

Sub-optimal household water access is associated with greater risk of intimate partner violence against women: evidence from Nepal

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ABSTRACT

Household water management is often women's responsibility, as related to the gendered nature of household roles. Ethnographic data suggest that household water insecurity could increase women's exposure to emotional and physical forms of intimate partner violence (IPV), as punishments for failures to complete socially expected household tasks that rely on water (like cooking and cleaning) and the generally elevated emotional state of household members dealing with resource scarcity. Here, we test the associations between sub-optimal household water access and women's exposure to IPV, using the nationally-representative data from Nepal Demographic and Health Survey, 2016. Drawing upon the intra-household bargaining model as the theoretical framework, we run instrumental variable probit regression, to test the association between household water access and prevalence of IPV against women. After controlling for other known covariates of IPV such as women's empowerment and education, the findings substantiate that worse household water access consistently elevates women's exposures to all forms of IPV. This suggests that improvements in household water access may have additional ramifications for reducing women's risk of IPV, beyond currently recognized socioeconomic benefits. While both household water access and IPV have known health consequences, linking them provides another pathway through which water could affect women's health.

Key words | gender, household water access, intimate partner violence, intra household bargaining, Nepal, women

INTRODUCTION

Household water insecurity – lack of access to sufficient, safe water to meet everyday needs – is a rising challenge for development (WHO 2017). It reinforces both illness and poverty through multiple and diverse pathways. Households with inadequate or unsafe water supplies are less able to produce their own food or prepare low-cost food, and can also face greater risk of exposure to toxic contaminants (e.g. Schell & Denham 2003; Workman & Ureksoy 2017). Insufficient water typically also means inadequate sanitation and, therefore, increased risk of diarrheal illnesses (Prüss *et al.* 2002; Pokhrel & Viraraghavan 2004; Bartram & Cairncross 2010). Thus, there is an established direct association between household's access to water and access to health.

Household water insecurity can also have indirect implications for women's well-being specifically, in part because globally women are those who more often have the burden of household water management (Ray 2007). Women are more often those tasked with fetching household water and this is associated with women's elevated risks of assaults and physical trauma (Geere *et al.* 2018). The time, physical, and cognitive drain of managing water scarcity also curtails opportunities for both education and earning (e.g. Gomez *et al.* 2019). Unsurprisingly, water insecurity is consistently associated with heightened depression and anxiety (Aihara *et al.* 2016; Bisung & Elliott 2017), and worry around water may even

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lead to physiological stress effects like hypertension (Brewis *et al.* 2019).

Here, we propose and test another basic pathway that links water insecurity to women's health: exposure to intimate partner violence (IPV), itself a major health care issue (Campbell 2002; Domenech del Rio & Sirvent Garcia del Valle 2017). Poor water access could be detrimental to women's physical, emotional, and economic health in particular, by exacerbating IPV (Kevany & Huisingsh 2013; House 2014; Ayoade *et al.* 2015; Geere *et al.* 2018). While analyses empirically connecting household water challenges and IPV are currently lacking, there is a theoretical rationale to assume these as related. To begin with, living with water insecurity is in itself emotionally difficult, and inter-personal conflict around water is so common that some scholars consider it a core dimension of the phenomenon of water insecurity (Jepson *et al.* 2017). Ethnographically-informed studies from very low-income and water scarce communities suggest that household water insecurity may act as a direct trigger for intra-household conflicts, increasing violence towards women (Stevenson *et al.* 2012; Kevany & Huisingsh 2013; Collins *et al.* 2017). In one small study in Bolivia, for example, intra-household conflict over water was cited as a common source of fights between spouses (Wutich 2009). Similarly, in Nepal, men's refusal to pay for water and compelling wives to make do with their neighbors' water source was deeply distressing to the wives (Udas *et al.* 2014).

Lack of water can mean that women's core household tasks, such as cooking and cleaning, cannot be completed as expected. In Lesotho, women described water-based development projects as a priority to maintain peace with their spouses, because it meant being able to complete their assigned household chores (Cairns *et al.* 2017). In Nepal, a rural drinking water project meant women had to travel further for non-drinking water. This time drain meant their domestic obligations such as laundry were less likely to be met, resulting in what they described as a justified basis for physical punishment by their husbands (Regmi 2000). Water insecurity seems to worsen the treatment of women by family members more generally. In Bangladesh, Sultana (2011) details many stressful ways in which women must monitor their emotions and social interactions to avoid conflicts when obtaining water from other

family members and community members. Generally, gender-related violent acts have been found to be more prevalent in water scarce contexts and drought-affected populations than in unaffected ones (Vins *et al.* 2015).

These small-scale ethnographic studies together theorise a wider pattern: that IPV and water scarcity should be directly connected. This proposition also fits within a broader economic literature suggesting that any conflicts around limited household resources elevate women's exposure to violence. Particularly, there is a recognition that men versus women's interests over control of household resources may be different and thus generate conflict (Chiappori 1988, 1992; Moser 1989; Behrman 1997). IPV has previously been identified as a key domain where family dynamics reflect failures to conform to Becker's (1965) cooperative mold (Tommasi & Wolf 2018; Farmer & Tiefenthaler 1997). Economists have increasingly relied upon the bargaining model to accommodate the non-unitary and heterogeneous nature of preferences, control, resource sharing and wellbeing outcomes within the household, especially the gendered nature of intra-household resource distribution (Sen & Sengupta 1983; Haddad & Kanbur 1990; Quisumbing 1994; Klasen 1996; Chen 2013; Roemling & Qaim 2013; Bargain *et al.* 2014; Rodriguez 2016). This model may also work for understanding how limited household resources, such as water, may impact IPV, which has known health consequences as well.

Generally, resource poor contexts such as increasing levels of household food insecurity are found to be associated with women's elevated exposure to IPV (Coates *et al.* 2010; De Cássia *et al.* 2016; Fong *et al.* 2016; Ricks *et al.* 2016; Andarge & Shiferaw 2018). Macroeconomic crises (such as price rise or recession resulting in acute reduction in resource availability) have also been found to be associated with increased prevalence of violence against women (Maxwell & Stone 2010; Stevenson *et al.* 2012; Van den Berg & Tertilt 2012; Cools *et al.* 2015; Abiona & Koppensteiner 2016). Since women are usually among those with comparative lack of command over resources, lower human capital attributes, lower place in gender hierarchy and less mobility, a resource (including water) scarce context is likely to exacerbate their exposure to IPV (Cunradi *et al.* 2000; Jewkes 2002; Vest *et al.* 2002; Bowlus & Seitz 2006; Gilroy *et al.* 2015).

Despite all the varied lines of evidence, there are to our knowledge no direct tests of the core proposition: household water challenges elevate women's risk of IPV. Here, we use large scale nationally-representative data from Nepal to test if inadequate household water access and women's experience of IPV are directly related. The study is innovative both in its scale and its instrumentation. Taking into account the known risk factors for IPV, such as women's lack of empowerment, maternal/marital histories, younger age, and other household resource stresses, we propose that sub-optimal access to water will consistently elevate women's exposures to both physical and emotional IPV. Making this empirical connection is important, because it indicates that local, household water-based interventions could act as an additional and important crucial point of leverage in efforts to advance women's status and health in the contexts of alleviating household poverty.

IPV and water in Nepal: some context

We select Nepal as our case because it has previously been documented to have both extremely high rates of IPV alongside high levels of household water insecurity. Water insecurity in Nepal is a daily reality for many households, with multiple challenges related to water pollution, poverty and scarcity (Pasakhala et al. 2013; Raina 2016; Thapa et al. 2018). A recent study shows that the median total per capita water consumption in Kathmandu's households is below the United Nation's mandate of 50 L per person per day for personal and domestic use (Pasakhala et al. 2013; Raina 2016).

Within Nepali households, coping with shortages is a responsibility that falls almost always to women (Upadhyay 2005; Gautam et al. 2018; Molden et al. 2018; Shrestha et al. 2019). Regmi & Fawcett (1999), in their study in Motipur, Magaragadhi, and Gajedi villages in western Nepal, found that women used to collect water 4–5 times a day, amounting to a total of 80 L per family per day. However, even after their water supply was closer to their homes, their burden did not decrease as the households' water use increased to nearly 200–300 L per day, which required women to make much greater numbers (10–15) of trips to fetch water. In one study on watershed in Nepal, it was found that

women spent up to 4 hours a day fetching water (Shrestha et al. 2019).

Nepali society is also known to conform to norms that allow and encourage the likelihood of IPV against women by their male spouses (Palladium 2016; Ghimire & Samuels 2017). Men's aggression and dominance are considered by many as natural and justified within the social order (UNDP 2014; Yoshikawa et al. 2014; Clark et al. 2018). According to a study cited in UNDP (2014), over 75% of men and women either completely or partially agreed that men are naturally aggressive, and nearly a quarter of men completely or partially agreed that it was shameful if a man could not or did not beat his wife. This acceptance of wife beating is considered as an important risk for IPV against women in Nepal (Yoshikawa et al. 2014). The few systematic studies in Nepal confirm a wide prevalence of IPV (Lamichhane et al. 2011; Pandey 2016). For example, a study undertaken on violence against women in Nepal found that 93% of women were exposed to psychological and emotional IPV, and 82% were exposed to physical IPV (Rana 1997). Further, domestic violence accounted for more than 80% of all violence experienced by women in Nepal (Dhakal 2008). The high level of IPV in Nepal is due to gendered norms (Yoshikawa et al. 2014), but it also reflects other contextual factors such as poverty and lack of economic independence of women, husband's consumption of alcohol, and lack of women's access to social support and services outside the household (Puri et al. 2010; Lamichhane et al. 2011; Puri et al. 2012; Pandey 2016). Shrestha et al. (2018) prepared an objective index to assess water security in the Kathmandu valley of Nepal and found that it is significantly and positively associated with household members' quality of life. Specifically, they attributed this association to constant worrying that the lack of adequate quantity or low quality of water causes.

METHODOLOGY

Data and variables

The data for this study is from the nationally-representative 2016 Nepal Demographic and Health Surveys (DHS). The survey deployed stratified sampling across all seven

administrative provinces of Nepal, with household selection carried out in two stages in rural areas and three stages in urban areas. A sub-set of interviewed married women with small children in selected households were then randomly selected for a 'domestic violence' module (https://dhsprogram.com/pubs/pdf/DHSQMP/domestic_violence_module.pdf.pdf). Here our analysis is limited to those women currently cohabitating with their husband ($N = 3708$ women). The mean age of the women is 32 years and the mean age of their husbands is 36 years.

Outcome variables of emotional and physical IPV

Our primary outcome variables are whether a woman reported if she ever experienced: (1) physical forms; and (2) emotional forms of IPV from her husband. DHS 'domestic violence' modules collect comprehensive self-reported information on women's experiences of physical and emotional violence from family members, including a particular focus on spouses. We look at physical forms of IPV through two variables based on questions related to types and levels of physical violence. The first variable is whether a woman reported ever experiencing what the DHS terms 'severe' or 'less severe' physical violence from their partners (combined as a single variable in analyses). In the DHS context, 'less severe' violence included being pushed, slapped, punched, arm twisted, or hair pulled. 'Severe' violence is defined as being kicked or dragged, strangled, or threatened with a weapon. Our second physical violence variable is whether a woman reported having ever experienced any physical injuries from physical violence. The outcome variable of experience of emotional IPV is also based on two question sets. One established if the woman ever felt 'humiliated' by her husband. The other related to whether women experienced any emotional IPV such as threats of physical harm. We consider these four indicators as four separate dependent variables to assess the level of exposure of women to IPV.

Characterizing household water challenges

Ready access to treated water in the house (i.e. without effort or time needed to fetch and make safe) is a key dimension of water security ([Jepson *et al.* 2017](https://doi.org/10.1080/14654744.2017.1353520)). Generally, a

readily available, safe household water source can be a reasonable proxy. Accordingly, in this paper we use 'source of water' in the DHS dataset to assess the water access level in terms of needs met. Following WHO norms given in [Howard & Bartram \(2003\)](https://www.who.int/water_sanitation_health/resources/WHO_Household_Water_Supply_Guidelines.pdf), water access based on levels of needs met is defined as: (1) optimal, when all consumption and hygiene needs are easily met; (2) intermediate, when consumption needs are assured and basic personal and food hygiene are met; and (3) basic or no access, when consumption needs are difficult to fulfill, hygiene needs may or may not be assured. We categorized the source of water variable in the following manner:

- (1) Optimal access – where sources of water include piped water, piped into dwelling, piped into yard, bottled water. We expect that among the available sources listed, these four sources are most likely to ensure water access in desirable quantity and quality, meeting all consumption and hygiene needs in a comfortable manner.
- (2) Intermediate access – where sources of water include piped to neighbour, public tap, tube well water, tube well or borehole, protected well, protected spring, tanker truck. These sources are likely to ensure that consumption needs are met and basic hygiene needs are likely to be met since even public sources are protected.
- (3) Basic or no access – where sources of water include dug well, unprotected well, unprotected spring, river/dam, rainwater and other. In these cases we expect that consumption needs may be met with difficulty whereas minimum hygiene norms can hardly be assured.

Water access defined as such is the main independent predictor variable in our analysis.

Other covariates

We include a range of covariates widely known to worsen women's risk of IPV. These include education and employment of women and their husbands. We include employment status in the model instead of household's wealth status since the DHS wealth class variable includes source of water variable, thus confusing the relationship between water access and IPV. The education status of both men and women is included in the model, noting

that education is a salient channel for female empowerment as well as male awareness.

Women's empowerment is a key covariate, well-known as a protection against IPV (Donta *et al.* 2016; Kim *et al.* 2018). We apply an empowerment index in our models that is constructed using principal component analysis on four DHS variables: whether the woman participates in the decision-making involving her own health issues, large household purchases, visiting relatives, and spending the money earned by her spouse. This is an unweighted index wherein the standardized first component which (with an eigenvalue greater than one) is the empowerment index. Of course, decision-making is not the only way to look at women's empowerment, but it is certainly an important indicator recommended as a proxy (Kabeer 1999). Further, several studies argue that empowerment (e.g. in terms of cash employment) can further instigate perpetration of spousal violence or IPV against women (Vyas & Watts 2008; Rahman *et al.* 2011). However, this depends upon how we measure empowerment. When it is assessed in terms of enhanced earning of women or greater mobility outside the household, it is likely that it manifests into a backlash from the spouse. However, in this model we measure empowerment in terms of women's participation in decision making alone or with her partner, which is likely to involve consensus between them. In this sense empowerment is unlikely to result in increased violence against women. However, we do agree with the endogenous nature of women's empowerment and the same is accommodated in our model.

Household food insecurity tends to co-vary with water access challenges (Wutich & Brewis 2014), and it may also elevate risks for IPV (de Moraes *et al.* 2016; Hidrobo *et al.* 2016). We used summary scores from the nine-item Household Food Insecurity Access Scale (HFIAS) scale (Coates *et al.* 2010) as our estimate of household food insecurity over the last 12 months. The scores potentially range from 0 to 27, where zero indicates complete food security and 27 represents severe food insecurity. Using standard HFIAS cut-offs, just over half of the surveyed households were food insecure in the last 12 months (52%); 20% of these are mildly food insecure, 22% are moderately food insecure, and 10% are severely food insecure, with rates higher in rural areas and in a relatively infertile/

mountainous province (Ministry of Health Nepal New ERA & ICF 2017).

Other variables that are included in our analysis include the age of women and their husbands, female household head (FHH), place of residence (rural or urban), religion and whether the husband uses alcohol, among others. Women's increasing age has been generally found to have a negative impact on their risk of IPV (Oshiro *et al.* 2010; Puri *et al.* 2012). In a patriarchal society, a female headed household (where an adult woman is the sole income earner or decision maker) usually comprises of widows, never-married women, and women with a partner who is a non-resident or who has migrated to another place (Udas & Choudhary 2017). They are therefore less likely to have exposure to IPV. Religion and religiosity is expected to influence the prevalence of IPV in multiple complex ways, such as setting gendered norms and roles and making it harder for women who are abused to seek outside assistance (Nason-Clark *et al.* 2017). Alcohol use is a known trigger for IPV (Oshiro *et al.* 2010; Pandey 2016). We also included whether the couple has at least one son and whether the couple is currently childless as both could lower and raise risk respectively (Choudhary 2016). Son preference in Nepal is notable if subdued when compared to India, where the lack of sons appears to put women at considerable additional risk of IPV (Choudhary 2016; Dasgupta & Fletcher 2018).

Estimation strategy

Since one of the predictors of exposure to IPV is women's empowerment, which is likely to be endogenous in nature so that the correlation between the regressors and the error term is not zero ($E(X, \varepsilon_a) \neq 0$), Ordinary Least Square regression can produce biased estimates. To accommodate the endogenous nature of women's empowerment, we employ an instrumental variable probit regression model. Applying this model, the probability that a woman experienced IPV can be expressed as:

$$\text{Prob}(Y_a = 1) = \alpha + \mu Y_b + \gamma X + \varepsilon_a \quad (1)$$

$$Y_b = \beta + \Phi Z + \varepsilon_b$$

where $Y_a = 1$ if the woman experienced physical or emotional violence or $= 0$, otherwise; Y_b = women's empowerment; X = vector of variables affecting the probability of a woman experiencing IPV; Z = vector of factors affecting women's empowerment; α and β = constant terms; μ and γ = vector of coefficients of explanatory variables in Equation (2); Φ = vector of coefficients of explanatory variables in Equation (2), including a set of exogenous regressors to be used as instruments; ε_a and ε_b = error terms.

The error terms ε_a and ε_b are expected to be correlated with parameter ρ . Wald's statistic is used to test the endogeneity of the variable. The success of this model, however, requires an efficient instrument which must fulfill three criteria – first, it should be a significant predictor of the variable to be instrumented, second, there should be more than a trivial relationship between the instrument and the instrumented variables and third, it should not be correlated with the outcome variable (Green 1997).

The instruments

Women's empowerment is an endogenous variable so that it affects the probability of woman being exposed to IPV but is not exogenous. To instrument women's empowerment we identify two variables – age gap between the husband and the wife and whether the husband has other wives. These two variables meet the criteria of efficient instruments as recommended by Green (1997). First, there is a non-trivial relationship between these two variables and women's empowerment. Greater age difference within the couple is usually a reflection of low status and agency of women (Carmichael 2011; Pal et al. 2015) and is considered as exogenous to the current period. At the same time, if the

husband has other wives, it tends to be associated with lower empowerment of women regardless of their educational and employment status (Hassouneh-Phillips 2001; Solanke et al. 2018); it also often results in a tangible resource loss for the wife and her children (Bove & Valeggia 2009; Cudeville et al. 2017). Second, we regressed women's empowerment separately on both age gap and whether the husband has other wives, and both of these variables appear as strong predictors of women's empowerment. Third, based on tests of association, our outcome variables of whether the woman is exposed to physical or emotional violence is not correlated with the proposed instruments, i.e. age gap and whether the husband has other wives. Thus, we can proceed with these two variables to instrument women's empowerment in our model.

Female labor force participation among Nepali women is considerably higher (82.7%) than other South Asian countries (see World Bank 2019). Nearly 70% of women in our sample are employed, the majority being engaged in agriculture. The husband's employment is more diversified across various occupational groups. Around 40% of women are uneducated as compared to only 17% of men. The majority of both women and men are educated up to secondary levels. Most respondents are Hindu (86%) followed by around 5% Buddhist. The percentage of female headed households (FHH) is 31.54. The majority (60%) of women sampled reside in urban areas.

RESULTS

Table 1 gives the percentage of women in the sample having ever experienced physical IPV, physical injury, humiliation

Table 1 | Percentage of women reporting IPV by water access categories ($N = 3708$)

	Emotional IPV		Physical violence		
	Any emotional violence	Humiliation	'Less severe' or 'severe' violence	Physical injury	Overall sample
Optimal	9.79	5.09	14.31	5.54	32.43
Intermediate	12.64	7.9	26.45	9.27	62.35
Basic or no access	13.18	8.5	23.97	8.62	5.22
Overall sample	11.77	7.17	22.14	7.93	

Source: Based on Nepal DHS (2016).

and emotional IPV (our four outcome variables) by household water access levels. The majority (62%) of women live in households with intermediate access to water while 5.22% of them survive with basic or no access to water. Only 32.5% of women have optimum access to water. Thus, water insecurity in terms of needs met is quite widespread in Nepal. The percentage of women who have ever experienced physical or emotional violence is the highest among those who have intermediate access to water followed by those with basic access to water (Table 1). This could also be due to the effect of small sample size (5.5% only) for women with basic or no access to water.

Finding 1: Sub-optimal water access enhances women's risk of emotional IPV

Table 2 gives the marginal effect estimated from the instrumental variable probit regression on the two emotional IPV outcomes. The model is a good fit and the endogeneity of women's empowerment is confirmed from the significance of Wald's test, thus rejecting the null hypothesis that women's empowerment is exogenous. To look first at our main predictor-household water access variable, it appears as a significant (at 0.01 level) determinant of both any emotional violence and humiliation against women. As compared to women with optimal water access, women with intermediate water access have a 10% higher probability of experiencing emotional violence and humiliation from their husbands. Among women with basic or no access to water, the probability of experiencing emotional violence and humiliation increases by 3.1 and 1.1%, respectively, as compared to women with optimal access to water, though these gaps are not statistically significant. Figure 1 provides the predicted probability of a woman experiencing emotional violence and humiliation by her husband at different levels of household water access. As seen, the predicted probability of experiencing any emotional violence and humiliation for a woman in households with optimal water access is 29.34 and 28 respectively, which is lower than that of a woman in a household with intermediate water access at 32 and 30.33 respectively. As the household's water access level shifts down from optimal to sub-optimal, there is a corresponding increase in women's probability of experiencing emotional IPV.

In terms of other covariates, one unit increase in household's food insecurity score raises the probability of women experiencing emotional violence and humiliation by 1.8 and 1.7%, respectively. Women's empowerment is also significantly associated with the probability of a woman being exposed to emotional violence and humiliation (Table 2). A unit increase in the empowerment score reduced the probability that women experience emotional violence and humiliation from their husbands by around 60–62%. Figure 2 depicts the predicted probability of women experiencing emotional violence by the water access level and empowerment index score.

At very low and very high levels of empowerment, the difference in probability between the optimum water access category and intermediate water access category is minimized. However, sub-optimal water access continues to increase the probability of women experiencing emotional violence and humiliation at all levels of empowerment.

Women's education level is also significantly associated with their probability of having experienced emotional violence and humiliation. As compared to uneducated women, those having primary, secondary and higher education are 17, 26 and 36% less likely, respectively, to have experienced emotional violence. Similarly, a woman who is uneducated is around 15, 23 and 37% more likely to experience humiliation as compared to a woman who has primary education, secondary education and higher education, respectively. The husband's education does not make any significant difference to the probability that they perpetrate emotional violence or humiliation against their wives. The husband's occupational pattern, however, is significantly associated with the same. As compared to an unemployed husband, husbands who are employed at any level (except agriculture) are less likely to cause emotional violence or humiliation to their wives (Table 2). In terms of women's employment, those engaged in agricultural work have a higher probability of experiencing emotional violence from their spouse as compared to an unemployed woman.

The type of place of residence, religion and women's age are also significant factors. The probability of a woman in rural areas being exposed to emotional violence and humiliation is 9.2 and 6.7% higher, respectively, than that of a woman in urban areas. Women practicing

Table 2 | Estimates from instrumental variable probit model predicting emotional violence and humiliation

	Any emotional IPV		Humiliation	
	Marginal effect	Standard error	Marginal effect	Standard error
Source of water (Ref: Optimal)				
Intermediate	0.1040126**	0.0483768	0.1011968**	0.0496856
Basic or no access	0.0310416	0.0920834	0.0117155	0.0917203
Household Food Insecurity Score	0.0179961**	0.0057474	0.0172801**	0.0052421
Women's empowerment	-0.6038119**	0.0747263	-0.619693**	0.0554105
Woman's education (Ref: no education)				
Primary education	-0.1747992*	0.0604404	-0.1481957**	0.0632092
Secondary education	-0.2555445**	0.0651495	-0.2299844**	0.0665006
Higher education	-0.3599647**	0.0955115	-0.3671311**	0.1040857
Husband's education (Ref: no education)				
Primary education	-0.0767669	0.0791584	-0.1128931	0.0891669
Secondary education	-0.0730302	0.0976754	-0.0815412	0.0989859
Higher education	-0.0502424	0.1676804	0.0234907	0.1711674
Husband's employment (Ref: not employed)				
Professional	-0.3799686**	0.1164621	-0.368996**	0.1128269
Sales and services	-0.4179532**	0.0815286	-0.4746037**	0.0678841
Manual	-0.4675793*	0.0762726	-0.4543382**	0.0747604
Agriculture	-0.3046264	0.1585684	-0.4795004*	0.1774986
Woman's employment (Ref: not employed)				
Professional	0.2461463	0.1594365	0.2288296	0.1464152
Sales and services	0.1231859	0.0926459	0.1097804	0.0924194
Manual	0.0911472	0.1287027	0.0712677	0.11431
Agriculture	0.1970585**	0.0609187	0.2002355**	0.0595324
Religion (Ref: Hindu)				
Buddhist	-0.169449*	0.106517	-0.1859665*	0.1073574
Other	0.1047022	0.0843024	-0.0343042	0.0855644
Type of residence (Ref: urban)				
Rural	0.0926211*	0.0470833	0.0699738*	0.0520307
Women's age	-0.0148939**	0.0068826	-0.0189538**	0.0056983
Husband's age	-0.0044009	0.0050991	-0.0019205	0.0047347
Childless (Ref: No)				
Yes	0.1028871**	0.1028871	0.2162872**	0.104798
Has at least one son (Ref: no)				
Yes	0.0275957	0.0600399	0.0982054	0.0641589
Husband uses alcohol (Ref: no)				
Yes	0.0392105	0.002310	0.082808	0.097884
	Wald χ^2 (26) = 130.24**		Wald χ^2 (26) = 116.17**	
	Wald test of exogeneity		Wald test of exogeneity	
	(/athrho = 0): χ^2 (1) = 2.307**		(/athrho = 0): χ^2 (1) = 2.362966**	

*significant at 0.05 level.

**significant at 0.01 level.

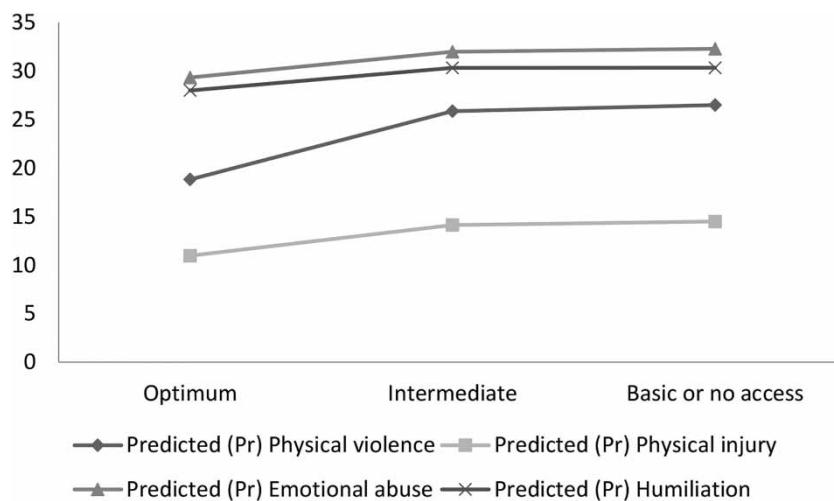


Figure 1 | Predicted probability of woman experiencing physical and emotional forms of IPV at different water access levels.

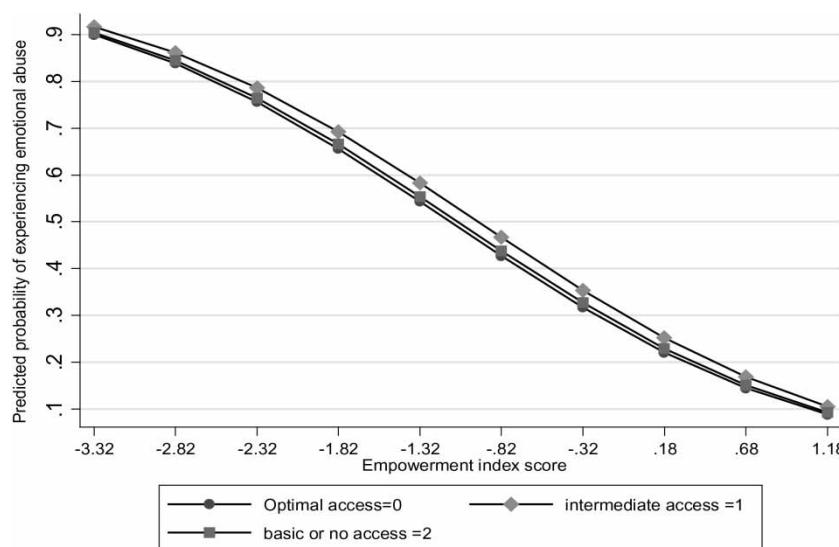


Figure 2 | Predicted probability of experiencing emotional IPV (including humiliation) by water access category and women's empowerment score.

Buddhism are less likely to experience emotional violence such as threats by 16% and humiliation by around 19%. With each additional year of age, the probability of a woman experiencing emotional violence and humiliation declines by around 1.5 and 1.9%, respectively. The husband's age does not appear to have any significant effect, nor does having a son make any significant difference to the probability of outcome. The husband's use of alcohol does not affect the probability of emotional violence either. However, as expected, childlessness enhances the

probability of a woman experiencing emotional IPV/humiliation (Table 2).

Finding 2: Sub-optimal water access causes even greater increase in risk of physical than emotional forms of IPV

Table 3 provides estimates for the probability that a woman experiences severe or less severe physical violence and physical injury from her husband's action. Again, our main

Table 3 | Estimates from instrumental variable probit model predicting physical violence and injury against women

	Physical violence		Physical injury due to violence	
	Marginal effect	Standard error	Marginal effect	Standard error
Source of water (Ref: Optimal)				
Intermediate	0.2459204**	0.0890851	0.1908252**	0.1068108
Basic or no access	0.0129671	0.1174097	0.0305126	0.1830677
Household food insecurity score	0.0179623**	0.0054559	0.0158138**	0.0052433
Women's empowerment	-0.6712701**	0.0699879	-0.6961603**	0.0339852
Woman's education (Ref: no education)				
Primary education	-0.0965703	0.1709761	-0.1464446	0.2682988
Secondary education	-0.3932468**	0.1325932	-0.4650054**	0.1070426
Higher education	-0.5649653**	0.1962756	-0.6881767**	0.2045782
Husband's education (Ref: no education)				
Primary education	-0.1953966	0.1085352	0.0008712	0.115236
Secondary education	-0.3431027*	0.1958935	-0.1133964	0.3730869
Higher education	-0.3603962**	0.2046862	-0.0117565	0.8545862
Husband's employment (Ref: not employed)				
Professional	-0.0302369	0.541177	-0.2651964	0.9684769
Sales and services	-0.1510741	0.4585895	-0.245666	0.859748
Manual	-0.0655605	0.5255498	-0.1832088	1.047978
Agriculture	-0.2650946	0.3972128	-0.4032734	0.5640059
Woman's employment (Ref: not employed)				
Professional	0.3148852	0.1993609	0.3148852	0.1993609
Sales and services	0.1238687	0.0852068	0.1238687	0.0852068
Manual	0.0653434	0.1136375	0.0653434	0.1136375
Agriculture	0.2057877**	0.0597659	0.2057877**	0.0597659
Religion (Ref: Hindu)				
Buddhist	-0.4533255**	0.1350047	-0.3728983*	0.1989229
Other	0.3389919**	0.1117282	0.2673352	0.2912358
Type of residence (Ref: urban)				
Rural	-0.0765712	0.1490735	-0.1207881	0.4244451
Women's age	-0.0036426	0.0229571	-0.013564	0.0387362
Husband's age	-0.005992	0.0060356	0.0011459	0.0066584
Childless (Ref: no)				
Yes	0.195153*	0.1286967	0.1961184	0.1280184
Has at least one son (Ref: no)				
Yes	0.0092806	0.0890859	-0.074861	0.2272455
Husband use alcohol (Ref: no)				
Yes	0.5334794**	0.2572247	0.4708519**	0.3165353
	Wald χ^2 (26) = 116.15**		Wald χ^2 (26) = 143.33**	
	Wald test of exogeneity (/athrho = 0):		Wald test of exogeneity (/athrho = 0):	
	χ^2 (1) = 1.916**		χ^2 (1) = 2.075**	

*significant at 0.05 level.

**significant at 0.01 level.

predictor variable, water access, appears significantly associated with the probability of women experiencing both severe or less severe physical violence as well as physical injury. As compared to women with optimal access to water, women with intermediate access to water are 24% more likely to experience physical violence and 19% more likely to experience physical injury as a result of IPV. Again, the probability difference in experiencing physical violence and injury between a woman with optimal water access and a woman with basic or no water access is not significant though the latter is more likely to experience the same by 1.3 and 3.05%, respectively. Figure 1 also shows the predicted probability at 95% level of confidence of women experiencing physical violence and physical injury across water access levels. At optimal water access the probability that a woman experiences physical violence and injury is 19 and 11 respectively. This increases to 26 and 14 respectively in the case of intermediate water access and 26.5 and 14.5 respectively in the case of basic or no water access. Noticeably, the predicted probability of women experiencing physical violence and injury is less than that of women reporting emotional IPV at each level of water access (see Figure 1).

The women's empowerment score lowers the probability of physical violence and injury (Figure 3). The

steepness in the probability curve as compared to that in Figure 2 reflects that physical violence is more sensitive to women's empowerment as compared to emotional forms. Again, at all levels of empowerment, women with intermediate access to water have the highest probability of experiencing physical violence. However, the husband's occupational status is no longer significantly associated with the probability that women experience physical forms of IPV. However, the husband's education now appears as a significant determinant of physical forms of IPV, though not injury.

Women's education retains its significance and women with more education are less likely to experience IPV. While in the case of emotional forms of IPV women's primary education had a significant impact in reducing their vulnerability, in the case of physical forms of violence any significant impact of education starts only from secondary or higher education of women. Rural residence or a woman's age no longer appear as significant determinants of a woman's likelihood of physical forms of IPV or injury. Religion, however, retains its significance. Women who identify as Buddhist have 45 and 37% less probability of experiencing physical violence and injury, respectively. Again, neither the husband's age nor having a son makes

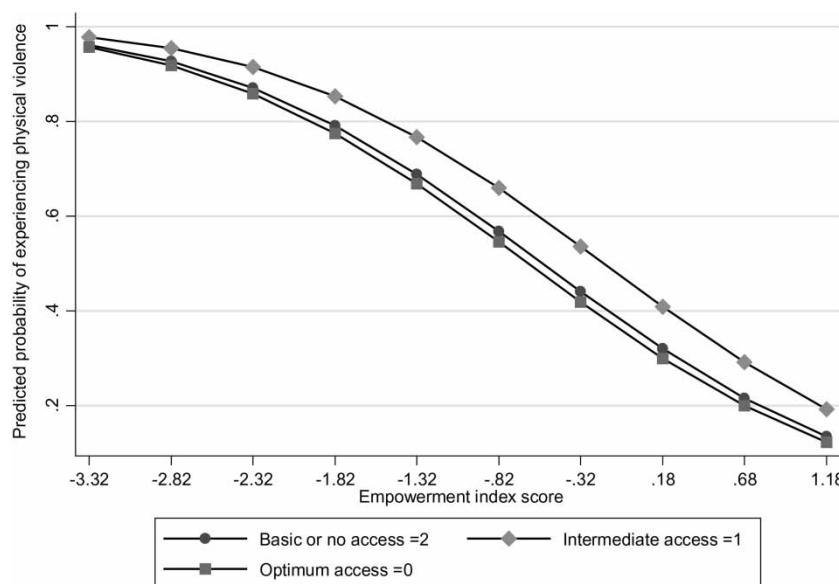


Figure 3 | Predicted probability of experiencing physical violence by water access type and empowerment score.

a significant difference, but childlessness increased the probability of women reporting physical forms of IPV and injury.

DISCUSSION

Sub-optimal water access enhances risk of violence by altering the intra household bargaining process

Our models unambiguously show that sub-optimal water access has a clear and negative association with the probability that women report exposure to intimate emotional and physical violence. Despite the significance of food insecurity in our model, and as substantiated in earlier studies (e.g. De Cássia *et al.* 2016; Andarge & Shiferaw 2018), water access emerges with a significant additional effect on the risk of IPV. The effect is independent so that low access to water enhances women's risk of experiencing violence, even as many other relevant risk factors have been controlled for in the model.

The gendered pattern of household water management in Nepal (Gautam *et al.* 2018; Shrestha *et al.* 2019) is likely to be the main pathway to mediate the impact of low access to water on increased risk of IPV. First, since women are primarily responsible for meeting intra household water needs, a failure in meeting this socially ascribed obligation is likely to be detrimental to their bargaining position within the household. This could be both linked to the judgment of the husband that the wife is incapable or irresponsible, and also because the woman herself accepts a sense of failure in not being able to fulfill her duty. Second, women's increased time use in accessing sub-optimal water takes a toll on time and effort available for other household chores, compromising the household's utility outcomes. This reinforces the sense of women's failure within the household in fulfilling their obligations and therefore further weakens their bargaining position. Third, water-scarce households are likely those with heightened emotions more generally, with more tensions and arguments, thus setting the stage for IPV as one socially-accepted way that men can react to this resource stressor. The reality that these mechanisms rigidly function within

the household is reflected from Figures 2 and 3 where, at any level of women's empowerment, low water access shifts the curve for probability of IPV upward. If we follow the classic bargaining model, underlying this trend would theoretically be a commensurate shift in the intra household bargaining process, which is less favorable to the wife compared to the husband.

On an additional note, our findings re-establish that women's education is a salient means to enhance women's intra household bargaining position which has been corroborated in a number of studies (Bowlus & Seitz 2006; Abramsky *et al.* 2011; Choudhary 2016). Women's command over resources has been found to decrease the risk of IPV (Gelles 1976; Pagelow 1981). However, in our model women's employment does not yield a positive effect on women's reduced risk of IPV. Rather, as compared to unemployed women, those engaged in agriculture have a higher risk of experiencing physical or emotional IPV from partners. This could be due to the worse economic context of households where women engage in agricultural wage labor, and constantly operating in a resource (including food and water) constrained environment (Jewkes 2002; Vest *et al.* 2002; Udas *et al.* 2019). This also reflects that just work/participation does not enable women to escape emotional abuse, and employment characteristics such as earning level may also play an important role (Tauchen *et al.* 1991; Farmer & Tiefenthaler 1997). Women's earning level may have a clearer impact on women's risk of experiencing IPV (Tauchen *et al.* 1991; Farmer & Tiefenthaler 1997; Bowlus & Seitz 2006) but we could not assess this here due to data limitations.

Interestingly, the husband's employment reduces the women's exposure to emotional forms of IPV, whereas the husband's education has a similar effect on physical forms of violence. Thus, women's position in the household and so their likelihood of experiencing IPV does not depend solely upon their own human capital but also on that of their husbands. This is somewhat reflected in Chowdhury *et al.* (2018), wherein they found that not just women's autonomous power but also their cooperative decision making reduces women's exposure to IPV. This is one likely reason why an increase in women's empowerment score measured by their participation in decision making

significantly reduces the risk of IPV. Further, Nepali men with more years of education are perhaps less likely to ascribe to social norms that promulgate gender inequality in the household and that permit or even prescribe violence against wives (e.g. *Clark et al. 2018*). Moreover, since IPV is ultimately theorized as a reflection and enactment of patriarchal power systems, it is also possible that steady employment outside the home lessens the need for domestic demonstrations of power like IPV. Emotional forms of IPV, however, remain prevalent irrespective of the husband's education status. Again, regardless of any level of education of the husband, the probability of women experiencing IPV is higher in households struggling to meet basic water needs.

Limitations

The lack of precise data on quantity and quality of water insecurity within the household and reliance on a proxy (water access) may be constraining for our analysis. There may have been underreporting or biased reporting of IPV. We also do not have direct evidence on who in the house is actually responsible for water, and it is another limitation of the study. Also, DHS only ask women about their experience of IPV: men's risk of IPV could also be elevated by water insecurity (even if the overall risk is lower than that of women).

CONCLUSION

Our analysis substantiates an independent role of sub-optimal water access on both physical and emotional forms of IPV experienced by married Nepali women, those predominantly responsible for managing household water. From the Nepali case, we propose that the gendered nature of household and water management responsibilities may put women at a disproportionate risk of harm from IPV. This study is the first, to our knowledge, to provide a rigorous, large-scale, systematic analysis of the relationship between sub-optimal water access and the probability of IPV against women.

The findings advance our theoretical understanding of the relationship between water insecurity and IPV, clarifying a new pathway through which water insecurity can

worsen women's health. To summarize, our findings significantly clarify the understanding on the pathways by which water insecurity can induce IPV, and suggests several points of possible intervention in intra-household dynamics that could help reduce the risk of IPV. From the perspective of development efforts, water insecurity weighs heavily upon the likelihood that women experience IPV and related health vulnerabilities regardless of the level of women's education and decision-making participation. Investing in better household water systems is likely to produce additional benefits for women, by reducing their risk of both emotional and physical harm and injury and by improving their bargaining position within the household.

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