socioeconomic conditions becomes particularly important during floods, droughts, and other extreme hydrometeorological events. Such events can simultaneously modify mosquito habitats and compromise the social and physical systems that ordinarily limit transmission. Flooding may initially disrupt existing breeding sites but subsequently generate stagnant water, damage drainage and sanitation infrastructure, interrupt piped water supplies, displace populations, and impair routine vector-control activities. Drought can also increase disease risk under specific ecological conditions by promoting household water storage and concentrating human-vector contact. Recent synthesis of malaria transmission in West Africa identified poverty, housing structure, place of residence, and access to information among important socioeconomic determinants operating alongside temperature, rainfall, humidity, and vegetation (4). A recent systematic review of flooding and infectious diseases similarly concluded that dengue and malaria frequently increase following floods, although effect magnitude, lag periods, and certainty vary substantially across regions and underlying public-health conditions (5). These observations indicate that the epidemiological consequences of extreme weather cannot be adequately understood by treating meteorological exposure independently of structural vulnerability.

The available evidence nevertheless remains fragmented across partly separate research traditions. One body of literature evaluates climatic and hydrological determinants of malaria and dengue, whereas another evaluates socioeconomic vulnerability largely independently of discrete extreme-weather events. More recent epidemiological studies increasingly demonstrate interaction between these domains. For example, analysis across 61 provinces of the Philippines showed substantial geographic heterogeneity in the temperature-dengue relationship and found that socioeconomic characteristics, including poverty incidence, household structure, population density, urbanization, and health expenditure, modified dengue risk at higher temperatures (6). Likewise, research following severe flooding in rural western Uganda identified spatial clusters of malaria infection associated not only with post-flood environmental changes but also with longer displacement and reduced access to insecticide-treated nets, illustrating how social and environmental processes can jointly shape post-disaster malaria vulnerability (7). Such findings move beyond simple climate-disease associations and suggest that socioeconomic conditions may function as effect modifiers, mediators, or contextual amplifiers of disease emergence.

This distinction is important because extreme-weather exposure does not necessarily translate into equivalent disease burden across populations experiencing the same climatic shock. Structural disadvantage may increase exposure through substandard housing, inadequate drainage, unsafe water storage, overcrowding, or displacement; constrain adaptive capacity by limiting access to insecticide-treated nets, repellents, secure shelter, transport, and health information; and increase clinical consequences by delaying diagnosis or treatment when health services are inaccessible or disrupted. Vulnerability frameworks developed for extreme-weather events similarly emphasize that health effects emerge from the interaction of environmental exposure, population sensitivity, and adaptive capacity rather than from hazard intensity alone (8). Accordingly, poverty, housing and basic-service conditions, and healthcare accessibility represent plausible structural pathways through which extreme-weather events may produce unequal malaria and dengue outcomes.

Despite the growing literature on climate-sensitive vector-borne disease and social determinants of health, comparatively limited synthesis has specifically examined the intersection between extreme-weather events, structural socioeconomic vulnerability, and malaria or dengue outcomes. Existing reviews establish that climatic extremes affect vector-borne disease transmission and that socioeconomic disadvantage independently influences malaria and dengue vulnerability, but they provide less clarity regarding which structural determinants consistently explain heterogeneity in disease emergence following extreme events, how these mechanisms differ across settings, and whether available observational evidence supports direct effect modification or only contextual associations (1-5). This distinction has practical relevance because interventions focused solely on vector suppression may have limited effectiveness when transmission is sustained by insecure housing, disrupted water systems, displacement, poverty, or inaccessible healthcare.

Accordingly, this systematic review with narrative synthesis evaluated how structural socioeconomic determinants influence malaria and dengue vulnerability in the context of extreme-weather events. Using a PECO-oriented framework, the population comprised human communities exposed to extreme hydrometeorological conditions; the principal exposure was an extreme-weather event or associated climatic disturbance; the socioeconomic factors of interest were poverty or socioeconomic disadvantage, housing and basic-service conditions, and healthcare accessibility; and the outcomes comprised malaria or dengue occurrence, transmission, incidence, vulnerability, or clinical burden. The review specifically sought to determine whether these socioeconomic factors modified, mediated, or amplified disease risk and to characterize the epidemiological pathways, consistency, methodological limitations, and public-health implications of the available observational evidence.

MATERIAL AND METHODS

This study was undertaken as a systematic review with narrative synthesis of observational evidence examining socioeconomic vulnerability in relation to malaria and dengue under extreme-weather conditions. Reporting was structured according to PRISMA 2020 principles, which emphasize transparent specification of eligibility criteria, information sources, selection processes, data collection, study appraisal, and synthesis methods (9). Reporting of the literature-search components was additionally informed by PRISMA-S recommendations for reproducible documentation of search sources and strategies (10). Because substantial clinical, geographic, exposure, outcome, and methodological heterogeneity precluded meaningful statistical pooling, findings were synthesized narratively using principles consistent with structured synthesis without meta-analysis, particularly explicit grouping of studies, transparent presentation of study characteristics, direction and magnitude of associations where available, and attention to heterogeneity and limitations of the evidence (11).

Eligibility was defined using an exposure-modifier-outcome framework. Eligible evidence concerned human populations exposed to floods, droughts, extreme precipitation, temperature extremes, or related hydrometeorological disturbances relevant to malaria or dengue transmission. Studies were required to provide empirical evidence concerning at least one prespecified structural socioeconomic determinant: poverty or socioeconomic position; housing, water, sanitation, or related basic-service conditions; displacement or material vulnerability where directly relevant to post-event exposure; or healthcare accessibility and health-system preparedness. Outcomes of primary interest were clinically diagnosed or laboratory-confirmed malaria or dengue, disease incidence or prevalence, outbreak occurrence, spatial or temporal transmission risk, hospitalization, clinical severity, or other quantitative measures of disease burden. Studies examining broader vulnerability pathways were retained in the narrative framework when they provided empirical information necessary to interpret how the prespecified socioeconomic factors could modify exposure or adaptive capacity under extreme-weather conditions, but such studies were distinguished from direct disease-specific evidence during synthesis.

Original observational research, including cohort, cross-sectional, case-control, retrospective epidemiological, spatial, and mixed-methods studies with an empirical human component, was considered eligible. Reviews, editorials, commentaries, purely mathematical projections without empirical human observations, laboratory or animal investigations, conference abstracts without sufficient data, and studies lacking relevant socioeconomic or structural information were excluded from the primary evidence synthesis. Because earlier foundational studies remained directly relevant to socioeconomic vulnerability and dengue or flood-related disease mechanisms, chronological relevance was evaluated according to contribution to the review question rather than using the previously reported 2020 cutoff as an absolute eligibility boundary. This approach avoided excluding informative empirical studies solely because of publication year while allowing recent evidence to receive greater interpretive weight.

The reported electronic search encompassed PubMed/MEDLINE, Scopus, Web of Science Core Collection, Embase, and the Cochrane Library. Search concepts combined terminology for extreme-weather exposure, socioeconomic vulnerability, and malaria or dengue.

A representative structure was: ("extreme weather" OR "extreme weather event" OR flood* OR drought* OR "extreme rainfall" OR "extreme precipitation" OR "climate extreme*" OR heatwave*) AND (poverty OR socioeconomic OR income OR "housing quality" OR housing OR "water supply" OR sanitation OR displacement OR "healthcare access" OR "health service access" OR infrastructure) AND (malaria OR dengue OR "dengue fever" OR Plasmodium). Vocabulary and field syntax were adapted to the indexing structure of individual databases.*

Reference lists of relevant reviews and eligible studies were additionally examined to identify potentially relevant empirical evidence. Recent literature identified during evidence reconciliation was used to strengthen contextual interpretation and to determine whether newer primary research altered the conceptual conclusions of the synthesis; review articles identified through this process were used as secondary supporting evidence rather than treated as primary included studies.

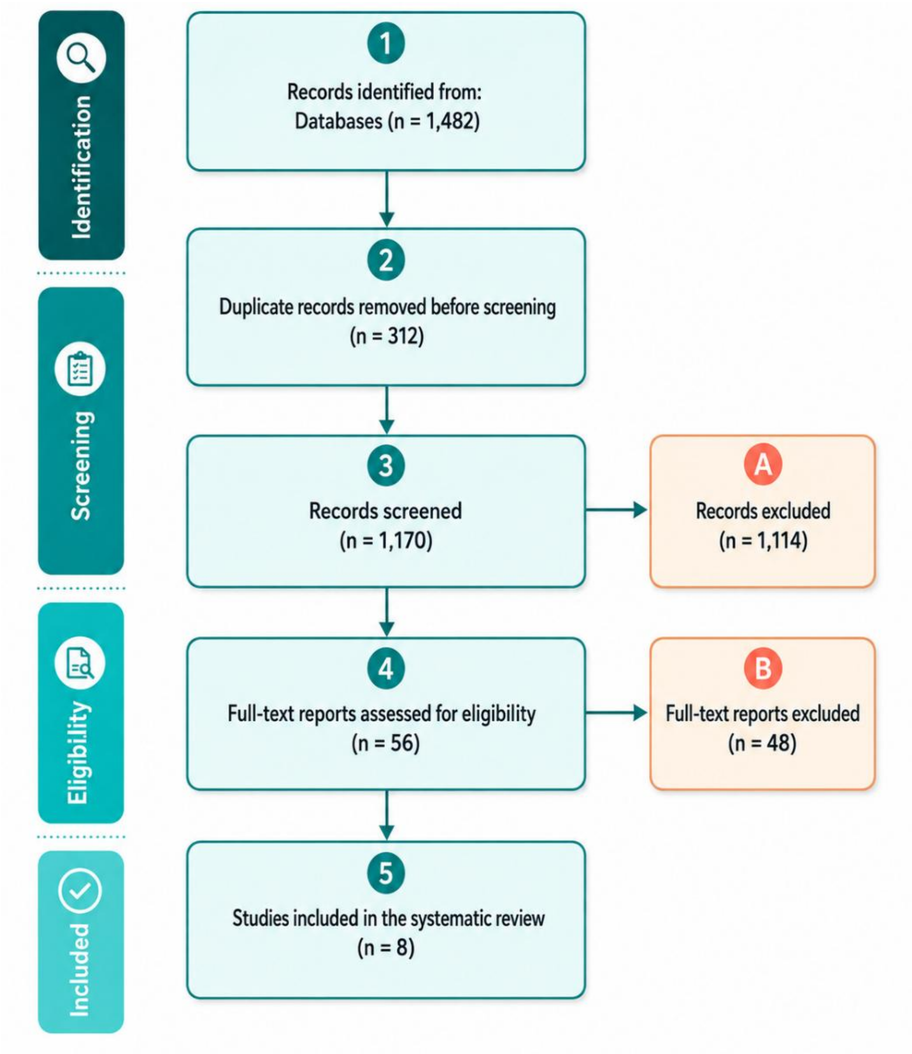

Figure 1 PRISMA Flowchart

Retrieved records were managed in EndNote and duplicates were removed before screening. Two reviewers independently evaluated titles and abstracts against the predefined eligibility framework, followed by full-text assessment of potentially eligible studies. Disagreements were resolved by discussion and consensus, with referral to a third reviewer where required. The supplied review dataset reported 1,482 records before deduplication, of which 312 were duplicates. This yielded 1,170 unique records for title and abstract screening; 1,114 records were excluded at that stage, and 56 reports proceeded to full-text evaluation. Eight studies were reported as contributing to the final narrative evidence set. Because the evidence-reconciliation process identified variation in how directly individual studies addressed all components of the exposure-modifier-outcome framework, the revised synthesis explicitly distinguishes direct disease-specific evidence from contextual vulnerability evidence rather than implying equivalent causal informativeness across all eight studies.

Data were extracted using a structured evidence form covering author, publication year, country or region, study design, population, extreme-weather or climatic exposure, pathogen or disease outcome, socioeconomic determinant, measurement approach, principal association, effect estimate where available, and methodological limitations relevant to interpretation. Where studies reported adjusted measures of association, these were prioritized over crude estimates. Quantitative findings were not transformed or pooled when definitions of socioeconomic exposure, climatic exposure, disease outcome, population, or analytic scale differed materially. Evidence was instead organized according to poverty and socioeconomic vulnerability, housing and basic-service conditions, and healthcare accessibility, followed by cross-cutting consideration of displacement, preventive-resource access, geography, disease type, and study design.

Methodological appraisal emphasized selection procedures, comparability or confounding control, exposure measurement, outcome ascertainment, temporal ordering, and completeness of reporting. Newcastle-Ottawa principles were considered for conventional cohort and case-control evidence, while cross-sectional and spatial epidemiological evidence was interpreted according to design-appropriate domains rather than forcing heterogeneous designs into a single numerical score. Greater interpretive weight was assigned to studies with temporally defined weather exposure, objectively measured disease outcomes, multivariable adjustment, and explicit assessment of socioeconomic modification. Cross-sectional, ecological, and spatial studies were treated as associational evidence and were not interpreted as establishing individual-level causation.

Narrative synthesis proceeded in four stages. First, study characteristics and methodological context were tabulated. Second, the direction and magnitude of associations were evaluated according to the prespecified socioeconomic domains. Third, the evidence was organized into mechanistic pathways linking extreme-weather exposure with structural vulnerability, vector exposure, preventive capacity, healthcare access, and disease outcomes. Fourth, heterogeneity was examined according to event type, geographic setting, pathogen, urban-rural context, socioeconomic measurement, and study design. Meta-analysis was not undertaken because socioeconomic indicators, climatic exposures, outcome definitions, analytic scales, and effect measures were insufficiently comparable. Statistical assessment of pooled heterogeneity or publication bias was therefore not applicable.

RESULTS

The reported search identified 1,482 records, of which 312 duplicates were removed, leaving 1,170 unique records. Following title and abstract screening, 1,114 records were excluded and 56 full-text reports were assessed. Eight studies contributed to the narrative evidence set after eligibility assessment. The evidence was geographically heterogeneous and included flood-affected communities, malaria-endemic populations, urban and peri-urban dengue settings, healthcare facilities, and populations characterized according to structural or socioeconomic vulnerability. Study designs included cross-sectional epidemiological studies, spatial and retrospective analyses, vulnerability mapping, mixed-methods observational research, and longitudinal post-flood malaria assessment. This heterogeneity, together with substantial variation in exposure and outcome definitions, supported narrative rather than quantitative synthesis.

Table 1. Characteristics and Contribution of Evidence Included in the Narrative Synthesis

Study	Setting/design	Extreme-weather or environmental context	Socioeconomic/structural determinant	Disease/outcome contribution	Principal finding relevant to synthesis
Abrams et al. (8)	South Africa; vulnerability-index methodology	Multiple extreme-weather hazards	Socioeconomic and adaptive-capacity indicators	Contextual health vulnerability	Demonstrated that vulnerability to extreme-weather health effects depends on social, physical, and adaptive-capacity characteristics rather than hazard exposure alone.
Ogony et al. (12)	Western Kenya; cross-sectional health-facility study	Climate-vulnerable infectious-disease setting	Facility preparedness, diagnostic and treatment capacity	P. falciparum and dengue-related febrile illness	Facility-level shortages and preparedness limitations were associated with reduced capacity to diagnose and manage acute febrile disease.
Bashier Abbas & Routray (13)	Sudan; flood-affected communities	Flooding	Poverty, displacement, sanitation and service access	Post-flood infectious-disease vulnerability	Flood impacts were concentrated among socially and materially vulnerable communities, with poor sanitation and limited adaptive capacity increasing post-flood health risk.

Study	Setting/design	Extreme-weather or environmental context	Socioeconomic/structural determinant	Disease/outcome contribution	Principal finding relevant to synthesis
Deebrah (14)	Guyana; mixed-methods flood study	Flooding	Household income, food security, livelihood loss	Contextual susceptibility after flooding	Flood-related livelihood and food-security disruption demonstrated a pathway through which socioeconomic shocks may increase post-event health vulnerability.
Dickin et al. (15)	Malaysia; spatial vulnerability mapping	Water-associated climatic vulnerability	Housing, piped water, socioeconomic vulnerability	Dengue vulnerability	Housing and water-related structural characteristics contributed materially to spatial dengue vulnerability.
Joyce et al. (16)	El Salvador; retrospective spatial epidemiology	Environmental variation relevant to dengue transmission	Socioeconomic and built-environment factors	Dengue incidence	Socioeconomic and housing-related characteristics were associated with spatial variation in dengue burden alongside environmental factors.
Xu et al. (7)	Rural western Uganda; longitudinal post-flood analysis	Severe flooding	Displacement duration, access to insecticide-treated nets	Malaria infection	Post-flood malaria clusters occurred in areas with marked environmental change; longer displacement and lower access to insecticide-treated nets were associated with positive malaria tests.
Seposo et al. (6)	Philippines; 61-province spatiotemporal analysis	Temperature variation/extremes	Poverty, population density, household size, urbanization, health expenditure	Dengue incidence	Socioeconomic conditions modified the temperature-dengue association, with higher risk in several more vulnerable provincial contexts at elevated temperatures.

Table 2. Narrative Synthesis of Socioeconomic Pathways

Domain	Direction of evidence	Principal pathway	Disease relevance	Overall interpretation
Poverty/economic vulnerability	Predominantly increased vulnerability	Reduced adaptive resources, livelihood loss, food insecurity, constrained prevention and recovery	Malaria and dengue vulnerability	Consistent contextual evidence; direct event-specific effect estimates remain limited
Housing/basic services	Predominantly increased exposure with poorer infrastructure	Greater mosquito entry, unsafe water storage, drainage deficits, vector breeding, crowding/displacement	Particularly dengue; also malaria	One of the most consistently supported structural pathways
Displacement/preventive-resource access	Increased post-event risk	Longer displacement, reduced access to treated nets or secure shelter	Malaria	Direct post-flood evidence supports this pathway
Healthcare access/preparedness	Increased potential severity and delayed management	Diagnostic shortages, disrupted transport, weak preparedness, delayed treatment	Malaria/dengue clinical burden	Biologically and operationally plausible; disease-specific post-event evidence remains comparatively sparse
Socioeconomic modification of climate effects	Heterogeneous but demonstrable	Climate exposure produces different disease risks according to underlying social conditions	Dengue	Direct evidence indicates effect modification rather than uniform climate effects

Poverty and broader economic vulnerability consistently emerged as upstream determinants of adaptive capacity. The evidence did not support a simple interpretation in which poverty independently caused malaria or dengue after an extreme-weather event; rather, economic disadvantage appeared to influence multiple intermediate pathways. Flood-related livelihood loss, reduced food security, limited ability to repair housing, constrained access to preventive resources, and displacement were recurrent mechanisms linking structural disadvantage with greater post-event vulnerability. The vulnerability-index work of Abrams et al. similarly conceptualized socioeconomic resources as part of adaptive capacity to extreme-weather exposure (8). Flood studies from Sudan and Guyana demonstrated that material disadvantage and disruption can compound environmental exposure through displacement, sanitation deficiencies, livelihood loss, and reduced household resilience (13,14).

Housing and basic-service conditions represented the most direct structural pathway linking socioeconomic circumstances to mosquito exposure. In Malaysia, the Water-Associated Disease Index incorporated housing and water-related indicators into spatial dengue vulnerability and showed that built-environment characteristics contributed materially to geographic risk patterns (15). In El Salvador, dengue incidence varied with socioeconomic and environmental characteristics, emphasizing that mosquito-borne disease risk reflects features of the human-built environment rather than climatic exposure alone (16). These findings are consistent with the broader mechanism whereby unreliable piped water can promote domestic water storage, inadequate drainage permits standing water accumulation, and poorly protected housing increases contact between vectors and occupants. The direction of evidence was therefore generally consistent, although heterogeneity in measurement prevented calculation of a pooled effect.

The clearest post-flood malaria evidence was provided by Xu et al., who evaluated malaria risk following severe flooding in rural western Uganda. Spatial malaria clusters emerged in areas experiencing substantial post-flood vegetation changes, but infection was also associated with longer displacement and lower access to long-lasting insecticidal nets (7). This finding is important because it demonstrates that meteorological disruption and social vulnerability are not independent explanatory systems: flood exposure altered the environment, while displacement and preventive-resource access influenced who remained at greater risk within the affected area. The study therefore provides direct empirical support for the conceptual pathway underlying this review.

A similar interaction was observed for dengue at a broader climatic scale. Across 61 provinces of the Philippines, Seposo et al. identified an inverted U-shaped temperature-dengue relationship and substantial provincial heterogeneity. Dengue risk at higher temperatures was greater in settings characterized by several socioeconomic features, including higher poverty incidence, larger household size, greater population density, lower urbanization in some contexts, and differences in health expenditure (6). These findings indicate that temperature does not exert a uniform effect across populations and support treatment of socioeconomic characteristics as effect modifiers rather than merely background covariates.

Healthcare access represented a further pathway through which environmental shocks could translate into greater clinical burden. Facility-level evidence from western Kenya demonstrated vulnerabilities in diagnostic availability, supplies, and preparedness affecting management of children presenting with P. falciparum and dengue-related acute febrile illness (12). Although the evidence did not permit attribution of these deficiencies exclusively to a discrete extreme-weather event, it illustrated the mechanism by which already constrained facilities may have reduced surge capacity when climate-sensitive disease transmission increases. The available evidence for healthcare accessibility was therefore considered supportive but less direct than the evidence relating housing, displacement, and socioeconomic modification to disease transmission.

Overall, methodological confidence was constrained by the predominance of observational, cross-sectional, spatial, and ecological analyses; differences in geographic scale; inconsistent socioeconomic definitions; varying climatic metrics; and limited direct mediation or interaction testing. The strongest evidence came from studies that explicitly connected an environmental exposure with social modifiers and disease outcomes, whereas contextual vulnerability studies contributed mainly mechanistic interpretation. Consequently, the synthesis supports socioeconomic amplification of climate-sensitive malaria and dengue risk but does not justify a universal causal effect size or a single pooled estimate.

DISCUSSION

This systematic review with narrative synthesis indicates that socioeconomic vulnerability can materially shape malaria and dengue risk under extreme-weather and climate-sensitive conditions. The evidence does not support a deterministic model in which floods, droughts, rainfall, or temperature extremes uniformly produce disease outbreaks. Instead, disease emergence appears to arise from interaction between environmental change and structural conditions that influence mosquito exposure, household adaptive capacity, preventive-resource access, displacement, and healthcare availability. Housing and basic services showed the most consistent structural relationship with vector exposure, while post-flood malaria evidence demonstrated that displacement and access to insecticide-treated nets can differentiate infection risk within an environmentally affected population. Socioeconomic modification of temperature-associated dengue risk provides complementary evidence that climate-disease relationships vary according to underlying social conditions (6,7).

These findings are consistent with the wider literature on socioeconomic determinants of vector-borne disease. Power et al. found that lower socioeconomic position was associated with multiple markers of arboviral vulnerability, including lower educational attainment, income poverty, inadequate healthcare coverage, poor housing materials, and interrupted water supply; pooled estimates particularly supported associations with lower education and interrupted water supply, although considerable heterogeneity was present across studies (1). For malaria, Wafula et al. found socioeconomic inequalities in 26 of 41 studies included in their review and identified housing, food security, antimalarial use, education, nutrition, and insecticide-treated nets as potential pathways linking socioeconomic position with malaria infection (2). The present synthesis extends this literature by situating these determinants within extreme-weather contexts, where disruption can intensify precisely those pathways through which socioeconomic inequality ordinarily operates.

Recent malaria-specific synthesis further supports this interpretation. Atusingwize et al. identified environmental conditions, housing, poverty, livelihoods, preventive-intervention use, and access to treatment as interconnected social determinants of malaria across low- and middle-income countries (3). Gbaguidi et al. similarly identified housing structure, poverty, residence, education-related factors, and environmental conditions as major determinants of malaria transmission in West Africa (4). Taken together with the present findings, these reviews suggest that climatic hazards are likely to exert their greatest population-health effects where structural conditions already increase exposure or constrain adaptation. The contribution of extreme weather should therefore be interpreted as interacting with baseline vulnerability rather than replacing established socioeconomic determinants of malaria.

The dengue evidence demonstrates a comparable interaction. Seposo et al. found that provincial socioeconomic characteristics altered the temperature-dengue association in the Philippines, providing direct evidence that a climatic exposure can produce different epidemiological consequences according to social context (6). More broadly, socioeconomic markers of arboviral infection identified by Power et al., including interrupted water supply and poor housing, are especially relevant during extreme-weather events because floods and droughts may themselves destabilize water infrastructure, sanitation, housing integrity, and routine municipal services (1). This creates the possibility of compound risk: households with inadequate infrastructure may have greater baseline vulnerability and simultaneously experience larger increases in exposure when climatic shocks disrupt already fragile systems.

The post-flood malaria study from Uganda offers particularly informative evidence for such compound vulnerability. Following severe flooding, infection risk was spatially related to environmental change but was also associated with prolonged displacement and reduced access to long-lasting insecticidal nets (7). This observation is epidemiologically important because displacement is not merely a socioeconomic descriptor; it can alter sleeping conditions, shelter quality, proximity to mosquito habitat, continuity of preventive practices, and access to health services. It therefore represents a plausible intermediate mechanism linking a discrete extreme-weather event to subsequent infection. Future studies should distinguish these mediating processes from baseline confounders and use longitudinal designs capable of determining whether socioeconomic conditions modify, mediate, or independently predict post-event disease risk.

The broader flood literature reinforces the plausibility of this model while also illustrating the limitations of the available evidence. Luangnara et al. synthesized 71 studies of flooding and waterborne or vector-borne infections and found that dengue and malaria commonly increased following floods, but the timing and magnitude of outbreaks varied substantially according to geography, pathogen, flood characteristics, and public-health context (5). The authors judged much of the evidence to be observational with low-to-moderate certainty and identified continuing deficiencies in information on hospitalization, mortality, and health-system burden. The present review suggests that some of this between-setting heterogeneity may reflect differences in socioeconomic vulnerability, infrastructure, population displacement, and access to preventive and clinical services, but direct comparative evidence remains insufficient to quantify how much variation is attributable to each determinant.

Housing and basic-service infrastructure deserve particular attention because they link structural inequality with vector ecology through readily identifiable mechanisms. Poorly protected housing can increase mosquito entry, inadequate drainage can prolong standing-water exposure, and unreliable piped-water systems can encourage water storage in containers that serve as Aedes breeding sites. These pathways are compatible with the Malaysian dengue vulnerability mapping and socioeconomic-spatial evidence from El Salvador included in the synthesis (15,16). They also align with the broader systematic evidence showing housing as a recurrent malaria determinant and interrupted water supply as an arboviral risk marker (1-4). Housing improvement, reliable water provision, drainage, and secure water-storage practices should therefore be conceptualized not merely as socioeconomic development measures but as components of climate-resilient vector-borne disease prevention.

Healthcare accessibility is likely to operate differently from housing because it may have a stronger influence on clinical progression and outbreak containment than on initial mosquito exposure. Extreme-weather events can damage facilities, interrupt transport routes and supply chains, reduce diagnostic capacity, and increase patient loads precisely when rapid recognition of malaria or dengue is required. The western Kenyan evidence demonstrated underlying facility vulnerabilities relevant to diagnosis and management of febrile children with malaria and dengue (12). More broadly, a 2026 thematic systematic review of 183 reports from low- and lower-middle-income countries found that extreme-weather events were repeatedly associated with community displacement, disruption of health-service delivery, and weaknesses across health-system functions, while documented resilience and recovery responses were comparatively less common (17). These findings support the plausibility of healthcare disruption as an important pathway but also underscore the need for disease-specific studies directly linking extreme events, service interruption, treatment delay, and malaria or dengue outcomes.

The present synthesis has several methodological strengths. It deliberately distinguishes the review question from broader climate-health literature and organizes evidence around explicit socioeconomic pathways rather than treating all social variables as a single composite exposure. It also avoids assuming that the absence of statistical pooling diminishes systematic-review status; narrative synthesis was appropriate because of substantial differences in climatic exposure definitions, socioeconomic measures, disease outcomes, spatial scales, and analytic methods. The reconstruction further distinguishes direct disease-specific evidence from contextual vulnerability evidence, reducing the risk of presenting mechanistic plausibility as equivalent to direct causal demonstration.

Several limitations nevertheless constrain interpretation. First, much of the evidence is observational and several studies use cross-sectional, spatial, or ecological designs, limiting temporal and causal inference. Second, socioeconomic exposures are measured inconsistently across studies, ranging from household-level poverty and preventive-resource access to area-level housing, water supply, population density, and health expenditure. These constructs are related but not interchangeable. Third, extreme-weather exposure also varies substantially, including discrete flooding, broader hydrological conditions, temperature variation, and vulnerability to multiple weather hazards. Fourth, only a subset of studies directly tests statistical interaction or mediation between climatic exposure and socioeconomic conditions. Consequently, the conclusion that socioeconomic vulnerability amplifies climate-sensitive disease risk is supported by convergent evidence but cannot be expressed as a single causal effect estimate.

A further limitation is the uneven geographic distribution of available studies. Much of the malaria evidence derives from sub-Saharan African settings, whereas dengue evidence is concentrated in tropical Asian and Latin American populations. Baseline endemicity, vector species, urbanization, housing, public-health infrastructure, surveillance quality, immunity, and disaster-response capacity differ substantially between regions. These contextual differences can alter both the direction and magnitude of climate-disease relationships. Generalization should therefore emphasize pathways rather than assuming that an effect estimate from one climatic or socioeconomic setting is transferable to another.

The findings have direct implications for disaster preparedness and climate-resilient disease control. Conventional post-event vector-control responses should be supplemented by vulnerability-informed targeting. Areas characterized by insecure housing, poor drainage, unreliable water supplies, high poverty, displacement, limited preventive-resource coverage, or weak healthcare access may warrant earlier surveillance intensification and pre-positioning of interventions. Practical measures include secure water-storage systems, rapid drainage restoration, distribution or replacement of insecticide-treated nets after displacement, repair of structural vector barriers, mobile diagnostic capacity, pre-positioned malaria diagnostics and treatment, strengthened dengue case recognition, and transport arrangements for communities at risk of being isolated during floods.

These interventions should also be integrated into surveillance and early-warning systems. Weather-based forecasting alone may identify where environmental conditions are suitable for transmission but may inadequately identify where the clinical and social consequences will be greatest. Incorporating indicators of poverty, housing, water and sanitation access, population displacement, health-facility accessibility, and preventive-resource coverage could improve prioritization of response resources. This approach is consistent with vulnerability frameworks in which hazard, exposure, sensitivity, and adaptive capacity jointly determine health consequences (8).

Future research should prioritize longitudinal and quasi-experimental studies that explicitly evaluate interaction between extreme-weather exposure and socioeconomic vulnerability. Investigators should specify the timing, intensity, and duration of floods, droughts, temperature extremes, or heavy rainfall; use standardized and clearly defined socioeconomic indicators; and obtain laboratory-confirmed malaria or dengue outcomes wherever feasible. Studies should report effect estimates with confidence intervals and distinguish confounding from mediation and effect modification. Repeated measures before and after extreme events would allow stronger assessment of temporal pathways, while multilevel models could simultaneously evaluate household, community, environmental, and health-system determinants. Geographic representation should also expand beyond currently dominant regions, particularly to climate-vulnerable settings with weak surveillance systems. Such studies would enable future systematic reviews to move beyond directional narrative synthesis toward quantitative estimation of how structural inequality modifies climate-sensitive vector-borne disease burden.

CONCLUSION

Socioeconomic vulnerability appears to be an important determinant of how extreme-weather and climate-sensitive conditions translate into malaria and dengue risk. The available observational evidence suggests that poverty and limited adaptive resources, inadequate housing and basic-service infrastructure, displacement and reduced access to preventive measures, and constrained healthcare capacity can amplify exposure or worsen the consequences of environmentally driven transmission. Housing and preventive-resource access currently provide some of the clearest mechanistic evidence, while direct statistical evaluation of socioeconomic modification remains comparatively limited. Climate-resilient malaria and dengue control should therefore integrate meteorological surveillance and vector management with structural interventions addressing housing, water systems, displacement, preventive-resource continuity, and healthcare accessibility. More rigorous longitudinal research using standardized socioeconomic measures and disease-specific outcomes is required to quantify these interactions and determine which interventions most effectively reduce inequitable post-event disease burden.

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