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A Theoretical Framework for the Spatial Ecology of Dengue Vectors: Linking Urban Water Storage Practices to Breeding Site Heterogeneity in Dar es Salaam

R, a, j, a, b, u, S, ., M, f, i, n, a, n, g, a, ,, A, m, i, n, a, J, u, m, a, ,, N, e, e, m, a, K, i, s, a, n, g, a, ,, G, o, o, d, l, u, c, k, M, w, a, m, b, e, n, e

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Abstract

Dengue fever is a significant public health threat in African cities, where transmission is influenced by the availability of Aedes mosquito breeding sites. In Dar es Salaam, unreliable piped water necessitates widespread household water storage, but the spatial relationship between these practices and vector breeding ecology is insufficiently theorised. This article develops a theoretical framework linking heterogeneous urban water storage practices to the spatial distribution and productivity of dengue vector breeding sites in Dar es Salaam's residential areas. It aims to provide a conceptual model for analysing this socio-ecological interface. The framework is constructed by synthesising principles from spatial ecology, health geography, and social practice theory. It integrates conceptual models of container hydrology, mosquito population dynamics, and the socio-material drivers of water storage behaviour to propose testable relationships between urban infrastructure, household practices, and breeding site heterogeneity. Key insights: The framework posits that the density and type of water storage containers are spatially clustered according to neighbourhood-level water infrastructure and socio-economic status. A central insight is a proposed positive feedback loop: areas with poor municipal water supply exhibit higher densities of storage containers, leading to greater breeding site availability, higher vector density, and consequently increased dengue risk in those same localities. This

theoretical framework provides an interdisciplinary lens for understanding how dengue vector breeding sites are generated in water-scarce urban environments. It clarifies how essential water security practices can inadvertently shape disease risk landscapes at a neighbourhood scale. Future empirical research should apply this framework to map and model the proposed relationships in Dar es Salaam. Public health interventions should integrate vector control with urban water planning, acknowledging this spatial linkage to develop more targeted and sustainable strategies. dengue, Aedes, spatial ecology, urban health, water storage, theoretical framework, Tanzania, breeding sites This article contributes a novel theoretical framework that integrates socio-material practices with spatial ecology to analyse the production of dengue vector habitats in African cities, offering a foundation for more spatially informed research and intervention.