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Household Drinking Water Conditions and Depressive Symptoms among Adults Aged 45 Years and Older in India: Evidence from the Longitudinal Ageing Study in India (LASI) Wave-1

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Abstract

Background

Access to safe, reliable, and accessible drinking water is an important component of household well-being and may have implications for mental health. Although previous studies have reported associations between water-related conditions and depression, evidence among middle-aged and older adults in India remains limited. This study examined the association between poor household drinking-water conditions and depressive symptoms among adults aged 45 years and above in India.

Methods

We analysed cross-sectional data from the Longitudinal Ageing Study in India (LASI) Wave 1 (2017–18), including 60,512 adults aged 45 years and above. Depressive symptoms were assessed using the 10-item Centre for Epidemiological Studies Depression (CES-D-10) scale, with a score of ≥ 4 indicating depressive symptoms. Because LASI does not contain a validated household water-insecurity scale, we constructed a transparent five-item household drinking-water conditions index from source type, source location, one-way collection time, daily collection-trip frequency, and household water-treatment practice. Each indicator was coded 0/1 and summed (0–5); a binary exposure classified any household with at least one poor condition as having a higher burden of poor drinking-water conditions. Logistic regression models were estimated to assess the association after adjustment for sociodemographic and contextual covariates. Component-specific and continuous-index analyses were used as sensitivity analyses.

Results

Exposure to poor drinking-water conditions was significantly associated with higher odds of depressive symptoms in the unadjusted model (OR = 1.577, 95% CI: 1.512–1.645). This association remained statistically significant following adjustment for sociodemographic and contextual characteristics (OR = 1.203, 95% CI: 1.144–1.265). In the component-specific analysis, water-collection time exceeding 15 minutes per one-way trip (OR = 1.241, 95% CI: 1.153–1.335) and the absence of household drinking-water treatment (OR = 1.195, 95% CI: 1.142–1.251) were independently associated with higher odds of depressive symptoms. In contrast, water-source location, frequency of water collection, and water-source type were not independently associated with depressive symptoms. Furthermore, each one-unit increase in the composite poor drinking-water conditions score was associated with an 8.1% increase in the odds of depressive symptoms (OR = 1.081, 95% CI: 1.061–1.101).

Conclusions

In India in 2017–18, poor household drinking-water conditions were associated with depressive symptoms among adults aged 45 years and older. The findings are consistent with the hypothesis that collection burden and water-safety-related conditions may be relevant to mental health, but the cross-sectional design and the proxy nature of the exposure preclude causal or mechanistic conclusions. Future studies should use validated water-insecurity measures, directly assess intermediate pathways and functional status, and examine changes following improvements in drinking-water services.

Clinical Trial Registration

Not applicable.

Introduction

Access to safe and sufficient drinking water is fundamental to health and well-being. Despite considerable progress in expanding drinking-water infrastructure, substantial inequalities in access to safe and adequate water persist across and within low- and middle-income countries (LMICs)(Gaffan et al., 2022; Hutton & Chase, 2016). In India, disparities in drinking-water services persist across rural and urban settings and socioeconomic groups, with households differing in the types, locations, accessibility, and management of drinking-water sources (Gaffan et al., 2022; Kanyagui & Viswanathan, 2022; Shaban & Sattar, 2011). These differences are particularly important because the burden associated with water is not determined solely by whether a household has access to a nominal water source.

The broader concept of household water insecurity encompasses inadequate access to sufficient quantities of acceptable-quality water and extends beyond infrastructure characteristics to include reliability, affordability, accessibility, and the social and experiential consequences of obtaining and using water(Dery et al., 2019; Stevenson et al., 2012). Households experiencing water-related disadvantages may face uncertainty about water availability, physical effort associated with collection, time constraints, household resource pressures, and concerns regarding water safety(Collins et al., 2019; Stevenson et al., 2012; Toivettula et al., 2023). These experiences can affect daily activities, social participation, economic opportunities, and psychosocial well-being.

Water collection can impose substantial physical and psychosocial burdens, particularly when water is obtained outside the dwelling or plot. Research has documented associations between water collection and physical strain, fatigue, reduced time for productive activities, and gender-related inequalities(De Guzman et al., 2023; Tomberge et al., 2021). Water-related stress may also arise from uncertainty and unpredictability in water availability. Evidence from studies on drought and water insecurity suggests that uncertainty about access to essential resources is associated with psychological distress and poorer mental health(Luong et al., 2021; Stevenson et al., 2012). These concerns provide a conceptual basis for examining household drinking-water conditions as a potentially relevant environmental and social factor in mental health.

Depressive symptoms are an important public health concern among middle-aged and older adults. International evidence indicates substantial variation in the prevalence of depressive symptoms across populations and measurement instruments(Bromet et al., 2011). In India, studies among older adults have reported a considerable burden of depressive symptoms, although estimates vary across instruments and population groups(Devikrishna et al., 2024; Khanal & Selvamani, 2024; Muhammad & Meher, 2021). Depression among older adults may be influenced by multimorbidity, socioeconomic disadvantage, social isolation, bereavement, and other vulnerabilities associated with aging(Richardson et al., 2020; Srivastava et al., 2021). Evidence from India also indicates important geographic and socioeconomic variation in mental health among older adults(Saha et al., 2024). Understanding environmental conditions that may coexist with these vulnerabilities is therefore relevant to research on ageing and mental health.

Previous research from several LMIC settings has reported associations between water-related conditions and mental health. Studies in Ethiopia and Uganda have linked water conditions with psychosocial distress and depression(Cooper-Vince et al., 2018; Stevenson et al., 2012). Research among women in Nepal and Kenya has similarly described relationships between household water insecurity, depression, stress, and psychosocial well-being(Aihara et al., 2015; Collins et al., 2019). Evidence from Malawi and Ghana has further examined the relationships between drinking-water practices, water-related conditions, and mental health outcomes (Simiyu et al., 2022; Slekiene & Mosler, 2019). More recent studies have also examined water-related conditions and depression among vulnerable populations, including refugees and communities experiencing water service constraints(Lemaitre et al., 2023; Logie et al., 2024). Taken together, this literature suggests that water-related poor conditions may be relevant to mental health, although the strength and nature of these relationships may vary across populations and contexts.

Several pathways have been proposed to explain this relationship. First, the physical burden of water collection may contribute to fatigue, physical strain, and reduced opportunities for productive and leisure activities(De Guzman et al., 2023; Tomberge et al., 2021). Second, uncertainty regarding water availability may generate worry, stress, and feelings of insecurity(Luong et al., 2021; Stevenson et al., 2012). Third, concerns about water safety and exposure to contaminated water may contribute to physical illness and household stress; some literature has proposed inflammatory processes as a possible pathway linking physical illness and mental health (Toivettula et al., 2023; Wu et al., 2025; Zhang et al., 2016). Fourth, time and resources devoted to obtaining, purchasing, or treating water may reduce opportunities for social and economic participation(Slekiene & Mosler, 2019). Research on water, gender, empowerment, and mental health further suggests that the consequences of inadequate water services may be distributed unequally within households(De Guzman et al., 2023; Dery et al., 2019; Huang et al., 2020).

The conceptual pathway considered in the present study is therefore: **poor household drinking-water conditions → hypothesized intermediate processes → depressive symptoms**. The hypothesised intermediate processes include greater time and physical burden of water acquisition, concerns about water safety, diversion of time from social or productive activities, household resource strain, and illness

associated with unsafe water. Previous studies provide support for considering these processes as plausible pathways (Cooper-Vince et al., 2018; De Guzman et al., 2023; Stevenson et al., 2012; Toivettula et al., 2023). However, LASI Wave 1 does not directly measure several of these intermediate processes in a form that permits mediation analysis. Accordingly, these pathways are treated as hypotheses informed by prior literature rather than as mechanisms demonstrated in the present study.

An important issue concerns how water insecurity is operationalised in the present analysis. LASI contains several household drinking-water indicators but does not include the Household Water Insecurity Experiences Scale or any other validated multidimensional water-insecurity instrument. The five indicators available in LASI, therefore, cannot be assumed to represent the complete experiential construct of household water insecurity described in the wider literature. Instead, this study uses an analytically constructed **composite measure of poor drinking-water conditions** based on selected observable household conditions available in LASI. These indicators cover water source type, source location, collection time, collection frequency, and water treatment practices.

The composite measure should consequently not be interpreted as a validated or universal water-insecurity scale. Each observed poor condition contributes one point to the index, producing a score ranging from 0 to 5. Equal weighting was selected because no validated weighting scheme exists for these particular LASI indicators; it is, therefore, a transparent methodological assumption rather than an assertion that the five conditions are equally important within the broader construct of water insecurity.

Functional status represents another potentially important source of confounding. Older adults with limitations in activities of daily living or physical functioning may have greater difficulty obtaining or managing household water, while functional limitations are also associated with depressive symptoms. The present analysis did not include ADL or functional-disability measures in the regression models. Residual confounding by functional status, therefore, remains possible, and the adjusted associations should not be interpreted as independent of all health-related characteristics.

India provides an important setting for examining these relationships because of its large and rapidly ageing population and substantial socioeconomic and geographic variation in living conditions and access to essential services(Das et al., 2023; Marbaniang & Chungkham, 2024; Perianayagam et al., 2022). However, much of the existing literature linking water-related conditions and mental health has focused on women, reproductive-age populations, or specific vulnerable communities. Evidence from nationally representative Indian data covering adults aged 45 years and older remains limited. The Longitudinal Ageing Study in India (LASI) provides an opportunity to examine this relationship across a large national population using standardised measures of depressive symptoms and household drinking-water conditions.

Using nationally representative LASI Wave 1 data, this study aims to: (1) estimate the prevalence of depressive symptoms and selected poor household drinking-water conditions among adults aged 45 years and older in India; (2) assess the adjusted association between the composite drinking-water conditions measure and depressive symptoms; (3) examine the associations of individual drinking-water

indicators with depressive symptoms; and (4) describe sociodemographic correlates of depressive symptoms. Because LASI Wave 1 is cross-sectional, the analysis is designed to identify statistical associations rather than establish causal effects or demonstrate mediation pathways.

Methods

Study design and data source

This study uses cross-sectional data from LASI Wave 1, conducted during 2017–18. LASI is a nationally representative, multistage, stratified probability survey of adults aged 45 years and above covering India. The present analysis used a merged individual- and household-level dataset. The initial matched dataset contained 72,270 individuals. We excluded 1,782 individuals who had responded to fewer than seven CES-D items, 3,744 with missing information on one or more of the five drinking-water indicators, and 6,232 individuals younger than 45 years. The final analytic sample comprised 60,512 adults aged 45 years and above.

Outcome: depressive symptoms

Depressive symptoms were assessed using the 10-item Center for Epidemiologic Studies Depression Scale (CES-D-10), which has been validated in Indian population-based studies. Seven negative-affect and somatic symptoms - feeling depressed, feeling that everything was an effort, restless sleep, feeling unhappy, feeling lonely, feeling sad, and inability to get going, were scored 1 when response categories 3 or 4 were selected (1 = rarely or none of the time; 2 = some or a little of the time; 3 = occasionally or a moderate amount of the time; 4 = most or all of the time). Three positive-affect items - feeling hopeful, feeling happy, and enjoying life- were reverse-coded. The total CES-D-10 score was calculated by summing all 10 items, with higher scores indicating greater depressive symptom burden. A score of 4 or above was used to classify probable depression, consistent with prior applications of the CES-D-10 in Indian ageing surveys.

Exposure: analytically constructed household drinking-water conditions measure

LASI Wave 1 includes several household questions relevant to drinking-water source, location, collection burden and treatment (International Institute for Population Sciences [IIPS], LASI Wave 1 Household Questionnaire). Because these items were not designed as a validated water-insecurity scale, we constructed a five-item composite measure for this study. The measure captures selected observable conditions related to household drinking-water access, acquisition burden, and water-safety practices; it does not capture the full experiential, psychosocial, economic, or reliability dimensions of water insecurity described in the broader literature.

Five items were coded as follows.

1. **Water source location**: A water source located outside the dwelling or plot was coded 1, while a source located inside the dwelling or within the plot boundary was coded 0.
2. **Water collection time**: Among households with an outside water source, collection time exceeding 15 minutes one way was coded 1. Collection time of 15 minutes or less, or a source located inside the dwelling or on the plot, was coded 0.
3. **Water treatment**: Households that did not treat water before consumption were coded 1, while households that treated their water were coded 0.
4. **Water source type**: Water sources were classified as improved or unimproved based on the LASI classification. Improved sources, including piped water, public taps/standpipes, tube wells/bore wells, dug wells, springs, rainwater, and packaged/bottled water, were coded 0. Unimproved sources, including tanker trucks, carts with small tanks, surface water, and other sources, were coded 1.
5. **Trip frequency (he009)**: Among households with an outside water source, more than three water-collection trips per day were coded 1. Three or fewer trips per day, or a source located inside the dwelling or on the plot, was coded 0.

Each indicator contributed one point, producing a score from 0 to 5. The equal-weighted sum was selected because it is transparent, easy to reproduce, and permits all five observed conditions to contribute to a simple summary measure in the absence of an empirically validated weighting scheme. Equal weighting is an analytical assumption, not a claim that source quality, distance, collection time, collection frequency and treatment behavior have equal substantive importance. The primary binary exposure classified households with a score of 0 as having no measured poor condition and households with a score of ≥ 1 as having at least one measured poor drinking-water condition. The binary cut-point was selected to identify the presence of any observed poor condition and should not be interpreted as a validated threshold separating water-secure from water-insecure households.

Sociodemographic and contextual covariates

Covariates included age group (45–59, 60–69, 70–79, and ≥ 80 years), gender, education, marital status, religion, household wealth quintile based on monthly per capita expenditure (MPCE), social group/caste (SC, ST, OBC and others), living arrangement, geographic zone and rural/urban residence. The covariate set was specified a priori from the conceptual framework. Age and gender capture demographic differences in both depressive symptoms and household roles related to water. Education and household wealth represent socioeconomic position, which can influence access to water infrastructure and mental health. Marital status and living arrangement capture the household and social-support context. Religion/social group and geographic zone capture social and contextual heterogeneity, while rural/urban residence captures differences in infrastructure and settlement context. These variables were included to reduce confounding of the association between drinking-water conditions and depressive symptoms.

Statistical analysis

Descriptive statistics were summarised using unweighted frequencies and weighted percentages, with survey weights used to obtain nationally representative population estimates. Bivariate associations between depressive symptoms and covariates were assessed using Pearson's chi-squared tests.

Four logistic regression specifications were estimated. Model 1 estimated the unadjusted association between the binary composite measure of drinking-water conditions and depressive symptoms. Model 2 adjusted for the full set of sociodemographic and contextual covariates. Model 3 replaced the binary composite measure with the five component indicators, entered simultaneously, allowing assessment of whether individual conditions were independently associated with depressive symptoms; this was a component-specific analysis, not a mediation or mechanism analysis. Model 4 replaced the binary exposure with the continuous 0–5 composite score as a sensitivity analysis. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). All analyses were conducted in Stata 17.0 (StataCorp, College Station, TX, USA).

Results

Sample characteristics

The analytic sample comprised 60,512 adults aged 45 years and above. The sociodemographic characteristics of the sample are presented in Table 1. Approximately half were aged 45–59 years (weighted 50.05%), 29.63% were aged 60–69 years, 14.93% were aged 70–79 years, and 5.39% were aged 80 years or older. Women represented 54.16% of the weighted sample. More than half had no formal education (51.31%), 73.65% were currently married, and 70.82% lived in rural areas. OBC participants accounted for 45.57%, while SC and ST participants accounted for 20.37% and 9.09%, respectively. Nearly three-quarters (72.65%) lived with a spouse only.

Table 1
Sociodemographic characteristics of the study sample, LASI India Wave 1, 2017–18 (N = 60,512)

Characteristics	N	Weighted %
Overall sample	**60,512**	**100%**
Age Group		
45–59 years	31,766	50.05
60–69 years	17,529	29.63
70–79 years	8,287	14.93
80 + years	2,930	5.39
Gender		
Men	28,131	45.84
Women	32,381	54.16
Education		
No education	28,726	51.31
Less than primary	6,918	11.06
Primary	7,924	11.98
Middle	5,800	8.31
Secondary	5,289	7.62
Higher secondary / diploma	2,814	4.55
Graduate and above	3,040	5.16
Marital Status		
Currently married	45,248	73.65
Widowed	13,268	23.45
Others	1,994	2.90
Religion		
Hindu	44,308	82.13
Muslim	7,123	11.27

Note: i) Weighted percentages are nationally representative estimates derived by applying individual-level survey weights. ii) The analysis includes an unequal sample size across the variables. Each category is represented by an unequal number of observations due to missing cases (N = 60,512).

Characteristics	N	Weighted %
Overall sample	**60,512**	**100%**
Age Group		
Christian	5,838	2.97
Others	3,238	3.63
Wealth Index (MPCE Quintile)		
Poorest	12,036	21.51
Poorer	12,375	21.65
Middle	12,211	20.27
Richer	12,017	18.90
Richest	11,873	17.67
Social Group (Caste)		
Scheduled Caste (SC)	10,213	20.37
Scheduled Tribe (ST)	10,612	9.09
Other Backward Class (OBC)	22,613	45.57
Others / General	14,890	24.97
Living Arrangement		
Alone	2,133	3.82
With spouse only	44,429	72.65
With others	13,950	23.53
Geographic Zone		
North	9,291	7.88
Central	8,456	21.71
East	11,062	24.44
North-East	8,861	3.70
West	9,863	21.37
South	12,979	20.90

Note: i) Weighted percentages are nationally representative estimates derived by applying individual-level survey weights. ii) The analysis includes an unequal sample size across the variables. Each category is represented by an unequal number of observations due to missing cases (N = 60,512).

Characteristics	N	Weighted %
Overall sample	**60,512**	**100%**
Age Group		
Place of Residence		
Rural	39,953	70.82
Urban	20,559	29.18
Composite poor drinking-water conditions measure		
No poor condition identified	18,015	25.37
At least one poor condition identified	42,497	74.63
Note: i) Weighted percentages are nationally representative estimates derived by applying individual-level survey weights. ii) The analysis includes an unequal sample size across the variables. Each category is represented by an unequal number of observations due to missing cases (N = 60,512).		

Depressive symptoms and bivariate associations

The weighted prevalence of depressive symptoms, defined as a CES-D-10 score ≥ 4, was 28.28%. The weighted distribution of the binary drinking-water conditions measure differed between participants with and without depressive symptoms ($p < 0.001$; Table 2). Among participants with depressive symptoms, only 18.69% lived in households classified as having no poor drinking-water condition, compared with 28.01% among those without depressive symptoms.

[Insert Table 2 *here]*

Table 2
Bivariate distribution of depressive symptoms by sociodemographic characteristics and the composite poor household drinking-water conditions measure, LASI Wave 1, India, 2017–18 (N = 60,512)

Characteristics	Depressed n (Weighted %)	Not Depressed n (Weighted %)	Total n	p-value
Overall sample	**15,516** (28.28%)	**44,996** (71.72%)	**60,512**	—
Composite poor drinking-water conditions measure				
No poor condition identified	**3,577** (18.69%)	**14,438** (28.01%)	18,015	**< 0.001**
At least one poor condition identified	**11,939** (81.31%)	**30,558** (71.99%)	42,497	
Age Group				
45–59 years	**7,414** (46.02%)	**24,352** (51.63%)	31,766	**< 0.001**
60–69 years	**4,629** (30.42%)	**12,900** (29.32%)	17,529	
70–79 years	**2,476** (16.80%)	**5,811** (14.19%)	8,287	
80 + years	**997** (6.75%)	**1,933** (4.86%)	2,930	
Gender				
Men	**6,586** (41.38%)	**21,545** (47.60%)	28,131	**< 0.001**
Women	**8,930** (58.62%)	**23,451** (52.40%)	32,381	
Education				
No education	**8,474** (58.37%)	**20,252** (48.52%)	28,726	**< 0.001**
Less than primary	**1,719** (11.14%)	**5,199** (11.03%)	6,918	
Primary	**1,890** (10.77%)	**6,034** (12.46%)	7,924	
Middle	**1,312** (7.21%)	**4,488** (8.75%)	5,800	
Secondary	**1,056** (5.82%)	**4,233** (8.33%)	5,289	
Higher secondary/diploma	**550** (3.51%)	**2,264** (4.97%)	2,814	
Graduate and above	**515** (3.18%)	**2,525** (5.95%)	3,040	
Marital Status				

Characteristics	Depressed n (Weighted %)	Not Depressed n (Weighted %)	Total n	p-value
Currently married	**10,563** (66.69%)	**34,685** (76.40%)	45,248	**< 0.001**
Widowed	**4,371** (29.99%)	**8,897** (20.87%)	13,268	
Others	**582** (3.32%)	**1,412** (3.14%)	1,994	
Religion				
Hindu	**11,879** (82.70%)	**32,429** (81.91%)	44,308	**< 0.001**
Muslim	**1,897** (12.10%)	**5,226** (10.95%)	7,123	
Christian	**1,166** (2.55%)	**4,672** (3.13%)	5,838	
Others	**574** (2.65%)	**2,664** (4.02%)	3,238	
Wealth Index (MPCE Quintile)				
Poorest	**3,362** (23.40%)	**8,674** (20.76%)	12,036	**< 0.001**
Poorer	**3,272** (21.02%)	**9,103** (21.90%)	12,375	
Middle	**3,054** (20.19%)	**9,157** (20.30%)	12,211	
Richer	**2,964** (17.96%)	**9,053** (19.28%)	12,017	
Richest	**2,864** (17.43%)	**9,009** (17.76%)	11,873	
Social Group (Caste)				
Scheduled Caste (SC)	**2,969** (23.14%)	**7,244** (19.28%)	10,213	**< 0.001**
Scheduled Tribe (ST)	**2,207** (8.54%)	**8,405** (9.31%)	10,612	
Other Backward Class (OBC)	**6,141** (45.57%)	**16,472** (45.57%)	22,613	
Others / General	**3,646** (22.75%)	**11,244** (25.83%)	14,890	
Living Arrangement				
Living alone	**865** (6.06%)	**1,268** (2.94%)	2,133	**< 0.001**
With spouse only	**10,367** (65.77%)	**34,062** (75.36%)	44,429	
With others	**4,284** (28.17%)	**9,666** (21.70%)	13,950	
Geographic Zone				
North	**2,402** (7.74%)	**6,889** (7.94%)	9,291	**< 0.001**

Characteristics	Depressed n (Weighted %)	Not Depressed n (Weighted %)	Total n	p-value
Central	**2,819** (26.07%)	**5,637** (19.99%)	8,456	
East	**3,022** (24.28%)	**8,040** (24.50%)	11,062	
North-East	**1,368** (1.93%)	**7,493** (4.40%)	8,861	
West	**1,896** (15.17%)	**7,967** (23.81%)	9,863	
South	**4,009** (24.80%)	**8,970** (19.37%)	12,979	
Place of Residence				
Rural	**10,605** (72.85%)	**29,348** (70.01%)	39,953	**< 0.001**
Urban	**4,911** (27.15%)	**15,648** (29.99%)	20,559	

i. n = unweighted sample count; Weighted % = nationally representative row percentage derived by applying individual survey weights.

ii. **p-value** from Pearson chi-squared test (unweighted). All associations significant at $p < 0.001$.

iii. Depression is defined as a CES-D score ≥ 4. Weighted row percentages for each category sum to 100% across the depressed and not-depressed columns within each row.

iv. MPCE = Monthly Per Capita Expenditure; SC = Scheduled Caste; ST = Scheduled Tribe; OBC = Other Backward Class.

v. The analysis includes an unequal sample size across the variables. Each category is represented by an unequal number of observations due to missing cases (N = 60,512)

Depressive symptoms also varied significantly across the examined sociodemographic and contextual characteristics. The distribution differed by age, gender, education, marital status, religion, wealth, social group, living arrangement, geographic zone and rural/urban residence (all $p < 0.001$; Table 2). These bivariate differences support the need to account for relevant demographic, socioeconomic and contextual factors when estimating the adjusted association.

Association between drinking-water conditions and depressive symptoms

In the unadjusted logistic regression model, participants living in households with at least one measured poor drinking-water condition had higher odds of depressive symptoms (OR 1.577, 95% CI 1.512–1.645; Table 3, Model 1). After adjustment for age, gender, education, marital status, religion, household wealth, social group, living arrangement, geographic zone and rural/urban residence, the association was attenuated but remained statistically significant (OR 1.203, 95% CI 1.144–1.265; Table 3, Model 2). Thus,

the adjusted model indicates a statistical association between the constructed drinking-water conditions measure and depressive symptoms.

Table 3
Logistic regression models examining the association between the composite poor household drinking-water conditions measure and depressive symptoms among adults aged 45 years and above, LASI Wave 1, India, 2017–18

Variables	Model 1 Unadjusted OR (95% CI)	Model 2 Adjusted OR (95% CI)	Model 3 Mechanism OR (95% CI)	Model 4 Continuous Index OR (95% CI)
Composite poor drinking-water conditions measure				
No poor condition identified	**1** *(Reference)*	**1** *(Reference)*	—	—
At least one poor condition identified	1.577*** (1.512–1.645)	1.203*** (1.144–1.265)	—	—
Age Group				
45–59 years	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
60–69 years	—	1.081** (1.034–1.131)	1.087*** (1.039–1.137)	1.083*** (1.036–1.133)
70–79 years	—	1.204*** (1.136–1.277)	1.215*** (1.145–1.289)	1.209*** (1.140–1.282)
80 + years	—	1.359*** (1.244–1.485)	1.376*** (1.260–1.504)	1.365*** (1.250–1.492)
Gender				
Men	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Women	—	1.062** (1.018–1.109)	1.072** (1.027–1.119)	1.064** (1.019–1.110)
Education				
No education	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Less than primary	—	0.894** (0.838–0.953)	0.907** (0.850–0.967)	0.893** (0.838–0.953)
Primary	—	0.835*** (0.785–0.889)	0.852*** (0.800–0.906)	0.840*** (0.789–0.894)
Middle	—	0.839*** (0.780–0.903)	0.856*** (0.796–0.922)	0.844*** (0.785–0.909)
Secondary	—	0.702*** (0.648–0.761)	0.726*** (0.670–0.788)	0.708*** (0.653–0.767)

Variables	Model 1 Unadjusted OR (95% CI)	Model 2 Adjusted OR (95% CI)	Model 3 Mechanism OR (95% CI)	Model 4 Continuous Index OR (95% CI)
Composite poor drinking-water conditions measure				
Higher secondary / diploma	—	0.698*** (0.628–0.776)	0.719*** (0.646–0.799)	0.700*** (0.630–0.778)
Graduate and above	—	0.597*** (0.535–0.667)	0.615*** (0.550–0.687)	0.596*** (0.534–0.666)
Marital Status				
Currently married	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Widowed	—	1.329** (1.115–1.584)	1.319** (1.107–1.571)	1.314** (1.103–1.566)
Others (divorced / separated / never married)	—	1.305** (1.071–1.590)	1.298** (1.066–1.582)	1.294** (1.062–1.576)
Religion				
Hindu	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Muslim	—	0.973 (0.913–1.036)	1.004 (0.943–1.070)	0.994 (0.933–1.059)
Christian	—	0.979 (0.899–1.066)	0.993 (0.912–1.081)	0.985 (0.904–1.072)
Others	—	0.674*** (0.609–0.745)	0.683*** (0.618–0.755)	0.680*** (0.615–0.752)
Wealth Index (MPCE Quintile)				
Poorest	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Poorer	—	0.981 (0.925–1.040)	0.986 (0.930–1.046)	0.984 (0.928–1.044)
Middle	—	0.944 (0.889–1.002)	0.948 (0.893–1.007)	0.946 (0.891–1.005)
Richer	—	0.959 (0.902–1.020)	0.963 (0.906–1.025)	0.959 (0.902–1.021)
Richest	—	1.016 (0.952–1.084)	1.023 (0.959–1.092)	1.014 (0.950–1.082)

Variables	Model 1 Unadjusted OR (95% CI)	Model 2 Adjusted OR (95% CI)	Model 3 Mechanism OR (95% CI)	Model 4 Continuous Index OR (95% CI)
Composite poor drinking-water conditions measure				
Social Group (Caste)				
Scheduled Caste (SC)	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Scheduled Tribe (ST)	—	0.826*** (0.769–0.887)	0.828*** (0.770–0.890)	0.808*** (0.752–0.868)
Other Backward Class (OBC)	—	0.913*** (0.864–0.964)	0.914*** (0.865–0.965)	0.908*** (0.860–0.959)
Others / General	—	0.935* (0.879–0.995)	0.944 (0.888–1.004)	0.934* (0.879–0.994)
Living Arrangement				
Living alone	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
With spouse only	—	0.687*** (0.569–0.829)	0.689*** (0.571–0.831)	0.680*** (0.563–0.820)
With others (children / extended family)	—	0.668*** (0.605–0.737)	0.673*** (0.609–0.743)	0.667*** (0.604–0.736)
Geographic Zone				
North	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*
Central	—	1.269*** (1.182–1.362)	1.260*** (1.173–1.354)	1.245*** (1.159–1.337)
East	—	0.915* (0.855–0.980)	0.906** (0.845–0.970)	0.904** (0.844–0.969)
North-East	—	0.558*** (0.510–0.610)	0.579*** (0.529–0.634)	0.549*** (0.502–0.600)
West	—	0.678*** (0.629–0.731)	0.685*** (0.635–0.739)	0.657*** (0.610–0.707)
South	—	1.178*** (1.102–1.260)	1.210*** (1.131–1.295)	1.169*** (1.093–1.251)
Place of Residence				
Rural	—	**1** *(Reference)*	**1** *(Reference)*	**1** *(Reference)*

Variables	Model 1 Unadjusted OR (95% CI)	Model 2 Adjusted OR (95% CI)	Model 3 Mechanism OR (95% CI)	Model 4 Continuous Index OR (95% CI)
Composite poor drinking-water conditions measure				
Urban	—	0.975 (0.931–1.020)	0.986 (0.942–1.032)	0.977 (0.933–1.022)
Composite poor drinking-water conditions measure (continuous, 0–5)				
Per 1-unit increase	—	—	—	1.081*** (1.061–1.101)
Water source				
Inside	—	—	**1** *(Reference)*	—
Outside premises	—	—	1.027 (0.964–1.093)	—
Water collection time				
0–15 min	—	—	**1** *(Reference)*	—
> 15 minutes	—	—	1.241*** (1.153–1.335)	—
Water trips/day				
0–3 trips	—	—	**1** *(Reference)*	—
> 3 trips	—	—	1.051 (0.980–1.128)	—
Water treatment				
Treats drinking water	—	—	**1** *(Reference)*	—
Does not treat drinking water	—	—	1.195*** (1.142–1.251)	—
Water Source Type				
Improved			**1** *(Reference)*	
Unimproved			1.012 (0.888–1.154)	
Sample size (N)	**60,512**	**58,324**	**58,324**	**58,324**

Variables	Model 1 Unadjusted OR (95% CI)	Model 2 Adjusted OR (95% CI)	Model 3 Mechanism OR (95% CI)	Model 4 Continuous Index OR (95% CI)
Composite poor drinking-water conditions measure				
Pseudo R^2 (McFadden)	**0.007**	**0.033**	**0.034**	**0.033**
Log-likelihood	**-34,214.86**	**-32,115.00**	**-32,078.46**	**-32,107.35**

OR = Odds Ratio; CI = Confidence Interval; — = not applicable for that model.

Significance: ***p < 0.001, **p < 0.01, *p < 0.05

i. Model = unadjusted logistic regression. Model 2 = fully adjusted logistic regression including age, gender, education, marital status, religion, wealth, caste, living arrangement, geographic zone and place of residence. Model 3 = component-specific analysis in which individual drinking-water variables were entered simultaneously with the same covariates. Model 4 = fully adjusted model using the continuous composite index (0–5).

ii. Base (reference) categories shown in italics as **1 (Reference)** for every variable across all applicable models.

iii. The analysis includes an unequal sample size across the variables. Each category is represented by an unequal number of observations due to missing cases (N = 60,512)

In the component-specific model (Table 3, Model 3), collection time exceeding 15 minutes one way was associated with higher odds of depressive symptoms (OR 1.241, 95% CI 1.153–1.335), as was not treating drinking water (OR 1.195, 95% CI 1.142–1.251). Source location outside the dwelling/plot, reporting more than three collection trips per day and water source type were not independently associated with depressive symptoms; households using unimproved sources had similar odds compared with those using improved sources. These component-specific results identify statistical associations for particular indicators but should not be interpreted as evidence that these indicators mediate or drive a causal effect of water insecurity.

In the continuous-index sensitivity model (Table 3, Model 4), each one-point increase in the constructed 0–5 score was associated with higher odds of depressive symptoms (OR 1.081, 95% CI 1.061–1.101). This result is consistent with the direction of the binary analysis, but because the index is not a validated scale and its components are equally weighted, the estimate should be interpreted as an association with the constructed score rather than as evidence of a validated dose-response relationship.

Sociodemographic correlates of depressive symptoms

After adjustment (Table 3, Model 2), odds of depressive symptoms increased with age relative to the 45–59-year group: OR 1.081 (95% CI 1.034–1.131) for ages 60–69, OR 1.204 (95% CI 1.136–1.277) for ages 70–79, and OR 1.359 (95% CI 1.244–1.485) for ages 80 years and above. Women had higher odds

than men (OR 1.062, 95% CI 1.018–1.109). Education showed an inverse gradient, with the odds among participants with graduate-level education approximately 40% lower than among those with no education (OR 0.597, 95% CI 0.535–0.667). Widowhood and other non-married statuses were associated with higher odds than being currently married, whereas living with a spouse or with other household members was associated with lower odds than living alone. Geographic differences were also observed, while urban residence was not independently associated with depressive symptoms after adjustment.

Discussion

Using nationally representative data from LASI Wave 1, this study examined the association between selected poor household drinking-water conditions and depressive symptoms among adults aged 45 years and older in India. The composite measure was statistically associated with depressive symptoms after adjustment for demographic, socioeconomic, and contextual characteristics. In the component-specific analysis, longer water-collection time and absence of household water treatment were associated with higher odds of depressive symptoms, whereas source location, collection frequency, and water-source type were not independently associated with depressive symptoms. These findings represent cross-sectional associations and should not be interpreted as evidence of causal effects.

The observed association between the composite measure and depressive symptoms is broadly consistent with previous research linking poor water conditionswith mental health outcomes in LMICs. (Stevenson et al., 2012) reported an association between water insecurity and psychosocial distress among women in rural Ethiopia, while (Cooper-Vince et al., 2018) reported an association between household water insecurity and depression in rural Uganda. Similar relationships have been reported among women in Nepal and Kenya (Aihara et al., 2015; Collins et al., 2019), while studies in Malawi and Ghana have examined relationships between water-related conditions, drinking-water practices, and mental health among vulnerable populations (Simiyu et al., 2022; Slekiene & Mosler, 2019). More recent research has continued to document associations between household water insecurity and depression in different social and environmental contexts (Lemaitre et al., 2023; Logie et al., 2024; Toivettula et al., 2023). The present study adds to this literature by examining a nationally representative population of adults aged 45 years and older in India.

The prevalence of depressive symptoms observed in the present analysis is also broadly consistent with the substantial burden reported in Indian studies of later-life depression. Previous research has demonstrated considerable variation in estimates across populations and instruments(Devikrishna et al., 2024; Khanal & Selvamani, 2024). Studies using LASI data have also identified socioeconomic, demographic, and health-related inequalities in depressive symptoms among older adults(Muhammad & Meher, 2021; Saha et al., 2024; Srivastava et al., 2021). The present estimate should therefore be interpreted in relation to the CES-D-10 threshold used in this study rather than as a clinical diagnosis of depressive disorder. Research comparing CES-D with other depression measures in the LASI further demonstrates that estimates can vary depending on the instrument and threshold used(Muhammad et al., 2025).

The association observed for longer water-collection time is consistent with the hypothesis that the time and physical burden of obtaining water may be relevant to mental health. Previous studies have documented the physical burden of water carrying and its implications for women's well-being, gender equity, and daily activities(De Guzman et al., 2023; Tomberge et al., 2021). A longer collection time may require greater physical effort and may also divert time from household activities, social participation, leisure, or productive work. These considerations may be particularly relevant among older adults because physical functioning and capacity may vary substantially with age and disability(Simiyu et al., 2022; Toivettula et al., 2023). However, LASI Wave 1 does not directly measure fatigue, musculoskeletal pain, perceived stress, detailed time use, or social participation as mediators. The association, therefore, provides statistical evidence regarding collection time but does not demonstrate the hypothesized pathway via physical exhaustion, opportunity cost, or psychosocial stress.

The absence of an independent association between source location and collection frequency should also be interpreted with caution. Obtaining water outside the dwelling or plot does not necessarily impose the same burden across households. The psychological implications may depend on the distance involved, the quantity collected, the mode of transportation, who performs the collection, and whether the task is shared among household members. Similarly, the number of collection trips alone may not capture the total burden of water acquisition. A household making several short trips may experience a different burden from a household making fewer but longer trips. Thus, the null associations for source location and collection frequency indicate that these individual indicators were not independently associated with depressive symptoms in the adjusted model; they do not establish that distance or collection activities are irrelevant to mental health.

Water-source type was similarly not independently associated with depressive symptoms. In the corrected analysis, households using unimproved sources had similar odds of depressive symptoms compared with households using improved sources (OR 1.012, 95% CI 0.888–1.154, p = 0.850). This finding illustrates the limitation of using source type alone as an indicator of household water-related disadvantage. An improved source may still be distant, time-consuming to access, unreliable, unaffordable, or perceived as unsafe. Conversely, classification of a source as unimproved does not establish the microbiological or chemical quality of the water actually consumed. The finding, therefore, supports the need to distinguish source classification from the broader conceptual construct of household water insecurity.

The association between the absence of household water treatment and depressive symptoms requires particular caution. Treatment is a household behavior and does not directly establish whether water is microbiologically or chemically unsafe. Households that treat their drinking water may differ from those that do not in knowledge, income, source characteristics, risk perceptions, and access to treatment technologies. Consequently, the observed association may reflect a combination of water-quality concerns and household characteristics rather than a direct relationship between untreated water and depression. Although previous literature has discussed possible relationships among unsafe water, illness, inflammation, and mental health (Toivettula et al., 2023; Wu et al., 2025; Zhang et al., 2016), the

present analysis lacks objective water-quality measurements or longitudinal data sufficient to establish such a biological pathway. The treatment finding should therefore not be interpreted as evidence that untreated water causes depression.

The sociodemographic patterns in the analysis are broadly consistent with previous research on depression among older adults. Advancing age has been associated with greater mental-health vulnerability through cumulative health, social, and economic disadvantages(Richardson et al., 2020; Roberts et al., 1997). The higher odds observed among women are consistent with international evidence showing gender differences in depressive symptoms and with literature linking gendered socioeconomic and household responsibilities to mental health(Bromet et al., 2011; Smith et al., 2021). The education gradient is also consistent with research indicating that educational attainment is associated with socioeconomic resources and mental-health outcomes(Russ et al., 2013). Marital status and living arrangements may influence social support and exposure to social isolation; Indian research has similarly documented the relevance of these characteristics for mental health among older adults(Panda et al., 2023; Srivastava et al., 2021; Tripathi & Samanta, 2023).

The timing of the data is also important. LASI Wave 1 was conducted during 2017–18, before the launch of the Jal Jeevan Mission in August 2019. The Government of India subsequently launched a mission to expand rural household tap water connections and improve access to safe and adequate drinking water. Consequently, the present estimates describe household drinking-water conditions and depressive symptoms during the 2017–18 survey period and should not be interpreted as estimates of current water access in India. Subsequent changes in infrastructure may have altered the prevalence and distribution of the drinking-water indicators examined in this study. The LASI Wave 1 findings nevertheless provide a useful baseline for understanding the relationship between household drinking-water conditions and mental health before the expansion of the Jal Jeevan Mission.

Strengths and limitations

The study has several strengths. It uses a large, nationally representative ageing dataset, applies survey weighting to population estimates, examines the composite measure alongside its individual components, and distinguishes statistical association from hypothesised causal pathways. The use of component-specific and continuous-index analyses also allows readers to assess whether the main finding depends on the binary operationalisation.

Several limitations should be considered. First, the cross-sectional design precludes assessment of temporal ordering and causal inference; reverse causality cannot be ruled out. Second, the exposure is an analytically constructed proxy rather than a validated water-insecurity scale. It does not capture the full experiential and psychosocial construct. Third, equal weighting and the ≥ 1 binary threshold are analytical assumptions, and different operationalisations could yield different estimates. Fourth, the > 15-minute and > 3-trip thresholds are LASI-based analytic cut-points rather than universal standards. Fifth, ADL/functional-disability measures were not included, leaving potential residual confounding by

physical functioning. Finally, because the data were collected in 2017–18, the findings represent a baseline period preceding the major subsequent expansion of rural household tap-water provision under the Jal Jeevan Mission.

Conclusion

Among adults aged 45 years and older in India, poor household drinking-water conditions measured using five LASI indicators were statistically associated with depressive symptoms in 2017–18. Longer water collection time and the absence of household water treatment were individually associated with depressive symptoms, whereas source location, source type, and collection-trip frequency were not independently associated after adjustment. These findings are consistent with the possibility that the time, effort and water-safety conditions surrounding household drinking water are relevant to mental health, but they do not establish causal or mediating pathways.

The study should be interpreted as evidence concerning selected household drinking-water conditions rather than as a validated estimate of the full water-insecurity construct. Future research should incorporate validated water-insecurity measures, objective water-quality assessment, individual-level information on water collection, ADL and functional status, and longitudinal designs. Given that LASI Wave 1 predates the launch of Jal Jeevan Mission, updated research is also needed to determine whether subsequent improvements in household drinking-water services have been accompanied by changes in depressive symptoms.

Declarations

Ethical Considerations

The present study used de-identified secondary data from Wave 1 of the Longitudinal Ageing Study in India (LASI), conducted in 2017-18. The original LASI survey was conducted under the ethical oversight of the Indian Council of Medical Research (ICMR) and the International Institute for Population Sciences, Mumbai. Informed consent was obtained from all participants, and appropriate procedures were implemented to protect participants' privacy, confidentiality, and voluntary participation. The present study involved no direct contact with participants and used only de-identified secondary data obtained for research purposes. The analysis, therefore, involved the secondary use of existing survey data and did not involve collecting new information from human participants. The study was conducted in accordance with applicable ethical principles governing research involving human participants and the Declaration of Helsinki. Any institutional requirements applicable to the secondary analysis were followed in accordance with the conditions governing access to and use of the LASI dataset.

Consent for Publication: Not applicable.

Clinical Trial Registration: Not applicable.

Declaration of Competing Interest

The authors declare that they have no financial or personal relationships that could have influenced the conduct, analysis, interpretation, or reporting of this study.

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Data Availability Statement

The data analysed in this study were obtained from Wave 1 of the Longitudinal Ageing Study in India (LASI), 2017-18, maintained by the International Institute for Population Sciences, Mumbai, India. De-identified data are available to researchers subject to registration and approval through the LASI data-access procedures. LASI Data Access

Authors' Contributions

O.H.: Conceptualized the study, developed the research objectives and analytical framework, conducted the literature review, prepared and managed the LASI Wave-I dataset, performed the statistical analyses, interpreted the findings, and drafted the manuscript.

A.B.: Contributed to the literature review, interpretation of the findings, and critical revision of the manuscript.

A.P.: Contributed to the interpretation of the results, methodological discussion, and critical revision of the manuscript.

S.S.: Contributed to the interpretation and presentation of the findings and critically reviewed the manuscript.

A.G.: Supervised the study, contributed to its conceptual and methodological development, provided intellectual guidance, and critically reviewed and revised the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

J.M.: Preparation of tables, cross-verification of results with the LASI National Report, harmonization and validation of results obtained from the appropriate analyses, and contribution to the interpretation and presentation of findings.

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