Gendered and Distributional Impacts of Scaling Water Access: Evidence from Tap Water Policy in India*

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Abstract

Improving water access can reduce the burden of time spent on water collection and enhance child health. However, most evidence comes from interventions with limited scope, and it remains unclear how benefits are distributed between advantaged and disadvantaged groups when programs are scaled to fill regional or national coverage gaps. We examine the gendered and distributional impacts of India's universal tap water policy. Exploiting temperature shocks that affect water demand, we find that the policy reduces water collection time, particularly for women and marginalized caste groups. At the same time, however, by examining district-level variations in tap water expansion, we identify an increase in child mortality, particularly among these marginalized groups. Our results suggest a possible quantity-quality tradeoff in scaling infrastructure and a need for more careful mitigation of potentially adverse behavioral responses.

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1 Introduction

Globally, over two billion people lack access to clean water, highlighting the urgent need to scale water access. Improving water access can reduce the burden of time spent on water collection; 292 million people, for example, are estimated to spend over 30 minutes per trip for this purpose (WHO, 2023). Clean water access can also improve child health, as unsafe drinking water is a leading cause of diarrheal diseases, resulting in over one million deaths annually (WHO, 2023). The time use and health benefits of improved water access have been demonstrated by numerous past studies on small-scale water programs (e.g., Kremer et al., 2011; Devoto et al., 2012; Burlig et al., 2025; Chandrasekaran et al., 2022).

It remains unclear, however, how these benefits are distributed between advantaged and disadvantaged when water programs are scaled to fill regional or national gaps in coverage, with large-scale policies. One might expect that disadvantaged groups, such as women and marginalized groups, would benefit more, as they are more likely to be engaged in collecting water from distant and unclean water sources and, therefore, have greater scope for improvement. Conversely, advantaged groups with greater political power in local villages may gain priority access to these scaled-up programs, especially in their initial phases when investment resources are scarce relative to the overall need. Moreover, scaling water programs quickly can compromise the quality of the infrastructure that is provided, potentially limiting health benefits for those who gain increased access. In such cases, quantity may be prioritized over quality, leading to the provision of poor-quality water that could even have negative health consequences. The consequences of scaling up to a nationwide, universal water policy, therefore, deserve careful empirical examination to help understand potential tradeoffs and determine best practices.

This paper examines the gendered and distributional impacts of India's universal tap water policy. Launched by the Government of India in August 2019, the Jal Jeevan Mission (JJM) is one of the most ambitious tap water initiatives implemented to date across the globe. JJM seeks to provide tap water connections to all rural households by 2024, and achieved increases in tap water coverage from 18% in 2018 to 76% of rural households by 2023. We examine whether scaled tap water access under the JJM offers greater benefits to women and historically marginalized caste groups, including Scheduled Caste (SC) and Scheduled Tribe (ST) populations, in terms of time use and health. For these analyses, we combine data from the 2019 Time Use Survey and the 2019-2021 National Family Health Survey with administrative JJM data on tap water connections. Given the timing of these surveys conducted shortly after JJM's launch, our analysis captures the short-run impacts of the policy's initial phase.

First, we examine the impact of tap water access on time use by exploiting plausibly random temperature shocks that can affect water use. Specifically, we examine whether higher temperatures on the day of the time use survey increase reported water collection times. We argue that the principal mechanism for this effect is that short-term temperature spikes raise water demand, rather than a decrease in water supply that would come from temperatures experienced over a longer term, or rainfall. Importantly, though, the effect of high temperatures on water collection times should be mitigated by new tap water access, as provided under the JJM policy. Thus, our hypothesis is that convenient water access facilitated by JJM should reduce collection time and insulate households from the demand shocks that accompany higher temperatures.

In the time-use analysis, we find that scaling tap water access under the JJM policy does effectively reduce water collection time, especially for women and marginalized caste groups. Our results show that an increase in average temperature by one degree Celsius raises water collection time by about 1.5 minutes. At the same time, the enhanced tap water access provided under JJM completely offsets the impact of high temperatures on water collection time. This time-use benefit of tap water access is predominantly found in households with only female collectors, highlighting the gendered effects for women, who are usually the primary water collectors. We also find that tap water access predominantly benefits marginalized caste groups, including SC and ST households, while providing no significant benefits to advantaged (general) caste groups, highlighting the distributional effects of mitigating inequality in water access. Further heterogeneity analyses also show that the time use benefit is particularly substantial among Hindu households, who have been shown, in previous work, to have lower levels of private water and sanitation investment, and in larger households that have a higher demand for water.

Next, we investigate the impact of tap water access on child health by leveraging the differential increase in tap water coverage across districts. Specifically, we adopt a difference-in-differences (DiD) design, using pre-JJM baseline tap water coverage as a treatment indicator to measure the intensity of new tap water connections established during the JJM period. The JJM policy aimed to achieve 100% tap water coverage in all districts by 2024, regardless of their baseline coverage levels. Consequently, districts with lower baseline coverage are expected to experience a larger increase in tap water connections under the policy, potentially leading to a larger reduction or increase in child mortality.

In this health analysis, we find that scaling tap water access under the JJM policy increases child mortality, particularly among marginalized caste groups who gained more water access. Specifically, a 10% lower baseline coverage of tap water leads to an increase in the infant mortality rate by 11.6–12.8 per 1,000 children (a 33–36% increase from pre-

JJM levels) seven to eight months after the launch of the JJM. These short-run effects are observed among male children, but not among female children. Moreover, the negative effects are pronounced among marginalized caste groups, including SC and ST, but are not observed for advantaged caste groups.

Given that these marginalized groups were found to experience larger gains in water access in the time-use analysis, our findings suggest that while the JJM policy has successfully improved access to tap water for disadvantaged groups, it may have compromised infrastructure quality or paid insufficient attention to compensatory behavioral adjustments (e.g., discontinuing water treatment before consumption), resulting in adverse health consequences for these groups. Consistent with this interpretation, our additional analysis shows that greater JJM connections are associated with an increase in the number of villages with contaminated water samples, particularly with respect to bacterial contaminants such as *E. coli*. This result suggests that water quality, as one dimension of infrastructure quality, was compromised during the rapid expansion of access.

A variety of tests corroborate our findings on the impacts of tap water access on time use and health. For example, the time use results remain robust after accounting for differences in characteristics between districts that received JJM tap water connections and those that did not. A falsification test reveals no differential effects in time use between these two types of districts in the pre-JJM period. An alternative DiD analysis comparing households surveyed before and after the start of JJM shows similar time use effects, with no evidence of differential pre-trends. In the health analysis, we find no differential pre-trends, and similar effects are found for alternative mortality indicators such as an under-5 mortality rate.

Taken together, our findings suggest that scaling water programs to a nationwide, universal scale can help reduce inequalities in water access, as evidenced by time savings for disadvantaged groups. However, such scaling can introduce tradeoffs for those same groups, possibly due to poor infrastructure quality or inattention to potentially quality-compromising behavioral responses. Scaling up water programs, therefore, requires a careful balance between the quantity and the quality of infrastructure to achieve the full benefits in both time use and health.

This paper makes two key contributions to the literature. First, we contribute to the literature on clean water access by investigating the heterogeneous benefits of a scaled-up, universal policy. Unlike most past studies, which largely focus on small-scale or targeted programs in specific regions (Kremer et al., 2011; Devoto et al., 2012; Dupas et al., 2023; Burlig et al., 2025), our project examines how these benefits are distributed across different genders and socioeconomic groups under a large-scale policy. We show that a scaled-up tap water policy especially benefits women and marginalized caste groups in terms of time use despite negative health consequences for these same groups.

Relatedly, this paper shows the quantity-quality tradeoff in clean water access within the context of a scaled-up policy. Previous studies highlight the dual benefits of clean water access: time use benefits from reduced water collection time (Devoto et al., 2012; Koolwal and Van de Walle, 2013; Meeks, 2017) and health benefits, such as reductions in diarrhea and mortality and improved child growth (Zhang, 2012; Alsan and Goldin, 2019; Kremer et al., 2023; Flynn and Marcus, 2023; Burlig et al., 2025). By examining the case of scaling water access, we identify a potentially important tradeoff: the quality of clean water access (measured in health) may be compromised to expand water access (measured in reduced water collection time).

Second, we contribute to the literature on the impacts of climate change by examining the relationship between temperature and water demand and the mitigating role of tap water access. Prior studies show that temperatures have a wide range of effects on economic outcomes, including labor productivity (Somanathan et al., 2021; Heyes and Saberian, 2022), agricultural productivity (Schlenker and Roberts, 2009), mortality (Deschênes and Greenstone, 2011; Carleton et al., 2022), and health investments (Motohashi, 2024). Our study extends this literature by showing that rising temperatures influence water collection behaviors through increased water demand. We further demonstrate that access to tap water moderates the relationship between temperature and water demand.

The remainder of this paper is organized as follows. Section 2 describes the JJM policy and its potential effects on time use and health. Section 3 describes our data for the empirical analysis. Sections 4 and 5 present the empirical strategy and results on the impact of tap water access on time use and health, respectively. Section 6 concludes.

2 Background

2.1 Scaling Tap Water Access under Jal Jeevan Mission in India

India has taken a number of steps to improve the supply of household water since independence. As water provision in India is a policy responsibility of the state government, national schemes funded by the central government are implemented at the state level. One of the earliest nationwide efforts was the 1972 Accelerated Rural Water Supply Programme, which aimed to deliver forty liters of safe water a day for each individual. Under this scheme, more than 3.5 million hand pumps were installed. This was modified as the National Rural Drinking Water Programme that launched in 2009, which aimed to provide all rural households with access to safe and adequate drinking water "within a reasonable distance", primarily through piped water rather than hand pumps. However, these centrally-sponsored schemes did not achieve their intended goals for several reasons, including malfunctions of water equipment and facilities, a lack of sustainable water management plans, and a general lack of community awareness and ownership (Government of India, 2013; Suhag, 2018).

To overcome these deficiencies, the Government of India launched the Jal Jeevan Mission (JJM) on August 15, 2019. Under the supervision of the Ministry of Jal Shakti (Ministry of Water Resources), JJM aims to provide "safe and adequate drinking water through individual household tap connections by 2024 to all households in rural India," with a minimum quantity of 55 liters per capita per day (Government of India, 2019).[1] The cost of piped water infrastructure is mostly subsidized by the central government, with Gram Panchayats (village governments) responsible for only 5-10% of costs.[2] As a result, the financial burden on individual households is minimal to nonexistent. Thanks to the JJM, the tap water coverage of rural households rapidly increased from 18% in 2018, reaching 76% in 2023 (Figure 1).

While the JJM policy is funded by the central government, Gram Panchayats (village councils) are responsible for forming committees to design village-specific water plans. These plans include identifying where to install piped water supply systems, managing and operating these systems to ensure water quality, and educating community members on safe water practices. States and localities also have discretion over the design of water usage charges. Some employ a graduated cost structure depending on consumption, others have a flat monthly fee, while still others use a single rate. For example, in Uttar Pradesh, although the state government covers the ten percent community costs for the infrastructure, each rural household pays a monthly operation & maintenance (O&M) fee of Rs.50 as their water usage charge. This bottom-up approach generates variation in the progress of clean water access across villages.

2.2 Tap Water Access and Water Collection Time

Water supply interventions can result in substantial time savings due to reduced water collection burdens (Bisung and Elliott, 2018; Winter et al., 2021). Women are the main beneficiaries of time saved from tap water access because they are often the primary water collectors in their households. The time saved may be particularly beneficial for women when they can reallocate it to labor (Meeks, 2017) and leisure (Devoto et al., 2012; Cook et al., 2023).

In terms of distributional consequences across households, tap water access improvements might be especially beneficial for marginalized caste groups like SC and ST. These groups

[1] The duration of the JJM has been extended until 2028.

[2] These local contributions are 5% in hilly areas or in villages with more than 50% SC/ST populations, and 10% in all other areas. Recently, several state governments, including Haryana, Uttar Pradesh, Bihar, Odisha, and West Bengal, have covered these community contributions.

tend to rely more on public and shared water sources and may spend more time collecting water due to caste-based discrimination. For example, the 2011 Census indicated that 28% of rural SC households had access to water within the premises compared to nearly 40% of non-SC households. According to Dutta et al. (2015), SC households face multiple forms of discrimination when fetching water, including being treated as untouchables and being denied access to hand pumps located in areas inhabited by dominant castes. For SC and ST populations, caste-based discrimination can result in additional time burdens from waiting in line or traveling to less convenient sources from which they are not excluded.[3] Therefore, the objective of providing private, household tap water access under the JJM might be expected to reduce water collection time, especially for these disadvantaged groups.

On the other hand, the benefits of government schemes may also be subject to capture by advantaged caste groups, particularly during the early phases of program scale up. Village councils, responsible for formulating water distribution plans, often have greater representation from these advantaged groups, except in cases where sufficient political positions are reserved for SC and ST members, who may also not be vested with adequate influence over decision-making processes. While the JJM policy is ultimately expected to provide tap water access to all households, advantaged groups may leverage their influence within village councils to prioritize tap water infrastructure in the areas where they reside, especially during the initial phases when investment resources are scarce relative to the overall need.

Given this ambiguity over the distribution of benefits from scaled-up tap water access between advantaged and disadvantaged groups, we conduct an empirical analysis to explore the heterogeneous effects of the JJM across gender and caste groups.

2.3 Temperature and Water Collection Time

Our empirical strategy for the time-use analysis relies on daily temperature shocks, which can affect water collection times. There are two main channels through which temperature shocks might influence water collection time.

First, higher temperatures increase water demand for drinking, cooking, bathing, etc., considering human physiology.[4] Increased water demand, in turn, will lead to more trips to

[3] While water collection time usually refers to the distance that people need to travel to collect and transport water, depending on the situation, it may also include the time that people spend waiting in line to collect water from shared sources or locating viable source where availability varies due to seasonal or irregular weather patterns.

[4] Several studies in environmental science have found a positive correlation between temperature and water demand in the context of municipal water supply in developed countries, where temperature is more likely to affect outdoor water use, such as landscaping (e.g., Gutzler and Nims, 2005). We focus on a developing country setting, where temperature is more likely to influence indoor water use, including for drinking, cooking, and bathing.

collect water from wells and surface water sources, subsequently increasing water collection time, unless households adjust their means of procurement (e.g., opting for home delivery, which is expensive and often unavailable, or using oxcarts or vehicles to transport a larger quantity of water).

Second, higher temperatures may reduce available water resources, for example, by increasing evaporation from local water sources or reducing groundwater recharge and levels.[5] Fewer choices of water sources can lead to longer collection times if the usual collection point(s) become unavailable and people have to travel further to access this resource. This mechanism is less likely to play a role in our case, however, because our empirical analysis relies on daily variations in temperature, and changes in water availability are more likely to be driven by longer-term, cumulative effects of high temperatures.

Given these two channels, we expect that higher temperatures increase water collection time, especially by raising water demand. However, when tap water is available, higher temperatures should not increase water collection times (much) because tap water access—if reliable, in the sense that tap water supply is unaffected by the same temperature shocks—diminishes the necessity of making trips to collect water. We test this hypothesis in the time-use analysis.

Of course, rainfall is another factor that could affect water collection time, so we control for rainfall in the time-use analysis. Rainfall can affect water collection time by influencing the water supply available from groundwater and surface water sources.[6] Thus, a reduction in water supply due to reduced rainfall would be expected to increase water collection time through a similar channel as the second one highlighted above for temperature.

2.4 Tap Water Access and Health

In addition to saving time, another key benefit of clean water access is its positive impact on health, especially for children under five.[7] Tap water infrastructure might reduce child mortality by decreasing the incidence of diarrhea, assuming that the water provided by such a system is of good quality. Some research suggests that piped water provision—if combined with centralized water treatment—can be more effective in preventing diarrhea than

[5] Many studies in hydrology discuss the relationship between temperatures and groundwater resources (e.g., Chen et al., 2002).

[6] A recent analysis for India by Praveen et al. (2020) found that rainfall has declined substantially since 1951. Accordingly, surface water availability was calculated to decrease by 35 percent in northern India over the same time period (Satoh et al., 2017).

[7] Many studies in economics and public health have shown that clean water access improves child health by reducing rates of child diarrhea and mortality, as well as enhancing growth in developing countries (Günther and Fink, 2011; Pickering and Davis, 2012; Zhang, 2012; Kremer et al., 2023). Nonetheless, findings are mixed, with some studies finding no significant health improvements (Devoto et al., 2012).

relying on point-of-use household water purification methods, such as boiling or chlorination (Vásquez and Aksan, 2015). Studies conducted in India from 1993 to 1994, before the implementation of the JJM policy, also demonstrated the positive effects of piped water on reducing both the prevalence and duration of diarrhea among children under five (Jalan and Ravallion, 2003).

Several mechanisms underlie the benefits of tap water access for child health. One key factor is cleaner water sourcing: water provided through pipelines is often sourced from deep, uncontaminated groundwater, in contrast to public open wells that may contain shallower, polluted water, or surface water sources. Another factor is the reduced need for water storage, which can compromise water quality over time (Shaheed et al., 2014). Households without reliable tap water often store water, risking deterioration in quality; by contrast, households with reliable tap water can draw from the system when needed, eliminating the need for storage.

These health benefits are not always guaranteed, however, especially given the challenges of infrastructure quality in scaled-up policy initiatives. Expanding tap water infrastructure at scale may compromise the reliability of supply, as well as quality, in favor of a more rapid expansion of the number of connections. Contamination risks may arise from poor infrastructure design, such as water being drawn from shallower, polluted sources to reduce costs, contamination within the network due to low-quality piping, or a lack of sufficient water treatment to ensure high quality. If people consume contaminated water without being aware of quality concerns, they may even experience adverse health effects. They might also adjust their health behavior—for example, by discontinuing water treatment before consumption—after receiving piped water, as they believe it to be safe (Bennett, 2012; Jeuland et al., 2021). This compensatory behavioral adjustment can also lead to adverse health effects.

Given these factors, the overall health impact of scaled-up tap water policies remains uncertain. To clarify this, we pair our time use analysis with an empirical analysis of health impacts. Health effects are expected to be more pronounced among those who experienced time-use gains or increased access to tap water.

3 Data

To examine the impact of tap water access on time use, we combine data from a government survey on time use with administrative data on JJM tap water connections and weather measures. Moreover, we use government survey data on health to evaluate the health impact of tap water connections.

3.1 Tap Water Access

We measure exposure to tap water connections by using administrative data on tap water infrastructure constructed under the JJM. The Department of Drinking Water and Sanitation under the Ministry of Jal Shakti publishes district-level progress on the number of households supplied with piped connections on a monthly basis. In the time-use analysis, this JJM dataset enables us to identify whether any households in specific districts had received new piped connections under JJM by the TUS survey date. Here, we assume a household is treated if any household in the district gained a JJM connection by the survey date, as determined from the district-level aggregate JJM dataset. For the health analysis, we construct the pre-JJM tap water coverage at the district level as of April 2019 by dividing the number of households with tap water access by the total number of households in that month.

3.2 Weather

The other key variable in the time-use analysis is the daily temperature shock. We rely on gridded temperature at 1-degree resolution provided by the India Meteorological Department (IMD) database (Srivastava et al., 2009). We also use daily gridded rainfall at a 0.25-degree resolution as a control variable; this variable comes from the same IMD data source (Rajeevan et al., 2008). These datasets are constructed by interpolating temperature measures from 395 stations and rainfall measures from 1,384 stations across India. For our empirical analysis, We use the average of the maximum and minimum temperatures recorded in the IMD temperature dataset.

To match these weather variables with the other datasets, We compute the district-level means of daily average temperature and rainfall based on the gridded datasets and the Survey of India district boundary data.

3.3 Time Use

One outcome of interest is the time spent on water collection. We use the 2019 Time Use Survey (TUS) to measure individual- and household-level water collection time. This is a nationally representative survey that was conducted from January to December 2019 by the National Sample Survey Organization.

The TUS provides data on how household members spend their time on various activities, including water collection, over a 24-hour period spanning from 4 a.m. on the day before the interview to 4 a.m. on the interview day, recorded in 30-minute intervals.[8] This time-use

[8] In the TUS survey, activities lasting less than 30 minutes were not recorded. Thus, our time-use

information was collected from each member of the sampled households aged six years or older. We also use socioeconomic characteristics from this survey, including household member counts and genders, caste, and religion, for heterogeneity analyses. Our analysis focuses on rural households, who are the target group for the JJM. For our baseline specification, we aggregate water collection time at the household level by summing the total time spent on this activity by all household members.

3.4 Health

The second outcome of interest is child health. We construct the child mortality rate using data from the 5th round of the National Family Health Survey (NFHS-5), conducted from June 2019 to April 2021. The NFHS-5 interviewed all women aged 15–49 years in the sampled households and recorded detailed information about their birth histories.

From the birth histories in the NFHS-5, we construct a child cohort panel dataset spanning from the 1980s to 2020, using the year of childbirth and whether the child died within 12 months of birth as an infant mortality indicator.[9] For robustness checks, we also construct an under-5 mortality indicator by identifying whether the child died within 5 years of birth. By multiplying these mortality indicators by 1,000, our health analysis presents the impacts on child mortality rates per 1,000 children.

3.5 Data Matching and Sample Construction

We construct two separate datasets for the time-use and health analyses. The first dataset comprises time-use data from 12,596 households living in 382 districts in 2019, along for which we have information on tap water access and weather variables.[10] We spatially match the household-level time-use survey data with district-level daily weather data according to the Survey of India district boundaries.

Our second dataset comprises child cohort panel data from the 1980s to April 2020, which includes 32,854 children with child mortality indicators. We match the child-level health dataset with the district-level tap water access data based on the districts where each child's household is located.

Table 1 presents summary statistics for the variables used in both the time-use and health

analysis focuses on the intensive margin effect of tap water access, specifically examining whether it reduces the time spent on water collection, conditional on engaging in this activity.

[9] We excluded children who were less than one year old at the time of the survey from our final sample, as their infant mortality status cannot be determined in this data source.

[10] Our final sample includes time-use data recorded from April to December 2019, aligning with the time period in the JJM dataset. As JJM started in August 2019, our final sample balances the number of months pre- and post-JJM.

analyses. Figure 2 provides a visual representation of the average water collection time across districts, alongside an indicator for whether each district received new tap water connections under the JJM in 2019. This variation in water collection time and the early implementation of JJM connections across districts serve as key elements in the time-use analysis.

4 The Impact of Scaling Tap Water Access on Time Use

We first examine the gendered and distributional impacts of scaling tap water access on time use, aiming to assess whether it alleviates the burden on women and reduces inequalities in water access.

4.1 Empirical Strategy for Time Use Analysis

Because tap water connections were not randomly assigned across districts and households under the JJM, a naive analysis of the effect of connections on time use would be liable to generate biased measures of impacts. To better identify the causal effects of tap water access on time use, we exploit the presumably random variation of daily temperature, which effectively serves as a shock to water demand. Specifically, we examine whether higher temperatures increase water collection time due to increased water demand and whether tap water access under the JJM insulates households from this shock.[11]

Specifically, we adopt the following specification that regresses time-use outcomes on temperature, the interaction term between temperature and the JJM connection indicator, and the JJM connection indicator after controlling for precipitation and district fixed effects:

$$Time_{h,d,t} = \alpha + \beta_1 Temp_{d,t} + \beta_2 Temp_{d,t} * JJM_{d,t} + \beta_3 JJM_{d,t} + \gamma \mathbf{X_{d,t}} + \delta_d + \varepsilon_{h,d,t} \tag{1}$$

where $Time_{h,d,t}$ is a water collection time for household h in district d on the survey date t.[12] $Temp_{d,t}$ is the average temperature in district d on the survey date t. $JJM_{d,t}$ is an indicator taking a value of one if any JJM connection occurred in the district d by the survey date t. We control for precipitation and the interaction term of precipitation and the JJM indicator ($\mathbf{X_{d,t}}$) to isolate the effects of temperature, which may be correlated with precipitation. We include district fixed effects (δ_d) to control for time-invariant unobserved district-level determinants of time use patterns. These district fixed effects also effectively

[11] This approach focusing on the interaction of the policy and presumably random variation of temperature aligns with the methodologies adopted in Colmer and Doleac (2023) and He and Tanaka (2023).

[12] More precisely, t is set to be the date one day before the interview because the Time Use Survey records time use in the previous day of the interview.

serve as time fixed effects to control for seasonality in water collection time, as survey timings within districts tend to be concentrated within a narrow range of months, as shown by the distribution of survey durations in Appendix Figure A1.[13] Standard errors are clustered at the district level because variations in the treatment variables (temperature and JJM indicator) are observed at this level.

The coefficients of interest are β_1 and β_2. We expect that higher temperature increases the demand for water and, consequently, the time allocated to water collection ($\beta_1 > 0$). However, tap water connections are expected to weaken or even eliminate this relationship by diminishing the need for water collection outside the home ($\beta_2 < 0$). The policy effect β_2 reflects a short-run effect, as the time-use outcome was gathered at the outset of the JJM in 2019.

Our regression specification exploits presumably random daily variation in temperature to estimate the causal effect of temperature on water collection time. By including district fixed effects, we identify the temperature effects from the variations in temperature shocks across households within the same district, which are attributed to surveys conducted on different dates. As shown in Appendix Figure A2, there is substantial variation in survey-date temperatures across our sample households. Because of unpredictable and presumably random fluctuation in temperature, the coefficients β_1 and β_2 can be interpreted causally.

Returning to the initial identification concern highlighted at the start of this section, one might still be concerned that the JJM indicator is not exogenous; early-phase JJM implementation might be influenced by district characteristics, which could drive our results. Indeed, our balance test of various district characteristics shows that JJM districts differ from non-JJM districts in terms of caste and religious composition, family size, and consumption levels (Appendix Table B2). To address this concern, we conduct robustness checks that also control for unbalanced district characteristics. Additionally, falsification tests show that the effect of the JJM indicator becomes insignificant during the pre-JJM period, mitigating concerns about other correlated characteristics driving the results.

4.2 Gendered Impacts on Time Use

We find that the JJM has effectively reduced water collection times, especially among women, who predominantly bear the burden of water collection, highlighting the gendered impact of the JJM policy. Although higher temperatures lead to increased water collection times, as hypothesized, tap water connections under JJM mitigate this effect.

[13] In some districts, the survey period extended over many months, which limits the ability of district-fixed effects to fully control for seasonality. To address this, we conduct a robustness check that includes quarter fixed effects, as discussed in Section 4.3.

Table 2 presents our main results on this effect of JJM tap connections reducing water collection time.[14] As shown in Column 1 of Table 2, an increase in average temperature by one degree Celsius increases water collection time by about 1.5 minutes per household. However, households living in districts gaining tap water connections under JJM by the survey date experience no such increase, as the point estimate of 2.5 minutes per degree rise in temperature in such locations completely offsets the main impact of temperature.

Regarding gendered effects, we observe that the positive impact of tap water connections is concentrated in households with only female water collectors, suggesting that such households are those where there is the greatest margin for increased water collection given a shock to demand. Accordingly, women in such households also benefit especially from access to tap water. As illustrated in Columns 2–4 of Table 2, the coefficient on the interaction terms between temperature and JJM connections is statistically significant only for households with exclusively female collectors. This finding aligns with the fact that women are primarily responsible for water collection and, thus, stand to gain the most from improved access to tap water. Although households with both female and male collectors may also benefit from tap water access, the estimate becomes imprecise, likely due to the limited sub-sample size (Column 4).

4.3 Robustness Checks for Time Use Analysis

Our results are robust to individual-level analysis, additional controls, a falsification test examining effects in the pre-JJM period, and an alternative DiD analysis comparing households surveyed before and after the start of JJM, as detailed below.

Individual-Level Analysis.—The time-use analysis highlights the impacts of tap water connections at the household level for different types of households, where these types are differentiated based on the gender composition of water collectors. However, the heterogeneous effects observed at the household level could be influenced by other household characteristics correlated with the gender composition of water collectors. To address this concern, we conduct the analysis at the individual level. In Appendix Table B3, our findings confirm that the time-use benefits of JJM connections persist in the individual-level analysis, with significant positive effects concentrated among female water collectors.

Additional Controls.—As discussed in Section 4.1, one concern is the exogeneity of JJM connections. To mitigate this, we directly control for unbalanced characteristics between JJM and non-JJM districts, which are found to be SC, ST, OBC, Hindu, number of household

[14] For reference, the complete results of the time-use analysis, including the coefficients for rainfall, are presented in Appendix Table B1.

members, and monthly consumer expenditure in Appendix Table B2. This approach allows us to better isolate the JJM effect by additionally controlling for these variables and their interactions with temperatures in regression 1. In Column 1 of Appendix Table B4, we continue to observe time-use benefits from JJM connections for households with only female water collectors, though the effect of average temperatures becomes somewhat less precise.

As another robustness check, we introduce stricter time controls by adding quarter fixed effects. As the district fixed effects may not fully control for seasonal variation in water collection time for districts with longer survey periods, as discussed in Section 4.1, the inclusion of quarter fixed effects provides more precise control for seasonality. The results remain consistent even with the inclusion of quarter fixed effects (Column 2 of Appendix Table B4).

Falsification Test.—To address concerns regarding the potential non-exogeneity of JJM connections, we also conduct a falsification test by examining the effects of temperatures and JJM during the pre-JJM period (April–July 2019). If our findings are attributable to the JJM policy rather than driven by other correlated district characteristics, we should not observe significant effects during the pre-policy period. Encouragingly, we find no significant effects of JJM on water collection time prior to the policy's implementation, as shown in Appendix Table B5. This result suggests that confounding district characteristics, correlated with the early implementations of JJM tap water connections in 2019, are unlikely to be driving our results.

Alternative DiD Analysis.—As an alternative identification strategy, we implement a DiD analysis that compares the time use of households surveyed before the start of JJM with those surveyed after, within the same district. Specifically, we regress water collection time on temperature and its interaction with survey time (year-month) dummies, as shown in the following specification:

$$Time_{h,d,t} = \alpha + \sum_{\ell=-\underline{\ell}}^{\overline{\ell}} \beta_\ell Temp_{d,t} \cdot T_\ell + \gamma Temp_{d,t} + \delta_d + \theta_t + \varepsilon_{h,d,t} \tag{2}$$

The key difference from the baseline time use regression 1 is that we interact temperature with survey time dummies to compare pre-JJM and post-JJM periods, rather than with a JJM indicator that switches to one upon the occurrence of the first JJM connection in the district. This DiD specification allows us to directly assess the parallel trends assumption and to examine dynamic effects using an event study design. The coefficients of interest are the β_ℓ coefficients, which capture how the effect of temperature on water collection time changes across pre- and post-policy periods. We include district fixed effects (δ_d) to identify the effect from within-district variation in water collection time. As we rely on within-district variation, we restrict the sample to the 239 districts (out of the 382 districts used in the baseline specification) that have households surveyed in both the pre- and post-policy periods. We also include survey time fixed effects to control for seasonal patterns and common time trends in time use. In this event study specification, July 2019, which is one month prior to the start of JJM, serves as the reference period. Standard errors are clustered at the district level, as in the baseline specification.

We find similar positive effects of the JJM policy in reducing water collection time. Appendix Figure A3 shows no differential trends prior to the start of the JJM. However, after the policy begins, higher temperatures lead to reduced water collection time relative to the pre-policy periods. This DiD result suggests that the JJM mitigates the relationship between temperature and water collection time, consistent with the baseline findings. The estimated magnitudes in the post-policy periods range from -2.3 to -2.6, which is comparable to the baseline results.

4.4 Distributional Effects on Time Use

We also find that tap water access predominantly benefits marginalized caste groups, including SC and ST households, demonstrating the distributional effects of mitigating inequality in water access. Moreover, further heterogeneity analyses show that the time use benefit is particularly substantial among Hindu households, who are known to have lower levels of private water investment, and for larger households, who likely have a higher demand for water.

Caste.—To analyze the distributional effects of tap water access, we examine how these effects vary across marginalized and non-marginalized caste groups. As discussed in Section 2.2, SC and ST often face discrimination in accessing various services, including water supplies. For this analysis, we define SC, ST, and Other Backward Classes (OBC)—the latter comprising other socially and educationally disadvantaged communities—as marginalized caste groups. We then compare the impact of tap water access on these groups relative to advantaged caste groups (General).[15]

As shown in Columns 1 and 2 of Table 3, we find that the benefits of JJM connections are pronounced for SC, ST, and OBC households, but are not observed for General households.

[15] This section's heterogeneity analyses focus on the 9,270 households with only female collectors, as they are the group shown to benefit from tap water access in Section 4.2. These households constitute 76% of the total sample.

This finding suggests that scaling up tap water access helps to reduce inequality in water access between advantaged and disadvantaged groups.

Religion.—We also find that the positive effects of tap water access are more pronounced for Hindu households than for Muslim households, as shown in Columns 3 and 4 of Table 3). These heterogeneous effects by religion could be attributed to pre-existing differences in private water infrastructure investments among religious groups. Muslim households in rural India are generally more likely to own and utilize water and sanitation facilities within their premises than Hindu households (Geruso and Spears, 2018). Consequently, Muslim households may invest more in in-home water facilities that lessen the need for women to fetch water outside, even prior to JJM program implementation, which could reduce the benefits derived from new JJM connections.

Household Size.—Considering household size, we find that the time-use benefits of tap water access, at least those owing to demand shocks from temperature, are more pronounced in larger households with a greater number of members, as indicated in Columns 5 and 6 of Table 3. This result aligns with expectations, as larger families generally have higher water demand, indicating that the time allocated to water collection would be substantially greater in these households absent receiving tap water access under the JJM.

5 The Impact of Scaling Tap Water Access on Health

We next examine the gendered and distributional impacts of scaling tap water access on child health, aiming to assess whether the quality of water infrastructure was sufficient to also improve health outcomes.

5.1 Empirical Strategy for Health Analysis

To identify the causal effects of tap water access on child health, we leverage the differential increases in tap water coverage across districts. Specifically, we adopt a DiD design, using the pre-JJM baseline tap water coverage as a treatment indicator to measure the intensity of new tap water connections established during the JJM period.[16] The JJM policy aims to achieve 100% tap water coverage in all districts by the target year of 2024, regardless of initial coverage levels. As a result, districts with lower baseline coverage are expected to see larger increases in tap water connections under the JJM. Supporting this approach, there was

[16] This DiD approach, using variation in the baseline degree of policy implementation, follows similar methods to those in Duflo (2001) and Bleakley (2007).

substantial variation in tap water coverage across districts prior to the JJM implementation (Figure 3).

For this DiD analysis, we adopt the following event study specification:

$$Mortality_{i,d,t} = \delta_d + \theta_t + \sum_{\ell=-\underline{\ell}}^{\overline{\ell}} \beta_\ell^{DID}(1 - JJM_d^{pre}) \cdot T_\ell + \varepsilon_{i,d,t} \tag{3}$$

where $Mortality_{i,d,t}$ is a child mortality indicator for child i in district d in year-month t. JJM_d^{pre} denotes the baseline tap water coverage in district d as of April 2019, prior to the launch of the JJM policy. T_ℓ are the year-by-month dummy variables. The interacted dummy variable for July 2019, one month before the start of JJM, is excluded from the regression to serve as a reference period. We include district fixed effects (δ_d) to control for time-invariant district characteristics that may affect child health. Year-by-month fixed effects (θ_t) are also included to account for seasonality and longer-run trends in child mortality across India. Standard errors are clustered at the district level because the baseline tap water coverage variation that we exploit is across districts.

The coefficient of interest, β_ℓ^{DID}, measures the treatment effect on child health for each year-month, relative to July 2019. We examine β_ℓ^{DID} for the period spanning August 2018 to June 2019 (2-12 months pre-JJM) to test the parallel trends assumption. In contrast, the β_ℓ^{DID} for August 2019 to April 2020 (0-8 months post-JJM) captures the short-run evolution of treatment effects in the first 8 months post-implementation.[17] A positive (negative) β_ℓ^{DID} indicates adverse (beneficial) health effects, and, as discussed in Section 2.4, the sign of this effect is theoretically ambiguous.

5.2 Gendered and Distributional Impacts on Health

We find that scaling tap water access under the JJM policy leads to an increase in child mortality, particularly among the marginalized caste groups who gained more water access. This suggests that, in the effort to scale up water access, the quality of water infrastructure may have been compromised, leading to adverse health consequences for those who benefited the most from increased access.

Main Results.—As shown in Panel A of Figure 4, we find negative health effects of tap water access on infant mortality, most notably seven to eight months after the launch of the JJM. The magnitude of these effects is an increase in infant mortality of 116–128 per 1,000

[17] April 2020 marks the latest birth year-month for children in our final sample, allowing us to examine the effects up to this point. For the pre-policy period, although child data dates back to 1980, we focus on child cohorts from one year prior to JJM to align with the length of the post-policy period in our sample.

children, with p-values of 0.001–0.032. This means that a 10% lower tap water coverage level prior to the JJM led to an increase in infant mortality by 11.6–12.8 per 1,000 children—a 33–36% increase from pre-JJM levels. Moreover, we find no differential effects during the pre-policy periods, supporting the assumption of parallel trends.

Our findings regarding this negative health effect are consistent across different time frequencies and with the adoption of an alternative mortality indicator. First, a quarterly analysis, presented in Panel B of Figure 4, shows a similar negative health effect, reinforcing the findings from the monthly analysis.[18] Second, we also find adverse health effects on the under-5 mortality rate, a commonly used alternative child mortality measure (Appendix Figure A4).

Heterogeneous Effects by Gender and Caste.—We also investigate the gendered and distributional effects on child health, focusing on heterogeneity across gender and caste groups.

First, we find gendered effects, with negative effects observed only among male children. Figure 5 illustrates the effects of tap water access on infant mortality rates, separately for male and female children. We find negative health effects for male children seven to eight months after the start of the JJM (Panel B), but not for female children (Panel A). This gendered effect may be attributed to the greater biological vulnerability of male children or the prioritization of using the new piped water system for male children due to male preference, without recognizing the associated risks.

Second, we find distributional consequences, with negative effects observed only among marginalized caste groups. Figure 6 presents the results, separately for children from marginalized caste groups (SC, ST, and OBC) and those from advantaged caste groups (General). The negative health effects are concentrated among the marginalized caste groups (Panel A), whereas the effects are statistically insignificant for the General caste group (Panel B).

Given that the time-use analysis indicated that marginalized caste groups experienced larger gains in water access, our findings suggest that while the JJM policy did successfully improve access to tap water for disadvantaged groups, it may have compromised on infrastructure quality or paid insufficient attention to compensatory behavioral adjustments, leading to adverse health consequences for these groups, at least in the short term.

5.3 Mechanism of Health Impacts

To further investigate the mechanism underlying the negative health effects, we examine whether the JJM worsens water quality indicators, as a test of compromised infrastructure

[18] The quarterly analysis aggregates monthly data by calculating averages and uses year-by-quarter fixed effects rather than year-by-month fixed effects.

quality. We find that increases in JJM connections are associated with a rise in the number of villages with contaminated water samples, particularly those affected by bacterial contamination.

To analyze the water quality mechanism, we use an additional JJM administrative dataset that records, for each district, the number of villages with contaminated water samples from 2021 to 2024. The number of villages with contamination is reported separately for each type of water quality indicator, including bacterial contaminants (e.g., *E. coli* and total coliform) and chemical contaminants (e.g., turbidity, arsenic, and nitrate).[19] Accordingly, we analyze the effects separately for each indicator, as well as for the total number of villages with contamination summed across all indicators. Although the source of the water samples is not explicitly reported in the dataset, they are likely drawn primarily from JJM piped water, as the dataset is published on the JJM website. We merge this district-level panel with JJM tap water connection data from 2021 to 2024.

Because water quality outcomes are available only for recent years in the post-JJM period, we cannot apply the same DiD specification as in regression 3. Instead, we regress water quality outcomes on the cumulative number of households connected to tap water under the JJM policy at the district-year level, controlling for district fixed effects and year fixed effects. This two-way fixed effects specification exploits within-district variation in tap water access while controlling for common time trends in water quality. However, we note that due to potential omitted variables and reverse causality, this analysis should be interpreted as correlational and suggestive rather than causal.

We find that a larger number of JJM connections is associated with an increase in the number of villages with contaminated water samples. Table 4 shows that JJM connections are positively correlated with the total number of villages with contamination, and that this relationship is driven primarily by bacterial contaminants, including *E. coli* and total coliform (Columns 1–3). This finding is consistent with the health results showing an increase in infant mortality, as bacterial contaminants are a leading cause of diarrhea, which in turn increases infant mortality. By contrast, we do not find a significant association between JJM connections and chemical contaminants (Columns 4–6). The absence of effects for chemical contaminants helps alleviate a potential concern about spurious correlations arising from increased water sample testing in areas with greater JJM connection intensity. If expanded piped water access simply led to more intensive testing, we would expect positive associations across all indicators affected by increased sampling. However, we do not observe such a

[19] The full set of available water quality indicators includes *E. coli*, total coliform, other bacteria, pH, total dissolved solids, turbidity, chloride, total alkalinity, total hardness, sulphate, iron, total arsenic, fluoride, nitrate, residual chlorine, and other chemicals.

pattern.

These water quality results suggest that JJM delivered infrastructure with compromised water quality by prioritizing the expansion of water access. While piped water is often contaminated and unsuitable for drinking, even in urban areas in India, rural populations may have consumed it under the belief that water from newer infrastructure is safer, without undertaking additional water treatment.

6 Conclusion

Scaling water programs to nationwide, universal implementation may benefit people differentially across genders and socioeconomic groups. This study examined the Jal Jeevan Mission, a nationwide tap water policy in rural India, focusing on its differential effects on time use and health outcomes for women and historically marginalized groups.

Exploiting the presumably random variation in daily temperature, we first found that the policy benefited women by reducing the time they spent collecting water, thereby addressing gender disparities. Additionally, the policy had a notable distributional impact, with historically marginalized caste groups benefiting the most from increased water access. This suggests that the policy helped to narrow inequalities in water availability.

However, in the health analysis, leveraging differential increases in tap water coverage across districts, we found a negative health effect of increased infant mortality. These negative effects were concentrated among marginalized caste groups who gained more water access under the policy. Taken together with our findings of increased bacterial contamination in water samples associated with greater JJM tap water connections, these results suggest that prioritizing access expansion over infrastructure quality may have unintended negative health consequences.

These findings have important policy implications. Scaling the program to a nationwide policy could indeed increase the number of beneficiaries and reduce inequalities in access. However, if resource allocation disproportionately favors expanding water access rather than enhancing infrastructure quality, the full potential benefits may not be realized. Achieving the program's full benefits (both in terms of time savings and health improvements in our case) requires a careful balance between infrastructure quantity and quality as the program scales.

Our study, however, is limited to examining the short-term effects of the policy, which may differ from its long-term impacts. As for time use, the benefits for disadvantaged caste groups might increase as more households gain access, further mitigating water access inequalities. In terms of health, the negative effects observed may diminish if water quality delivered by the piped network is improved or if households eventually recognize and respond to health risks associated with poor tap water quality, either by changing their use patterns or by treating water at home. Indeed, once universal access is achieved, the policy focus could shift from expanding access to improving quality, potentially enhancing infrastructure quality over time and thereby delivering positive health effects across the board.

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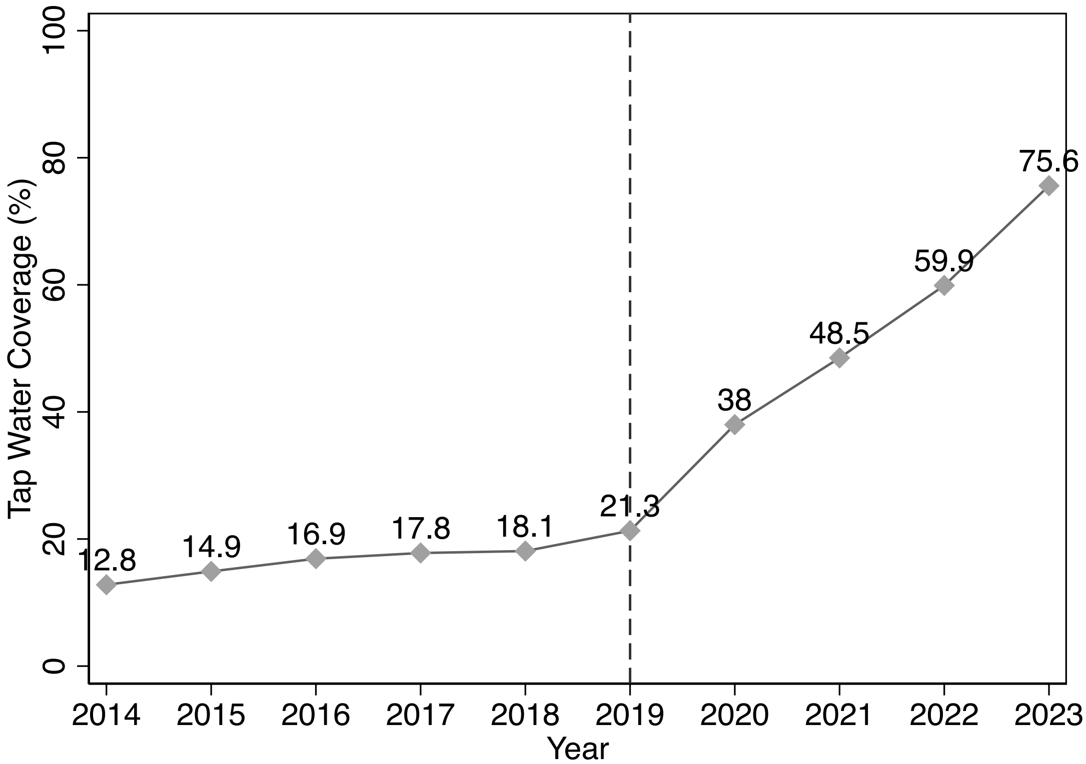

Figure 1: Tap Water Coverage in Rural India

Notes: This figure documents the proportion of households connected to tap water in rural India between the fiscal years 2014 and 2023. A vertical dashed line shows the starting year of the JJM.

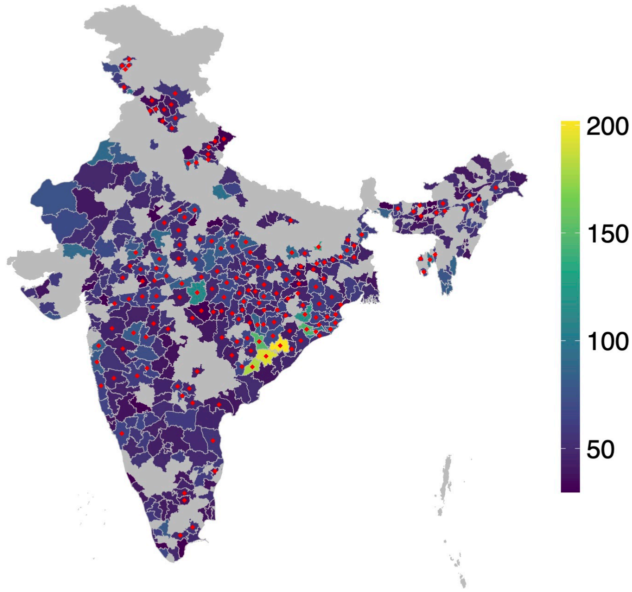

Figure 2: Water Collection Time and JJM Tap Water Connections

Notes: The gradient colors indicate the average daily water collection time per household (minutes) for each district in 2019. The red diamonds show that new JJM tap water connections were provided during the TUS period in 2019. Grey areas represent districts with missing data on water collection time.

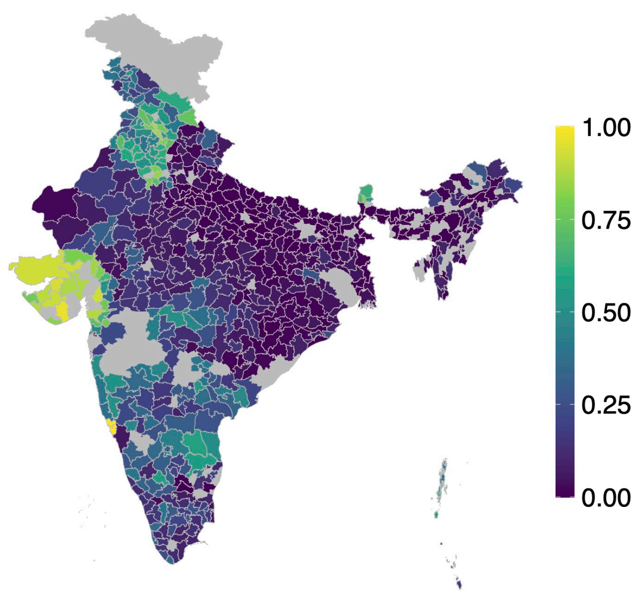

Figure 3: Pre-JJM Tap Water Coverage

Notes: The gradient colors indicate rural tap water coverage in each district as of April 2019, prior to the launch of the JJM. Grey areas represent districts with missing data on tap water coverage.

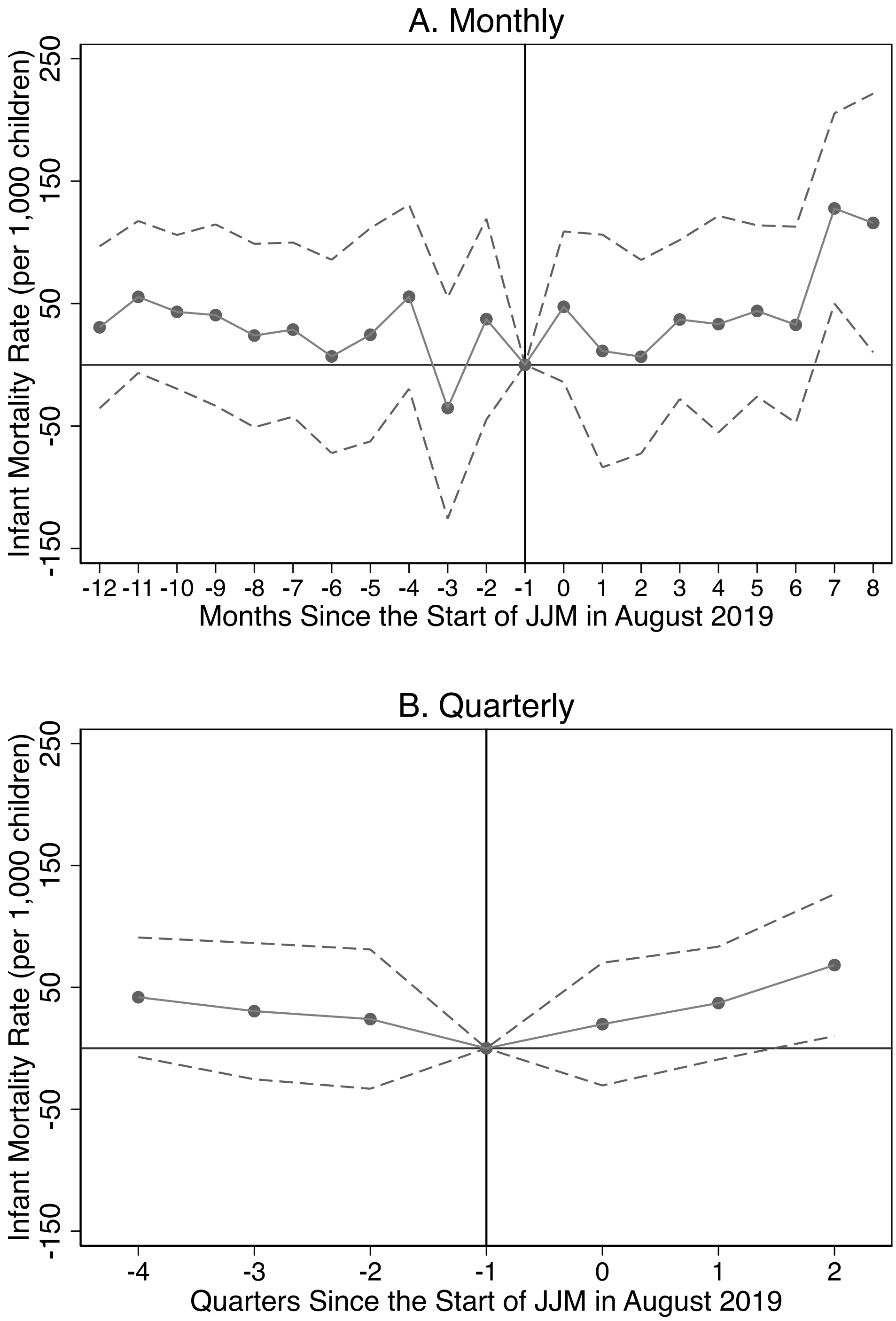

Figure 4: The Effect of Tap Water Access on Health (Infant Mortality Rate)

Notes: This figure shows the regression coefficients of the infant mortality rate from regression 3. The 95% confidence intervals are shown with dashed lines. Standard errors are clustered at the district level. The regressions include district fixed effects, along with year-by-month fixed in Panel A and year-by-quarter fixed effects in Panel B.

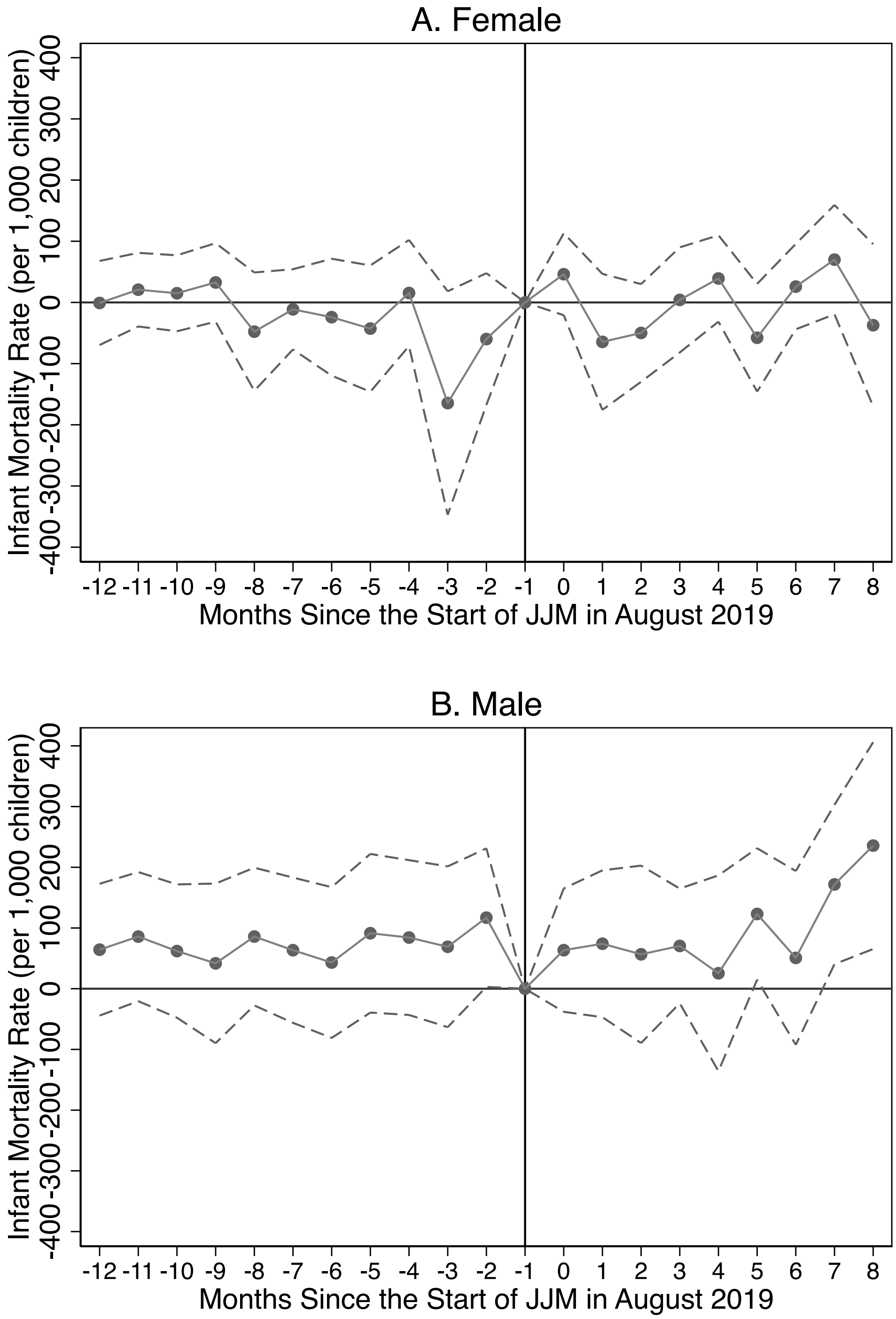

Figure 5: The Gendered Effects of Tap Water Access on Health (Infant Mortality Rate)

Notes: This figure shows the regression coefficients of the infant mortality rate from regression 3. The 95% confidence intervals are shown with dashed lines. Standard errors are clustered at the district level. The regressions include district fixed effects and year-by-month fixed effects.

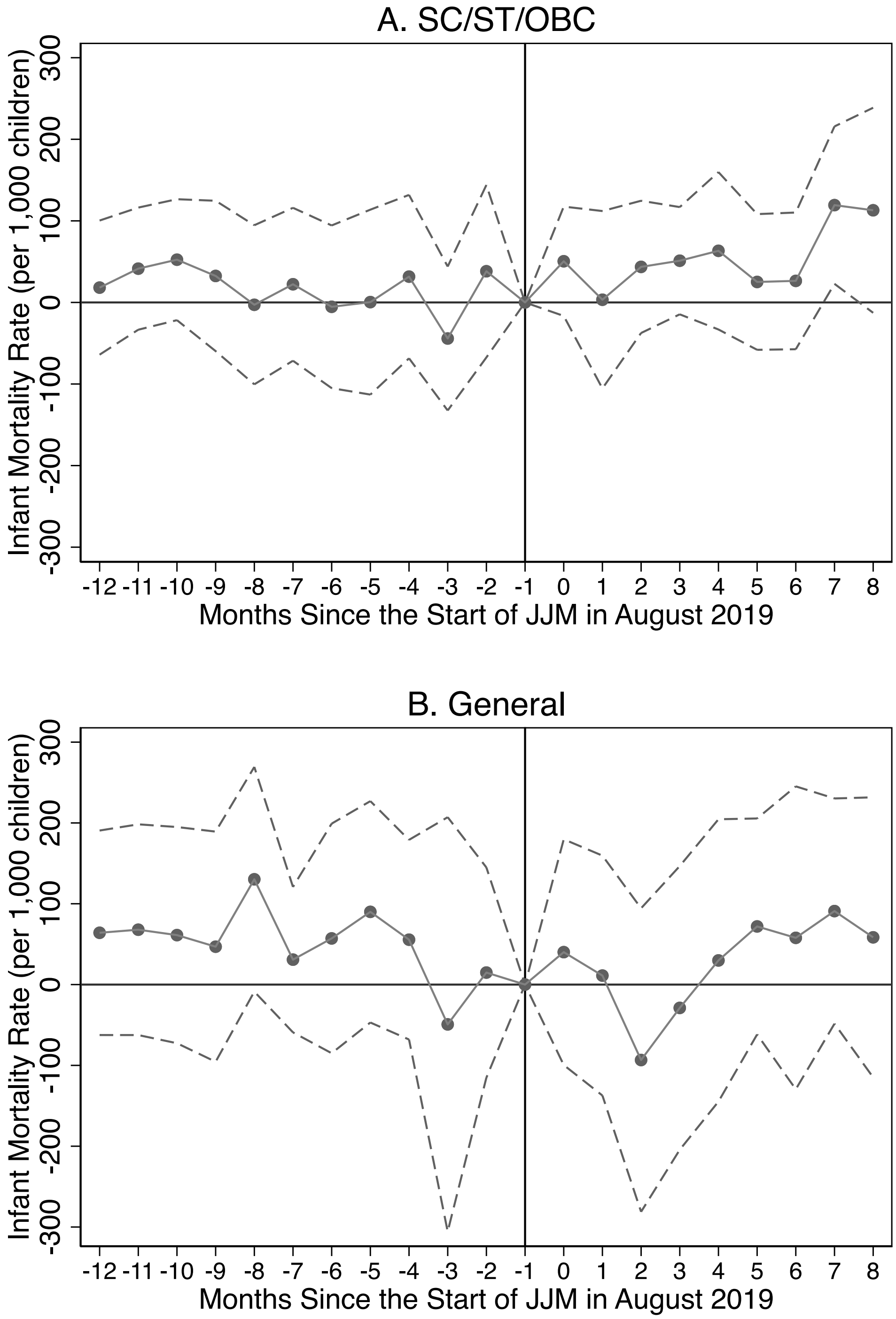

Figure 6: The Distributional Effects of Tap Water Access on Health (Infant Mortality Rate)

Notes: This figure shows the regression coefficients of the infant mortality rate from regression 3. The 95% confidence intervals are shown with dashed lines. Standard errors are clustered at the district level. The regressions include district fixed effects and year-by-month fixed effects.

Table 1: Summary Statistics

	Mean	SD	Min	Max	Obs.
Panel A. Time Use Analysis					
Daily water collection time per household (minutes)	68.72	49.45	30	600	12596
Number of female water collectors	0.96	0.54	0	5	12596
Number of male water collectors	0.26	0.5	0	4	12596
Any JJM connections by the survey (0/1)	0.11	0.31	0	1	12596
Average temperature on survey date (C)	27.21	4.23	8.97	38.71	12596
Number of household members	3.95	1.75	1	22	12596
SC, ST, or OBC	0.81	0.39	0	1	12596
Hindu	0.82	0.39	0	1	12596
Muslim	0.08	0.27	0	1	12596
Panel B. Health Analysis					
Infant mortality indicator (0/1)	0.04	0.19	0	1	32854
Under-5 mortality indicator (0/1)	0.04	0.19	0	1	32854
Pre-JJM tap water coverage	0.18	0.23	0	1	660
Women	0.48	0.5	0	1	32854
SC, ST, or OBC	0.85	0.36	0	1	32030
Panel C. Water Quality Analysis					
Number of villages with any contamination (sum of indicators)	232.37	602.79	0	6724	2470
Number of villages with E. coli contamination	19.98	107	0	1714	2470
Number of villages with total coliform contamination	34.01	147.23	0	1872	2470
Number of villages with turbidity contamination	30.46	131.65	0	2095	2470
Number of villages with arsenic contamination	5.4	65.91	0	1432	2470
Number of villages with nitrate contamination	28.64	90.47	0	1147	2470
Cumulative JJM Connections (1k households)	108.12	104.85	0.03	1036.77	2470

Notes: This table reports summary statistics for the household-level variables used in the time use analysis (Panel A), child or district-level variables used in the health analysis (Panel B), and district-level variables used in the water quality analysis in the mechanism of health impacts (Panel C).

Table 2: The Gendered Effects of Tap Water Access on Water Collection Time

	All	Female Only	Male Only	Gender Mix
	(1)	(2)	(3)	(4)
Average Temperature	1.491***	1.166***	1.332***	3.340*
	(0.291)	(0.241)	(0.411)	(2.002)
Average Temperature	-2.475**	-2.937***	-0.362	-2.032
* JJM Connections (=1)	(1.033)	(1.073)	(1.471)	(5.065)
Observations	12,596	9,622	1,852	984
R^2	0.259	0.312	0.278	0.374
Number of Districts	382	369	228	162
Mean of Dep. Variable	68.722	64.867	56.226	129.421

Notes: This table reports the estimated effects of temperatures and JJM connections on daily water collection time (minutes) at the household level. Standard errors, clustered at the district level, are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects, along with controls for precipitation and the interaction between precipitation and the JJM indicator. Column 1 shows the estimated effects for all households. Columns 2, 3, and 4 show the estimated effects for households with only female water collectors, only male collectors, and both female and male collectors, respectively.

Table 3: The Distributional Effects of Tap Water Access on Water Collection Time

	Caste		Religion		Household Size	
	(1) SC/ST/OBC	(2) General	(3) Hindu	(4) Muslim	(5) Large	(6) Small
Average Temperature	1.113***	1.494***	1.170***	2.319*	0.968***	1.212***
	(0.260)	(0.497)	(0.263)	(1.257)	(0.352)	(0.272)
Average Temperature	-3.615***	-0.161	-3.287***	-0.888	-6.705***	-1.350
* JJM Connections (=1)	(1.153)	(1.532)	(1.034)	(1.326)	(1.713)	(1.147)
Observations	7,787	1,779	8,069	776	3,135	6,435
R^2	0.336	0.245	0.337	0.264	0.300	0.404
Number of Districts	346	178	332	92	304	347
Mean of Dep. Variable	66.569	57.707	65.443	62.552	71.962	61.469

Notes: This table reports the estimated effects of temperatures and JJM connections on daily water collection time (minutes) at the household level. The sample is limited to households with only female collectors. Standard errors, clustered at the district level, are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects, along with controls for precipitation and the interaction between precipitation and the JJM indicator. Columns 1 and 2 show the estimated effects for SC, ST, OBC, and General households, respectively. Columns 3 and 4 show the estimated effects for Hindu and Muslim households, respectively. Column 5 shows the estimated effects for larger households with numbers of household members larger than the sample median, while Column 6 shows the estimated effects for smaller households.

Table 4: Mechanism of Health Impact: Water Quality

	Any Contaminants	Bacterial Contaminants		Chemical Contaminants		
	(1) Sum of Indicators	(2) E. coli	(3) Total Coliform	(4) Turbidity	(5) Arsenic	(6) Nitrate
Cumulative JJM	0.785***	0.440***	0.374***	0.085	-0.031	0.026
Connections (1k households)	(0.263)	(0.102)	(0.083)	(0.054)	(0.040)	(0.028)
Observations	2,470	2,470	2,470	2,470	2,470	2,470
R^2	0.894	0.741	0.858	0.932	0.882	0.776
Number of Districts	663	663	663	663	663	663
District FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Mean of Dep. Variable	232.371	19.976	34.006	30.457	5.400	28.643

Notes: This table reports the estimated effects of the cumulative number of households connected to tap water under the JJM policy on the number of villages with contaminated water samples for each water quality indicator. The dependent variable in the first column is the total number of villages with contamination, summed across all indicators. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects and year fixed effects.

Online Appendix

Gendered and Distributional Impacts of Scaling Water Access:
Evidence from Tap Water Policy in India

Marc Jeuland Julia YuJung Lee Kazuki Motohashi

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A Additional Figures

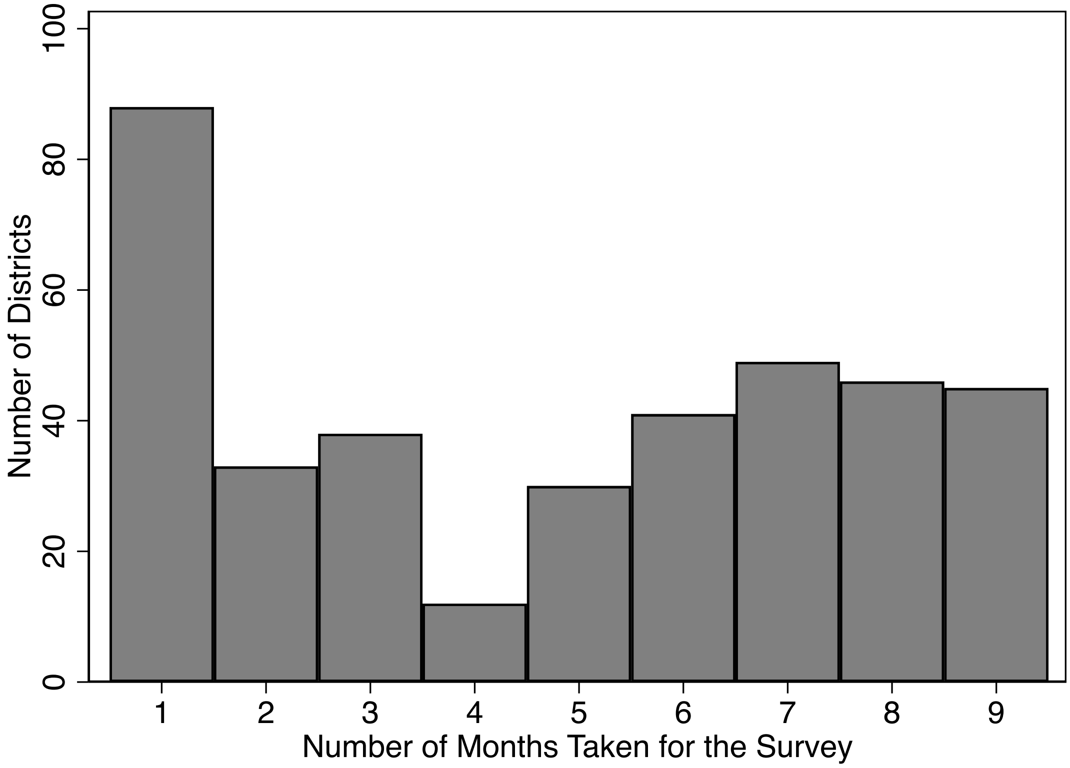

Figure A1: Duration of Time Use Survey by District

Notes: This figure shows the distribution of the number of months taken to conduct the survey in each district for the 2019 Time Use Survey.

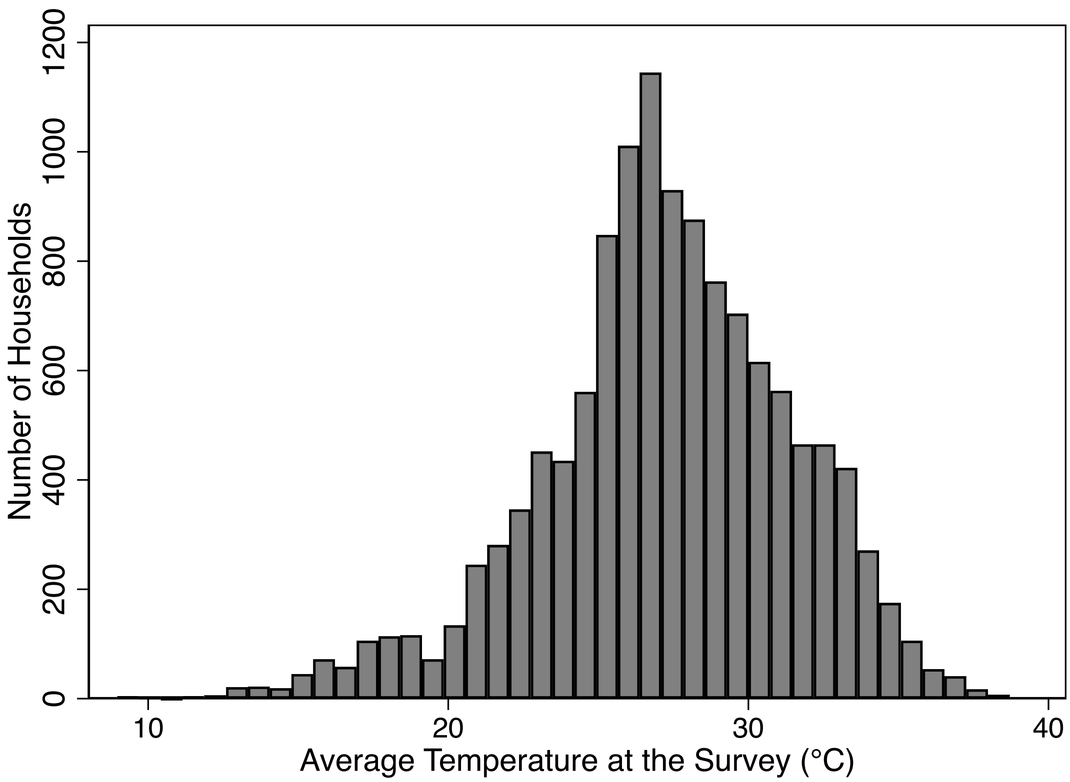

Figure A2: Household-level Temperature Distribution

Notes: This figure shows the temperature distribution across our sample households, with temperatures measured on the day before the interview for the 2019 Time Use Survey. This day corresponds to when time use was recorded.

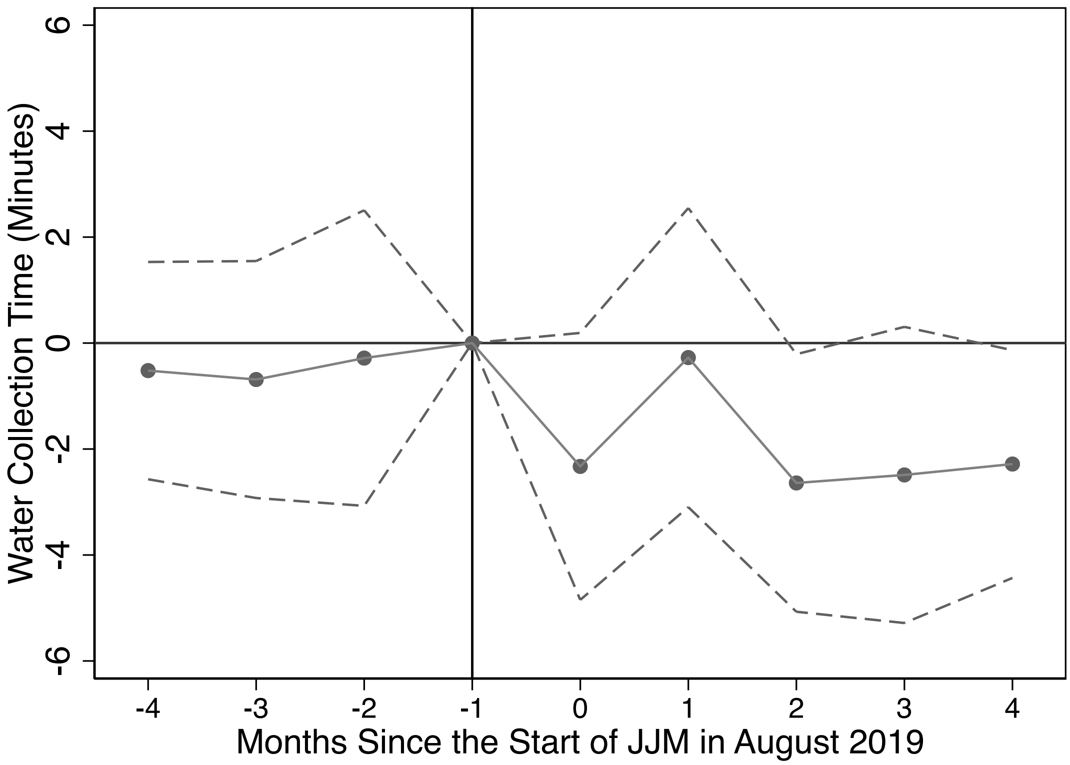

Figure A3: Robustness Checks: Alternative DiD Analysis

Notes: This figure shows the regression coefficients of the water collection time from regression 2. The 95% confidence intervals are shown with dashed lines. Standard errors are clustered at the district level. The regressions include district fixed effects and survey time fixed effects.

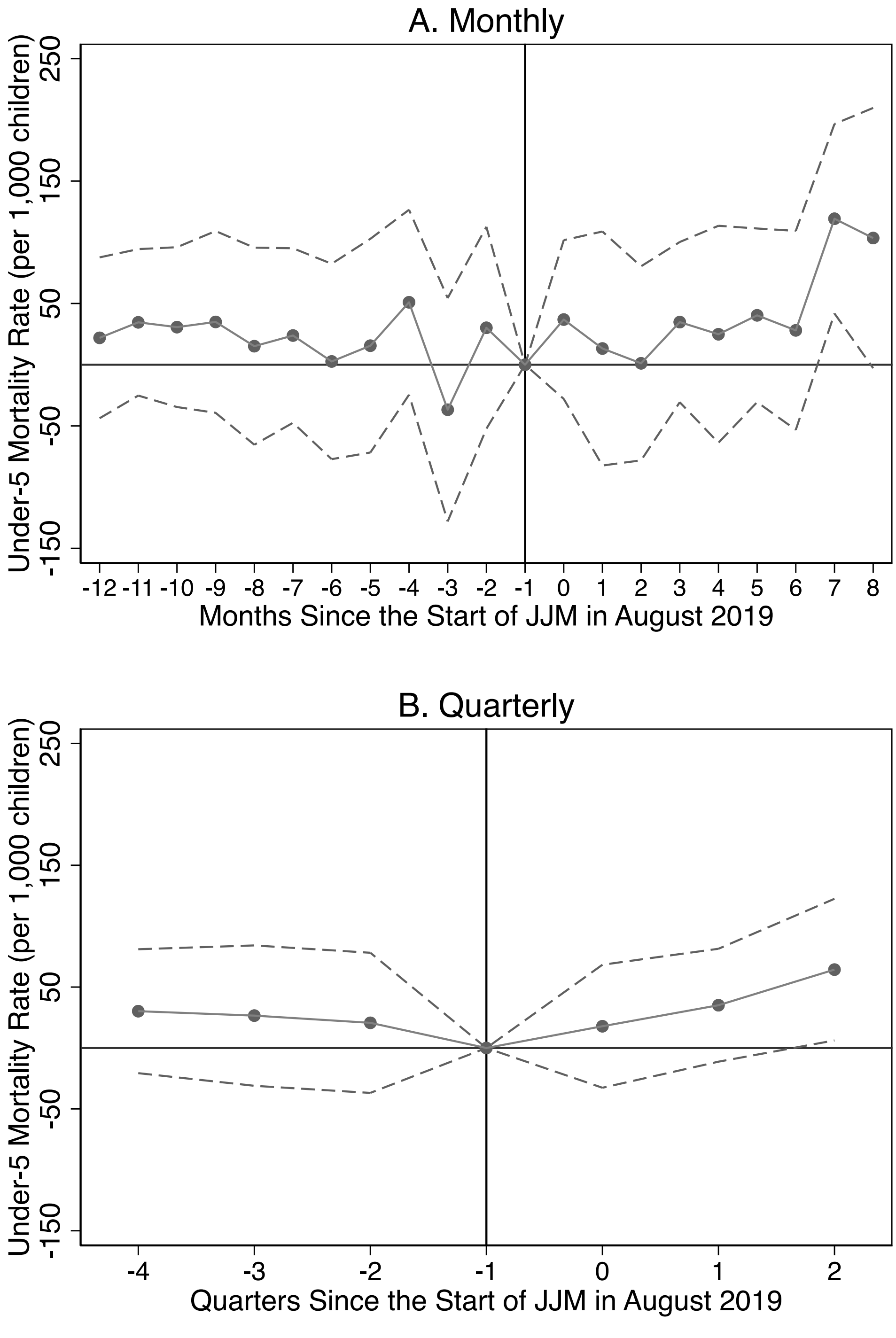

Figure A4: The Effect of Tap Water Access on Under-5 Mortality Rate

Notes: This figure shows the regression coefficients of the under-5 mortality rate from regression 3. The 95% confidence intervals are shown with dashed lines. Standard errors are clustered at the district level. The regressions include district fixed effects, along with year-by-month fixed in Panel A and year-by-quarter fixed effects in Panel B.

B Additional Tables

Table B1: Full Results of Time Use Analysis

	All	Female Only	Male Only	Gender Mix
	(1)	(2)	(3)	(4)
Average Temperature	1.491***	1.166***	1.332***	3.340*
	(0.291)	(0.241)	(0.411)	(2.002)
Average Temperature * JJM Connections (=1)	-2.475**	-2.937***	-0.362	-2.032
	(1.033)	(1.073)	(1.471)	(5.065)
JJM Connections (=1)	47.912**	59.616***	8.840	27.676
	(21.490)	(20.896)	(34.640)	(124.127)
Rainfall	-0.021	-0.015	0.054	-0.132
	(0.043)	(0.045)	(0.050)	(0.214)
Rainfall * JJM Connections (=1)	-1.086	-0.617	-0.664	-4.104
	(0.830)	(0.804)	(1.306)	(2.558)
Observations	12,596	9,622	1,852	984
R^2	0.259	0.312	0.278	0.374
Number of Districts	382	369	228	162
Mean of Dep. Variable	68.722	64.867	56.226	129.421

Notes: This table reports the estimated effects of temperatures, rainfall, and JJM connections on daily water collection time (minutes) at the household level. Standard errors, clustered at the district level, are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects, along with controls for precipitation and the interaction between precipitation and the JJM indicator. Column 1 shows the estimated effects for all households. Columns 2, 3, and 4 show the estimated effects for households with only female water collectors, only male collectors, and both female and male collectors, respectively.

Table B2: Balance Tests between Districts with and without JJM conenctions

	Means		Difference	Obs.
Variable	JJM Districts	Non-JJM Districts		
SC, ST, or OBC	0.785	0.829	0.043*	382
	(0.280)	(0.222)	(0.026)	
Hindu	0.723	0.863	0.140***	382
	(0.365)	(0.250)	(0.033)	
Muslim	0.076	0.071	-0.005	382
	(0.149)	(0.178)	(0.017)	
Number of Household Members	4.083	3.878	-0.205**	382
	(0.824)	(0.758)	(0.082)	
Monthly Consumer Expenditure (Rs)	8,547.174	6,711.498	-1,835.675***	382
	(3,150.778)	(2,181.406)	(281.620)	

Notes: This table reports the means of household characteristics for two distinct groups: households located in districts that received new tap water connections during the TUS period in 2019 (JJM districts) and households in districts without these new connections (non-JJM districts). The final column tests the differences between JJM and non-JJM districts, with ***, **, and * indicating significance at the 1%, 5%, and 10% levels, respectively.

Table B3: Robustness Checks: Individual-level Time Use Analysis

	All	Female	Male
	(1)	(2)	(3)
Average Temperature	0.927***	0.879***	1.191***
	(0.178)	(0.191)	(0.398)
Average Temperature * JJM Connections (=1)	-1.595** (0.684)	-1.928** (0.768)	0.217 (1.420)
Observations	15,446	12,149	3,226
R^2	0.333	0.364	0.268
Number of Districts	382	373	256
Mean of Dep. Variable	56.055	57.086	52.309

Notes: This table reports the estimated effects of temperatures and JJM connections on daily water collection time (minutes) at the individual level. Standard errors, clustered at the district level, are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects, along with controls for precipitation and the interaction between precipitation and the JJM indicator. Column 1 shows the estimated effects for all individuals. Columns 2 and 3 show the estimated effects for female and male individuals, respectively.

Table B4: Robustness Checks: Additional Controls

	Additional Controls	
	(1)	(2)
	Unbalanced Variables	Quarter FE
Average Temperature	-0.137	0.555**
	(0.668)	(0.266)
Average Temperature	-2.388**	-2.366**
* JJM Connections (=1)	(1.029)	(1.049)
Observations	9,622	9,622
R^2	0.340	0.314
Number of Districts	369	369
Mean of Dep. Variable	64.867	64.867

Notes: This table reports the estimated effects of temperatures and JJM connections on daily water collection time (minutes) at the household level. The sample is limited to households with only female collectors. Standard errors, clustered at the district level, are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects, along with controls for precipitation and the interaction between precipitation and the JJM indicator. In addition to these controls, Column 1 adds controls for unbalanced variables and the interaction between these unbalanced variables and average temperatures, while Column 2 includes quarter fixed effects.

Table B5: Robustness Checks: Falsification Test

	All	Female Only	Male Only	Gender Mix
	(1)	(2)	(3)	(4)
Average Temperature	-0.483	0.031	-1.937	1.097
	(0.768)	(0.774)	(1.180)	(2.295)
Average Temperature	0.983	0.471	2.296	1.269
* JJM Connections during 2019 (=1)	(1.115)	(1.075)	(1.916)	(3.969)
Observations	5,062	3,809	702	426
R^2	0.308	0.367	0.374	0.422
Number of Districts	279	259	126	94
Mean of Dep. Variable	76.387	71.334	62.308	146.761

Notes: This table reports the estimated effects of temperatures and JJM connections in 2019 on daily water collection time per household (minutes) recorded during the pre-JJM period. Standard errors, clustered at the district level, are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. All regressions include district fixed effects, along with controls for precipitation and the interaction between precipitation and the JJM binary indicator. Column 1 shows the estimated effects for all households. Columns 2, 3, and 4 show the estimated effects for households with only female water collectors, only male collectors, and both female and male collectors, respectively.