

Socioeconomic and geographic inequalities in access to improved drinking water among rural households in Ghana: Evidence from the 2017/18 Multiple Indicator Cluster Survey

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Abstract

Background

Access to improved drinking water is a critical public health priority and a central target of Sustainable Development Goal (SDG) 6.1. While Ghana has made national progress in water access, rural areas continue to face substantial disparities shaped by socioeconomic, geographic, and service-related factors. Understanding these inequities is essential for advancing equitable water policies and interventions.

Methods

We analyzed data from the 2017/18 Ghana Multiple Indicator Cluster Survey (MICS), focusing on 5,838 rural households. Access to improved drinking water sources was defined according to WHO/UNICEF Joint Monitoring Programme standards and coded as a binary outcome. Explanatory variables included sociodemographic characteristics, household wealth, ecological zone, connectivity, and water-use behaviours. Descriptive statistics, bivariate associations, and survey-weighted logistic regression models were employed, accounting for clustering and stratification.

Results

Overall, 79% of rural households reported using improved drinking water sources. Access varied significantly by wealth, education, sex of household head, and ecological zone. In multivariable models, household wealth demonstrated the strongest associations: compared to the poorest households, middle- and high-wealth households had 3.28 (95% CI: 2.61–4.13) and 7.64 (95% CI: 5.18–11.29) times higher odds of using improved sources, respectively. Female-headed households and those in the Savannah zone also had higher odds of access. Service-related factors such as water collection time and perceived insufficiency influenced source use, while households using improved sources were less likely to treat water.

Conclusions

Access to improved drinking water in rural Ghana remains uneven, shaped by interlinked socioeconomic and geographic factors. The findings highlight the need to complement national coverage statistics with equity-sensitive monitoring and planning. Strengthening rural water policy frameworks to address disparities in service quality and household capacity is critical for achieving SDG 6.1.

Research Highlights

- Rural access to improved drinking water in Ghana remains uneven despite high national coverage.

- Household wealth is the strongest predictor of improved drinking water access in rural settings.
- Geographic inequalities persist, with access varying substantially across ecological zones.
- Service-related conditions, including collection time and water insufficiency, shape lived access beyond source type.
- Binary indicators of improved water access mask important inequities relevant to SDG 6.1 monitoring.

Introduction

Access to safe drinking water is a cornerstone of public health, social equity, and sustainable development. Improved water services reduce exposure to waterborne diseases, enhance child growth and nutrition, and strengthen community resilience. Despite substantial global progress, approximately two billion people worldwide still lack safely managed drinking water services, with the majority residing in low- and middle-income countries (LMICs) [1]. In sub-Saharan Africa, access to safely managed drinking water remains uneven, with only 65 percent of the population served, and over 400 million individuals relying on unimproved or unsafe sources [1]. These disparities hinder progress toward Sustainable Development Goal (SDG) 6.1, which calls for universal and equitable access to safe and affordable drinking water by 2030 [2].

In Ghana, national statistics report that about 90 percent of the population had access to basic drinking water services by 2024, but only 44 percent benefitted from safely managed sources [1, 3]. Rural areas, in particular, continue to lag behind urban centres, with 74 percent of rural households using improved sources compared to 98 percent in urban areas [4, 5]. Such figures mask deep inequalities driven by structural and contextual factors, including ecological constraints, economic limitations, and service reliability. Initiatives like the Sustainable Rural Water and Sanitation Project have expanded infrastructure in underserved areas, yet regional disparities remain pronounced, especially in the areas where challenges such as drought, hydrogeological fragility, and water pollution persist [6, 7][8, 9].

Previous studies have examined determinants of household access to improved drinking water in Ghana and other LMICs. Wealth consistently emerges as a strong predictor, with richer households more likely to afford improved infrastructure and reside in better-served areas [10, 11]. Educational attainment has also been linked to improved access, likely due to increased awareness and proactive health behaviours [4, 12]. Gender roles, ecological differences, and infrastructure functionality further influence access patterns, but many studies are limited in scope focusing on urban settings, dated datasets, or narrow subpopulations [13–17].

This study addresses these gaps by providing a nationally representative, rural-focused analysis of household-level factors associated with access to improved drinking water in Ghana. Using data from the 2017/18 Multiple Indicator Cluster Survey (MICS), we examine a broad range of variables, including sociodemographic characteristics, socioeconomic status, ecological zone, household infrastructure, and water-use behaviours. Our approach applies a unified multivariable framework, enabling us to assess

independent associations while controlling for potential confounders. Notably, we include underexplored variables, such as household internet access and perceived water insufficiency, which serve as proxies for broader development and service-delivery conditions.

The objective of this study is to identify correlates of access to improved drinking water among rural households in Ghana, with a focus on equity-sensitive indicators. By investigating how structural, spatial, and behavioural factors interact to shape access, the study contributes to evidence-based planning and monitoring efforts aimed at fulfilling SDG 6.1. These insights are timely and relevant for Ghana and other LMICs facing similar challenges in achieving inclusive and sustainable water service delivery.

Methods

Data source

This study uses household-level data from the 2017/18 Ghana Multiple Indicator Cluster Survey (MICS), a nationally representative dataset collected by the Ghana Statistical Service in partnership with UNICEF. The MICS provides detailed data on household characteristics, health, water, sanitation, education, and infrastructure. The 2017/18 round was selected because it includes a wide range of relevant explanatory variables related to household water access and service delivery.

We restricted the analysis to households classified as rural in the survey, consistent with the study's focus on geographic inequities. Households with missing values for the outcome variable or explanatory variables used in the regression models were excluded. After applying survey weights and eligibility criteria, the final analytic sample comprised 5,838 rural households.

Sampling design

The MICS employed a two-stage stratified cluster sampling approach based on the national population sampling frame derived from the Population and Housing Census. In the first stage, enumeration areas (EAs) were selected using probability proportional to size. In the second stage, a fixed number of households were systematically sampled from each EA after a comprehensive listing. Stratification was based on geographic region and rural-urban residence to ensure representativeness.

Survey sampling weights, provided by the MICS, were applied to correct for unequal selection probabilities and non-response and to adjust for population distribution. All analyses accounted for the complex survey design, incorporating clustering at the EA level and stratification.

Outcome variable

The dependent variable was access to an improved drinking water source, coded as a binary outcome. Consistent with the WHO/UNICEF Joint Monitoring Programme (JMP) definitions, improved sources

included piped water (on-premises or public), boreholes, protected wells/springs, rainwater, and qualifying packaged or delivered water. Unimproved sources included unprotected wells, surface water, and other unsafe sources. Households using improved sources were coded as “1,” and those using unimproved sources as “0.”

Explanatory variables

Explanatory variables were selected based on theoretical relevance and prior empirical findings from Ghana and comparable LMICs. They include:

- **Sociodemographic:** sex, age, education, and religion of household head; household size.
- **Socioeconomic status:** household wealth index (poor, middle, rich).
- **Ecological zone:** Coastal, Middle, Savannah.
- **Connectivity:** internet access, mobile phone, and radio ownership.
- **Water-use behaviours:** water treatment practices, time to collect water, frequency of water collection, number of people involved in collection, and perceived water insufficiency in the past month.

These variables, as presented in Table 1, were categorized to reflect meaningful policy and behavioural differences and to ensure comparability with related studies.

Statistical analysis

Survey-weighted descriptive statistics were used to summarise household characteristics and the distribution of access to improved drinking water sources among rural households. Design-adjusted chi-square tests were used to assess bivariate associations between each explanatory variable and the outcome, corresponding to the univariate and bivariate results presented in Table 1.

Inferential analysis was conducted using survey-weighted logistic regression. Two models were estimated. Model I consisted of unadjusted logistic regression models examining the association between each explanatory variable and access to improved drinking water sources. Model II was a multivariable model including all explanatory variables simultaneously to estimate adjusted associations, as reported in Table S1.

Categorical variables were entered as indicator variables. Reference categories were selected based on substantive relevance and consistency with prior literature, and match those shown in the regression tables. Model fit was assessed using the likelihood ratio chi-square test and pseudo R-squared. Model specification was evaluated using the link test, and multicollinearity was assessed using variance inflation factors, with results presented in Table S2.

Missing data were minimal across the variables included in the models and were handled using complete-case analysis, resulting in consistent analytic sample sizes across models. Statistical significance was assessed at the 5% level, and results were reported as odds ratios with 95% confidence intervals.

Ethical considerations

The study involved a secondary analysis of anonymised, publicly available data. Ethical approval for the 2017/18 Ghana MICS was obtained by the implementing institutions, and informed consent was obtained from all participating households prior to data collection. Permission to use the data was granted through the official MICS data access process. The present analysis involved no direct interaction with human participants and required no additional ethical approval.

Results

Descriptive statistics for the study

Sample characteristics

The analysis included 5,838 rural households with complete information on drinking water source and explanatory variables (weighted; Table 1). Male-headed households comprised 72% of the survey sample, and 28% were female-headed. Household heads aged 35 years or older accounted for 78% of households. Educational attainment was generally low: 34% of household heads reported no formal education, 55% had primary or junior high school education, and only 11% had senior high school or higher education (Table 1).

Most households were classified in the poor wealth quintile (63%), followed by the middle (20%) and rich (17%) quintiles. Over half of households resided in the Middle ecological zone (52%), with 27% in the Coastal zone and 21% in the Savannah zone. Christianity was the predominant religion (70%), followed by Islam (16%). Large households were common, with 57% reporting five or more members (Table 1).

Household access to amenities and water-related characteristics varied substantially. Internet access at home was reported by 11% of households, and 85% reported ownership of a mobile phone. Only 8% reported treating drinking water to make it safe. Most households (85%) reported a round-trip water collection time of 31 minutes or more, and 10% reported water insufficiency during the month preceding the survey (Table 1).

Prevalence of access to improved drinking water sources

Overall, 79% of rural households reported using an improved drinking water source (95% CI: 0.78–0.80), and 21% relied on unimproved sources (data not shown; Table 1). Access to improved sources varied across household characteristics. Female-headed households reported a higher prevalence of access (83%) than male-headed households (77%). Access increased with educational attainment, from 76%

among households with no formal education to 85% among households with senior high school or higher education (Table 1).

Clear wealth-related disparities were observed. Improved water access was reported by 74% of households in the poor quintile, 89% in the middle quintile, and 95% in the rich quintile (Table 1). By ecological zone, access ranged from 76% in the Middle zone to 80% in the Savannah zone. Households with internet access reported a higher prevalence of improved water use (90%) compared with those without internet access (78%).

Water access and use characteristics were also associated with prevalence patterns (Table 1). Households reporting water collection times of 0–30 minutes had a lower prevalence of improved source use (68%) compared with households reporting collection times of 31 minutes or more (81%). A lower prevalence was observed among households that reported frequent water collection (≥ 10 times in the previous seven days). A higher prevalence was observed among households that reported water insufficiency in the preceding month. Most bivariate associations between improved water access and explanatory variables were statistically significant ($p < 0.05$; Table 1).

Table 1: Summary of Descriptive Statistics and Access to Improved Drinking Water by Key Household Characteristics (Weighted N=5,838)

Explanatory variables	Univariate		Bivariate		X ²	Sig. level
			Unimproved water source	Improved water source		
	N	%	%	%		
<i>Sex of household head</i>					27.669	0.000
Male	4184	72	23	77		
Female	1654	28	17	83		
<i>Age of household head (in years)</i>					1.945	0.377
15-24	252	4	24	76		
25-34	1037	18	22	78		
≥3	4549	78	21	79		
<i>Educational attainment of household head</i>					32.965	0.000
No education	1975	34	24	76		
Primary/JHS	3209	55	20	80		
SHS/Higher	654	11	15	85		
<i>Wealth status of household head</i>					218.842	0.000
Poor	3664	63	26	74		
Middle	1198	20	11	89		
Rich	976	17	5	95		
<i>Ecological zones</i>					9.680	0.008
Coastal zone	1566	27	21	79		
Middle zone	3049	52	24	76		
Savanna zone	1223	21	20	80		
<i>Religion of household head</i>					33.077	0.000
Christian	4105	70	19	81		
Muslim	937	16	26	74		
Traditionalist	426	7	24	76		

No religion	370	7	26	74		
<i>Household size</i>					9.154	0.010
1-2members	876	15	20	80		
3-4members	1632	28	19	81		
≥5 members	3330	57	23	77		
<i>Internet access at home</i>					43.624	0.000
Yes	631	11	10	90		
No	5208	89	22	78		
<i>Ownership of radio</i>					0.707	0.400
Yes	3168	54	22	78		
No	2670	46	21	79		
<i>Ownership of mobile telephone</i>					4.938	0.026
Yes	4934	85	21	78		
No	904	15	24	76		
<i>Treat water to become safe for drinking</i>					166.714	0.000
Yes	447	8	46	54		
No	5391	92	19	81		
<i>Travelling time to get water (in minutes)</i>					84.225	0.000
0-30	862	15	32	68		
≥31	4976	85	19	81		
<i>Persons collecting water</i>					1.895	0.388
1-2 members	3467	59	22	78		
3-4 members	1728	30	21	79		
≥5 members	643	11	20	80		
<i>Times person collected water last 7days</i>					7.962	0.019
0-4 times	872	15	18	82		
5-9 times	987	17	21	79		
≥10 times	3979	68	22	78		
<i>Insufficiency of water in the last month</i>					8.957	0.003

Yes	603	10	16	84
No	5235	90	22	78

Source: GMICS (2017/18)

Inferential Results for the study

Factors associated with access to improved drinking water sources

Results from unadjusted (Model I) and multivariable-adjusted (Model II) logistic regression models are presented in Supplementary Information (Table S1). The adjusted odds ratios are presented as a forest plot in Fig. 1. After adjustment, several sociodemographic, socioeconomic, and water-related factors remained independently associated with access to improved drinking water sources.

Female-headed households had higher odds of access compared with male-headed households (aOR = 1.67; 95% CI: 1.41–1.98; Table S1). Educational attainment was associated with access. Households whose heads had primary or junior high school education had higher odds of access relative to those with no formal education (aOR = 1.30; 95% CI: 1.11–1.52). The association for senior high school or higher education was attenuated and not statistically significant in the adjusted model (aOR = 1.25; 95% CI: 0.94–1.65).

Wealth status showed the strongest and most consistent associations (Table S1). Compared with households in the poor quintile, those in the middle quintile had more than threefold higher odds of access (aOR = 3.28; 95% CI: 2.61–4.13). Households in the rich quintile had substantially higher odds (aOR = 7.64; 95% CI: 5.18–11.29).

Ecological zone was independently associated with access. Relative to households in the Coastal zone, those in the Middle zone had higher odds of improved water access (aOR = 1.25; 95% CI: 1.04–1.51). Households in the Savannah zone had markedly higher odds (aOR = 3.14; 95% CI: 2.53–3.91; Table S1).

Religious affiliation was also associated with access. Compared with Christian households, Muslim households had lower odds of access to improved drinking water sources (aOR = 0.63; 95% CI: 0.53–0.76). Associations for traditionalist and non-affiliated households were not statistically significant after adjustment (Table S1). Household size was not independently associated with access in the adjusted model.

Indicators of household connectivity and water practices remained associated with access (Table S1). Households without internet access had lower odds of improved water access compared with those with internet access (aOR = 0.67; 95% CI: 0.49–0.93). Mobile phone ownership was not associated after adjustment. Households that did not report treating water to make it safe had higher odds of using improved water sources (aOR = 3.80; 95% CI: 3.05–4.72).

Water access characteristics showed consistent associations. Households reporting water collection times of 31 minutes or more had higher odds of improved water access compared with households reporting collection times of 0–30 minutes (aOR = 1.90; 95% CI: 1.61–2.23). More frequent water collection (≥ 10 times in the previous seven days) was associated with lower odds of access (aOR = 0.76; 95% CI: 0.61–0.95). Households reporting no water insufficiency in the preceding month had lower odds of improved water access compared with households reporting insufficiency (aOR = 0.64; 95% CI: 0.50–0.83; Table S1).

The adjusted model demonstrated acceptable fit (LR χ^2 = 646.09, $p < 0.001$; pseudo R^2 = 0.106). Link test results did not indicate model misspecification, and multicollinearity was minimal (mean VIF = 1.16; Table S2).

Discussion

This study contributes new insights into the socioeconomic and geographic disparities that shape rural access to improved drinking water in Ghana. Using a nationally representative sample and rigorous analytic methods, we found that access remains significantly associated with household wealth, education, female household headship, ecological zone, and several water-related behaviours. These findings affirm and extend prior evidence while highlighting underexplored dimensions of service inequity relevant to policy and SDG 6.1 monitoring [4, 12].

Household wealth emerged as the strongest and most consistent determinant of access. Households in the richest wealth tercile had over 7 times the odds of using improved drinking water sources than households in the poorest wealth tercile. This stark disparity reinforces earlier findings from Ghana and other sub-Saharan African contexts.

Wealthier households tend to reside in areas with better infrastructure, including functional boreholes and piped water systems, and are better able to meet the direct and indirect costs associated with water access, such as tariffs, maintenance fees, and the use of alternative sources during service disruptions [17, 18]. In Ghana, rural water supply has historically depended on point-source technologies, particularly boreholes fitted with handpumps, whose functionality and service reliability vary widely across communities due to differences in maintenance capacity and governance arrangements [19, 20]. Households with greater economic resources are therefore better positioned to cope with breakdowns, seasonal variability, or user fees associated with maintenance, reinforcing observed wealth-related differentials. By contrast, poorer households often face competing financial demands that limit their ability to contribute to maintenance costs or invest in improved water options, increasing their reliance on unimproved or less reliable sources [21]. Similar wealth gradients in water access have been documented in Ethiopia, Nigeria, and other low- and middle-income settings, indicating that affordability, infrastructure quality, and settlement-level investment patterns remain fundamental constraints to equitable progress toward SDG [10, 11, 22]. These dynamics underscore that achieving equitable water access cannot be separated from broader poverty-alleviation and social-protection strategies.

Educational attainment of the household head was also positively associated with improved access, although the effect was attenuated for higher levels of education after adjustment. This pattern suggests that while education enhances awareness and decision-making around water quality and source selection, its effect may be mediated by other factors such as wealth and geographic location [4, 12, 23–25]. These findings are consistent with earlier studies, which show that education effects often diminish when adjusted for economic status and settlement characteristics [26].

Geographic variation was also substantial. Surprisingly, households in the Savannah zone had significantly higher odds of access compared to those in the Coastal zone, contradicting historical narratives of northern disadvantage. This may reflect targeted groundwater investments in northern Ghana, which have expanded borehole infrastructure in response to limited surface water options and recurrent drought (Adams et al., 2016; CWSA, 2018). In contrast, coastal areas may face hydrogeological constraints such as salinity and aquifer contamination, limiting the availability of reliable, improved sources [28–30]. Similar ecological heterogeneity has been reported in other West African contexts and in global JMP analyses. These findings underscore the value of ecological zoning over administrative regions in understanding spatial inequities [31].

The observed association between female household headship and improved water access requires careful interpretation. Female-headed households were more likely to use improved water sources, consistent with prior findings from Ghana, Ethiopia, and Nigeria [10, 15, 32, 33]. In many sub-Saharan African contexts, just as in rural Ghana, women bear the primary responsibility for water collection and domestic water management. Female-headed households may therefore prioritise proximity to reliable, improved sources or reside in settings where access is more assured. Alternatively, this association may reflect compositional differences in household structure, settlement type, or the benefits of targeted social support program [34]. Evidence from DHS-based studies across sub-Saharan Africa shows mixed but recurring associations between female headship and improved water access, suggesting that gendered roles interact with local service delivery contexts rather than operating through a single pathway [35, 36]. However, the causal mechanisms remain complex and warrant further qualitative research.

Service-related characteristics, including water collection time, frequency, and perceived insufficiency, further contextualize household access. The relationship between longer reported collection times and improved source use likely reflects rural realities where improved sources (e.g., boreholes) may be located farther from households than unimproved alternatives. This aligns with findings from JMP reports indicating that improved sources are not necessarily closer or more convenient in rural settings [37]. According to JMP standards, collection times over 30 minutes are still classified as “limited service,” highlighting that improved sources do not guarantee convenience or adequacy [38, 39]. Similar associations between longer collection times and improved source use have been reported in Ethiopia and Nigeria [11, 40, 41].

Frequent water collection and reported water insufficiency were also associated with a lower likelihood of improved source use, suggesting that households facing unreliable or insufficient service may rely on multiple sources, including unimproved options, to meet their daily needs. Mixed-source use has been widely documented in rural Africa and is increasingly recognised as a defining feature of household water insecurity that is not captured by source-type indicators alone [34, 42, 43].

The inverse association between household water treatment and improved source use aligns with behavioural evidence indicating that households relying on improved sources often perceive treatment as unnecessary, whereas households using unimproved sources adopt treatment as a risk mitigation strategy. Similar patterns have been reported in Ghana and other low-income settings, underscoring the importance of interpreting treatment practices within the broader context of source-to-source comparisons, trust in infrastructure, and perceived water quality [34, 44–46].

Collectively, these findings highlight the limitations of relying solely on binary indicators of improved water access to assess progress toward SDG 6.1. While source type remains an important metric, it obscures critical dimensions of equity, reliability, and user experience that shape everyday water security in rural settings. From a policy perspective, improving rural water access in Ghana will require approaches that extend beyond infrastructure expansion to address service functionality, affordability, and spatial inequities. Incorporating disaggregated, equity-sensitive indicators into national monitoring frameworks could support more targeted investments and a more accurate assessment of progress among underserved rural populations.

Several limitations should be considered when interpreting these results. The cross-sectional design of the MICS data precludes causal inference and limits assessment of changes in access over time. All measures are self-reported and may be subject to recall or reporting bias, particularly for water-use behaviours and perceived insufficiency. In addition, the analysis could not account for unmeasured community-level factors such as water point functionality, management capacity, or local governance arrangements, which are known to influence rural water service performance. Future research combining household surveys with geospatial, administrative, or qualitative data would provide a more comprehensive understanding of service dynamics.

Despite these limitations, this study provides robust, nationally representative evidence on the socioeconomic, geographic, and service-related determinants of improved drinking water access among rural households in Ghana. By demonstrating how structural inequalities persist beneath national coverage gains, the findings reinforce the need to operationalise SDG 6.1 through an explicit equity lens. Addressing rural water access as a service-delivery challenge rather than solely as an infrastructure deficit will be essential to achieving inclusive and sustainable progress in Ghana and similar low- and middle-income settings.

Conclusion

This study offers nationally representative evidence that access to improved drinking water in rural Ghana remains deeply unequal, even as headline coverage indicators suggest substantial progress. Bringing together socioeconomic, geographic, and service-related dimensions within a single rural-focused analysis reveals that water access reflects more than the presence of infrastructure; it also mirrors household capacity, environmental context, and service conditions.

Although access to improved drinking water sources remains central to global monitoring indicators for SDG 6.1, these findings demonstrate the limitations of treating access as a binary outcome (improved vs unimproved). Differences in distance, reliability, and households' capacity to manage constraints all influence access in ways not captured by source type alone. As a result, progress assessed through aggregate coverage indicators may obscure persistent inequities or overstate equitable improvements in water access.

Through its exclusive focus on rural households and its inclusion of underexamined service-related indicators, this study extends existing evidence on water access in Ghana and similar low- and middle-income settings. It highlights the need for equity-sensitive approaches to monitoring and planning rural water services. Ensuring that national progress toward SDG 6.1 translates into meaningful and inclusive access will require sustained attention to inequalities in rural areas and greater emphasis on service performance.

Declarations

Ethics approval and consent to participate

The present study utilised an existing dataset. Therefore, the authors of this study had no hand in all fieldwork and activities that led to the generation of the datasets used in the study. As such, the ethical principles applicable to studies involving human participants did not apply to this study. However, the datasets were requested from the MICS UNICEF platform and downloaded after access was granted. MICS UNICEF anonymised the dataset before making it public.

Consent for publication

Not applicable

Competing Interest

The authors declare that they have no competing interests

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Author Contribution

GAD was responsible for writing the manuscript, performing data analyses, reviewing the current literature, and coordinating the overall research process. EAE and BGK contributed to the conceptualization, supervision, and review. AAW and KBN were responsible for reviewing the final manuscript. All authors read and approved the final manuscript.

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Data Availability

All data generated or analysed during this study are included in this published article and its supplementary information files.

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Figures

Adjusted Odds Ratios for Improved Drinking Water Access Among Rural Households in Ghana

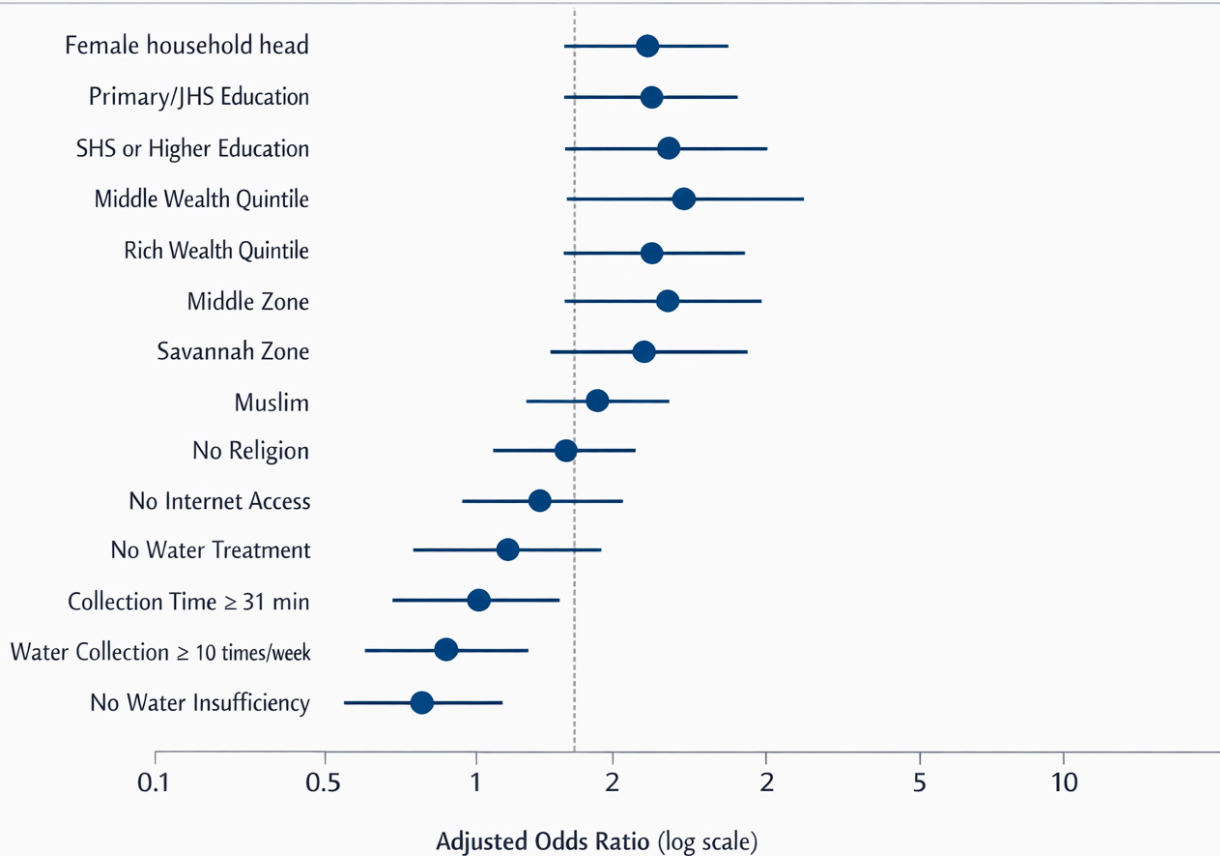


Figure 1

Forest plot of adjusted odds ratios for factors associated with access to improved drinking water among rural households in Ghana

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