



## Determinants of Dengue Transmission in Pakistan: A Meta-Synthesis of Environmental, Social, and Institutional Factors

Ishtiaq Hussain<sup>1</sup> & Nisha Irfan<sup>2</sup>

### Abstract

Dengue fever has emerged as a major public health threat in Pakistan over the past decade, driven by a convergence of environmental, socio-economic, and institutional vulnerabilities. Despite substantial primary research on individual determinants, there remains a lack of integrated analysis that consolidates cross-disciplinary findings. This study aims to synthesize evidence from 32 empirical studies conducted in Pakistan between 2015 and 2024 to identify and analyze key factors associated with dengue transmission. The objective is to map thematic convergence across disciplines and propose a holistic framework to inform sustainable epidemic response strategies. A systematic review and thematic meta-synthesis were conducted, following STROBE quality criteria. Studies included cross-sectional surveys, retrospective case analyses, GIS-based spatial studies, and behavioral assessments. Thematic coding was applied using a grounded theory approach to identify recurrent determinants and conceptual linkages. Four dominant thematic clusters emerged: (1) climatic variability and urban ecology, (2) socio-economic disparities and risk exposure, (3) gendered patterns in prevention and treatment access, and (4) limitations in institutional preparedness and inter-sectoral coordination. These factors interacted with the shape of the scale, timing, and geographic intensity of outbreaks. Dengue transmission in Pakistan is shaped by a complex interplay of climatic, social, and institutional factors. This meta-synthesis highlights the need for integrated, anticipatory, and locally adaptive responses grounded in interdisciplinary evidence. Policy responses must move beyond episodic containment toward structural investments in climate resilience, equity in health access, and public health system capacity.

### Article History

Received 13 July 2025  
Revised 18 July 2025  
Accepted 21 July 2025  
Published 23 July 2025

### OPEN ACCESS

### Keywords

Socio-economic; Cultural; Psychological; Child Malnutrition; Mental Growth Dengue Fever; Socio-ecological Determinants; Climate Change; Vector Control; Epidemic Preparedness; Meta-synthesis

### Introduction

Dengue fever has become a pressing public health concern in Pakistan over the past two decades, with a significant increase in frequency, severity, and geographic spread of outbreaks. The endemic nature of dengue in major urban centers, such as Lahore, Karachi, and Rawalpindi, underscores the systemic vulnerabilities in Pakistan's public health and urban infrastructure systems. Studies across epidemiological, environmental, and social sciences have shown that climatic changes, inadequate sanitation, high population densities, and poor vector control practices converge to create fertile conditions for dengue outbreaks. Furthermore, institutional responses to outbreaks have been primarily reactive, driven by crisis management rather than proactive surveillance or preparedness strategies (Akhtar & Abbas, 2020; Imran et al., 2021).

Despite the growing body of literature, significant knowledge gaps remain in how various social, environmental, and institutional factors interact to influence dengue transmission. Existing

<sup>1</sup>The author is a Postgraduate Researcher at Faculty of Science, Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, United Kingdom (UK). He is corresponding author and can be reached at Gmail: ishtiaq.hussain@strath.ac.uk

<sup>2</sup>The author is a graduate researcher and student, School of Sociology, Quaid I Azam University Islamabad, Pakistan. She can be reached at Gmail: nishairfan026@gmail.com

studies often focus on isolated determinants, such as rainfall or housing conditions, without accounting for their interdependencies. Moreover, while gender has emerged as a critical lens in understanding differential exposure and access to treatment, few studies systematically incorporate gender-disaggregated data into epidemic modeling or policy recommendations. Similarly, although spatial models have advanced our understanding of regional transmission patterns, these insights remain underutilized in policy implementation due to weak intersectoral coordination. These limitations hinder the development of an integrated framework necessary for effective public health response and long-term planning. (Khan et al., 2022; Hanif & Mehmood, 2019).

This study aims to address these gaps by synthesizing findings from 32 empirical studies conducted in Pakistan between 2015 and 2024. Through a structured meta-synthesis approach, this research analyzes the convergence of environmental, socio-economic, and institutional factors that shape dengue epidemiology in Pakistan. By identifying thematic patterns and causal linkages across disciplines, the paper contributes to a comprehensive understanding of dengue determinants and offers evidence-informed recommendations for integrated and resilient epidemic response strategies.

## **Research Methods**

This study employs a meta-synthesis design to systematically consolidate and interpret empirical findings from 32 peer-reviewed studies focused on the determinants of dengue transmission in Pakistan, published between 2015 and 2024. The methodology was developed using the PICOS framework (Population, Intervention, Comparator, Outcome, Study design), complemented by rigorous data extraction and quality appraisal protocols (Amir-Behghadami & Janati, 2020).

## **Population**

The included studies cover a diverse range of populations residing in dengue-endemic urban and peri-urban regions across Pakistan. These populations include adult males and females, children, and elderly citizens from both high-income neighborhoods and informal settlements, reflecting the socioeconomic heterogeneity of Pakistan's urban demographics.

## **Intervention/Exposure**

All selected studies investigate environmental, social, behavioral, or institutional exposures associated with dengue transmission. This includes meteorological variables (temperature, humidity, precipitation), population density, waste management, gender-based exposure risks, community practices, and public health intervention programs. While no direct control groups were used across studies, comparative analysis was enabled by contrasting outbreak patterns across regions, time periods, intervention levels, and demographic subgroups.

## **Outcomes**

Outcomes measured in the included studies encompassed dengue case incidence, mortality, seasonal and spatial clustering, seroprevalence, risk perception, community engagement, gender differences in health-seeking behavior, and vector density.

## **Study Design**

The corpus includes cross-sectional surveys, case-control analyses, spatiotemporal modeling studies, qualitative interviews, and retrospective hospital-based analyses. The diversity in methodological approaches enriches the robustness and contextual relevance of the synthesized findings.

## **Data Extraction**

A standardized extraction form was developed to systematically document critical attributes of each study, including:

- Study ID, year, and sample size.
- Population characteristics (age, gender, socioeconomic context).
- Type of exposure/intervention and outcome variables.
- Reported effect sizes (Odds Ratios, Relative Risks, Standardized Mean Differences).

Data were double-entered independently by two researchers to ensure accuracy and consistency. Discrepancies were resolved through consensus and validated against the original texts.

### **Risk of Bias and Study Quality Assessment**

To evaluate the methodological quality of the included studies, the research team adopted the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist. The STROBE criteria assess clarity in research design, sampling strategies, data collection methods, outcome measurement, and statistical reporting (Von Elm et al., 2014). Studies were categorized based on the proportion of fulfilled criteria:

- High quality ( $\geq 80\%$ )
- Moderate quality (60–79%)
- Low quality ( $< 60\%$ )

Studies rated as low quality were excluded from the final synthesis. Inter-rater reliability was ensured by independent reviews and consensus meetings.

### **Results and Analysis**

The synthesis of 32 empirical studies conducted between 2015 and 2024 reveals a complex web of interacting determinants contributing to the transmission of dengue in Pakistan. The analysis was organized into four major thematic domains: (1) environmental and climatic drivers, (2) socio-demographic and behavioral determinants, (3) gender and access inequities, and (4) institutional capacity and policy implementation gaps. Each of these themes interacts in dynamic and often compounding ways to shape the scale, intensity, and duration of dengue outbreaks across diverse ecological and socio-political landscapes.

#### **Environmental and Climatic Drivers**

Environmental and climatic factors have consistently emerged as foundational determinants in shaping the vector ecology of dengue. Studies have demonstrated that fluctuations in ambient temperature, particularly within the range of 25°C to 32°C, combined with high relative humidity levels exceeding 60%, create optimal breeding conditions for *Aedes* mosquitoes (Akhtar & Abbas, 2020; Munazzah & Naqvi, 2022). Urban environments characterized by the heat island effect—where temperatures are elevated due to asphalt, concrete, and reduced vegetation—exacerbate this trend, especially in major cities like Lahore, Karachi, and Faisalabad.

Rainfall patterns, especially those associated with monsoon seasons, further contribute to dengue proliferation by creating stagnant water pools in poorly drained neighborhoods. Spatial analyses using GIS technologies have uncovered significant correlations between rainfall intensity and dengue incidence in cities such as Rawalpindi and Multan, suggesting a need to incorporate weather forecasting into early warning systems (Imran et al., 2021; Naqvi et al., 2021). Furthermore, poorly managed water storage practices, as documented in low-income settlements, have been linked to inadvertent mosquito breeding (Zaman & Batool, 2020), indicating that micro-level environmental practices contribute meaningfully to broader ecological risks.

#### **Socio-Demographic and Behavioral Determinants**

Socioeconomic status, educational attainment, and public awareness significantly affect exposure to dengue and the effectiveness of preventive behaviors. Residents of low-income

neighborhoods are often disproportionately exposed to risk due to a lack of basic infrastructure, including sanitation services, clean water access, and consistent garbage collection (Raza et al., 2018; Luqman et al., 2013). These deficiencies not only foster mosquito breeding but also limit residents' access to timely health information and care.

Cultural perceptions and misconceptions further influence behavior. In many cases, dengue is viewed as a routine seasonal illness, leading to delayed care-seeking and reliance on traditional remedies (Syed et al., 2010). Studies have also shown that knowledge about dengue prevention such as eliminating stagnant water, using insect repellents, and seeking timely medical help is positively correlated with education level (Javed et al., 2021; Khan et al., 2021). Behavior changes campaigns rooted in community-based models, such as the Positive Deviance approach in Islamabad's slums, have shown promise in promoting effective dengue prevention practices in hard-to-reach populations (Shafique et al., 2022).

### ***Gender and Access Inequities***

Gendered disparities in health outcomes are starkly apparent in the context of dengue, particularly in marginalized communities. Studies have documented that women, especially in conservative and low-income households, face mobility restrictions and reduced autonomy in health-related decision-making (Gul & Fatima, 2021). This results in delayed or entirely foregone healthcare access during outbreaks, increasing the severity of infections. Women also have limited access to vector control tools such as insecticide-treated nets or repellents due to both economic constraints and prioritization of male household members' needs (Fatima & Qamar, 2020). Furthermore, female-headed households often lack the political and social capital to advocate for inclusion in sanitation campaigns or community-based awareness drives (Khan et al., 2022). While several studies acknowledge these inequities, the majority fail to collect or report gender-disaggregated data systematically, pointing to a critical omission in research design that inhibits the development of gender-responsive public health strategies.

### ***Institutional Capacity and Policy Implementation Gaps***

Institutional inefficiency and fragmentation present some of the most pervasive challenges to dengue control. Although multiple government bodies are involved in response efforts including municipal health offices, provincial disaster management authorities, and national public health agencies, there is little coherence in their roles or coordination mechanisms (Hanif & Mehmood, 2019; Shah & Riaz, 2023). Most efforts are episodic, reactive, and short-term, focusing on fogging campaigns and emergency hospital setups during outbreaks without any long-term prevention planning.

Moreover, surveillance systems are often underfunded and rely on manual data collection processes, delaying real-time monitoring. Even when spatial and predictive modeling tools have been developed, their integration into public health policy remains minimal due to capacity deficits and bureaucratic inertia (Usman & Iqbal, 2023; Alam & Waheed, 2019). Several studies call for a revamp of surveillance strategies to include climate forecasting, geospatial risk mapping, and community engagement as foundational pillars of epidemic preparedness.

## ***Discussion***

The findings of this meta-synthesis indicate that dengue in Pakistan cannot be fully understood or addressed through a biomedical lens alone. Rather, its proliferation reflects a syndemic interaction of climatic variability, environmental degradation, socio-economic disparities, gender inequities, and institutional inertia. These results not only align with regional and global findings but also provide Pakistan-specific insights that underscore the importance of local context in shaping outbreak dynamics and response efficacy.

### ***Structural Vulnerability and Spatial Risk***

Environmental exposure to dengue is highly spatialized, with low-income and peri-urban neighborhoods bearing the brunt of recurrent outbreaks. The clustering of cases in under-resourced urban zones reflects longstanding structural inequalities, particularly in access to sanitation, clean water, and urban planning services (Zaman & Batool, 2020; Syed et al., 2010). Aslam and Naveed (2018) further reinforce this point, suggesting that spatial risk is a direct manifestation of uneven urban development, where some communities are chronically exposed due to policy neglect. Additionally, unseasonal weather patterns now more common due to climate change—serve as early signals of potential outbreaks. Yet, as Khawaja and Riaz (2020) observe, these predictive indicators are rarely acted upon in a proactive manner. Pakistan's dengue response remains crisis-driven, with little attention to long-term infrastructure solutions such as covered drainage systems or climate-adaptive urban planning.

### ***Gender as a Critical Determinant***

This meta-synthesis elevates gender as an under-recognized but crucial factor in dengue vulnerability. Women's limited access to health education and mobility constraints have tangible implications for their exposure, diagnosis, and recovery trajectories (Gul & Fatima, 2021). The marginalization of women from health outreach programs is not incidental but systemic, reinforced by socio-cultural norms and institutional blind spots.

Khan et al. (2022) highlight that gender-disaggregated data collection is sporadic at best, impeding the design of targeted interventions. This omission has real-world consequences, such as resource allocation strategies that ignore the specific needs of female patients or caregivers. Future interventions must therefore embed gender equity into their planning, implementation, and evaluation frameworks.

### ***Institutional Fragmentation and Policy Gaps***

Despite the existence of numerous policies and technical tools, a common theme across studies is the absence of coordination and continuity in public health governance. Shah and Riaz (2023) and Hanif and Mehmood (2019) illustrate how overlapping bureaucratic responsibilities dilute accountability and hinder timely decision-making. Even when innovative tools like digital dashboards and mobile reporting platforms are piloted, their mainstream adoption is hampered by low institutional capacity and lack of political will (Alam & Waheed, 2019).

Moreover, there is a disconnect between data generation and utilization. Studies employing spatial modeling techniques (e.g., Naqvi et al., 2021; Imran et al., 2021) produce valuable insights, yet these are seldom used to inform intervention design or resource deployment. Bridging this gap requires not only technical upgrades but also shifts in institutional culture toward evidence-informed decision-making.

### ***Theoretical and Policy Implications***

This meta-synthesis supports a theoretical re-framing of dengue as a socially determined disease. The syndemic approach is especially apt, as it recognizes the co-occurrence of social vulnerabilities and biological risk factors in amplifying disease burden. This view has important policy implications. It suggests that interventions must not only target the mosquito vector but also address the broader determinants of vulnerability—such as poverty, housing, and gender discrimination.

Khawaja and Riaz (2020) advocate for climate-resilient health systems, a recommendation that finds resonance in the studies reviewed. Early warning systems combining weather data, spatial risk maps, and behavioral insights have shown promise but remain underutilized due to institutional inertia. Participatory models of epidemic governance where communities are involved in planning and evaluation offer a path forward, as demonstrated by successful behavioral interventions (Shafique et al., 2022).

## Conclusion

This meta-synthesis of 32 empirical studies reveals that dengue transmission in Pakistan is driven by a complex interplay of environmental stressors, social inequities, gender-based vulnerabilities, and institutional shortcomings. While the role of climate in shaping vector dynamics is well-documented, its interaction with spatial poverty, poor sanitation, and weak health infrastructure creates deeply uneven geographies of risk. These risks are magnified for marginalized groups especially women who face structural and cultural barriers to prevention, diagnosis, and treatment.

A central contribution of this study is the identification of cross-cutting patterns that have remained fragmented in the literature. By thematically synthesizing interdisciplinary research, this paper offers a unified understanding of the socio-ecological determinants of dengue and highlights the necessity of rights-based, gender-sensitive, and climate-resilient health strategies. Furthermore, it reveals a systemic policy blind spot: while rich data exist within individual sectors, these are not translated into integrated, anticipatory responses due to institutional fragmentation and lack of political prioritization.

Future epidemic preparedness efforts must therefore move beyond reactive measures to invest in inclusive surveillance, coordinated governance, and public health systems that address not just the biological, but also the social and political determinants of health. Addressing dengue in Pakistan and by extension, other climate-sensitive vector-borne diseases demands a rethinking of policy frameworks through the lens of equity, interdisciplinarity, and resilience.

### Author Contributions:

The Conception and design: Ishtiaq Hussain. Collection and assembly of data and Statistical Analysis and interpretation of the data: Nisha Irfan. Drafting and Critical revision of the article The intellectual content Management: Ishtiaq Hussain.

Ishtiaq Hussain is a Corresponding Author and his Email: [ishtiaq.hussain@strath.ac.uk](mailto:ishtiaq.hussain@strath.ac.uk)

Conflict of Interest: None declared.

Source of Funding: None disclosed.



## References

- Abir, T., Kalimullah, N. A., Husain, T., Yazdani, D. M. N. A., Nury, A. T. M. S., Salahin, K. F., & Agho, K. (2020). Use of the Health Belief Model for the assessment of public knowledge and household preventive practices in Dhaka, Bangladesh, a dengue-endemic city. *Journal of Xi'an University of Architecture & Technology*, 12, 2800–2815.
- Ahmad, A., Ahmad, H., & Bilal, H. (2022). Assessment of health knowledge regarding dengue fever: A cross-sectional study in rural Pakistan. *Pakistan Journal of Public Health*, 12(2), 67–71.
- Akhtar, R., & Abbas, T. (2020). Environmental determinants of dengue outbreaks in Pakistan: A GIS-based analysis. *Asian Journal of Atmospheric Environment*, 14(1), 43–49.
- Alam, S., & Waheed, M. (2019). Leveraging digital tools for dengue surveillance: A case study. *Journal of Health Informatics in Pakistan*, 6(1), 28–35.
- Amir-Behghadami, M., & Janati, A. (2020). Population, intervention, comparison, outcomes and study (PICOS) design as a framework to formulate eligibility criteria in systematic reviews. *Emergency Medicine Journal*.
- Arif, M., & Farooq, S. (2017). Community-based health interventions in dengue-prone areas of Pakistan: An evaluation. *Pakistan Journal of Community Medicine*, 11(3), 98–104.
- Aslam, T., & Naveed, S. (2018). Spatio-temporal trends in dengue infections: A statistical analysis. *International Journal of Biostatistics*, 7(2), 95–102.
- Awan, K. A., & Tariq, F. (2022). The interplay of urban planning and dengue control strategies. *Journal of Urban Epidemiology*, 3(3), 61–69.
- Bano, F., & Hassan, R. (2021). Awareness and behavioral patterns of school children during dengue outbreaks. *Pakistan Journal of Child Health*, 4(2), 18–24.
- Bashir, A., & Khalid, S. (2018). The economic burden of dengue in Pakistan: A public health challenge. *Health Economics and Policy Review*, 4(2), 33–39.
- Fatima, Z., & Qamar, A. (2020). Barriers to effective dengue control programs in peri-urban settings. *Health Promotion and Practice*, 14(4), 311–317.
- Gul, S., & Fatima, N. (2021). Gender-based differences in access to dengue awareness and preventive resources. *International Journal of Gender and Health Research*, 3(2), 101–107.
- Hanif, S., & Mehmood, A. (2019). Assessing the gaps in national dengue surveillance system in Pakistan. *Pakistan Journal of Surveillance Studies*, 2(2), 37–43.
- Imran, M., Hamid, Y., Mazher, A., & Ahmad, S. R. (2021). Geo-spatially modelling dengue epidemics in urban cities: A case study of Lahore, Pakistan. *Geocarto International*, 36(2), 197–211.
- Jahan, F., & Junaid, M. (2015). A study on awareness and preventive measures among university students in Islamabad. *International Journal of Advanced Research in Biological Sciences*, 2(6), 123–129.
- Javed, A., Qasim, M., & Khan, S. A. (2021). Sociodemographic correlates of dengue knowledge and prevention practices in Punjab. *Pakistan Journal of Health Sciences*, 15(1), 42–49.
- Khan, A. A., Toseef, M. U., & Rehman, A. (2021). Knowledge and practice about dengue fever among local population. *Pakistan Journal of Medical and Health Sciences*, 15(4), 858–861.
- Khan, M. J., Shabbir, S., & Fatima, T. (2022). Gender difference in awareness and prevention of dengue fever among residents of Lahore. *Pakistan BioMedical Journal*, 5(6), 148–151. <https://doi.org/10.54393/pbmj.v5i6.322>
- Khawaja, K., & Riaz, F. (2020). Analyzing climate-health linkages: A review of dengue policy responses. *Pakistan Environmental Policy Journal*, 5(3), 74–80.
- Luqman, M., Sattar, T., Farid, S., Warraich, I. A., & Khan, W. A. (2013). Effects of dengue incidence on socio-economic status of patient's family: A comparative analysis of Multan and Lahore City (Pakistan). *Journal of Economics and Sustainable Development*, 4(13), 28–39.
- Munazzah, M., & Naqvi, S. (2022). Exploring seasonal variability of dengue in urban Pakistan: A time series analysis. *Pakistan Journal of Medical and Health Sciences*, 16(3), 290–293.
- Naqvi, S. A. A., Sajjad, M., Waseem, L. A., Khalid, S., Shaikh, S., & Kazmi, S. J. H. (2021). Integrating spatial modelling and space-time pattern mining analytics for vector disease-related health

- perspectives: A case of dengue fever in Pakistan. *International Journal of Environmental Research and Public Health*, 18(22), 12018.
- Noor, M., & Saeed, A. (2022). Public response to dengue outbreaks: Evidence from focus groups in Sindh. *Journal of Social Sciences and Public Health*, 10(1), 1–8.
- Rauf, M. A., & Siddiqui, A. (2022). Monitoring community engagement in dengue prevention through mobile health platforms. *Journal of Mobile Health and Technology*, 2(1), 45–52.
- Raza, F. A., Ashraf, S., Hasnain, S., Ahmad, J., & Iqbal, M. (2018). Dengue seroprevalence and its socioeconomic determinants in Faisalabad, Pakistan: A cross-sectional study. *Revista da Sociedade Brasileira de Medicina Tropical*, 51(4), 503–507.
- Saleem, H., Qureshi, S., & Javed, M. A. (2019). Vector control measures and awareness campaign evaluation: A case study of Rawalpindi. *Pakistan Journal of Tropical Medicine*, 7(1), 12–17.
- Schaber, K. L., Perkins, T. A., Lloyd, A. L., Waller, L. A., Kitron, U., Paz-Soldan, V. A., Elder, J. P., Rothman, A. L., Civitello, D. J., & Elson, W. H. (2021). Disease-driven reduction in human mobility influences human-mosquito contacts and dengue transmission dynamics. *PLoS Computational Biology*, 17(1), e1008627.
- Shafique, M., Mukhtar, M., Areesantichai, C., & Perngparn, U. (2022). Effectiveness of positive deviance, an asset-based behavior change approach, to improve knowledge, attitudes, and practices regarding dengue in low-income communities (slums) of Islamabad, Pakistan: A mixed-method study. *Insects*, 13(1), 71.
- Shah, A., & Riaz, T. (2023). Local governance and dengue response coordination in urban Pakistan. *Public Administration and Health Policy Journal*, 9(1), 21–30.
- Syed, M., Saleem, T., Syeda, U.-R., Habib, M., Zahid, R., Bashir, A., Rabbani, M., Khalid, M., Iqbal, A., & Rao, E. Z. (2010). Knowledge, attitudes and practices regarding dengue fever among adults of high and low socioeconomic groups. *Journal of the Pakistan Medical Association*, 60(3), 243.
- Tariq, M., & Imran, H. (2021). Evaluating the effectiveness of school-based dengue awareness programs. *Journal of School Health Research*, 3(1), 9–15.
- Usman, R., & Iqbal, Z. (2023). Assessing policy impact on dengue outbreak control in metropolitan areas. *Pakistan Policy Review*, 8(2), 55–63.
- Zaman, N., & Batool, F. (2020). Impact of household water storage practices on mosquito breeding in Karachi. *Urban Health Review*, 6(4), 127–134.
- Zhang, Y., Wang, M., Huang, M., & Zhao, J. (2024). Innovative strategies and challenges mosquito-borne disease control amidst climate change. *Frontiers in Microbiology* 15, 1488106. <https://doi.org/10.3389/fmicb.2024.1488106>