Water Access and Time Allocation: Evidence from Jal Jeevan Mission in India

1 Abstract

This study investigates the causal impact of the Jal Jeevan Mission (JJM) on women's time use, with a particular focus on assessing whether the program alleviates the burden of unpaid domestic labor, especially time spent fetching water. The analysis also explores whether implementing JJM influences young females' time allocation toward learning activities and examines its potential effect on school dropout rates among girls. The research is based on a repeated cross-sectional framework, utilizing two key datasets from 2019: the Time Use Survey (TUS) 2019, which provides detailed individual-level data on daily time allocation, and the administrative data from JJM 2019, which offers month-wise records of new household water connections provided under the scheme. Given the phased implementation of JJM across districts and months, the primary methodological approach adopted is the **staggered Difference-in-Differences**(DiD) design, following the framework of Chaisemartin and D'Haultfoeuille (2020), which accounts for variation in treatment timing. A traditional **Difference-in-Difference** analysis uses October, November, and December as post-treatment periods for comparison and robustness. Recognizing the importance of validating the assumption of parallel trends, future study extensions will consider alternative techniques, such as synthetic control methods, to enhance the credibility of causal claims.

2 Introduction

The study analyzes the causal impact of the JJM on time allocation for females. The study examines whether JJM increased the time spent by young girls in Learning and whether it reduced the burden of fetching water.JJM ensures the installation of functional household tap connections (FHTC)to deliver water directly to homes in rural areas, minimizing the effort required for water collection. The Jal Jeevan Mission (JJM) represents a transformative policy initiative to ensure the universal availability of clean drinking water through FHTCs. This study investigates the causal impact of JJM on individuals' time allocation across various activities, particularly emphasizing its effects on young girls' educational engagement and the Time spent by women and girls fetching water. The availability of FHTC is expected to significantly reduce the time burden of collecting water, which asymmetrically falls on Females and young girls in rural households. By alleviating this constraint, JJM has the potential to generate far-reaching societal, economic, and health benefits. Jal Jeevan Mission was solely focused on providing FHTC in rural households. So, the receivers of the mission were people in rural areas. It thus focused on empowering and developing the rural area. The societal impact of JJM is perhaps one of the most profound aspects of the mission. By reducing the unpaid labor burden traditionally borne by women and girls,

JJM reallocates their time to more productive and empowering activities, such as education and other activities. Notably, the mission asserts that ensuring reliable access to household water connections can lead to a decline in school dropout rates among girls, as they are no longer required to spend substantial portions of their day fetching water (Annual Report, 2019-2020).

Access to clean water plays a crucial role in shaping daily routines, and this research seeks to determine whether the implementation of JJM has led to significant changes in these activities. To examine this relationship, the study draws on data from the Time Use Survey (TUS) 2019 and information on JJM's implementation in the same year. The TUS 2019 dataset provides detailed insights into how individuals allocate their time to different activities. By combining this with JJM data, the study assesses whether the provision of FHTCs has influenced the Time for water collection and, in turn, increased the Timetable for learning. A key aspect of this research is including a TUS variable that records the Time of attending school or university. This is particularly relevant as it allows the study to explore whether JJM has affected school or university attendance rates. By analyzing this data, the research also looks at the possible link between improved water access and school dropout rates, especially among young girls. By taking this approach, the study provides a deeper understanding of how access to water affects education and the distribution of household responsibilities, particularly from a gender perspective. The findings offer valuable insights into the broader socio-economic effects of JJM, shedding light on its role in promoting educational opportunities and reducing the domestic workload for women and girls.

By ensuring piped water connections to households, the program significantly eases the burden on women, who have traditionally been responsible for fetching water. Also, JJM reduces the burden of fetching water, which was the primary activity in rural areas (Singh and Naik (2024)). With this responsibility reduced, women gain the freedom to invest their time in education, skill-building, or income-generating activities, allowing them to become more self-reliant. This change improves their quality of life and strengthens their social and economic roles. As women gain more control over their time choices, traditional gender roles that limit their opportunities can gradually be challenged.

3 Objectives

The primary aim of this study is to assess the causal impact of the Jal Jeevan Mission (JJM) on the time allocation of young girls and women in rural areas, with a particular focus on their engagement in learning activities. In many rural households, access to clean and reliable water remains a persistent challenge, and the responsibility of collecting water largely falls on women and girls. This daily chore consumes significant time, which could otherwise be spent on education or other productive activities. By examining unmarried women aged 6 to 21, this study seeks to determine whether the provision of FHTCs under JJM has reduced the time spent on water collection and, in turn, increased their participation in educational

activities. Since the lack of accessible water often forces girls to prioritize household duties over schooling, this study also aims to explore whether JJM has played a role in reducing school and university dropout rates among young girls in rural areas. If JJM has facilitated better access to water, more girls can likely dedicate their Time to learning, improving their academic outcomes and future opportunities. To analyze unmarried females ' learning outcomes, I further divided the age group into 6-11, 12-14, 15-16, 17-18, and 19-21. This is whether any of the age groups, especially whether teenagers, got a significant impact by the policy.

Beyond its impact on education, this study also investigates whether JJM has alleviated the burden of water collection for women, specifically married and unmarried women between the ages of 19 and 30. This study examines whether this reduction in domestic workload has increased women's participation in Learning activities. Implementing JJM, which provides FHTCs, can free up significant time fetching water. This study examines whether this reduction in domestic workload has increased women's participation in Learning activities. By analyzing pre- and post-JJM time allocation patterns, this research intends to highlight the extent to which improved water access can positively transform the lives of rural women.

Additionally, the study examines whether JJM has reduced the burden of water collection for unmarried girls aged 10 to 18, a group particularly susceptible to household labor demands. In many rural families, young girls are expected to assist in fetching water, significantly limiting their Time studies, play, and other developmental activities. Since water collection is a task that predominantly falls on women and girls, this study aims to explore how improved access to water influences their daily schedules. If JJM has successfully minimized the timesheet for this unpaid household work, it could create a more enabling environment for girls to prioritize their education and personal development. By evaluating these aspects, this study seeks to contribute to the understanding of how policy-driven improvements in water accessibility can enhance educational outcomes, reduce gender-based disparities in time use, and ultimately foster more remarkable economic and social development in rural communities.

4 background

4.1 Jal Jeevan mission

The Jal Jeevan Mission was introduced on August 15, 2019. On August 15, from the historic Red Fort, the importance of water was brought to the forefront of India's development agenda. Emphasizing the long-standing burden faced by women and young girls in rural areas—who travel several kilometers daily to fetch even a minimal amount of potable water—the need for a transformative solution was highlighted. Recognizing this challenge, the government launched the Jal Jeevan Mission, a time-bound initiative to ensure "Har Ghar Jal" (piped water for every household) by 2024, and the policy focused on providing FHTC

in rural areas only, (Ministry of Jal Shakti, 2019).

JJM aims to establish sustainable infrastructure to provide rural households with reliable water availability. The availability of FHTC serves as a key measure of its success. Beyond infrastructure, the mission's impact extends across multiple dimensions:

From a health perspective, exposure to clean water is expected significantly reduce incidence of Acute Diarrheal Diseases (ADD), thereby improving overall health indicators in rural areas. Socially, the initiative is transformative for women and girls. Eliminating the need to travel long distances to fetch water reduces their daily drudgery, empowers women, and contributes to higher school retention rates, particularly among upper primary-level girls who might otherwise drop out due to household responsibilities. Economically, the mission generates employment opportunities by fostering the development of in-village water supply infrastructure. The demand for both semi-skilled and skilled workers in construction, plumbing, water management, and maintenance creates sustainable livelihood opportunities for rural communities, (Annual Report, 2019-2020).

The Jal Jeevan Mission is not just about providing functional household tap connections; it also takes a holistic approach to water resource management. For the first time, a national water supply program has integrated sustainability measures, making conservation and water reuse essential components of its design. By prioritizing long-term water security, the initiative seeks to create a lasting impact on rural households nationwide.

Moreover, JJM prioritizes competency enhancement and advocacy by hosting Educational initiatives and outreach efforts to inform communities about the significance of water conservation and its impact on improving the quality of life. Recognizing the need for financial support, the mission also facilitates resource mobilization, ensuring that States and UTs receive adequate financial assistance for its effective implementation.

JJM aims to give FHTCs to every rural household, ensuring clean and safe drinking water access. A key focus of the initiative is to prioritize the provision of FHTCs in areas facing severe water quality issues, including drought-prone regions, desert villages, and those covered under the Sansad Adarsh Gram Yojana (SAGY). Additionally, the mission seeks to extend functional tap connections to essential public institutions such as schools, Anganwadi centers, Gram Panchayat buildings, health centers, wellness centers, and other community buildings, ensuring that these critical facilities have access to a safe and reliable water supply.

JJM prioritizes awareness-building and stakeholder engagement, emphasizing the importance of safe drinking water and its impact on public health and well-being. By involving communities and relevant stakeholders in water conservation and management efforts, the mission strives to make water a collective responsibility that benefits everyone. Through these comprehensive objectives, the Jal Jeevan Mission aims to create a sustainable and community-driven water supply system, improving the quality of life in rural India.

5 Data and Methodology

5.1 Data

5.1.1 Time Use Survey Data 2019

The primary data source for this study is the Time Use Survey (TUS) 2019, which was utilized to analyze variations in time allocation potentially influenced by the Jal Jeevan Mission (JJM) policy. This cross-sectional dataset offers detailed insights into how individuals distribute their time across various activities—including paid work, unpaid labor, and other daily engagements—which is not typically captured in other large-scale surveys. Notably, the TUS provides valuable data on time spent on Employment, Learning, unpaid domestic work, caregiving, volunteer services, learning, social interaction, leisure, and self-care activities.

The National Statistical Office (NSO) surveyed from January to December 2019 and included a nationally representative sample of 1,38,799 households—82,897 rural and 55,902 urban households. For this study, which focuses on rural dynamics, a subset of 82,890 rural households was used after merging the TUS data with additional datasets related to the JJM implementation. Data was collected through personal interviews, with respondents reporting their time use over a 24-hour reference period—from 4:00 A.M. on the day before the interview to 4:00 A.M. on the interview day. There are 9 Major and 165 minor activities in Time Use Survey Data.

The major activities in the TUS 2019 are as follows:

Activity 1	Employment and related activities
Activity 2	Production of goods for own final use
Activity 3	Unpaid domestic services for household and family members
Activity 4	Unpaid caregiving services for household and family members
Activity 5	Unpaid volunteer, trainee, and other unpaid work
Activity 6	Learning
Activity 7	Socializing and communication, community participation and religious practice
Activity 8	Culture, leisure, mass media, and sports practices
Activity 9	Self-care and maintenance

Table 1: Major Activity Number and Their Descriptions

The Time Use Survey (TUS) 2019 dataset captures individual, household, temporal, and geographical variations. The variables used from the TUS 2019 data in this study are as follows in Table 2

Since the study mainly focuses on the societal outcomes, the desirable outcomes are learning and fetching water. The study focuses on young girls' learning outcomes and analyses women's and girls' time in fetching water. The learning outcomes were observed regarding time spent in learning, formal education, and time spent in attending school/university. For learning outcomes, I observed unmarried females of ages 6 to 21. I further divided the age group into education cohorts: unmarried females aged 6 to 11, 12 to 14, 15 to 16, 17 to 18, and 19 to 21. The time spent in Fetching water is an integral part of the study to analyze. This is because JJM aimed to reduce the burden women and young girls face in fetching water. So, I had four dependent variables associated with fetching water: Fetching water, Fetching water inside the premise, Fetching water outside the premise, and Fetching water from a nonfixed location. I observed unmarried females of ages 10 to 30. I divided the age group into ages 10 to 18, 19 to 21, and 19 to 30. I have also analyzed married women aged 19 to 30.

The outcome variables and their TUS 2019 codes are as follows, and these codes are based on ICATUS 2016 in Table 3.:

The study focuses on a targeted population comprising two distinct groups: unmarried females aged 6 to 30 years, totaling 33,180 individuals, and married females aged 19 to 30 years, totaling 27,155 individuals.

5.1.2 Jal Jeevan Mission Data 2019

The data used in this study pertains to 2019 and focuses on implementing the Jal Jeevan Mission (JJM), which was officially launched on August 15, 2019. The dataset provides monthly information on the number of new functional household tap connections (FHTCs) provided under the JJM across all rural districts and states in India. The data captures explicitly month-wise progress regarding household coverage, enabling a granular understanding of the program's rollout across regions. To facilitate analysis, the dataset also includes district-level information on the total number of rural households, allowing for the computation of the share of households covered.

Notably, no connections were reported under JJM until September 2019, as the program was still in its initial phase. The provision of tap connections began staggered from October onwards, with variations in timing and intensity across districts. To better capture the implementation dynamics, I constructed a cumulative measure of the number of households provided with connections at the district-month level. This cumulative indicator enables an assessment of the pace and scale of the JJM rollout, which is critical for identifying treatment exposure in the subsequent empirical analysis.

Table 2: Classification of Independent Variables

Category	**Variables**
Individual-level(Independent variables)	Age, Highest education and marital status
Household-level(Independent variables)	Usual monthly consumer expenditure, Household size, Number of female members in a household, Education of head, Land possessed as on the date of survey, Type of structure of dwelling unit, Religion, Social Group, Gender of head, and Highest female education in a household
Geographical-level (Fixed Effects)	District
Time-level (Fixed Effects)	Day and Month

Table 3: Learning and Water Fetching Activities

Code	**Category**	**Sub-code**	**Activity**
6	Learning	61	Formal education
		611	School/university attendance
		612	Extracurricular activities
		613	Breaks at the place of formal education
		614	Self-study for distance education (video, audio, online)
		619	Other activities related to formal education
		620	Homework, being tutored, course review, research
		630	Additional study, non-formal education and courses
		640	Travelling time related to learning
		690	Other activities related to learning
242	Water Fetching	242	Time spent in fetching water
		242_1	Time Timet in fetching water inside the premise
		242_2	Time Timet in fetching water outside the premise
		242_3	Time Timet in fetching water from non-fixed location

5.2 Methodology

5.2.1 Staggered Difference-in-Differences: de Chaisemartin & D'Haultfoeuille (2020)

Till September 2019, no household tap connections had been established under the mission. Since October 2019, tap connections have been gradually rolled out to districts in a staggered manner. The distribution of connections varied between districts, with some receiving tap water connections in October, others in November, and some in December 2019. Here, the empirical strategy used for the analysis is staggered DID. Since the connection was delivered staggered for districts, this method will work here. I have used de Chaisemartin & D'Haultfoeuille's Staggered DID; this is because for Jal Jeevan Mission 2019 data, the connection was provided in a staggered manner from the month October to December, So there were not any values before those months, so the correct staggered DiD method will be de Chaisemartin & D'Haultfoeuille's Staggered DID. The study looked Binary and continuous treatment effects.

The identification equation when the treatment was binary:

$$Y_{ihtd} = \lambda_d + \delta_t + \sum_{\{d,t\}\in\{1\}g} w_{d,t}\,\tau^g_{d,t} + X_{ihtd}\beta + \epsilon_{ihtd} \tag{1}$$

Where Y_{ihtd} is the dependent variable, measuring an outcome for female i in household h in district d in month t. The summation term $\sum_{\{d,t\}\in\{1\}g} w_{d,t}\,\tau^g_{d,t}$ captures the treatment effect, where $w_{d,t}$ represents the weights assigned to the treatment effect $\tau^g_{d,t}$ for district d at time t it takes the binary treatment value, ensuring that the treatment effect is applied only to those who are part of the treated group at a given time. The term $X_{ihtd}\beta$ includes a set of control variables X_{ihtd} that influence the outcome, with β representing the corresponding coefficients that measure the strength of these relationships. Finally, ϵ_{ihtd} is the error term in the model, capturing unobserved factors that may influence the outcome variable.

The identification equation when the treatment was continuous:

$$Y_{ihtd} = \lambda_d + \delta_t + \sum_{\{d,t\}\in g} w_{d,t}\,\gamma_{d,t}\cdot T^g_{d,t} + X_{ihtd}\beta + \epsilon_{ihtd} \tag{2}$$

Where Y_{ihtd} is the dependent variable, measuring an outcome for a female i in household h, in district d, and in month t. The summation term $\sum_{\{d,t\}\in g} w_{d,t}\,\gamma_{d,t}\cdot T^g_{d,t}$ captures the continuous treatment effect, where $w_{d,t}$ are weights assigned to the treatment effects $\gamma_{d,t}$ for district d at time t, and $T^g_{d,t}$ represents the Number of Household received Connection in district d at time t in the treated district. This formulation allows treatment to vary in magnitude rather than being a simple binary indicator. The term $X_{ihtd}\beta$ includes a set of control variables X_{ihtd} that influence the outcome, with β representing the corresponding

coefficients that measure the strength of these relationships. Finally, ϵ_{ihtd} is the error term, capturing unobserved factors that may influence the outcome variable.

Here, the treatment is heterogeneous; it varies over time and in districts. The $DIDM_{+,t}$ estimator measures the effect of starting treatment. It compares the group that starts treatment at a time 't' that remains untreated. It measures the change in the outcomes that differ between newly treated and never treated groups. The $DIDM_{-,t}$ measures the effect of stopping treatment; it compares groups that stop receiving treatments to groups that remain treated. That is, it measures how change in outcome differs between those who stay in treatment and those who stop treatment. So DIDM is the weighted average of $DIDM_{+,t}$ and The $DIDM_{-,t}$. For a staggered setup, once a unit gets treated, it is considered as treated over time, so for a staggered setting, DIDM takes the weighted average of $DIDM_{+,t}$ (de Chaisemartin and D'Haultfœuille, 2020).

For placebo, it measures how the outcome changed from t-2 to t-1 for two groups. It compares the treated group with those never treated. It observes what happens if the treated group does not receive treatment and compares it with the non-treated group. It observes the change if the treated units were untreated with the never-treated groups. To hold a parallel trend assumption, placebo has to be insignificant.

5.2.2 Difference-in-Difference Strategy

As a robustness check to complement the primary staggered Difference-in-Differences (DiD) analysis, the study also employs standard DiD models, where the treatment variable is the Cumulative number of household connections provided under the Jal Jeevan Mission, and the post-intervention period corresponds to October, November, and December. For each DiD specification, one treatment month is examined at a time, and observations from the other two treatment months are excluded to isolate the treatment effect.

Model 1: DiD Specification for October-treated Units

As a part of the robustness analysis, the following Difference-in-Differences specification is estimated for units treated in October. Observations from November and December are excluded from this model. The pre-intervention period is the months before October. The post-period is October only. (Post_10) is the month of October.

The identification equation is given by:

$$Y_{ihtd} = \alpha + \lambda_d + \delta_t + \beta_1 \cdot (\text{Connections}_d \times \text{Post}_{10}) + X'_{ihtd}\theta + \varepsilon_{ihtd} \tag{3}$$

The outcome variable Y_{ithd} represents the observed outcome for a female i in household h, interviewed in week t within district d. The term λ_d denotes district fixed effects, which

account for time-invariant differences across districts. Similarly, δ_t represents time-fixed effects, capturing common shocks that affect all districts within a given month. The treatment here is binary that is if the cumulative number of households provided with water connection is positive, then the exposure variable takes the value one.

Model 2: DiD Specification for November-treated Units

As a part of the robustness analysis, the following Difference-in-Differences (DiD) specification is estimated for units treated in November. Observations from October and December are excluded from this model. The pre-intervention period is the months before November. The post-period is November only. (Post_11) is the month of November.

The identification equation is given by:

$$Y_{ihtd} = \alpha + \lambda_d + \delta_t + \beta_1 \cdot (\text{Connections}_d \times \text{Post}_{11}) + X'_{ihtd}\theta + \varepsilon_{ihtd} \tag{4}$$

The outcome variable Y_{ithd} represents the observed outcome for a female i in household h, interviewed in week t within district d. The term λ_d denotes district fixed effects, which account for time-invariant differences across districts. Similarly, δ_t represents time-fixed effects, capturing common shocks that affect all districts within a given month. The treatment here is binary that is if the cumulative number of households provided with water connection is positive, then the exposure variable takes the value one.

Model 3: DiD Specification for December-treated Units

As a part of the robustness analysis, the following Difference-in-Differences (DiD) specification is estimated for units treated in December. Observations from October and November are excluded from this model. The pre-intervention period is the months before December. The post period is the month of December only.

The identification equation is given by:

$$Y_{ihtd} = \alpha + \lambda_d + \delta_t + \beta_1 \cdot (\text{Connections}_d \times \text{Post}_{12}) + X'_{ihtd}\theta + \varepsilon_{ihtd} \tag{5}$$

The outcome variable Y_{ithd} represents the observed outcome for a female i in household h, interviewed in week t within district d. The term λ_d denotes district fixed effects, which account for time-invariant differences across districts. Similarly, δ_t represents time-fixed effects, capturing common shocks that affect all districts within a given month. The treatment here is binary that is if the cumulative number of households provided with water connection is positive, then the exposure variable takes the value one. (Post_12) is the month of December.

6 Results

6.1 Staggered DiD results

6.1.1 Unmarried Females of ages 6 to 21 (Binary Treatment & continuous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	6_binary	61_binary	611_binary	6_conti	61_conti	611_conti
Av_tot_eff	48.70*	36.26*	35.46**	0.03*	0.02***	0.02***
	(26.03)	(18.99)	(16.44)	(0.02)	(0.00)	(0.01)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results indicate a positive and statistically significant impact of treatment on the outcome variable. The binary treatment specification suggests larger effect sizes, while the continuous treatment specification presents smaller but more precise estimates. The placebo tests provide mixed evidence, reinforcing the validity of the main results; the placebo says there is no parallel trend assumption. That is, there is some difference between the treated and non-treated districts. This is because the p-value is significant here. The findings suggest that unmarried females aged 6–21 experience a meaningful change in the outcome variable due to the intervention, with more substantial evidence in the continuous treatment model.

6.1.2 Unmarried Females of ages 6 to 11 (Binary Treatment & Continuous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	6_binary	61_binary	611_binary	6_conti	61_conti	611_conti
Av_tot_eff	112.00**	60.72*	63.10**	0.07***	0.04***	0.04***
	(50.36)	(34.92)	(31.25)	(0.01)	(0.01)	(0.00)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The above table shows that the Average treatment effect on the treated group is positive and significant for binary and continuous treatment. The ATE is more positive and significant for Learning and School/University attendance when the treatment is binary. However, when the treatment was continuous, the coefficient was smaller, but the results were more significant. So, the time spent in Learning, Formal education, and Attending School/University increases for an additional unit increase in connection provided. For an additional unit of water connection provided, the time spent in learning increased by 0.07 minutes, and time in formal education and attending school increased by 0.04 minutes. Also, the placebo says that the pre-trends were insignificant, so it holds the parallel trend assumption for this age group.

6.1.3 Unmarried Females of ages 12 to 14 (Binary & continuous Treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	6_binary	61_binary	611_binary	6_conti	61_conti	611_conti
Av_tot_eff	23.97	45.00*	48.16**	0.02	0.04	0.05
	(33.97)	(25.34)	(22.24)	(0.03)	(0.05)	(0.04)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The ATE is positive but not significant. It is significant when the treatment was binary for attending School/Univerity. However, continuous treatment has no significance. Also, the placebo is significant for all activities. The placebo shows the failure of the parallel trend assumption. So overall, we can say that except for the outcome of Attending Schools/Universities for treated districts, no other outcome is impacted by the Jal Jeevan Mission. Also, there was no significant impact when the treatment was continuous, so providing one additional unit of water connection does not impact the Learning outcome for girls in this age group.

6.1.4 Unmarried Females of ages 15 to 16 (Binary Treatment & Continous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	6_binary	61_binary	611_binary	6_conti	61_conti	611_conti
Av_tot_eff	1.72	45.54	42.49	0.01	0.04	0.04
	(61.72)	(50.43)	(45.32)	(0.18)	(0.11)	(0.10)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The average treatment effect was positive but not significant. So, for this age group, policy does not impact the outcomes. However, we can see a violation of the parallel trend assumption. It says that the treated and untreated groups were not similar before the treatment began. So overall, JJM does not impact learning outcomes for the ages 15-16 unmarried females.

6.1.5 Unmarried Females of ages 17 to 18 (Binary Treatment & Continous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	6_binary	61_binary	611_binary	6_conti	61_conti	611_conti
Av_tot_eff	-68.60	-30.05	-13.87	-0.11***	-0.05**	-0.03
	(57.95)	(34.18)	(30.05)	(0.02)	(0.02)	(0.03)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Average treatment effect is negative for this age group. It is negative and significant for continuous treatment when Learning and formal education are outcomes. The placebo is not significant, so the parallel trend assumption holds. However, the effect was negative, so we can say that the Jal Jeevan Mission did not impact the Learning outcomes in this case.

6.1.6 Unmarried Females of ages 19 to 21 (Binary Treatment & Continous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	6_binary	61_binary	611_binary	6_conti	61_conti	611_conti
Av_tot_eff	48.04	42.62	53.30*	0.06***	0.04***	0.05***
	(50.62)	(32.12)	(29.63)	(0.02)	(0.00)	(0.01)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The average treatment effect is positive for Binary and continuous treatment for 19 to 21. The time spent in Learning, Formal education, and Attending School/University increased and was statistically significant for the continuous treatment. So JJM impacted the learning outcomes of this age group; for an additional unit of Water Connection provided to a district, the time spent by unmarried females of ages 19 to 21, their learning outcome increased by 0.06 minutes, formal education increased by 0.04 minutes. Their school/university attendance also increased, and the time spent attending educational institutions increased by 0.05 minutes. So JJM significantly impacts the Learning outcomes of unmarried females aged 19 to 21. Although the coefficient for the continuous treatment is statistically significant, its magnitude is extremely small. In real-world terms, an effect of just 0.06, 0.04, or 0.05 minutes is negligible and lacks practical significance.

6.1.7 Unmarried Females of ages 10 to 18 (Binary Treatment & Continous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	242	242_1	242_2	242_3	242_c	242_1_c	242_2_c	242_3_c
Av_tot_eff	-6.507	-2.307	-4.220	0.020	-0.004*	-0.001	-0.003**	0.000***
	(6.653)	(2.352)	(7.344)	(0.017)	(0.003)	(0.001)	(0.001)	(0.000)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The average treatment effect on time spent fetching water decreased. For continuous treatment, the time spent fetching outside and fetching water from a nonfixed location decreased and was significant. We can say that the time spent fetching water from outside the premises decreased by 0.003 minutes for an additional unit of water connection. We can see that the time spent fetching water from outside the premise and the nonfixed locations for a continuous treatment placebo was significant and positive. So, we can say that JJM impacted the time spent fetching water for the ages 10 to 18.

6.1.8 Unmarried Females of ages 19 to 30 (Binary Treatment & continuous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	242	242_1	242_2	242_3	242_c	242_1_c	242_2_c	242_3_c
Av_tot_eff	-5.172	-7.243	2.081	-0.010	-0.002	-0.003	0.001	-0.000
	(8.330)	(4.753)	(7.017)	(0.038)	(0.023)	(0.022)	(0.002)	(0.000)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The average treatment effect on time spent fetching water decreased. But the effects were insignificant. The placebo says that the pre-trend or parallel-trend assumption holds. The pre-trends were positive and significant; after the intervention of JJM, the time spent fetching water decreased, but we cannot confirm the causality here since the values were insignificant.

6.1.9 Unmarried Females of ages 19 to 21 (Binary Treatment & Continous treatment)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	242	242_1	242_2	242_c	242_1_c	242_2_c
Av_tot_eff	-13.779	-5.471	-8.308	-0.010	-0.005	-0.005
	(11.952)	(6.230)	(10.412)	(0.014)	(0.006)	(0.008)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The average treatment effect is not significant for the ages 19 to 21. However, the negative effect is that the time spent fetching water decreases. So, JJM does not significantly impact this group's time fetching water. Still, the average treatment coefficient is negative for all outcomes.

6.1.10 Married Females of ages 19 to 30 (Binary Treatment & Continous)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	242	242_1	242_2	242_3	242_1_c	242_2_c	242_3_c	242_4_c
Av_tot_eff	7.230*	0.251	6.973*	0.006	0.005***	0.000	0.005***	0.000**
	(4.162)	(1.399)	(3.843)	(0.006)	(0.001)	(0.000)	(0.001)	(0.000)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

JJM does not have an impact on married females of the ages of 19 to 21. The average treatment effect is positive and significant. Still, the coefficient is very small, so the policy does not reduce the burden of fetching water for unmarried females aged 19 to 21.

7 Summary of Results from Staggered DiD model

There is an overall impact of JJM policy on Learning outcomes; those districts that got treatment increased School/University attendance. Those treated spent 35.46 minutes more Attending School/university. When the treatment was continuous, we found that the intensity of treatment, the time spent in Formal education, and School/University attendance increased by 0.02 minutes, which was highly significant. So we can say that for the Unmarried females of the ages 6 to 21, their Formal education and Attendance increased by 0.02 minutes for an additional unit of FHTC provided. The pre-trend is positive and significant, which is a violation of the parallel trend assumption. However, the Average treatment effect is still positive and significant for Attendance(binary & continuous treatment) and Formal education(continuous). So, we can say that JJM had an impact on Learning outcomes. However, in real terms, the impact was less since the coefficient is small.

For the age group 6-11, the Average treatment effect on Learning and Formal education was significant and highly positive for the treated group; when the treatment was continuous, the Average treatment effect was slightly positive but highly significant. One additional unit of FHTC increased by 0.07 minutes in learning, 0.04 minutes in formal education, and 0.04 minutes in attending School/University. The placebo estimates hold the parallel trend assumption.

For the age group 12-14, JJM does not impact the Learning outcomes when the treatment is continuous. However, when the treatment was binary, there was a significant increase in school/university attendance. Those treated spent 48.16 minutes more Attending School, reducing dropout rates. The placebo is highly positive and significant, so the parallel trend assumption is violated. However, the treatment effect on those treated earlier is positive and highly significant. However, the Average treatment effect is insignificant because those treated in December did not have an impact.

There was no significant impact on Learning outcomes for the age group 15 -16. The average treatment effect was positive but was insignificant, so JJM does not impact learning outcomes for the age group 15 - 16. For the age group 17-18 also, there was no significant impact on JJM policy in the learning outcomes of the individuals.

For the age group 19-21, the JJM impacted the learning outcomes; for continuous treatment, the three learning outcomes are significant and positive. For an additional FHTC delivered, the time spent on learning increased by 0.06 minutes, the time spent in formal education increased by 0.04 minutes, and the time spent attending School/University increased by 0.05.

For Fetching Water, I looked at the age group of unmarried females of ages 10-18, 19-21, 19-30, and married females of 19-30. For the age 10-18 , the time spent in fetching water decreased and was significant for continuous treatment. For an additional unit of FHTC provided, the time spent spend in fetching water outside the premise decreased by 0.003 minutes. Also, the time spent fetching water from a nonfixed location decreased. This is a significant impact.

For the age group 19-21 unmarried females, there was no significant impact in the reduction of time spent in fetching water; even though the time spent in fetching water decreased, the effect was insignificant. For unmarried females aged 19-30, time spent in fetching water reduced but was insignificant. However, the placebo was positive and significant. JJM reduced the time spent on fetching water, but the impact were insignificant.

For married females aged 19-30, the time spent fetching water was not reduced. Jal Jeevan Mission does not impact the time spent fetching water for those aged 19 to 30.

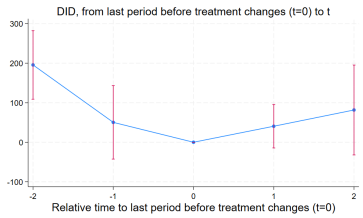
8 Staggered Event study plots

8.1 Staggered Event Study Plots: Females; where the treatment is Binary

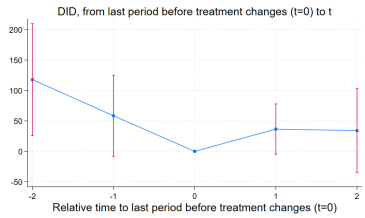
The identification equation for Staggered event study plots, when the treatment was binary, is as follows:

$$Y_{ihtd} = \lambda_d + \delta_t + \sum_{k \neq -1} \beta_k \cdot \mathbf{1}[\text{EventTime}_{ihtd} = k] \cdot \mathbf{1}[\text{Treated}_{ihtd} = 1] + X_{ihtd} \cdot \gamma + \varepsilon_{ihtd} \quad (6)$$

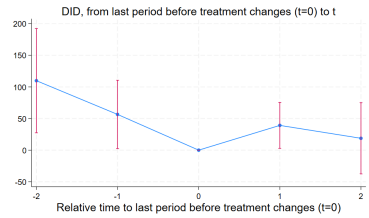
Where Y_{ihtd} is the dependent variable, measuring an outcome for female i in household h in district d in month t. λ_d represents the district fixed effects, capturing all time-invariant characteristics specific to district d. δ_t denotes the time-fixed effects, accounting for shocks or trends common across all districts in month t. $\sum_{k \neq -1} \beta_k \cdot \mathbf{1}[\text{EventTime}_{ihtd} = k] \cdot \mathbf{1}[\text{Treated}_{ihtd} = 1]$ represents the set of event-time dummies interacted with the treatment indicator. Here, β_k captures the effect of being k periods away from the treatment relative to the omitted period $k = -1$ (i.e., the baseline period just before treatment). $\mathbf{1}[\text{EventTime}_{ihtd} = k]$ is an indicator variable equal to 1 if individual i in household h, district d, and time t is in event time k, and 0 otherwise. $\mathbf{1}[\text{Treated}_{ihtd} = 1]$ is an indicator variable equal to 1 if the individual belongs to a treated unit and zero otherwise. $X_{ihtd} \cdot \gamma$ is a vector of control variables for individual i in household h, district d, and time t, with associated coefficients γ. ε_{ihtd} is the error term.



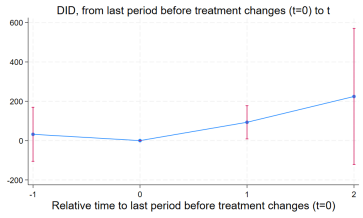
(a) Learning (Ages 6-21)



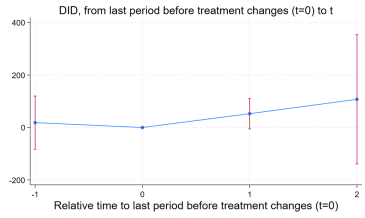
(b) Formal Education (Ages 6-21)



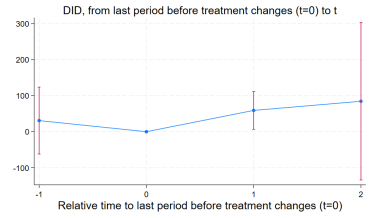
(c) Attendance (Ages 6-21)



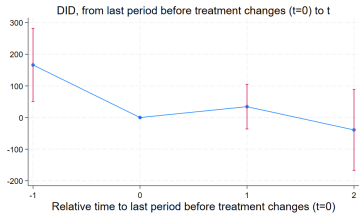
(d) Learning (Ages 6-11)



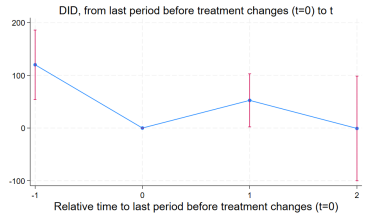
(e) Formal Education (Ages 6-11)



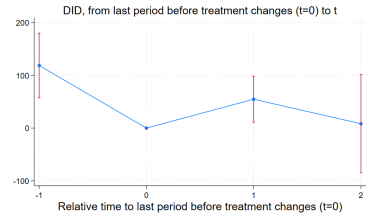
(f) Attendance (Ages 6-11)



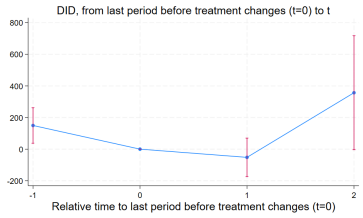
(g) Learning (12-14)



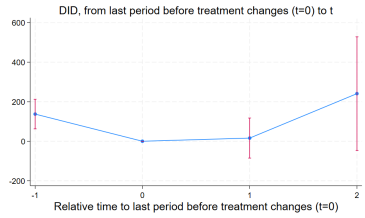
(h) Formal Education (12-14)



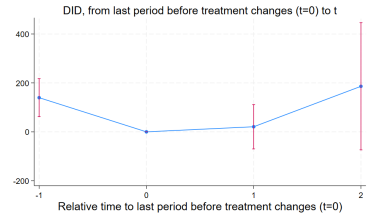
(i) Attendance (12-14)



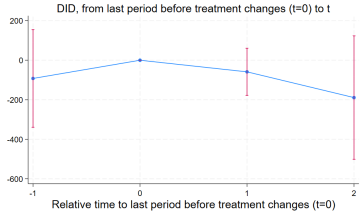
(j) Learning (15-16)



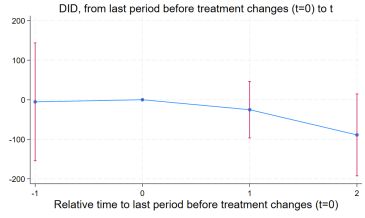
(k) Formal Education (15-16)



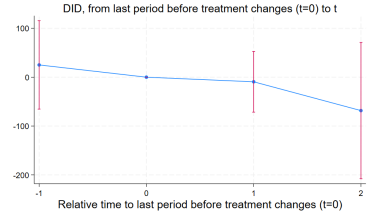
(l) Attendance (15-16)



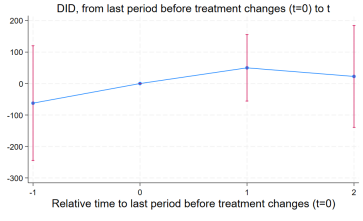
(m) Learning (17-18)



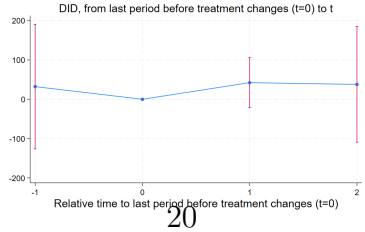
(n) Formal Education (17-18)



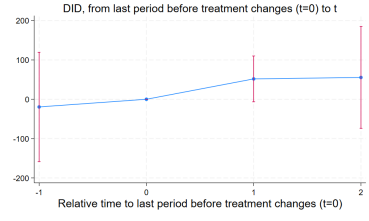
(o) Attendance (17-18)



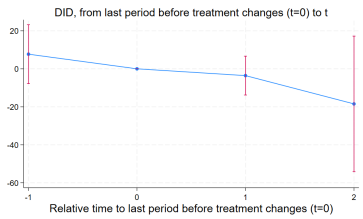
(p) Learning (19-21)



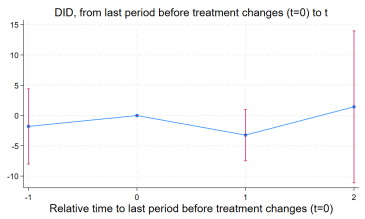
(q) Formal Education (19-21)



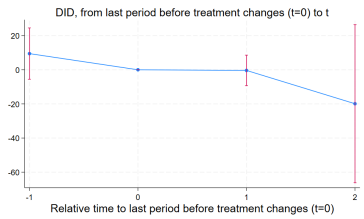
(r) Attendance (19-21)



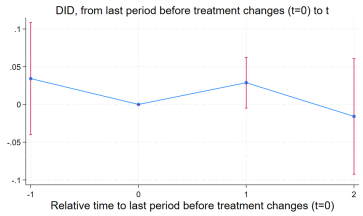
(a) Fetching Water (10-18)



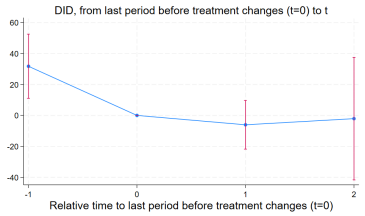
(b) Water Inside (10-18)



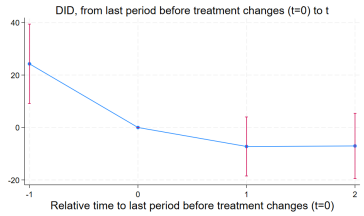
(c) Water Outside (10-18)



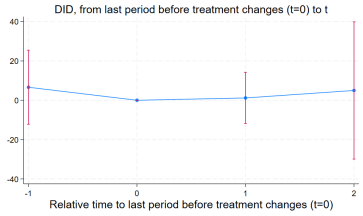
(d) Water Non-fixed (10-18)



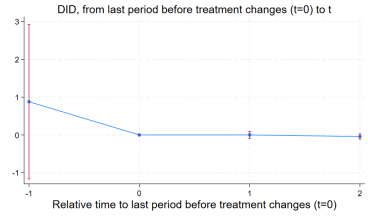
(e) Fetching Water (19-30)



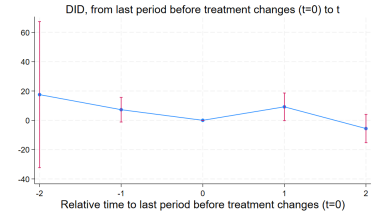
(f) Water Inside (19-30)



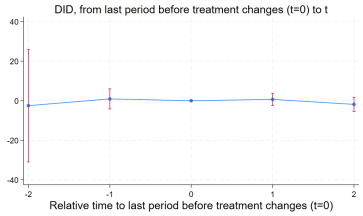
(g) Water Outside (19-30)



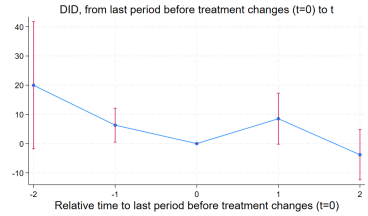
(h) Water Non-fixed (19-30)



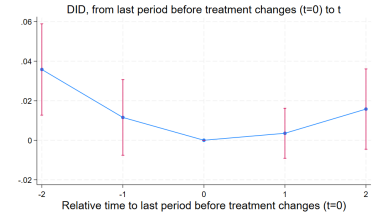
(i) Fetching water(19-30, married females)



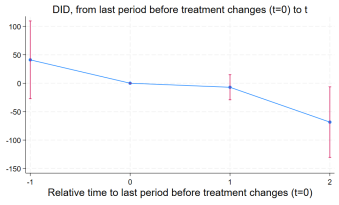
(j) Fetching water inside (19-30, married females)



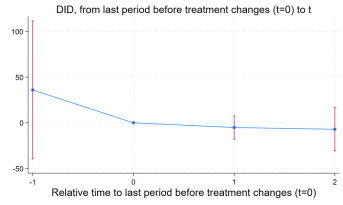
(k) Fetching water outside 19-30, married females)



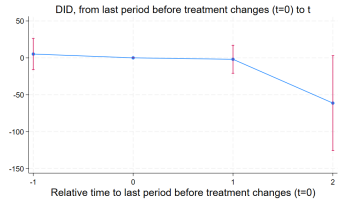
(l) Fetching water from non-fixed location(19-30, married females)



(m) Fetching Water (19-21, Unmarried)



(n) Water Inside (19-21, Unmarried)



(o) Water Outside (19-21, Unmarried)

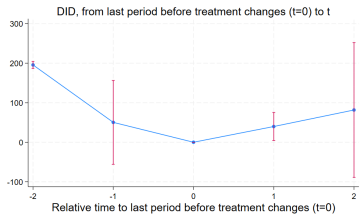
Figure 2: Staggered Event study plots for females for binary treatment (ages 6-21, 6-11, 12-14, 15-16, 17-18, 19-21, 10-18, and 19-30)

8.2 Staggered Event Study Plots: Females; where the treatment is Continuous

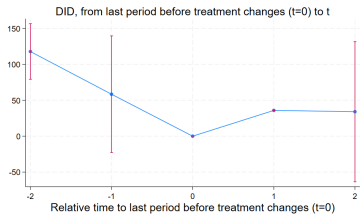
The plots below are the staggered event study plots for continuous treatment. Continuous treatment can observe the intensity of the treatment. Continuous treatment can predict the variation in the number of households provided with connection-impacted Learning outcomes and time spent Fetching water. Continuous treatment helps examine how time allocation in different activities changed due to the increased number of Functional Household Tap Connections (FHTC). Continuous treatment provide more accurate estimates by appropriately accounting for the heterogeneity in treatment effects ((de Chaisemartin and D'Haultfœuille, 2020, Online Appendix)) .

$$Y_{ihtd} = \lambda_d + \delta_t + \sum_{k \neq -1} \beta_k \cdot \mathbf{1}[\text{EventTime}_{ihtd} = k] \cdot T_{ihtd} + X_{ihtd} \cdot \gamma + \varepsilon_{ihtd} \tag{7}$$

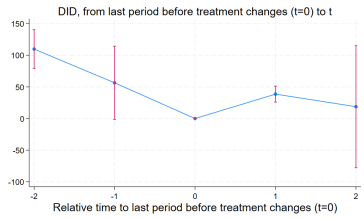
Where Y_{ihtd} is the dependent variable, measuring an outcome for female i in household h, in district d, in month t. λ_d represents the district-fixed effects, capturing time-invariant characteristics specific to district d, and δ_t denotes time-fixed effects, accounting for month-specific shocks common across all districts. The term $\sum_{k \neq -1} \beta_k \cdot \mathbf{1}[\text{EventTime}_{ihtd} = k] \cdot T_{ihtd}$ represents a set of event-time indicators interacted with the continuous treatment variable T_{ihtd}, which measures treatment intensity (that is the treatment changes with number of connections provided to districts). Here, β_k captures the marginal effect of a unit increase in treatment intensity at event time k, relative to the omitted period $k = -1$, which serves as the baseline (one month before the intervention). $\mathbf{1}[\text{EventTime}_{ihtd} = k]$ is an indicator variable equal to 1 if the observation corresponds to k periods away from the intervention month, and zero otherwise.$X_{ihtd} \cdot \gamma$ is a vector of control variables with their associated coefficients γ, and ε_{ihtd} is the idiosyncratic error term.



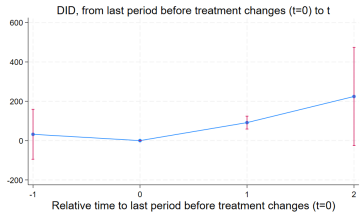
(a) Learning (Ages 6-21)



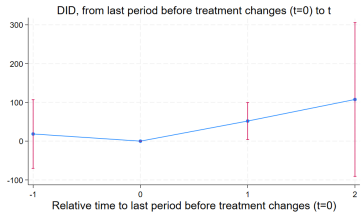
(b) Formal Education (Ages 6-21)



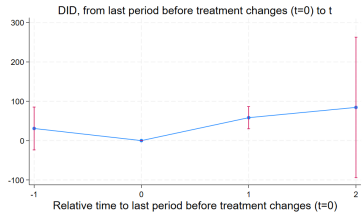
(c) Attendance (Ages 6-21)



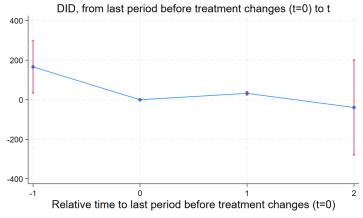
(d) Learning (Ages 6-11)



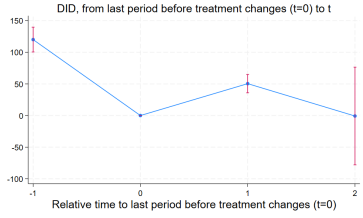
(e) Formal Education (Ages 6-11)



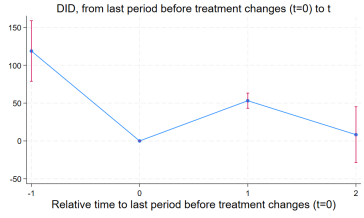
(f) Attendance (Ages 6-11)



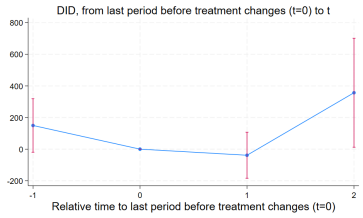
(g) Learning (12-14)



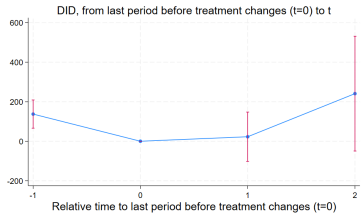
(h) Formal Education (12-14)



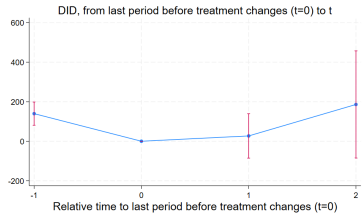
(i) Attendance (12-14)



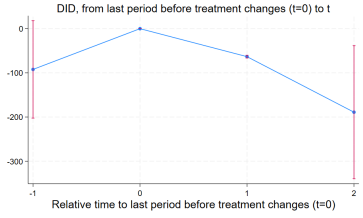
(j) Learning (15-16)



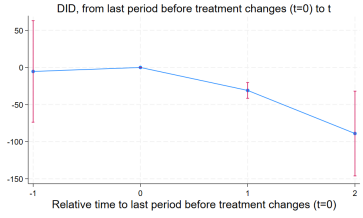
(k) Formal Education (15-16)



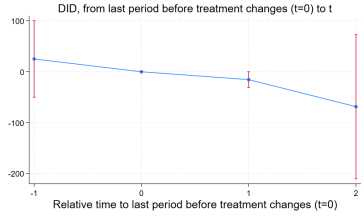
(l) Attendance (15-16)



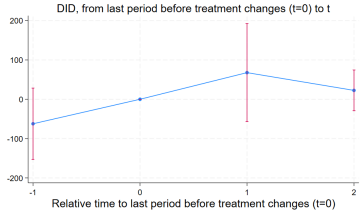
(m) Learning (17-18)



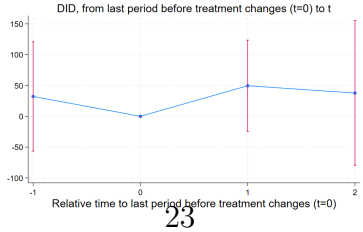
(n) Formal Education (17-18)



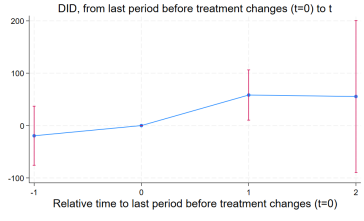
(o) Attendance (17-18)



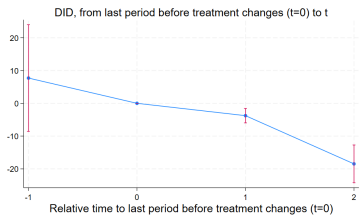
(p) Learning (19-21)



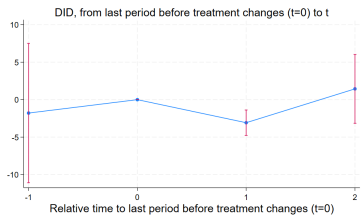
(q) Formal Education (19-21)



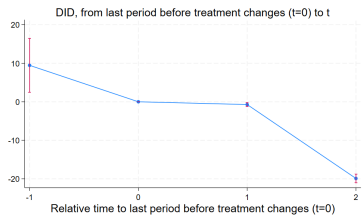
(r) Attendance (19-21)



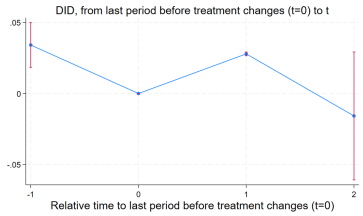
(a) Fetching Water (10-18)



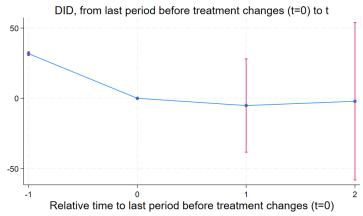
(b) Water Inside (10-18)



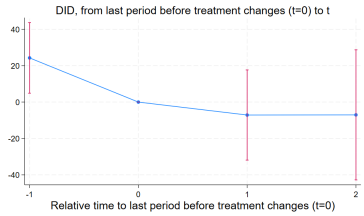
(c) Water Outside (10-18)



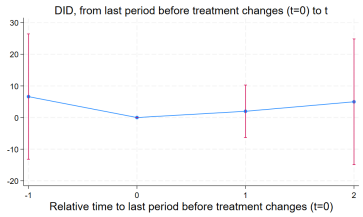
(d) Water Non-fixed (10-18)



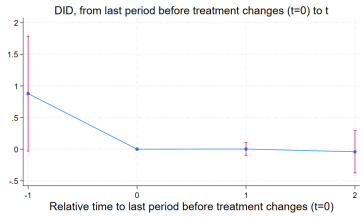
(e) Fetching Water (19-30)



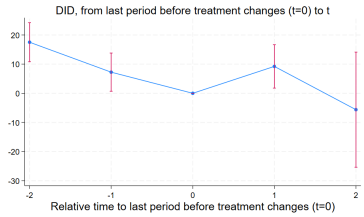
(f) Water Inside (19-30)



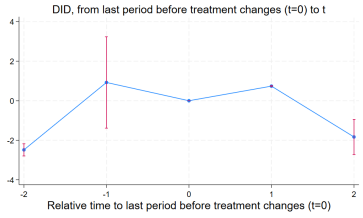
(g) Water Outside (19-30)



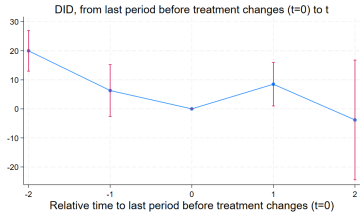
(h) Water Non-fixed (19-30)



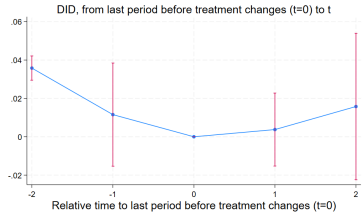
(i) Fetching water(19-30, married females)



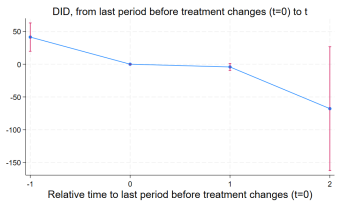
(j) Fetching water inside (19-30, married females)



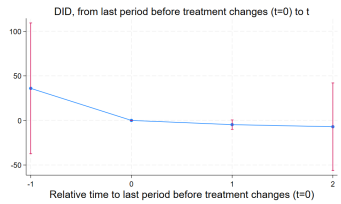
(k) Fetching water outside 19-30, married females)



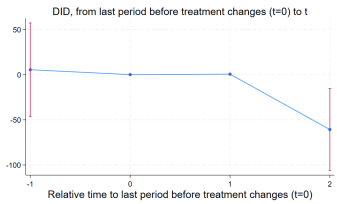
(l) Fetching water from non-fixed location(19-30, married females)



(m) Fetching Water (19-21, Unmarried)



(n) Water Inside (19-21, Unmarried)



(o) Water Outside (19-21, Unmarried)

Figure 4: Staggered Event study plots for females for continuous treatment (ages 6-21, 6-11, 12-14, 15-16, 17-18, 19-21, 10-18, and 19-30)

8.3 Difference-in-Difference model results

8.3.1 Unmarried Females of ages 6 to 21 (Binary Treatment)

Table 4: Learning Outcomes for the ages 6-21

	(1) Learning	(2) Formal Education	(3) Attendance
int_oct	0.886	-4.297	0.763
	(40.623)	(27.752)	(24.217)
Constant	317.226***	255.227***	229.333***
	(47.047)	(35.055)	(30.488)
Observations	25,536	25,536	25,536
R-squared	0.381	0.362	0.360
int_nov	-26.602	-21.913	-15.329
	(28.527)	(19.018)	(16.554)
Constant	321.920***	238.392***	215.756***
	(46.502)	(33.708)	(29.555)
Observations	25,773	25,773	25,773
R-squared	0.386	0.368	0.366
int_dec	20.706	-6.000	1.317
	(21.755)	(15.318)	(13.677)
Constant	304.338***	243.301***	218.372***
	(48.854)	(35.137)	(30.806)
Observations	24,707	24,707	24,707
R-squared	0.387	0.369	0.368

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

From the above table, it can be observed that the JJM intervention does not have a statistically significant impact on learning outcomes. Although there is an increase in time spent on learning and school/university attendance among those treated in October and December, these changes are not statistically significant. This suggests that while there may be a positive trend, the increase cannot be confidently attributed to the JJM policy within the observed period.

8.3.2 Unmarried Females of ages 6 to 11 (Binary Treatment)

Table 5: Learning Outcomes for the ages 6-11

	(1) Learning	(2) Formal Education	(3) Attendance
int_oct	-30.935	-16.020	-5.850
	(62.484)	(38.958)	(35.325)
Constant	298.237***	225.907***	178.653***
	(62.275)	(48.161)	(43.229)
Observations	8,990	8,990	8,990
R-squared	0.451	0.429	0.426
int_nov	-11.317	-15.085	-12.749
	(38.942)	(26.002)	(22.813)
Constant	306.163***	223.589***	175.661***
	(61.849)	(47.388)	(43.054)
Observations	9,071	9,071	9,071
R-squared	0.454	0.431	0.428
int_dec	32.858	-0.386	10.185
	(30.783)	(21.559)	(18.459)
Constant	306.235***	228.838***	179.618***
	(64.197)	(48.156)	(43.251)
Observations	8,617	8,617	8,617
R-squared	0.464	0.443	0.441

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In this case, the Jal Jeevan Mission (JJM) did not significantly impact learning outcomes for children aged 6–11. Although those treated in December showed a positive effect, it was not statistically significant. Overall, the findings suggest that the JJM intervention did not significantly influence learning outcomes within this age group during the observed period.

8.3.3 Unmarried Females of ages 12 to 14 (Binary Treatment)

Table 6: Learning Outcomes for the ages 12-14

	(1) Learning	(2) Formal Education	(3) Attendance
int_oct	12.418	-27.265	-32.464
	(76.065)	(45.748)	(39.900)
Constant	482.947***	382.828***	374.765***
	(81.021)	(60.660)	(52.317)
Observations	5,859	5,859	5,859
R-squared	0.469	0.444	0.437
int_nov	-29.820	-35.065	-17.089
	(43.055)	(28.888)	(24.846)
Constant	478.184***	379.949***	372.533***
	(82.494)	(61.474)	(53.710)
Observations	5,925	5,925	5,925
R-squared	0.468	0.442	0.436
int_dec	26.024	-16.306	-1.207
	(28.254)	(21.067)	(18.696)
Constant	473.756***	386.184***	375.214***
	(84.806)	(62.981)	(54.626)
Observations	5,683	5,683	5,683
R-squared	0.479	0.450	0.445

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Overall, time spent on learning increased among unmarried girls aged 12–14 who received the intervention in October and December. However, the increase was not statistically significant. This suggests that the Jal Jeevan Mission did not have a meaningful impact on the learning outcomes of this age group during the study period.

8.3.4 Unmarried Females of ages 15 to 16 (Binary Treatment)

Table 7: Learning Outcomes for the ages 15-16

	(1) Learning	(2) Formal Education	(3) Attendance
int_oct	-44.609	-38.348	-35.775
	(70.305)	(54.287)	(47.670)
Constant	453.107***	410.342***	405.740***
	(119.491)	(84.721)	(76.049)
Observations	3,928	3,928	3,928
R-squared	0.469	0.434	0.425
int_nov	-10.402	10.664	7.936
	(43.785)	(31.108)	(28.916)
Constant	489.397***	391.853***	379.151***
	(119.451)	(81.962)	(73.263)
Observations	3,941	3,941	3,941
R-squared	0.478	0.441	0.436
int_dec	-11.244	-34.127	-18.948
	(42.823)	(30.091)	(27.295)
Constant	434.426***	378.593***	378.382***
	(124.968)	(88.028)	(80.257)
Observations	3,834	3,834	3,834
R-squared	0.481	0.447	0.438

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For the age group 15–16, the time spent in formal education slightly increased for those treated in November; however, the effect is not statistically significant. For those treated in other months, there was no notable increase. Hence, the Jal Jeevan Mission does not appear to have significantly impacted the learning outcomes of unmarried females in this age group.

8.3.5 Unmarried Females of ages 17 to 18 (Binary Treatment)

Table 8: Learning Outcomes for the ages 17-18

	(1) Learning	(2) Formal Education	(3) Attendance
int_oct	69.979	30.413	32.267
	(53.212)	(33.617)	(29.765)
Constant	3.663	41.668	46.003
	(118.775)	(83.774)	(74.330)
Observations	3,643	3,643	3,643
R-squared	0.440	0.401	0.387
int_nov	-76.741*	-46.982	-46.657*
	(40.887)	(28.560)	(24.839)
Constant	-12.347	4.479	0.415
	(116.764)	(78.829)	(70.338)
Observations	3,646	3,646	3,646
R-squared	0.438	0.402	0.390
int_dec	19.386	3.294	-5.262
	(44.350)	(31.402)	(28.521)
Constant	16.282	38.701	29.690
	(121.035)	(83.223)	(73.559)
Observations	3,530	3,530	3,530
R-squared	0.440	0.405	0.393

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For those treated in October and November, there is an observed increase in the time spent on learning activities; however, this increase is statistically insignificant. Therefore, it cannot be concluded that the Jal Jeevan Mission had a causal impact on learning outcomes for the age group 17-18.

8.3.6 Unmarried Females of ages 19 to 21 (Binary Treatment)

Table 9: Learning Outcomes for the ages 19-21

	(1) Learning	(2) Formal Education	(3) Attendance
int_oct	27.298	6.845	29.552
	(70.168)	(47.331)	(46.024)
Constant	79.315	-56.103	-40.970
	(105.594)	(77.112)	(67.358)
Observations	3,116	3,116	3,116
R-squared	0.445	0.407	0.402
int_nov	43.292	20.927	22.347
	(44.843)	(25.855)	(24.213)
Constant	42.931	-105.136	-77.898
	(104.418)	(72.997)	(64.107)
Observations	3,190	3,190	3,190
R-squared	0.431	0.408	0.402
int_dec	-5.704	-14.742	-13.416
	(46.419)	(33.534)	(30.844)
Constant	55.870	-93.856	-84.354
	(108.525)	(76.682)	(66.641)
Observations	3,043	3,043	3,043
R-squared	0.449	0.415	0.409

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For those treated in October and November, time is increased across all learning outcomes. However, this increase is not statistically significant, indicating that the Jal Jeevan Mission did not have a meaningful impact on the learning outcomes of females aged 19–21.

8.3.7 Unmarried Females of ages 10 to 18 (Binary Treatment)

Table 10: Fetching Water for the ages 10-18

	(1) 242	(2) 242_1	(3) 242_2	(4) 242_3
int_oct	-15.776	-8.030	-7.812	0.067
	(20.146)	(14.327)	(12.761)	(0.063)
Constant	15.567	1.967	13.441	0.159
	(14.062)	(6.369)	(11.578)	(0.748)
Observations	16,962	16,962	16,962	16,962
R-squared	0.324	0.233	0.279	0.061
int_nov	-4.262	-1.895	-2.424	0.057
	(6.858)	(3.867)	(5.555)	(0.054)
Constant	14.882	-0.026	14.771	0.137
	(15.263)	(6.771)	(12.275)	(0.734)
Observations	17,037	17,037	17,037	17,037
R-squared	0.322	0.243	0.276	0.056
int_dec	1.050	-4.101	5.112	0.040
	(5.036)	(2.579)	(4.871)	(0.035)
Constant	12.288	4.068	8.022	0.198
	(14.142)	(6.346)	(11.567)	(0.758)
Observations	16,434	16,434	16,434	16,434
R-squared	0.336	0.261	0.286	0.061

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For ages 10–18, the time spent fetching water decreased for those treated in October and November, while no decrease was observed for those treated in December. However, the reductions in October and November are statistically insignificant. Therefore, it cannot be concluded that the Jal Jeevan Mission reduced the time spent fetching water for this age group.

8.3.8 Unmarried Females of ages 19 to 21 (Binary Treatment)

Table 11: Fetching Water for the ages 19-21

	(1) 242	(2) 242_1	(3) 242_2	(4) 242_3
int_oct	-7.188	-14.061	6.432	0.441
	(22.375)	(20.124)	(5.174)	(0.641)
Constant	11.936	2.222	11.879	-2.164
	(24.998)	(15.494)	(19.028)	(5.545)
Observations	3,116	3,116	3,116	3,116
R-squared	0.460	0.352	0.442	0.213
int_nov	-7.205	-5.974	-0.927	-0.305
	(11.708)	(6.234)	(8.292)	(0.637)
Constant	8.241	-1.295	12.393	-2.858
	(23.260)	(13.324)	(18.691)	(4.769)
Observations	3,190	3,190	3,190	3,190
R-squared	0.459	0.374	0.427	0.213
int_dec	-3.759	1.114	-4.580	-0.293
	(11.241)	(6.595)	(8.701)	(0.610)
Constant	4.391	-8.974	15.879	-2.515
	(25.455)	(15.268)	(19.536)	(5.707)
Observations	3,043	3,043	3,043	3,043
R-squared	0.462	0.351	0.449	0.214

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For unmarried females aged 19–21, there is a decline in the time spent fetching water across all treatment months—October, November, and December. However, the decreases are not statistically significant. Therefore, it cannot be concluded that the Jal Jeevan Mission caused the reduction in time spent fetching water.

8.3.9 Unmarried Females of ages 19 to 30 (Binary Treatment)

Table 12: Fetching Water for the ages 19-30

	(1) 242	(2) 242_1	(3) 242_2	(4) 242_3
int_oct	-4.313	-5.299	1.008	-0.022
	(10.992)	(9.290)	(3.664)	(0.340)
Constant	13.840	0.768	13.324	-0.251
	(18.922)	(12.783)	(14.388)	(2.405)
Observations	5,445	5,445	5,445	5,445
R-squared	0.386	0.276	0.354	0.193
int_nov	-3.650	-6.198	2.701	-0.154
	(9.017)	(4.651)	(6.239)	(0.422)
Constant	13.431	3.764	10.227	-0.561
	(17.917)	(12.356)	(13.853)	(2.175)
Observations	5,487	5,487	5,487	5,487
R-squared	0.391	0.277	0.358	0.196
int_dec	-9.287	-7.174	-1.981	-0.131
	(9.486)	(5.636)	(7.061)	(0.213)
Constant	6.499	-5.602	12.421	-0.320
	(19.015)	(12.950)	(14.845)	(2.473)
Observations	5,284	5,284	5,284	5,284
R-squared	0.383	0.269	0.356	0.197

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For unmarried females aged 19 to 30, there is a decrease in time spent fetching water among those treated in October. However, since the estimates are statistically insignificant, this reduction cannot be attributed to the Jal Jeevan Mission. As a result, no causal relationship can be established between the intervention and the observed decrease.

8.3.10 Married Females of ages 19 to 30 (Binary Treatment)

Table 13: Fetching Water for married females of ages 19-30

	(1) 242	(2) 242_1	(3) 242_2	(4) 242_3
int_oct	0.923	-4.887	5.733	0.077
	(8.853)	(5.413)	(6.668)	(0.084)
Constant	9.566	-0.713	10.774	-0.495
	(8.544)	(4.502)	(7.303)	(0.548)
Observations	22,266	22,266	22,266	22,266
R-squared	0.294	0.183	0.263	0.028
int_nov	2.542	2.040	0.475	0.027
	(5.451)	(3.007)	(5.271)	(0.038)
Constant	20.734**	0.879	20.322***	-0.467
	(9.979)	(5.277)	(7.732)	(0.531)
Observations	22,558	22,558	22,558	22,558
R-squared	0.301	0.190	0.260	0.030
int_dec	5.104	-1.238	6.352*	-0.011
	(4.112)	(1.756)	(3.516)	(0.015)
Constant	16.496*	-0.862	17.855**	-0.496
	(8.732)	(4.447)	(7.478)	(0.570)
Observations	21,773	21,773	21,773	21,773
R-squared	0.301	0.187	0.275	0.033

District and Month Fixed Effects included in all models

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For married females aged 19 to 30, the time spent fetching water within the household decreased for those treated in October and December. However, since the estimates are statistically insignificant, we cannot infer a causal impact of the Jal Jeevan Mission.

9 Summary of Results from DiD model

This study examines the impact of the Jal Jeevan Mission (JJM) on learning outcomes and time spent on water-fetching activities among different age groups of females. For learning outcomes, the analysis focuses exclusively on unmarried females aged 6 to 21. Although there is an observed increase in time spent on learning and school/university attendance among those treated in October and December—particularly in age groups 6–11, 12–14, 15–16, 17–18, and 19–21—these increases are not statistically significant. As such, the results

suggest that while the intervention may show a positive trend in learning engagement, there is no strong evidence of a causal impact of JJM on educational outcomes within the observed period.

Regarding time spent fetching water, the analysis includes unmarried and married females. For unmarried females aged 10–18, 19–21, and 19–30, there is a general decrease in time spent fetching water for those treated in October and November, with little to no change for December-treated groups. Similarly, married females aged 19–30 show a reduction in water-fetching time, particularly for those treated in October and December. However, these reductions are statistically insignificant across all groups and treatment months. Therefore, it cannot be concluded that the JJM intervention led to a meaningful or causal decrease in time spent fetching water.

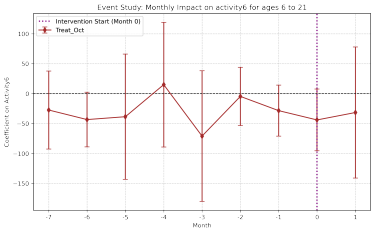
10 Event study plots

10.1 Event Study Plots: Females; whose treatment was on October

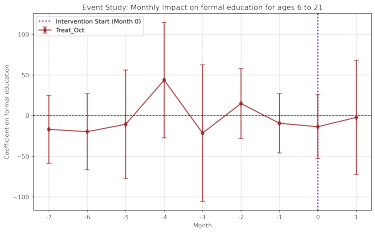
The event study graphs help analyze the treatment group's dynamic effect over months. It helps diagnose the treated cohorts' monthly variation in time spent on activities. For the event study plot for those get treatment in October, the month **September** as the starting month of the intervention, month 0. So, the month after 0 is 1, which is **October(post-intervention period)** here, excluding November and December. The treatment is **Binary**. The post-intervention only has the month of October since this is a Difference in Difference Strategy.

$$Y_{ihtd} = \alpha + \lambda_d + \delta_t + \sum_{k=1}^{10} \beta_k(\text{treated}_d \times \text{month}_k) + X_{ihtd}\theta + \epsilon_{ihtd} \tag{8}$$

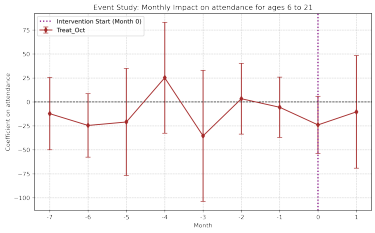
where The outcome variable Y_{ithd} represents the observed outcome for individual i in household h, interviewed in month t within district d. The term λ_d denotes district fixed effects, which account for time-invariant differences across districts. Similarly, δ_t represents time-fixed effects, capturing common shocks that affect all districts within a given month.



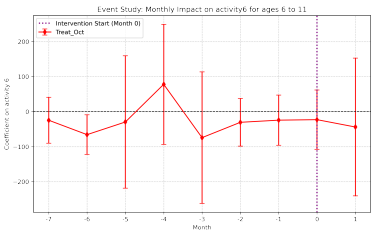
(a) Learning (Ages 6-21)



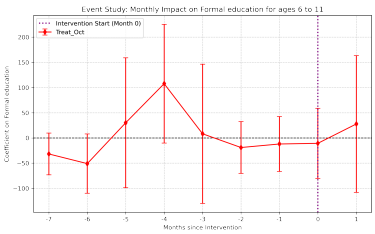
(b) Formal Education (Ages 6-21)



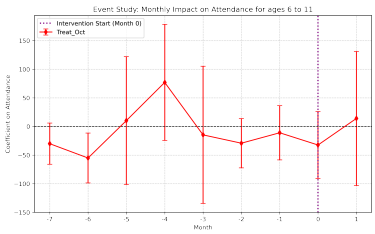
(c) Attendance (Ages 6-21)



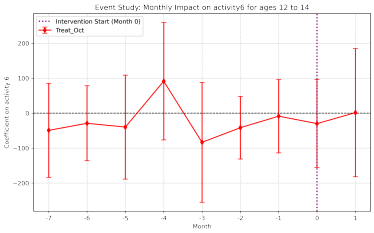
(d) Learning (Ages 6-11)



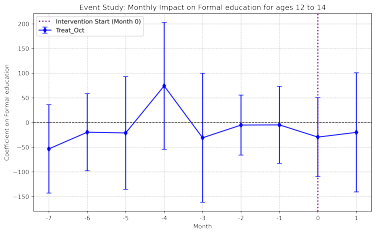
(e) Formal Education (Ages 6-11)



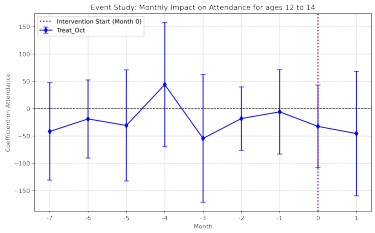
(f) Attendance (Ages 6-11)



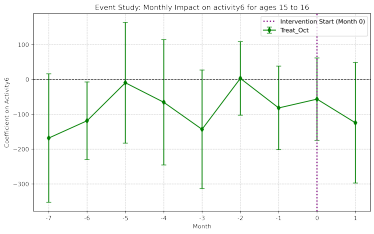
(g) Learning (12-14)



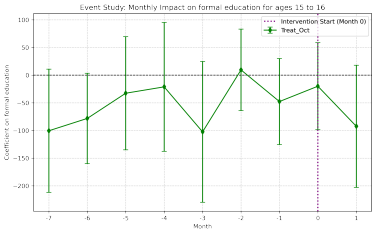
(h) Formal Education (12-14)



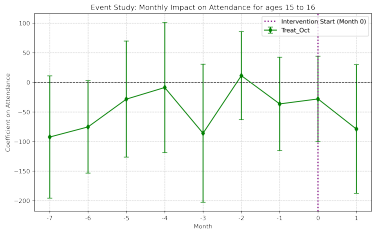
(i) Attendance (12-14)



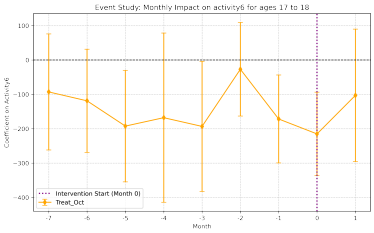
(j) Learning (15-16)



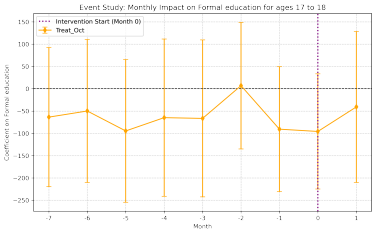
(k) Formal Education (15-16)



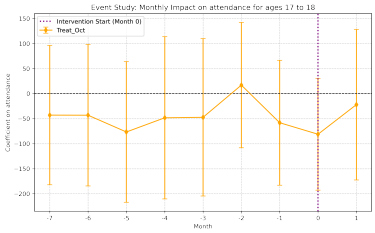
(l) Attendance (15-16)



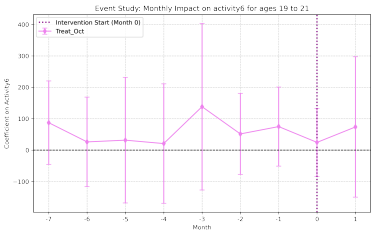
(m) Learning (17-18)



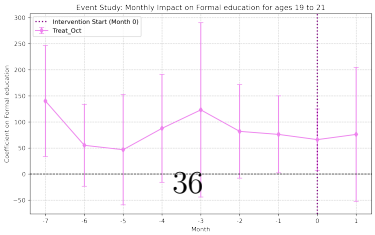
(n) Formal Education (17-18)



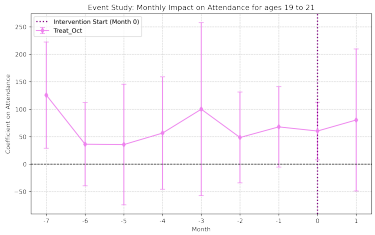
(o) Attendance (17-18)



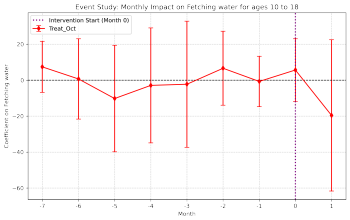
(p) Learning (19-21)



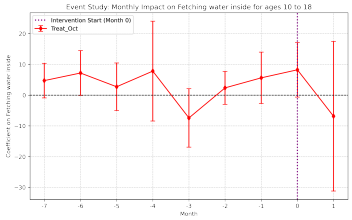
(q) Formal Education (19-21)



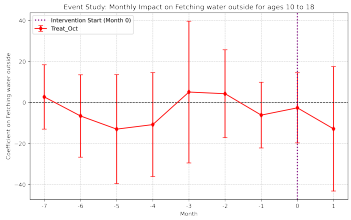
(r) Attendance (19-21)



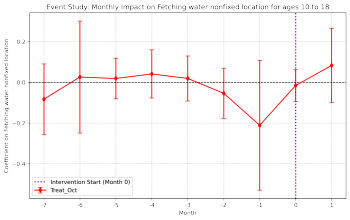
Fetching Water (10-18)



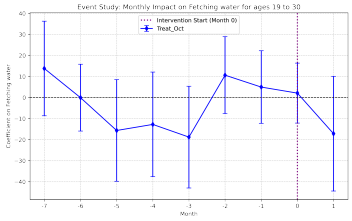
Water Inside (10-18)



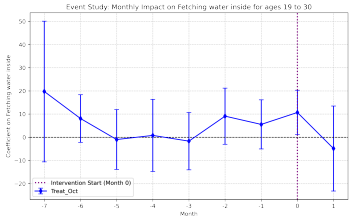
Water Outside (10-18)



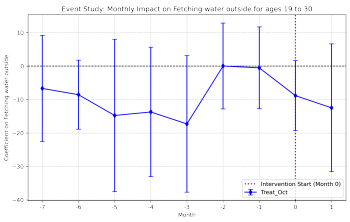
Water Non-fixed (10-18)



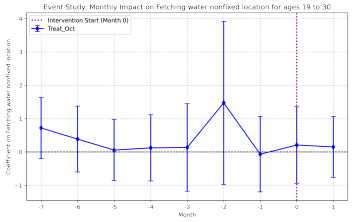
Fetching Water (19-30)



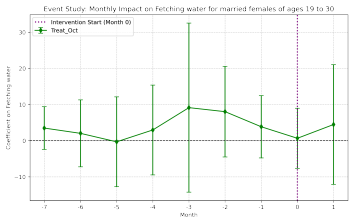
Water Inside (19-30)



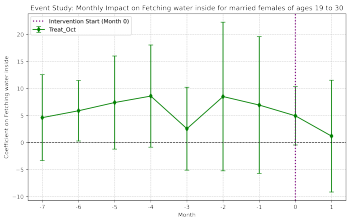
Water Outside (19-30)



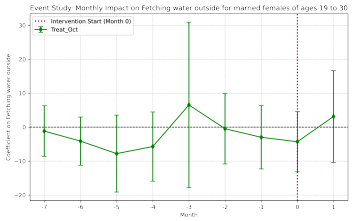
Water Non-fixed (19-30)



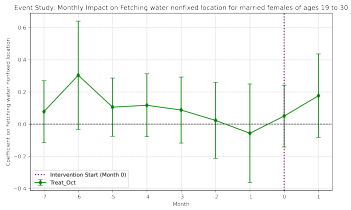
Fetching Water (19-30, Married)



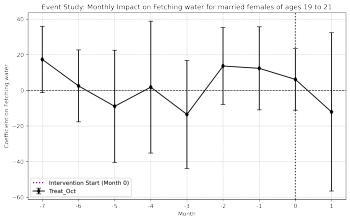
Water Inside (19-30, Married)



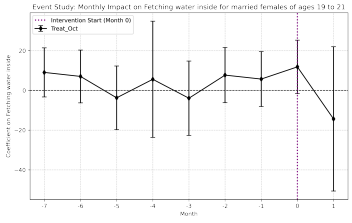
Water Outside (19-30, Married)



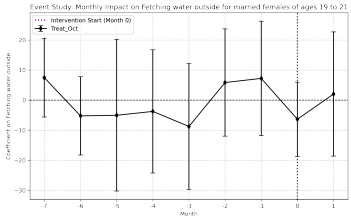
Water Non-fixed (19-30, Married)



Fetching Water (19-21, Unmarried)



Water Inside (19-21, Unmarried)



Water Outside (19-21, Unmarried)

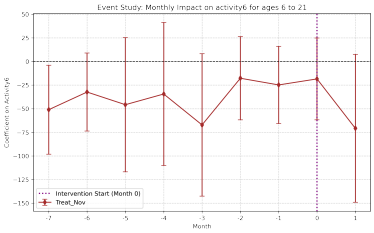
Figure 6: Event study plots for females (ages 6-21, 6-11, 12-14, 15-16, 17-18, 19-21, 10-18, and 19-30)

10.2 Event Study Plots: Females; whose treatment was on November

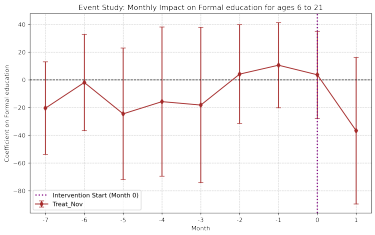
The event study graphs help analyze the treatment group's dynamic effect over months. It helps diagnose the treated cohorts' monthly variation in time spent on activities. For the event study plot for those get treatment in November, the month **September** as the starting month of the intervention, month 0. So, the month after 0 is 1, which is **November(post-intervention period)** here, excluding October and December. The treatment is **Binary**. The post-intervention only has the month of November since this is a Difference in Difference Strategy.

$$Y_{ihtd} = \alpha + \lambda_d + \delta_t + \sum_{\substack{k=1 \\ k \neq 10}}^{11} \beta_k(\text{treated}_d \times \text{months}_k) + X_{ihtd}\theta + \epsilon_{ihtd} \tag{9}$$

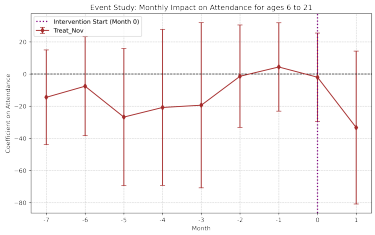
where The outcome variable Y_{ithd} represents the observed outcome for female i in household h, interviewed in month t within district d. The term λ_d denotes district fixed effects, which account for time-invariant differences across districts. Similarly, δ_t represents time-fixed effects, capturing common shocks that affect all districts within a given month.



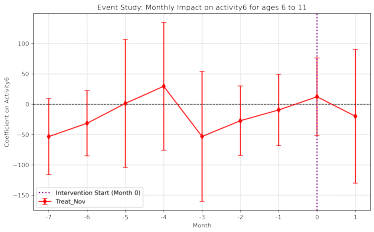
(a) Learning (Ages 6-21)



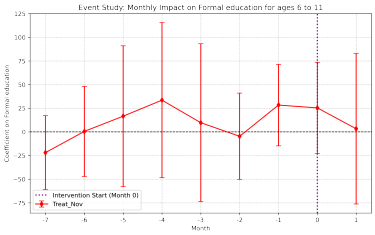
(b) Formal Education (Ages 6-21)



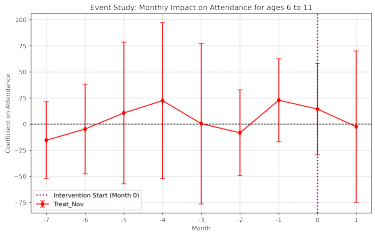
(c) Attendance (Ages 6-21)



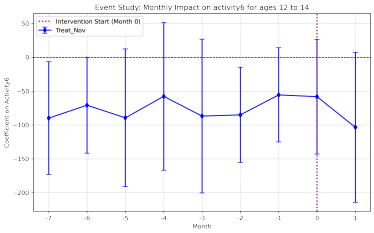
(d) Learning (Ages 6-11)



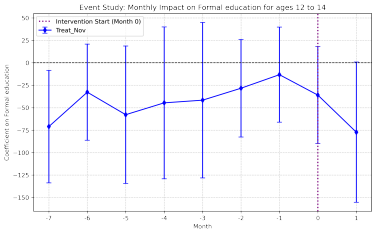
(e) Formal Education (Ages 6-11)



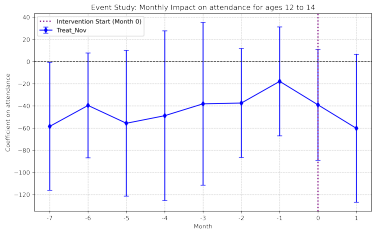
(f) Attendance (Ages 6-11)



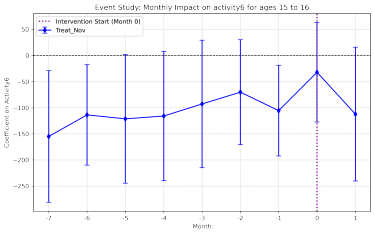
(g) Learning (12-14)



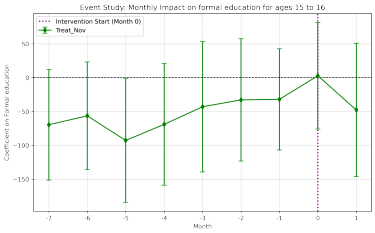
(h) Formal Education (12-14)



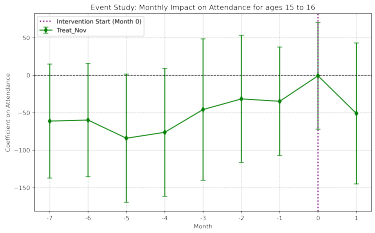
(i) Attendance (12-14)



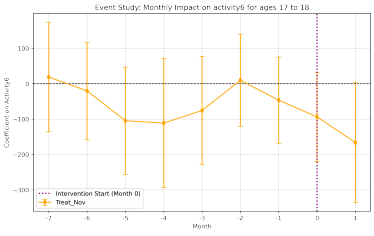
(j) Learning (15-16)



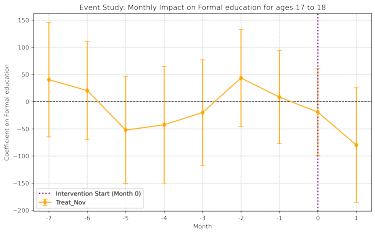
(k) Formal Education (15-16)



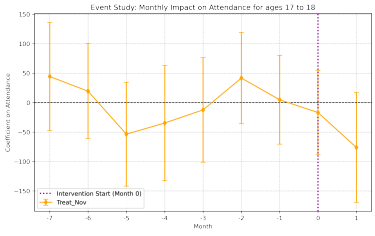
(l) Attendance (15-16)



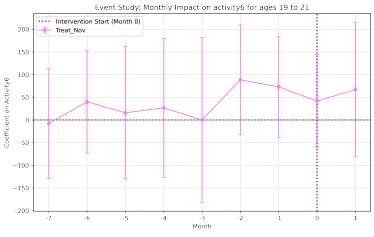
(m) Learning (17-18)



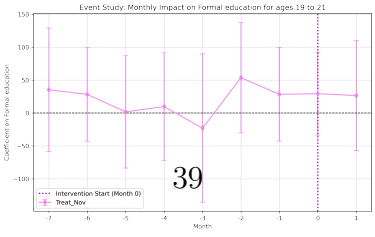
(n) Formal Education (17-18)



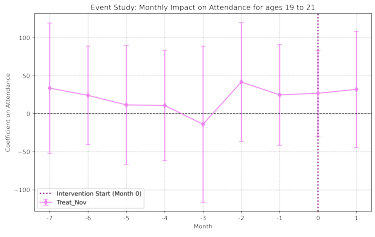
(o) Attendance (17-18)



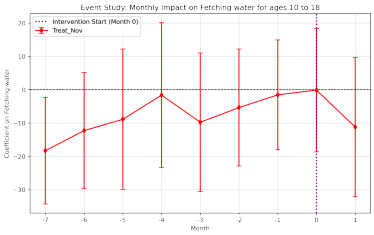
(p) Learning (19-21)



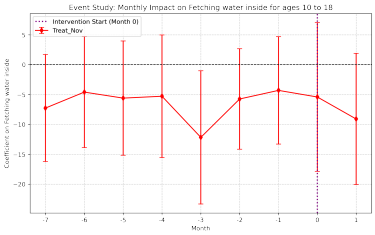
(q) Formal Education (19-21)



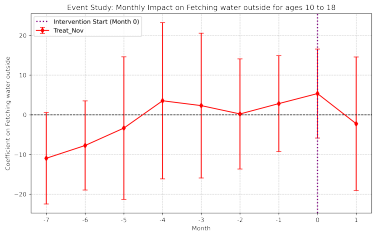
(r) Attendance (19-21)



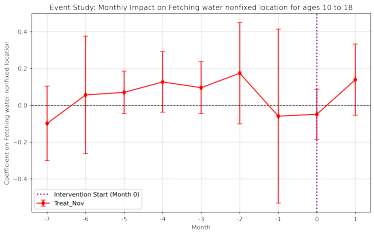
(a) Fetching Water (10-18)



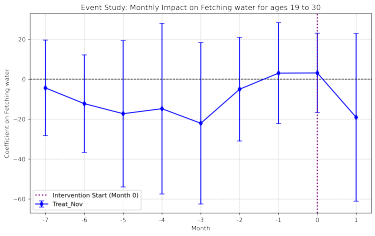
(b) Water Inside (10-18)



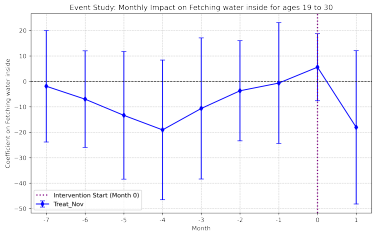
(c) Water Outside (10-18)



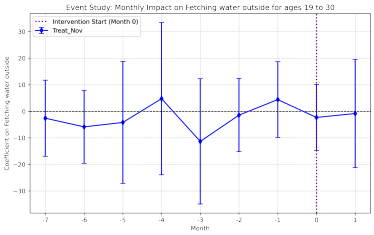
(d) Water Non-fixed (10-18)



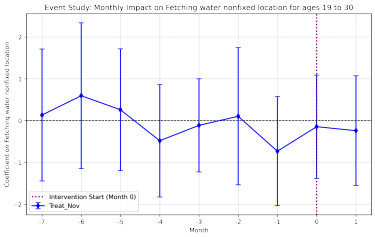
(e) Fetching Water (19-30)



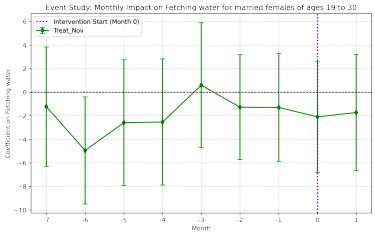
(f) Water Inside (19-30)



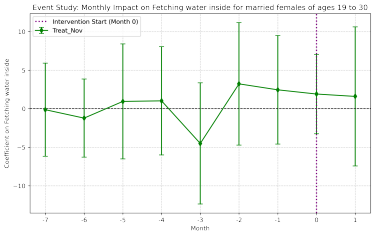
(g) Water Outside (19-30)



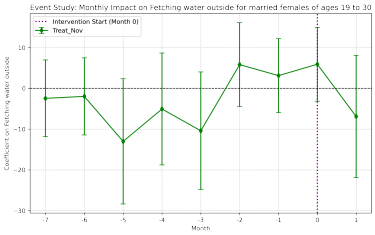
(h) Water Non-fixed (19-30)



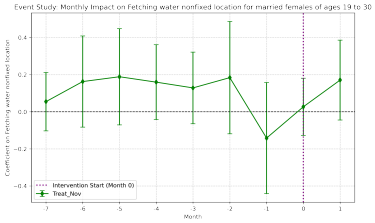
(i) Fetching water(19-30, married females)



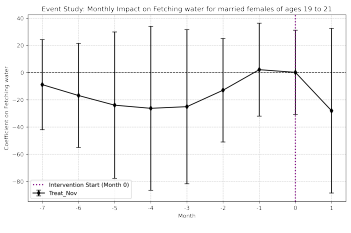
(j) Fetching water inside (19-30, married females)



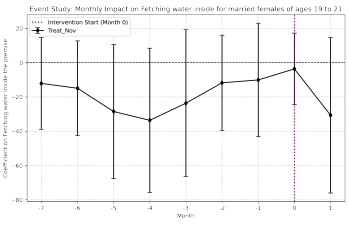
(k) Fetching water outside 19-30, married females)



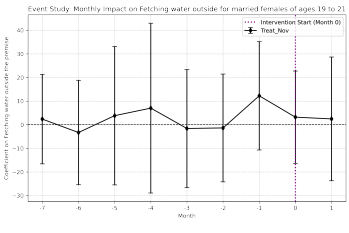
(l) Fetching water from non-fixed location(19-30, married females)



(m) Fetching Water (19-21, Unmarried)



(n) Water Inside (19-21, Unmarried)



(o) Water Outside (19-21, Unmarried)

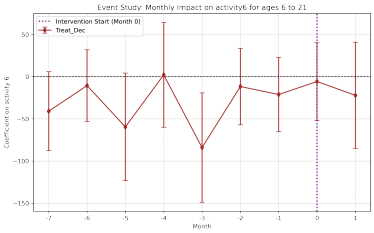
Figure 8: Event study plots for females (ages 6-21, 6-11, 12-14, 15-16, 17-18, 19-21, 10-18, and 19-30)

10.3 Event Study Plots: Females; whose treatment was on December

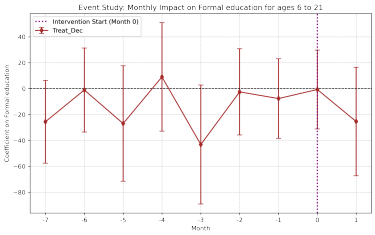
The event study graphs help analyze the treatment group's dynamic effect over months. It helps diagnose the treated cohorts' monthly variation in time spent on activities. For the event study plot for those get treatment in December, the month **September** as the starting month of the intervention, month 0. So, the month after 0 is 1, which is **December(post-intervention period)** here, excluding October and November. The treatment is **Binary**. The post-intervention only has the month of December since this is a Difference in Difference Strategy.

$$Y_{ihtd} = \alpha + \lambda_d + \delta_t + \sum_{\substack{k=1 \\ k \neq 10,11}}^{12} \beta_k(\text{treated}_d \times \text{months}_k) + X_{ihtd}\theta + \epsilon_{ihtd} \tag{10}$$

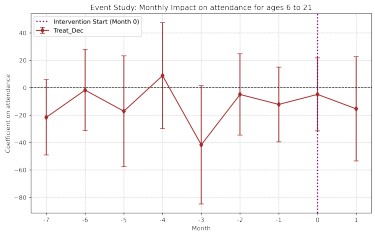
where The outcome variable Y_{ithd} represents the observed outcome for female i in household h, interviewed in month t within district d. The term λ_d denotes district fixed effects, which account for time-invariant differences across districts. Similarly, δ_t represents time-fixed effects, capturing common shocks that affect all districts within a given month.



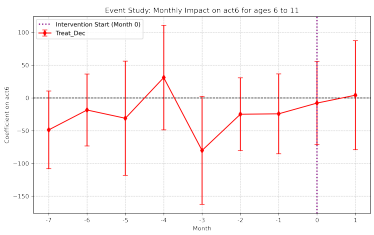
(a) Learning (Ages 6-21)



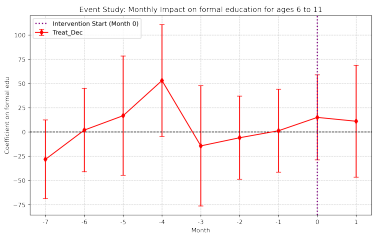
(b) Formal Education (Ages 6-21)



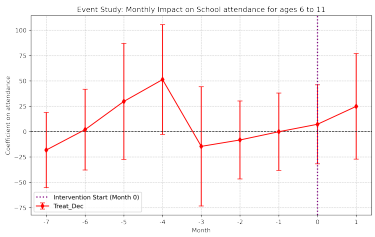
(c) Attendance (Ages 6-21)



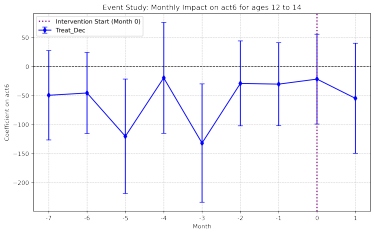
(d) Learning (Ages 6-11)



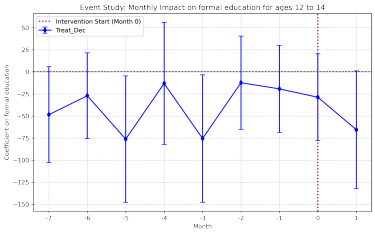
(e) Formal Education (Ages 6-11)



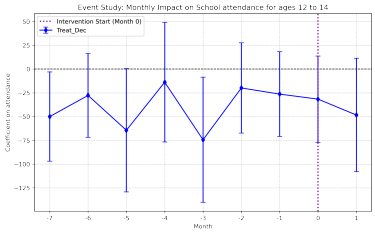
(f) Attendance (Ages 6-11)



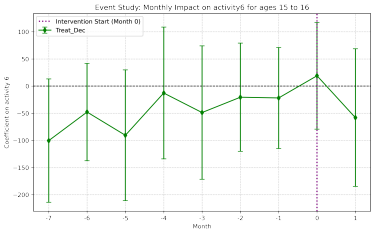
(g) Learning (12-14)



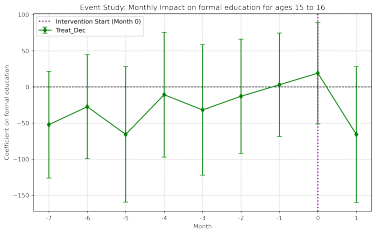
(h) Formal Education (12-14)



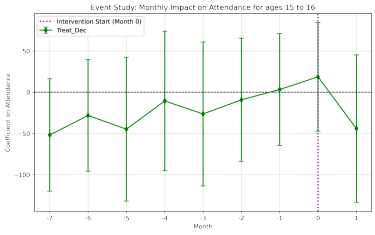
(i) Attendance (12-14)



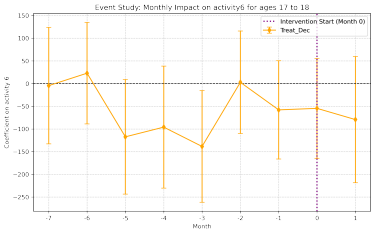
(j) Learning (15-16)



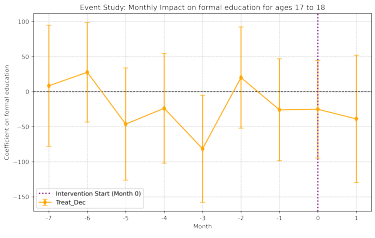
(k) Formal Education (15-16)



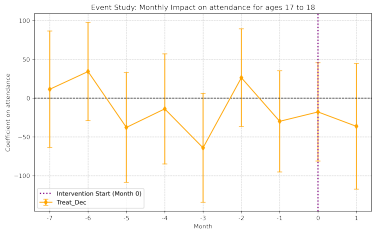
(l) Attendance (15-16)



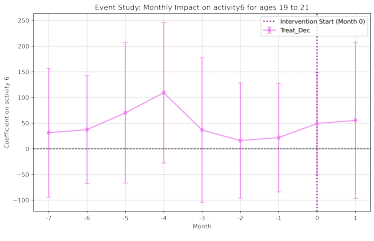
(m) Learning (17-18)



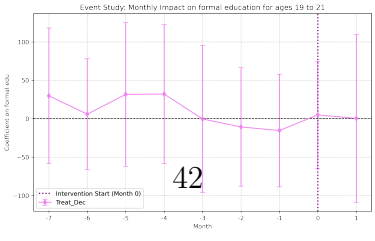
(n) Formal Education (17-18)



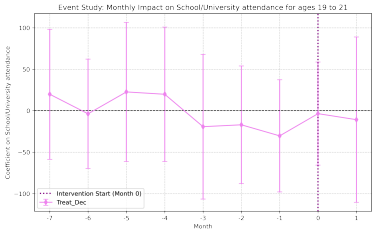
(o) Attendance (17-18)



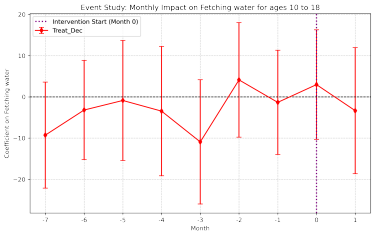
(p) Learning (19-21)



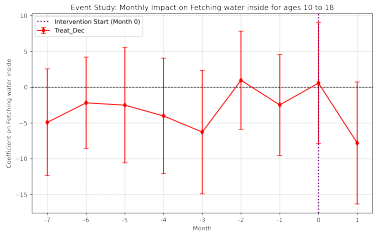
(q) Formal Education (19-21)



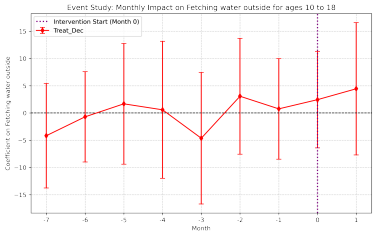
(r) Attendance (19-21)



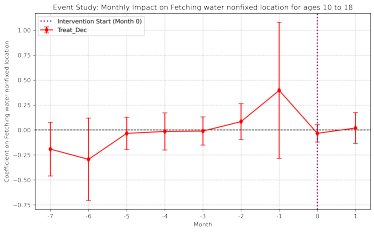
(a) Fetching Water (10-18)



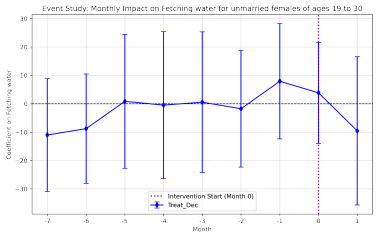
(b) Water Inside (10-18)



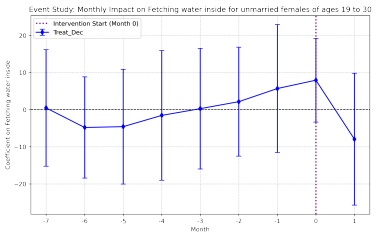
(c) Water Outside (10-18)



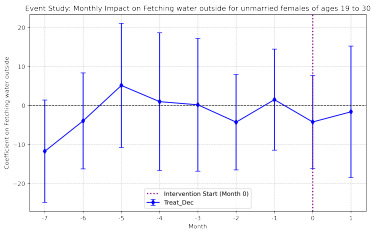
(d) Water Non-fixed (10-18)



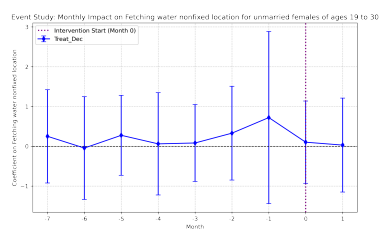
(e) Fetching Water (19-30)



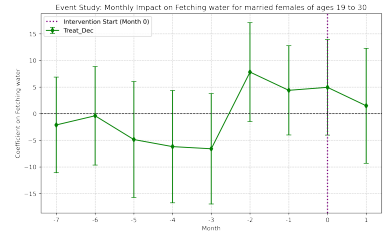
(f) Water Inside (19-30)



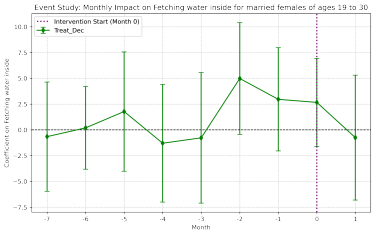
(g) Water Outside (19-30)



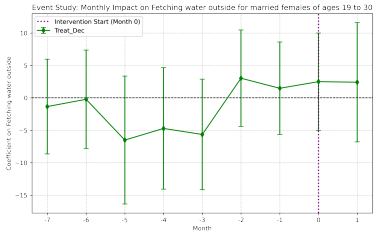
(h) Water Non-fixed (19-30)



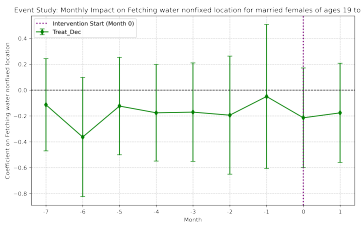
(i) Fetching water(19-30, married females)



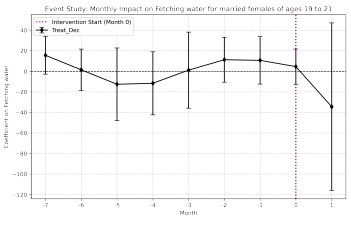
(j) Fetching water inside (19-30, married females)



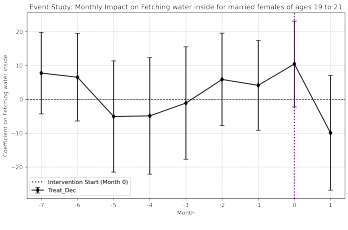
(k) Fetching water outside 19-30, married females)



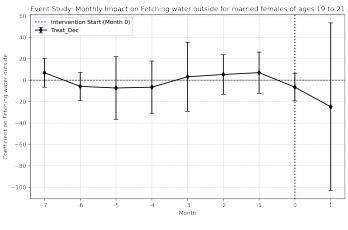
(l) Fetching water from non-fixed location(19-30, married females)



(m) Fetching Water (19-21, Unmarried)



(n) Water Inside (19-21, Unmarried)



(o) Water Outside (19-21, Unmarried)

Figure 10: Event study plots for females (ages 6-21, 6-11, 12-14, 15-16, 17-18, 19-21, 10-18, and 19-30)

11 Conclusion

This study offers compelling causal evidence on the early effects of the Jal Jeevan Mission (JJM) on educational outcomes and time use patterns among young females in India, primarily focusing on those aged 6–21. Utilizing a staggered difference-in-differences (DiD) approach as the primary identification strategy—validated through a standard DiD for robustness—the analysis underscores both the promise and limitations of early-stage implementation impacts.

The staggered DiD estimates indicate a statistically significant and positive impact of JJM on school/university attendance and learning outcomes, particularly for the 6–14 and 19–21 age groups. Notably, the intervention improved actual learning outcomes among 6–11 and 19–21-year-olds while increasing attendance among those aged 12–14. However, no measurable effect was found for those aged 15–18, likely due to educational transitions or external constraints, pointing to the need for age-specific complementary interventions.

While the traditional DiD analysis reveals a positive trend in educational engagement, it does not yield statistically significant results—suggesting that the more nuanced staggered DiD approach is superior in capturing the heterogeneous and time-varying nature of JJM's rollout. Moreover, the study finds that binary treatment (i.e., whether a district was treated or not) showed stronger impacts than continuous treatment measures. However, the latter remained statistically significant with modest intensity—highlighting the importance of both the presence and intensity of intervention.

On the dimension of time use, JJM significantly reduced the burden of water-fetching for unmarried females aged 10–18, particularly under the continuous treatment specification. Though observed, the reductions for older females (19–30) were statistically insignificant—suggesting either a delayed response or deeper household role entrenchments. No significant change was detected for married women, indicating a potential need for complementary gender-targeted strategies.

Importantly, placebo tests confirm the robustness of the main estimates, with significant Average Treatment Effects (ATEs) for water-fetching time across several subgroups. These results suggest that early intervention—especially yields more substantial educational benefits, affirming the importance of program timing in enhancing policy effectiveness.

From a policy perspective, the findings emphasize JJM's potential as a water infrastructure scheme and a catalyst for broader social development—by easing domestic burdens and enabling more significant investment in girls' education. To further strengthen impact, policymakers should consider targeted strategies for adolescents in transition (15–18 age group) and tailor interventions for married women who may face deeper structural barriers.

Future research should build on these findings by exploring the medium- and long-term impacts of JJM, incorporating post-2019 data to capture the program's maturation. Synthetic Control Method causal inference tools could provide further validation and insights. Ad-

ditionally, disaggregating impacts by socioeconomic status, caste, or rural-urban residence could yield a richer understanding of policy equity and inclusivity.

In summary, this study provides early yet meaningful evidence that JJM, even in its initial phase, generated measurable improvements in learning outcomes and reduced time poverty among young females. With timely implementation, strategic targeting, and longitudinal evaluation, the program holds transformative potential for enhancing gender equity in education and domestic labor in rural India.

12 References

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