

# Validation of household water insecurity scale in urban Nepal

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## Abstract

Water security is one of the central global issues today. This study aimed to describe and test the validity and reliability of a household water insecurity scale, and to assess the impact of household water insecurity on psychological distress among 371 women living in urban Nepal. A household interview survey was conducted using a structured questionnaire. Approximately 70% of the participants experienced collecting less water than they needed. Four domains of household water insecurity emerged from the principal components factor analysis: (i) difficulties in house-work related to water, (ii) lost opportunity costs and social interactions related to water, (iii) an insufficient safe water supply, and (iv) difficulties in basic activities related to water. Multivariate regression analysis showed that the domains of ‘lost opportunity costs and social interactions’, ‘difficulties in house-work’ and ‘difficulties in basic activities’ were associated with psychological distress among women. The impact of household water insecurity on psychological distress differed by water supply service levels. The current household water insecurity scale is a simple instrument which can be used to prioritise the target population for water interventions. Further research should be conducted towards the development of a universally applicable measurement tool.

*Keywords:* Household water insecurity scale; Nepal; Psychological distress; Urban setting; Women

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## 1. Introduction

### 1.1. The global issue of water insecurity

Water insecurity is one of the main problems faced by many societies, and this issue is increasing in severity, with 1.2 billion ( $10^9$ ) people living in water-scarce regions worldwide today. Furthermore, by 2025, this number will have increased to 1.8 billion ( $10^9$ ) people living in areas with absolute water scarcity (UNESCO, 2012). The consequences of limited water availability include negative effects on

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health, poverty, and vulnerability (Hunter *et al.*, 2010). Water is central to all aspects of development, underpinning every social and economic sector. Capturing a common definition of water security will strengthen the coordination, formulation, and achievement of common sustainable development goals (UNESCO, 2012). When proposing a leading concept for post-2015 sustainable development goals, the United Nations accepted the definition of water security as a state in which there is (Burchi *et al.*, 2013):

*‘... the capacity of population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.’*

To assess the societal challenge of overcoming water insecurity issues, many indicators of water insecurity, or water scarcity, have been developed. However, most indices are generally expressed in terms of annual per capita water and used in assessment on a country-wide scale (Brown & Matlock, 2011). For example, the Asian Development Bank (ADB) developed a water security index at household level, which is a composite of three sub-indices: proportion of access to piped water supply, proportion of access to improved sanitation, and age-standardised disability-adjusted life years per 100,000 people for the incidence of diarrhoea (ADB, 2013). The global coverage of improved water supply was 89% in 2010, which had increased by 13% since 1990 (World Health Organization & United Nations Children’s Fund Joint Monitoring Programme for Water Supply and Sanitation, 2014), while there were differences in the child-health gains from access to piped water according to income or education level (Jalan & Ravallion, 2003). The concept underlying the current water security definition is very comprehensive and too broad for an analysis of micro-level health outcomes. Water security, or access to water and control of water resources, is dependent upon a sense of security and beliefs at the individual level, which can be assured through recognition of the human right to water and sanitation (Kafakoma & Silungwe, 2003; UNESCO, 2012). Like food insecurity, water insecurity may differ at the community, household, and individual level (Tarasuk, 2001; Stuff *et al.*, 2004; Wutich & Ragsdale, 2008; Wutich, 2009).

Hadley & Wutich (2009) developed a unidimensional household water insecurity scale, using an ethnographic approach in urban Bolivia. To the authors’ knowledge, their study was the first to measure experience-based water insecurity by household level. To extend the utility of a locally developed household water insecurity scale, Stevenson *et al.* (2012) assessed the association between the water insecurity scale and psychological distress using a mixed approach in Ethiopia. The commonalities and differences in the experience of water insecurity in different countries and areas should be assessed when developing a tool to measure household water insecurity across cultures.

## 1.2. Water insecurity in South Asia

Asia-Pacific regions face an imminent water crisis; for example, 60% of the households in the region live without a safe, piped water supply or improved sanitation, and South Asia is faring the worst (ADB, 2013). South Asia is one of the most densely populated regions in the world, and water demand has been particularly increasing in urban areas in this region due to rapid urban population growth and industrial growth. In addition, a poor water-management system has led to broken water pipes and an intermittent

water supply (Whittington, 2003; Mollah & Aramaki, 2010). Several studies have evaluated the state of water resources and the operational sustainability of water-supply systems using a variety of measurement scales in South Asia (Bhandari & Grant, 2007; Manandhar *et al.*, 2012), but, to the authors' knowledge, the experience of water insecurity at the household level in these regions is little known. To consolidate the water insecurity issue in South Asia, particularly in urban settings, the present study aimed to describe the experience of household water insecurity in Kathmandu Valley, Nepal.

### 1.3. *Water insecurity in public health terms*

Water insecurity is a centrally important public health issue. A vast number of papers have already demonstrated that an inadequate water supply adversely affects physical health outcomes (Dangendorf *et al.*, 2002; Hunter *et al.*, 2010). To reduce the global health burden, many public health researchers have argued for effective intervention programmes, such as improvements in water quality vs access to water (Fewtrell *et al.*, 2005). As water security from the perspective of sustainable development accounts for the social contexts of water use, policy makers and public health researchers need to be tempered by a recognition of the experience-based water insecurity that reflects psychological well-being. Although recent studies report the impact of an insufficient and inadequate safe water supply on psychological health or well-being (Wutich & Ragsdale, 2008; Stevenson *et al.*, 2012; Guardiola *et al.*, 2013), the pathways of household water insecurity on psychological health are little known. Therefore, we also examined the impact of household water insecurity on psychological distress among women. We targeted women as research participants because women play a key role in household water management (Cameron *et al.*, 2011) and more women than men experience water insecurity (Hadley & Wutich, 2009). In international policy statements and initiatives, a focus on women has been seen as critical to improving the management or governance of water within the overall context of poverty alleviation (Ray, 2007).

The objectives of the present study were threefold: (1) to describe the experience of household water insecurity of women living in urban Nepal, (2) to test the validity and reliability of the instrument used to measure household water insecurity, and (3) to assess the impact of household water insecurity on perceived distress in Nepali women.

## 2. **Materials and methods**

### 2.1. *Study setting*

The study was conducted in Kathmandu Valley, Nepal, in urbanised areas with rapid population growth. Kathmandu Upatyaka Khanepani Limited (KUKL) is responsible for supplying piped water in the valley. In 2010, KUKL covered 79% of the population in that region (ADB, 2010). Owing to water resource scarcity, and despite a high proportion of households in the valley being connected to piped water, the average piped water supply duration was 11.3 hours per week in the wet season (Yoden, 2010). According to international guidelines, a household water supply level below 20 litres per capita per day (LPCD) is a serious health concern (Howad, 2003). A population-based survey in the valley showed that approximately 30% of households consumed less than 20 LPCD in the wet season, and those who consumed this amount had a higher risk of developing diarrhoeal diseases

(Shrestha et al., 2013). To solve the water scarcity issue in the valley, the Government of Nepal planned the Melamchi Water Supply Projects, which aim to supply 170 million litres per day of freshwater to the valley. Although an international donor approved the plan in 2000, the projects have not yet been completed.

The present study was a cross-sectional household survey. For sample selection, we used a multi-stage cluster sampling method. The service area of KUKL covers five municipalities (Kathmandu, Kirtipur, Lalitpur, Bhaktapur, and Madhyapur Thimi) and 49 village development committees. First, we randomly selected 12 areas by water supply service levels (categorised as duration of water supply hours per week: >7 hours; 4–7 hours; and <4 hours) based on an empirical report (Yoden, 2010). This resulted in four areas being selected for each of the three water supply levels. Figure 1 shows the location of selected areas in the valley. Second, we selected 372 households, using a convenience sampling method (31 households in each area). We selected households that met the inclusion criteria, in which adult women aged between 18 and 60 years were living. So far, no studies have assessed the individual household water insecurity scale in the target area. Therefore, the sample size was calculated based on household water consumption level. An empirical study shows that around 60% of households in the valley consume less than 50 LPCD (Shrestha et al., 2013), which is the minimum international water provision standard (Peter, 2004). Applying the statistical sample size calculation in the clinical research method (Suresh & Chandrashekhara, 2012), we assumed that the prevalence of household

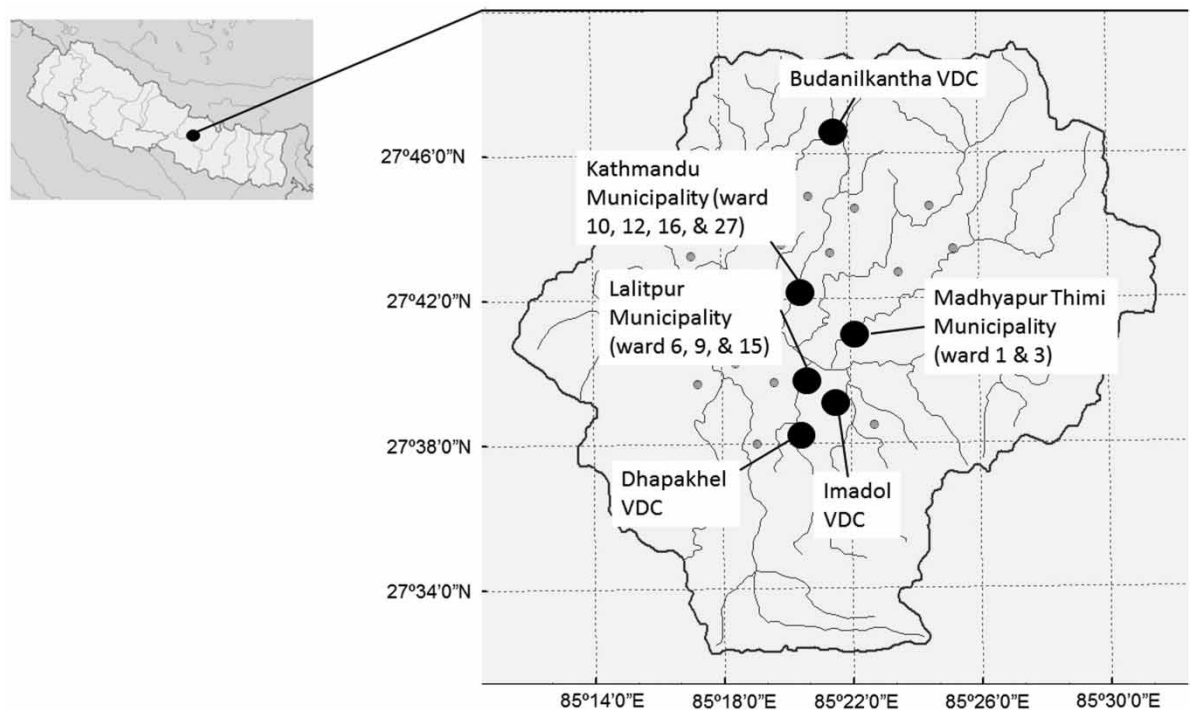


Fig. 1. Location of study areas in Kathmandu Valley (Source: map produced and designed by V. P. Pandey, International Research Centre for River Basin Environment, the University of Yamanashi, 2011). VDC: village development committees.

water insecurity will be less than 60% within a 5% margin of error and with a 95% confidence interval (~369 participants).

## 2.2. Data collection and variables

We targeted adult women who agreed to participate in this study. All participants provided written informed consent and received a small gift for their participation in the interview. Local trained interviewers collected data through personal interviews, using a structured questionnaire, between January and March 2013 (the dry season).

We developed a household water insecurity scale based on the literature (Stevenson *et al.*, 2012). In a preliminary survey, 30 household women living in the valley were asked about their experience of water insecurity over the past 30 days. The possible answers were: 4 (always), 3 (often), 2 (sometimes), 1 (rarely), and 0 (never), with higher scores indicating higher household water insecurity. From the 34 items in the preliminary survey, we adopted 22 items with good internal consistency (Cronbach's  $\alpha = 0.96$ ). In addition, the participants were asked about the impact of water insecurity on their general quality of life (QOL) with the item 'how often does your QOL deteriorate due to a water scarcity problem?' We also measured the quantity of collected water per household member, and frequency of bathing, washing clothes, and cleaning the house.

Psychological distress indicators were assessed with the 10-item perceived stress scale (PSS), which measures a person's sense of control over daily life demands (Cohen *et al.*, 1983). Each item was rated on a five-point scale ranging from 'never' to 'very often'. The internal consistency of the PSS in the present study was acceptable (Cronbach's  $\alpha = 0.70$ ). We also collected data on other potential associated factors: age, having children, ethnicity, monthly household income, participant's final education, satisfaction with social support and personal relationships, and subjective rated health (*excellent, very good, good, fair, or poor*).

## 2.3. Analysis

The frequency distributions of the household water insecurity scale and each variable were checked for descriptive purposes. Affirmative responses were defined as the participants experiencing household water insecurity more than 'sometimes'. Exploratory factor analysis (principal component analysis with varimax rotation) was used to analyse the construct validity of the household water insecurity scale. The final scale comprised items with an eigenvalue of  $>1$ , when the cumulative proportion of variance explained was  $>70\%$  and the absolute value of rotated factor loading for each item was 0.4 or more. We also checked uniqueness in testing error variance. The internal consistency of the scale was examined using Cronbach's  $\alpha$ . To test convergent validity, Pearson's correlation coefficients were calculated for the association between the scale and amount of collected water. Then, we applied a multivariate regression analysis to assess the impact of household water insecurity on psychological distress controlled for possible confounding factors. We used a stepwise procedure that selected a set of predictive variables best explaining the association between household water insecurity and psychological distress. To check the multicollinearity of each variable, the variance inflation factor was calculated. Consequently, multivariate regression with stepwise procedures was applied, stratified by water supply service levels. All analyses were conducted using STATA 12.1 (Stata Corp., USA) and the statistical significance level was set at  $p < 0.05$ .

### 3. Results

#### 3.1. Participants' characteristics

Of the potential participants, 371 women agreed to participate in the study. The sample characteristics are shown in Table 1. The average amount of daily collected water per capita was 15.4 LPCD (range: 0–175 LPCD). The volume of collected water was lowest in households with <4 hours/week of piped water supply ( $p = 0.001$ ). Approximately 11% of participants answered that they always or most of the time felt that their QOL deteriorated due to water problems.

#### 3.2. Household water insecurity

From 22 items of household water insecurity, we examined the principal factors for each of the domains. The item 'unable to cook desirable meals due to water scarcity' was eliminated because the rotated factor loading was below 0.4. While the rotated factor loading of 'thought of leaving current place due to water scarcity' was over 0.4, we eliminated this variable because the uniqueness value was 0.55 and we considered this variable as error variance (Table 2). Therefore, 20 items were retained based on the criteria for determining valid items. Four domains (factors) were extracted on the basis of factor loadings: 'difficulties in house-work related to water', 'lost opportunity costs and social interactions related to water supply', 'insufficiency of a safe water supply', and 'difficulties in basic activities related to water.' Cronbach's  $\alpha$  for the full set of items was 0.94. The eigenvalue, per cent of variance, and Cronbach's  $\alpha$  of adapted domains are shown in Table 3. The internal consistency of the domain was good, with Cronbach's  $\alpha$  ranging from 0.86 to 0.93. The item with the highest number of women experiencing water insecurity was 'collect less water than needed' (70.6%). In contrast, the item with the lowest number of women experiencing water insecurity was 'cannot join in any social functions (e.g. wedding, occasions, or festivals) due to the time consumed by water collection' (13.5%).

After the confirmation of the items of the household water insecurity scale, the mean scores of items were calculated. Households in poor water supply service areas (i.e. <4 hours/week) had significantly higher household water insecurity scores than households with supply for over 4 hours/week ( $p < 0.001$ ). Regression analysis showed that higher scores for 'difficulties in house-work related to water' ( $\beta = 0.34$ ,  $p < 0.01$ ), 'lost opportunity costs and social interactions related to water' ( $\beta = 0.19$ ,  $p < 0.01$ ), and 'insufficiency of a safe water supply' ( $\beta = 0.15$ ,  $p < 0.05$ ) were associated with lower QOL because of water scarcity problems. There was also a moderate negative correlation between the quantity of collected water and household water insecurity score ( $r = -0.44$ ,  $p < 0.001$ ).

#### 3.3. Impact of household water insecurity scales and psychological distress

Table 4 shows the regression coefficients of the univariate linear regression and multivariate regression models. The univariate linear regression showed that there was no association between overall household water insecurity scores and psychological distress in the participants ( $\beta = 0.61$ ,  $p = 0.11$ ).

The multivariate regression showed that women who experienced 'lost opportunity costs and social interactions related to water' had higher psychological distress than women who had not experienced this. However, the impact of household water insecurity on psychological distress differed by water supply level. There was no association between the household water insecurity scores of each

Table 1. Participants' characteristics ( $n = 371$ ).

Characteristics	Value <i>n</i> (%)
Mean age in years (SD)	34.0 (8.9)
Mean household size (SD)	4.9 (2.2)
Marital status	
Married	314 (84.6)
Not married	57 (15.4)
Having children	
Yes	294 (79.5)
No	76 (20.5)
Ethnicity	
Brhamin/Chettri	146 (40.2)
Newar/Janajati	210 (57.9)
Dalit	7 (1.9)
Educational level	
No formal education	35 (9.4)
Primary (1–5 years)	104 (28.0)
Lower secondary (6–9 years)	93 (25.1)
Upper secondary (10–12 years)	59 (15.9)
University/college	73 (19.7)
Do not answer	7 (1.9)
Monthly household income	
Not fixed income	56 (15.1)
Less than NRs. 5,000	17 (4.6)
NRs. 5,000–9,999	57 (15.4)
NRs. 10,000–14,999	43 (11.6)
NRs. 15,000–19,999	46 (12.4)
More than NRs. 20,000	51 (13.6)
Missing/do not know	101 (27.2)
Mean frequency of bathing per week (min–max)	2.4 (1–7)
Mean frequency of washing clothes per week (min–max)	2.6 (1–7)
Mean frequency of mopping the floor per week (min–max)	3.8 (0.06–14)
Mean frequency of cleaning the latrine/toilet per week (min–max)	3.8 (0.5–7)
Mean litres of collected water per capita per day (SD)	15.4 (20.1)
Deterioration of quality of life due to a water scarcity problem	
Always	8 (2.7)
Most of the time	30 (8.1)
Sometimes	125 (34.0)
Rarely	86 (23.4)
Never	119 (32.3)

SD: standard deviation, min: minimum, max: maximum.

Note: NRs. 1 = USD 0.011.

domain and psychological distress among women who were living in areas with >7 hours/week of water supply. In moderate water supply areas (4–7 hours/week), women who experienced 'lost opportunity costs and social interactions related to water' had higher distress than women who did not experience this. In poor water supply areas (<4 hours/week), women who experienced 'difficulties in house-work related to water' and 'difficulties in basic activities related to water' had higher distress

Table 2. Twenty-two items of household water insecurity and factor loadings and uniqueness of the items, and affirmative responses in Nepali women ( $n = 371$ ).

Household water insecurity items (22 items)	Rotated factor loadings				Uniqueness	Affirmative responses
	Factor 1	Factor 2	Factor 3	Factor 4		
1. Difficulties in cleaning house	<b>0.79</b>	0.19	0.25	0.32	0.18	41.2%
2. Difficulties in laundry	<b>0.79</b>	0.19	0.28	0.23	0.20	48.3%
3. Difficulties in cleaning latrine/toilet	<b>0.83</b>	0.18	0.23	0.25	0.17	45.3%
4. Difficulties in bathing	<b>0.76</b>	0.23	0.24	0.30	0.22	44.2%
5. Living in unhygienic place due to water scarcity	<b>0.53</b>	0.27	0.46	0.16	0.16	43.4%
6. Dispute with neighbours/tenants/owners due to issue in water collection and water scarcity	0.38	<b>0.70</b>	0.01	−0.02	0.37	17.5%
7. Dispute with family members due to issue in water collection and water scarcity	0.29	<b>0.79</b>	−0.11	0.01	0.29	14.6%
8. Less time for daily work and income generating activities due to water collection	0.28	<b>0.64</b>	0.41	0.20	0.31	32.6%
9. Less sleep due to the inappropriate water supply schedule	0.10	<b>0.60</b>	0.32	0.29	0.45	27.5%
10. Having health problem or tiredness caused difficulties in water collection	0.06	<b>0.75</b>	0.43	0.18	0.23	29.7%
11. Reduced efficiency of other daily work caused by water-related health problems	0.12	<b>0.71</b>	0.40	0.30	0.23	28.6%
12. Unable to join social functions such as wedding/occasions/festivals due to water collection	0.14	<b>0.73</b>	0.13	0.10	0.42	13.5%
13. Collect less water than needed	<b>0.54</b>	0.22	<b>0.59</b>	0.04	0.32	70.6%
14. Use less quality of water or unsafe water source due to water scarcity	0.18	0.20	<b>0.75</b>	0.16	0.34	45.6%
15. Cannot collect enough piped water because not enough water at the source	0.48	0.18	<b>0.68</b>	0.04	0.27	60.1%
16. Cannot collect enough water from other sources due to water scarcity	0.46	0.19	<b>0.66</b>	0.08	0.31	51.5%
17. Pay more money for buying water due to water scarcity	<b>0.54</b>	0.12	<b>0.52</b>	0.17	0.39	42.3%
18. Difficulties in washing hands or face	<b>0.58</b>	0.16	0.04	<b>0.65</b>	0.22	25.6%
19. Difficulties in cooking	0.30	0.17	0.14	<b>0.82</b>	0.18	14.8%
20. Difficulties in drinking	0.19	0.08	0.07	<b>0.85</b>	0.23	43.4%
21. Unable to cook desirable meals due to water scarcity	0.36	0.33	0.37	0.33	0.52	26.1%
22. Thought of leaving current place due to water scarcity	<b>0.65</b>	0.12	0.10	0.06	0.55	21.0%
Eigenvalue	10.45	2.14	1.53	1.06		
Per cent of variance	24%	18%	15%	12%		

Note: Factor loadings over 0.50 appear in bold.

than women who did not experience these. None of the groups showed an association between quantity of collected water and psychological distress.

Among all of the study participants, psychological distress scores were lower in those who have children, a higher education level, higher monthly income, and better physical health status than in women



Table 3. Adapted items (20-item) of household water insecurity and rotated factor loadings of the items, and eigenvalue, per cent of variance, and Cronbach's  $\alpha$  of each factor in Nepali women ( $n = 371$ ).

Household water insecurity items (20 items)	Rotated factor loadings
<b>Difficulties in house-work related to water</b> ( $E = 9.7$ , % of variance = 25%, Cronbach's $\alpha = 0.93$ )	
1. Difficulties in cleaning house	0.82
2. Difficulties in laundry	0.83
3. Difficulties in cleaning latrine/toilet	0.86
4. Difficulties in bathing	0.80
5. Living in unhygienic place due to water scarcity	0.51
<b>Lost opportunity costs and social interactions related to water</b> ( $E = 2.1$ , % of variance = 19%, Cronbach's $\alpha = 0.89$ )	
6. Dispute with neighbours/tenants/owners due to issue in water collection and water scarcity	0.69
7. Dispute with family members due to issue in water collection and water scarcity	0.78
8. Less time for daily work and income generating activities due to water collection	0.63
9. Less sleep due to the inappropriate water supply schedule	0.59
10. Having health problem or tiredness caused difficulties in water collection	0.75
11. Reduced efficiency of other daily work caused by water-related health problems	0.71
12. Unable to join social functions such as wedding/occasions/festivals due to water collection	0.73
<b>Insufficiency of a safe water supply</b> ( $E = 1.5$ , cumulative % = 16%, Cronbach's $\alpha = 0.88$ )	
13. Collect less water than needed	0.59
14. Use less quality of water or unsafe water source due to water scarcity	0.72
15. Cannot collect enough piped water because not enough water at the source	0.68
16. Cannot collect enough water from other sources due to water scarcity	0.67
17. Pay more money for buying water due to water scarcity	0.54
<b>Difficulties in basic activities related to water</b> ( $E = 1.1$ , cumulative % = 12%, Cronbach's $\alpha = 0.86$ )	
18. Difficulties in washing hands or face	0.64
19. Difficulties in cooking	0.81
20. Difficulties in drinking	0.85

*E*: eigenvalue.

who did not have children, had no education, had monthly income of less than NRs. 5,000 (=USD 55), and had poor physical health.

#### 4. Discussion

The present study tested the validity and reliability of a household water insecurity scale developed by the authors based on the definition of water insecurity (Grey & Sadoff, 2007). Exploratory factor analysis showed that it comprised four main domains: 'difficulties in house-work related to water', 'lost opportunity costs and social interactions related to water', 'insufficiency of a safe water supply', and 'difficulties in basic activities related to water'. The results revealed that our scale had good internal consistency (Cronbach's  $\alpha$  for the full scale = 0.94, and Cronbach's  $\alpha$  for each domain = 0.86–0.93). Although more than half of the participants experienced being able to collect less water than needed or being unable to collect piped water, of the four domains 'difficulties in house-work related to water' contributed to 25% of the total explained variance. Culturally, women play a pivotal role in domestic work. Hence, domains related to house-work may explain a high amount of variance in household water insecurity. The study by Stevenson *et al.* (2012) which was conducted in rural Ethiopia,

Table 4. The linear regression and stepwise multivariate regression for the impact of household water insecurity scale on psychological distress in Nepali women.

Variables	Univariate regression $\beta$ (SE)	All ( $n = 353$ ) $\beta$ (SE)	>7 hours/week ( $n = 117$ ) $\beta$ (SE)	4–7 hours/ week ( $n = 117$ ) $\beta$ (SE)	<4 hours/ week ( $n = 119$ ) $\beta$ (SE)
Total scores of household water insecurity	0.61 (0.37)				
Difficulties in house-work related to water	0.52 (0.30)				1.24 (0.42) <sup>b</sup>
Lost opportunity costs and social interactions related to water	0.76 (0.30) <sup>a</sup>	0.82 (0.30) <sup>b</sup>		2.36 (0.52) <sup>c</sup>	
Insufficiency of a safe water supply	−0.57 (0.30)				
Difficulties in basic activities related to water	0.22 (0.30)				0.92 (0.38) <sup>a</sup>
Quantity of collected water (litres/capita/day)	1.03 (1.95)				
Age in years	0.02 (0.03)				
Household size	0.26 (0.13)	0.26 (0.13) <sup>a</sup>			
Having children (1 = yes, 0 = no)	−0.55 (0.75)	−1.69 (0.77) <sup>a</sup>	−3.89 (1.35) <sup>b</sup>		
Educational level	−0.87 (0.23) <sup>c</sup>	−0.93 (0.25) <sup>c</sup>	−1.28 (0.50) <sup>a</sup>	−0.89 (0.35) <sup>a</sup>	−1.13 (0.37) <sup>b</sup>
Monthly household income (Ref. <NRs. 5,000)					
NRs. 5,000–9,999	−2.41 (1.56)	−1.79 (1.56)		−3.88 (3.10)	
NRs. 10,000–14,999	−3.14 (1.62)	−3.12 (1.61)		−4.83 (3.10)	
NRs. 15,000–19,999	−4.27 (1.60) <sup>b</sup>	−3.80 (1.61) <sup>a</sup>		−5.13 (3.14)	
More than NRs. 20,000	−4.55 (1.58) <sup>b</sup>	−3.54 (1.57) <sup>a</sup>		−5.00 (3.15)	
< Not fixed income	−6.05 (1.56) <sup>c</sup>	−4.62 (1.58) <sup>b</sup>		−6.82 (3.17) <sup>a</sup>	
Missing/do not know	−4.04 (1.48) <sup>b</sup>	−3.38 (1.49) <sup>a</sup>		−5.67 (2.99)	
Ethnicity (Ref. Brahmin/Chettri)					
Newar/Janajati	0.13 (0.63)		0.10 (1.14)		
Dalit	−2.83 (2.24)		−10.97 (4.29) <sup>a</sup>		
Subjective rated health (4 = excellent, 0 = poor)	−1.19 (0.35) <sup>b</sup>	−0.82 (0.35) <sup>a</sup>	−2.23 (0.65) <sup>b</sup>		
Social support (4 = very satisfied, 0 = very dissatisfied)	−1.09 (0.38) <sup>b</sup>				
Personal relationships (4 = very satisfied, 0 = very dissatisfied)	−1.29 (0.39) <sup>b</sup>				−1.25 (0.58) <sup>a</sup>
Water supply service level (Ref. >7 hours/week)					
4–7 hours/week	−0.61 (0.74)				
< 4 hours/week	−0.89 (0.73)				
Intercept		26.77 <sup>c</sup>	32.02 <sup>c</sup>	25.97 <sup>c</sup>	25.81 <sup>c</sup>
Adjusted- $R^2$		0.11	0.17	0.19	0.18

$\beta$ : adjusted coefficient, SE: standard error, Ref.: reference. <sup>a</sup> $p$ -value <0.05, <sup>b</sup> $p$ -value <0.01, <sup>c</sup> $p$ -value <0.001.

Note: NRs. 1 = USD 0.011.

constructed a household water insecurity scale with six domains. Unlike Stevenson *et al.*, the present study eliminated the domain of ‘obstacles to water access’. In Kathmandu Valley, the coverage of connected piped water is as high as 78% and most of the households own a private well (Yoden, 2010). As most of the households in the valley collect water from a tap or well in their house, we assumed that questions regarding the accessibility of a water source are not relevant in these urban settings.

Although water supply coverage in the study area was high, the results revealed that a high percentage of the participants had experienced being able to collect less water than needed. A population-based study in the valley reports that 89% of the households complain to KUKL about limited, or non-existent, water supply. In reality, the average amount of daily household water consumption in households with a private well is 67 LPCD, and in those households without a private well it is 41 LPCD (Yoden, 2010). In contrast, in rural Nepal, the average household water consumption is 45–60 LPCD (Bhandari & Grant, 2007). Although the accessibility of water sources is better in the valley than in rural Nepal, the household water consumption level does not differ much between urban and rural areas. Moreover, since the present study was carried out in the dry season and water supply levels were decreasing, the complaint by a high percentage of households of limited water collection is accurate.

Although the model explained a relatively low level of variance in psychological distress (adjusted  $R^2 = 0.11–0.19$  in Table 4), we found that some domains of the household water insecurity scale are associated with psychological distress in the participants, and the impact is more significant among women living in poor water service areas. The domain of ‘lost opportunity costs and social interactions related to water’ is associated with poor psychological well-being among the participants, particularly those living in areas with a water supply of 4–7 hours/week. Uncertainty over food supply is responsible for severe psychological distress and insomnia (Coates *et al.*, 2006). Limited water supply may be an obstacle in women’s daily life, including their sleeping and social participation. In addition, the availability of water from KUKL differs between household owners and tenants, as owners can use nearly double the amount compared to tenants (Yoden, 2010). Even for residents living in the same building, the water tariff is higher for tenants than for owners. Although we did not collect information regarding owners or tenants in a building, the gap in water use may be the basis of disputes, and social interaction related to water may influence the psychological burden in the participants. More study participants living in an area with 4–7 hours/week of water supply collected water from a tube-well or dug-well compared to participants living in an area with >7 hours/week or <4 hours/week of water supply. In contrast, the major domestic water sources for collection among the women living in an area with >7 hours/week and <4 hours/week were private KUKL piped water and tankers, respectively (while the data are not shown in this paper, the information can be provided on request). Water collection from the wells may require women or their families to spend long and stressful hours standing under the sun (Ochodo *et al.*, 2014). Previous studies have reported that women feel that water insecurity creates wasted time and economic hardship more than men (Wutich, 2009). Moreover, extensive contamination of water by microbes in deep tube-wells in the valley has been reported previously (Tanaka *et al.*, 2012). Using poor quality water may also lead to decreased psychological well-being among the participants.

Among women living in areas with a poor water supply service level (<4 hours/week), ‘difficulties in house-work related to water’ and ‘difficulties in basic activities related to water’ were associated with psychological distress. Difficulty managing the household, and inadequate hygiene cause women constant distress (Subbaraman *et al.*, 2014). In comparison with other domains, washing hands, drinking, and cooking are directly linked to survival or physiological outcomes. Unhygienic environments and

inadequate hand hygiene cause a diarrhoeal disease burden, particularly among small children (Pruss-Ustun *et al.*, 2014). Women in the household may also have responsibility for the health of their family members. The threat of illness in family members due to economising water use for drinking, cooking, and washing hands, owing to a water shortage, may lead to the deterioration of the women's well-being. In addition, these results imply that an unstable water supply enforces community dwellers to sacrifice their basic human needs.

Our data also show that education and income play important roles in the protection against psychological distress. A systematic review revealed that education, food insecurity, and financial strain have a consistent and strong association with mental health in low- and middle-income countries (Lund *et al.*, 2010). Better educated women can control household resources (Qadir *et al.*, 2011). However, due to cultural and traditional aspects, women have less opportunity to go to school than men in Nepalese society. The experience of water insecurity increases the burden on psychological well-being among women with low education and from poor households.

Although the present household water insecurity scale has high reliability, we still do not have scientifically valid measures of the experience of household water insecurity. For example, the present survey was conducted only in the dry season. As the incidence of water-related diseases varies seasonally, household water insecurity scores and the impact of each domain of water insecurity may also change across wet and dry seasons (Hadley & Wutich, 2009). As mentioned in empirical studies which measure household water insecurity, the experience of household water insecurity is based on locally relevant experiences (Wutich & Ragsdale, 2008; Stevenson *et al.*, 2012). Similar to the food insecurity scale, the development of a universally applicable tool for measuring household water insecurity needs more discussion in order to identify the degree of adaptation of core domains of household water insecurity across countries and cultures (Swindale & Bilinsky, 2006).

## 5. Conclusion

The present study shows that the impact of aspects of household water insecurity on psychological distress differs by water supply service levels. Enormous efforts and comprehensive projects are required to solve the global issue of water insecurity. The focus of water insecurity has been mainly on the provision of improved drinking water and accessibility of water sources. However, due to progress in water access, more people today are concerned with the maintenance and operation of water facilities. User satisfaction with water services is associated with users' willingness to pay (Bhandari & Grant, 2007). Like food insecurity scales, the current household water insecurity scale identifies some domains, and contributes to policy-making, by detecting which elements of the water insecurity experience are a burden on the user's well-being and which can be used to provide better water services (Coates *et al.*, 2006). Moreover, the developed household water insecurity scale is a simple measure but it is able to identify priority target populations, and to evaluate the impact of interventions. For example, it will be able to compare the seasonal differences (dry season and wet season), and experience of different individuals in the same family (e.g., gender, age-group) of the burden of household water insecurity. The finding that water insecurity is linked to mental health outcomes suggests that the health-related costs of water insecurity could be even higher than previously anticipated (Ennis-McMillan, 2001; Wutich, 2009). The scale provides a way for public health researchers to assess the physical and psychological health disparities related to water insecurity. The results of this study suggest that further studies

should be carried out to construct a scientifically valid and widely acceptable household water insecurity scale for identifying the commonalities of how people experience, express, and manage water insecurity across cultures.

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