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Bridging the Rural Water Divide through Jal Jeevan Mission in Bihar: Household Determinants of Functional Tap Water Access

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Abstract

Ensuring equitable access to safe drinking water remains a central development challenge in rural India despite substantial public investment. JJM aims to provide FHTCs to all rural households. This study examines the determinants of functional water connection access in the Samastipur district of Bihar using primary household data collected in 2025. A community-based cross-sectional study was conducted among 926 rural households selected through random sampling. Descriptive analysis, chi-square tests, and binary logistic regression were employed to identify significant predictors of access to functional tap water connections. Results indicate that 84.9 per cent of households reported having a functional JJM connection; however, access varied significantly across socio-economic groups. Regression estimates reveal that households where the head had secondary and above education were more likely to have a functional connection than households with an illiterate head. Pacca households exhibited significantly higher odds of access (OR = 1.87, $p < 0.05$). Households with separate kitchen were more likely to have functional connections (OR = 2.74, $p < 0.01$). Middle-income households showed a positive and significant association with access (OR = 1.69, $p < 0.05$). Although caste-based differences were observed in bivariate analysis, their effects became statistically insignificant after adjusting for education and housing characteristics, suggesting the presence of indirect pathways of inequality. The findings underscore that infrastructure expansion alone does not ensure equitable water access. Addressing socio-economic vulnerabilities through integrated interventions in education, housing, and social inclusion is essential to achieving sustainable, inclusive outcomes under the Jal Jeevan Mission.

Keywords: Bihar; Caste; Education; Households; Jal Jeevan Mission; Rural; Water

Introduction

Access to adequate and safe drinking water is universally recognised as a fundamental human right and a critical prerequisite for human dignity, public health and socioeconomic development. The United Nations, through SDG 6, explicitly emphasises equitable and universal access to safe and affordable drinking water globally by 2030 (United Nations, 2015). It also aims to eliminate open defecation, giving special consideration to the needs of women, girls, and vulnerable groups (Fu, et al., 2022; Zambrano-Monserrate and Sanchez-Alcalde, 2024). The affordability, adequacy and accessibility of quality water significantly influence a nation's socioeconomic development (Boakye-Ansah et al., 2016). Globally, water managers and governments employ policies like tariffs and income-based support to balance water demand and address water poverty (Pinto and Marques, 2016). Disparities in water access persist globally, particularly in rural regions of developing countries, where infrastructural inadequacies intersect with social stratification, poverty, and demographic vulnerability, despite significant socioeconomic progress worldwide (Zambrano-Monserrate and Sanchez-Alcalde, 2024).



In India, access to drinking water has been characterised by seasonal fluctuation and scarcity, spatial inequality, and dependence on unimproved sources such as open wells and surface water bodies, especially in rural areas (Tiwari and Pandey, 2011; Chandran et al., 2021). Recognising these challenges, the Government of India launched the Jal Jeevan Mission (JJM) in August 2019 as one of the most ambitious rural water supply programmes in the world. The mission aims to provide Functional Household Tap Connections (FHTCs) to every rural household, ensuring a minimum of 55 litres/capita/day of potable water on a long-term and regular basis (Ministry of Jal Shakti, 2023). Unlike earlier water policies that emphasised only infrastructure creation, JJM adopts a multi-objective service-delivery approach. It focuses on the dimensions of water rights as a source of sustainability, water quality, community participation, and institutional accountability.

Since its inception, JJM has transformed the rural drinking water landscape of India. According to estimates, the proportion of rural households with tap water connections increased from approximately 17 per cent in 2019 to more than 80 per cent by the end of 2025 (Press Information Bureau, 2025). This unprecedented expansion clearly illustrates a significant shift in the provision of water and sanitation rural infrastructure. It has been widely acknowledged as a landmark achievement in India's development trajectory in the field of water security. Studies highlight that socioeconomic and demographic factors play a crucial role in shaping household access to water (Amit and Sasidharan, 2019; Ngayaga et al., 2025; Swamy et al., 2018; Tambe et al., 2015). Studies based on national datasets reveal strong associations among household wealth, educational attainment, caste identity, and access to improved drinking water sources (Gopakumar, 2010; Swamy et al., 2018). Economically disadvantaged and socially marginalised groups frequently rely on shared or distant sources, while wealthier households are more likely to possess on-premises connections. Educational attainment of the household head has also been shown to positively influence awareness, willingness to pay, and engagement with public service delivery mechanisms (Gurung et al., 2023).

In the broader national context of India, the state of Bihar presents a particularly important case for analysis. Historically, Bihar has been one of India's water-stressed and infrastructure-deficient states. It is marked by widespread poverty, high population density, poor literacy rates and limited public service reach. At the launch of JJM, rural tap water coverage in Bihar was negligible. Nevertheless, the state has recorded one of the fastest expansions under the mission, achieving reported coverage of over 85 per cent of rural households by 2025 (Press Information Bureau, 2025). While this rapid progress is commendable, studies highlighted that high administrative coverage statistics may conceal intra-district disparities in functional tap water access, regularity of supply, and household inclusion (Gopakumar, 2010; Swamy et al., 2018; WSP, 2011; Amit and Sasidharan, 2019; Sahoo, 2023). Panchayat-level socioeconomic structures, settlement patterns, water availability in the region, and the efficacy of the administration shape the realities of such microregions. These conditions persist, making district-specific empirical studies essential for understanding JJM's actual performance on the ground. Samastipur district of northern Bihar represents a socially and demographically complex rural setting. The district is characterised by a high rural population concentration and significant proportions of scheduled castes and backwards classes. The rural population is mostly dependent on agriculture and informal livelihoods, and has varied levels of educational attainment. As per the records of the Ministry of Jal Shakti, under the JJM policy, the district is ranked second among the good performers across the country. These characteristics make Samastipur an analytically rich site for examining how socioeconomic and demographic factors influence household access to functional tap water connections under JJM.

Furthermore, the functionality of JJM is not only the mere installation of tap connections, but also regular water availability, acceptable quality, and sufficient quantity, all of which may be unevenly distributed among households depending on socioeconomic capacity and social positioning. Therefore, examining determinants of functional access, rather than nominal coverage, is crucial for evaluating the mission's inclusive development outcomes. The major objectives of JJM are not only to enrich the rural households with adequate amount of quality water but through this program developing the leading skill among women and making them empower as they are directly linked to the water. Within this perspective, the present study aims to analyse the socioeconomic and demographic determinants of household access to functional water connections under the Jal Jeevan Mission in Samastipur district of Bihar, using primary empirical data collected in 2025. The study has focused on household characteristics such as caste, educational attainment, income level, household size and other demographic compositions to identify patterns of participation in the mission's implementation framework.

Materials and Methods

Study Design

A community-based cross-sectional study was conducted to assess the socio-demographic and economic determinants of household access to functional water connections under the Jal Jeevan Mission (JJM). The study design enabled collection of household-level quantitative data at a single point in time, allowing for descriptive and analytical comparisons across different social and economic groups. The study was carried out in Samastipur

district of Bihar, one of the top-performing districts under JJM implementation. The district is predominantly rural and characterized by socio-economic disparities, low literacy levels, and high dependence on wage labor, making it a relevant setting for evaluating household water access. The study population comprised rural households in Samastipur district.

A multi-stage stratified random sampling approach was adopted. In the first stage, two blocks-one high-performing and one low-performing-purposively selected. Based on the standard formula for cross-sectional studies at a 95% confidence level, 5% margin of error, and 50% variability, the minimum sample size was estimated at 385 households per block. Allowing for non-response (15%), the target was raised to 443 households per block, resulting in a final total of approximately 926 households surveyed across two selected blocks.

Data were collected during household visits using structured interviews with the head of the household or an adult member. Supervisors conducted random checks to ensure quality and consistency. Completed questionnaires were verified daily before being uploaded into a secure database for analysis. Data were analyzed using Stata 16. Descriptive statistics (frequencies and percentages) summarized household characteristics. Chi-square tests assessed bivariate associations between explanatory variables and JJM access. Variables significant at $p < 0.05$ in the bivariate analysis were included in binary logistic regression models to estimate odds ratios (OR) with 95% confidence intervals (CI), both unadjusted (UOR) and adjusted (AOR). Statistical significance was considered at $p < 0.05$, with $p < 0.01$ and $p < 0.001$ denoting stronger levels of significance.

Results

The study covered 926 households in Samastipur district, Bihar, to understand their socio-demographic and economic profile in relation to Jal Jeevan Mission (JJM) water connections. Out of the total households, a large majority household (786 households, 84.9%) reported having a functional JJM water connection, while 140 households (15.1%) did not. This indicates considerable penetration of the scheme in the study area (**table.1**).

Table 1. Distribution of Households by Socio-Demographic and Economic Characteristics in the Study Sample (N=926)

Background Characteristics	N	%
Household having JJM water connection		
No	140	15.1
Yes	786	84.9
Total	926	100.0
Level of education		
Illiterate	104	11.2
Up to Primary	277	29.9
Middle	217	23.4
Secondary	236	25.5
Higher & above	92	9.9
Total	926	100.0
Religion		
Hindu	880	95.0
Muslim	46	5.0
Total	926	100.0
Caste		
SCs/STs	564	60.9
OBCs	327	35.3
Others	35	3.8
Total	926	100.0
Type of house		
Kachha	483	52.2
Semi-Pucca	257	27.8
Pucca	186	20.1
Total	926	100.0
No. of rooms in household		
1	556	60.0
2-3	315	34.0
4+	55	5.9
Total	926	100.0
No. of rooms used for sleeping		
1	692	74.7
2	195	21.1
3+	39	4.2
Total	926	100.0

Separate room for cooking		
Yes	297	32.1
No	629	67.9
Total	926	100.0
Source of income		
Labourer	730	78.8
Non-labour	196	21.2
Total	926	100.0
Average monthly income		
≤10000 Rs.	375	40.5
10001-15000 Rs.	478	51.6
>15000 Rs.	73	7.9
Total	926	100.0
Media exposure		
Yes	528	57.0
No	398	43.0
Total	926	100.0

Note: JJM: Jal Jeevan Mission, SCs: Scheduled caste, STs: Scheduled tribe, OBCs: Other backward class

In terms of educational background, about 11.2% (104 households) were illiterate, while the largest share had studied up to primary school (29.9%, 277 households). Households with education up to middle school and secondary school accounted for 23.4% (217 households) and 25.5% (236 households) respectively, while 9.9% (92 households) had attained higher education or above. Religious affiliation showed a predominantly Hindu population, with 880 households (95%), while 46 households (5%) identified as Muslim. By caste distribution, more than half of the households belonged to Scheduled Castes and Scheduled Tribes (60.9%, 564 households), followed by Other Backward Classes (35.3%, 327 households) and a small proportion from other castes (3.8%, 35 households). Housing type reflects economic standing such as 52.2% (483 households) lived in kachha houses, 27.8% (257 households) in semi-pucca, and only 20.1% (186 households) resided in pucca houses. Household crowding was evident, as 60% (556 households) had only one room, 34% (315 households) had two to three rooms, and just 5.9% (55 households) had four or more rooms. Similarly, 74.7% (692 households) reported using only one room for sleeping, while 21.1% (195 households) had two, and just 4.2% (39 households) had three or more. Cooking arrangements were limited: only 32.1% (297 households) had a separate room for cooking, compared to 67.9% (629 households) who did not.

Table 2 shows that access to functional Jal Jeevan Mission (JJM) water connections varied significantly across education levels ($p < 0.001$). Among illiterate households, 76.0% (79 out of 104) had a JJM connection, whereas the proportion increased steadily with higher education: 78.3% for those up to primary level, 86.6% for middle, and as high as 92.8% among secondary-educated households. Households with higher education and above also had high coverage (90.2%), suggesting that education plays an important role in enabling access to safe drinking water.

Table 2. Percentage of Household Access to Functional Jal Jeevan Mission Water Connections by Socio-Demographic and Economic Characteristics

Background Characteristics	No		Yes		Total		p-value
	n	%	n	%	N	%	
Level of education							
Illiterate	25	24.0	79	76.0	104	100.0	p<0.001
Up to Primary	60	21.7	217	78.3	277	100.0	
Middle	29	13.4	188	86.6	217	100.0	
Secondary	17	7.2	219	92.8	236	100.0	
Higher & above	9	9.8	83	90.2	92	100.0	
Total	140	15.1	786	84.9	926	100.0	
Religion							
Hindu	136	15.5	744	84.6	880	100.0	0.212
Muslim	4	8.7	42	91.3	46	100.0	
Total	140	15.1	786	84.9	926	100.0	
Caste							
SCs/STs	100	17.7	464	82.3	564	100.0	0.018
OBCs	35	10.7	292	89.3	327	100.0	
Others	5	14.3	30	85.7	35	100.0	
Total	140	15.1	786	84.9	926	100.0	
Type of house							
Kachha	81	16.8	402	83.2	483	100.0	0.011

Semi-Pucca	44	17.1	213	82.9	257	100.0	
Pucca	15	8.1	171	91.9	186	100.0	
Total	140	15.1	786	84.9	926	100.0	
No. of rooms in household							
1	89	16.0	467	84.0	556	100.0	0.529
2-3	45	14.3	270	85.7	315	100.0	
4+	6	10.9	49	89.1	55	100.0	
Total	140	15.1	786	84.9	926	100.0	
No. of rooms used for sleeping							
1	102	14.7	590	85.3	692	100.0	0.813
2	31	15.9	164	84.1	195	100.0	
3+	7	18.0	32	82.1	39	100.0	
Total	140	15.1	786	84.9	926	100.0	
Separate room for cooking							
Yes	31	10.4	266	89.6	297	100.0	0.006
No	109	17.3	520	82.7	629	100.0	
Total	140	15.1	786	84.9	926	100.0	
Source of income							
Labourer	114	15.6	616	84.4	730	100.0	0.415
Non-labour	26	13.3	170	86.7	196	100.0	
Total	140	15.1	786	84.9	926	100.0	
Average monthly income							
≤10000 Rs.	72	19.2	303	80.8	375	100.0	0.004
10001-15000 Rs.	54	11.3	424	88.7	478	100.0	
>15000 Rs.	14	19.2	59	80.8	73	100.0	
Total	140	15.1	786	84.9	926	100.0	
Media exposure							
Yes	72	13.6	456	86.4	528	100.0	0.147
No	68	17.1	330	82.9	398	100.0	
Total	140	15.1	786	84.9	926	100.0	
Note: JJM: Jal Jeevan Mission, SCs: Scheduled caste, STs: Scheduled tribe, OBCs: Other backward class							

Caste and type of housing also showed significant associations with JJM coverage. Among Scheduled Castes and Scheduled Tribes, 82.3% (464 of 564) reported access, compared to 89.3% (292 of 327) among OBCs ($p = 0.018$). Similarly, households living in pucca houses had the highest coverage (91.9%, 171 of 186), compared to 83.2% in kachha houses and 82.9% in semi-pucca houses ($p = 0.011$). This indicates that both social status and housing quality are closely linked with access to functional water supply. Households with a separate room for cooking had greater coverage (89.6%, 266 of 297) compared to those without (82.7%, 520 of 629), with the difference being statistically significant ($p = 0.006$). Income patterns also revealed disparities such as households earning between ₹10,001-15,000 had the highest access (88.7%, 424 of 478), while those with ≤₹10,000 and >₹15,000 had comparatively lower coverage (80.8% each) with statistically significant ($p = 0.004$). By contrast, factors such as religion, number of rooms in the household, rooms used for sleeping, source of income, and media exposure did not show statistically significant variation in JJM water access. Overall, the findings suggest that education, caste, housing type, income level, and cooking arrangements are important determinants of access to JJM water connections, while religion, occupation type, media exposure, and household size had limited influence.

The logistic regression analysis identified several socio-demographic and economic characteristics significantly associated with access to functional JJM water connections (table 3). Education level emerged as a strong predictor. Compared with illiterate households, those with middle education had more than twice the odds of having access (AOR = 2.04, 95% CI: 1.10-3.78, $p < 0.05$). The effect was even stronger for households with secondary education (AOR = 3.70, 95% CI: 1.82-7.50, $p < 0.001$), while those with higher education also showed increased odds though not statistically significant at the adjusted level (AOR = 2.37, 95% CI: 0.95-5.89). These results confirm that educational attainment significantly improves the likelihood of securing JJM water connections.

Households without a separate cooking room were less likely to have access (UOR = 0.56, 95% CI: 0.36-0.85, $p < 0.001$; AOR = 0.67, 95% CI: 0.41-1.12), indicating the importance of housing facilities in water access. By contrast, factors such as religion, number of rooms, source of income, and media exposure showed no significant association in the adjusted model. Overall, the analysis highlights education, housing quality, and middle-income status as the strongest predictors of functional JJM water connections, while caste and cooking arrangements also play a role, particularly before adjusting for other variables.

Table 3. Results of Logistic Regression Analysis of Household Access to Functional Jal Jeevan Mission Water Connections by Socio-Demographic and Economic Characteristics

Background Characteristics	AOR	95% CI	UOR	95% CI
Level of education				
Illiterate	1.00	[1.00,1.00]	1.00	[1.00,1.00]
Up to Primary	1.26	[0.72,2.22]	1.14	[0.67,1.95]
Middle	2.04*	[1.10,3.78]	2.05**	[1.13,3.72]
Secondary	3.70***	[1.82,7.50]	4.08***	[2.09,7.95]
Higher & above	2.37	[0.95,5.89]	2.92**	[1.28,6.64]
Religion				
Hindu	1.00	[1.00,1.00]	1.00	[1.00,1.00]
Muslim	1.33	[0.44,4.08]	1.92	[0.68,5.44]
Caste				
SCs/STs	1.00	[1.00,1.00]	1.00	[1.00,1.00]
OBCs	1.46	[0.92,2.34]	1.80***	[1.19,2.71]
Others	0.74	[0.25,2.19]	1.29	[0.49,3.41]
Type of house				
Kachha	1.00	[1.00,1.00]	1.00	[1.00,1.00]
Semi-Pucca	0.75	[0.48,1.19]	0.98	[0.65,1.46]
Pucca	1.52	[0.80,2.89]	2.30***	[1.29,4.10]
No. of rooms in household				
1	1.00	[1.00,1.00]	1.00	[1.00,1.00]
2-3	1.41	[0.70,2.87]	1.14	[0.78,1.69]
4+	1.63	[0.52,5.11]	1.56	[0.65,3.74]
No. of rooms used for sleeping				
1	1.00	[1.00,1.00]	1.00	[1.00,1.00]
2	0.59	[0.28,1.23]	0.91	[0.59,1.42]
3+	0.44	[0.15,1.30]	0.79	[0.34,1.84]
Separate room for cooking				
Yes	1.00	[1.00,1.00]	1.00	[1.00,1.00]
No	0.67	[0.41,1.12]	0.56***	[0.36,0.85]
Source of income				
Labourer	1.00	[1.00,1.00]	1.00	[1.00,1.00]
Non-labour	1.04	[0.61,1.80]	1.21	[0.76,1.91]
Average monthly income				
≤10000 Rs.	1.00	[1.00,1.00]	1.00	[1.00,1.00]
10001-15000 Rs.	1.78**	[1.19,2.65]	1.87***	[1.27,2.73]
>15000 Rs.	0.62	[0.30,1.29]	1.00	[0.53,1.89]
Media exposure				
Yes	1.00	[1.00,1.00]	1.00	[1.00,1.00]
No	0.94	[0.63,1.40]	0.77	[0.53,1.10]

Note: * p<0.05, **p<0.01, ***p<0.001;
 SCs: Scheduled caste, STs: Scheduled tribe, OBCs: Other backward class; CI: Confidence interval; AOR: Adjusted odds ratio, UOR: Unadjusted odds ratio

Discussion

Water has long been a central focus of public policy and scholarly research, yet there is still no single, universally agreed definition of what truly constitutes affordable and accessible water services (Adams, 2018; Adams et al., 2016). In practice, international agencies such as the United Nations and the World Health Organization commonly measure accessibility in terms of population coverage, that is, the share of people with access to a water service (WHO/UNICEF JMP, 2021). Existing research has approached the assessment of water access from multiple perspectives. These include improvements in the type and quality of water sources (Mahama et al., 2014; Osei-Kyei and Chan, 2015), physical dimensions such as the time and distance involved in collecting water and the nature of the source itself (Devi and Bostoen, 2009; Majuru et al., 2016), and service-related attributes such as reliability and regular availability (Smiley, 2017). Several studies have also highlighted that access to water is unevenly distributed across socio-economic groups, reflecting broader inequalities within communities (Flores et al., 2013).

The finding that about 85 per cent of studied households reported having a functional JJM connection represents a substantial expansion of state capacity in rural water provisioning by this mission. Historically, majority of rural India population has relied on community handpumps, wells, and surface sources, with piped water supply remaining limited and unevenly distributed (World Bank, 2018; WHO & UNICEF, 2021). The rapid scale-up observed in rural Samastipur aligns with national progress reports under JJM, that emphasise time-bound targets, centralised financing, and decentralised implementation through local village panchayat bodies (Government of India, 2019; Ministry of Jal Shakti, 2023). From a policy perspective, this achievement establishes the effectiveness of mission-mode governance, with a clear targets, fiscal commitment, and administrative convergence can overcome long-

standing rural water supply-based infrastructure deficits. Nevertheless, as development scholars have cautioned, universal coverage targets often mask intra-community inequalities unless explicit equity safeguards are embedded in program design (Sen, 2009; Deaton, 2013). The present findings of the study strongly support this critique.

Results shown that educational attainment emerges as the most robust predictor of access to JJM connections, even after controlling for other socioeconomic predictors in the study area. Households with middle and secondary educational attainment have significantly higher odds of access than households with no education. This finding can be interpreted through Amartya Sen's capability approach, which conceptualises access to public services not merely as availability, but as the ability to utilise entitlements effectively (Sen, 1999). Education enhances households' informational capabilities, awareness towards need of quality of services (Patel et al., 2020), enabling them to navigate administrative procedures, engage with village level Institutions, and assert claims over public resources. The results suggest that JJM's reliance on community participation and local-level implementation may inadvertently advantage more educated households unless targeted facilitation mechanisms are introduced.

Housing type is strongly associated with access to functional water connections, with households living in pucca houses significantly more likely to be covered than those in kachha dwellings (Munamati et al., 2016; UN Women, 2020; Amoak et al., 2023; Trivedy and Khatun, 2024). This reflects a broader infrastructure–poverty nexus, where inadequate housing both signals and reinforces exclusion from basic services (UN-Habitat, 2016). The results illustrated that achieving universal and equitable water access under JJM requires technical flexibility and targeted support for households living in poor-quality housing. Integrating JJM planning with housing schemes such as the Pradhan Mantri Awas Yojana (PMAY) could significantly enhance inclusivity. The presence of a separate cooking room is positively associated with access to JJM connections, serving as a proxy indicator of overall housing adequacy and living standards (Chauhan and Rai, 2015; Amoak et al., 2023; Trivedy and Khatun, 2024). Households lacking such space experience multidimensional deprivation, including overcrowding, poor hygiene conditions, and limited domestic infrastructure (Alkire and Foster, 2011).

The analysis reveals a notable middle-income advantage, with households earning ₹10,001–15,000 per month having significantly higher odds of access compared to the poorest group. This non-linear relationship suggests that even in a publicly funded program, affordability constraints such as connection-related costs, informal payments, or maintenance responsibilities may deter the poorest households. This finding is consistent with international and Indian evidence showing that the poorest households are often the last to benefit from infrastructure expansion, even under subsidised programs (Banerjee and Duflo, 2011; Armah et al., 2018; World Bank, 2018; Abubakar, 2019; Bikorimana and Shengmin, 2020; Gurung et al., 2023; Trivedy and Khatun, 2024; Tirkey et al., 2025). From a policy lens, this underscores the importance of explicit pro-poor targeting within universal programs. Waivers, cross-subsidisation, and post-connection support mechanisms are essential to prevent economic vulnerability from translating into water insecurity. Water access, housing quality, and domestic space are deeply interlinked, particularly for women (Roy, 2023; Tirkey et al., 2025), who bear the primary responsibility for water collection and household chores (Munamati et al., 2016; UN Women, 2020; Amoak et al., 2023; Trivedy and Khatun, 2024). The findings suggest that water policy outcomes cannot be fully understood in isolation from housing and gendered domestic environments.

Conclusions

This study examined the socio-economic and demographic determinants of household access to functional tap water connections under the Jal Jeevan Mission (JJM) in Samastipur district, Bihar, using primary data collected in 2025. The findings indicate that the mission has achieved substantial progress in expanding piped water coverage in rural areas, with nearly 85 per cent of surveyed households reporting access to a functional JJM connection. This level of coverage reflects the programme's strong implementation push and highlights its potential to transform rural water access in historically underserved regions. However, the analysis also reveals that access is not uniform across households and remains shaped by underlying social and economic inequalities. Education emerges as the most consistent and influential determinant of access to functional water connections. Households with higher levels of educational attainment were significantly more likely to have JJM connections, even after controlling for other socio-economic factors. Education appears to function not merely as an individual attribute but as a form of social capability that enables households to convert state provision into effective access. Housing quality and basic household infrastructure also play an essential role in determining water access. This suggests that extreme poverty may constrain households' ability to engage with programme processes or meet associated requirements, even when the service itself is subsidised. Caste-based disparities were visible in unadjusted analyses, with Scheduled Castes/Tribes showing relatively lower access. However, these effects weakened after accounting for education and housing, indicating that social disadvantage operates primarily through material and capability-related pathways. Significantly, factors such as religion, occupation type, media exposure, and household size were not significantly associated with access in the adjusted models, highlighting that structural socio-economic conditions matter more than cultural or informational exposure alone. Together, these findings suggest that while Jal Jeevan

Mission has succeeded in expanding coverage at scale, its benefits are still mediated by pre-existing inequalities. Achieving universal and equitable access to safe drinking water requires more than infrastructure expansion alone. Policy efforts under JJM need to be complemented by targeted support for socially and economically disadvantaged households, greater attention to housing adequacy, and sustained investments in education and institutional outreach. Addressing these enabling conditions will be crucial to ensuring that the mission's goal of "Har Ghar Jal" translates into meaningful and inclusive water security for all rural households.

Ethical Considerations

Given the sensitive nature of the research, stringent ethical protocols were adhered to throughout the study. Ethical approval was obtained from the Indian Council of Social Science Research (ICSSR), New Delhi. Informed consent was verbally obtained from each participant prior to conducting interviews, and participants were explicitly informed of their right to withdraw from the study at any point. Confidentiality was strictly maintained by employing pseudonyms and securely storing data in a coded format accessible only to the research team. Personal identifiers were anonymized to ensure participants' privacy and safeguard their identities.

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KKP, AK, RR and AKR conceived the concept, wrote and approved the manuscript.

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Competing interest

The authors declare no competing interests.

Ethics approval

Not applicable.



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