e-ISSN : 2597-6052

MPPKI
MEDIA PUBLIKASI PROMOSI KESEHATAN INDONESIA

Review Articles Open Access

Determinants of Malaria Re-emergence in Coastal and Island Elimination Settings: A PRISMA-Based Systematic Review

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ARTICLE INFO

Manuscript Received: 19 Nov, 2025
Revised: 17 Jun, 2026
Accepted: 25 Jun, 2026
Date of Publication: 16 Jul, 2026
Volume: 9
Issue: 7
DOI: 10.56338/mppki.v9i7.9252

KEYWORDS

Malaria Re-Emergence;
Coastal Areas;
Island Settings;
Surveillance;
Systematic Review

ABSTRACT

Introduction: Malaria elimination remains vulnerable in receptive coastal and island settings where ecological change, vector adaptation, human mobility, imported infections, surveillance gaps, and governance constraints may interact. This systematic review aimed to synthesize determinants of malaria re-emergence, resurgence, reintroduction, and re-establishment of local transmission in coastal and island elimination settings, with relevance to Indonesia and other tropical archipelagic regions.

Method: A systematic review was conducted following PRISMA 2020 guidelines. Literature was searched in Scopus, ScienceDirect, and PubMed for studies published from 2019 to 2025. Eligible studies addressed malaria re-emergence, elimination sustainability, ecological receptivity, vector or parasite factors, imported transmission, surveillance capacity, or governance issues in coastal, island, archipelagic, low-transmission, or elimination-related contexts. From 1,054 identified records, 30 studies met the inclusion criteria and were synthesized thematically.

Result: Malaria re-emergence in coastal and island elimination settings was not attributable to a single determinant. Ecological and climatic factors, including land-use change, wetland formation, coastal modification, rainfall variability, and rising temperature, may increase suitable habitats for Anopheles vectors. Vector behavioral adaptation, outdoor biting, altered resting behavior, and insecticide resistance may reduce the effectiveness of indoor-based interventions. Human mobility through migration, fishing, mining, tourism, port activity, and inter-island travel may facilitate parasite importation into receptive areas. Plasmodium vivax relapse, low-density infection, and asymptomatic carriage may further complicate case detection and classification. Surveillance weaknesses, limited molecular diagnostic capacity, delayed investigation, fragmented reporting, unstable financing, and weak intersectoral coordination may reduce elimination resilience.

Conclusion: Sustaining malaria elimination in coastal and island settings requires integrated, adaptive surveillance linking epidemiological, entomological, climatic, mobility, and laboratory data. Strengthening port-based surveillance, vector monitoring, molecular diagnostics, community participation, intersectoral coordination, and sustainable financing is essential to prevent reintroduction and local transmission re-establishment.

Publisher: Fakultas Kesehatan Masyarakat Universitas Muhammadiyah Palu

INTRODUCTION

Malaria remains a major global public health problem and continues to affect health systems, economic productivity, and population resilience in many endemic and elimination-oriented countries. The World Health Organization reported more than 249 million malaria cases and 608,000 malaria-related deaths globally, with the highest burden concentrated in sub-Saharan Africa and parts of Southeast Asia (1). Indonesia has achieved substantial progress in reducing malaria incidence through phased elimination strategies at provincial, district, and local levels (2,3). However, the recurrence of malaria cases in areas that had achieved elimination or low transmission status indicates that elimination gains remain epidemiologically fragile, particularly in geographically complex regions with high ecological receptivity, population mobility, and uneven surveillance capacity (4).

In this review, several epidemiological terms are used with distinct meanings. Malaria re-emergence refers to the renewed occurrence of malaria risk or cases in areas where transmission had previously declined or been interrupted. Resurgence refers to an increase in malaria incidence after a period of reduction. Reintroduction refers to the entry of malaria parasites into a receptive area through imported infections. Re-establishment of local transmission occurs when introduced infections lead to sustained onward transmission. Relapse, particularly in Plasmodium vivax infection, refers to recurrence from dormant hypnozoites rather than new mosquito-borne infection. Receptivity refers to the ecological and entomological capacity of an area to support malaria transmission, while vulnerability refers to the risk of parasite importation through human movement. These distinctions are important because each process requires different surveillance, diagnostic, treatment, and vector control responses.

Coastal and island settings are particularly vulnerable to malaria re-emergence because they combine ecological receptivity with operational challenges in surveillance and control. Mangrove ecosystems, wetlands, brackish water pools, coastal development, land-use change, and hydrological modification can create suitable breeding habitats for Anopheles mosquitoes, including Anopheles sundaicus and Anopheles maculatus (5). These ecological factors may interact with climatic variability, including rainfall, temperature, and humidity, which can influence vector abundance and transmission potential. In addition, mining, fishing, tourism, port activity, and inter-island mobility increase the probability of imported malaria entering receptive areas (6,7). Weak early warning systems and delayed case investigation may further increase the risk that imported or relapsing infections develop into local transmission.

Previous studies have examined malaria resurgence, imported malaria, vector ecology, surveillance systems, and elimination strategies. However, much of this evidence remains fragmented across ecological, epidemiological, entomological, and governance perspectives. Prior reviews have not sufficiently differentiated coastal and island elimination settings from inland or generalized endemic contexts. They also have not fully integrated how ecological receptivity, vector behavioral adaptation, P. vivax relapse, imported transmission, surveillance fragility, and governance limitations interact to shape malaria vulnerability. This gap is important for Indonesia and other archipelagic countries, where geographical fragmentation, uneven health-system capacity, and cross-border or inter-island mobility can undermine elimination sustainability (8,9).

Therefore, this PRISMA-based systematic review aims to synthesize evidence on the ecological, vector-related, mobility-related, surveillance, and governance determinants of malaria re-emergence in coastal and island elimination settings. The review focuses on how these determinants interact to increase the risk of malaria reintroduction, resurgence, and re-establishment of local transmission. By integrating evidence across multiple determinant categories, this study seeks to strengthen the conceptual basis for adaptive malaria surveillance, port-based monitoring, ecosystem-sensitive vector control, and sustainable elimination policy in Indonesia and comparable tropical archipelagic regions.

METHOD

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Although PRISMA was used as the reporting guideline, this study did not conduct a meta-analysis. Instead, the review applied thematic synthesis because the included studies varied in epidemiological context, study design, determinant categories, and outcome measures.

Literature published between 2019 and 2025 was retrieved from three major databases, namely Scopus, ScienceDirect, and PubMed. The final database search was conducted on November 5, 2026. The search strategy used combinations of the following keywords and Boolean operators: "malaria elimination," "malaria re-emergence," "malaria resurgence," "malaria reintroduction," "imported malaria," "coastal," "island," "archipelagic," "surveillance," "vector," "receptivity," and "vulnerability." This review focused on studies related to malaria elimination sustainability, imported transmission, vector adaptation, surveillance systems, ecological receptivity, and governance determinants in coastal and island settings.

The inclusion criteria consisted of: (1) studies published between 2019 and 2025; (2) studies discussing malaria re-emergence, resurgence, reintroduction, relapse-associated transmission, vector adaptation, surveillance gaps, or elimination maintenance; (3) studies conducted in coastal, island, archipelagic, low-transmission, or elimination-related settings; (4) empirical, epidemiological, entomological, surveillance, molecular, modeling, or policy-related studies; and (5) English-language publications. Studies were excluded if they focused on unrelated infectious diseases, discussed general clinical malaria without relevance to elimination sustainability, lacked relevance to coastal or island settings, or did not provide sufficient methodological and contextual information.

The initial database search identified 1,054 records in total, consisting of Scopus (n = 480), ScienceDirect (n = 245), and PubMed (n = 329). Four duplicate records were removed, leaving 1,050 records for title and abstract screening. During the screening stage, 923 records were excluded because they were not related to malaria re-emergence or elimination sustainability, were not related to coastal, island, or archipelagic settings, focused on unrelated infectious diseases, were non-English publications, or had irrelevant epidemiological contexts. A total of 127 full-text articles were then assessed for eligibility. During full-text assessment, 97 articles were excluded because they did not focus on malaria elimination sustainability, focused only on clinical malaria outcomes, were not related to surveillance, vector ecology, imported transmission, or governance determinants, or had insufficient methodological or contextual information. Finally, 30 studies met the eligibility criteria and were included in the thematic synthesis.

The screening and eligibility assessment processes were conducted independently by the authors. Any discrepancies during study selection were resolved through discussion and consensus to reduce selection bias and improve review transparency. This procedure ensured that the final included studies were aligned with the review objective and eligibility criteria.

A structured quality appraisal was conducted to evaluate the methodological relevance and evidentiary strength of the included studies. The appraisal considered the clarity of study objectives, appropriateness of study design, population and setting description, adequacy of data sources, transparency of analytical procedures, and relevance to the review question. The appraisal findings were used to guide interpretation of the synthesized evidence and to avoid overgeneralization from studies with limited methodological relevance.

Data extraction was performed using a structured evidence matrix. Extracted information included author, publication year, country or region, study setting, elimination context, determinant category, study design, data source, and principal findings. Thematic synthesis was then employed to group the findings into five analytical categories: (1) ecological and climatic receptivity, (2) vector and parasite-related determinants, (3) population mobility and imported transmission, (4) surveillance system capacity, and (5) governance and financing.

The thematic synthesis was conducted through repeated reading of the included studies, initial coding of determinant-related findings, grouping of similar codes into analytical categories, and comparison across study contexts. The final themes were validated through author discussion to ensure consistency between extracted evidence and thematic interpretation. Because the included studies were methodologically and contextually heterogeneous, pooled quantitative synthesis was not performed.

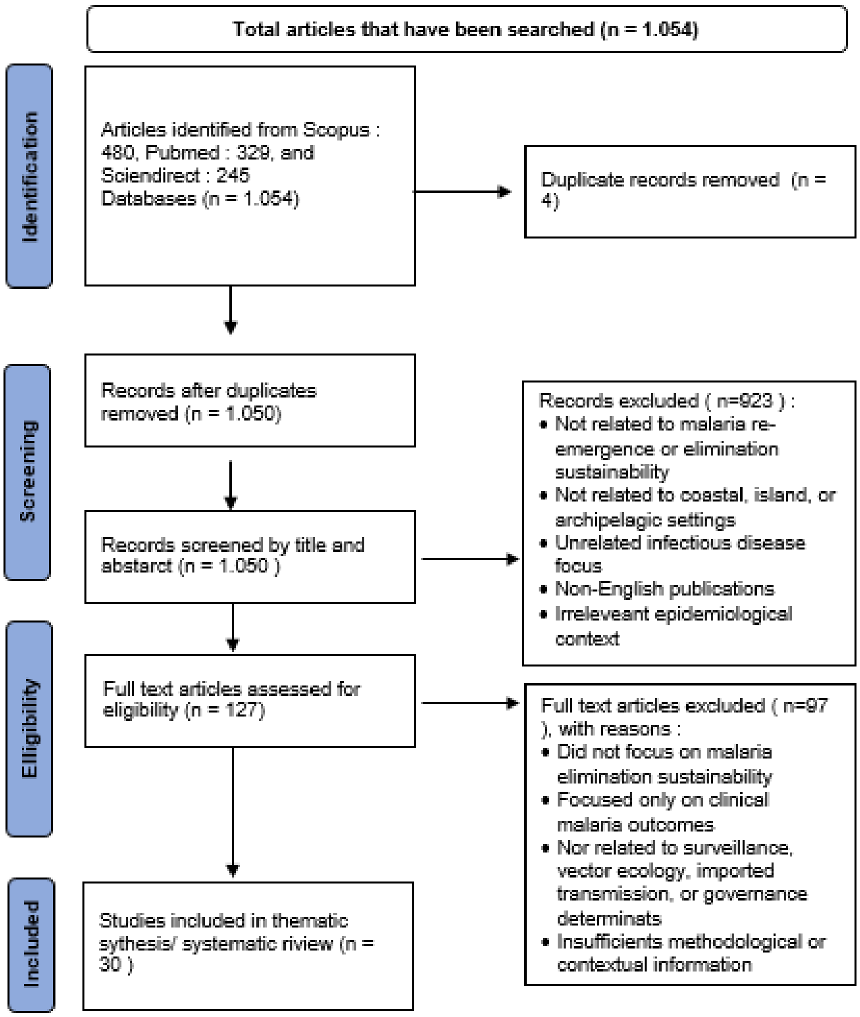

Figure 1. PRISMA flow diagram of literature screening and study selection process

RESULTS

A total of 30 studies published between 2019 and 2025 met the eligibility criteria and were included in the thematic synthesis. The included studies covered diverse geographical settings, including Indonesia, China, Vanuatu, South Africa, Uganda, Kenya, India, Eritrea, Myanmar, Pacific Island regions, and other malaria-endemic or elimination-oriented areas. The studies represented several methodological designs, including epidemiological investigations, entomological surveillance, molecular surveillance, genomic analysis, spatial and climatic analysis, modeling studies, retrospective surveillance studies, and policy-oriented evaluations. Most studies addressed coastal, island, archipelagic, low-transmission, or elimination-related settings where malaria vulnerability was shaped by ecological receptivity, imported transmission, vector adaptation, and surveillance capacity.

The thematic synthesis identified five major determinant categories associated with malaria re-emergence in coastal and island elimination settings: ecological and climatic determinants, vector and parasite-related determinants, imported transmission and population mobility, surveillance system fragility, and governance and financing limitations. These categories were not equally represented across the included studies. Ecological and climatic determinants were more frequently reported in studies from Indonesia, South Africa, Eritrea, and tropical coastal or wetland regions. Vector and parasite-related determinants were more prominent in studies from Kenya, Uganda, Ethiopia, Myanmar, India, and low-transmission settings with persistent vector or parasite adaptation. Imported transmission and population mobility were especially prominent in island, border, and archipelagic contexts, including Vanuatu, Zanzibar, China, and Indonesia. Surveillance and governance-related determinants were reported across multiple settings but varied in depth, with some studies providing direct surveillance evidence and others discussing governance mainly as contextual explanation (10).

Ecological and climatic determinants included wetland expansion, mangrove or coastal ecosystem modification, land-use change, hydrological alteration, rainfall variability, humidity, temperature increase, vegetation change, and flooding. These factors were generally associated with greater suitability for Anopheles breeding and increased malaria transmission risk. Evidence from coastal and island settings suggests that ecological receptivity may persist even after malaria incidence declines. However, the strength and form of this relationship differed across regions. In archipelagic and coastal settings, brackish-water habitats, mangrove ecosystems, and coastal development were more relevant to vector breeding. In several African studies, rainfall instability, vegetation indices, wetland expansion, and broader climatic variation were more frequently emphasized. This indicates that ecological receptivity is not a uniform determinant. It depends on local vector species, hydrology, land-use patterns, and climate variability (11).

Vector and parasite-related determinants were also recurrent across the evidence matrix. Several studies reported vector behavioral adaptation, outdoor biting, altered resting behavior, insecticide resistance, and vector invasion as factors that may reduce the effectiveness of indoor-based interventions such as insecticide-treated nets and indoor residual spraying. Evidence from Kenya and Uganda highlighted geographic variation in insecticide resistance, while studies from Ethiopia emphasized the epidemiological relevance of Anopheles stephensi invasion. Parasite-related findings included low-density infection, asymptomatic malaria, antimalarial resistance, and Plasmodium vivax relapse. These findings are important because conventional diagnostic and control strategies may miss infections that persist at low density or recur through hypnozoite activation. Nevertheless, the evidence base was heterogeneous. Some studies used molecular or genomic approaches, while others relied on routine surveillance or retrospective data. Therefore, the findings support the importance of vector and parasite monitoring, but the strength of inference differs by study design and diagnostic method (12,13).

Imported transmission and population mobility were identified as major determinants in island, border, and archipelagic settings. Migration, fishing, mining, tourism, labor mobility, forest exposure, port activity, and inter-island transportation were reported as pathways for parasite reintroduction into receptive areas. Studies from Vanuatu, Zanzibar, China, and island or border regions showed that imported infections can persist in low-transmission settings and may contribute to local transmission risk when surveillance is delayed or ecological receptivity remains high. In Indonesia and comparable archipelagic settings, the relevance of mobility is especially important because coastal districts, ports, islands, and resource-extraction areas are often connected through frequent population movement. However, not all mobility-related evidence had the same level of specificity. Some studies directly examined parasite importation or genetic relatedness, while others discussed mobility as a contextual driver. This difference should be considered when interpreting the strength of mobility-related conclusions (14,15).

Surveillance system fragility appeared as a cross-cutting determinant across the included studies. Delayed diagnosis, incomplete case investigation, fragmented reporting, limited molecular diagnostic capacity, weak entomological surveillance, and insufficient data integration were repeatedly associated with reduced outbreak detection and response capacity. Studies using molecular, genomic, and surveillance-based approaches showed that hidden infections, imported cases, and low-density parasitemia may remain undetected when diagnostic systems depend mainly on routine or passive reporting. Evidence from elimination-oriented settings also showed that active case detection, integrated surveillance, port or border-based screening, and rapid response mechanisms may strengthen outbreak control. However, the evidence also indicates that surveillance capacity is uneven across settings. Resource-limited island and coastal districts may face greater barriers in laboratory capacity, trained personnel, transport access, and inter-district data sharing (14,16).

Governance and financing limitations were reported less frequently than ecological or vector-related determinants, but they appeared consistently as enabling or constraining factors for elimination sustainability. Several studies highlighted unstable financing, fragmented institutional coordination, donor dependence, limited district-level resources, and weak intersectoral integration as barriers to sustained malaria control. These governance issues are especially relevant in coastal and island settings because malaria prevention often requires coordination beyond the health sector, including environmental management, port authorities, migration control, transportation systems, local government, and community networks. The evidence suggests that governance does not act as an isolated determinant. It shapes the capacity to sustain surveillance, maintain vector control, respond to imported cases, and finance laboratory or field operations after malaria incidence declines (17,18).

Overall, the results show that malaria re-emergence in coastal and island elimination settings is not explained by a single dominant determinant. The evidence points to a layered pattern in which ecological receptivity creates the environmental possibility of transmission, vector and parasite adaptation complicate control, mobility introduces or reintroduces parasites, surveillance fragility delays detection and response, and governance limitations reduce long-term program resilience. Table 1 presents the key studies that contributed most directly to the thematic synthesis. The remaining included studies were used to support contextual interpretation (14,19).

Table 1. Thematic Evidence Matrix of Key Included Studies on Malaria Re-emergence in Coastal and Island Elimination Settings

No	Author(s)	Country/Region	Coastal/Island or Elimination Context	Determinant Category	Study Design	Key Findings
1	Sean V. Connelly et al.(14)	Zanzibar	Island, low-transmission setting	Imported transmission and surveillance	Cross-sectional molecular epidemiology	Genetic relatedness indicated ongoing low-level transmission and imported malaria contribution.
2	Sho Sekine et al.(20)	Vanuatu	Island post-elimination setting	Relapse and parasite dynamics	Molecular epidemiological study	*Plasmodium vivax* resurgence originated from genetically related strains, suggesting relapse or localized parasite persistence.
3	Yuchun Li et al.(21)	Hainan Island, China	Island elimination setting	Surveillance and vector control	Retrospective study	The Three-Layer Strategy supported outbreak response through case detection, vector control, and local health worker training.
4	Mihirini Hewavitharane et al.(22)	Sri Lanka	Coastal ecological zone	Ecological and climatic determinants	Observational ecological study	Rainfall, humidity, and temperature influenced *Anopheles* abundance and distribution.
5	Brian Polo et al.(12)	Kenya	Vector-endemic setting	Vector adaptation and resistance	Molecular surveillance study	Geographic heterogeneity in insecticide resistance mechanisms was identified across *Anopheles arabiensis* populations.

No	Author(s)	Country/Region	Coastal/Island or Elimination Context	Determinant Category	Study Design	Key Findings
6	Nikhat Khan et al.(10)	India	Elimination-oriented endemic region	Asymptomatic infection and parasite diversity	Molecular epidemiology study	Asymptomatic infections, mixed species, and parasite genetic diversity may complicate malaria elimination.
7	Chim W. Chan and Akira Kaneko(9)	Vanuatu and Papua New Guinea	Island elimination settings	Governance and community engagement	Mixed-methods observational study	Community engagement and institutional collaboration strengthened malaria control and elimination efforts.
8	Fredros Okumu et al.(18)	Africa	Endemic ecological settings	Ecological vulnerability and vector control	Descriptive mixed-methods study	Environmental management and structural resilience may strengthen control against persistent vector vulnerability.
9	Wataru Kagaya(23)	Southeast Asia	Low-transmission setting	Low-density infection and surveillance	Cross-sectional molecular study	Low-density infections may contribute to hidden transmission and require more sensitive diagnostic approaches.
10	Loick P. Kojom Foko and Amit Sharma(24)	EMR, WPR, and SEAR regions	Post-elimination and low-transmission settings	*Plasmodium vivax* resurgence	Molecular observational study	Increasing *P. vivax* resurgence was reported in several regions, showing the need for relapse-sensitive surveillance.
11	Min Kramyoo et al.(16)	Thailand and Sudan	High-risk population settings	Diagnostic surveillance	Cross-sectional molecular study	ddPCR detected asymptomatic infections that were missed by microscopy.
12	Osadolor Ebhuoma et al.(11)	South Africa	Coastal/endemic region	Ecological and climatic determinants	Bayesian spatial-temporal analysis	Environmental and geographical factors influenced malaria transmission dynamics.
13	Emilie Mosnier et al.(25)	French Guiana and Brazil border	Border and riverine setting	Imported transmission and vector ecology	Longitudinal entomological study	Seasonal vector density and cross-border conditions increased malaria resurgence risk.

No	Author(s)	Country/Region	Coastal/Island or Elimination Context	Determinant Category	Study Design	Key Findings
14	Guofa Zhou et al.(19)	Ethiopia	Expanding endemic setting	Vector invasion and resurgence	Retrospective epidemiological and entomological analysis	*Anopheles stephensi* invasion was associated with increased malaria cases and hotspot expansion.
15	Maru W. Aregawi et al.(17)	Uganda	Epidemic-prone endemic region	Surveillance fragility and programmatic weakness	Retrospective analysis	Programmatic weaknesses contributed to epidemic escalation and excess malaria cases.
16	Ambrose Oruni et al.(13)	Uganda	Resurgence setting	Vector resistance	Longitudinal entomological surveillance	Persistent insecticide tolerance was detected in major vector species, indicating reduced control effectiveness.

Source: author's development

DISCUSSION

Ecological Receptivity and Vector Adaptation in Coastal and Island Settings

The findings of this review indicate that malaria re-emergence in coastal and island elimination settings is shaped by the interaction between ecological receptivity, climatic variability, and vector adaptation. Coastal wetlands, mangrove ecosystems, brackish-water pools, land-use change, and hydrological modification may create suitable habitats for *Anopheles* mosquitoes, especially in tropical coastal and archipelagic environments (3,26). Evidence from ecological and spatial studies suggests that environmental change can increase vector suitability, but the dominant ecological drivers differ across settings. In island and coastal environments, brackish-water habitats and coastal wetland dynamics are more relevant, whereas in several African settings, vegetation indices, rainfall variability, humidity, and broader climatic instability are more prominent determinants of transmission risk (4).

This contextual difference is important because malaria receptivity cannot be interpreted as a uniform ecological condition. Receptivity depends on local vector species, hydrology, land use, climate patterns, and human activity around breeding habitats. Therefore, malaria re-emergence in coastal and island settings should not be explained only by climate variability. It should be understood as a combined ecological process in which environmental modification increases vector habitat suitability while local surveillance and control capacity determine whether this receptivity develops into transmission risk (3,26).

Vector adaptation further complicates elimination maintenance. Studies on vector behavior and insecticide resistance show that outdoor biting, altered resting patterns, and reduced insecticide susceptibility may reduce the effectiveness of indoor-based interventions, including long-lasting insecticidal nets and indoor residual spraying (13,27). This is particularly relevant for coastal and island communities where fishing, mining, port activity, and night-time outdoor work may increase human-vector contact outside protected indoor spaces. Thus, elimination programs should not rely only on conventional indoor vector control. They need routine entomological monitoring, insecticide resistance surveillance, environmental management, and locally adapted vector control strategies (28).

Imported Malaria, *Plasmodium vivax* Relapse, and Local Transmission Risk

Imported malaria and *Plasmodium vivax* relapse represent different epidemiological pathways and require different responses. Imported malaria occurs when parasites enter a receptive area through human movement, including migration, labor mobility, fishing, mining, tourism, port activity, and inter-island travel (5,29). This pathway requires port-based surveillance, border screening, travel-history assessment, migrant monitoring, rapid case investigation, and cross-district data sharing. In contrast, *P. vivax* relapse results from dormant hypnozoites in previously infected individuals and requires radical cure, adherence monitoring, appropriate diagnostic support, and follow-up systems (30,31).

The distinction between these two pathways is critical for coastal and island elimination settings. Imported cases may trigger local transmission when they enter ecologically receptive areas with competent vectors and delayed surveillance response. Relapse-associated infections may sustain transmission risk even without new parasite importation if radical cure is incomplete or access to follow-up care is weak (31). Studies from island and low-transmission settings show that parasite persistence, genetic relatedness, and recurrent *P. vivax* infections can complicate the classification of cases and the design of surveillance responses (9,11). Therefore, lumping imported malaria and relapse into a single category can weaken intervention planning.

In Indonesia and other archipelagic countries, this distinction has practical implications. Port mobility, inter-island travel, and uneven district-level health capacity may increase vulnerability to imported infections. At the same time, *P. vivax* relapse requires clinical and laboratory systems that can support radical cure and follow-up. A sustainable elimination strategy must therefore combine mobility-based surveillance with relapse-sensitive case management (8,32).

Surveillance System Resilience and Health-System Capacity

Surveillance emerged as a central determinant of malaria elimination sustainability. Delayed reporting, incomplete case investigation, weak laboratory networks, limited molecular diagnostic capacity, and poor integration between epidemiological and entomological data may allow imported or relapsing infections to progress into local transmission (21,33). In post-elimination and low-transmission settings, surveillance should not function only as passive reporting. It should act as an active intervention that links case detection, case classification, treatment, follow-up, focus investigation, vector assessment, and targeted response.

The mechanism is clear. When imported or relapsing infections are not detected quickly, local vectors may sustain onward transmission in receptive environments. When reporting systems are fragmented across districts, ports, laboratories, and primary health facilities, response teams may fail to identify clusters, trace infection sources, or interrupt transmission early. When diagnostic systems rely only on routine microscopy or passive case detection, low-density and asymptomatic infections may remain undetected (16,25). These weaknesses are especially important in geographically isolated islands and coastal districts where transport access, laboratory infrastructure, trained personnel, and digital reporting systems are uneven.

Recent evidence also supports the need for molecular and genomic surveillance in selected high-risk settings. Genomic tools can help identify imported infections, detect cryptic transmission, and distinguish local persistence from new introduction (14,17). However, these tools should be framed as evidence-informed strategic options, not as universal requirements for all districts. Their implementation depends on laboratory readiness, workforce capacity, cost, sample transport, data interoperability, and sustainable financing. This distinction is important because resource-limited coastal districts may need stepwise strengthening before advanced genomic surveillance can operate effectively.

Governance, Financing, and Implementation Feasibility

Governance and financing limitations influence whether ecological receptivity, imported infections, and surveillance gaps develop into malaria re-emergence. Sustaining elimination requires stable financing, clear institutional responsibility, intersectoral coordination, and long-term investment in surveillance after case numbers decline (34,35) . In decentralized health systems, malaria programs may weaken when elimination status reduces political attention or when districts rely on general health budgets without dedicated resources for surveillance, entomology, laboratory strengthening, and rapid response (8,35).

This issue is highly relevant for coastal and island settings. Malaria prevention in these areas cannot depend only on health facilities. It requires coordination among district health offices, port health authorities, environmental agencies, transportation sectors, local governments, laboratories, and community networks. Weak coordination may delay case notification, reduce the quality of travel-history assessment, and limit rapid vector response in receptive areas. Therefore, governance should be understood as an operational determinant of malaria elimination sustainability, not merely as an administrative background factor.

The Three-Layer Strategy and community-based surveillance offer useful models, but they should be evaluated critically before adoption in Indonesian coastal and island settings (20,21). Their scalability depends on trained local personnel, reliable reporting systems, laboratory support, financing continuity, and coordination across administrative levels. Community-based surveillance may improve early detection in remote areas, but it requires supervision, standardized reporting, and integration with formal surveillance systems. Without these elements, community participation may remain fragmented and fail to support timely outbreak response.

Overall, the discussion of this review shows that malaria re-emergence in coastal and island elimination settings is not driven by a single cause. It results from the interaction of ecological receptivity, vector adaptation, parasite persistence, imported transmission, surveillance fragility, and governance limitations. Sustaining elimination therefore requires more than biomedical intervention. It requires adaptive governance, environmentally informed surveillance, financing sustainability, port-based health coordination, and locally embedded community participation.

CONCLUSION

Malaria re-emergence in coastal and island elimination settings remains a major challenge to sustaining malaria elimination. The reviewed evidence shows that vulnerability in these settings is shaped by the interaction between ecological receptivity, vector adaptation, imported infections, *Plasmodium vivax* relapse, surveillance gaps, governance limitations, and financing constraints. Coastal wetlands, mangrove ecosystems, land-use change, climatic variability, and inter-island mobility can increase receptivity and create conditions that support malaria reintroduction or re-establishment of local transmission.

The findings suggest that malaria elimination requires an adaptive and data-driven surveillance system. Integrated surveillance should combine epidemiological, entomological, climatic, genomic, and mobility-related information to support early detection and rapid response. Surveillance should not operate only as passive reporting. It should function as an active intervention that connects case detection, case classification, outbreak investigation, vector monitoring, and targeted response.

In coastal and island settings such as Indonesia, port-based surveillance, molecular diagnostic capacity, sentinel laboratory networks, health quarantine governance, and community-based active surveillance should be strengthened as evidence-informed strategic priorities, not as definitive one-size-fits-all interventions. Their implementation requires stable financing, trained personnel, laboratory readiness, intersectoral coordination, and locally embedded community participation.

The main contribution of this review is the integration of ecological, vector-related, mobility-related, surveillance, and governance determinants into a unified framework for understanding malaria re-emergence in coastal and island elimination settings. However, these conclusions should be interpreted with caution because the included studies were heterogeneous in design, setting, and evidentiary strength. Future research should prioritize longitudinal studies on imported and relapse-associated malaria, operational research on 1-3-7 surveillance, genomic tracking of parasite introduction, entomological monitoring in coastal areas, and cost-effectiveness studies of integrated early warning systems.

AUTHOR'S CONTRIBUTION STATEMENT

Rahmah RA AZ is fully responsible for the entire research process, including the design of the study, data collection, analysis and interpretation of the findings, development of the theoretical framework, and the drafting, revision, and finalization of the manuscript.

CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

Generative artificial intelligence tools, including DeepL and Blackbox, were used only to support language refinement, such as grammar checking and improving readability. AI was not used for content creation, data analysis, conceptual development, or critical interpretation. All intellectual contributions, including research design, data handling, analysis, and manuscript preparation, were carried out entirely by the author.

SOURCE OF FUNDING

This research received no external funding or financial support from any institution or organization.

ACKNOWLEDGMENTS

The author would like to express sincere gratitude to individuals and institutions that provided support during the research process. Appreciation is extended to those who assisted in data collection, offered academic guidance, and facilitated access to research materials or facilities. Although their contributions were valuable, they do not meet the criteria for authorship and are therefore acknowledged here.

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