

Spatial Clustering of Childhood Stunting and Household Water Insecurity in Peri-Urban Settlements of Sub-Saharan Africa: A Multilevel Geospatial Analysis of the 2019–2022 DHS Cohort

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Abstract. Childhood stunting remains a pervasive indicator of chronic undernutrition and structural inequity across sub-Saharan Africa, yet its geospatial co-distribution with household water insecurity in peri-urban zones is insufficiently characterised. This study applied multilevel logistic regression and kernel density estimation to Demographic and Health Survey (DHS) data from six sub-Saharan African nations (2019–2022; $n = 48,714$ child-records) to identify spatial clusters of stunting prevalence co-localised with inadequate access to potable water. Moran's I statistic confirmed significant positive spatial autocorrelation ($I = 0.47$; $p < 0.001$). Adjusted analyses revealed that children in water-insecure households faced a 2.3-fold elevated odds of stunting (aOR = 2.31; 95% CI: 2.09–2.56). Hotspot convergence zones were concentrated in peri-urban transitional belts. Findings underscore the necessity of spatially targeted water, sanitation, and hygiene (WASH) interventions integrated within national nutritional surveillance frameworks.

Keywords: childhood stunting, household water insecurity, peri-urban health disparities, geospatial epidemiology, sub-Saharan Africa, multilevel analysis, WASH interventions, Demographic and Health Survey, spatial autocorrelation

Introduction

Chronic undernutrition, operationalised through the anthropometric proxy of height-for-age z-scores (HAZ) below -2 standard deviations, constitutes one of the most consequential and persistent public health challenges confronting low- and middle-income countries (LMICs) in the contemporary era. As of 2024, the United Nations Children's Fund (UNICEF) estimates that approximately 148 million children under the age of five globally are affected by stunted linear growth, with sub-Saharan Africa accounting for over 40% of the global burden — a proportion that continues to rise in absolute terms despite marginal reductions in prevalence rates across select high-performing national programmes. Stunting is no longer viewed solely as a nutritional deficit; it is now recognised as a syndemic outcome shaped by the convergent pressures of food system fragility, environmental contamination, socioeconomic marginalisation, and critically, compromised access to safe drinking water and adequate sanitation infrastructure. The nexus between water insecurity and childhood stunting has been theorised through multiple biological and sociobehavioural pathways. Enteric pathogen exposure resulting from the consumption of microbiologically contaminated water sources drives environmental enteric dysfunction (EED), a subclinical inflammatory condition of the small intestinal mucosa that impairs nutrient absorption and blunts growth trajectories even in the context of adequate dietary intake. Simultaneously, time burdens associated with household water fetching — disproportionately allocated to women and adolescent girls — constrain maternal caregiving capacity, breastfeeding exclusivity rates, and complementary feeding practices, thereby compounding nutritional risk among infants and toddlers. Despite a robust theoretical framework, the spatial epidemiology of this co-exposure relationship within peri-urban transitional zones of sub-Saharan Africa remains markedly underdeveloped. Peri-urban settlements are characterised by a paradoxical health ecology: they lack the formal WASH infrastructure provisioned in urban cores, yet do not benefit from the community-level social cohesion and traditional dietary diversity more frequently observed in rural settings. This epidemiological liminality renders peri-urban populations particularly vulnerable, yet systematically underrepresented in nationally aggregated surveillance datasets that obscure intra-urban heterogeneity. The present study addresses this gap by employing a multilevel geospatial analytical framework applied to harmonised DHS microdata from six sub-Saharan African nations — Ethiopia, Kenya, Nigeria, Tanzania, Uganda, and Zambia — covering survey rounds conducted between 2019 and 2022. Kernel density estimation (KDE), spatial autocorrelation indices, and multilevel logistic regression models adjusted for community- and household-level confounders are deployed to delineate high-risk convergence zones and to quantify the independent contribution of water insecurity to stunting odds after accounting for maternal education, household wealth quintile, child sex, and sanitation facility type. This paper is structured as follows: Section 2 details the data sources, variable operationalisation, and analytical procedures; Section 3 presents the descriptive, regression, and spatial findings; Section 4 contextualises results within current WASH policy discourse and outlines programmatic implications; and Section 5 concludes with reflections on study limitations and directions for future longitudinal inquiry.

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