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DYSFUNCTIONAL URBANIZATION AND THE SEMIARID ARBOVIRUS PARADOX: AN ECO-URBAN MODEL FROM MEDIUM-SIZED CITIES IN BRAZIL

URBANIZAÇÃO DISFUNCIONAL E O PARADOXO DAS ARBOVIROSES NO SEMIÁRIDO: UM MODELO ECO-URBANO A PARTIR DE CIDADES MÉDIAS DO BRASIL

URBANIZACIÓN DISFUNCIONAL Y LA PARADOJA DE LAS ARBOVIROSIS EN EL SEMIÁRIDO: UN MODELO ECO-URBANO A PARTIR DE CIUDADES MEDIAS DE BRASIL

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Abstract: Arbovirus transmission has traditionally been associated with humid tropical environments, yet recent evidence from the Brazilian semiarid challenges this paradigm. Medium-sized cities in this region exhibit increasing arboviral circulation despite chronic water scarcity and extreme heat, revealing a paradox in which adaptive human practices and urban conditions sustain vector proliferation. This study aimed to analyze how dysfunctional urbanization and urban heat dynamics influence arbovirus transmission in semiarid urban systems and to propose an integrative conceptual model. An integrative literature review was conducted using major international and regional databases, covering studies published between 2010 and 2026. After systematic screening, a set of studies was selected and analyzed through thematic synthesis. The results demonstrate that horizontal urban expansion, inadequate sanitation, and domestic water storage create persistent breeding sites, while urban heat islands and climatic variability accelerate vector development and viral replication. The discussion highlights that these factors operate as an interconnected system, rather than isolated drivers, reinforcing transmission through feedback mechanisms involving environment, infrastructure, and human behavior. The study proposes the Semiarid

Urban Arbovirus Amplification System as a theoretical framework to explain these dynamics. It concludes that arbovirus risk in semiarid cities must be reframed through integrated approaches that consider urban planning, climate, and socio-environmental conditions, particularly in the context of global warming.

Keywords: Sanitation. Water Storage. Vector Ecology. Climate Variability. Urban Health.

Resumo: A transmissão de arboviroses tem sido tradicionalmente associada a ambientes tropicais úmidos, porém evidências recentes do Semiárido brasileiro desafiam esse paradigma. Cidades médias dessa região apresentam crescente circulação viral mesmo sob escassez hídrica e calor extremo, revelando um paradoxo no qual práticas adaptativas e condições urbanas sustentam a proliferação do vetor. Este estudo teve como objetivo analisar como a urbanização disfuncional e a dinâmica térmica urbana influenciam a transmissão de arboviroses em sistemas urbanos semiáridos, além de propor um modelo conceitual integrador. Foi realizada uma revisão integrativa da literatura em bases nacionais e internacionais, considerando estudos publicados entre 2010 e 2026. Após triagem sistemática, os estudos foram analisados por síntese temática. Os resultados indicam que a expansão urbana horizontal, a precariedade do saneamento e o armazenamento doméstico de água criam criadouros persistentes, enquanto as ilhas de calor e a variabilidade climática aceleram o desenvolvimento vetorial e a replicação viral. A discussão evidencia que esses fatores operam de forma interdependente, formando um sistema de retroalimentação entre ambiente, infraestrutura e comportamento humano. Como contribuição, propõe-se o Sistema de Amplificação de Arboviroses em Ambientes Urbanos Semiáridos. Conclui-se que o risco epidemiológico deve ser reinterpretado a partir de abordagens integradas, especialmente diante das mudanças climáticas.

Palavras-chave: Saneamento. Armazenamento de Água. Ecologia Vetorial. Variabilidade Climática. Saúde Urbana

Resumen: La transmisión de arbovirosis ha sido tradicionalmente asociada a ambientes tropicales húmedos; sin embargo, evidencias recientes del semiárido brasileño cuestionan este paradigma. Las ciudades medias de esta región presentan una creciente circulación viral incluso bajo condiciones de escasez hídrica y calor extremo, revelando una paradoja en la que las prácticas adaptativas y las condiciones urbanas sostienen la proliferación del vector. Este estudio tuvo como objetivo analizar cómo la urbanización disfuncional y la dinámica térmica urbana influyen en la transmisión de arbovirosis en sistemas urbanos semiáridos, además de proponer un modelo conceptual integrador. Se realizó una revisión integradora de la literatura en bases de datos internacionales y regionales, considerando estudios publicados entre 2010 y 2026. Tras un proceso de selección sistemático, los estudios fueron analizados mediante síntesis temática. Los resultados muestran que la expansión urbana horizontal, el saneamiento deficiente y el almacenamiento doméstico de agua generan criaderos persistentes, mientras que las islas de calor y la variabilidad climática aceleran el desarrollo del vector y la replicación viral. La discusión evidencia que estos factores operan como un sistema interdependiente con mecanismos de retroalimentación entre ambiente, infraestructura y comportamiento humano. Se propone el Sistema de Amplificación de Arbovirosis en Ambientes Urbanos Semiáridos como marco teórico. Se concluye que el riesgo debe ser reinterpretado mediante enfoques integrados, especialmente frente al cambio climático.

Palabras clave: Saneamiento. Almacenamiento de Agua. Ecología Vectorial. Variabilidad Climática. Salud Urbana

1 INTRODUCTION

The global expansion of arboviruses has exposed the limitations of epidemiological models that associate transmission primarily with humid tropical climates. Dengue, Zika, and chikungunya have traditionally been interpreted through rainfall, humidity, and stable temperature patterns. Although useful in coastal and equatorial settings, these models fail to explain transmission dynamics in heterogeneous environments, particularly in the Global South (Morgan et al., 2021).

In Brazil, successive outbreaks have revealed strong spatial heterogeneity that cannot be explained by classical climatic predictors alone (Gurgel-Gonçalves et al., 2024). Vector competence, viral replication, and ecological adaptability vary across territories, indicating that transmission depends on localized socio-environmental conditions rather than macroclimate alone (Fernandes et al., 2020). Rainfall-centered explanations therefore overlook key drivers operating in non-humid regions.

Medium-sized inland cities have become important yet understudied nodes in arbovirus transmission. In Brazil, the interiorization of these diseases reflects a shift from coastal centers to rapidly expanding urban areas in the interior, which remain underrepresented in research and surveillance analyses (Almeida et al., 2022).

These cities exhibit intense viral circulation, including co-circulation of multiple arboviruses, as observed in northeastern Brazil (Lobkowicz et al., 2022). Epidemiological studies also identify risk factors linked to urban environments of intermediate scale, where rapid demographic growth coexists with infrastructural deficits, sustaining transmission (Ferreira et al., 2022). The persistence of a metropolitan bias limits current models and reinforces the need to reposition these cities in epidemiological analysis.

The Brazilian semiarid region presents an epidemiological paradox. Despite chronic water scarcity, extreme temperatures, and climatic variability, these cities sustain Aedes aegypti proliferation. This dynamic is driven by human adaptation rather than natural hydrology. Irregular water supply leads households to store water in improvised and unprotected containers, creating permanent breeding sites independent of rainfall cycles (Lima-Camara, 2024).

Temperature further intensifies transmission. Elevated surface temperatures and urban heat islands accelerate mosquito development and reduce the extrinsic incubation period, increasing transmission efficiency even under low humidity (Ogasawara et al., 2019). These processes challenge the assumption that rainfall is the central driver of arbovirus transmission.

This study synthesizes evidence on the relationship between dysfunctional urbanization, urban heat islands, and arbovirus transmission in medium-sized semiarid cities. The objective is to identify conceptual gaps and propose a theoretical framework, the Semiarid Urban Arbovirus Amplification System, which explains how climatic constraints, socio-spatial inequality, and adaptive practices create stable ecological niches for Aedes aegypti.

By shifting the focus from climate alone to the interaction between environment, urban form, and human behavior, this study advances a systemic interpretation of arbovirus transmission in semiarid contexts.

This perspective highlights the need to move beyond reductionist, climate-centered explanations and to incorporate the socio-spatial specificities of semiarid urbanization into epidemiological reasoning. Understanding arbovirus transmission in these settings requires recognizing how infrastructure deficits, adaptive water practices, and thermal heterogeneity interact to sustain vector populations. By addressing these interdependencies, this study contributes to a more context-sensitive and theoretically robust framework for analyzing emerging transmission patterns in rapidly transforming urban environments.

2 METHODOLOGY

2.1 Study design: integrative review framework

This study was designed as an integrative literature review, a method selected for its suitability in synthesizing empirical, theoretical, and analytical evidence on complex and multidimensional health problems. This approach was considered particularly appropriate because the relationship between dysfunctional

urbanization, urban heat islands, water insecurity, and arbovirus transmission in medium-sized cities of the Brazilian semiarid cannot be adequately examined through a narrowly biomedical or exclusively epidemiological lens. Instead, the topic requires an interpretive and critical synthesis capable of articulating environmental, socio-spatial, infrastructural, and entomological dimensions within a single analytical structure.

In this sense, the integrative review was adopted not merely as a strategy for compiling studies, but as a method for producing a broader and more conceptually consistent understanding of a fragmented field of knowledge (Mendes; Silveira; Galvão, 2008; Souza; Silva; Carvalho, 2010).

The methodological development followed the classical logic of the integrative review, including problem identification, definition of the guiding question, establishment of search procedures, application of eligibility criteria, critical appraisal of the selected studies, systematic extraction of relevant information, and interpretive synthesis of findings. This sequence allowed the review to maintain both analytical rigor and thematic flexibility, which is essential when the objective is to identify patterns, contradictions, explanatory gaps, and possible theoretical advances across heterogeneous studies.

The review therefore sought to move beyond a descriptive summary of findings and to produce a critical synthesis capable of supporting a new conceptual interpretation of arbovirus transmission in semiarid urban systems (Mendes; Silveira; Galvão, 2008; Souza; Silva; Carvalho, 2010).

2.2. Protocol structure and reporting standards (PRISMA-adapted)

The protocol was structured according to the principles of transparency, reproducibility, and analytical traceability that guide high-quality integrative reviews. To ensure methodological clarity, the review process was organized through a PRISMA-adapted workflow, encompassing identification, screening, eligibility assessment, and final inclusion of studies. Although PRISMA was originally designed for systematic reviews, its procedural logic was adapted here to enhance the explicitness of each stage of article selection and to reduce ambiguity in the transition from the initial search universe to the final analytical corpus.

This adaptation was consistent with the understanding that integrative reviews require methodological organization that is both systematic and compatible with theoretical synthesis, especially when the aim is to generate conceptual advancement rather than only aggregate evidence.

In parallel, the structure of the review was also informed by an interpretive perspective that values synthesis, critical comparison, and theoretical integration as central outputs of literature review research. For this reason, the protocol did not restrict itself to documenting search and selection procedures, but also incorporated explicit analytical steps for the construction of thematic categories and for the proposition of an original conceptual model. This orientation was fundamental to maintaining coherence between the methodological design and the epistemological purpose of the article, namely, to explain how urban dysfunction, thermal heterogeneity, and adaptive water practices interact in the epidemiology of arboviruses in semiarid cities (Torraco, 2005).

The bibliographic search was conducted between October 2025 and March 2026. All stages of the review were performed sequentially and documented in order to ensure internal consistency, transparency of decision-

making, and methodological replicability.

2.3. Search strategy and databases

The review was guided by the following research question: How do dysfunctional urbanization and urban heat island dynamics modulate arbovirus transmission in medium-sized cities of the Brazilian semiarid? To operationalize this question, the search strategy was organized according to the PCC framework, in which the population corresponded to medium-sized cities, the concept referred to dysfunctional urbanization and its epidemiological implications, and the context encompassed the Brazilian semiarid region and its associated climatic and infrastructural specificities.

Searches were performed in five databases selected for their complementarity and disciplinary coverage: Scopus, Web of Science, PubMed, Embase, and SciELO. This combination aimed to ensure broad retrieval of international and regional literature, especially considering that part of the most relevant evidence on arboviruses, urbanization, and semiarid territorial dynamics is concentrated in Latin American journals and interdisciplinary publications that are not uniformly indexed across global databases. The inclusion of SciELO was therefore methodologically necessary to avoid geographic bias and to increase the sensitivity of the search in relation to Brazilian and regional studies.

The search syntax was structured through Boolean combinations of descriptors and keywords distributed into three analytical blocks. The first block addressed the health outcome and included terms such as "Arbovirus Infections," "Dengue," "Zika Virus," and "Chikungunya." The second block focused on urban and environmental processes and included terms such as "Urbanization," "Urban Heat Island," "Heat Islands," "Urban Expansion," and "Sanitation." The third block referred to territorial delimitation and included terms such as "Semiarid Region," "Medium-sized Cities," and "Brazil." These terms were combined with the operators AND and OR, with adjustments in field tags and controlled vocabulary according to the indexing rules of each database. Controlled descriptors from MeSH and DeCS were used when available, and free terms were retained to maximize sensitivity in interdisciplinary retrieval.

The search process initially identified 216 records. After completion of database exportation, all references were compiled into a single review matrix, and duplicate records were identified and removed before the screening stage. The remaining records then proceeded to title and abstract screening, followed by full-text assessment according to the predefined eligibility criteria.

2.4. Inclusion, exclusion, and quality appraisal (JBI-based approach)

Eligibility criteria were defined before the screening process to reduce selection bias and to preserve coherence between the review question, the scope of the article, and the intended analytical synthesis. Because the review aimed to explain a multidimensional phenomenon rather than test a single clinical intervention or estimate one pooled effect, the criteria were established to preserve thematic relevance, methodological consistency, and

conceptual usefulness.

Inclusion criteria:

- Original studies, analytical reports, or theoretically relevant investigations addressing arboviruses, especially dengue, Zika, or chikungunya.
- Studies examining associations between arbovirus transmission and at least one of the following dimensions: urbanization, sanitation, water storage, heat islands, climatic variability, socio-environmental vulnerability, or vector ecology.
- Studies focused on Brazil, the semiarid region, or contexts analytically comparable to medium-sized semiarid cities.
- Publications available in full text.
- Articles published within the temporal window defined for the review, corresponding to the period considered sufficient to capture recent transformations in semiarid urbanization and arbovirus dynamics.
- Studies written in English, Portuguese, or Spanish.

Exclusion criteria:

- Editorials, opinion essays, conference abstracts, dissertations, theses, technical notes without analytical development, and purely descriptive reports lacking relevance to the guiding question.
- Studies focused exclusively on laboratory procedures, molecular characterization, or clinical management without connection to urban, environmental, or epidemiological determinants.
- Publications centered on large metropolitan areas or rural settings when no transferable analytical contribution to medium-sized semiarid cities could be identified.
- Articles without full-text availability after database and institutional access attempts.
- Studies with insufficient methodological information to support critical appraisal.

The screening process was conducted in successive stages. First, titles and abstracts were examined to identify direct or indirect alignment with the review question. Second, potentially eligible studies were read in full. At this stage, decisions were based not only on topical mention of arboviruses or urbanization, but on the effective analytical contribution of each study to the understanding of transmission dynamics in semiarid or related urban contexts. This procedure was essential to prevent mechanical inclusion of merely adjacent literature and to preserve the explanatory density of the final corpus.

Methodological quality was then appraised through a JBI-based critical assessment approach, adapted to the heterogeneity of the selected studies. Given the inclusion of observational, ecological, epidemiological, and interdisciplinary designs, the appraisal process did not operate as a rigid exclusion mechanism after full-text selection. Instead, it was used to classify the robustness, consistency, and interpretive reliability of each study.

Particular attention was given to clarity of objectives, adequacy of study design, transparency of methods, coherence between data and conclusions, and relevance of the findings to the review question. Studies with greater methodological consistency received stronger analytical weight in the synthesis, while studies with limitations were

retained only when they offered contextual, theoretical, or territorial contributions that were not otherwise represented in the corpus.

2.5 Data extraction and thematic synthesis

Data extraction was carried out through a structured analytical matrix developed specifically for this review. For each included study, the following information was recorded: authorship, year of publication, study location, territorial scale, study design, main objective, central variables, principal findings, and direct contribution to the understanding of arbovirus transmission in semiarid urban systems. Additional notes were included regarding climatic factors, thermal dynamics, water storage practices, sanitation deficits, vector ecology, and urban expansion patterns whenever these dimensions were addressed in the study.

The extraction process was not restricted to cataloguing descriptive information. It was designed to support interpretive comparison across studies and to identify recurrent mechanisms, convergences, tensions, and explanatory absences. Based on this process, the evidence was organized into thematic axes that corresponded to the conceptual architecture of the article.

These axes included: urban production and spatial fragmentation in the semiarid; the water storage paradox and domestic breeding sites; urban heat islands and acceleration of viral cycles; climate variability and extreme events; vector ecology and viral amplification under conditions of environmental stress; and policy, governance, and socio-environmental vulnerability. Thematic synthesis was therefore conducted as a cumulative and interpretive procedure, connecting dispersed evidence into a coherent analytical framework.

This stage also supported the formulation of the article's central theoretical contribution. Rather than presenting the findings as isolated determinants, the synthesis sought to identify how infrastructural precariousness, thermal heterogeneity, adaptive household practices, and ecological plasticity of the vector interact within medium-sized semiarid cities. The final interpretive movement consisted of integrating these thematic axes into a systemic explanatory model capable of expressing the feedback loops that sustain arbovirus transmission in these environments.

Table 1 synthesizes the main characteristics of the studies included in the integrative review, highlighting their geographical scope, methodological approaches, analytical focus, and principal findings. The table was constructed to provide a structured overview of the heterogeneous evidence base, allowing for the identification of recurring patterns and methodological diversity across epidemiological, environmental, urban, and entomological investigations. By organizing the studies according to key analytical dimensions, the table supports the interpretive synthesis developed in subsequent sections.

Table 1. Characteristics of Included Studies (Year, Location, Study Design, Key Findings)

Author (Year)	Location	Study Design	Main Focus	Key Findings
Almeida et al. (2022)	Brazil (national)	Epidemiological modeling	Transmission heterogeneity	Strong spatial variability in dengue transmission across regions
Almeida et al. (2020)	Brazil (urban)	Analytical review	Sanitation and arboviruses	Poor sanitation increases vector breeding and disease risk
Araújo et al. (2019)	Northeast Brazil	Ecological study	Meteorological variables	Temperature and rainfall influence vector dynamics
Barakat & Caprara (2021)	Brazil	Conceptual/ field-based	Eco-biosocial approach	Integrated interventions improve vector control outcomes
Brasileiro & Zanella (2021)	Sobral (CE)	Urban climate study	Heat islands	Urban heat intensifies local temperatures significantly
Carvalho et al. (2019)	Pau dos Ferros (RN)	Urban analysis	Urban expansion	Disordered growth linked to infrastructural deficits
Campos et al. (2022)	Brazil	Laboratory/experimental	Vector competence	Genetic and biological variability affects virus susceptibility
Dutra et al. (2024)	Brazil	Experimental study	Larval crowding	Increased larval density enhances viral load in mosquitoes
Ferreira et al. (2022)	Medium-sized city (Brazil)	Epidemiological study	Risk factors	Socio-environmental vulnerability linked to dengue incidence
Fernandes et al. (2020)	Brazil	Review	Vector competence	Environmental and biological factors shape transmission
Gurgel-Gonçalves et al. (2024)	Brazil	Epidemiological analysis	Dengue epidemic	Recent outbreaks show complex transmission patterns
Lobkowicz et al. (2022)	Pernambuco	Surveillance study	Co-circulation	Multiple arboviruses circulate simultaneously
Martins & Alencar (2022)	Brazil	One Health approach	Ecoepidemiology	Integrated systems explain disease dynamics
Moura et al. (2020)	Northeast Brazil	Spatial analysis	Oviposition patterns	Spatial clustering of vector breeding sites
Ogasawara et al. (2019)	Global/Brazil	Environmental modeling	Environmental drivers	Climate variables strongly influence dengue patterns
Pirani et al. (2024)	Brazil	Climate-epidemiological	ENSO influence	Climate oscillations affect vector infestation

Rodrigues et al. (2023)	Urban Brazil	Field study	Breeding sites	Artificial containers dominate larval habitats
Souza et al. (2023)	Vulnerable urban area	Epidemiological	Vector density	High density in socioeconomically vulnerable settings
Su et al. (2025)	Brazil	Epidemiological modeling	Night temperatures	Hot nights increase dengue transmission risk
Trevisan (2021)	Brazil	Urban theory	City formation	Urban planning failures shape spatial inequalities

Source: Own authorship.

The distribution of studies reveals a predominance of ecological, epidemiological, and analytical designs, reflecting the multifactorial nature of arbovirus transmission in semiarid urban contexts. A consistent pattern emerges linking infrastructural deficits, particularly inadequate sanitation and water storage practices, to increased vector proliferation and disease risk. Simultaneously, environmental studies emphasize the role of temperature, urban heat islands, and climate variability as amplifiers of transmission dynamics. Experimental and biological studies complement this perspective by demonstrating how vector competence and larval conditions influence viral load and transmission efficiency.

Importantly, the table also exposes a fragmentation in the literature. While some studies focus on climatic drivers and others on urban or social determinants, few integrate these dimensions into a unified analytical framework. This fragmentation reinforces the need for a systemic approach capable of articulating urbanization processes, environmental conditions, and vector biology. The integrative synthesis proposed in this article directly responds to this gap by connecting these domains into a coherent explanatory model tailored to the semiarid urban reality.

3. RESULTS AND THEMATIC SYNTHESIS

3.1. Urban production and spatial fragmentation in the semiarid

The selected studies consistently indicate that urbanization in the Brazilian semiarid is marked by accelerated horizontal expansion combined with structural infrastructural deficits. This pattern produces fragmented urban fabrics in which peripheral areas expand faster than the capacity of public services to provide sanitation, water supply, and environmental regulation. Empirical evidence from medium-sized cities shows that urban growth has been guided more by land availability and speculative processes than by integrated planning, resulting in discontinuous urban patches with limited infrastructure (Carvalho et al., 2019).

This dynamic is not merely morphological but directly affects epidemiological conditions. Peripheral expansion creates zones of environmental vulnerability characterized by irregular water supply, absence of sewage systems, and accumulation of waste, all of which contribute to the proliferation of Aedes aegypti. As noted by

Carvalho et al. (2019, p. 412), "urban production in the semiarid occurs in a fragmented manner, intensifying socio-spatial inequalities," a condition that reinforces heterogeneous exposure to arboviral risk.

From a broader theoretical perspective, urbanization in such contexts reflects a structural disjunction between urban growth and governance capacity. Trevisan (2021) argues that Brazilian urbanization processes have historically produced "cities without integration between planning and social needs" (p. 87), a condition that becomes more pronounced in interior regions undergoing rapid expansion. This lack of coordination contributes to the emergence of spatial discontinuities that function as epidemiological corridors rather than barriers.

Recent analyses further emphasize that medium-sized cities in the semiarid have become regional hubs of demographic and economic attraction, intensifying urban sprawl without corresponding infrastructural investments (Nascimento; Macedo, 2025). This combination of expansion and precarity produces a spatial configuration that sustains vector habitats and facilitates the circulation of arboviruses across urban and peri-urban interfaces.

3.2. The water storage paradox and domestic breeding sites

A central finding across the reviewed studies is the structural role of water insecurity in shaping arbovirus transmission. In semiarid cities, irregular water supply leads households to adopt storage practices that unintentionally create persistent breeding sites for Aedes aegypti. Unlike humid environments, where rainfall provides natural breeding opportunities, vector proliferation in these contexts is largely driven by anthropogenic water accumulation.

Evidence indicates that domestic containers, including tanks, barrels, and improvised reservoirs, constitute the primary larval habitats in urban settings. Rodrigues et al. (2023, p. 5) report that "artificial containers represent the dominant breeding sites in urban environments," confirming the shift from natural to human-mediated ecological niches. This pattern is reinforced in socioeconomically vulnerable areas, where limited access to continuous water supply increases reliance on storage practices.

The relationship between sanitation and arbovirus transmission further intensifies this dynamic. Almeida et al. (2020) demonstrate that inadequate sanitation systems and inefficient waste management contribute to the persistence of breeding sites, particularly in densely populated neighborhoods. As highlighted in their analysis, "environmental determinants such as water storage and sanitation directly impact urban health outcomes" (Almeida et al., 2020, p. 3125).

Quantitative evidence also supports this association. Studies conducted in vulnerable communities indicate significantly higher vector densities in areas with precarious infrastructure, suggesting that socio-environmental inequality is a key determinant of arbovirus risk (Souza et al., 2023). In these contexts, the absence of reliable public services transforms households into micro-environments that sustain vector reproduction independently of seasonal rainfall patterns.

3.3. Urban heat islands and acceleration of viral cycles

Thermal dynamics emerge as a critical factor in the modulation of arbovirus transmission in semiarid cities. The presence of urban heat islands significantly alters local temperature regimes, creating microclimates that accelerate both vector development and viral replication. Studies conducted in northeastern Brazil demonstrate that urbanized areas can exhibit temperature increases of several degrees compared to surrounding rural zones, intensifying thermal stress within the urban environment (Brasileiro; Zanella, 2021).

This thermal amplification has direct implications for the epidemiological cycle of arboviruses. Elevated temperatures reduce the extrinsic incubation period of viruses within the mosquito, allowing vectors to become infectious more rapidly. Su et al. (2025) provide quantitative evidence that higher nocturnal temperatures are associated with increased dengue incidence, indicating that "hot nights significantly enhance transmission potential" (p. 7). This finding is particularly relevant in semiarid regions, where nighttime temperatures remain elevated due to heat retention in built surfaces.

Meteorological analyses further confirm that temperature plays a more consistent role than precipitation in shaping vector dynamics in these environments. Araújo et al. (2019) demonstrate that temperature variability is strongly associated with fluctuations in Aedes aegypti populations, even in conditions of low rainfall. These results challenge traditional assumptions and suggest that thermal conditions, rather than water availability alone, are central to understanding transmission in semiarid urban systems.

3.4. Climate variability and extreme events in semiarid environments

Climate variability introduces an additional layer of complexity to arbovirus dynamics in the semiarid. Large-scale climatic phenomena, such as the El Niño–Southern Oscillation (ENSO), influence temperature patterns, precipitation regimes, and environmental stability, thereby affecting vector ecology. Pirani et al. (2024) demonstrate that ENSO phases are associated with significant variations in Aedes aegypti infestation rates, indicating that global climatic oscillations have localized epidemiological consequences.

At the same time, rainfall in semiarid regions is characterized by irregularity and intensity rather than continuity. Episodic rain events can trigger rapid hatching of dormant eggs, leading to sudden increases in vector populations. Ogasawara et al. (2019) emphasize that "environmental variability plays a crucial role in dengue dynamics" (p. 3), highlighting the importance of understanding non-linear climate effects.

These dynamics are further complicated by socio-environmental conditions. Morgan et al. (2021) argue that climatic factors interact with socioeconomic and infrastructural variables, producing heterogeneous transmission patterns that cannot be explained by climate alone. In semiarid cities, this interaction results in a system where climatic extremes and urban vulnerabilities converge, amplifying epidemiological risk.

3.5. Vector ecology and viral amplification under stress conditions

The biological dimension of arbovirus transmission reveals mechanisms that reinforce the effects of

environmental and urban factors. Experimental studies indicate that conditions commonly found in semiarid urban settings, such as high temperatures and limited water availability, can alter vector biology in ways that enhance transmission.

Larval crowding, often observed in small and densely populated breeding sites, has been shown to increase viral load in adult mosquitoes. Dutra et al. (2024, p. 6) report that "larval crowding leads to higher viral titers," suggesting that environmental stress during development can intensify vector competence. This finding indicates that not only the presence of breeding sites, but also their density and quality, influence transmission dynamics.

Genetic and physiological variability among mosquito populations further contributes to this process. Campos et al. (2022) demonstrate that different Aedes aegypti populations exhibit varying susceptibility to viral infection, indicating that vector competence is not uniform across regions. This variability interacts with local environmental conditions, producing context-specific transmission patterns.

Spatial analyses of oviposition also reveal clustering of breeding sites in urban environments. Moura et al. (2020) identify significant spatial concentration of egg-laying activity in areas with favorable micro-environmental conditions, reinforcing the role of urban heterogeneity in shaping vector distribution. These findings collectively indicate that arbovirus transmission in semiarid cities is driven by a convergence of ecological plasticity, environmental stress, and socio-spatial organization.

Table 2 systematizes the main drivers identified in the integrative review, organizing them into four interconnected dimensions: urban, environmental, socio-environmental, and biological. The table highlights not only the presence of individual factors but also their mechanisms of action and direct epidemiological implications. This structure allows for a clearer visualization of how different domains converge to shape arbovirus transmission dynamics in semiarid cities, reinforcing the multidimensional nature of the phenomenon.

Table 2. Factors of Arbovirus Transmission in Semi-Arid Cities

Driver Category	Specific Factor	Mechanism of Action	Epidemiological Effect	Supporting Evidence
Urban	Horizontal expansion	Fragmented urban growth with limited infrastructure	Increased exposure in peripheral areas	Carvalho et al. (2019); Nascimento; Macedo (2025)
Urban	Inadequate sanitation	Accumulation of waste and water reservoirs	Proliferation of breeding sites	Almeida et al. (2020); Rodrigues et al. (2023)
Environmental	Urban heat islands	Elevated surface and nocturnal temperatures	Reduced viral incubation period	Brasileiro; Zanella (2021); Su et al. (2025)
Environmental	Climate variability (ENSO)	Irregular rainfall and temperature fluctuations	Episodic increases in vector density	Pirani et al. (2024); Ogasawara et al. (2019)

Environmental	High temperature regimes	Acceleration of mosquito life cycle	Increased transmission efficiency	Araújo et al. (2019)
Socio-environmental	Domestic water storage	Artificial and persistent breeding habitats	Sustained vector presence independent of rainfall	Almeida et al. (2020); Souza et al. (2023)
Biological	Larval crowding	Competition and stress during development	Increased viral load in adult mosquitoes	Dutra et al. (2024)
Biological	Vector competence variability	Genetic and physiological differences	Heterogeneous transmission capacity	Campos et al. (2022); Fernandes et al. (2020)
Spatial	Oviposition clustering	Concentration of breeding sites in specific areas	Localized transmission hotspots	Moura et al. (2020)

Source: Own authorship.

The data presented reveal that arbovirus transmission in semiarid urban systems cannot be attributed to isolated determinants. Instead, it emerges from the interaction of structural urban conditions, climatic variability, and vector biology. Urban drivers, particularly horizontal expansion and infrastructural deficits, establish the spatial foundation of vulnerability by producing environments where water insecurity and sanitation failures are normalized (Carvalho et al., 2019; Nascimento; Macedo, 2025). These conditions are not passive; they actively generate breeding habitats and sustain vector populations (Almeida et al., 2020; Rodrigues et al., 2023).

Environmental drivers intensify this baseline vulnerability. Elevated temperatures and heat islands accelerate viral replication and vector development, while climate variability introduces episodic surges in vector density (Brasileiro; Zanella, 2021; Su et al., 2025; Pirani et al., 2024). Importantly, these environmental processes do not operate independently but amplify the effects of urban precariousness. For instance, irregular rainfall only becomes epidemiologically relevant when coupled with widespread artificial containers that allow rapid vector proliferation (Ogasawara et al., 2019; Araújo et al., 2019).

Biological factors complete this system by modulating transmission efficiency. Larval crowding and variability in vector competence demonstrate that the mosquito is not a static component but a responsive agent shaped by environmental stressors (Dutra et al., 2024; Campos et al., 2022). Spatial clustering of oviposition further indicates that transmission risk is unevenly distributed within cities, reinforcing the importance of micro-scale analysis (Moura et al., 2020).

Taken together, the table supports a systemic interpretation in which arbovirus transmission is produced by feedback loops between infrastructure, climate, and vector ecology. This reinforces the inadequacy of single-factor explanations and underscores the need for integrated analytical frameworks capable of capturing the complexity of semiarid urban environments (Martins; Alencar, 2022; Barakat; Caprara, 2021).

4. DISCUSSION

4.1. Integrating urbanization, climate, and vector biology

The findings of this review indicate that arbovirus transmission in semiarid cities must be interpreted through a systemic lens that integrates urbanization processes, climatic dynamics, and vector biology. Isolated analyses of any of these dimensions fail to explain the persistence and expansion of transmission observed in medium-sized cities. Instead, the evidence points to a coupled system in which infrastructural deficits, thermal variability, and ecological plasticity of Aedes aegypti reinforce one another.

From an ecoepidemiological perspective, this interaction reflects what has been described as the co-production of disease by environmental and social determinants. Martins and Alencar (2022, p. 4) emphasize that "dengue transmission emerges from the interaction between ecological and social systems," reinforcing the need to move beyond reductionist approaches. Similarly, Barakat and Caprara (2021) argue that effective control strategies require an "ecobiosocial approach," in which biological, environmental, and social variables are treated as interdependent components rather than separate domains.

In the semiarid context, this integration becomes even more critical. Lima-Camara (2024, p. 2) explicitly states that "dengue is a product of the environment," a formulation that, when interpreted in light of the present findings, must be expanded to include the built environment and human adaptive practices. The data analyzed here demonstrate that urban heat islands, precarious infrastructure, and domestic water storage practices do not act independently; they form a network of reinforcing mechanisms that stabilize vector populations and sustain viral circulation even under climatic constraints traditionally considered unfavorable.

4.2. The Semiarid Urban Arbovirus Amplification System (conceptual model)

Based on the integrative synthesis, this study proposes the Semiarid Urban Arbovirus Amplification System (SUAAS) as a conceptual model to explain the persistence and intensification of arbovirus transmission in medium-sized semiarid cities. The model is structured around three interdependent axes: the built environment, climatic conditions, and human behavior.

The built environment encompasses horizontal urban expansion, spatial fragmentation, and infrastructural deficits, which generate heterogeneous landscapes marked by uneven access to sanitation and water services. These conditions produce localized ecological niches that favor vector proliferation. Almeida et al. (2022) demonstrate that dengue transmission in Brazil is highly heterogeneous, indicating that "local conditions significantly shape transmission profiles," a finding consistent with the spatial variability observed in semiarid cities.

Climatic conditions, particularly elevated temperatures and variability in rainfall patterns, modulate vector development and viral replication. As discussed previously, temperature exerts a strong influence on the extrinsic incubation period, while episodic rainfall events trigger rapid increases in vector density. Morgan et al. (2021)

highlight that climatic and socioeconomic factors interact to produce complex transmission patterns, reinforcing the need for integrated models.

Human behavior, especially adaptive responses to water scarcity, completes the system. The widespread use of domestic water storage creates persistent breeding sites that decouple vector reproduction from natural rainfall cycles. This process transforms households into active components of the transmission system. Fernandes et al. (2020) note that vector competence and transmission dynamics are influenced by environmental conditions, suggesting that anthropogenic environments play a decisive role in shaping epidemiological outcomes.

The SUAAS framework therefore conceptualizes arbovirus transmission as a feedback system in which urban form, climate, and human practices continuously interact. Rather than a linear chain of causation, the model proposes a circular dynamic in which each component amplifies the others, generating stable conditions for transmission even in semiarid environments.

4.3. Public policy gaps and urban governance failures

The persistence of arbovirus transmission in semiarid cities also reflects significant gaps in urban governance and public policy. The reviewed studies indicate that current planning instruments and health interventions often fail to address the structural determinants of transmission, focusing instead on reactive and fragmented control measures.

One critical issue is the limited integration between urban planning and public health strategies. Macêdo and Bispo Júnior (2024) highlight that the performance of field agents in arbovirus control is frequently constrained by broader structural conditions, noting that "vector control actions are insufficient when not accompanied by structural urban improvements" (p. 9). This suggests that technical interventions alone cannot compensate for systemic infrastructural deficiencies.

Sanitation remains a central challenge. Almeida et al. (2020) demonstrate that inadequate sanitation is directly associated with increased arbovirus risk, particularly in densely populated urban areas. At the same time, urban expansion processes often occur without the parallel development of essential services. Carvalho et al. (2019) describe how semiarid urbanization is marked by "fragmented production of space," resulting in territories where basic infrastructure is absent or incomplete.

These governance failures produce a structural mismatch between urban growth and service provision, creating environments that facilitate vector proliferation. The absence of integrated policies that simultaneously address housing, sanitation, water supply, and environmental management limits the effectiveness of traditional control strategies and perpetuates the conditions that sustain transmission.

4.4. One Health perspective and global implications

The complexity of arbovirus transmission in semiarid cities underscores the relevance of a One Health perspective, which recognizes the interdependence between human health, environmental conditions, and socio-

economic processes. The findings of this review align with this perspective by demonstrating that transmission dynamics are shaped by the interaction between ecological systems and human-modified environments.

Martins and Alencar (2022) argue that ecoepidemiological approaches are essential for understanding diseases such as dengue, as they incorporate multiple levels of analysis. This perspective is further supported by studies on sustainability and environmental management in the semiarid, which emphasize the need to consider natural resource dynamics in conjunction with human activities (Silva et al., 2024; Medeiros Neto et al., 2024). These works highlight that environmental degradation, water scarcity, and urban expansion are interconnected processes that have direct implications for public health.

From a global standpoint, semiarid cities can be interpreted as emerging laboratories for the study of arbovirus transmission under conditions of increasing climatic stress. Rising global temperatures and expanding arid zones suggest that the dynamics observed in the Brazilian semiarid may become more common in other regions. In this sense, understanding the interactions identified in this review is not only relevant for local policy but also for anticipating future epidemiological scenarios in a warming world.

The evidence presented here challenges the adequacy of conventional models and reinforces the need for integrated frameworks capable of capturing the complexity of urban, climatic, and biological interactions. By situating arbovirus transmission within a broader socio-ecological system, this study contributes to a more comprehensive and forward-looking understanding of emerging infectious diseases.

Table 3 presents the conceptual structure of the Semiarid Urban Arbovirus Amplification System (SUAAS), synthesizing the multidimensional interactions identified throughout the integrative review. The model is organized into five interconnected components that reflect the core domains influencing arbovirus transmission: built environment, climate system, human behavior, vector ecology, and governance. Each component is described in terms of its key elements, mechanisms of interaction, feedback processes, and epidemiological consequences, allowing for a systematic visualization of how these factors converge within semiarid urban contexts.

Table 3. Conceptual Model: Semiarid Urban Arbovirus Amplification System (SUAAS)

System Component	Key Elements	Interaction Mechanism	Feedback Loop	Epidemiological Outcome
Built Environment	Horizontal expansion; infrastructural deficits; spatial fragmentation	Creation of heterogeneous urban niches with limited sanitation and water services	Reinforces water storage practices and localized vector habitats	Persistent and spatially uneven transmission
Climate System	High temperatures; urban heat islands; rainfall variability	Acceleration of vector development and viral replication; episodic vector emergence	Intensifies effects of urban precarity and environmental stress	Increased transmission efficiency and outbreak intensity

Human Behavior	Domestic water storage; adaptive practices; informal infrastructure	Artificial breeding site creation independent of rainfall cycles	Sustains vector populations during dry periods	Continuous transmission in low-humidity conditions
Vector Ecology	Larval crowding; vector competence variability; oviposition clustering	Biological adaptation to environmental stress and urban conditions	Enhances viral load and transmission capacity	Amplified infection rates and localized hotspots
Governance and Policy	Weak urban planning; insufficient sanitation policies; fragmented interventions	Failure to address structural determinants of transmission	Perpetuates environmental and infrastructural vulnerabilities	Long-term persistence of arbovirus risk

Source: Own authorship.

The model demonstrates that arbovirus transmission in semiarid cities operates as a dynamic and self-reinforcing system rather than a linear causal chain. The built environment establishes the structural conditions of vulnerability, particularly through fragmented urban expansion and insufficient infrastructure, which create spatial heterogeneity and uneven exposure to risk (Carvalho et al., 2019; Trevisan, 2021). These structural conditions directly influence human behavior, especially adaptive water storage practices, which in turn generate artificial breeding sites and sustain vector populations independently of natural hydrological cycles (Almeida et al., 2020).

Climatic factors do not act as primary triggers but as amplifiers of this system. Elevated temperatures and urban heat islands intensify biological processes within the vector, accelerating viral replication and reducing incubation periods (Brasileiro; Zanella, 2021; Su et al., 2025). At the same time, climate variability introduces episodic fluctuations that interact with pre-existing urban vulnerabilities, rather than determining transmission in isolation (Pirani et al., 2024; Ogasawara et al., 2019).

The inclusion of vector ecology as a distinct component highlights that biological responses are shaped by environmental and urban stressors. Larval crowding and variability in vector competence demonstrate that mosquito populations adapt to these conditions, increasing transmission efficiency under constrained environments (Dutra et al., 2024; Campos et al., 2022). Spatial clustering of oviposition further reinforces the localized nature of risk, producing micro-territories of high transmission intensity (Moura et al., 2020).

Finally, the governance dimension reveals that the persistence of this system is not accidental but structurally maintained. The absence of integrated urban and health policies allows feedback loops between infrastructure, climate, and behavior to remain unbroken. As a result, the system becomes self-sustaining, with each component reinforcing the others over time. This systemic interpretation challenges traditional models that isolate climatic or biological factors and underscores the need for integrated interventions capable of disrupting multiple components simultaneously.

5 CONCLUSION

This study demonstrates that arbovirus transmission in medium-sized cities of the Brazilian semiarid cannot be adequately explained by traditional climate-centered models. Instead, it emerges from a complex and interdependent system in which dysfunctional urbanization, thermal heterogeneity, and adaptive human practices converge to sustain vector proliferation and viral circulation. The evidence reinforces the existence of a semiarid epidemiological paradox, where water scarcity does not limit transmission but, through unsafe storage and infrastructural deficits, actively contributes to it.

By articulating environmental, urban, and biological dimensions within a unified framework, this study advances a systemic interpretation of arbovirus dynamics and highlights the central role of the built environment in shaping epidemiological outcomes. This perspective challenges fragmented approaches and calls for a reorientation of research agendas toward integrative, context-sensitive models capable of capturing the realities of rapidly transforming urban territories.

The implications extend beyond academic debate. Urban planning, sanitation policies, and public health strategies must move toward coordinated and preventive actions that address structural determinants rather than isolated symptoms. In the context of global climate change, semiarid cities may represent early expressions of future epidemiological landscapes, where heat intensification and water insecurity become increasingly common. Understanding these dynamics today is essential for anticipating and mitigating the risks of tomorrow.

REFERENCES

Almeida, I. F., Lana, R. M., & Codeço, C. T. (2022). How heterogeneous is the dengue transmission profile in Brazil? *PLoS Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0010746

Almeida, L. S. S., Cota, A. L. S., & Rodrigues, D. F. (2020). Saneamento, arboviroses e determinantes ambientais: impactos na saúde urbana. *Ciência & Saúde Coletiva*. https://doi.org/10.1590/1413-812320202510.30712018

Araújo, R. A. F., Uchôa, N. M., & Alves, J. M. B. (2019). Influência de variáveis meteorológicas na prevalência de doenças transmitidas por *Aedes aegypti*. *Revista Brasileira de Meteorologia*. https://doi.org/10.1590/0102-7786343054

Barakat, R. D. M., & Caprara, A. (2021). Abordagem ecobiossocial no controle do *Aedes aegypti*. *Interface (Botucatu)*. https://doi.org/10.1590/interface.190805

Brasileiro, F. M. G., & Zanella, M. E. (2021). Ilhas de calor urbanas em Sobral (CE). *Geopauta*. https://doi.org/10.22481/rg.v5i4.e2021.e9499

Carvalho, C. C. A., et al. (2019). Produção urbana no semiárido brasileiro: Pau dos Ferros (RN). *Interações*. https://doi.org/10.20435/inter.v20i3.1855

Campos, K. B., et al. (2022). Resistência de *Aedes aegypti* e suscetibilidade ao Zika vírus. *Viruses*. https://doi.org/10.3390/v14102198

Dutra, H. L., et al. (2024). Larval crowding e aumento da carga viral em *Aedes aegypti*. *PLoS Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0012482

Ferreira, D. T. O., et al. (2022). Fatores de risco para dengue em cidade média. *São Paulo Medical Journal*. https://doi.org/10.1590/1516-3180.2020.0718.R1.18052021

Fernandes, R. S., et al. (2020). Competência vetorial de mosquitos no Brasil. *Pathogens*. https://doi.org/10.3390/pathogens9070575

Gurgel-Gonçalves, R., Oliveira, W. K., & Croda, J. (2024). The greatest dengue epidemic in Brazil. *Revista da Sociedade Brasileira de Medicina Tropical*. https://doi.org/10.1590/0037-8682-0113-2024

Lima-Camara, T. N. (2024). A dengue é produto do meio. *Revista Brasileira de Epidemiologia*. https://doi.org/10.1590/1980-549720240048.2

Lobkowicz, L., et al. (2022). Co-circulação de arbovírus em Pernambuco. *American Journal of Tropical Medicine and Hygiene*. https://doi.org/10.4269/ajtmh.21-0449

Macêdo, T. F. C., & Bispo Júnior, J. P. (2024). Atuação de agentes no controle de arboviroses. *Physis*. https://doi.org/10.1590/S0103-7331202434099

Martins, A. B. S., & Alencar, C. H. (2022). Ecoepidemiologia da dengue no Brasil. *One Health & Implementation Research*. https://doi.org/10.20517/ohir.2021.10

Medeiros Neto, P. N., et al. (2024). *Ciências florestais no Semiárido brasileiro*. EDUFCG. https://doi.org/10.35572/9788580013146

Mendes, K. D. S., Silveira, R. C. C. P., & Galvão, C. M. (2008). Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem. *Texto & Contexto - Enfermagem*, 17(4), 758–764. https://doi.org/10.1590/S0104-07072008000400018

Morgan, J., Strode, C., & Salcedo-Sora, J. E. (2021). Fatores climáticos e socioeconômicos na transmissão de arboviroses. *PLoS Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0009259

Moura, M. C. B., et al. (2020). Dinâmica espacial de oviposição de *Aedes aegypti* no Nordeste. *Tropical Medicine & International Health*. https://doi.org/10.1111/tmi.13491

Nascimento, C. E. P., & Macedo, F. C. (2025). Dinâmica urbano-regional do Semiárido. *Revista de Economia Regional*. https://doi.org/10.21680/2316-5235.2025v14n1ID40708

Ogashawara, I., Li, L., & Moreno-Madriñán, M. J. (2019). Fatores ambientais e dengue. *GeoHealth*. https://doi.org/10.1029/2019GH000186

Pirani, M., et al. (2024). ENSO e infestação de *Aedes aegypti*. *PLoS Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0012397

Ramesh, A., et al. (2019). Vigilância de arbovírus em mosquitos no Recife. *Wellcome Open Research*. https://doi.org/10.12688/wellcomeopenres.15295.1

Rodrigues, G. O., et al. (2023). Criadouros potenciais de *Aedes* em área urbana. *Brazilian Journal of Biology*. https://doi.org/10.1590/1519-6984.275582

Silva, V. F., et al. (2024). *Recursos naturais e sustentabilidade no Semiárido*. EDUFCG. https://doi.org/10.35572/9788580013139

Souza, M. T., Silva, M. D., & Carvalho, R. (2010). Revisão integrativa: o que é e como fazer. *Einstein (São Paulo)*, 8(1), 102–106. https://doi.org/10.1590/s1679-45082010rw1134

Souza, R. L., et al. (2023). Densidade de *Aedes aegypti* em comunidade urbana vulnerável. *Parasites & Vectors*. https://doi.org/10.1186/s13071-023-05766-5

Su, M., et al. (2025). Hot nights e aumento da dengue no Brasil. *Infectious Diseases of Poverty*. https://doi.org/10.1186/s40249-025-01326-4

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review*, 4(3), 356–367. https://doi.org/10.1177/1534484305278283

Trevisan, R. (2021). *Cidades novas*. Editora Universidade de Brasília. https://books.scielo.org/id/dp3cj