RESEARCH PAPER

The Himalayan Paradox: An Epidemiological Analysis of Water, Sanitation, and Hygiene (WASH) and their Determinants on Child Health Outcomes in Uttarakhand, India

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ABSTRACT

Background: The state of Uttarakhand presents a unique epidemiological landscape due to its dual topography of high-altitude Himalayan districts and industrial plains. Despite achieving 'Open Defecation Free' (ODF) status under the Swachh Bharat Mission (SBM), child health indicators—specifically stunting and diarrheal morbidity—persist at concerning levels.

Objective: This study aims to evaluate the correlation between household Water, Sanitation, and Hygiene (WASH) infrastructure and key child health outcomes (stunting, wasting, and diarrheal prevalence) among children under five years of age in Uttarakhand.

Methods: A secondary data analysis was conducted utilizing datasets from the National Family Health Survey (NFHS-4, 2015-16 and NFHS-5, 2019-21). The study employs multivariate logistic regression to assess the association between improved sanitation facilities, source of drinking water, and hygiene practices with child anthropometry and morbidity, controlling for maternal education and socioeconomic status.

Results: While access to improved sanitation facilities in Uttarakhand rose to 81.0% in NFHS-5, the prevalence of childhood stunting remains high at roughly 27%, with significant inter-district disparity. The analysis reveals a strong statistical significance ($p < 0.05$) between lack of dedicated handwashing stations and recurrent diarrheal episodes. Crucially, the "Hill vs. Plain" dichotomy shows that while plains suffer from pathogen density, hill districts suffer from "dry latrines" due to water scarcity, leading to poor hygiene compliance.

Conclusion: Infrastructure alone is insufficient to mitigate sanitation-related health burdens. The persistence of Environmental Enteric Dysfunction (EED) markers suggests that fecal pathogens remain in the environment. Policy must shift from toilet construction to "fecal sludge management" and water-security-integrated sanitation.

Keywords: WASH, Uttarakhand, Stunting, Environmental Enteropathy, Swachh Bharat Mission, Child Health, Epidemiology.

How to cite this article: Rana A, Bohra P, Tiwari A, Chikocho D, Pujari M, Tiwari S, Ram G, The Himalayan Paradox: An Epidemiological Analysis of Water, Sanitation, and Hygiene (WASH) and their Determinants on Child Health Outcomes in Uttarakhand, India. Int J Drug Deliv Technol. 2026;16(14s): 771-774. DOI: 10.25258/ijddt.16.14s.89.
Source of support: Nil
Conflict of interest: None

INTRODUCTION

The symbiotic relationship between human development and environmental sanitation is nowhere more critical than in the early years of life. Globally, inadequate Water, Sanitation, and Hygiene (WASH) practices are attributed to 60% of the diarrheal disease burden (WHO, 2019). In India, the discourse on sanitation has shifted from mere "convenience" to a critical health intervention, primarily driven by the Swachh Bharat Mission (SBM).

Uttarakhand, a northern Indian state carved out of Uttar Pradesh in 2000, offers a distinct case study. The state is characterized by ecological fragility and difficult terrain. While the state reports high literacy rates relative to the national average, its child health indicators present a paradox. The availability of toilets has not linearly translated into the eradication of water-borne diseases or malnutrition.

This paper posits that the "hardware" of sanitation (toilets) has outpaced the "software" (behavioral change and water availability) and the "system" (fecal sludge management). Consequently, the fecal-oral route of disease transmission remains active, manifesting in high rates of stunting (chronic malnutrition) and diarrheal morbidity among children under five.

1.1 Problem Statement

Despite the ODF declaration in 2017, NFHS-5 data indicates that 27% of children in Uttarakhand are stunted and 13.2% are wasted. The persistence of these malnutrition markers, which are strongly correlated with environmental enteropathy caused by poor sanitation, suggests a gap in the efficacy of current WASH interventions.

1.2 Research Objectives

1. To analyze the trends in WASH coverage in Uttarakhand between NFHS-4 and NFHS-5.
2. To investigate the association between specific WASH indicators (toilet type, water source, handwashing) and child health outcomes (diarrhea, stunting).
3. To examine the geographical disparities in sanitation efficacy between the Garhwal/Kumaon hill regions and the Terai plains.

LITERATURE REVIEW

2.1 The Biological Mechanism: WASH and Malnutrition

The traditional understanding of malnutrition focused on caloric intake. However, seminal work by Humphrey (2009) introduced the concept of Environmental Enteric Dysfunction (EED). EED is a subclinical disorder of the small intestine caused by chronic ingestion of fecal pathogens. This leads to:

Blunting of intestinal villi (reducing surface area for absorption).

Systemic inflammation.

Malabsorption of nutrients.

In this context, a child may eat sufficient food but fail to grow (stunting) because their gut is compromised by a dirty environment. This is highly relevant to Uttarakhand, where livestock often cohabit with humans in rural hill households.

2.2 The Indian Context

Spears et al. (2013) demonstrated that differences in open defecation density could explain a significant portion of the height variation in Indian children compared to African children. India's sanitation drive (SBM) focused heavily on toilet construction. However, studies (Coffey et al., 2014) have shown that "latrine use" does not always follow "latrine ownership," particularly in rural North India where cultural notions of purity/pollution deter the use of pit latrines.

2.3 The Uttarakhand Scenario

Limited literature exists specifically focusing on Uttarakhand's sanitation-health nexus.

Semwal et al. (2018) noted that in the Himalayan belt, natural springs (naulas) are frequently contaminated by surface runoff from upper-slope settlements.

Colborn et al. (2020) highlighted that in high-altitude regions, the challenge is not just pathogen load but the energy cost of fetching water, which reduces the frequency of handwashing.

METHODOLOGY

3.1 Study Design

This research employs a quantitative, cross-sectional design based on secondary data analysis.

3.2 Data Sources

The primary datasets are the National Family Health Survey-4 (2015-16) and National Family Health Survey-5 (2019-21). These are large-scale, multi-round surveys

conducted in a representative sample of households throughout India.

Sample Size (Uttarakhand NFHS-5): Approximately 12,000 households.

Target Population: Children aged 0–59 months.

3.3 Statistical Analysis
Data was analyzed using SPSS and R.

Descriptive Statistics: To determine prevalence rates.

Bivariate Analysis: Chi-square (\chi^2) tests to check associations between WASH variables and health outcomes.

Multivariate Analysis: Binary Logistic Regression was used to calculate Adjusted Odds Ratios (AOR) to isolate the impact of sanitation while controlling for wealth and education.

RESULTS
4.1 Status of WASH in Uttarakhand (NFHS-4 vs. NFHS-5)

The infrastructure push has yielded measurable results.

Sanitation: Households with improved sanitation facilities increased from 66.2% to 81.0%.

Water: Access to improved drinking water sources is near universal at 96%, though this figure masks the issue of "dry taps" in summer months.

Hygiene: Only 78% of rural households were observed to have water and soap at the place where hands are washed.

4.2 Child Health Indicators
Despite sanitation improvements, health metrics show mixed progress:

Stunting (Chronic Malnutrition): Decreased marginally from 33.5% (NFHS-4) to 27.0% (NFHS-5).

Wasting (Acute Malnutrition): Paradoxically increased in several districts, averaging 13.2%.

Diarrhea: Prevalence in the 2 weeks preceding the survey dropped from 6.9% to 4.4%.

4.3 Correlation Analysis
4.3.1 Sanitation and Diarrhea
A Chi-square test indicated a significant association between the type of toilet facility and diarrheal incidence ($\chi^2 = 14.2$, $p < 0.01$).

Children in households sharing toilet facilities were 1.4 times more likely to suffer from diarrhea than those with private improved facilities.

Rural Disparity: In rural districts (e.g., Tehri Garhwal), the protective effect of toilets was weaker, likely due to water shortages preventing proper flushing and cleaning.

4.3.2 Hygiene and Stunting
The regression model showed that the absence of soap at the washing station was a stronger predictor of stunting than the absence of a toilet itself (AOR: 1.23; 95% CI: 1.05-1.44). This supports the EED hypothesis—pathogens are ingested via dirty hands/food, not just direct fecal contact.

4.4 Regional Variations
Haridwar & Udham Singh Nagar (Plains): Highest burden of stunting. High population density leads to groundwater contamination. Even with toilets, the water table is often polluted by leaching pits.

Almora & Pithoragarh (Hills): Better nutritional status but persistent diarrheal issues during monsoons. The issue here is surface water contamination (springs) rather than groundwater.

DISCUSSION
The data reveals a "Sanitation Quality Gap." Uttarakhand has successfully built toilets, but it has not successfully separated children from fecal pathogens.

5.1 The "Hardware-Software" Mismatch
The SBM focused on the construction of Twin-Pit Pour-Flush latrines. However, in the Himalayas, carrying water is labor-intensive. When water is scarce, toilets become foul-smelling and unusable, leading men to return to open defecation or families to use toilets for storage (dry usage). This "slippage" negates the health benefits of the infrastructure.

5.2 Environmental Enteropathy in the Plains
In the plains (Haridwar), the water table is high. The rapid proliferation of soak-pits (common in SBM toilets) without proper spacing from hand-pumps results in the recycling of pathogens. The child drinks water that looks clean but is biologically contaminated, leading to gut inflammation and stunting, explaining the high stunting rates in Haridwar despite better economic indicators than the hills.

5.3 The Neglected Hygiene Factor
The strong correlation between lack of soap and stunting is a critical finding. In the cold climate of the hills, washing hands with cold water is discouraged. Without heated water or sensitization, handwashing compliance drops, maintaining the fecal-oral transmission route.

CHALLENGES AND POLICY IMPLICATIONS
6.1 Challenges
Topography: Building sewer lines in the hills is geologically unstable and expensive. Septic tanks are difficult to empty in narrow lanes.

Water Scarcity: "Sanitation without water is a contradiction." As springs dry up in Uttarakhand, maintaining hygiene becomes secondary to survival needs (drinking/cooking).

Cultural/Behavioral: In some communities, cleaning latrines is associated with caste-based stigmas, leading to poor maintenance.

6.2 Policy Recommendations

Integration of Jal Jeevan Mission and SBM: Sanitation planning must be coupled with water supply. A toilet should not be sanctioned without a verified water source.

Fecal Sludge Management (FSM): For hill towns, conventional sewers are not feasible. Small-scale mechanical de-sludging vehicles (adapted for narrow roads) and co-treatment plants are needed.

Focus on "Effective" Coverage: Metrics should move from "ODF" (access) to "ODF++" (safe disposal of waste).

Targeted Nutrition-WASH Interventions: In districts like Haridwar, Anganwadi centers must focus on WASH education for mothers, specifically regarding handwashing before feeding.

CONCLUSION

The reduction of child mortality and malnutrition in Uttarakhand is contingent upon closing the loop on sanitation. The current research highlights that while the state has made commendable progress in infrastructure, the biological impact on children remains stunted by water quality issues and hygiene behavior.

To protect the next generation of Uttarakhand, the state must treat sanitation not as a civil engineering task, but as a public health imperative. The solution lies in context-specific technologies—bio-digesters for the hills and rigorous groundwater protection for the plains—ensuring that the "Devbhoomi" is truly clean, not just on paper, but in practice.

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