



Why is water insecurity so distressing? Evidence from Iran that interpersonal conflict is key

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ABSTRACT

Chronic household water insecurity is consistently linked to distress and poor mental health, yet the social pathways remain under-tested. We examine multiple theorized socially situated mechanisms that may explain how household water insecurity translates into depressive symptoms, using population-representative 2024 survey-interview data ($N = 685$) from Sistan and Baluchestan, Iran. Household water insecurity (HWISE-12), depressive symptoms (PHQ-9), and five mechanisms—interpersonal conflict, distributive injustice, procedural injustice, institutional distrust, and water-labor burden—were measured with validated or locally developed scales. Structural equation modeling estimated direct and indirect effects, adjusting for gender, residence, age, education, income, and household size. Mean HWISE scores exceeded prior global benchmarks and mean PHQ-9 scores were higher than clinical cut-points for moderate depression, confirming both extreme insecurity and high levels of psychosocial distress. Findings suggest multiple nonmaterial mechanisms work simultaneously to link water insecurity to poor mental health. The model explained more variance in men's depression ($R^2 = .34$) than women's ($R^2 = .14$). Interpersonal conflict was the strongest and most consistent statistical mediator of PHQ-9 scores. Stronger effects for men ($\beta = .47$) than women ($\beta = .22$) are likely related to men's roles in local water governance. Perceived distributive injustice was associated with higher PHQ-9 scores across groups, while procedural injustice was significant only for men and in urban settings. Distrust of water-related institutions was significant only among women, while burdens of water labor were associated with PHQ-9 scores for both genders, particularly in rural settings. Household income did not account for these associations once social mechanisms were considered. We highlight the need for mixed-method research to refine theory and interventions that recognize the many ways water insecurity operates socially to shape distress and related mental health outcomes.

1. Introduction

A growing number of studies are showing that the chronic experience of living with water insecurity is consistently associated with emotional distress and worse mental health, including heightened levels of depression (Kimutai et al., 2023; Maxfield, 2020; Wutich et al., 2016, 2020; Tallman, 2019; Brewis et al., 2019a; Bisung and Elliott, 2017). The material experience of living with water insecurity certainly creates practical challenges in everyday life that stretch limited resources like

time and cash, compete with other material needs (like food, energy, or sanitation), and otherwise require complex day-to-day management. Financial stress has been identified as a key element (Bisung and Elliott, 2017). Yet, such practical conditions of water insecurity in themselves do not adequately explain the strength and forms of observed associations with estimated levels of distress, depression, and similar signals of emotional and psychological stress. One of the clearest cases showing this is an intervention in Ethiopia that improved household water access without simultaneous improvement in depression and other measured

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indicators of psychosocial wellbeing (Stevenson et al., 2016).

Rather, the cultural meanings and social consequences of inadequate access to sufficient and safe water to meet all household and personal needs appear to amplify distress or related indices of psychosocial stress (Wutich et al., 2020; Bisung and Elliott, 2017). The current theorizations about pathways that link the lived experience of water insecurity to distress and implied mental health effects are predominantly based in ethnographic observation (e.g., Mushavi et al., 2020; Tallman, 2019; Shinyemba and Cloete, 2023). Wutich et al. (2020) summarized the ethnographic evidence of candidate socially situated mechanisms. One proposed mechanism is water insecurity's ability to spotlight one's low social position and reveal everyday injustices through which one is being disadvantaged or mistreated relative to others (e.g., Brewis et al., 2021; Wutich and Ragsdale, 2008). Another is as a potential trigger for general interpersonal conflict both inside and outside the home (e.g., Pearson et al., 2021). Others include fears related to water or bodily safety regardless of actual threat (e.g., Kangmennaang et al., 2020), loss of meaningful connections to place and to others (e.g., Ženko and Menga, 2019) that were embedded in water, inadequate water as a source of shame and signal of social failure (Sultana, 2011), and the worry, reduced autonomy, and frustrated aspirations linked to spending effort and time managing water-related responsibilities (e.g., Molden et al., 2020; Wutich and Brewis, 2014).

Empirical studies testing such nonmaterial mechanisms that connect water insecurity to validated mental health or other measured psychosocial outcomes are few. But existing research suggests the possibilities for distinguishing empirically the relative roles of different proposed mechanisms. In Uganda, Mushavi et al. (2020) identified a strong association between material household water insecurity and depression level and then shared nonmaterial explanations gained ethnographically including frustrations around choicelessness. However, this study did not test further for any mediating effect. The reality of living with extreme water insecurity also means it is unlikely these factors operate in isolation from each other, although direct studies assessing exactly how they may interact are limited in the scholarly literature. In a population-representative study in Eastern Ethiopia that included both the burden of water responsibility and perceived unfairness to explain variance in depressive symptoms, Brewis et al. (2019a) showed that perceived unfairness explained the majority of the observed effect.

To further advance theory-building, here we model data from survey interviews with population-representative sampling of adults in households from southeastern Iran. We test how five previously theorized socially-situated mechanisms might operate to explain individual levels of depression symptoms in the context of southeast Iran's chronic water crisis. The novel contribution is considering how varied theorized mechanisms might operate simultaneously and in relation to each other. Such an approach is crucial to clarifying and isolating how and why social elements of water insecurity translate into psychological distress. Understanding which nonmaterial aspects of water insecurity exert more influence is important to theory-building, but also can provide important clues for how to design more effective interventions.

The case of Sistan and Baluchestan province in southeast Iran is a potentially illuminating setting in which to test simultaneously multiple such theorized mechanisms. Iran's largest province has been experiencing a deepening water crisis for over two decades. While the crisis is situated within a challenging environmental context of arid climate, irregular rainfall, and limited vegetation, this has been accelerated by intensive groundwater extraction and the completion of the Kamal Khan Dam in neighboring Afghanistan with a devastating loss of surface water that includes the disappearance of Iran's Hamun lake (Loodin, 2025; Ahrari, 2018; Raziei et al., 2007). This has yielded severe negative impacts on local agriculture, economies, livelihoods, and health (Omidvar et al., 2024; Darroudi et al., 2022; Khosnoodifar et al., 2022; Mahmoudi et al., 2015; Firoozi et al., 2020; Piri et al., 2013), with over a quarter of the population forced to relocate internally to other areas of Iran as a result. The decline in agriculture and livestock farming due to water

scarcity has particularly contributed to male labor out-migration from rural areas (Minority Rights Group, 2023). But the challenges are not only rural. In urban centers such as Zahedan and Zabol, water and sanitation infrastructure is inadequate, unevenly distributed, and intermittent. So, in both contexts, securing adequate and safe household water is a chronic challenge. Sustainable interventions for the province remain elusive, a task complicated by the particular economic, political, and social vulnerabilities of a large minoritized population.

1.1. Study aim, design, and setting

Our goal in this study was to differentiate and identify the varied independent direct and indirect effects of theorized social mechanisms that might explain water insecurity's connection to distress and related negative mental health outcomes. We limited ourselves to five theorized mediating mechanisms that made sense in this specific southeastern Iranian context and were amenable to survey-based data collection. These were: exposures to interpersonal conflict, people's perceptions of distributive and procedural injustices, institutional distrust, and the personal burden of being responsible for accessing household water.

We set out to design our study to test how specified social mechanisms might independently and collectively explain associations between household water insecurity and individual depression symptoms. Our specific research questions were.

- Can we confirm the overall relationship between household water insecurity measures and PHQ-9 scores (as a measure of distress/mental health) in this sample?
- What is the relative role of five previously theorized socially-situated stressors—distributive/procedural injustice, institutional distrust, interpersonal conflict, and the burden of water labor—in explaining PHQ-9 scores?
- Which of the candidate mechanisms have the strongest associations with our depression measures?
- Do sociodemographic factors (particularly gender and residence status) moderate or confound the association between water insecurity, candidate mechanisms, and PHQ-9 scores?
- Can we make sense of these overall results in the contexts of everyday life in Sistan and Baluchestan's ongoing water crisis?

2. Background

2.1. Candidate mechanisms

In this section we outline the theoretical rationale for the selection of each of the proposed mechanisms considered in this study.

2.1.1. Proposed mechanism #1: interpersonal conflict

Early ethnographic work by Wutich (e.g., 2009) in informal settlements in Bolivia suggested that limited household water could amplify interpersonal conflict *between* households, such as heated arguments with and social avoidance of neighbors. Integrating data from small-scale surveys at 22 water insecure sites globally, Wutich et al. (2022) clarified subsequently that requesting water from neighbors was consistently associated with feelings of anger and interpersonal conflict. Similarly, through more recent qualitative study in South Africa, Seretlo-Rangata et al. (2025) described how social strain and disputes readily erupted between households when sharing a limited water source.

Other research has documented the associations between water insecurity and interpersonal conflict *within* the household, and in ways that suggest that the issue is not only fights around access to water *per se*. Rather, limited water seems to aggravate overall tension and arguments within households. One repeatedly measured association of household water insecurity related to more general interpersonal conflict within the home is prevalence of intimate partner violence (IPV) where gender

norms and power disparities are differentiated within couples (Nunbogu and Elliott, 2021). In a population-representative study from Nepal, where women are the primary water managers, Choudhary et al. (2020) show how risk of IPV increases in line with reductions in household access to water. Similarly, study in Indonesia by Cole et al. (2024) estimated that women from water insecure households were at more than double the risk of gender-based violence in the last year, including from violence in their own homes.

Thus water insecurity can both lead to direct fights about water itself, but also is theorized to heighten overall conflict because water is integrated with so many aspects of everyday household finances and functioning. For example, a review of the relevant literature by Tallman et al. (2023) identified failures to complete domestic chores as the most common explanation given for intimate partner violence, a situation resulting from lack of water for cooking, cleaning, and so on. But this conflict may not be recognized by those involved as “water-related.” So, for the purposes of this study, we decided to recognize general everyday conflict (with family, friends, and neighbors) not just “water-related” conflicts in how we approached testing of this proposed mechanism.

2.1.2. Proposed mechanism #2: institutional distrust

Distrust of institutions that provide or oversee water has been identified as a factor in how people relate to their water emotionally, with implications for mental health (e.g., Cuthbertson et al., 2016). The distrust in water systems is related to objective water safety but also such factors as past experiences, community history, and wider systems of exclusion, exploitation and oppression that can be manifest in water delivery systems (Meehan et al., 2020; Wilson et al., 2023). For example, Sultana et al. (2022) describe how Six Nations members in Canada recognize water as a fundamental human right that is denied and mistrust state water supplies, and also connect this to their mental health.

2.1.3. Proposed mechanisms #3 and #4: perceived procedural and distributive injustice

Recognition that one has been subject to systemic and structural unfairness is linked generally to worse mental health overall (Jackson et al., 2006). In this way, the symbolic meanings of perceived water injustice are another factor theorized as explanatory for why living with water insecurity causes distress and worsens mental health (Wutich and Brewis, 2014; Wutich et al., 2020). In a study of 1543 women in rural Ethiopia, Brewis et al. (2021) showed that perceived unfairness in water allocation mediated 2/3rd of the observed effect of water insecurity on depression levels.

In the Ethiopian study, the authors evaluated perceived injustice based on one general question: “how unfair is your water situation compared to others?” But multiple dimensions of injustice can intersect with water insecurity, potentially with different effects on psychological wellbeing (Wutich and Brewis, 2014). Roque et al. (2023) particularly suggest procedural and distributive forms of injustice can be recognized as distinct constructs particularly relevant and comparatively better theorized as relevant to understanding the local dynamics of water insecurity. Distributive injustice refers to the unfairness of how resources are allocated, such as reflected in reduced water access for some compared to others based on such factors as regional marginalization or ethnic discrimination. Procedural injustice relates to the unfairness of rules and practices around how water is managed through institutions, such as by local committees, government officials and agencies, or private companies.

2.1.4. Proposed mechanism #5: psychological burdens of responsibility for water fetching

Labor responsibilities for household water potentially intersects with all the above mechanisms but may also be considered a separate mechanism. Particularly, being responsible for water fetching is often reported as highly stressful, with identified factors including anticipated

and realized threats to physical safety journeys to water sources (Venkataramanan et al., 2020; Geere et al., 2018). Also implicated is frustrating or distressing loss of time for economic, educational, or other responsibilities and opportunities based on the time needed to fetch water, including queueing or waiting for slow water to fill containers. Dinko and Nyantakyi-Frimpong (2023) compared villagers living at different distances from irrigation channels in Gahan, and found that longer journeys to water predicted additional physical and psychological distress. Thomas and Godfrey (2018) explain, in the case of an Ethiopian village, how water quantity or distance to water was not distressing. Rather, it was loss of valuable time.

2.2. Additional considerations

2.2.1. Implications of gender

Certainly, gender is complexly inter-related with all these proposed mechanisms. Multiple studies have shown women and men – even living together in the same households – can experience the mental health effects of water insecurity very differently (e.g., Brewis et al., 2019; Wutich, 2009). Water labor is the best theorized and demonstrated, with negative effects assumed to track gendered norms related to who carries the responsibility for ensuring the adequacy and safety of household water (Dickin and Caretta, 2022). In many observed cases, effects on mental health appear to conform to this assumption. For example, a study in rural Uganda by Mushavi et al. (2020) showed an association between water insecurity and heightened depression symptoms, with qualitative interviews identifying that gendered norms create considerable additional stress for women because it was intolerable for them to ask husbands for support for water collection activities, even when heavily pregnant or sick. In a study of physiological stress (measured as blood pressure) in Nepal, where women and girls do almost all household water-related labor, women’s stress levels tracked household water insecurity. That of their matched husbands did not, even while living together under exactly the same conditions of household water insecurity (Brewis et al., 2019b). In a Malawi case, Adams suggests that men are psychologically affected by household water fetching more than women when they participate because it is considered “women’s work” and hence humiliating. As a supporting non-finding, some qualitative studies of contexts where water collection is considered a shared household task between men and women suggest less or no gender difference in the emotional toll of water insecurity (de Jong and Butt, 2025).

2.2.2. Implications of rural versus urban residence

The stress of securing adequate and safe household water can vary between urban and rural contexts. Water in urban areas is increasingly commodified and often requires more cash to access. Different estimates of the trade-offs of time spent accessing water also relate to livelihood differences. For example, Pearson et al. (2021) identified the possibility of heightened strain in urban households as a general pattern, perhaps – they suggest – because time spent on water fetching reduces the time available to earn cash income. Further, gender roles that are relevant to water may vary between urban and rural settings, showing how both should be considered. For example, in urban areas men may have more responsibility for accessing water compared to men in rural households if they control household cash purchasing or if urban water-fetching requires the use of vehicles like motorcycles (Geere and Cortobius, 2017).

2.2.3. Distinguishing distress, depression, and other signals of psychosocial stress

The original work by Wutich in Bolivia (e.g., 2009) and follow up theoretical integration by Wutich and Brewis (2014) and Wutich et al. (2020) has theorized around ethnographic observations of “distress” in association with water insecurity. But this is then assumed to be a proxy for level of depression and other common mental health conditions (e.g.,

Wutich, 2009: 437–438). Other studies simply collapse these as a single construct, such as “psycho-emotional distress” used in Achore and Bisung’s (2022) research in Ghana or the clumping of negative emotions with anxiety/depression in Kenya by Kimutai et al. (2025). To complicate further, some studies treat signals of distress and/or depression as a proxy measure for water insecurity itself (Libey et al., 2022; Hutchings et al., 2022; Cooper et al., 2019) or use reports of the level of water-related conflict (e.g., arguments) as their measure of water-related distress (e.g., Kangmennaang et al.’s (2020) study in urban Ghana). But while the varied theorization of water-related “distress” encompasses an array of means to conceptualize this in locally-relevant ways, a focus on levels of depression symptoms – or related measures of validated, standardized mental health status – is particularly relevant as the construct for theory-building because it should allow greater comparability across studies and allow better tracking through time (Wutich et al., 2020). Thus, while the theoretical basis of this research is built from studies considering varied forms of “distress,” we used depression symptoms measured on a validated scale (the PHQ-9) because it is potentially more comparable from site to site.

3. Sample, materials, and methods

3.1. Sample

The study population consisted of all residents above 15 years of age in Sistan and Baluchestan province in 2024. According to Statistical Center of Iran (2024), the 26 counties have 1,875,128 residents above 15 years of age. The sample size for the proposed structural equation modeling was determined using Cochran’s (1977) formula as 384, but the final target was increased to 685 samples for better allocation of samples to the subgroups of the statistical population (i.e., gender and resident status in rural/urban areas). Multi-stage cluster random sampling began with random selection of 10 out of 26 counties, then selection for both rural and urban areas, then blocks and then roads, streets, and alleys were randomly selected. Then every third house was selected. Within each household, all members aged 15 years and older were listed. If multiple eligible members were present, a random selection procedure was applied using a Kish grid to ensure equal probability of selection. This approach minimized household-level selection bias and guaranteed that the respondent was not necessarily the household head. The response rate was 95.2 %, 58 % of respondents were male and 42 % were female, and 57 % of respondents lived in rural areas and 43 % in urban areas. Data were collected through a dedicated survey carried out specifically for this study in winter 2024. Following informed consent, trained interviewers with familiarity with the targeted communities conducted the interviews in Persian. This study has been registered with the Research Ethics Committee of Arak University of Medical Sciences with the code IR.Arakmu.rec.1404.021.

3.2. Independent and key mediating variables

Household Water Insecurity: The construct captures the inability of households to reliably obtain adequate, safe, and acceptable water. It was assessed using the 12-item validated Household Water Insecurity Experiences scale with a 4-week recall (Young et al., 2019, see Appendix 1).

Interpersonal conflict: This construct captures the relative frequency of arguments with family, friends, and neighbors over the preceding 4 weeks (see Appendix 1). Scale items were developed locally through consultations with community members and local experts. Content validity was confirmed by expert panel review, then internal consistency (Cronbach’s $\alpha = .83$; CR = .85) was established in the full survey sample.

Institutional Distrust: This construct captures lack of trust in institutions responsible for water management, captured using 4 items from a forthcoming “water trust” scale (Stoler et al., n.d., Pearson et al.,

2025).

Perceived Procedural and Distributive Injustice. Perceived water injustice was assessed using two dimensions (distributive and procedural) each with 4 elicitation items (see Appendix 1). Respondents were asked to assess their sense of justice in terms of access to water, decent livelihoods, respect for the rights of ethnic minorities, and equal legal protection. The selection of items reflected prior studies by Suiseeya (2020) and Parris et al. (2020) suggesting that in this local context there is significant injustice discourse around the environmental sector in general and the water sector in particular, particularly on these four issues. All items were measured using a Likert-type scale that ranged from 1 (completely disagree) to 4 (completely agree) with a summary score used as a continuous variable.

All the above variables were derived from Likert-type scale responses summed to derive continuous measures.

Burden of Responsibility for Water Labor: To assess respondent’s relative personal burden for household water labor, we first assessed how much total time was allocated to accessing household water in minutes in the prior week, including queueing and travel time. We used a weekly measure because households because time allocations can shift from day to day based on use of alternate sources. We then weighted minutes based on whether this labor burden was the respondent’s alone (multiplied by 2), shared (multiplied by 1), or carried by other household members (multiplied by 0).

3.3. Dependent variables and covariates

Patient Health Questionnaire (PHQ-9): The PHQ-9 assesses the frequency of nine core depressive symptoms over the prior 4 weeks to create a continuous score (Appendix 1). We used a Persian-language version validated for use in Iran (Farrahi et al., 2021).

Key Covariates included self-reported respondent gender (male/female) and residence status (urban/rural), as potentially important explanatory factors in interpreting data patterns (see above). Gender was specified as a dummy variable with (1) male, (2) female. Residence status was specified as (1) residence in an urban area, (2) residence in a rural area. Urban residence was defined by the household being located within a defined municipality.

Additional descriptive variables included participant age and education, household size, marital status, and estimated monthly household income (USD). Marital status was specified as (1) never married, (2) married, (3) divorced/widowed. Education was measured by the number of years of formal education. Household income and household size were actual counts.

3.4. Validity and reliability of measurement instruments

All the key independent variables except water labor were created as additive scales. All the scales were found to have high internal consistency ($\alpha > .70$; CR $> .70$, see Table 1) as recommended by Esposito Vinzi et al. (2010). We also tested discriminant validity by exploring the average variance extracted (AVE) shared between a construct and its measures. AVE indices were higher than .50 as recommended by

Table 1
Scale reliability and factor loadings from CFA.

Variables	Factor loadings (min-max)	AVE	C. R	α
Household water insecurity	.66–.81	.57	.91	.94
Sense of distributive environmental/ water injustice	.77–.83	.64	.86	.82
Sense of procedural environmental/ water injustice	.71–.81	.61	.85	.80
Institutional distrust	.65–.78	.51	.83	.71
Interpersonal conflict	.82–.89	.74	.85	.83
PHQ-9	.68–.80	.58	.92	.91

Rodgers and Pavlou (2003). Finally, we conducted a first order confirmatory factor analysis (CFA) for these scales; factor loadings for all the items were significant ($>.50$). Moreover, the CFA revealed good fit indices for all scales (Byrne, 2016).

3.5. Analytic approach

Variables were analyzed using the Statistical Package for the Social Sciences (SPSS, version 23). The independent and dependent variables were described and presented by mean and standard error. To achieve the main goal of the study, we used visually-based structural equation models (SEM) via AMOS software (SPSS, version 23) as shown in Fig. 1. SEM was selected because it allowed simultaneous testing of both the direct and indirect effects of independent variables on the dependent variable. Gender and residence status (urban/rural) were specified as key covariates. In contrast, age, household size, income, and education were modeled as independent variables. This strategy allowed us to both control for potential confounding and explicitly assess the extent to which major demographic-socioeconomic indicators shaped the observed relationships. This approach yielded estimates of the degree of

impact of the control variables (age, household size and income and individual education), other key variables (gender, residence location), and key independent variables (household water insecurity, water injustice, institutional distrust, interpersonal conflict, and water labor) on dependent variable (PHQ-9); The results from the model are reported as standardized beta coefficients. All analyses were conducted at the individual level, with each respondent serving as the unit of analysis. Although data were collected within households, no household-level aggregation was performed, as the primary interest was in individual experiences and depression status.

3.6. Model specification rationale

We specified structural equation models to clarify the pathways linking household water insecurity to depressive symptoms. We first estimated the direct association between household water insecurity and PHQ-9 scores without mediators to establish a baseline relationship. Then we added the five theorized mediating mechanisms—interpersonal conflict, distributive and procedural injustice, institutional distrust, and burden of water labor simultaneously to

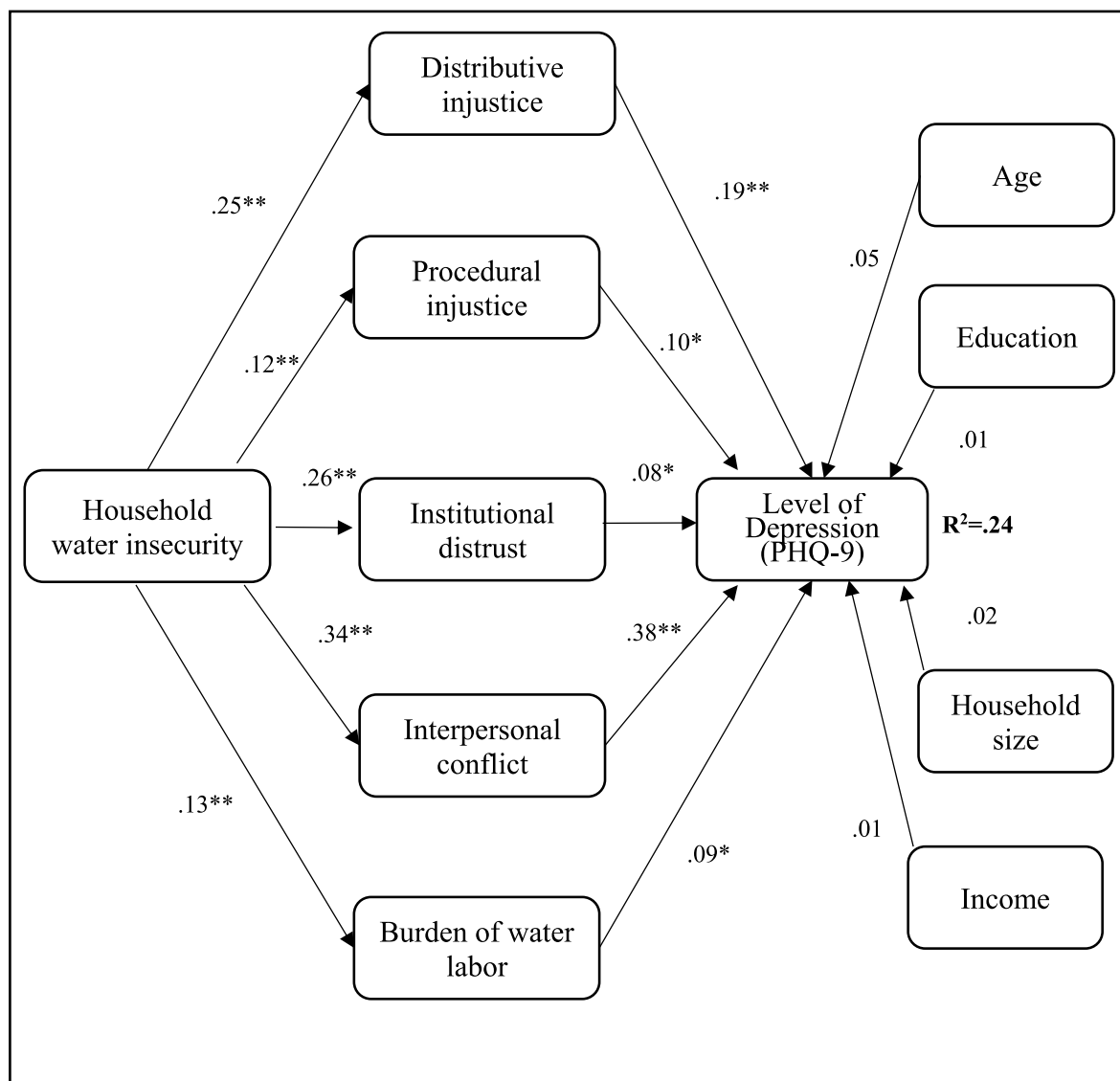


Fig. 1. Structural equation model showing direct and indirect pathways linking household water insecurity to depressive symptoms (PHQ-9). Standardized coefficients are shown for significant paths ($p < .05$). Mediators include interpersonal conflict, distributive and procedural injustice, institutional distrust, and burden of water labor.

evaluate their combined indirect effects, while also incorporating sociodemographic covariates (age, education, household size, and income) to control for potential confounding and to assess whether associations persisted net of these factors. Then we developed stratified models by gender and place of residence. This stepwise approach allowed us to test both the robustness of the main associations and the incremental explanatory value of the social mechanisms while maintaining theoretical coherence across models.

4. Results

4.1. Descriptive results

Descriptive statistics for demographic characteristics, household water sources, and reported water-fetching responsibilities are summarized in Table 2. Rural residents reported larger household sizes and

significantly more time spent collecting water, while urban and male respondents had higher average incomes and education levels. Mean values of key variables are provided in Table 3. Both household water insecurity and PHQ-9 mean scores were high overall. Household water insecurity, interpersonal conflict, water-labor burden, and PHQ-9 scores were higher on average among rural residents according to t-tests. Table 4 shows that PHQ-9 scores have a positive and significant relationship with independent variables of household water insecurity, sense of distributive and procedural injustice, water-relevant institutional distrust, interpersonal conflict, and burden of water labor.

4.2. Confirmation of SEM assumptions

To begin, assumptions of the structural equation model were confirmed (see Table 5), including sample size adequacy, normality, multicollinearity and homogeneity of variances. Kline (2016) suggests at

Table 2
Sample descriptives.

Variables	All	Male	Female	T-value	Rural	Urban	T-value
Age mean (SD)	28.7 (9.4)	29.2 (9.5)	28.1 (9.2)	1.33	28.9 (9.5)	28.7 (9.2)	.191
Education mean (SD)	12.7 (1.4)	12.9 (1.3)	12.6 (1.5)	2.35*	12.5 (1.6)	14.1 (1.2)	4.30**
Household size mean (SD)	5.6 (2.4)	5.7 (2.4)	5.5 (2.3)	.998	5.9 (2.7)	5.1 (1.8)	3.86**
Household income mean per USD (SD)	332.2 (48.1)	342.4 (49.9)	327.6 (47.4)	.342	292.6 (45.9)	383.8 (51.1)	2.13*
Time spent collecting household water per week [Mean per minutes (SD)]	252.1 (74.4)	258.2 (89.2)	257.1 (68.8)	.140	373.5 (101.6)	103.4 (26.3)	4.16**
Who in your household is most responsible for ensuring the household has water?	Self Another female and male adult All adults equally Male and female child or children Sum	40.7 % 17.6 % 23.8 % 12.2 % 100 %	47.6 % 31.2 % 24.9 % 14 % 100 %		42.2 % 23.2 % 23.9 % 10.7 % 100 %	38.4 % 24.4 % 21.9 % 15.3 % 100 %	
Main source of drinking water at home	Piped water into dwelling Piped water to yard/plot Public tap/standpipe Tubewell/borehole Protected dug well Unprotected dug well Protected spring Unprotected spring Rainwater collection Cart with small tank/drum Tanker-truck Surface water (river, dam, lake, pond, stream, canal, irrigation channels) Purchased, borrowed, or gifted from other households Other Sum	46.1 % 13.4 % 6.1 % 10.7 % 3 % 2 % 1.5 % – 1 % 2 % 4.8 % 1.7 % 1.5 % 6.3 % 100 %	42.6 % 13.9 % 6.5 % 13 % 2.4 % 2.1 % 1.8 % – 1.5 % 1.2 % 5 % 1.8 % 1.2 % 7.1 % 100 %	51 % 12.6 % 5.9 % 7.9 % 2.9 % 2.1 % 1.3 % – .4 % 2.5 % 4.6 % 1.7 % 1.7 % 5.4 % 100 %	34.5 % 17.8 % 8 % 13.2 % 4 % 3.7 % 2.2 % – 1.8 % 1.5 % 3.4 % 1.8 % 2.5 % 5.5 % 100 %	63.7 % 8.5 % 4 % 5.2 % 1.2 % – .8 % – – 2 % 6.9 % .8 % – 6.9 % 100 %	
Main source of non-drinking water at home	Piped water into dwelling Piped water to yard/plot Public tap/standpipe Tubewell/borehole Protected dug well Unprotected dug well Protected spring Unprotected spring Rainwater collection Cart with small tank/drum Tanker-truck Surface water (river, dam, lake, pond, stream, canal, irrigation channels) Purchased, borrowed, or gifted from other households Other Sum	45.7 % 17.7 % 5 % 12.6 % 3.8 % 1.7 % 1 % 1.2 % 1.2 % 1 % 4 % 1.2 % .5 % 3.6 % 100 %	41.9 % 18 % 5.3 % 15.3 % 3.8 % 1.5 % 1.8 % 1.5 % 1.8 % .3 % 2.9 % 1.2 % .3 % 4.4 % 100 %	51 % 17.2 % 4.6 % 9.2 % 3.3 % 2.1 % .8 % – .4 % 2.1 % 5.4 % 2.5 % – 2.5 % 100 %	32.4 % 19.9 % 7.6 % 16.8 % 4.6 % 2.1 % 1.2 % 1.8 % 1.8 % .9 % 4 % 1.8 % .3 % 4.6 % 100 %	65.4 % 16.3 % 1.6 % 4.5 % 2.4 % .8 % .4 % .4 % .4 % 1.2 % 3.7 % – .4 % 2.4 % 100 %	
Marital status	Single Married Others Sum	37.7 % 59.3 % 4 % 100 %	40.4 % 57.8 % 1.8 % 100 %	33.2 % 62.6 % 4.2 % 100 %	35.9 % 60.2 % 3.9 % 100 %	39 % 59.3 % 1.6 % 100 %	

Note: SD=Standard deviation, * $p < .05$, ** $p < .01$.

Table 3

Description of the independent and dependent variables.

Variables	All respondents			Per gender and residence status					
	Mean	SD	Range	Male	Female	T-value	Rural	Urban	T-value
Household water insecurity	21.79	8.55	0–36	21.96	21.92	.064	23.16	20.1	4.26**
Distributive injustice	12.69	2.67	4–16	12.64	12.83	.869	12.64	12.71	.294
Procedural injustice	12.87	2.61	4–16	12.81	12.75	.256	12.73	12.84	.523
Institutional distrust	11.52	2.51	4–16	11.55	11.43	.546	11.53	11.44	.445
Interpersonal conflict	7.89	3.17	3–15	8.03	7.71	1.21	8.24	7.4	3.23**
Water labor	121.36	55.7	0–700	157.51	107.6	.944	202.5	45.15	3.02**
PHQ-9	12.47	6.64	0–27	12.2	12.57	.659	12.9	11.54	2.41**

Note: * $p < .05$, ** $p < .01$.**Table 4**

Bivariate correlations between independent and dependent variables.

Variables	1	2	3	4	5	6	7
1-Household water insecurity	1						
2- Distributive injustice	.26**	1					
3- Procedural injustice	.12**	.71**	1				
4- Institutional distrust	.27**	.48**	.55**	1			
5- Interpersonal conflict	.35**	.04	.11**	.10*	1		
6-Water labor	.19**	.11*	.07	.09*	.02	1	
7- PHQ-9	.35**	.29**	.24**	.27**	.37**	.12**	1

Note: * $p < .05$, ** $p < .01$.**Table 5**

Tests of normality, multicollinearity and homogeneity of independent and dependent variables.

Variables	Normality test		Multicollinearity		Homogeneity test	
	KS statistic	KS P-value	Tolerance	VIF	Levene's F	Levene's p
Household water insecurity	.902	.354	.895	1.21	.711	.450
Sense of distributive environmental/water injustice	1.32	.133	.823	1.28	.837	.574
Sense of procedural environmental/water injustice	.784	.841	.912	1.11	1.68	1.41
Institutional distrust	.943	.332	.922	1.01	.865	.541
Interpersonal conflict	1.47	.075	.784	1.37	1.75	.085
Water labor	1.68	.096	.957	1.27	.748	.477
PHQ-9	.854	.457	–	–	1.67	.138

Note: KS= Kolmogorov-Smirnov.

least 30 cases for each variable in the model. There are 7 variables in this study, so with 685 respondents this study meets this standard, as do the sub-samples. With the significance value of independent and dependent variables being above .05, variables have an acceptably normal distribution. Non-multicollinearity is one of the assumptions of the SEM. Hair et al. (2012) states that if the VIF value is less than 5 and the tolerance value is greater than .2, and based on this the independent variables have adequate non-multicollinearity. Based on Kaplan's (2008) suggestion that a significance value of the Levene's statistic is greater than .05, the variables of this study have homogeneity. In the present study, missing data was very limited (less than 2 %). Missing cases were addressed using the variable mean replacing method in SPSS.

4.3. Direct effects

Structural equation modeling (SEM) confirmed that household water insecurity was positively associated with depressive symptoms (PHQ-9). In the baseline model, without mediators, higher water insecurity significantly predicted higher PHQ-9 scores ($\beta = .34$, $p < .01$), establishing a strong direct relationship between material water scarcity and psychological distress. The water insecurity variable explained 12 % of variance in PHQ-9 scores.

4.4. Indirect effects: total samples

Fig. 1 depict the results of the structural equation model (SEM) of

PHQ-9 scores when the total sample is modeled, after introducing the five theorized social mechanisms. The results showed that several indirect pathways linked water insecurity to depression. Interpersonal conflict emerged as the strongest and most consistent mediator, followed by distributive and procedural injustice, institutional distrust, and burden of water labor. Collectively, these variables explained about 24 % of the variance in PHQ-9 scores, indicating that social and relational dynamics play a central role in shaping mental health outcomes under water-insecure conditions. Bootstrap tests (2000 replications, 95 % CI) in Table 6 confirmed significant indirect effects of household water insecurity on PHQ-9 through all five mediators (overall standardized indirect $\approx .22$). The full model demonstrated good fit indices ($\chi^2/df = 1.36$, $p < .001$; RMSEA = .01; CFI = .98; TLI = .96; SRMR = .03).

4.5. Gender-stratified models

Figs. 2 and 3 show gender-specific models. Among men, interpersonal conflict had the largest standardized effect on PHQ-9 ($\beta = .47$, $p < .01$), followed by distributive injustice ($\beta = .22$, $p < .01$) and procedural injustice ($\beta = .11$, $p < .01$). Among women, interpersonal conflict ($\beta = .22$, $p < .01$), distributive injustice ($\beta = .21$, $p < .01$), institutional distrust ($\beta = .12$, $p < .01$), and burden of water labor ($\beta = .08$, $p < .05$) were significant predictors. The models explained 34 % of variance in men's PHQ-9 scores and 14 % in women's, suggesting stronger explanatory power of the social mechanisms among men. Fit indices were acceptable for both models (e.g., CFI $> .95$, RMSEA $\leq .02$).

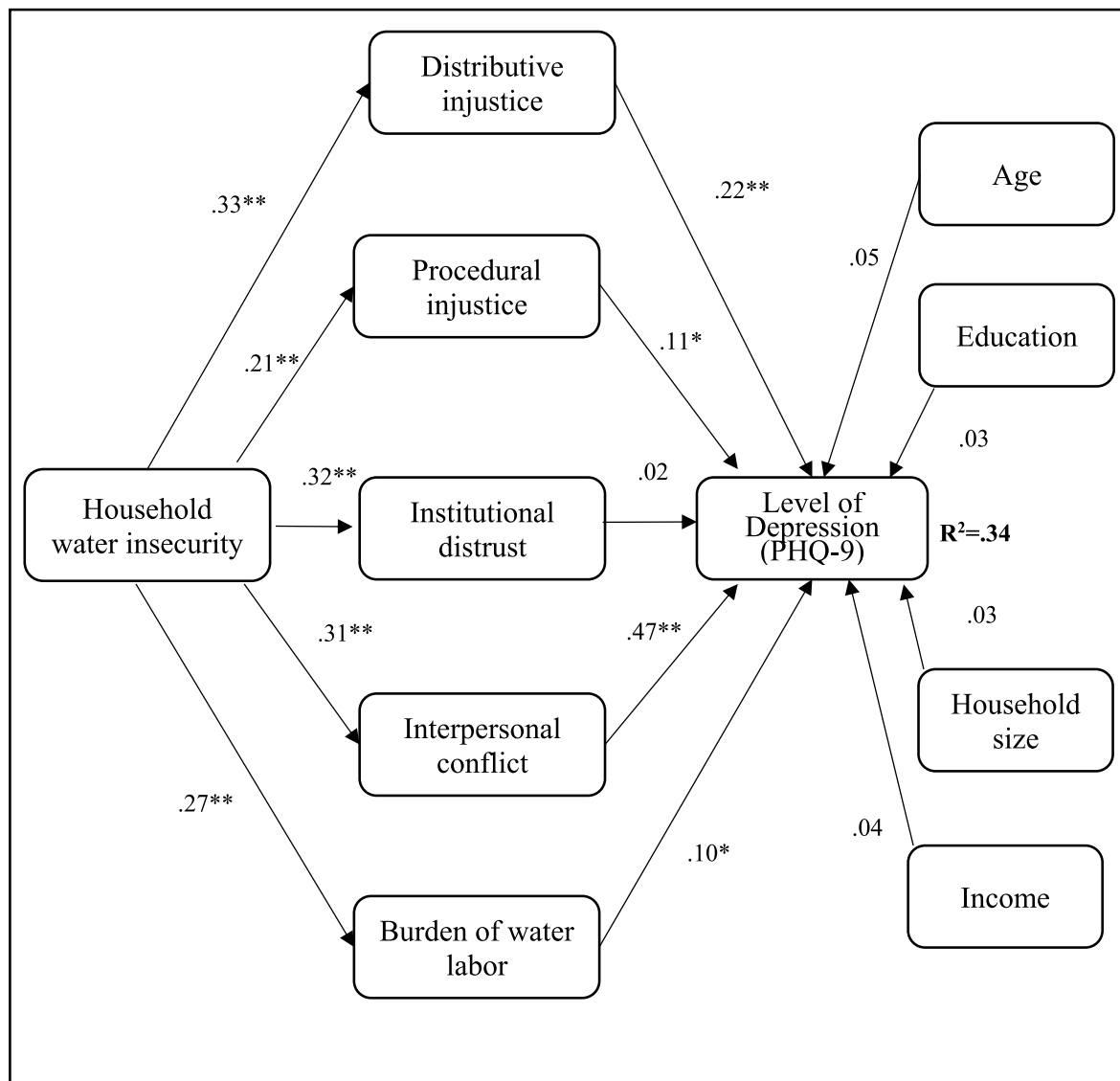


Fig. 2. Gender-stratified SEM model for men ($N = 397$) showing standardized effects of water insecurity mechanisms on depressive symptoms (PHQ-9).

4.6. Residence-stratified models

Figs. 4 and 5 present models disaggregated by residence. Among rural respondents, interpersonal conflict ($\beta = .36, p < .01$), distributive injustice ($\beta = .25, p < .01$), and water labor ($\beta = .10, p < .05$) were key mediators, explaining 25 % of the variance in PHQ-9. For urban residents, interpersonal conflict ($\beta = .38, p < .01$), distributive injustice ($\beta = .19, p < .01$), procedural injustice ($\beta = .13, p < .05$), and institutional distrust ($\beta = .09, p < .05$) were significant, accounting for 23 % of the variance. Age had small but positive associations with PHQ-9 in both urban ($\beta = .12, p < .05$) and women's models, whereas income was nonsignificant in all cases.

4.7. Summary of findings

Across all specifications, interpersonal conflict consistently showed the largest mediating effect, reinforcing its centrality in the social-psychological consequences of water insecurity. The indirect effects remained significant after accounting for covariates, confirming that distress related to water scarcity is transmitted primarily through social and institutional mechanisms rather than purely material deprivation (Table 6).

5. Discussion

This study demonstrates that household water insecurity in Sistan and Baluchestan, Iran, is strongly associated with depressive symptoms and that this relationship is primarily transmitted through social and institutional mechanisms rather than material deprivation alone. Structural equation modeling revealed that interpersonal conflict was the most influential mediator linking water insecurity to depression, followed by perceived distributive and procedural injustice, institutional distrust, and the burden of water labor. These pathways remained significant after controlling for demographic and socioeconomic factors. Gender- and residence-stratified models further indicated that social mechanisms explained a greater proportion of depressive symptoms among men and rural residents, underscoring the importance of context-specific social dynamics in shaping mental health responses to water insecurity.

Notably, household water insecurity in this study site is extremely high, with a mean household water insecurity experiences (HWISE) score of 21.8 ($SD = 8.55$). This exceeds all measures applying the same scale in 27 other water insecure sites, with the highest previously recorded mean score of 20.9 (Stoler et al., 2021). Similarly, depression levels based on the self-reported PHQ-9 are also extremely high, with

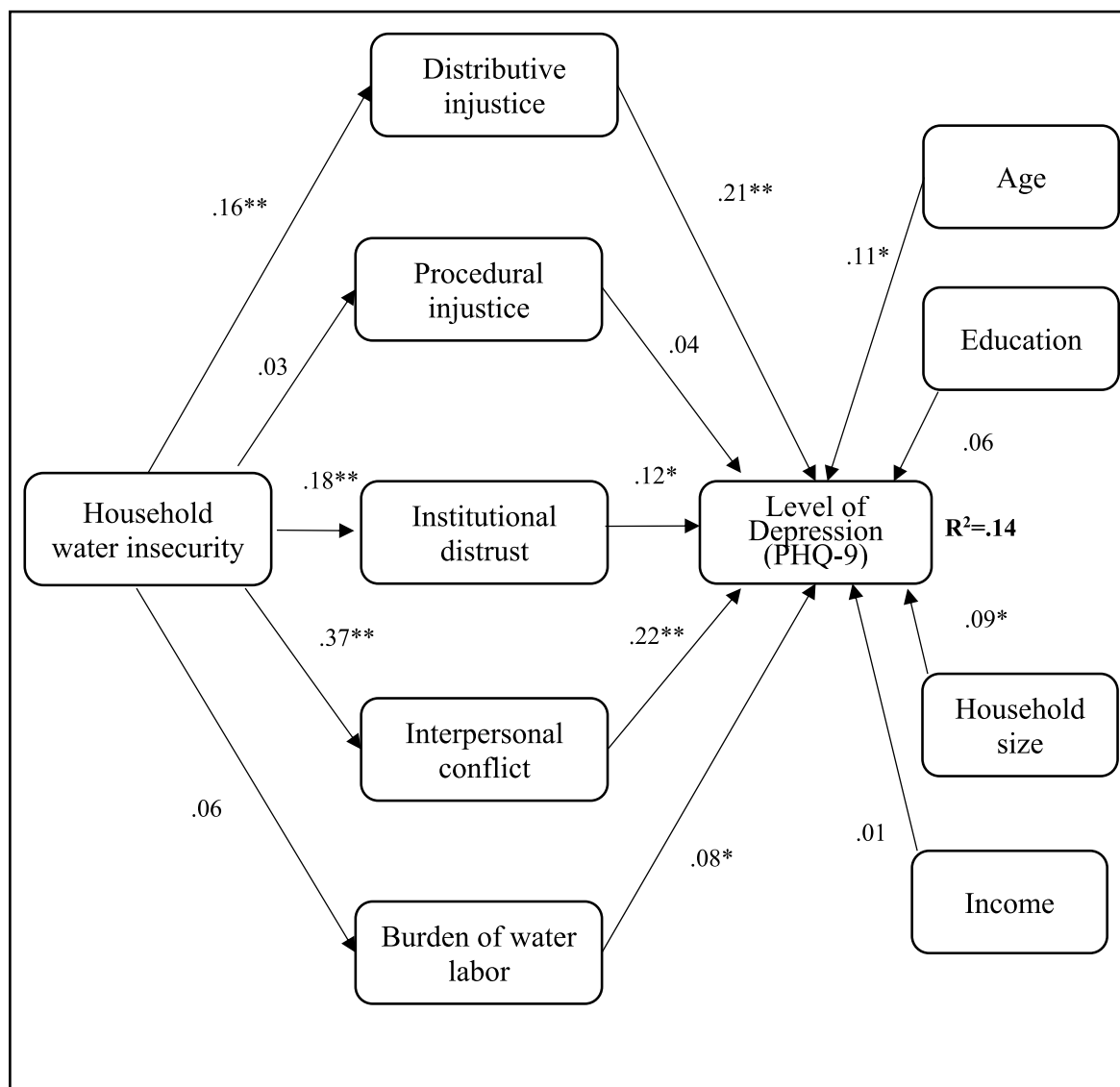


Fig. 3. Gender-stratified SEM model for women (N = 288) showing standardized effects of water insecurity mechanisms on depressive symptoms (PHQ-9).

mean scores in all sub-samples that exceed suggested clinically-significant cut-points in the range of 8–11 to screen for moderate depression (Manea et al., 2012). We can confirm that, in this Iranian case, water insecurity is associated with higher PHQ-9 scores, both directly and through all the tested mechanisms: reported levels of interpersonal conflict, perceived distributive and procedural injustice, distrust of relevant institutions, and a greater personal burden of responsibility for water labor. These hold even when the effects of the other factors are considered, including household income, meaning we can interpret these as independent statistical associations. That is, the theorized social mechanisms appear to co-occur with higher depression scores, while a key material factor (household income) did not show such associations.

Among the tested mechanisms, interpersonal conflict showed the strongest statistical association with PHQ-9 scores for men and women, in both rural and urban contexts, and overall. This pattern suggests that interpersonal conflict may be a particularly important element in explaining the association of living with water insecurity with level of depression in this Iranian context. Demonstrating these associations empirically alongside other potential mechanisms provides new evidence of the centrality of conflict in shaping the psychosocial impacts of water insecurity. This also suggests that future research around the

mental health consequences of water insecurity could benefit from more focused theorization and mixed-method testing related to social conflict as a central mechanism. For example, which types of arguments (public versus intra-household) matter most, and why? Is water itself driving conflicts? Or perhaps do conflicts become manifest in the contexts of water insecurity because it affects so many aspects of everyday household wellbeing. Or maybe water simply is a concrete and symbolically important thing that arguments can then revolve around (i.e., as finances might otherwise in water insecure households)? Considering conflicts outside the household, how might efforts to support local water systems that motivate and support cooperation rather than conflict be helpful in reducing the individual and collective psychological costs of managing insecure water?

Overall, men's depression more generally is better explained by the collective action of the five studied mechanisms. And, while models begin from household water insecurity and converge on PHQ-9 depression symptoms, the associations with intervening mechanisms varied in degree by gender. That is, the theorized social mechanisms appear to co-occur with higher depression scores, while material factors did not show such associations, with procedural injustice and distributive injustice also significantly contributing. Men's water labor burdens were suggested to have a slightly stronger association with PHQ-9 scores

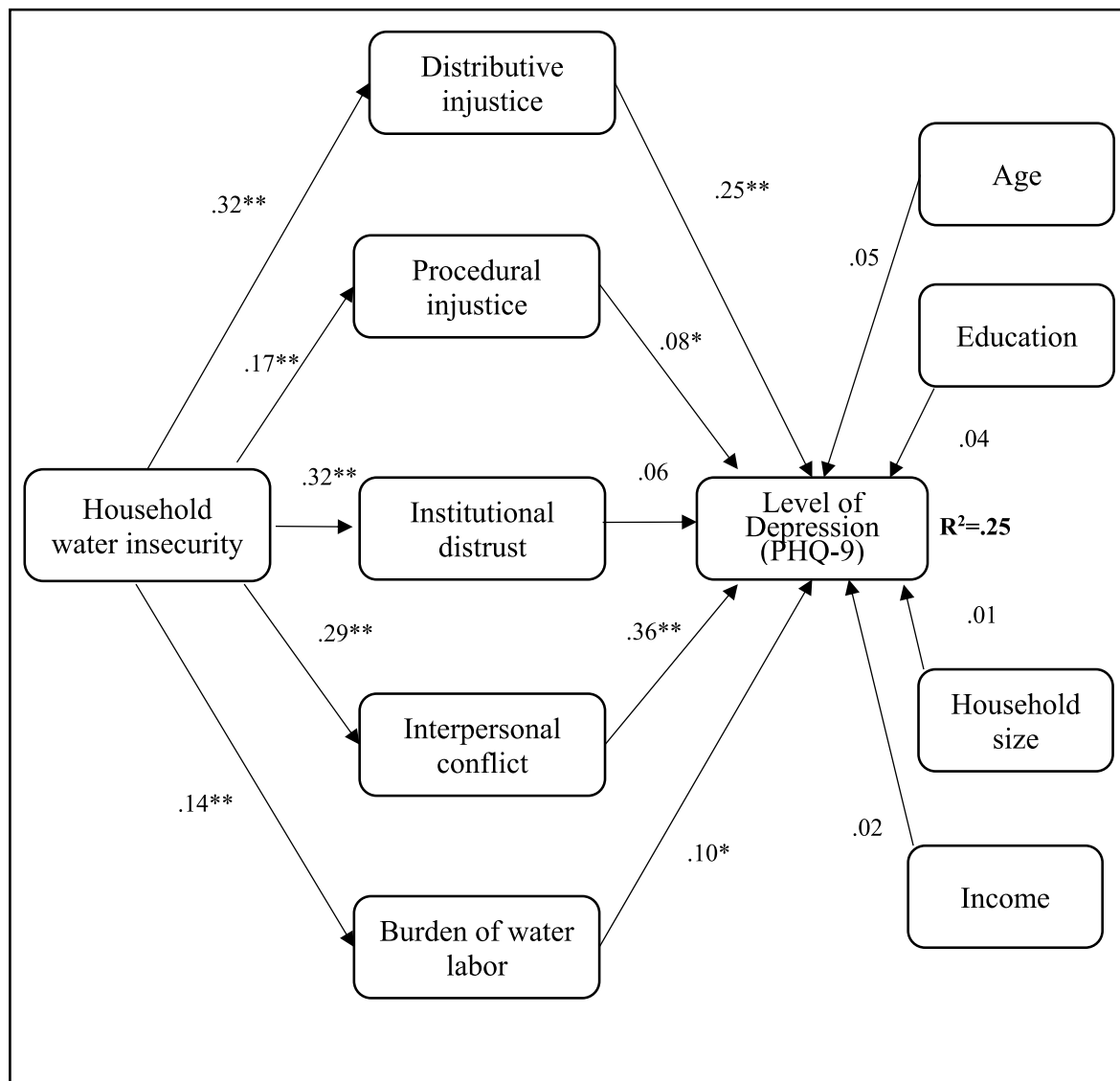


Fig. 4. SEM model for rural residents (N = 390) showing standardized effects of water insecurity mechanisms on depressive symptoms (PHQ-9).

(.10) than women's (.08). Men's PHQ-9 scores were more strongly associated with interpersonal conflict than women's, even though both are significant. For women, the strongest suggested mediations were through interpersonal conflict (.22) and distributive justice (.21). Procedural justice is not a significant explanatory mechanism for women. Age and household size had more relevance in the women's model than in that for men.

We can offer some explanation for these patterns based in the contexts of masculinities in southeastern Iran. First, and most directly, chronic water insecurity in rural areas of the province has led to both localized and wider tribal conflicts over water resources. Men are those involved in the attendant negotiations, disputes, or violence arising from competition for access to water (Madani, 2014). Even in the cities where structures are more formalized, women are often excluded from decision-making processes. Gender roles in Sistan and Baluchestan society also place the responsibility for providing livelihoods and material household resources on men so that an inability to provide water for the family, livestock, or agriculture is particularly shameful for men. The direct impact of the water crisis on traditional male occupations such as agriculture, animal husbandry, and fishing also implicates their social roles as producers and threatens economic insecurity. We are not readily able to unravel why women are significantly impacted by institutional

distrust compared to men in this context, and this is a point suggested for further focused research. One possible explanation is that women's exclusion from decision-making processes in patriarchal structures could shape their experiences. This might make institutional distrust relatively more salient while somewhat reducing exposure to interpersonal conflict.

Perceived distributive injustice, which refers to inequality in access to resources, was higher in rural areas. This makes sense in this province, where rural residents are disadvantaged in general, but in particular feel more discriminated against in terms of access to water. In many villages in Sistan and Baluchestan, inefficient water supply infrastructure, polluted water sources, and the absence of regulatory institutions have long caused people to feel abandoned and inequitably treated compared to those in the cities. Perceived procedural injustice had a slightly larger mediating effect in urban contexts and was not significant in the women's model. Placing these differences the contexts of rural and urban life in southeastern Iran, the difference in the predictive strength of the two tested forms of injustice are notable. It may be that procedural injustice matters more where people engage more with formal water institutions (as happens in urban areas) and for those who are more likely to interact with them (men). The negative effect of water labor is only relevant to mediation in rural (typically agricultural) households

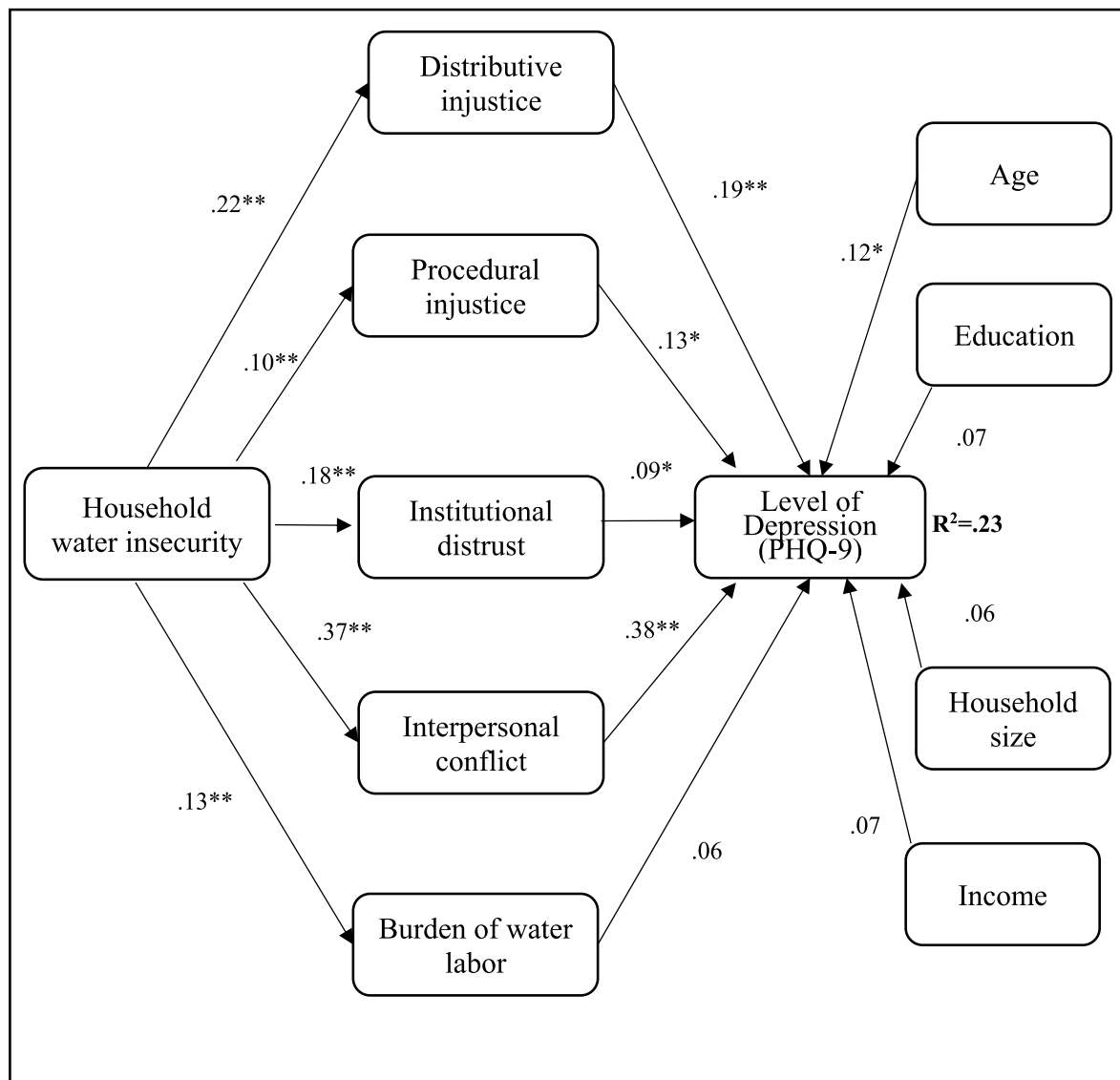


Fig. 5. SEM model for urban residents (N = 295) showing standardized effects of water insecurity mechanisms on depressive symptoms (PHQ-9).

when they were distinguished from urban ones. This makes sense since the economic and practical contexts of daily water needs, collection, and management are different between the two.

5.1. Policy implications and cautions

Overall, the research findings confirm that water insecurity is not simply a material, technical, or environmental crisis, but rather a reflection of social, gender, and institutional inequalities that operate differently across contexts and that these differentiations have significant negative associations with mental health. To design effective interventions, policymakers need to pay attention to these contextual differences and consider water justice not only at the level of resource distribution, but also at the level of decision-making procedures and structures and the constraints of people navigating them in their daily lives. While these findings suggest potential policy entry points to mitigate the mental health consequences of water insecurity, the cross-sectional design limits causal inference. Therefore, the results should be interpreted as identifying plausible mechanisms rather than definitive causal pathways. Interventions that aim to reduce household conflict, strengthen institutional trust, or improve perceptions of fairness should be considered exploratory and complemented by longitudinal and

mixed-methods research. Future work that establishes temporal and causal relationships will be critical for developing evidence-based policies that address both water insecurity and its psychosocial effects.

6. Study strengths and limitation

6.1. Conceptual considerations

As a cross-sectional study, causal relationships cannot be directly inferred. While the analysis supports theoretically grounded pathways between water insecurity and depressive symptoms, longitudinal and mixed-methods research will be essential to confirm the temporal ordering of these associations and to test their generalizability.

6.2. Methodological considerations

Data were derived from self-reported measures, which may be subject to recall and social desirability bias. Although gender and residence status were included as key covariates, unmeasured factors such as food insecurity or other stressors may still confound observed relationships. The use of locally validated scales and rigorous sampling procedures, however, enhances confidence in the robustness and representativeness

Table 6
Direct and indirect effects on PHQ-9.

Paths	Group	Direct Effects				Indirect Effects			
		Water Insecurity → Mediator		Mediator → PHQ-9		β	Bootstrap β 95 % CI (Lower-Upper)	B	Bootstrap B 95 % CI (Lower-Upper)
		β	B	β	B				
Water Insecurity → Distributive Injustice→ PHQ-9	Overall	.25**	.08**	.19**	.47**	.05**	.02–.09	.03**	.01–.07
	Men	.33**	.10**	.22**	.52**	.07**	.04–.11	.05**	.02–.11
	Women	.16**	.08**	.21**	.51**	.03**	.01–.06	.04**	.005–.08
	Rural	.32**	.10**	.25**	.61**	.08**	.05–.11	.06**	.01–.10
	Urban	.22**	.09**	.19**	.44**	.04**	.01–.07	.04**	.01–.07
Water Insecurity → Procedural Injustice→ PHQ-9	Overall	.12**	.37**	.10*	.23**	.01*	(-.01)–.02	.08**	.03–.13
	Men	.21**	.07**	.11*	.27**	.02*	.015–.09	.02*	.004–.07
	Women	.03	.01	.04	.11	.001	(-.01)–.02	.001	(-.02)–.01
	Rural	.17**	.05**	.08*	.18**	.01*	.001–.03	.01*	(-.02)–.02
	Urban	.10**	.08**	.13**	.30**	.01*	(-.01)–.03	.02*	(-.02)–.03
Water Insecurity → Institutional distrust→ PHQ-9	Overall	.26**	.07**	.08*	.20**	.02*	.014–.04	.01*	(-.01)–.02
	Men	.32**	.10**	.02	.05	.006	.001–.02	.005	(-.02)–.01
	Women	.18**	.09**	.12*	.32*	.02*	.01–.03	.03*	.008–.06
	Rural	.32**	.10**	.06	.16**	.02*	.011–.04	.02*	.005–.04
	Urban	.18**	.11**	.09*	.17**	.02*	.016–.03	.02*	.01–.03
Water Insecurity → Interpersonal conflict→ PHQ-9	Overall	.34**	.13**	.38**	.78**	.13**	.09–.17	.10**	.03–.17
	Men	.31**	.12**	.47**	.94**	.15**	.11–.19	.11**	.06–.18
	Women	.37**	.13**	.22**	.47**	.08**	.06–.10	.06**	.01–.10
	Rural	.29**	.11**	.36**	.75**	.10**	.07–.13	.08**	.03–.12
	Urban	.37**	.13**	.38**	.74**	.14**	.11–.17	.10**	.06–.15
Water Insecurity → Water Labor→ PHQ-9	Overall	.13**	.36**	.09*	.09*	.01*	.001–.03	.03*	.001–.06
	Men	.27**	.24**	.10*	.08*	.03*	.01–.05	.02*	.005–.04
	Women	.06	.05	.08**	.07**	.005	(-.01)–.01	.003	(-.02)–.02
	Rural	.14**	.16**	.10*	.08*	.01*	(-.01)–.02	.01*	(-.02)–.03
	Urban	.13**	.18**	.06	.02	.008	(-.02)–.02	.004	(-.02)–.02
Total Indirect Effects	Overall					.22**	.18–.26	.25**	.16–.34
	Men					.27**	.22–.32	.20**	.15–.25
	Women					.13**	.10–.16	.13**	.07–.19
	Rural					.22**	.19–.25	.18**	.13–.23
	Urban					.21**	.17–.24	.18**	.12–.24

Note: β = Standardized estimates, B= Unstandardized estimates; * $p < .05$; ** $p < .01$.

of the findings. The interpersonal conflict scale was newly developed for this study; further validation is warranted to confirm its psychometric properties across settings. The measure of water labor relied on self-reported weekly water collection time, which may contain estimation error. Nonetheless, internal consistency and reliability tests indicated strong scale performance across constructs.

6.3. Study strengths

Despite these limitations, this study has several notable strengths. It draws on a large, population-representative sample from one of the most water-insecure regions globally, employs validated and locally adapted measures, and applies structural equation modeling to disentangle complex direct and indirect pathways. The integration of gender and residence-stratified analyses provides novel insights into how social mechanisms shape mental health outcomes under extreme water scarcity.

7. Conclusion

Using a population-representative sample of adults that we collected in households in a severely water insecure region in Iran, we find that multiple nonmaterial mechanisms explain why living with water insecurity is associated with worse mental health, assessed as level of depression. Better theorizing of why water insecurity has such a consistent and powerful association with depression requires us to move beyond singular proposed mechanisms and begin to understand for whom, when, and why these matter, including how they interact and why these might shift through time. Moving to longitudinal studies that can test causal relationships between water insecurity and mental health will help identify the forms of intervention that might best advance both

community water security and mental health.

CRedit authorship contribution statement

Seyed Ahmad Mir Mohamad Tabar: Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alexandra Brewis:** Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **Mahmod Teimouri:** Writing – original draft, Validation, Data curation. **Maryam Sohrabi:** Writing – original draft, Validation, Formal analysis.

AI declaration

ChatGPT 5.0 was used to assist in adapting a longer abstract to required length and to check for any inconsistencies in table and reference formatting; authors fully vetted any suggested edits. AI was otherwise not used in the production of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.socscimed.2025.118864>.

Data availability

Anonymized data are available on request from the lead author.

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