# Who benefits from piped water supply? Empirical evidence from a gendered analysis in India

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**Abstract**

The disproportionate burden on women of water collection and distribution in the household in developing economies calls for a study on the relationship between piped water supply and gender differences in employment, women's health, child health and education. I use spatiotemporal data from the largest gender disaggregated human development survey in India, 2005–2012, and carry out econometric analyses using conditionally exogenous village fixed effects and instrumental variable regressions to evaluate the effects. Results show that village access to piped water increases the likelihood of wage salary employment by 11.3 percentage points, and annual earnings increase by 17.5 percent for women, comparatively higher than men. With piped water, women's self-reported health improves, child's health and education outcomes also improve. Our study recommends evaluating the social demand curve for piped water supply, and the consideration of piped water supply as a basic necessity as part of a broader strategy to reduce gender differences.

**Keywords:** piped drinking water, gender, employment, health, education, India
**JEL Codes: Q25, R11, J16, J21**

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# 1 Introduction

The importance of water for personal and household use in everyday life is understood most sharply when one does not have access and must wait for it and/or carry it from a distance. This unproductive burden is disproportionately placed on women and children in India, where men choose, or are socially conditioned to be responsible for providing labor income or farming. In contrast, women and children are mostly responsible for home production—such as fetching water and firewood, cleaning, cooking, and general maintenance.[1] Given the disproportionate burden of home production on women, and the fact that India not only has little access to indoor piped water but also very high rates of open defecation, the intra-household labor and health inequality could be larger in the absence of piped water access in the household.

The basic trade-offs in the context of indoor piped drinking water (IPDW) are highlighted in the standard economic theory of time allocation and labor productivity [Becker, 1965]. These trade-offs can be clearly understood as, first, lack of indoor piped drinking water affects women disproportionately through an increase in the amount of time spent on household chore of collecting water. The argument for employment is that the time saved from not having to fetch water daily, could be reallocated to the labor market [Meeks, 2017]. Second, lack of IPDW leads to weak personal health due to higher surface-water contamination-based illness. Third, in the absence of IPDW, families often resort to public and less clean water sources of drinking water (such as open wells, hand pumps, or other surface level sources), may wash their hands less often—more illness in the family implying more time spent on unpaid care by women (such as caring for diarrhea-stricken children, or elders with fever, cough and other infection).[2] A sick child in the house, due to the lack of IPDW, constrains women's labor force participation because of child's reduced school participation and increased unpaid care time for women.

This background is compelling enough to further ask: Do women with access to basic infrastructures (IPDW in this instance) tend to participate more in the labor market? Is the lack of IPDW at the village level a significant constraint on women's wage and salary employment? Can IPDW reduce wage and labor inequality between men and women? Is women's health significantly affected by the lack of IPDW? With IPDW, are children less likely to have short term morbidities or miss school? Though the issue of IPDW and women empowerment has been broadly studied in developing economies including India [Ashraf et al., 2021, Ilahi and Grimard, 2000], these studies have largely been cross-sectional [Koolwal and Van de Walle, 2013, Ivens, 2008]. So far, a detailed longitudinal study on IPDW and its impact on gender differences in labor, earnings, health and schooling at the national level in India is missing. This study aims to fill this gap by identifying the labor, health and educational consequences of the lack of access to IPDW on rural and urban households disaggregated by gender.

The National Rural Drinking Water Program (NRDWP, 2009), along with the inception of Integrated Management Information System (IMIS) for monitoring the status of water supply projects and coverage across rural India were launched to improve piped water delivery to households. The impact of these programs provides ample variation in the treatment (IPDW) with significant increase in the investment outlay from 2009-2013 [Wescoat Jr et al., 2016, Cronin and Thompson, 2014].[3] To capture the variation in treatment, I use the nationally representative

[1] See O'Reilly [2006], Fletcher et al. [2017], Jayachandran [2019].

[2] For details, see Dehury and Mohanty [2017], Koolwal and Van de Walle [2013], Ashraf et al. [2021].

[3] The Eleventh Five Year Plan, 2007-2012, in India identified major issues that needed tackling during the period: the problem of sustainability, water availability and supply, poor water quality, centralized vs. decentralized

gender-disaggregated panel of the India Human Development Survey (2005-2012) which covers the pre and post treatment period for the fixed effects (FE) analysis.

I use a Two Stage Least Squares Instrumental Variable Individual Fixed Effects (2SLS-IV-FE) approach with 'non-self community access to IPDW in the household's district' as the instrument to identify the casual point estimates. The same 'leave out' community strategy has been used by Mangyo [2008] and Lamichhane and Mangyo [2011] to identify the effect of in-yard water access on child and maternal health in China, and by Vanaja [2020] in India. Following Koolwal and Van de Walle [2013], I aggregate individual level observations to community level (village/PSU) by incorporating time varying exogenous village level characteristics (see table 5) to identify the village level effects. The empirical model controls for recall bias and infrastructure placements, as the selection into IPDW has been argued to be a household and not community level phenomenon in developing economies [Choudhuri and Desai, 2021, Mangyo, 2008, Zhang and Xu, 2016]. In addition, I interact the state and year variables in a fixed effects model to attenuate any initial state specific conditions that could drive the point estimates. Fixed effects control for all time-invariant unobserved heterogeneity, and our main results are derived from the instrumental variable regressions.[4] Village fixed effects with exogenous village characteristics allow us to interpret our point estimates as conditionally exogenous [Koolwal and Van de Walle, 2013], while the instrumental variables provide the local average treatment effects. In addition, I analyze the recent longitudinal survey on Access to Clean Cooking Energy and Electricity–Survey of States (ACCESS), 2015-2018, and using household fixed effects examine latent outcomes of women empowerment and household welfare.

The point estimates of the IV-FE show that access to IPDW at the household level increases the likelihood of any work (wage, salary, farm, business, animal husbandry etc.) by 11.8 percentage points (pp) for the overall sample. In rural areas, the margins are higher for women, 19.5 pp as compared to 12.1 pp for men, however, in urban areas there is no effect of IPDW on women, but a significant positive effect on men. With respect to wage and salary employment in rural areas, access to IPDW increases the likelihood of wage/salary employment by 16 pp for women and 8.8 pp for men, underscoring the large disguised agricultural unemployment [Mazumdar and Sarkar, 2020]. Here again, the effect of IPDW on urban women's employment is small and insignificant, whereas for men it is positive and significant. Access to IPDW leads to 17.5 percent increase in women's annual earnings, and an 11.2 percent increase in men's earnings. The earnings effect is also a rural story with no significant effects in urban areas for women. With IPDW, annual work days increase by 28 days for women in rural areas. There are no significant differences in the effect on work days between men and women after controlling for annual work hours. Contrary to the employment outcomes, the self reported health of women significantly improves with IPDW, both in rural and urban areas, especially for the poor. The likelihood of diarrhea reduces by 1.5 pp for poor households and by 2.2 pp in urban areas. A smaller, but significant effect of IPDW is

approaches and financing of operation and management cost while ensuring equity in regard to gender, socially and economically weaker sections of the society, school children, socially vulnerable groups such as pregnant and lactating mothers, specially disabled senior citizens, etc. In order to address the above issues, the rural water supply program and guidelines were revised w.e.f. Jan, 4, 2009 as the National Rural Drinking Water Program (NRDWP) (erstwhile known as the Accelerated Rural Water Supply Program (ARWSP), introduced in 1972-73 by the Government of India). The project's stated objective was to increase the supply and coverage of potable water to rural communities.

[4] In the empirical analysis, I control for the trend effects, household electricity access, any public program for sanitary toilets, household size, any social networks or acquaintance with doctors and health care workers, teachers, school workers, politicians, police, military,government officials, individual's age, age squared, marital status, adult male and female education.

visible in rural areas on diarrhea. In rural areas, school absence with IPDW reduces by 2.4 days for girls and by 1.3 days for boys, while there is no significant effect in urban areas.

Section II discuss the literature on water scarcity for households, available studies that highlight the effect of household water supply on women's employment, and studies that look at the effect of household water supply on women and child health and educational outcomes. Section III and IV discuss the data and the empirical methodology. Section V discusses the results of disproportionate effects of IPDW on women and section VI concludes with policy implications and the need for a social demand curve for IPDW.

## 2 Linkages: water and and women's empowerment

### 2.1 Household water scarcity in India

Access to government-provided water services vary widely across the country [Balasubramaniam et al., 2014]. As of 2015, while 87.9% of the urban households were found to have access to water for use in toilets, only 42.5% rural households had this facility [Malakar et al., 2018]. India ranks among the poorest in household water access in the world. In 2001, the per capita annual surface water availability was 1902 $m^3$, which went down to 1614 $m^3$ in 2011 and is expected to reach 1154 $m^3$ in 2050 [Jain, 2011].

Water supply in India, both in rural areas and in cities is only available for a few hours per day, pressure is irregular and the water is of questionable quality [McKenzie and Ray, 2009]. Adding to the scarcity, water inequality is pertinent in both urban and rural India owing to social (caste) and religious differences, which are major challenges to the water distribution system. Inequality and scarcity of water is expected to increase in the future due to the increasing depletion of ground water resources and the demand side pressures due to the rising urban population [Malakar et al., 2018]. The majority of India's population in rural area depends heavily on publicly provided water and have to deal with economic hardship due to sustained water shortage. In addition to poverty and inequality, historically persistent social divisions are intricately linked to access to water in rural India with caste boundaries and hierarchies [Banerjee et al., 2005, Freed, 1970].[5]

In 2008, no major Indian city had 24 hour supply of water, with 4 to 5 hours of supply per day being the norm [McKenzie and Ray, 2009].[6] In comparison to Asia-Pacific region where the average is 19 hours per day, the reliability of water supply in India is dismal. Even the averages conceal a great deal of heterogeneity within and between rural and urban areas. National level estimates from the IHDS, 2012 survey show that only 25% of the households had 24 h supply of indoor pipe drinking water with the average hours of water supply being 6 h a day. The market failure in household water supply imposes both financial (employment, assets, earnings, capital costs) and health costs (short and long term morbidities) on households [Ambrus et al., 2020, Blakeslee et al., 2020, Hill and Ma, 2017, Galiani et al., 2005]. Recently, the government has decided to make access to IPDW universal in India by 2024. The argued Rs. 3.6 trillion ($49 billion) program will put piped water in all of India's 192 million rural homes — more than all the houses in the US —over the next four years. The government aims to supply at least 55

[5] To this extent, even pop up infrastructures for water supply, such as the Water ATMs have faced the issue of social division in access and distribution of drinking water [Schmidt, 2020].

[6] The argument is also valid up until 2012, where using the IHDS survey, I find that the average supply hours of indoor pipe drinking water is 3-4 h a day.

liters of potable water to each person per day by building new pipelines and refurbishing existing networks.

Infrastructure placements, such as IPDW in a populous country, where monitoring of water distribution and quality is haphazard, is challenging. McKenzie and Ray [2009] found that ground water in most urban areas in India exceeded permissible limits in terms of fluoride, ammonia and hardness. Municipal water supply in some cities was also high in contaminants. A 2003 survey of 1,000 locations in Kolkata found that 87% of water reservoirs serving residential buildings and 63% of taps had high levels of fecal contamination. Interestingly, a 2003 study by the Centre for Science and Environment in Delhi, subsequently repeated in 2006, found that even popular brands of bottled water had high levels of pesticides [McKenzie and Ray, 2009]. Overall, given the myriad social, economic and political aspects of water supply to households in India, a market or a public solution, either subsidized or sponsored or both, should take priority.

### 2.2 Water, time use and employment

Women in developing economies are argued to spend more than economically efficient time in domestic labor tasks, and too little time in other productive tasks, including market-based labor activities.[7] Women are argued to be spending significantly more time in fuel and water collection in developing economies, especially in South Asia [Koolwal and Van de Walle, 2013, Ilahi and Grimard, 2000]. In Zambia, Ashraf et al. [2021] find that a one standard deviation increase in water supply complaints is associated with about 10 minutes more housework per day for young women. In India, in addition to the decreased economic autonomy and access to pooled income, the family system presses women to provide domestic labor (cooking, cleaning, collecting water and fuel, etc.). This is especially true for daughters-in-law or young married women in India, both in rural and urban areas [Dhanaraj and Mahambare, 2019, Anukriti et al., 2020]. These issues call for better tailored infrastructure investments, so as to reduce the time needed for domestic chores. One such infrastructure is provisioning access to piped water within the household [Dinkelman, 2011, Ilahi and Grimard, 2000].

Adult women in India, on average, typically spend 1-2 hours every day in collecting and distributing water for the household, more than men, both in proportion and levels [Fletcher et al., 2017, Ferrant and Thim, 2019]. The relationship between water and gender mirrors gender inequalities in various realms, including ownership and control over assets, employment, wages, household division of labor, exposure to and management of risk, access to services, and decision making, all of which are often intertwined with basic household infrastructures, such as the access to indoor piped drinking water (IPDW).[8] This issue, in the context of gender differences, i.e., women's employment, socio-economic well-being and health, is central to resource planning, not only in India, but in many low-income nations struggling to provide adequate and safe water supply to households.

Household constraints, such as the lack of access to water, electricity, clean cooking fuel and credit have limited women's economic opportunities and restricted their contributions to socio-economic decision making in the household, and elsewhere [Anderson and Baland, 2002, Anderson and Eswaran, 2009, Dinkelman, 2011, Rathi and Vermaak, 2018, Sedai et al., 2020, Aklin et al.,

[7] See [Ilahi and Grimard, 2000, Fletcher et al., 2017, Choudhuri and Desai, 2021, Anderson and Eswaran, 2009, Meeks, 2017].

[8] see Das [2017], Fletcher et al. [2017], Ferrant et al. [2014], Koolwal and Van de Walle [2013], Hulland et al. [2015]

2016]. Decision-making about basic infrastructure provisions—whether by household heads, local leaders, or higher-level authorities—undervalue women's time in domestic labor and thus, may place inadequate weight on the implications for women [Koolwal and Van de Walle, 2013, Berik et al., 2009, Darity and Mason, 1998].

It is widely observed that earned income through labor market participation and entrepreneurship by women could lead to desirable empowerment and developmental outcomes for women at the household and national level [Anderson and Eswaran, 2009, Sedai et al., 2021b]. Labor force participation enhances control over economic resources which could then translate into higher financial independence, socio-economic status and bargaining power in the household [Anderson and Eswaran, 2009]. Market work by women has also been associated with child welfare, especially for girls through more equitable investment of women's earnings on children in the household [Schultz, 2001]. In these contexts, I argue that the effect of IPDW on women's employment and economic freedom is channeled through: (i) reduced time spent in household chores; (ii) better personal health and productivity gains; (iii) improvements in child health due to reduced likelihood of water borne illnesses which increases school participation; and (iv) better health for family members overall, implying less domestic work for women.

### 2.3 Water, Health and Education

According to Bartram et al. [2005], far more people endure largely preventable effects of poor sanitation and water supply than by war, terrorism, and weapons of mass destruction combined; yet somehow the issue of hygiene and water receive comparatively lower public and political imagination and public resources. The irony, as also argued by Bartram et al. [2005] of water supply issue is that the ones who can read articles such as this find it hard to imagine defecating daily in plastic bags, open pits, agricultural fields, and public areas for want of a private hygienic alternative (as do some 2·6 billion people).

In much of the world, especially in developing economies, diseases from inadequate safe water supply such as diarrhea, fever, cough and respiratory problems are a major public health issue and constraint to development. The most widespread health hazards linked to water are diarrheal diseases, which disproportionately affect young children.[9] The UNICEF [2012] report underscores the need to intensify global commitment and funding for the fight against childhood diarrhea and argues that scaling up key interventions among the poorest children would save lives. Key preventive interventions include an improved water supply and the promotion of community-wide sanitation.

In India, where diarrhea is most common among all developing economies [WHO et al., 2009], it is important to examine the effect of indoor pipe drinking water on the likelihood of diarrheal disease among children under 5. Previous research by Jalan and Ravallion [2003] using propensity score matching technique to combine two cross-section surveys find that expanding piped water reduces the likelihood of diarrhea in India. They find that the prevalence of diarrheal diseases amongst those without piped water would be 21% higher and illness duration would be 29% higher, than those with IPDW. However, they also argue that indoor pipe water supply is not a sufficient condition to improve child health status; the source of ambiguity lies in the uncertainty about

[9] Kumar and Vollmer [2013] in their study of India using the District Level Household Survey 3, 2008, find that the incidence of diarrhea for children living in a household with improved sanitation is 2.2 percentage points lower than that for children living in a household without improved sanitation.

how access to piped water interacts with private health inputs, such as hygienic water storage, boiling water, oral re-hydration therapy, medical treatment, sanitation, nutrition, and also adult women's education and household income [Jalan and Ravallion, 2003]. Also, contamination of drinking water due to the sheer volume of production in cities could drive the level of diarrheal, typhoid, fever, cough and cholera diseases up. In this regard, when analyzing the effect of IPDW on diarrhea, I control for the hygiene behavior post access to piped water.

For households living on the edge of subsistence, lack of, or shocks to the provision of a human necessity, such as IPDW, can have considerable consequences.[10] If households end up drinking dirtier water and wash their hands less often,[11] this increases the risk of waterborne illnesses and infectious diseases. If households, especially women spend long hours to get water, then this could decrease their labor hours and earnings, and the time that children spend doing schoolwork or getting vaccinations. Direct time loss and illness may also decrease overall economic activity.

## 3 Data

The data used for our analysis is derived from the second and third wave of the Indian Human Development Survey (2005-2012) [Desai and Vanneman, 2018]. IHDS are nation-wide multi topic gender-desegregated stratified random sample surveys jointly carried out by researchers from the University of Maryland and the National Council of Applied Economic Research (NCAER) in New Delhi. IHDS covers wide-ranging topics at the household, individual, village and school level on demographic, health, education and socio-economic characteristics. The survey covers key gender disaggregated labor and non-labor market characteristics, employment: wage salary, farm, non-farm employment, annual earnings, work days, self-reported health, incidence of illness, such as diarrhea, and water collection minutes, among others at the individual level which are of relevance in our analysis.[12] The interviewers ask a knowledgeable person, typically the male head of household, questions related to the socioeconomic status of the household (members), including questions related to income, employment, consumption expenditure, physical and social capital. An eligible woman between the ages of 15 and 59 in each household are interviewed about health, education, and gender relations, among others, in the household and community.

The treatment variable 'access to indoor piped drinking water (IPDW)' is derived from the household survey item, "Does your household have access to indoor pipe drinking water?" Yes is 1 and No is 0. After dropping the observations for households missing IPDW and individuals below the age of 14, I have a time balanced sample of 78,751 men and 71,623 women in each round of the IHDS survey.[13] Employment and health variables are derived from the individual level

[10] See Sedai et al. [2021b,a, 2020], Ashraf et al. [2021].

[11] Ashraf et al. [2021] argue that different medical technology, political institutions and culture affect the quality of water supply to households in developing economies, but IPDW is nevertheless the most secure source of drinking water for households. They argue that antibiotics and water therapy for water supplied through pipes have significantly reduced the mortality consequences of many diseases.

[12] Unlike the National Sample Surveys that asks for a woman's principal and secondary status activities, the IHDS has separate modules for different types of work (e.g., own farm and non-farm work, wage and salary labor, animal husbandry) and asks which household members participated in each type of work during the previous year. In this study, following Chatterjee et al. [2018], anyone who worked for at least 240 hours in the previous year across all types of work is considered to be in the labor force.

[13] Note: the balancedness of the sample is by observations at the beginning of the analysis, not by each outcome variable. In other words, I am referring to some missing observations for some variables, but there is no sample attrition.

questionnaire. Treatment variable, IPDW, is from the household level questionnaire. Control variables are from individual, household and village level questionnaires. For the conditionally exogenous analysis, I use village level data from 1401 villages covered in both rounds of the survey. However, due to missing observations for some variables, I am restricted to 1,386 villages for the rural village level analysis. It is important to note that the comparison of outcomes between men and women is not necessarily for the same household. The inferences drawn and compared are not for couples, or adults in the same household, but for the overall sample. A unique contribution from our analysis is the use of conditionally exogenous village fixed effects in a dynamic set up.

As a measure of robustness, I also analyze the effect of IPDW on household outcomes more recently using the ACCESS panel, 2015-2018. The ACCESS survey cover six relatively poorer and populous states: Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Odisa and West Bengal. Similar data coding, estimation, control and treatment strategy is followed for both surveys. However, due to data limitations in the ACCESS survey, the outcome variables in both surveys are not similar. Therefore, I use latent effect variables to analyze gender differences as a measure of robustness through the ACCESS survey analysis. In addition, I use the India Time Use Survey, 2019 to motivate the hypothesis of the effect of time spent on water collection on employment outcomes. I also use the rainfall shocks measured as the z-score in a single season by district between 1996-2011 constructed from Climate Hazards Group Infrared Precipitation (CHIRPS) as a control in the fixed effect regressions, this is because rainfall has been found to be positively correlated with access to IPDW, and has been found to be affect employment outcomes and agricultural output especially in rural India [Fishman, 2018, Emerick, 2018].

# 4 Empirical Model

There are both time variant and invariant unobserved heterogeneity that affect selection into or out of IPDW [Kumar and Vollmer, 2013, Balasubramaniam et al., 2014]. Given the likelihood of strong endogeneity of access to IPDW (one of the most basic good for survival), one should clearly not expect to be able to infer the causal impact with confidence [Koolwal and Van de Walle, 2013, Ravallion, 2008].[14] With the panel structure of the IHDS data, the time-invariant unobserved heterogeneity affecting the treatment is controlled for. The individual fixed effects model is as follows:

$$Y_{it} = \pi Z_{it} + \phi X_{it} + \delta_i + \sigma_t + \epsilon_{it} \tag{1}$$

$Y_{it}$ is the outcome variable for household $i$ at time $t$ and $Z_{it}$ is an indicator for access to IPDW. The reference households are those that do not have access to indoor pipe drinking water, and the treatment is switching from no access to IPDW to access between 2005-2012, or vice versa. $X_{it}$ are a vector of exogenous individual and household characteristics. $\delta_j$ captures the individual specific effects. $\sigma_t$ captures the trend effect. The aim is to estimate the impact of $Z_{it}$ on $Y_{it}$. However, the problem is that the observed variation in $Z_{it}$ reflects latent factors that also influence $Y_{it}$.

[14] A randomized control trail would not be a feasible option given that our aim is to observe the macro-level effects of the intervention of IPDW. Also, Ravallion [2008] argue that is rarely feasible to randomize the location of infrastructure projects and related programs, which are core activities in almost any poor country's development strategy.

Despite using the individual fixed effects, household selection to IPDW due to time varying unobserved heterogeneity cannot be ignored.[15] Within a given locality, some households will have latent preferences, knowledge, or unobserved resources that lead them to have better access to infrastructure than other (observationally similar) households [Koolwal and Van de Walle, 2013]. Any natural or policy shock not covered in the IHDS survey could be affecting access to water.[16]

Following Koolwal and Van de Walle [2013], I exploit the difference in average community level access to IPDW by controlling for time-varying exogenous community characteristics affecting the supply of IPDW, while in addition, also controlling for any individual and community specific effects overtime. The technique requires adequately capturing relevant geographic characteristics jointly influencing outcomes and infrastructure through the vector $G_{jt}$, and any geographic means of $X_{it}$ not included in $G_{jt}$. The addition of community specific effects and time trends presents an additional layer of robustness compared to Koolwal and Van de Walle [2013]. The modification to the analysis in equation 1 is given below:

$$Y_{ijt} = \pi Z_{ijt} + \phi X_{ijt} + \lambda G_{jt} + \delta_i + \sigma_t + \theta_{jt} + \epsilon_{ijt} \tag{2}$$

Here, the exogenous community characteristics $G_{jt}$ affects the placement of IPDW.[17] In equation 2, the error term has two components, a geographic effect $\theta_{jt}$ and an idiosyncratic (household-specific) effect $\epsilon_{ijt}$. The geographic component of the error term sweeps up all level differences in the error term between areas, so that the geographic mean of $\epsilon_{ijt}$ vanishes [Koolwal and Van de Walle, 2013]. All regressors are exogenous except $Z_{ijt}$, which is correlated with $\epsilon_{ijt}$through individual choices, that is, $Cov(Z_{ijt}; \epsilon_{ijt}/G_{jt}; X_{ijt}) \neq 0$. Following Koolwal and Van de Walle [2013], I argue that the key identifying assumption is that the endogeneity in IPDW arises entirely from household choices within areas, such that on aggregating across individuals within a given area I can treat access to IPDW as conditionally exogenous; that is, I assume that $Cov(\bar{Z}_{jt}; \epsilon_{jt}/\bar{G}_{jt}; \bar{X}_{it}) = 0$, where the bar over a variable denotes its geographic or community-level mean.

I then aggregate equation 2 over geographic areas, giving the standard "between estimator" overtime, as below:

$$\bar{Y}_{jt} = \pi \bar{Z}_{jt} + \phi \bar{X}_{jt} + \lambda \bar{G}_{jt} + \theta_{jt} \tag{3}$$

While household fixed effects applied to equation 1 could still yield a biased and inconsistent estimate given that $Cov(Z_{ijt}; \epsilon_{ijt}/G_{jt}; X_{ijt}) \neq 0$, equation 3 shows that $\pi$ can be identified by geographic aggregation under our weaker assumption that the geographic placement is conditionally exogenous. In addition, I use a range of time-varying geographic controls such that the latent geographic effects on outcomes and placement can be treated as uncorrelated. To do so, I refer to geographic controls used by Koolwal and Van de Walle [2013]. Also, residential location choice that could seriously undermine our identifying assumption is controlled by the fixed effects.

The issue with the community fixed effects is that water projects might be placed in the

[15] There is a strong likelihood that the household-specific differences in treatment, $Z_{it}$ are endogenous to outcomes due to the time varying unobserved heterogeneity.

[16] The wave dummy $\sigma_t$ does capture any trend changes, but household specific time variant heterogeneity could bias the point estimates.

[17] Note: $G_{jt}$ also includes community means of $X_{ijt}$. In the absence of $G_{jt}$ and $\theta_{jt}$, the regression specification in equation 2 is similar to that of equation 1.

area where employment and health are getting worse or better over time (despite any number of controls for time varying exogenous community characteristics). If such water facilities were placed in the areas where employment and health was poorest, the impact of the facilities would exhibit a downward bias. On the other hand, facilities might be placed in more accessible and prosperous areas, it would lead to a positive bias [Lamichhane and Mangyo, 2011]. Therefore, despite the conditional exogeneity, the effect of time-varying unobserved heterogeneity (correlation with the error of the outcome and access to IPDW across time due to unobserved data) cannot be accounted by the conditional village fixed effects model. Following Vanaja [2020], Mangyo [2008], Li et al. [2021], Zhang and Xu [2016], Ilahi and Grimard [2000] and Lamichhane and Mangyo [2011] I use 'non-self community level access to IPDW' in the district as an instrument.[18] The instrument captures average access to IPDW at the community level (village and PSU level), excluding the community of the household in the district of the state at time $t$. The instrument has been widely used in the literature to capture the unobserved heterogeneity in infrastructure placements such as electricity and water supply.[19] The first stage estimation is given as:

$$IPDW_{it} = \rho IPDW_{-jt} + \phi X_{it} + \delta_i + \sigma_t + \epsilon_{it} \tag{4}$$

Where, $IPDW_{-jt}$ represents the non-self community level access to IPDW. It gives the average level of village/PSU level access to IPDW in the district of a state, excluding the village/PSU of the treatment household.

Following the argument that there is high levels of self-selection in access to IPDW at the household level [Choudhuri and Desai, 2021],[20] I use the non-self community (PSU/village) level access to IPDW in the district of the state in year $t$ as an instrument.

Insert figure 1 about here

Figure 1 shows the change in non-self community level access to IPDW between 2005-2012 in the six administrative regions in India. States in West, South and North-East saw a significant increase in access to IPDW at the community level between the survey waves, while states in central and eastern regions saw little to no increase in community level access to IPDW.

The instrument, I argue is strong because (i) higher non-self community level IPDW in neighboring communities indicates the economic and geographic feasibility of having IPDW in own community, which implies higher likelihood of the household $i$ having access to IPDW, and (ii) higher IPDW in other communities, $-j$, does not directly affect a household $i$'s gendered outcomes in community $j$. The exogeneity condition for the instrument holds as IPDW in other

[18] An IV for presumably high degree of selection is a demanding requirement, as one can reasonably question whether any observed household characteristic that might influence access to household-specific infrastructure would not also be a relevant determinant of overall outcomes, independently of infrastructure [Koolwal and Van de Walle, 2013, Ravallion, 2008, Kumar and Vollmer, 2013, Gamper-Rabindran et al., 2010].

[19] See Sedai et al. [2020], Sedai et al. [2021b], Vanaja [2020], Dang and La [2019].

[20] There are low costs to household access to IPDW once the pipe water supply infrastructure is present in the village [Mangyo, 2008, Vanaja, 2020]. Choudhuri and Desai [2021] present a detailed discussion on the issue of endogeneity of IPDW in India. They argue that the more significant role in facilitating access to drinking water to the household are played by village infrastructure and water systems, and the local administrative units, and these are largely external to the household decisions in India. Note, I have used village level panel fixed effects following the same analogy, as also discussed by Koolwal and Van de Walle [2013].

communities does not directly affect labor market differences in one's own community.[21] As discussed in the potential threats to identification, I do anticipate that household's own community level IPDW and the availability of other infrastructures will have an impact on individual LFP, hence excluding one's home district from the instrument is key to the exclusion restriction.

# 5 Results

## 5.1 Descriptive analysis

Figure 2 shows district level access to IPDW in 2005 and 2012. It shows a clear lack of adequate IPDW at the household level in India. A significant increase in IPDW (above 5 pp) is visible in Punjab, Haryana, Himachal Pradesh, Uttarakhand, Manipur, Nagaland, Mizoram, Andhra Pradesh, Goa, Maharashtra, Tamil Nadu and Karnataka, while Delhi, Madhya Pradesh and Puducherry saw a significant decline between the survey waves. The figure also shows disparities between and within states in India. Districts within states have differential access to IPDW.[22] Average is around 0.25 to 0.5 percentage access at the district level. Figure 3 shows hours of water supply on a typical day in the household at the district level in India. Barring a few districts where the average hours of supply are between 6-12 hours, most districts, regardless of state receive water supply for about 1-7 hours a day. Figure 2 and 3 together present the picture of a serious lack of drinking water infrastructure at the household level in India, which exemplifies the universal lack of IPDW within India.

Insert figure 2 about here

Insert figure 3 about here

Figure 4 shows the access to IPDW, water within house, water supply hours, distance to water in minutes, and men and women's daily water collection minutes from the IHDS survey. The figure shows that there was a significant increase in rural IPDW (in percentage) between 2005-2012, highlighting the effect of the revised NRDWP, effective 2009 which focused on rural household water supply, moving away from community water infrastructure provisioning. In urban areas there is no significant difference in access to IPDW. There was no significant change in the availability of water supply within the household premises both in rural and urban areas. Figure 4 shows that women's water collection minutes dropped significantly in rural areas between 2005-2012, a similar but smaller drop in women's water collection minutes was noted in urban areas. Men's water collection minutes also dropped both in rural and urban areas between the survey period, but the drop was from a smaller base as compared to women's water collection minutes.

Insert figure 4 about here

[21] Our IV method follows Zhang and Xu [2016] and captures the implementation of the water program through large or discrete increase in the ratio of households with access to water in a community, which is more likely a exogenous government program rather than a spontaneous change in each household's demand.

[22] Since IHDS does not cover all districts, some districts have white color meaning no data is available.

Figure 5 shows the kernel density plot of time spent in water collection by men and women between 2005-2012 and in 2019. Figure 3.a shows that at around 60 minutes and onwards the time spent by women in water collection is higher than that of men, the difference is neutralized after 200 minutes of water collection in a day.[23] Figure 3.b shows similar statistics using the latest India Time Use Survey, 2019. Also, the number of women collecting water daily are 2.5 times more than men in the IHDS sample,[24] this could further skew the labor force participation between men and women.

Figure 6 shows correlation between time spent per day on water collection and minutes of market work activity using an ordinary least squares regression (controlling for National Sample Survey Region, education, marital status and age). The data for the figure is derived from the India Time Use Survey, 2019, a nation wide survey, where 22,800 individuals out of 3,81,100 eligible people above 14 years reported time spent on 'fetching water from natural or other sources for own and household consumption use' on the day of the interview. The figure shows that the falling trend of market work activity with water collection activity is evident across gender, and all castes (panel (a) shows the result by gender in rural and urban areas and panel (b) shows the effect for men and women by caste categories). The correlations show a stronger negative effect of time spent on fetching water on paid employment activity for men as compared to women.

Insert figure 5 about here

Insert figure 6 about here

Table 1 shows that the richest income quintile of households did not register any increase in access to IPDW, which was stagnant at 62%. These descriptions show that higher income does not automatically correlate with higher levels of IPDW, as also argued by Choudhuri and Desai [2021] in their analysis, using the same data set as in this study.

Insert table 1 about here

The descriptive statistics in table 2 shows that the national level access to IPDW in 2005 was 26% and it increased to 30% in 2012. However, for the six relative poor and populous states in India (ACCESS survey of rural areas), access to IPDW was 5.7% in 2015 and 6.6% in 2018. I also mapped the six states of the ACCESS survey in the IHDS data set and found the same corresponding level of access to IPDW between 2005 and 2012 for the states of Odisha, West Bengal, Uttar Pradesh, Madhya Pradesh, Jharkhand and Bihar. Therefore, using the IHDS data set does not disregard any recent development in household access to IPDW.

Insert table 2 about here

Table 3 shows the descriptive statistics for the IHDS dataset with the treatment being access to IPDW between 2005 and 2012. 33% of the households had access to water within household

[23] Very few observations above 90 minutes of water collection, for both men and women, is noted in the IHDS. Also in ITUS, 2019, I find 22,849 observations out of 445000 people reported collecting water on a daily basis.

[24] I found a similar number of women and men, 17,811 and 5038 respectively, collecting water in the India Time Use Survey, 2019, which is the largest individual time use survey in India.

premises in 2005, similar to 2012. There is no significant difference in water supply hours between households that had and did not have access to IPDW, conditional on having source of water in the house. On average, the walk time to water was around 10-12 minutes for households that did not have IPDW. Figure 4 shows that in 2005, on average, women spent significantly higher time in water collection, 73 minutes as compared to men's 35 minutes in households that did not have IPDW. In 2012, the average water collection time was 50 minutes for women and 29 minutes for men with no IPDW. Choudhuri and Desai [2021] report that among households without IPDW, the participation rate in water collection activity was 94.8% among women and 70% among men in 2012.

Insert table 3 about here

Insert table 4 about here

Households without IPDW tend to have slightly higher employment (wage, salary, farm, business and animal husbandry) as compared to household with IPDW. Similarly, households without IPDW tend to have slightly higher likelihood of having a wage/salary employment (24% in 2005 and 32% in 2012) as compared to households with IPDW (20% in 2005 and 28% in 2012). Households with IPDW tend to have higher annual work days as compared to households without IPDW. Descriptively, there is no significant difference in self-reported health for women with and without the access to IPDW. The likelihood of having diarrhea (past month) is slightly lower in households with IPDW as compared to households without IPDW in 2005, and there is no such difference observed in 2012. However, the number of days a child missed school in the last month is significantly lower in households with IPDW as compared to household without IPDW. Table 5 shows the time varying exogenous village level characteristics used in the conditionally exogenous village fixed effects results as controls. Table 4 shows the descriptive statistics of the household, individual and district level controls used for our analysis. The wetness and/or dryness characteristics of the district affects both our outcome variables and access to IPDW, hence the standardized Z score for rainfall at the district level is used as a control variable.[25]

Insert table 5 about here

Insert figure 7 about here

Figure 7 shows the individual fixed effects estimates of sources of water on any employment (farm, business, wage, salary and animal husbandry) for men and women in rural and urban areas. For the analysis, I control for the time trends, individual specific effects and the month of the interview. Piped water supply is the base category in the fixed effects regression, with the point estimates being compared for tube-well, hand-pump, open-well and all others.[26] Results show that having hand-pumps as a source of water for the household has a significant negative effect

[25] Rainfall shocks measured as the z-score in a single season's rainfall is constructed from CHIRPS. I extract daily precipitation for each day in a monsoon season that is 1st June to 30th September and sum it for a given year. I construct rainfall z-score for a given year as a deviation from the long-term average precipitation (1996-2011) and scale it with long term standard deviation. I assign rainfall z-score calculated for 2004 and 2011 to wave 1 and 2 respectively to construct rainfall z-score used in the analysis.

[26] All other categories of sources of water include: covered-well, rainwater, tankers, bottled water, etc. All of these sources combined are less than 5% of the overall sources of water and hence, are clubbed in the other category.

on both men's and women's employment, both in rural and urban areas. For men, open-well also has a significant negative effect on their employment in rural areas. In urban areas, the sources of water in comparison to piped water do not yield any significant differences in the likelihood of employment.

## 5.2 IPDW, Time Use & Employment

Table 6 shows the point estimates of the effects of IPDW on overall employment and wage salary employment for both men and women, in rural and urban areas using IV-FE and community fixed effects. In table 6 and all remaining analysis where village fixed effects are used, the exogenous village characteristics controlled for are described in table 5. The sharpened two stage q-values are derived from Anderson [2008] to reduce the likelihood of false rejections. The measure is a way of adjusting for the fact that I am testing multiple hypotheses.

Insert table 6 about here

Panel (a) shows the point estimates of the IV-FE regressions: having access to IPDW increases women's likelihood of any employment ($\geq$ 30 days) by 11.3 percentage points (pp), and men's likelihood of employment by 11.9 pp. The effects vary across rural and urban areas. In rural areas, access to IPDW leads to a 19.5 pp increase in the likelihood of employment for women, significantly higher than a 12.1 pp increase in the likelihood of employment for men. In contrast, in urban areas, the positive effect of IPDW on employment is visible only for men (17.4 pp), while women experience no effects of IPDW on their employment.

In terms of wage salary employment, the IV-FE model shows that access to IPDW increases women's likelihood of employment by 12.1 pp and that for men by 11 pp for the overall sample. In rural areas, IPDW increases the wage-salary employment by 16 pp compared to 8.9 pp for men. This shows that the employment gains for women from IPDW are not limited to farm employment or self-employment; the gains are visible in wage salary employment. However, as observed with any form of employment, there is no effect of IPDW on women's wage and salary employment in urban areas. These gains in wage employment as argued by Anderson and Eswaran [2009] are critical for women's economic and social autonomy. Given the high degree of disguised unemployment (surplus labor), especially for women in the agricultural sector in India [Mazumdar and Sarkar, 2020, Ivens, 2008], a higher increase in wage salary employment with IPDW as compared to overall employment (with farm work) is expected.

The village fixed effect results in panel (b) show that a one percentage point increase in IPDW at the village level increases the likelihood of any work (wage, salary, farm, business, animal husbandry etc.) by 0.054 pp for the overall rural sample. In terms of any employment which is mostly dominated by farm employment, the effect of IPDW is stronger for men as compared to women, the coefficients are 0.064 and 0.041 pp respectively. However, in terms of wage and salary employment (subset of overall employment), a one percentage point increase in IPDW at the village level increases wage/salary employment by 0.054 pp for women, while there is no significant effect on men. A trend of increase in women's relative share of wage salary employment as compared to men's employment with household water supply has also been observed in India during 1996/97 by Koolwal and Van de Walle [2013]. They argue that the farm-employment for women in India is highly disguised, and so access to IPDW might not reflect a higher likelihood of overall employment. The free time hypothesis related with IPDW could be related with higher wage salary employment for women as compared to men.

Table 7 shows the effect of access to IPDW on annual earnings after controlling for the number of hours worked annually. In panel (a), the IV-FE coefficients show that access to IPDW increases annual earnings by 13.8 percent for the aggregate sample. The effect is stronger for women, 17.5 percent increase in annual earnings as compared to 11.2 percent for men. However, the increase in annual earnings for women is observed only in rural areas, while in urban areas there is no significant effect on the earnings for women with IPDW. Men, on the other hand, have increased earnings both in rural and urban areas with IPDW. The positive effect of IPDW on women's earnings, and it being higher for women than men in rural areas, I argue could be due to a combination of time, health and productivity effects which could ease up the disproportionate burden of household water collection and availability of clean water on women.

Insert table 7 about here

Panel (b) shows the conditionally exogenous village fixed effects results in rural areas. Results corroborate with the individual fixed effects results in that a one percentage point higher average access to IPDW in the village implies a 0.18 percent higher annual earnings for the aggregate sample, a 0.18 percent higher annual earnings for men and a 0.3 percent higher annual earnings for women in rural areas. Results showing stronger positive effects on both employment and earnings for women could be because of the low base to begin with, as men on average have higher levels of employment and earnings than women. Also, the time conservation argument with IPDW for disproportionately burdened women could be a significant criteria for higher employment gains for women. Nevertheless, access to IPDW seems to reduce the gender differences in economic autonomy through employment gains between men and women, especially in rural India where the IPDW infrastructure is severely lacking compared to the urban areas.

Table 8 shows the effect of IPDW on annual work days by gender in rural and urban areas (controlling for work hours and applicable only for working individuals in both survey waves). Panel (a) shows the IV-FE regression results, and panel (b) shows the conditionally exogenous village fixed effects results.

Insert table 8 about here

In panel (a), access to IPDW increases annual work days by 22 days on aggregate. The increase is 28 days for women in rural areas, while there is no significant effect in urban areas. For men, the effects are 19 and 21 days in rural and urban areas, respectively. In panel (b), the village fixed effects regression in rural areas shows that a one percentage point higher average access to IPDW in the village implies 11.49 more annual work days for employment for the overall sample. For men, the effect is 13.74 more days of work while for women, the effect is 7 more days of employment. The effect of IPDW on men is higher than that for women. Overall, results on employment, time-use and earnings indicate that IPDW has a potential to reduce gender differences in employment and earnings. The relatively better individual level economic outcomes for women with IPDW could be critical in empowering women, especially in rural India.

### 5.3 IPDW Health and Education

In this section, I discuss the effects of IPDW on the self-reported health outcomes for adult women, likelihood of diarrhea in the household in the past month, and school absence of the child in the past month. I use fixed effects and instrumental variable fixed effects for the analysis. In addition, I extensively control for household time varying factors that could affect access to IPDW such as average community income, education, household size, public programs for sanitation (latrines/toilets), wide range of social networks, electrification, and any time trends.

Insert table 9 about here

Table 9 shows the effect of IPDW on women's self-reported health. I make two classifications of self-reported health (i) assigning good and very good health as equal to 1 and assigning poor, very poor and OK health as 0, and (ii) assigning good, very good and OK health as equal to 1 and assigning poor and very poor health as 0. In the first scenario, instrumental variable fixed effects analysis shows that access to IPDW leads to a 33.7 pp increase in women's self-reported health in rural areas and 50.6 pp increase in self-reported health for poor women. In the second case of moving from poor health to OK health and above, having IPDW has significant positive association with self-reported health for rural and poor women. Due to data limitations on the self-reported health (available only for the eligible women's survey in both the IHDS waves), I could not draw the same estimates for men.

Household IPDW and health outcomes are intricately linked, both directly and indirectly. The direct impact of water disruptions is that families may substitute into less clean water, which should increase the prevalence of water-borne illnesses [Ashraf et al., 2021]. Due to a large amount of time spent in the household [Sedai et al., 2021b, Fletcher et al., 2017], the impact of water disruptions on women could extend beyond water-borne illnesses into highly contagious diseases (for instance, respiratory issues, intestinal worms or malaria) due to the lack of piped water for hand-washing and consumption. This consequently affects women's labor productivity and participation, meaning more sick people in the household will lead to less working opportunities, days and hours. According to the study by Ashraf et al. [2021] in Lusaka, Zambia, a one standard deviation increase in outstanding supply complaints was associated with 57 extra cases of respiratory infections and 0.83 extra cases of the measles, increases of 13% and 18%, respectively.

Table 10 shows the effect of IPDW and diarrhea and the number of days individuals were ill in the last month. In addition to the controls used in the previous analyses, I include two additional controls, purify water (0/1) and store drinking water with lid (0/1), which could lead to illness regardless of the sources of water for the household. Diverging from the previous specifications for gendered analysis, I analyze the full sample, the rural-urban sample and the poor and non-poor sample. In panel (a), the IV-FE model shows that having access to IPDW reduces the likelihood of diarrhea by 1.5 percentage points for the overall sample, approximately 4500 less death as per the National Commission on Macroeconomics and Health report in 2005 [Lakshminarayanan and Jayalakshmy, 2015]. I anticipated and found a stronger effect of IPDW on diarrhea in urban areas, a 2.2 percentage point reduction owing to higher surface level contamination of household water supply [Paul, 2020, McPike and Luke, 2012, Jalan and Ravallion, 2003]. In panel (b), the IV-FE model shows that IPDW reduces the number of days an individual is ill by 0.31 days for the overall sample, and by 0.58 days for women from poor households.

Insert table 10 about here

Our finding is in line with meta analysis of literature by McKenzie and Ray [2009] who argued that in India, the surface level contamination of water, which could lead to diarrheal diseases among others, is higher in urban areas as compared to rural areas. Hence, I anticipate a higher negative association between IPDW and diarrhea cases in urban areas. The fixed effect analysis also shows that access to IPDW has a significant association with reduction of diarrheal disease for poor households, the coefficient is 0.7 pp, while no significant association exists for non-poor households. Similar to our study, Ashraf et al. [2021] find that a one standard deviation increase in outstanding supply complaints (24 days) led to an increase of 24 cases of diarrhea, and 0.05 cases of typhoid fever, an increase of 12% and 22%, respectively.

Next, I analyze the association between IPDW and school absence for boys and girls (monthly) under age 15 for the overall sample and by rural and urban areas. The individual fixed effect and instrumental variable analysis shows that access to IPDW is negatively associated with school absence in the past month, the negative association is expectedly stronger for girls as compared to boys.

Insert table 11 about here

Access to IPDW leads to 1.48 less days of absence from school for the overall sample. For girls the association is 1.55 less days of school absence in a month. The association is also more pronounced for rural girls as compared to urban girls, 2.44 and 1.39 less days of school absence in the past month, respectively. There is a negative effect of IPDW on school absence for boys, both in rural and urban areas, however, the association is insignificant in urban areas. In a cross-country analysis involving nine developing countries, including India, Koolwal and Van de Walle [2013] noted that increased access to piped water improves the extent of children's enrolment in schools.

### 5.4 Robustness

As means of robustness, I interact the State of the household with time period in a fixed effects model. As another set of robustness analysis, using the ACCESS survey, 2015-2018, I conduct fixed effect regressions on total cooking hours, non-male head decision making and total annual household savings.[27] I do this to control for the time-variant location factors that could be correlated with both IPDW and employment outcomes. I also cluster the standard error at the village/PSU level to check for the robustness of the standard errors.

Insert table 12 about here

Table 12 shows the individual fixed effects results with the standard error clustered at the village/PSU level. Results from this analysis confirm to the individual fixed effect results in table 6. Women tend to gain more in terms of overall employment and wage salary employment as

[27] Following Kabeer [1999], Sedai et al. [2021a], Pelz et al. [2021] and Sedai et al. [2021b], I choose the outcome variables out of the possible indicator variables that could have a latent effect on women empowerment from the ACCESS survey.

compared to men. Women gain 3.6 pp increase in the likelihood of any employment (discussed in other sections) and 4.3 pp in terms of wage salary employment. The coefficients are close to the observed point estimates in the village fixed effects analysis. For men, there are no significant increases in employment as also shown in table 6. Overall, with individual fixed effects, village fixed effects, 2SLS IV fixed effects and modified fixed effects regressions, I can say that the point estimates point to disproportionate benefit of IPDW on women's employment.

To supplement this analysis, I also examine whether access to IPDW has a significant effect on women's outcomes using a recently released different panel data, ACCESS survey, 2015-2018. However, the caveat with the use of the ACCESS survey is that the data are available only at the household level and comparison of individual level employment outcomes is not feasible.[28] Therefore, to capture latent effects on household welfare and women empowerment outcomes, I use the following variables: (i) non-male head decision making in the household, (ii) cooking hours in a day, (iii) total fuel collection minutes in a day, and (iv) household savings annually.

Following Sedai et al. [2020] and Kabeer [1999], I argue that the above variables have a latent effect on women's economic decision making and social empowerment. Non-male head decision making in the household can be inferenced to be women's decision making ability in the ACCESS data. This ability to take decisions in the household is critical for women's social empowerment and household bargaining power [Sedai et al., 2021a, Ashraf, 2009]. Long cooking hours, which is mostly women's responsibility, tend to have a negative effect on women's health [Parikh, 2011], and women would benefit more with overall reduction in fuel collection time in the household [Ferrant et al., 2014, Sedai et al., 2021b].

Insert table 13 about here

For the analysis, I control for: ration card of the household (with no ration card as the base and Above Poverty Line, Below Poverty Line and Antodaya Group as the controls), household adult education, age, household size (number of children and adults), household monthly consumption expenditure in Rs., and the wave dummy. Table 13 shows that access to IPDW increases the likelihood of non-male decision making ability by 3.5 pp (the mechanism of effect is presumed to be either through economic empowerment of women through employment because of the time saved in water collection, health improvements for women and children as discussed earlier). Having access to IPDW reduces cooking hours by 5.4 percent, a considerable amount of time saved in the cooking process which often involves collecting and purifying water. Access to IPDW also reduces time spent in fire-wood 0.61 hours on a daily basis. Access to IPDW also increases annual household savings by Rs. 2558 (nominal savings, Rs. 2400 in real savings). These results confirm to the trend of a positive effect of IPDW on women's empowerment in recent times and is robust to sample changes.

[28] ACCESS survey has 8,562 households in each round of the survey. Approximately 65% of the respondents across the ACCESS survey are household heads. Analysis is carried out using the balanced sample of the households across the surveys, and not for each outcome. For certain outcome variables, observations might be lower due to truly missing data points.

# 6 Policy and conclusion

## 6.1 Policy

A number of studies have argued for direct policy intervention to reduce the gender gap in employment and economic outcomes—not just because it is ethical, but because it would help alleviate poverty. One step in this direction would be to relieve the burden of water collection and maintenance which can facilitate women's participation in market-oriented activities. This is expected to increase their contribution to personal care expenses and household income. In addition, with lesser burden of water collection and maintenance, women would be more likely to invest their time in children's nutrition, and education. Therefore, a significant long-term consequence of better work opportunities and earnings through IPDW for women could be inducing households to invest in the education of their daughters. As a result, IPDW could be critical in breaking the vicious cycle of women not getting quality formal education leading to limited employment opportunities leading to limited or no earnings leading to little human capital.

Given the recent progress in provisioning of basic infrastructures such as electricity, liquefied petroleum gas, toilets and bank accounts, a similar and in fact stronger impetus should be laid on provisioning of indoor pipe drinking water as it has multi-dimensional effects on gendered and household outcomes, especially in rural areas. A back of the envelope benefit calculation as shown in table 13 (column 1) shows that average household savings with IPDW is approximately Rs.2400 annually (in six relatively poorer and populous states). This estimate could be regressed across income levels and socio-economic status to understand the willingness to pay for indoor pipe water.

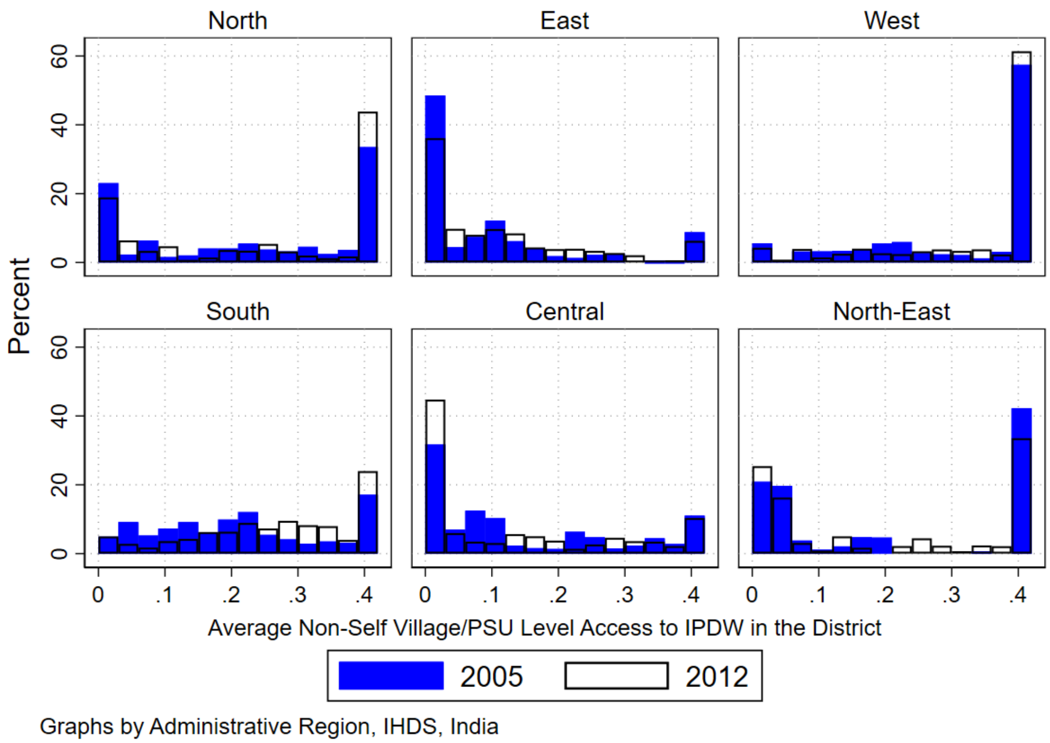
## 6.2 Conclusion

This study examines the effects of access to indoor piped drinking water on gender differences in general employment, wage and salary employment, amount of annual earnings and annual work days between men and women in India. In addition, the study examines the effect of indoor piped water on the likelihood of incidence of diarrhea, and the likelihood of child school absence. The study is a first in India to use longitudinal analysis approach which controls for time invariant factors that could affect selection into piped water in the household, and any systematic recall bias. In addition, the study is the first one at the national level which allows for a comparison of rural-urban effects of indoor pipe water on gendered outcomes. The study uses three empirical strategies to arrive at a conservative point estimate of effects which could be policy relevant. To control for arguments of self-selection which is imperative in basic household infrastructures, such as access to water, I use conditionally exogenous (village fixed effects) and instrumental variables regressions. The study finds indoor piped water to be critical in reducing gender differences in employment with women disproportionately benefitting from access to pipe water in the house in terms of employment opportunities, especially in rural areas both on and off the farm. Underscoring the rapid fall in women's labor force participation rate in India, 30% in 1990 to 20% in 2020, especially in rural areas, the positive effect of IPDW on employment and earnings, especially in rural India could be critical in reducing gender differences in rural India.

After controlling for the process of water purification and storage, I found significant decreases in diarrhea with access to indoor pipe water, suggesting that indoor piped water is a superior substitute to other sources of drinking water for the house, both in terms of employment and health. Any other source of water is found to be inferior to piped drinking water in terms of its effects on employment for both men and women, as was also found by Ashraf et al. [2021] in Lusaka, Zambia. Having access to piped water influences a number of everyday activities, therefore there are significant costs to not having it. For families with fewer resources, the substitutes such as hand sanitizers, bottled water or gym showers are hard to come by; therefore, a policy solution to supply adequate drinkable water through pipes should be a priority, if human development is of significant concern.

Results show that when piped water is lacking, women's economic freedom is lower than what it could be. Increase in adult women's employment and earnings through adequate provisioning of basic infrastructures–water, electricity, toilets, gas–could be a welcome increase in consumption at the national level, potentially better technology and standard of living. If the poorer people could be protected from the drudgery of water collection from open wells, boreholes, civic taps, etc., it could go a long way in reducing economic inequality. Given the consistency in the effect of piped water on women's socio-economic outcomes in developing economies, lack of access to piped water could indeed be a crucial determinant of differences in women's socio-economic outcomes between developed and developing economies.

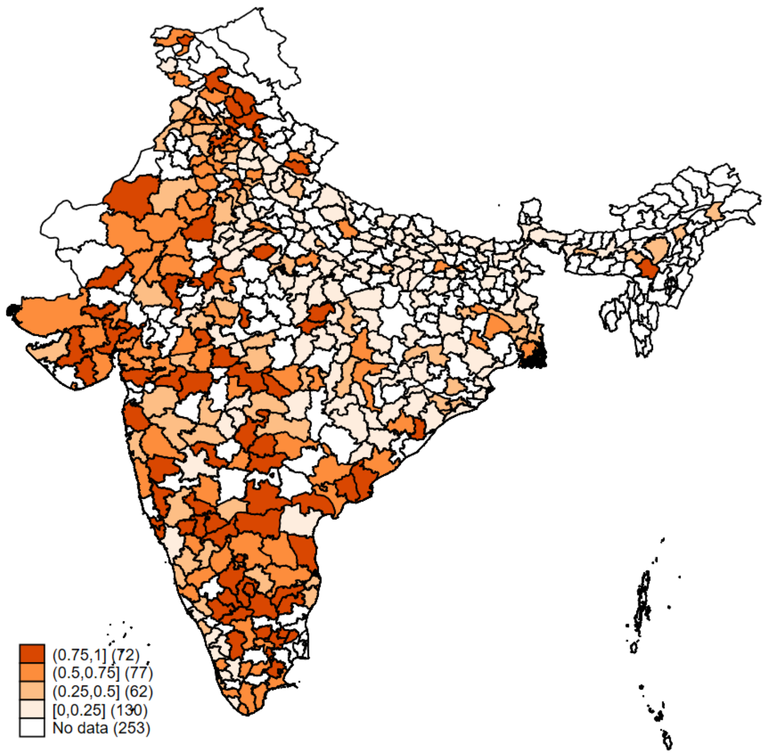
**Figure 1: Average non-self community level access to IPDW by regions in India**



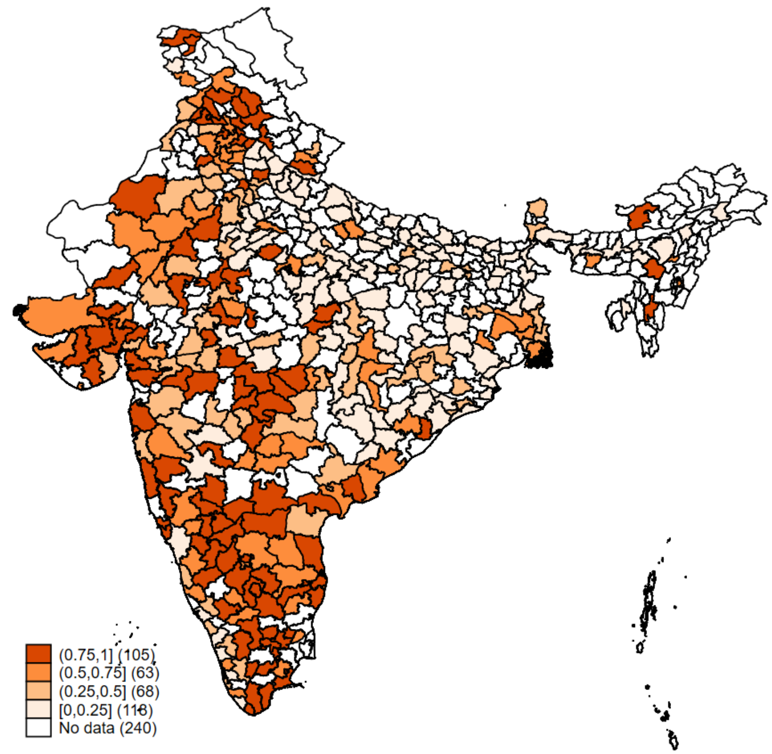

**Notes:** Authors' computations using IHDS-1 and IHDS-2. North Zone includes Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand , Uttar Pradesh and Haryana. East Zone includes Bihar, Orissa, Jharkhand, and West Bengal. West Zone includes Rajasthan, Gujarat, Goa and Maharashtra. South Zone includes Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. In 2014, the state of Andhra Pradesh was divided into the two states of Andhra Pradesh and Telangana. Central Zone includes Madhya Pradesh and Chhattisgarh. North East Zone includes Assam, Sikkim, Nagaland, Meghalaya, Manipur, Mizoram, Tripura and Arunachal Pradesh.

**Figure 2: Intensity of pipe water access at the District Level**

**Panel A: 2005**

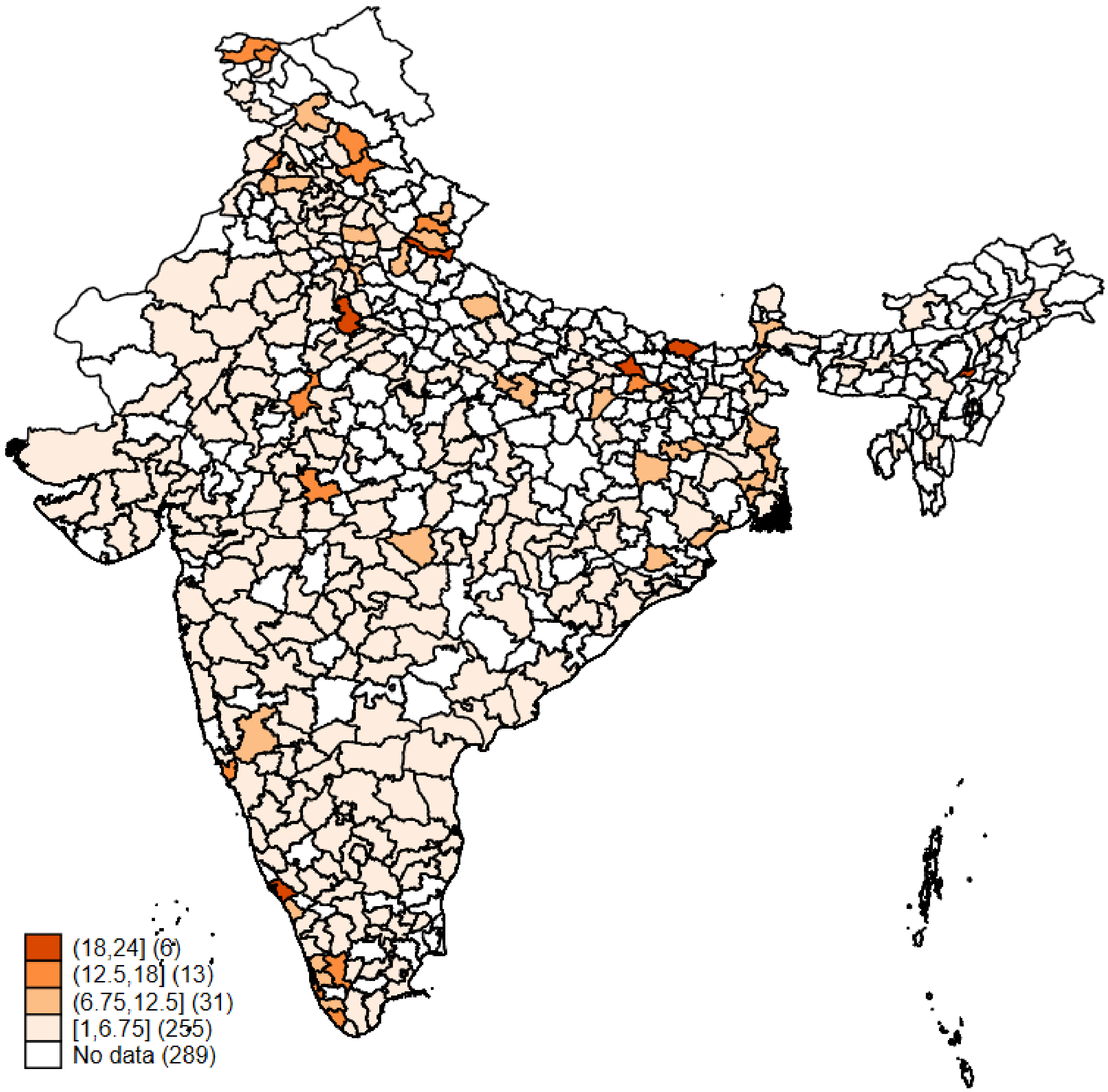



**Panel B: 2012**



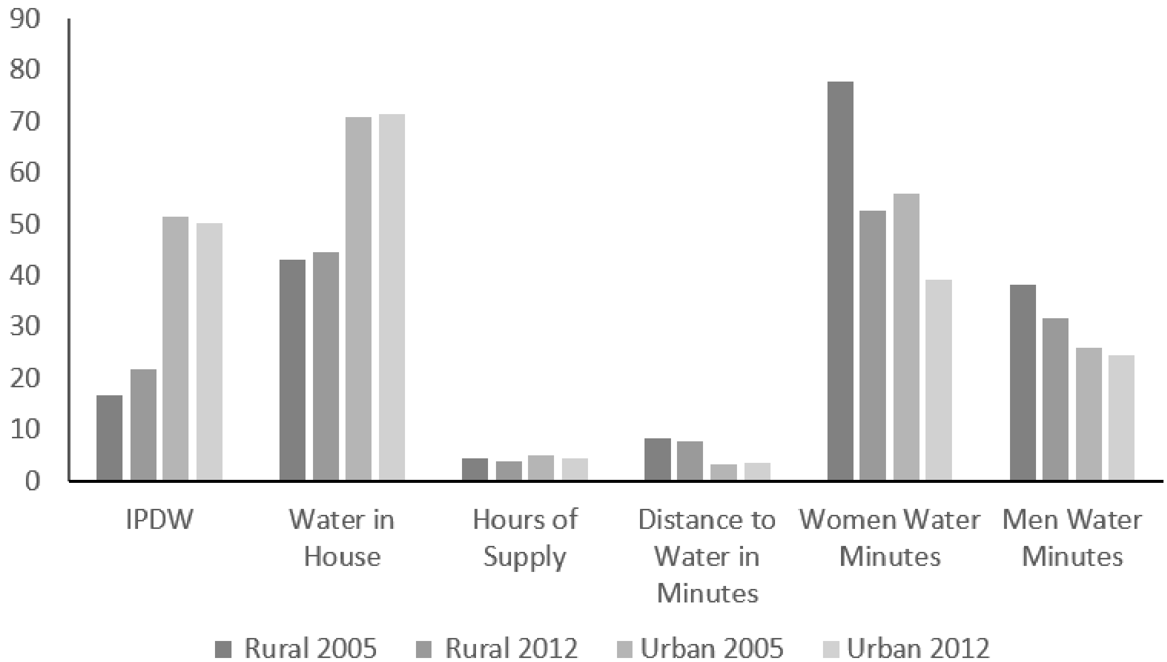

**Notes:** Authors' computations using IHDS-1 and IHDS-2. Note the map is not representative of actual boundary. The data here is derived from the administrative boundary, "https://www.diva-gis.org/gdata".

**Figure 3:** Hours of Indoor Pipe Drinking Water on a typical day, India, District Level, Label: Cumulative hours (0-24), IHDS (2012).




Source: Authors calculations, IHDS, 2012. The overlaying map has been taken from the "https://www.diva-gis.org/gdata". The figure was drawn according to the administrative boundary of India, not the actual boundary

**Figure 4:** Descriptive Statistics of Access to Water and Water Collection by Gender, 2005-2012. Note IPDW and Water in House are in percentages. Water collection minutes are daily averages conditional on at least some time spent on water collection.



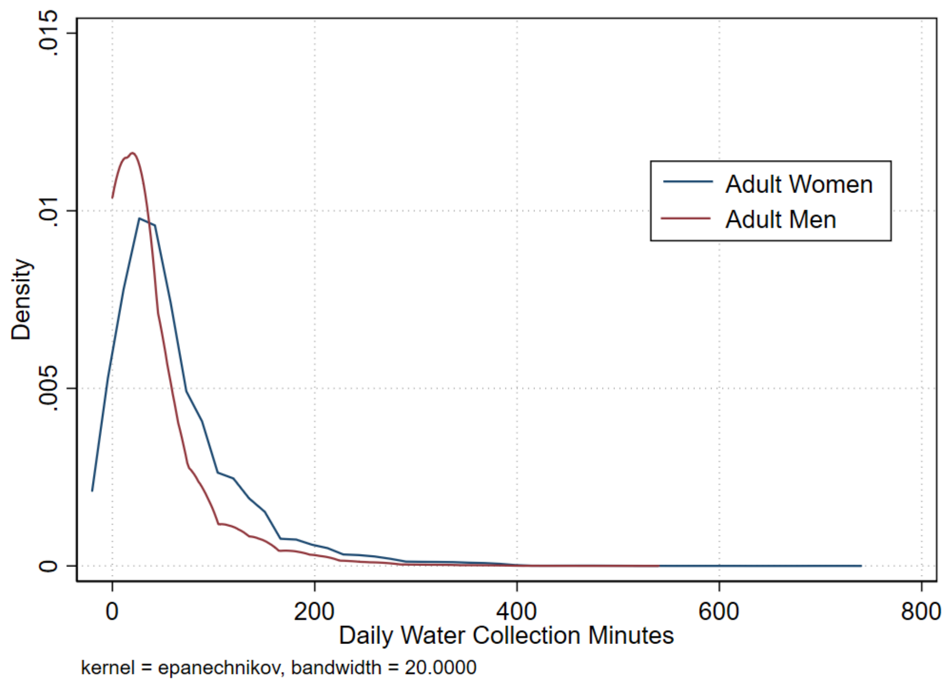

Source: Authors calculations, IHDS, 2005-2012.

**Table 1:** Access to piped drinking water, percentage by relative asset levels, 2005-2012.

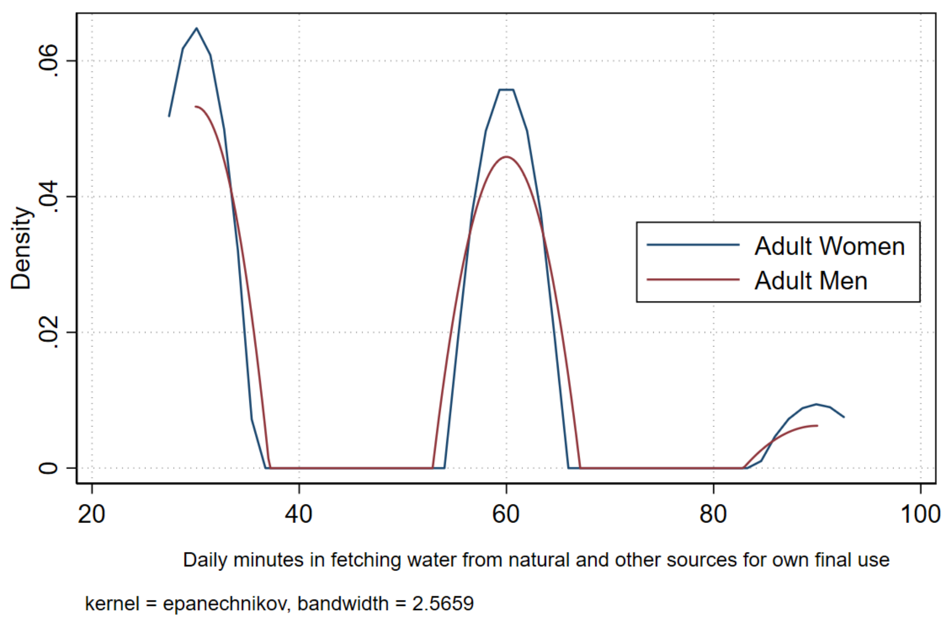
| | | Poor | Lower Middle | Middle | Upper Middle | Richest |
|---|---|---|---|---|---|---|
| | | Mean (sd) | Mean (sd) | Mean (sd) | Mean (sd) | Mean (sd) |
| **2005** | | | | | | |
| | IPDW | 0.02 | 0.06 | 0.19 | 0.38 | 0.62 |
| | | (0.13) | (0.25) | (0.39) | (0.49) | (0.49) |
| **2012** | | | | | | |
| | IPDW | 0.04 | 0.13 | 0.26 | 0.44 | 0.62 |
| | | (0.20) | (0.34) | (0.44) | (0.50) | (0.49) |
| | Observations | 7723 | 6801 | 9639 | 7888 | 7780 |

Source: author elaboration, IHDS, 2005-2012

**Figure 5:** Daily water collection minutes, adult men and women (age $\geq 14$) in India. Figure 3.a is derived from the India Human Development Survey, 2005-2012, sample: 217,000. Figure 3.b is derived from the India Time Use Survey, 2019, sample: 382,000



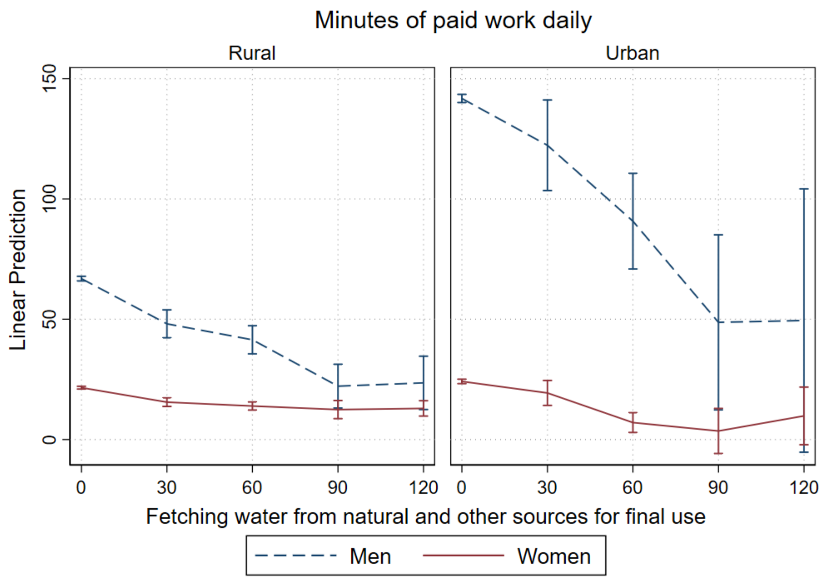

**(a)** fig 3.a



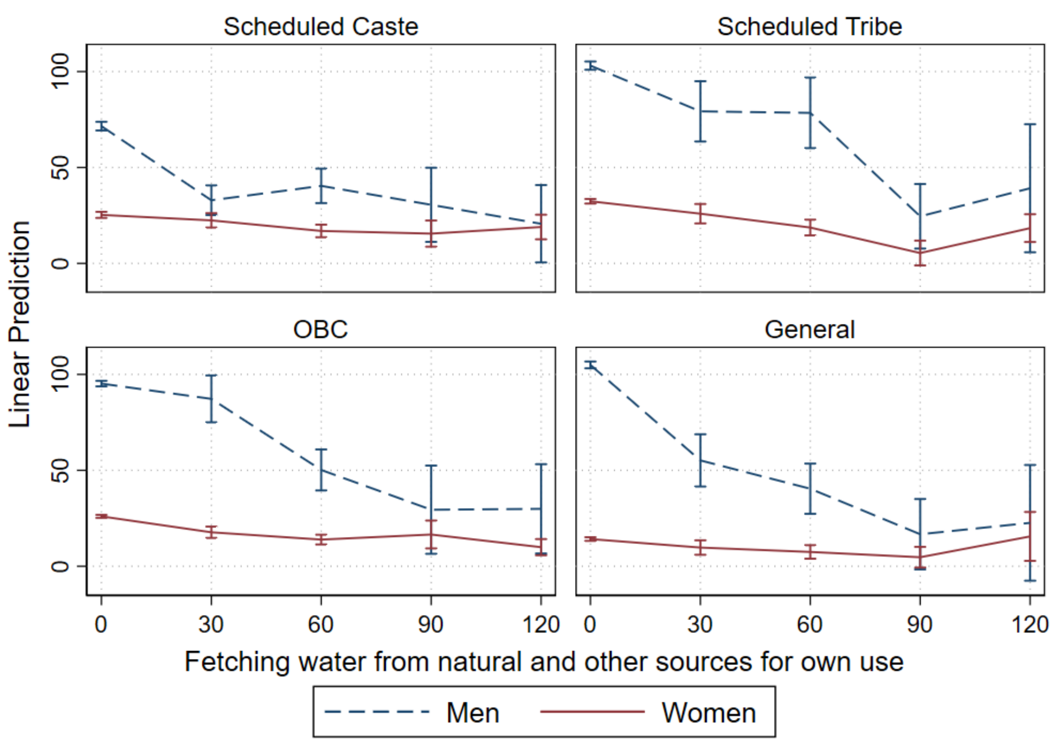

**(b)** fig 3.b

**Figure 6: Daily water collection minutes and paid employment (age $\geq$ 14) in India**

**Panel A: Rural-Urban**

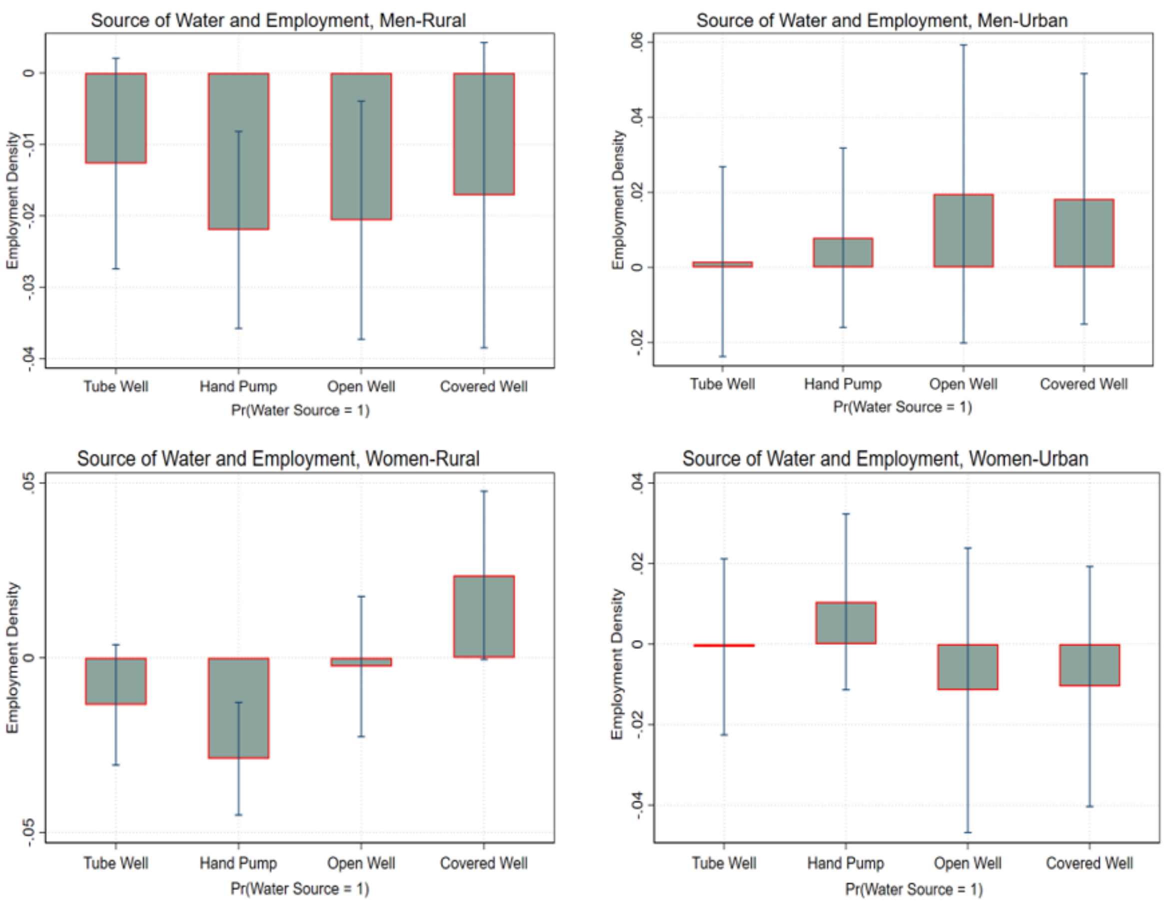



**Panel B: Social Groups**




**Notes:** Authors' computations using India Time Use Survey, 2019. Margins using OLS

**Figure 7:** Panel fixed effects: Source of Water and Employment by Gender and Location.




Authors calculations, IHDS, 2005-2012. Controlled for the time trend and the month of interview.

**Table 2:** Descriptive Statistics from two household surveys India, 2005-2018

| | | 2005 | | 2012 | | |
|---|---|---|---|---|---|---|
| IHDS | Obs | Mean | SD | Mean | SD | T test |
| IPDW | 40,018 | 0.256 | 0.442 | 0.302 | 0.459 | *** |
| ACCESS | | 2015 | | 2018 | | |
| IPDW | 8563 | 0.057 | 0.232 | 0.066 | 0.248 | |

Author elaboration, IHDS, 2005-2012, ACCESS survey, 2015-2018. ACCESS survey is for the rural areas in the six relatively poorer states in India namely: Madhya Pradesh, Uttar Pradesh, Odisha, Bihar, Jharkhand, West Bengal. Note, I check for six states average of the ACCESS survey in the IHDS survey for consistency and the averages between 2005-2012 are similar to averages between 2015-2018. The t-test shows mean difference in access to IPDW by the year of survey, 2015 and 2018.

**Table 3:** Descriptive statistics by treatment and time: Access to Indoor Piped Drinking Water (IDPW), India, 2005-2012

| | 2005 | | | | 2012 | | | |
|---|---|---|---|---|---|---|---|---|
| | No IDPW | | IDPW | | No IDPW | | IDPW | |
| Variable | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Water | | | | | | | | |
| Water in house | 0.33 | 0.47 | 1.00 | 0.00 | 0.32 | 0.47 | 1.00 | 0.00 |
| Water supply hours | 4.23 | 6.14 | 4.92 | 6.38 | 3.88 | 5.35 | 4.18 | 5.78 |
| Walk time water | 10.35 | 10.57 | 0.00 | 0.00 | 10.43 | 12.30 | 0.00 | 0.00 |
| Work | | | | | | | | |
| Employment (>30 days) | 0.40 | 0.49 | 0.36 | 0.48 | 0.47 | 0.50 | 0.44 | 0.50 |
| Wage Salary Employment (0/1) | 0.24 | 0.43 | 0.20 | 0.40 | 0.32 | 0.46 | 0.28 | 0.45 |
| Annual work days | 201 | 98 | 243 | 95 | 200 | 110 | 242 | 105 |
| Real ann. ear. (2011-$) | 252 | 745 | 498 | 1320 | 228 | 752 | 383 | 1187 |
| Health & Education | | | | | | | | |
| Self-reported health (0-5) | 2.26 | 0.81 | 2.18 | 0.76 | 2.19 | 0.87 | 2.02 | 0.84 |
| Diarrhea (30 days) (0/1) | 0.03 | 0.17 | 0.01 | 0.12 | 0.02 | 0.15 | 0.02 | 0.13 |
| Days ill (30 days) | 0.96 | 3.35 | 0.63 | 2.62 | 1.17 | 3.57 | 0.80 | 2.81 |
| School absence (30 days) | 3.38 | 5.79 | 1.81 | 3.96 | 3.95 | 5.26 | 2.94 | 5.04 |
| Observations | 109700 | | 40676 | | 103969 | | 46340 | |

Author elaboration, IHDS, 2005-2012

**Table 4:** Descriptive Statistics of Individual and Household Characteristics, IHDS 2005-2012

| | 2005 | | | | 2012 | | | |
|---|---|---|---|---|---|---|---|---|
| | No IDPW | | IDPW | | No IDPW | | IDPW | |
| Variable | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Purify water | 0.15 | 0.36 | 0.28 | 0.45 | 0.16 | 0.36 | 0.32 | 0.46 |
| Water stored with lid | 0.92 | 0.26 | 0.93 | 0.25 | 0.85 | 0.35 | 0.89 | 0.31 |
| **Networks** | | | | | | | | |
| Doctors/Health Care | 0.30 | 0.46 | 0.40 | 0.49 | 0.55 | 0.50 | 0.63 | 0.48 |
| Teachers/School Workers | 0.39 | 0.49 | 0.49 | 0.50 | 0.59 | 0.49 | 0.67 | 0.47 |
| Politicians/Police | 0.29 | 0.46 | 0.47 | 0.50 | 0.48 | 0.50 | 0.63 | 0.48 |
| Government Officials | 0.29 | 0.46 | 0.47 | 0.50 | 0.27 | 0.44 | 0.40 | 0.49 |
| Log community income | 12.00 | 0.44 | 12.30 | 0.38 | 11.63 | 0.47 | 11.98 | 0.42 |
| Log household income | 11.53 | 0.97 | 12.15 | 0.94 | 11.16 | 1.01 | 11.71 | 0.98 |
| Electricity | 0.69 | 0.46 | 0.97 | 0.17 | 0.83 | 0.38 | 0.99 | 0.10 |
| Public prog. for sanitation | 0.03 | 0.18 | 0.03 | 0.17 | 0.05 | 0.23 | 0.05 | 0.21 |
| Male education | 6.47 | 4.89 | 9.36 | 4.46 | 7.21 | 4.92 | 9.66 | 4.43 |
| Female education | 3.69 | 4.53 | 6.84 | 5.19 | 4.75 | 4.97 | 7.68 | 5.17 |
| Age | 26.71 | 18.90 | 28.70 | 18.76 | 33.69 | 19.28 | 35.54 | 19.05 |
| Household size | 6.56 | 3.12 | 6.32 | 3.11 | 5.82 | 2.72 | 5.66 | 2.61 |
| Rain Z score | -0.36 | 0.64 | -0.32 | 0.66 | 0.57 | 0.85 | 0.71 | 0.89 |
| | 109700 | | 40676 | | 103969 | | 46340 | |

Author elaboration, IHDS, 2005-2012

**Table 5:** Characteristics of time varying exogenous village level variables, India, IHDS 2005-2012

| | 2005 | | 2012 | | t-test |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Percentage of households with electricity | 68.46 | 33.28 | 78.29 | 27.39 | *** |
| Local government body in the village | 0.61 | 0.49 | 0.67 | 0.47 | *** |
| Agricultural cooperative in the village | 0.36 | 0.48 | 0.36 | 0.48 | |
| Number of private schools in the village | 0.78 | 1.59 | 0.82 | 1.62 | ** |
| Number of government schools in the village | 1.77 | 1.64 | 1.74 | 1.56 | * |
| Distance to bank in kilometers from the village | 2.92 | 4.49 | 2.81 | 4.51 | * |
| ROSCAs in the village | 0.25 | 0.42 | 0.22 | 0.38 | *** |
| Pucca road in the village | 0.67 | 0.47 | 0.87 | 0.34 | *** |
| Bus frequency in the village in a day | 1.84 | 3.24 | 1.84 | 3.43 | |
| Distance to market from the village | 6.44 | 6.80 | 6.53 | 6.67 | * |
| Village level | | | | | |
| Wage men rabi harvest | 56.92 | 35.68 | 176.01 | 79.71 | *** |
| Wage men kharif | 59.68 | 35.84 | 168.67 | 77.45 | *** |
| Wage women kharif | 36.04 | 26.46 | 130.16 | 66.13 | *** |
| Wage men rabi | 55.61 | 37.03 | 169.29 | 75.27 | *** |
| Wage women rabi | 30.10 | 27.62 | 129.66 | 61.35 | *** |
| Wage men kharif harvest | 59.80 | 34.07 | 175.85 | 80.09 | *** |
| Wage women kharif harvest | 41.08 | 29.43 | 137.61 | 68.47 | *** |
| Wage women rabi harvest | 38.39 | 30.47 | 137.84 | 67.29 | *** |
| Observations | 1,378 | | 1,378 | | |

Source: Authors elaboration from the India Human Development Survey, 2005-2012

**Table 6:** Panel fixed effects instrumental variables: Household's access to indoor pipe drinking water on any employment (wage salary farm business) ($\geq$ 30 days) and only wage and salary employment by gender in rural and urban India, 2005-2012.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Variables | All | Men | Women | Men Rural | Men Urban | Women Rural | Women Urban |
| Panel (a): Individual IV-FE | | | | | | | |
| Any Employment (>30 days) | | | | | | | |
| IPDW | 0.118*** | 0.119*** | 0.113*** | 0.121*** | 0.174*** | 0.195*** | -0.029 |
| | (0.017) | (0.022) | (0.026) | (0.026) | (0.046) | (0.033) | (0.044) |
| F test (IV) | 1,966 | 1,073 | 1,029 | 888 | 764 | 912 | 623 |
| Two-stage q-values | 0.001 | 0.002 | 0.001 | 0.002 | 0.001 | 0.004 | 0.671 |
| Wage/Salary Employment | | | | | | | |
| IPDW | 0.116*** | 0.110*** | 0.121*** | 0.088*** | 0.136*** | 0.160*** | 0.000 |
| | (0.017) | (0.024) | (0.022) | (0.029) | (0.049) | (0.029) | (0.037) |
| F test (IV) | 1,961 | 1,045 | 1,031 | 891 | 745 | 906 | 608 |
| Two-stage q-values | 0.008 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.624 |
| Ind. and HH. Controls | Y | Y | Y | Y | Y | Y | Y |
| Observations | 209,860 | 111,061 | 98,799 | 74,901 | 36,160 | 67,534 | 31,265 |
| Number of individuals | 119,054 | 62,863 | 56,193 | 43,033 | 20,982 | 38,626 | 18,054 |
| Panel (b) Village FE (Rural) | | | | | | | |
| Any Employment (>30 days) | | | | | | | |
| IPDW | 0.054*** | 0.064*** | 0.041* | | | | |
| | (0.016) | (0.017) | (0.023) | | | | |
| Sharpened two-stage q-values | 0.001 | 0.001 | 0.045 | | | | |
| Wage/Salary Employment | | | | | | | |
| IPDW | 0.031* | 0.012 | 0.054*** | | | | |
| | (0.016) | (0.019) | (0.020) | | | | |
| Sharpened two-stage q-values | 0.063 | 0.212 | 0.002 | | | | |
| Village Fixed Effects | Y | Y | Y | | | | |
| Village controls | Y | Y | Y | | | | |
| Observations | 2,488 | 2,488 | 2,488 | | | | |
| Number of PSUs | 1,378 | 1,378 | 1,378 | | | | |

Robust standard errors (clustered at the individual level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. $\beta$ reports the percentage point effect of access to piped drinking water within the house on any paid employment for over 30 days in a year. For panel (a): additional independent variables in all regressions: log of average community income, household electricity access, any public program for sanitary toilets, household size, social networks or acquaintance with doctors and health care workers, teachers, school workers, politicians, police, military, government officials. Individual's age, age squared, marital status, adult male, female education and district level rain Z score. For panel (b) (rural areas), all controls in panel (a) are used (excluding electricity access and marital status). In addition, all exogenous village level variables discussed in the data section are used as additional controls. The sharpened two stage q-values are derived from Anderson [2008] to reduce the likelihood of these false rejections. The measure is a way of adjusting for the fact that I am testing multiple hypotheses.

**Table 7:** Panel fixed effects: Household's access to indoor pipe drinking water on log of real annual earnings, by gender in rural and urban India, 2005-2012

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Variables | All | Men | Women | Men Rural | Men Urban | Women Rural | Women Urban |
| Panel (a) IV-FE | | | | | | | |
| IPDW | 0.138** | 0.112** | 0.175** | 0.102** | 0.132** | 0.199*** | 0.079 |
| | (0.070) | (0.068) | (0.082) | (0.066) | (0.069) | (0.076) | (0.094) |
| F test (IV) | 1,121 | 832 | 429 | 554 | 348 | 393 | 112 |
| Two-stage q-values | 0.001 | 0.002 | 0.002 | 0.002 | 0.003 | 0.001 | 0.414 |
| Observations | 124,836 | 85,244 | 39,592 | 59,827 | 25,417 | 33,622 | 5,970 |
| Number of individuals | 80,957 | 52,744 | 28,215 | 37,184 | 16,312 | 23,506 | 4,752 |
| Panel (b) Village FE | | | | | | | |
| IPDW | 0.181** | 0.182** | 0.304** | | | | |
| | (0.072) | (0.075) | (0.124) | | | | |
| Two-stage q-values | 0.021 | 0.023 | 0.040 | | | | |
| Observations | 2,486 | 2,486 | 2,431 | | | | |
| Number of PSUs | 1,378 | 1,378 | 1,369 | | | | |

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. $\beta$ reports the percent effect of access to piped drinking water within the house on log of real annual individual earnings. All additional controls are as discussed in table 6. Estimates are conditional on working in both waves. The sharpened two stage q-values are derived from Anderson [2008] to reduce the likelihood of these false rejections. The measure is a way of adjusting for the fact that I am testing multiple hypotheses.

**Table 8:** Panel fixed effects: Household's access to indoor pipe drinking water on annual work days, by gender in rural and urban India, 2005-2012

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Variables | All | Men | Women | Men Rural | Men Urban | Women Rural | Women Urban |
| Panel (a) IV-FE | | | | | | | |
| IPDW | 22.755*** | 20.060*** | 27.031*** | 19.075*** | 21.667*** | 28.751*** | 10.132 |
| | (2.951) | (3.449) | (5.388) | (4.217) | (6.450) | (5.566) | (18.270) |
| F test (IV) | 1,224 | 841 | 440 | 599 | 376 | 401 | 133 |
| Sharpened two-stage q-values | 0.311 | 0.762 | 0.002 | 0.172 | 0.563 | 0.001 | 0.516 |
| Observations | 129,410 | 87,415 | 41,995 | 61,795 | 25,620 | 35,877 | 6,118 |
| Number of individuals | 82,752 | 53,427 | 29,327 | 37,798 | 16,397 | 24,530 | 4,844 |
| Panel (b) Village FE (Rural) | | | | | | | |
| Indoor Pipe Water | 11.49*** | 13.74*** | 7.04* | | | | |
| | (3.18) | (4.06) | (3.35) | | | | |
| Sharpened two-stage q-values | 0.011 | 0.007 | 0.070 | | | | |
| Observations | 2,486 | 2,486 | 2,431 | | | | |
| Number of PSUs | 1,378 | 1,378 | 1,369 | | | | |

Robust standard errors (clustered at the individual level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All additional controls are as discussed in table 6. Estimates are conditional on working in both waves. The sharpened two stage q-values are derived from Anderson [2008] to reduce the likelihood of these false rejections. The measure is a way of adjusting for the fact that I am testing multiple hypotheses.

**Table 9:** Panel fixed effects: Household's access to indoor pipe drinking water and women's self-reported health, 2005-2012.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | All | Rural | Urban | Poor | Non-poor |
| Good & V. Good=1, OK, Poor & V. Poor=0 | | | | | |
| FE | | | | | |
| IPDW | 0.0294** | 0.0316** | 0.0352* | 0.0686*** | 0.0241*** |
| | (0.0122) | (0.0154) | (0.0200) | (0.0379) | (0.0128) |
| IV-FE | | | | | |
| IPDW | 0.312*** | 0.337*** | 0.273*** | 0.506*** | 0.274*** |
| | (0.0432) | (0.0518) | (0.0827) | (0.116) | (0.0465) |
| Good, V. Good & OK=1, Poor & V. Poor=0 | | | | | |
| FE | | | | | |
| IPDW | 0.00974 | 0.0163* | 0.000689 | 0.00115 | 0.0102 |
| | (0.0066) | (0.0084) | (0.0110) | (0.0198) | (0.0070) |
| IV-FE | | | | | |
| IPDW | 0.0896*** | 0.142*** | -0.0191 | 0.0951 | 0.0878*** |
| | (0.0247) | (0.0298) | (0.0400) | (0.0626) | (0.0255) |
| F test (IV) | 866 | 750 | 312 | 181 | 542 |
| Observations | 47,225 | 32,527 | 14,698 | 7,819 | 39,402 |
| Number of Individuals | 24,909 | 17,196 | 7,713 | 4,133 | 20,772 |

Robust standard errors (clustered at the individual level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. $\beta$ reports the percentage point effect of access to piped drinking water within the house on the self-reported health of women (respondents from the eligible women's questionnaires of IHDS, 2005-2012). The model used is individual fixed effects. Additional independent variables in all regressions: household income, household electricity access, any public program for sanitary toilets, individual's age, marital status, education, household size, any social networks or acquaintance with doctors and health care workers, teachers, school workers, politicians, police, military, government officials and the rain Z score.

**Table 10:** Indoor Pipe Drinking Water and likelihood of Diarrhea and illness, India, 2005-2012

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | All | Rural | Urban | Poor | Non-Poor |
| Panel (a) Diarrhea | | | | | |
| FE | | | | | |
| IPDW | -0.002** | 0.001 | -0.008*** | -0.007** | -0.002 |
| | (0.001) | (0.001) | (0.002) | (0.003) | (0.001) |
| IV-FE | | | | | |
| IPDW | -0.015*** | -0.012* | -0.022*** | -0.015** | -0.014* |
| | (0.006) | (0.007) | (0.004) | (0.005) | (0.006) |
| F test (IV) | 1562 | 1301 | 831 | 693 | 1414 |
| Panel (b) Days ill last month | | | | | |
| FE | | | | | |
| IPDW | -0.007 | 0.037 | -0.076** | 0.082 | -0.022 |
| | (0.024) | (0.031) | (0.038) | (0.063) | (0.025) |
| IV-FE | | | | | |
| IPDW | -0.318*** | -0.462*** | -0.205* | -0.580*** | -0.399*** |
| | (0.123) | (0.156) | (0.115) | (0.192) | (0.136) |
| F test (IV) | 1521 | 1227 | 836 | 668 | 1471 |
| HH & Individual controls | Y | Y | Y | Y | Y |
| Observations | 273,942 | 188,645 | 85,297 | 51,857 | 222,015 |
| Number of individuals | 144,810 | 101,528 | 45,785 | 27,333 | 117,424 |

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. $\beta$ reports the percentage point effect of access to piped drinking water within the house on the self-reported health of women (respondents from the eligible women's questionnaires of IHDS, 2005-2012). The model used is individual fixed effects. Additional independent variables in all regressions: household income, household electricity access, any public program for sanitary toilets, individual's age, marital status, education, household size, any social networks or acquaintance with doctors and health care workers, teachers, school workers, politicians, police, military, government officials and the rain Z score.

**Table 11:** Panel fixed effects: Effect of IPDW on absence from school in the past month, India, 2005-2012

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Variables | All | Boys | Girls | Rural Boys | Urban Boys | Rural Girls | Urban Girls |
| FE | | | | | | | |
| IPDW | -0.437** | -0.272 | -0.640*** | -0.212 | -0.453 | -0.882* | -0.568** |
| | (0.174) | (0.243) | (0.246) | (0.323) | (0.379) | (0.417) | (0.312) |
| IV-FE | | | | | | | |
| IPDW | -1.484** | -1.423* | -1.559** | -1.347** | -0.149 | -2.440*** | -1.393 |
| | (0.586) | (0.636) | (0.419) | (0.362) | (1.151) | (1.106) | (1.484) |
| F test (IV) | 732 | 512 | 487 | 399 | 118 | 354 | 87 |
| Observations | 54,446 | 30,305 | 24,141 | 20,738 | 9,567 | 16,358 | 7,783 |
| Number of Individuals | 42,421 | 23,732 | 18,690 | 16,471 | 7,424 | 12,883 | 5,956 |

Robust standard errors (clustered at the individual level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Additional independent variables in all regressions: water stored with lid, log of annual community income, time trends, any public program for sanitation (latrines/toilets), adult male education, adult female education, household size, age of the respondent, networks with doctors, hospitals and health care workers, teachers, educators, government officials and local politicians.

**Table 12:** Panel fixed effects: Household's access to IPDW and any employment (wage salary farm business) ($\geq$ 30 days), and only wage and salary employment by gender in rural and urban India, 2005-2012. Note, all regressions have state and year interaction as controls.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Variables | All | Men | Women | Rural Men | Urban Men | Rural Women | Urban Women |
| Treatment: IPDW | | | | | | | |
| Any Employment (>30 days) | | | | | | | |
| Indoor Pipe Water | 0.006 | 0.006 | 0.019** | 0.001 | -0.011 | 0.036*** | -0.006 |
| | (0.006) | (0.007) | (0.009) | (0.010) | (0.012) | (0.012) | (0.012) |
| Wage/Salary Employment | | | | | | | |
| Indoor Pipe Water | 0.003 | -0.013 | 0.021*** | 0.001 | -0.017 | 0.043*** | -0.009 |
| | (0.006) | (0.008) | (0.008) | (0.011) | (0.013) | (0.010) | (0.010) |
| Observations | 95,966 | 50,909 | 45,057 | 26,153 | 24,756 | 23,452 | 21,605 |
| Number of individuals | 63,989 | 33,931 | 30,060 | 18,478 | 15,710 | 16,450 | 13,715 |

Robust standard errors (clustered at the village level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Additional independent variables in all regressions: age, age squared, marital status, individual's education, household size, log of per-capita household consumption, electricity access, public program for sanitation, networks with doctors, hospitals and health care workers, politicians, educators, government officials, state and year interaction.

**Table 13:** Household fixed effects: Effect of IPDW on household savings, decision making, time spent in cooking and firewood collection

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Variables | Annual Savings Rs. | Non male-head decision making | Log of cooking hours | Firewood collection hours daily |
| Indoor Pipe Water | 2,558.249* | 0.035* | -0.054*** | -0.612** |
| | (1,383.294) | (0.021) | (0.017) | (0.303) |
| Household Controls | Y | Y | Y | Y |
| Wave Dummy | Y | Y | Y | Y |
| Observations | 16,447 | 16,057 | 17,062 | 4,761 |
| Number of Households | 8,562 | 8,548 | 8,563 | 3,794 |

Robust standard errors (clustered at the household level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Additional independent variables in all regressions: age, education, household size, monthly household consumption expenditure, wave dummy. The data is derived from the ACCESS panel, 2015-2018.

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