

Impact of WaSH Practices on Stomach-Related Diseases in Indian Households : A Public Policy Perspective

Kamaldeep Kaur Sarna¹
Simrit Kaur²

Abstract

Purpose : Water, Sanitation, and Hygiene (WaSH) play a pivotal role in fostering inclusive growth and sustainable development. The global economic, social, and environmental repercussions of poor WaSH facilities are substantial, with developing countries bearing the major brunt. In this context, the present study examined the impact of WaSH practices on the prevalence of stomach-related diseases among Indian households.

Methodology : Using data from the National Sample Survey 76th round, the study employed cross-tabulations and binary logistic regression to empirically investigate the correlates of health outcomes in India.

Findings : A significant relationship between poor WaSH conditions and a higher incidence of stomach-related illnesses was found. Further disparities across socioeconomic settings highlighted the disproportionate impact of WaSH practices prevailing among the vulnerable sections. Notably, lower education levels, involvement in informal sector occupations, unimproved water sources, insufficient water availability, poor sanitation facilities, and inefficient water treatment methods significantly increased the likelihood of stomach ailments.

Practical Implications : Providing safe and sufficient WaSH access should be prioritized by expanding WaSH infrastructure, strengthening water treatment facilities, promoting affordable household filters, facilitating regular quality inspections, and mandating proper housing and ventilation standards. Targeted interventions should be designed for marginalized groups by providing subsidized facilities and educating households across formal and informal settlements. Technological innovations and cross-sector collaborations should be leveraged for the successful implementation of the initiatives.

Originality : The present paper contributed to the scant literature wherein the influence of WaSH practices on Indian households' well-being was investigated. Further, the impact of both demographic and contextual variables was analyzed, providing valuable policy insights.

Keywords : water, sanitation, and hygiene (WaSH) ; disease incidence ; sustainable development ; stomach-related illnesses ; health equity ; public policy

JEL Classification Codes : I15, I18, O15, Q53

Paper Submission Date : June 5, 2024 ; **Paper sent back for Revision :** October 1, 2024 ; **Paper Acceptance Date :** October 20, 2024

Water, Sanitation, and Hygiene (WaSH) are essential pillars of sustainable development, fostering social resilience and inclusive growth. They are not just a fundamental right of every human being (United Nations, 2011; WHO, 2023b) but also represent equity, dignity, and security, linking various

¹Research Scholar, Faculty of Management Studies, University of Delhi, Malkaganj Marg, Kamla Nagar, New Delhi - 110 007 & ¹Assistant Professor, Shri Ram College of Commerce, University of Delhi.

(Email : kamaldeep.phd19@fms.edu ; kamaldeepkaur.sarna@srcc.du.ac.in) ;

ORCID iD : <https://orcid.org/0000-0002-7179-1482>

²Professor of Economics and Public Policy (Corresponding Author), Principal, Shri Ram College of Commerce, University of Delhi, Maurice Nagar, Near Patel Chest, New Delhi - 110 007.

(Email : principal@srcc.du.ac.in ; kaur.simrit@gmail.com) ; ORCID iD : <https://orcid.org/0000-0001-9947-2435>

DOI : <https://doi.org/10.17010/aijer/2024/v13i4/174044>

elements of public well-being (Kumar & Rajendran, 2016; Parikh et al., 2021; The World Bank, 2023). Safe WaSH improves attendance, boosts productivity, enhances living standards, and contributes to livelihoods (Mackinnon et al., 2018; McMichael, 2019). Several severe diseases, such as waterborne diseases (diarrhea, dysentery, giardiasis, cryptosporidiosis, and hepatitis A), vector-borne diseases (malaria, dengue fever, and chikungunya), respiratory infections, skin disorders, nutritional deficiency, and neglected tropical diseases (NTDs) can be mitigated by ensuring safe and sufficient WaSH facilities (Deshpande et al., 2020; Meki et al., 2022; Prüss-Ustün et al., 2017).

Unfortunately, the world continues to face significant concerns about safe WaSH conditions (Berihun et al., 2022; Howard, 2021; Portillo et al., 2023; Sifullah et al., 2024). For instance, in 2022, nearly 2.2 billion people didn't have access to safely managed drinking water, 3.5 billion individuals were without safely managed sanitation conditions, and 2 billion were deprived of basic handwashing amenities (United Nations, 2023; WHO, 2023a). Further, globally, there prevail notable disparities associated with access to safe WaSH facilities. For instance, several regions of Sub-Saharan Africa and Asia experience relatively higher mortality rates relative to developed nations (Azevedo, 2017; Perin et al., 2022; WHO, 2024). Each year, fatalities of around 400,000 children aged less than five years are attributable to poor WaSH conditions (UNICEF, 2023). Diarrhea, a disease caused by inadequate WaSH facilities, is primarily behind the death of 1.5 million individuals. Additionally, the annual economic losses due to WaSH-related illness are substantial (around USD 600 million), with 73 million lost labor days (The World Bank, 2017). Various multifaceted forces such as urbanization, pollution, climate change, poor infrastructure, and exploitation of resources are behind the worsened socio-economic settings (Raychaudhuri & Singh, 2011; Saarangapani & Sripathi, 2015).

Basis the crucial relevance of the topic, even one of the sustainable development goals (SDG), “Clean Water and Sanitation,” aims to achieve affordable and equitable access to safe drinking water, sanitation, and hygiene for all and eradicate open defecation by 2030. The goal also seeks to pay special focus to vulnerable populations (such as girls, women, and elders) who are impacted disproportionately by the poor WaSH practices. Particularly post-COVID-19 pandemic, the significance of improved WaSH interventions has increased manifold in fostering public health and well-being.

Thus, due to the rising pertinence of the theme, researchers and practitioners have started delving into several facets of WaSH, including but not limited to examining WaSH quality, availability, accessibility, and governance (Berihun et al., 2022; Bishoge, 2021; Kuberan et al., 2015; Lin & Feng, 2023; Okesanya et al., 2024; Saroj et al., 2020). Gera et al. (2018), Kim et al. (2018), Taylor et al. (2015), Wani et al. (2022), and Wolf et al. (2022) assessed the disease burden of unsafe WaSH facilities, and researchers also specifically investigated the significance of safe WaSH practices during the COVID-19 pandemic (Biswas & Karmakar, 2022; Jatav et al., 2021). Nevertheless, only particular aspects of WaSH, such as sanitation or drinking water (Basu & Dasgupta, 2021; Gyanendra et al., 2022; Maraddi & Ho, 2022) or specific determinants of access or availability of WaSH facilities (Mondal, 2022; Mishra & Khan, 2023; Ray et al., 2024) have been examined, limiting the understanding of the real impact. Thus, the existing literature is inadequate in analyzing the health outcomes among Indian households due to prevailing WaSH practices. The literature also lacks comprehensive empirical analysis of disease incidences due to unsafe WaSH facilities, especially in developing nations such as India, which faces unique challenges (Biswas et al., 2022; Kanungo et al., 2021). Therefore, the present study intends to bridge the existing gaps by empirically assessing the impact of WaSH practices on health outcomes in India using a unit-level National Sample Survey, 76th Round undertaken from July 2018-December 2018, namely, “Drinking Water, Sanitation, Hygiene, and Housing Condition” (Ministry of Statistics and Programme Implementation, 2018). The paper attempts to provide a broader understanding of the influence of WaSH practices on Indian households' well-being, investigating the impact of both demographic characteristics and contextual variables.

Review of Literature

The nexus between WaSH facilities and health outcomes has been demonstrated by several researchers, revealing significant health hazards due to poor WaSH conditions in India. Contaminated water and poor sanitation, especially in rural regions, can result in a myriad of diseases ranging from dental fluorosis, diarrhea, typhoid fever, hepatitis A, chronic kidney disorders, and cryptosporidium to hypertension and low intelligence quotient (IQ) levels. A few relevant studies that portray a significant association between WaSH practices and health outcomes in India are discussed herewith.

The WaSH practices of the mothers with children below five years old were examined in rural areas of Nayagarh district, Odisha, and were linked with the health outcomes of their children. Using a cross-sectional survey of 370 participants, it was found that mothers who did not push children to wash their hands often reported a higher chance of diarrhea in children. Furthermore, the frequency pattern of mothers' handwashing practices was significantly connected with children contracting fever and the common cold (Jena et al., 2024). Wolf et al. (2022) reported the recent estimates of disease burden associated with WaSH practices. They assessed the disease incidences in terms of pediatric diarrhea in low and middle-income countries over the period 2016 to 2021. Employing random effects meta-analysis technique and meta-regression models, the study identified that favorable WaSH interventions such as point-of-use water treatment, sanitation facilities with sewer connections, and hand washing promotion led to the fall in the risk of diarrhea by 52%, 24%, and 30% respectively. Palo et al. (2021) also analyzed the impact of WaSH intervention on health outcomes in Odisha, India. Using a community-based cross-sectional design survey, they concluded that tube wells and dug wells were the primary sources of drinking water for the surveyed population, leading to acute diseases (9.2%) and chronic diseases (19.1%), such as respiratory infections, diarrhea, and musculoskeletal disorders. The authors emphasized the need for prioritizing health awareness and social and behavioral changes in improving public health.

Ray et al. (2024) scrutinized the WaSH practices among slum residents of Kolkata, revealing that lower education levels, high population density and inadequate ventilation were significantly associated with unsatisfactory WaSH practices. Furthermore, the lack of exclusive toilets, waterlogging, and blocked sewers were primary hindrances faced by the slum dwellers. Donde et al. (2021) analyzed the role of WaSH measures in coping with the COVID-19 pandemic in low-income countries. They highlighted the effectiveness of WaSH practises in controlling the disease spread despite facing greater socioeconomic barriers and having poor medical facilities. Goyanka (2021) also assessed the disease burden and cost associated with WaSH-attributable diseases in India. Using the NSSO 75th round survey, the author employed a multi-level logistic regression model and found that about 5.7% of the outpatient visits and 6.9% of the hospital admissions were due to WaSH-associated diseases. Furthermore, on average, the cost associated was ₹ 703 for outpatient visits and ₹ 9,656 for the hospital stay. Gupta and Misra (2019) examined the health impact of consuming contaminated water in Haryana. Over 15% of the sampled individuals encountered water-related diseases (6% of them had stomach issues, and 9% reported mild to moderate dental fluorosis). Additionally, the residents had to also spend an average monthly expense of ₹ 1,000 – 2,000 for the treatment of the illness.

Recent studies have also attempted to explore the health impacts of chemical contaminants such as fluoride and arsenic found in drinking water. These are responsible for creating serious health problems, especially in rural India. High levels of fluoride in Andhra Pradesh have led to a loss in bone density, resulting in skeletal fluorosis (Adimalla et al., 2019). Further, lower IQ levels in children aged 12–13 years were attributed to excessive fluoride concentration in different areas in India (Kaur et al., 2022). Arsenic contamination in West Bengal's water was linked to Blackfoot disease, skin cancer, heart issues, and other waterborne infections (Biswas et al., 2023; Palit et al., 2012). In Bihar, people drinking arsenic-contaminated water over longer periods were more likely to suffer from hypertension (Xu et al., 2021), and coliform contamination in Chennai was connected with the occurrence of cryptosporidium oocysts (Anbazhagi et al., 2007). Instances of typhoid fever were also found in

Vellore, Tamil Nadu, due to contaminated water. Further, mothers who mostly consume street food have higher chances of disease transmission, particularly in urban India (Giri et al., 2021). Contaminated water in the dug wells of Kollam, Kerala, had led to incidences of hepatitis A among the residents, resulting in decreased productivity and increased medical expenses (Usha et al., 2014). Mohanty et al. (2020), Reddy and Gunasekar (2013), and Singh et al. (2016) reported the cases of chronic kidney diseases. High levels of coliform in Sumari Village, Uttarakhand, were found to be the underlying reason for outbreaks of dysentery, diarrhea, and typhoid among 38%, 23%, and 17% of residents, respectively (Chauhan et al., 2020).

In addition to contaminants, poor user practices also exacerbated waterborne diseases. Studies revealed that personal hygiene significantly impacted health, with these practices often outweighing microbiological water quality in determining disease transmission (Giri et al., 2022; Merid et al., 2023; Ravindra et al., 2019; Soboksa et al., 2020). In Maharashtra, for instance, inadequate hygiene worsened illness outcomes, while government efforts such as the Swachh Bharat Abhiyaan have had a positive effect in mitigating diseases but faced limitations due to insufficient funding and limited execution at local levels (Karande et al., 2021; Kumar, 2018; Ravindra et al., 2019).

Thus, the review of the existing body of literature indicates the impact of particular elements of WaSH on limited disease incidence lacking a comprehensive assessment of their integrated influence on health outcomes. Further, there is a limited investigation concerning the influence of socioeconomic and contextual factors on stomach-related disease incidence in a large number of surveyed populations. Thus, the present study attempts to address this gap by conducting a comprehensive empirical analysis across diverse household characteristics in India.

Materials and Methods

The data sources utilized, research design, and methods employed by the study are put forward in the pursuing section.

Data Sources

The present study examines the impact of WaSH practices on health outcomes of Indian households, primarily on stomach problems such as diarrhea, dysentery, and cholera. Secondary data from the National Sample Survey 76th round on “Drinking Water, Sanitation, Hygiene, and Housing Condition” undertaken during July–December 2018 comprising 1,06,838 households (63,736 in rural areas and 43,102 in urban areas) has been utilized. The survey tallied 4,66,527 individuals at all India levels (2,92,208 in rural areas and 1,74,319 in urban areas). The dataset encompasses information on specific types of illnesses affecting the household members during the last 365 days, such as stomach problems (diarrhea/dysentery/cholera) and other diseases (Ministry of Statistics and Programme Implementation, 2018).

Further, as the study utilized data from a nationally representative sample of households from the NSS 76th Round, the sampling frame, size, and unit selection were designed to cover a comprehensive population, providing robust insights into the state of WaSH outcomes in both rural and urban settings. The reliability of the measures was ensured through standardization in data collection procedures by the NSS, and scales were consistent across the survey instruments.

Research Methods

The study has primarily employed quantitative analysis (descriptive and inferential statistical techniques) to examine the association between WaSH practices and stomach related health outcomes in India. A descriptive

Table 1. Description of Response and Predictor Variables

Variables	Description
Response Variable	
Stomach Problem	Yes, No
Predictor Variables - Household Characteristics	
Gender	Male, Female
Age	Less than 10 years, 10 – 29 years, 30 – 59 years, 60 years and above
Education	Illiterate, Up to Upper Primary, Up to Higher Secondary, Graduation and above
Occupation	Self-Employed, Regular Salaried Employee, Casual Wage Labor, Others
Social Group	General, Scheduled Tribe (ST), Scheduled Caste (SC), Other Backward Class (OBC)
Religion	Hindu, Muslim, Others
Predictor Variables - Contextual Characteristics	
Primary Source of Drinking Water	Improved (e.g., Tap, Piped), Unimproved (e.g., Well, River)
Primary Drinking Water Sufficiency Throughout the Year	Yes, No
Primary Drinking Water Treatment Method	Electric Purifiers, Boiling, Others (e.g., Chemically Treated, Non-Electric Purifier, Filtered with Cloth), Not Treated
Type of Sanitation Facility	Flush Latrine (flush/pour-flush to sewer system, septic tank, twin leach pit, single pit, open drain), Pit Latrine (ventilated improved pit latrine, pit latrine with slab, pit latrine without slab), Composting Latrine
Exclusive Use of Toilet	Yes, No
Handwash Before Meals	Yes, No
Housing Condition	Good, Satisfactory, Bad
Ventilation Condition	Good, Satisfactory, Bad

analysis through cross-tabulations is delineated to facilitate researchers and practitioners in understanding the data on the prevalence of disease incidences in India. After that, a binary logistic regression model was employed to empirically investigate the correlates of health outcomes in India. The disease analyzed in the present study is “stomach problems,” as findings indicate that it impacts 16% of households. The logistic model assesses the likelihood of an individual experiencing stomach problems as a function of household and contextual characteristics. The research has hypothesized that safe WaSH practices lead to a lower prevalence of stomach problems among Indian household members. Several predictor variables have been taken into account for the analysis. These have been classified in Table 1. The Stata 14 software package has been used for data analysis.

In pursuant to examining the correlates of disease incidence in India, health outcomes in terms of stomach problems such as diarrhea, dysentery, and cholera have been undertaken as a dichotomous variable (Y). This dependent variable has binary values 0 and 1. Value “1” is assigned if the household has a stomach problem, and “0” is assigned if the household does not have a stomach problem (Tiwari et al., 2022). The correlates of health outcomes in the context of stomach problems are empirically estimated using the following econometric regression equation:

$$Y_{ij} = \alpha_0 + \beta_1 (H_{ij}) + \beta_2 (C_{ij}) + \mu_{ijt} \quad \dots\dots\dots (1)$$

where,

Y_{ij} represents a polychotomous variable representing the incidence of stomach problems for the i^{th} individual belonging to the j^{th} household (0, if the individual does not have a Stomach Problem; 1, if the individual has a Stomach Problem).

H_{ij} represents a vector of household characteristics for the i^{th} individual living in the j^{th} household (such as gender, age, highest educational level, occupation, social group, and religion).

C_{ij} represents a vector of contextual characteristics for the i^{th} individual living in the j^{th} household (such as drinking water source, sufficiency, sanitation, hygiene, and housing conditions).

β represents the marginal effects of the explanatory variables.

μ is the random error term assumed to be independently and identically distributed with constant variance.

Analysis and Results

The following section discusses the findings of the association between health outcomes and predictor variables, as mentioned above. The results are presented in two sub-sections. In the first sub-section, the cross-tabulations between stomach problems and household characteristics are provided. After that, in the second sub-section, econometric results are put forward along with appropriate interpretations.

Association Between Stomach Problems and Household Characteristics in India

The incidence of disease in India varies widely across demographic groups, influenced by factors such as age, gender, and socioeconomic status. Understanding these demographic characteristics is crucial for designing targeted public health interventionist policies. Cross-tabulation, often known as contingency tables, is utilized here to identify associations among categorical variables and provide granular insights (refer to Table 2). This approach improves the precision and effectiveness of data analysis, facilitating the identification and resolution of crucial aspects that impact results (White, 2004).

Table 2. Proportion of Members Reporting Stomach Problems Across Household Characteristics

Variables	Category	Not Having Stomach Problem (%)	Having Stomach Problem (%)	Total (%)
Gender	Male	84.74	15.26	100
	Female	84.85	15.15	100
Age	≤ 10 years	81.94	18.06	100
	> 10 and ≤ 30 years	84.6	15.4	100
	> 30 and ≤ 60 years	85.96	14.04	100
	> 60 years	87.45	12.55	100
Educational Level	Illiterate	82.97	17.03	100
	Upto Upper Primary	83.64	16.36	100
	Upto High School	87.1	12.9	100
	Graduation and above	90.5	9.5	100
Occupation	Self-Employed	84.64	15.36	100
	Regular Salaried	90.8	9.2	100
	Casual Worker	85.05	14.95	100
	Others	84.2	15.8	100
Religion	Hinduism	85.33	14.67	100
	Islam	83.18	16.82	100
	Others	81.41	18.59	100

Social Group	General	87.28	12.72	100
	Scheduled Tribe (ST)	80.86	19.14	100
	Scheduled Caste (SC)	83.54	16.46	100
	Other Backward Class (OBC)	84.7	15.3	100

The analysis presents a detailed description of the prevalence of disease incidence in terms of stomach problems across various demographic and socioeconomic variables in India. First, examining the gender variable, it is observed that both genders, males and females, exhibit similar distributions in reporting stomach problems (approximately 15%). This proposes that gender does not have a significant role in the probability of experiencing stomach concerns in the sample population. Assessing the age group suggests that the likelihood of suffering from stomach problems decreases with age. Younger individuals, i.e., children below the age of 10, are more prone to stomach problems (18.06%) relative to the older age groups. Individuals above 60 years of age report a lower prevalence (12.55%). Examining the educational outcomes, data reveals a negative association between educational attainments and occurrences of stomach-related illnesses, presumably offering a preventive impact. Individuals who have attained the highest education levels among the surveyed population have the lowest occurrence of stomach disorders (9.5%), contrary to illiterate individuals (17.03%).

Discussing the occupational status of the individuals, regular salaried employees report the lowest incidence of stomach problems (9.2%). In contrast, self-employed individuals and casual workers have higher rates of stomach problems, implying that individuals who are less secure or have physically demanding jobs might be at a greater risk of stomach problems. This may be because individuals with consistent and predictable incomes typically have improved healthcare accessibility and better living conditions. In the context of social groups, data reveals disparities in the incidents of stomach problems. Individuals belonging to the ST group exhibit the highest prevalence, accounting for 19.14% of the reported cases. This is closely matched by those from the SC category (16.46%) and OBC (15.30%). The general category indicates a relatively lower likelihood of the disease, though the rate is still substantial. At the outset, this trend may be indicative of wider socioeconomic disparities in marginalized communities as they might be facing greater barriers in obtaining healthcare facilities and causing inferior health outcomes. Religion groups also show differences in the incidences of stomach problems, with Hindus reporting the lowest likelihood (14.67%) compared to Muslims (16.82%) and other religious groups (18.59%). Overall, the results highlight that demographic and socio-economic variables such as age, education, occupation, religion, and social group influence the occurrence of stomach problems in Indian households. Regular employment and higher education levels are linked with lower incidence rates, whereas marginalized communities and younger age groups are more susceptible to higher risks. Hence, targeted interventions are necessary to achieve more favorable and sustainable health outcomes in India.

Association Between Stomach Problems and WaSH Practices in India: An Econometric Analysis

To examine the influence of household characteristics and WaSH practices on the prevalence of stomach problems in India, binary logistic regression analysis has been employed. The study has 373,816 observations as data points. The log-likelihood ratio has been estimated to be -158,552.49. The significance level achieved affirms that the predictors incorporated in the model are strongly correlated with the outcome variable. The value of Pseudo R^2 (0.752) also indicates the robustness of the model (refer to Table 3). The results have been discussed based on household and contextual characteristics as below.

🔗 **Household Characteristics:** The analysis majorly demonstrates a statistically significant relationship between different predictor variables and the likelihood of experiencing a stomach ailment. With respect to gender, being a female is associated with a 4.1% decrease in the likelihood of developing a stomach ailment compared to males.

Table 3. Determinants of Stomach Problems Among Indian Household Members

Variables	Coefficient	Standard Error	Odds Ratio
Gender (Reference: Male)			
Female	-0.0422	-0.0105	0.959
Age Groups (Reference: ≤ 10 years)			
> 10 and ≤ 30 years	-0.0566***	-0.0143	0.945
> 30 and ≤ 60 years	-0.122***	-0.0153	0.886
> 60 years	-0.245***	-0.0213	0.782
Highest Education Level (Reference: Illiterate)			
Upto Upper Primary	0.0134	-0.0127	1.013
Upto Higher Secondary	-0.0825***	-0.0155	0.921
Graduation and Above	-0.169***	-0.0212	0.844
Occupation (Reference Category: Self-Employed)			
Regular Salaried Employee	-0.235***	-0.0221	0.791
Casual Wage Labour	-0.203***	-0.0211	0.816
Social Group (Reference Category: General)			
Others	-0.0341**	-0.0159	0.966
ST	0.504***	-0.0156	1.656
SC	0.136***	-0.0156	1.146
OBC	0.120***	-0.0117	1.128
Religion (Reference Category: Hinduism)			
Islam	0.244***	-0.0131	1.276
Others	0.880***	-0.0144	2.411
Primary Drinking Water Source (Reference Category: Unimproved Source)			
Improved Source	-0.273***	-0.00938	0.761
Primary Drinking Water Sufficiency (Reference: No)			
Yes	-0.220***	-0.0132	0.803
Primary Drinking Water Treatment Method (Reference: Not Treated)			
Electric Purifier	-0.159***	-0.0196	0.853
Boiling	-0.208***	-0.0153	0.812
Others	0.147***	-0.0112	1.159
Sanitation Facility (Reference Category: Composting Latrine)			
Flush Latrine	-0.357***	-0.0636	0.710
Pit Latrine	-0.158**	-0.0645	0.854
Exclusive Use of Latrine (Reference: No)			
Yes	0.174***	-0.0158	1.191
Handwash Before Meals (Reference: No)			
Yes	-0.421***	-0.0494	0.656
Structure Condition (Reference: Bad)			
Good	-0.123***	-0.0213	0.884
Satisfactory	-0.0868***	-0.0192	0.912
Ventilation Condition (Reference: Bad)			

Good	-0.280***	-0.0200	0.756
Satisfactory	-0.0817***	-0.0177	0.922
Constant	-0.678***	-0.0847	0.507
Observations		3,73,816	
Log Likelihood		-158,552.49	
LR χ^2 (212)		14,904.38	
Prob > χ^2		0.000	
Pseudo R^2		0.752	

Note. *, **, and *** indicates 1%, 5%, and 10% level of significance, respectively.

However, the result is not significant. This indicates that gender does not have a significant impact on disease prevalence. Furthermore, the data reveals that age has varying implications on the probability of experiencing stomach problems compared to the reference group, children up to 10 years of age. Individuals aged above 10 years to 30 years report a drop of 5.5% in the probability of disease prevalence. For those between 30 and 60 years, a reduction of 11.4% in the odds is observed. Finally, individuals over 60 years old indicate the highest fall in the probability (21.8%) relative to the reference group.

Additionally, those with higher levels of education, such as graduation and beyond, exhibit a reduced likelihood of experiencing gastrointestinal problems (15.6%) in comparison to those who are illiterate. Analysis further reveals that individuals with a higher secondary education have a 7.9% reduced probability of suffering from stomach problems. Similarly, relative to being self-employed, salaried workers or casual wage laborers have a lower likelihood of experiencing stomach issues, with a probability of 20.9% and 18.4%, respectively. Social groups and religion also exert substantial influence on health outcomes. Individuals belonging to Scheduled Tribes (ST) have a significantly elevated likelihood of approximately 65.6% of encountering gastrointestinal issues relative to the General group. The odds of Scheduled Castes (SC) and Other Backward Classes (OBC) are similarly elevated by 14.6% and 12.8%, respectively. Furthermore, Hindus have a much lower likelihood of experiencing stomach issues relative to other religions. Specifically, Muslims have a 141.1% higher likelihood, and individuals belonging to other religions have a 27.6% higher chance relative to Hindus.

☞ **Contextual Characteristics:** Several WaSH practices also significantly influence the likelihood of suffering from stomach ailments. For instance, individuals utilizing an improved drinking water source are associated with a 23.9% lower likelihood of experiencing stomach issues compared to unimproved sources. Additionally, the presence of sufficient drinking water throughout the year reduces the probability of reporting stomach disease by 19.7% relative to insufficient availability of drinking water. The choice of treatment methods also influences the level of contracting the ailment.

For instance, employing an electric purifier leads to a 14.7% decrease, while boiling water results in an 18.8% reduction. Nevertheless, any alternative approach enhances the chances of stomach problems by 15.9%. Regarding sanitation facilities, relative to a composting pit, individuals using a flush toilet experienced a decreased likelihood of stomach ailment by 29.0%, while those using a pit latrine reported a reduction of 14.6%. Additionally, using a latrine exclusively is linked to a 19.1% higher likelihood relative to not using a toilet exclusively. Moreover, engaging in handwashing resulted in a noteworthy decrease of 34.4% in the likelihood of experiencing stomach issues compared to those who did not. The state of the living structure also has a significant impact on health outcomes. Good housing structure condition is correlated with an 11.6% reduction in the likelihood of the disease, while satisfactory circumstances lead to an 8.8% reduction. Effective ventilation also

decreases the likelihood of ailment by 24.4%, whereas satisfactory ventilation conditions result in a smaller reduction of 7.8%. Thus, demographic factors and WaSH practices have been estimated to have a substantial influence on the occurrence of stomach problems in India.

Theoretical and Policy Implications

The following section highlights the significant contributions of the present research to the literature and policy on health disparities among Indian household members. By incorporating both demographic factors and individual WaSH practices, this study provides valuable insights into health equity and the social determinants of stomach problems in India.

Theoretical Implications

The present study provides a profound understanding of the complex interplay between social determinants and health outcomes, especially focusing on disparities in stomach-related illnesses. Our study finds that inadequate WaSH significantly contributes to the prevalence of diseases such as diarrhea, dysentery and cholera. The findings further reveal substantial variations in the incidence of stomach problems across demographic groups, indicating the differential influence of WaSH practices. This adds to the existing literature that often addresses health disparities broadly, lacking granular insights concerning sub-groups, specifically within developing nations. This also aligns with the growing body of literature that supports a direct relationship between health outcomes and economic productivity. Poor health outcomes driven by unsafe WaSH not only diminish productivity but also reduce labor force participation, promote absenteeism, and pose high pressure on healthcare systems, especially in low and middle-income countries, such as India. It further exacerbates inequality as poor WaSH facilities limit educational opportunities, particularly for girls, resulting in malnutrition, impaired cognitive development as well as reduced prospects for future economic participation (Dimble & Menon, 2017).

The global economic cost attributable to poor sanitation is estimated to be \$222.9 billion in 2015. This amount accounted for 0.9% of the GDP in afflicted nations. Further, 5.2% of India's GDP is estimated to be lost due to inadequate sanitation facilities (LIXIL Group Corporation, 2016). This huge burden emphasizes the need for adequate WaSH interventions to promote a healthier nation with enhanced efficiency. Further, the economic benefits of investing in WaSH are immense, as noted by the United Nations (2014). For every 1 USD invested in water and sanitation, a USD 4.3 return is received in the form of reduced healthcare costs for individuals and society. Therefore, our study supports the economic justification for investing in safe WaSH outcomes. By addressing the existing gaps, communities can escape poverty nutrition traps by reinforcing a virtuous loop of improved health, enhanced education, higher productivity, and better economic output. Thus, prioritizing WaSH is not just a public health concern but a strategic economic move that can drive social equity, alleviate poverty, bring long-term economic opportunities, and foster inclusive growth in India.

Policy Implications

Basis the findings, several pertinent public policies emerge. First, expanding WaSH infrastructure by installing additional community water treatment plants and household filters is the need of the hour, as also stressed by Balasooriya et al. (2023). Second, consumption from improved water sources such as piped water and protected springs should be preferred and prioritized over unimproved sources. However, for ensuring safe and consistent drinking water quality, regular inspection of improved sources and their sufficiency is also desirable. Third, technological advancements such as smart monitoring systems and affordable household filters should be harnessed to further improve the WaSH facilities, as also supported by Silva (2023). Fourth, effective methods for

treating water, especially in underserved areas, such as boiling water and electric purifiers, should be encouraged, and other alternatives, such as cloth filtration, should be avoided. Fifth, targeted interventions for both rural and urban areas, such as hygiene education campaigns and age-specific school programs, will further improve the health outcomes, as also corroborated by Prüss-Ustün et al. (2014) and Tiwari et al. (2022). The COVID-19 pandemic has widely advocated proper handwashing regimes as a cure for a wide spectrum of diseases, including stomach-related ailments and therefore, should be further strengthened, as also supported by Jatav et al. (2021). Finally, the government should promote urban planning policies that incorporate health considerations to improve public well-being on a larger scale. Initiatives such as the Swachh Bharat Mission and National Rural Drinking Water Program are steps in the right direction for achieving SDG 6, “Clean Water and Sanitation,” and building healthier communities.

Conclusion

Over time, unsafe WaSH has become one of the greatest risks to human existence due to multifaceted challenges. Safe WaSH conditions prevent diseases and promote human dignity, quality of life, and sustainable development. Due to the critical relevance of WaSH practices, researchers and practitioners worldwide are delving into several facets of WaSH, such as examining the WaSH quality, availability, accessibility, and governance. However, there remains a lack of understanding and empirical evidence concerning the impact of WaSH practices among Indian households. A comprehensive analysis of WaSH practices and their association with disease incidences in India is examined based on the National Sample Survey, 76th Round on “Drinking Water, Sanitation, Hygiene, and Housing Condition,” offering crucial insights for public health policy. Both cross-tabulations and binary logistic regression are employed to empirically test the significance. The findings reveal significant correlations between inadequate WaSH facilities/practices and the prevalence of stomach problems. The studies of Chastonay and Chastonay (2022) and Tirumala and Tiwari (2022) highlighted disparities across demographic attributes such as gender, age, religion, education, social groups, and housing conditions, indicating that vulnerable populations are disproportionately affected by inadequate WaSH practices. Lower education levels and poorer housing conditions are associated with higher disease incidences, emphasizing the necessity for socioeconomic interventions.

Furthermore, individuals who utilize unimproved or untreated drinking water sources or do not have sufficient water access are more susceptible to higher risks of contracting stomach ailments. Inadequate sanitation facilities (such as poor ventilation and lack of handwashing before meals) further exacerbate these health risks. A comprehensive policy approach toward improved WaSH practices could significantly reduce the disease burden in India.

Limitations of the Study and Scope for Further Research

While this study offers valuable insights, a further scope of research exists. For instance, the present research relies on cross-sectional data, which limits the ability to infer the trends over time. The long-term impact of the interventions can be determined through longitudinal studies. Further, the study focuses specifically on stomach ailments, which, while significant, may not fully represent the broader spectrum of health outcomes impacted by WaSH practices. Future research can expand this scope to include other diseases as well. Additionally, the cost-effectiveness of various interventions should be examined to assist policymakers in providing effective resource allocations. Investigating the economic benefits of improved health outcomes resulting from enhanced WaSH practices could bolster the case for increased investment in such interventions, thereby contributing to better public health policies, economic growth, and sustainable development in India.

Authors' Contribution

Prof. Simrit Kaur conceived the idea and developed a quantitative design to undertake the empirical study. Kamaldeep Kaur Sarna extracted relevant research papers and reviewed the literature. Ms. Sarna also carried out the econometrics computations. The authors jointly prepared the manuscript.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

Funding Acknowledgement

The authors received no financial support for the research, authorship, and/or for the publication of this article.

References

- Adimalla, N., Venkatayogi, S., & Das, S. V. (2019). Assessment of fluoride contamination and distribution: A case study from a rural part of Andhra Pradesh, India. *Applied Water Science*, 9, Article No. 94. <https://doi.org/10.1007/s13201-019-0968-y>
- Anbazhagi, M., Loganathan, D., Tamilselvan, S., Jayabalou, R., Kamatchiammal, S., & Kumar, R. (2007). Cryptosporidium oocysts in drinking water supply of Chennai city, Southern India. *CLEAN: Soil, Air, Water*, 35(2), 167–171. <https://doi.org/10.1002/clen.200600034>
- Azevedo, M. J. (2017). The state of health system(s) in Africa: Challenges and opportunities. In *Historical perspectives on the state of health and health systems in Africa* (Vol. 2, pp. 1–73). Palgrave Macmillan. https://doi.org/10.1007/978-3-319-32564-4_1
- Balasooriya, B. M., Rajapakse, J., & Gallage, C. (2023). A review of drinking water quality issues in remote and indigenous communities in rich nations with special emphasis on Australia. *Science of The Total Environment*, 903, Article ID 166559. <https://doi.org/10.1016/j.scitotenv.2023.166559>
- Basu, M., & Dasgupta, R. (2021). Where do we stand now? A bibliometric analysis of water research in support of the sustainable development goal 6. *Water*, 13(24), 3591. <https://doi.org/10.3390/w13243591>
- Berihun, G., Adane, M., Walle, Z., Abebe, M., Alemnew, Y., Natnael, T., Andualem, A., Ademe, S., Tegegne, B., Teshome, D., & Berhanu, L. (2022). Access to and challenges in water, sanitation, and hygiene in healthcare facilities during the early phase of the COVID-19 pandemic in Ethiopia: A mixed-methods evaluation. *PLoS ONE*, 17(5), Article ID e0268272. <https://doi.org/10.1371/journal.pone.0268272>
- Bishoge, O. K. (2021). Challenges facing sustainable water supply, sanitation and hygiene achievement in urban areas in sub-Saharan Africa. *Local Environment*, 26(7), 893–907. <https://doi.org/10.1080/13549839.2021.1931074>
- Biswas, S. S., & Karmakar, R. (2022). Determinants of hand-hygiene practices in India: Reflections from the 76th round National Sample Survey, 2018. *Journal of Water & Health*, 20(1), 68–82. <https://doi.org/10.2166/wh.2021.140>

- Biswas, S., Dandapat, B., Alam, A., & Satpati, L. (2022). India's achievement towards sustainable development goal 6 (ensure availability and sustainable management of water and sanitation for all) in the 2030 agenda. *BMC Public Health*, 22, Article no. 2142. <https://doi.org/10.1186/s12889-022-14316-0>
- Biswas, T., Pal, S. C., Saha, A., & Ruidas, D. (2023). Arsenic and fluoride exposure in drinking water caused human health risk in coastal groundwater aquifers. *Environmental Research*, 238(Part 2), Article ID 117257. <https://doi.org/10.1016/j.envres.2023.117257>
- Chastonay, A. H., & Chastonay, O. J. (2022). Housing risk factors of four tropical neglected diseases: A brief review of the recent literature. *Tropical Medicine and Infectious Disease*, 7(7), 143. <https://doi.org/10.3390/tropicalmed7070143>
- Chauhan, J. S., Badwal, T., & Badola, N. (2020). Assessment of potability of spring water and its health implication in a hilly village of Uttarakhand, India. *Applied Water Science*, 10(2), Article no. 73. <https://doi.org/10.1007/s13201-020-1159-6>
- Deshpande, A., Miller-Petrie, M. K., Lindstedt, A., Baumann, M. M., Johnson, K. B., Blacker, F., Abbastabar, H., Abd-Allah, F., Abdelalim, A., Abdollahpour, I., Abegaz, K. H., Abejie, A. N., Abreu, L. G., Abrigo, M. R., Abualhasan, A., Accrombessi, M. M., Adamu, A., Adebayo, O. M., & Adedeji, I. A. (2020). Mapping geographical inequalities in access to drinking water and sanitation facilities in low-income and middle-income countries, 2000–17. *The Lancet Global Health*, 8(9), E1162–E1185. [https://doi.org/10.1016/S2214-109X\(20\)30278-3](https://doi.org/10.1016/S2214-109X(20)30278-3)
- Dimble, V., & Menon, N. (2017). *Health policy, health outcomes, and economic growth: Lessons from India*. International Growth Centre. <https://www.theigc.org/sites/default/files/2017/05/Dimble-and-Menon-2017-policy-brief-6.pdf>
- Donde, O. O., Atoni, E., Muia, A. W., & Yillia, P. T. (2021). COVID-19 pandemic: Water, sanitation and hygiene (WASH) as a critical control measure remains a major challenge in low-income countries. *Water Research*, 191, Article ID 116793. <https://doi.org/10.1016/j.watres.2020.116793>
- Gera, T., Shah, D., & Sachdev, H. S. (2018). Impact of water, sanitation and hygiene interventions on growth, non-diarrheal morbidity and mortality in children residing in low- and middle-income countries: A systematic review. *Indian Pediatrics*, 55(5), 381–393. <https://www.indianpediatrics.net/may2018/381.pdf>
- Giri, M., Behera, M. R., Behera, D., Mishra, B., & Jena, D. (2022). Water, sanitation, and hygiene practices and their association with childhood diarrhoea in rural households of Mayurbhanj district, Odisha, India. *Cureus*, 14(10), e29888. <https://doi.org/10.7759/cureus.29888>
- Giri, S., Mohan, V. R., Srinivasan, M., Kumar, N., Kumar, V., Dhanapal, P., Venkatesan, J., Gunasekaran, A., Abraham, D., John, J., & Kang, G. (2021). Case-control study of household and environmental transmission of typhoid fever in India. *The Journal of Infectious Diseases*, 224(Suppl_5), S584–S592. <https://doi.org/10.1093/infdis/jiab378>
- Goyanka, R. (2021). Burden of water, sanitation and hygiene related diseases in India: Prevalence, health care cost and effect of community level factors. *Clinical Epidemiology and Global Health*, 12, Article ID 100887. <https://doi.org/10.1016/j.cegh.2021.100887>
- Gupta, R., & Misra, A. K. (2019). Drinking water quality problem in Haryana, India: Prediction of human health risks, economic burden and assessment of possible intervention options. *Environment, Development and Sustainability*, 21(5), 2097–2111. <https://doi.org/10.1007/s10668-018-0125-z>

- Gyanendra, Y., Yumnam, G., Alam, W., & Singh, C. I. (2022). A bibliometric analysis and assessment of scientific studies trend on groundwater research in India during 1989–2020. *Arab Journal of Geosciences*, 15, Article no. 1417. <https://doi.org/10.1007/s12517-022-10707-0>
- Howard, G. (2021). The future of water and sanitation: Global challenges and the need for greater ambition. *AQUA: Water Infrastructure, Ecosystems and Society*, 70(4), 438–448. <https://doi.org/10.2166/aqua.2021.127>
- Jatav, S. S., Nayak, S., Meher, S., & Narang, S. (2021). Coping to COVID-19 in Uttar Pradesh, India: Evidence from NSSO 76th round data. *Current Urban Studies*, 9(2), 206–217. <https://doi.org/10.4236/cus.2021.92013>
- Jena, M., Panda, B., Behera, D., Mohanty, S., & Behera, M. R. (2024). Water, sanitation, and hygiene (WASH) practices of mothers and the health status of under-five children: A study from rural Nayagarh, Odisha. *Journal of Water & Health*, 22(7), 1293–1305. <https://doi.org/10.2166/wh.2024.096>
- Kanungo, S., Chatterjee, P., Saha, J., Pan, T., Chakrabarty, N. D., & Dutta, S. (2021). Water, sanitation, and hygiene practices in urban slums of Eastern India. *The Journal of Infectious Diseases*, 224(Suppl_5), S573–S583. <https://doi.org/10.1093/infdis/jiab354>
- Karande, K., Tandon, S., Vijay, R., Khanna, S., Banerji, T., & Sontakke, Y. (2021). Prevalence of water-borne diseases in western India: Dependency on the quality of potable water and personal hygiene practices. *Journal of Water, Sanitation & Hygiene for Development*, 11(3), 405–415. <https://doi.org/10.2166/washdev.2021.200>
- Kaur, D., Kaur, K., Sharma, A., Goyal, H., Pahuja, A., & Solanki, D. (2022). Assessment of fluoride content in water and its impact on the intelligence quotient of school children aged 12–13 years. *Cureus*, 14(10), Article ID e30157. <https://doi.org/10.7759/cureus.30157>
- Kim, J.-H., Cheong, H.-K., & Jeon, B.-H. (2018). Burden of disease attributable to inadequate drinking water, sanitation, and hygiene in Korea. *Journal of Korean Medical Science*, 33(46), Article ID e288. <https://doi.org/10.3346/jkms.2018.33.e288>
- Kuberan, A., Singh, A. K., Kasav, J. B., Prasad, S., Surapaneni, K. M., Upadhyay, V., & Joshi, A. (2015). Water and sanitation hygiene knowledge, attitude, and practices among household members living in rural setting of India. *Journal of Natural Science, Biology, and Medicine*, 6(Suppl_1), S69–S74. <https://doi.org/10.4103/0976-9668.166090>
- Kumar, A. (2018). Swachh Bharat Mission: A missed opportunity for the Indian economy. *Arthshastra Indian Journal of Economics & Research*, 7(3), 40–52. <https://doi.org/10.17010/aijer/2018/v7i3/130155>
- Kumar, K. U., & Rajendran, S. (2016). A study on water and sanitation facilities in higher secondary schools in Salem District, Tamil Nadu. *Arthshastra Indian Journal of Economics & Research*, 5(6), 21–30. <https://doi.org/10.17010/aijer/2016/v5i6/107519>
- Lin, J., & Feng, X. L. (2023). Exploring the impact of water, sanitation and hygiene (WASH), early adequate feeding and access to health care on urban–rural disparities of child malnutrition in China. *Maternal & Child Nutrition*, 19(4), Article ID e13542. <https://doi.org/10.1111/mcn.13542>
- LIXIL Group Corporation. (2016). *The true cost of poor sanitation*. LIXIL. https://www.lixil.com/en/impact/sanitation/pdf/white_paper_en_cc_2016.pdf

- Mackinnon, E., Ayah, R., Taylor, R., Owor, M., Ssempebwa, J., Olago, I. D., Kubalako, R., Dia, A. T., Gaye, C., Campos, L. C., & Fottrell, E. (2018). 21st century research in urban WASH and health in sub-Saharan Africa: Methods and outcomes in transition. *International Journal of Environmental Health Research*, 29(4), 457–478. <https://doi.org/10.1080/09603123.2018.1550193>
- Maraddi, K. S., & Ho, Y.-S. (2022). A bibliometric analysis of publications on drinking water research in India. *Current Journal of Applied Science and Technology*, 41(44), 24–42. <https://doi.org/10.9734/cjast/2022/v41i444010>
- McMichael, C. (2019). Water, sanitation and hygiene (WASH) in schools in low-income countries: A review of evidence of impact. *International Journal of Environmental Research and Public Health*, 16(3), 359. <https://doi.org/10.3390/ijerph16030359>
- Meki, C. D., Ncube, E. J., & Voyi, K. (2022). Frameworks for mitigating the risk of waterborne diarrheal diseases: A scoping review. *P L o S O N E*, 17(12), Article ID e0278184. <https://doi.org/10.1371/journal.pone.0278184>
- Merid, M. W., Alem, A. Z., Chilot, D., Belay, D. G., Kibret, A. A., Asratie, M. H., Shibabaw, Y. Y., & Aragaw, F. M. (2023). Impact of access to improved water and sanitation on diarrhea reduction among rural under-five children in low and middle-income countries: A propensity score matched analysis. *Tropical Medicine and Health*, 51, Article no. 36. <https://doi.org/10.1186/s41182-023-00525-9>
- Ministry of Statistics and Programme Implementation. (2018). *Unit level data & report on NSS 76th round for schedule 1.2, July-December, 2018 (Drinking water, sanitation, hygiene and housing condition)*. Government of India. <https://mospi.gov.in/unit-level-data-report-nss-76th-round-schedule-12-july-december-2018-drinking-water-sanitation>
- Mishra, V. K., & Khan, K. (2023). Determinants of discrimination in access to housing for marginalised social groups in India. *Journal of Social Inclusion Studies*, 9(1), 7–26. <https://doi.org/10.1177/23944811231169194>
- Mohanty, N. K., Sahoo, K. C., Pati, S., Sahu, A. K., & Mohanty, R. (2020). Prevalence of chronic kidney disease in Cuttack district of Odisha, India. *International Journal of Environmental Research and Public Health*, 17(2), 456. <https://doi.org/10.3390/ijerph17020456>
- Mondal, D. (2022). Access to latrine facilities and associated factors in India: An empirical and spatial analysis. *Indian Journal of Human Development*, 16(3), 528–547. <https://doi.org/10.1177/09737030221141248>
- Okesanya, O. J., Eshun, G., Ukoaka, B. M., Manirambona, E., Olabode, O. N., Adesola, R. O., Okon, I. I., Jamil, S., Singh, A., Lucero-Prisno III, D. E., Ali, H. M., & Chowdhury, A. B. (2024). Water, sanitation, and hygiene (WASH) practices in Africa: Exploring the effects on public health and sustainable development plans. *Tropical Medicine and Health*, 52, Article no. 68. <https://doi.org/10.1186/s41182-024-00614-3>
- Palit, A., Batabyal, P., Kanungo, S., & Sur, D. (2012). In-house contamination of potable water in urban slum of Kolkata, India: A possible transmission route of diarrhea. *Water Science & Technology*, 66(2), 299–303. <https://doi.org/10.2166/wst.2012.177>
- Palo, S. K., Kanungo, S., Samal, M., Priyadarshini, S., Sahoo, D., & Pati, S. (2021). Water, sanitation, and hygiene (WaSH) practices and morbidity status in a rural community: Findings from a cross-sectional study in Odisha, India: WaSH practices and morbidity in rural community. *Journal of Preventive Medicine and Hygiene*, 62(2), E392–E398. <https://doi.org/10.15167/2421-4248/jpmh2021.62.2.1503>

- Parikh, P., Diep, L., Hofmann, P., Tomei, J., Campos, L. C., Teh, T.-H., Mulugetta, Y., Milligan, B., & Lakhanpaul, M. (2021). Synergies and trade-offs between sanitation and the sustainable development goals. *UCL Open Environment*, 2. <https://doi.org/10.14324/111.444/ucloe.000016>
- Perin, J., Mulick, A., Yeung, D., Villavicencio, F., Lopez, G., Strong, K. L., Prieto-Merino, D., Cousens, S., Black, R. E., & Liu, L. (2022). Global, regional, and national causes of under-5 mortality in 2000–19: An updated systematic analysis with implications for the sustainable development goals. *The Lancet Child & Adolescent Health*, 6(2), 106–115. [https://doi.org/10.1016/S2352-4642\(21\)00311-4](https://doi.org/10.1016/S2352-4642(21)00311-4)
- Portillo, L. J., Kayser, G. L., Ko, C., Vasquez, A., Gonzalez, J., Avelar, D. J., Alvarenga, N., Franklin, M., & Chiang, Y.-Y. (2023). Water, sanitation, and hygiene (WaSH) insecurity in unhoused communities of Los Angeles, California. *International Journal for Equity in Health*, 22, Article no. 108. <https://doi.org/10.1186/s12939-023-01920-8>
- Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., Bonjour, S., Dangour, A. D., De France, J., Fewtrell, L., Freeman, M. C., Gordon, B., Hunter, P. R., Johnston, R. B., Mathers, C., Mäusezahl, D., Medlicott, K., Neira, M., Stocks, M., ... Wolf, J. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: A retrospective analysis of data from 145 countries. *Tropical Medicine & International Health*, 19(8), 894–905. <https://doi.org/10.1111/tmi.12329>
- Prüss-Ustün, A., Wolf, J., Corvalán, C., Neville, T., Bos, R., & Neira, M. (2017). Diseases due to unhealthy environments: An updated estimate of the global burden of disease attributable to environmental determinants of health. *Journal of Public Health*, 39(3), 464–475. <https://doi.org/10.1093/pubmed/fdw085>
- Ravindra, K., Mor, S., & Pinnaka, V. L. (2019). Water uses, treatment, and sanitation practices in rural areas of Chandigarh and its relation with waterborne diseases. *Environmental Science and Pollution Research International*, 26(19), 19512–19522. <https://doi.org/10.1007/s11356-019-04964-y>
- Ray, K., Shukla, V., Basu, M., Manna, S., Rashid, M., & Mondal, A. (2024). Water, sanitation, and hygiene (WASH) practices among residents of different slum settlements in a ward of Kolkata: A mixed-methods study. *Journal of Education and Health Promotion*, 13(1), 113. https://doi.org/10.4103/jehp.jehp_995_23
- Raychaudhuri, P. S., & Singh, A. (2011). An exploratory study of hygiene, sanitation, and health awareness of people at some prominent public places in Delhi. *Prabandhan: Indian Journal of Management*, 4(7), 18–26. <https://doi.org/10.17010/pijom/2011/v4i7/62573>
- Reddy, D. V., & Gunasekar, A. (2013). Chronic kidney disease in two coastal districts of Andhra Pradesh, India: Role of drinking water. *Environmental Geochemistry and Health*, 35(4), 439–454. <https://doi.org/10.1007/s10653-012-9506-7>
- Saarangapani, B., & Sripathi, K. (2015). Environmental degradation in India - Dimensions and concerns: A review. *Prabandhan: Indian Journal of Management*, 8(4), 51–62. <https://doi.org/10.17010/pijom/2015/v8i4/63821>
- Saroj, S. K., Goli, S., Rana, M. J., & Choudhary, B. K. (2020). Availability, accessibility, and inequalities of water, sanitation, and hygiene (WASH) services in Indian metro cities. *Sustainable Cities and Society*, 54, Article ID 101878. <https://doi.org/10.1016/j.scs.2019.101878>

- Sifullah, M. K., Sohel, M. S., Jamil, S., Hasan, M. M., Anika, J., Swadhin, H. R., Chaudhary, N., Rahman, M. N., Shaiara, M., Islam, M. T., Ahmad, B., Shomapto, M. I., Sarker, M. F., & Sohag, S. M. (2024). Assessment of water, hygiene, and sanitation practice and associated factors among Bihari refugee camp in Bangladesh: A cross-sectional study. *Health Science Reports*, 7(2), Article ID e1910. <https://doi.org/10.1002/hsr2.1910>
- Silva, J. A. (2023). Wastewater treatment and reuse for sustainable water resources management: A systematic literature review. *Sustainability*, 15(14), 10940. <https://doi.org/10.3390/su151410940>
- Singh, J., Hazrana, J., & Nazrana, A. (2016). Agriculture sustainability in Punjab with reference to groundwater availability. *Arthshastra: Indian Journal of Economics & Research*, 5(5), 49–55. <https://doi.org/10.17010/aijer/2016/v5i5/105153>
- Soboksa, N. E., Gari, S. R., Hailu, A. B., & Alemu, B. M. (2020). Association between microbial water quality, sanitation and hygiene practices and childhood diarrhea in Kersa and Omo Nada districts of Jimma Zone, Ethiopia. *PLoS ONE*, 15(2), Article ID e0229303. <https://doi.org/10.1371/journal.pone.0229303>
- Taylor, D. L., Kahawita, T. M., Cairncross, S., & Ensink, J. H. (2015). The impact of water, sanitation and hygiene interventions to control cholera: A systematic review. *PLoS ONE*, 10(8), Article ID e0135676. <https://doi.org/10.1371/journal.pone.0135676>
- The World Bank. (2017). *Waterlife: Improving access to safe drinking water in India*. World Bank Group. <https://documents1.worldbank.org/curated/en/586371495104964514/pdf/115133-WP-P152203-PUBLIC-17-5-2017-12-28-1-WaterlifeCaseApril.pdf>
- The World Bank. (2023). *Water: As the world's largest multilateral source of financing for water in developing countries, the World Bank is committed to Water for People and Planet*. World Bank Group. <https://www.worldbank.org/en/topic/water/overview>
- Tirumala, R. D., & Tiwari, P. (2022). Household expenditure and accessibility of water in urban India. *Environment and Planning B: Urban Analytics and City Science*, 49(8), 2072–2090. <https://doi.org/10.1177/23998083221080178>
- Tiwari, P., Tirumala, R. D., & Shukla, J. (2022). Household choices of sanitation infrastructure and impact on disease in India. *Environment and Planning B: Urban Analytics and City Science*, 49(8), 2054–2071. <https://doi.org/10.1177/23998083221088293>
- United Nations (UN). (2011). *The human right to water and sanitation: Media brief*. United Nations Water for Life Decade. https://www.un.org/waterforlifedecade/pdf/human_right_to_water_and_sanitation_media_brief.pdf
- United Nations. (2014). 'Learning to live together' is vital in today's world, says UNESCO on International Day of Tolerance. UN News.
- United Nations. (2023). *Health, water and sanitation*. <https://india.un.org/en/171844-health-water-and-sanitation>
- United Nations Children's Fund (UNICEF). (2023). *Triple threat: Unmet needs in water, sanitation and hygiene (WASH), nutrition and health have disastrous consequences for children*. <https://www.unicef.org/media/137206/file/triple-threat-wash-EN.pdf>

- Usha, S., Rakesh, P. S., Subhagan, S., Shaji, M., & Salila, K. (2014). A study on contamination risks of wells from Kollam district, Southern India. *Journal of Water, Sanitation & Hygiene for Development*, 4(4), 727–732. <https://doi.org/10.2166/WASHdev.2014.151>
- Wani, H., Smeets, P., & Shrivastava, S. (2022). Evaluation of WASH indicators associated with diarrhoeal disease among under-five children in an urban slum pocket, Mumbai city, India: A community-based repeated cross-sectional study. *Journal of Water, Sanitation & Hygiene for Development*, 12(4), 359–374. <https://doi.org/10.2166/WASHdev.2022.196>
- White, D. R. (2004). A student's guide to statistics for analysis of cross tabulations. *World Cultures*, 14(2), 179–193. <https://escholarship.org/uc/item/8xn2s349>
- Wolf, J., Hubbard, S., Brauer, M., Ambelu, A., Arnold, B. F., Bain, R., Bauze, V., Brown, J., Caruso, B. A., Clasen, T., Colford, J. M., Freeman, M. C., Gordon, B., Johnston, R. B., Mertens, A., Prüss-Ustün, A., Ross, I., Stanaway, J., Zhao, J. T.,& Cumming, O. (2022). Effectiveness of interventions to improve drinking water, sanitation, and handwashing with soap on risk of diarrhoeal disease in children in low-income and middle-income settings: A systematic review and meta-analysis. *The Lancet*, 400(10345), 48–59. [https://doi.org/10.1016/S0140-6736\(22\)00937-0](https://doi.org/10.1016/S0140-6736(22)00937-0)
- World Health Organization. (2023a). *1 in 3 people globally do not have access to safe drinking water*. <https://www.who.int/news/item/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who>
- World Health Organization. (2023b). *Drinking water*. WHO. <https://www.who.int/news-room/fact-sheets/detail/drinking-water>
- World Health Organization. (2024). *Mortality rate attributed to exposure to unsafe WASH services (per 100,000 population) (SDG 3.9.2)*. World Health Organization. [https://www.who.int/data/gho/data/indicators/indicator-details/GHO/mortality-rate-attributed-to-exposure-to-unsafe-wash-services-\(per-100-000-population\)-\(sdg-3-9-2\)](https://www.who.int/data/gho/data/indicators/indicator-details/GHO/mortality-rate-attributed-to-exposure-to-unsafe-wash-services-(per-100-000-population)-(sdg-3-9-2))
- Xu, L., Suman, S., Sharma, P., Kumar, R., Singh, S. K., Bose, N., Ghosh, A., Rahman, M. M., Polya, D. A., & Mondal, D. (2021). Assessment of hypertension association with arsenic exposure from food and drinking water in Bihar, India. *Ecotoxicology and Environmental Safety*, 223, Article ID 112572. <https://doi.org/10.1016/j.ecoenv.2021.112572>

About the Authors

Ms. Kamaldeep Kaur Sarna is an Assistant Professor at Shri Ram College of Commerce, University of Delhi. She is presently pursuing her Ph.D. from the Faculty of Management Studies, University of Delhi. Her research areas of interest include sustainable development, financial economics, and public policy. She has published/presented several research papers in reputed journals and co-authored Opinion articles in *The Indian Express* and *The Pioneer*.

Prof. Simrit Kaur is the Principal of Shri Ram College of Commerce (SRCC), University of Delhi. As a trained Economist, she has undertaken several research projects and acted as an advisor to reputed institutes and organizations. Nominated by the Indian Council of Cultural Relations, Dr. Kaur has been a “Visiting Professor” at the University of Social Sciences and Humanities, Ho Chi Minh City, Vietnam, and a “Visiting Scholar” at Kingston University, London. Dr. Kaur’s book *Privatization and Public Regulation: The Indian Experience*, published by Macmillan, received the Best Book Award.