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BEHAVIORAL ADAPTATION TO IMPROVED ENVIRONMENTAL QUALITY

EVIDENCE FROM A SANITATION INTERVENTION

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In this publication, "KN" refers to Lao People's Democratic Republic kip and "$" to United States dollar.
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ABSTRACT

This paper investigates behavioral adaptation to local improvements in environmental quality. Using exogenous variation in village sanitation coverage generated by the randomized allocation of financial incentives to latrine construction in the Lao People's Democratic Republic, we find that the generalized adoption of improved sanitation led to significant reductions in the practice of boiling water for drinking. Our analysis suggests that this change is likely a behavioral response to a reduction in the health benefits associated with treating water, which decline and eventually become negligible as local adoption of improved sanitation increases. Estimates of the value of time savings associated with the reduction in water boiling suggest that this adaptation is an additional important benefit of sanitation investments, most of which likely accrues to girls and women.

Keywords: WASH, water boiling, height-for-age, firewood collection
JEL codes: I12, O15, Q50

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1 Introduction

Access to safe drinking water, sanitation, and hygiene (WASH) in developing countries is recognized as critical for global public health. In 2015, it was estimated that 2.3 billion people lacked access to basic sanitation facilities, with millions of people dying each year due to fecal-borne diseases (most commonly diarrhea) as a result of inadequate WASH (WHO and UNICEF, 2019).

The WASH research literature to date has largely focused on the effectiveness of various interventions in increasing sanitation coverage and on the associated health improvements (Clasen et al., 2014; Patil et al., 2014; Briceno et al., 2017; Null et al., 2018; Luby et al., 2018; Augsburg and Rodriguez-Lesmes, 2018; Pickering et al., 2019; Cameron et al., 2019, 2021, 2022), with a smaller, but growing, number of studies examining other outcomes, such as education and cognitive development (Adukia, 2017; Coswosk et al., 2019; Orgill-Meyer and Pattanayak, 2020; Spears and Lamba, 2016; Zhang and Xu, 2016), and labor supply, reflecting a decrease in the domestic cleaning burden (Wang and Shen, 2022). With few exceptions, these studies focus on the impact of own toilet construction on household outcomes.

Improved sanitation however can also generate externalities to surrounding households through a cleaner and healthier local environment. Three recent studies suggest that such externalities matter. Cameron et al. (2022), using data from randomized trials in India, Indonesia, Mali and Tanzania, find that child height increases once village sanitation coverage exceeds 50%; and Cameron et al. (2021) show, using the same data as this study, that improvements in children's height-for-age z-score (HAZ) mostly reflect the degree of adoption of improved sanitation at the local (village) level, rather than their household's decision alone. In a similar vein, Motohashi (2022) analysis of a sanitation policy in India that incentivized the construction of over 100 million latrines, finds that its effect in terms of reduced diarrheal mortality is much weaker in areas with poor fecal sludge treatment, because the newly built latrines contribute to river pollution, which affects the whole community.

In this paper we contribute to the sparse literature on behavioral adaptations (in terms of changes in preventive health behavior) to the cleaner local environment provided by improved sanitation. Specifically, we present empirical evidence that local sanitation coverage decreases the likelihood that households will boil water before

drinking (or not), a behavior adaptation that reflects decreases in the perceived benefits of such behavior, given the persistent high opportunity costs of boiling water.[1]

We focus on drinking water treatment for several reasons. First, because unsafe drinking water and poor sanitation are equally important contributors to health (WHO and UNICEF, 2019) and microbial contamination of drinking water through contact with feces poses the greatest risk to drinking water safety. Second, around 80% of the households in our study sample rely on wells or rivers as their source of drinking water. These sources are susceptible to fecal contamination from open defecation and unimproved sanitation facilities. The quality of untreated water from these sources is thus likely to be highly correlated with sanitation coverage and the prevalence of open defecation at village level. Third, more than 60% of households in our sample treated water before drinking at baseline (Figure 1), with boiling water the most common approach (practiced by 98% of households who treat water). Finally, water boiling also has potentially large implications in terms of time use, given that most households in our sample collect firewood as a primary energy source.

We examine this question in the context of an intervention that coupled the randomized allocation of financial incentives for toilet construction with universal provision of Community-Led Total Sanitation (CLTS) in the Lao People's Democratic Republic (Lao PDR). CLTS aims to create demand for sanitation through behavior change but, in its standard form, provides no financial assistance for households and communities to construct sanitation infrastructure. That is not the case in our experiment where, on top of CLTS that is universally provided, in some randomly selected villages poor households are eligible to receive rebates for toilet construction; in other randomly-selected villages the community receives a monetary reward once all households in the community have installed and use an approved toilet; and in a third randomly-selected group of villages both forms of financial incentive were applied. The randomized assignment of financial incentives for the construction of latrines provides a source of exogenous variation in the adoption of improved sanitation that we exploit to identify the causal effect of improved sanitation coverage on drinking water treatment. Our results suggest that a 10-percentage point increase in village sanitation coverage reduces the probability of boiling water for drinking by 2.5 percentage points (approximately 6% of the control mean). We are aware of no other experimental studies

[1] The demand for preventive health behaviors has been shown to be highly sensitive to costs (Berry et al., 2020; Kremer et al., 2011; Ashraf et al., 2010) and so may be similarly sensitive to reductions in the perceived benefits.

that have studied the water treatment decision in conjunction with the adoption of improved sanitation.[2]

Reductions in the practice of water boiling, driven by increased prevalence of improved sanitation at the local level, are potentially concerning, as access to an improved source of drinking water has been shown to improve child health (Jalan and Ravallion, 2003) and boiling water is one of the most effective and widely used preventative health measures when water supplies are unsafe (WHO, 2015).[3] Thus, we examine whether the reduction in water boiling is associated with negative health costs that could offset the positive health impacts of improved sanitation. The association between child health measures and water treatment however appears to be negligible once the majority of households in a village own improved sanitation—as is common in our endline sample.

We then reflect on what benefits may result from this change. A reduction in the time devoted to gathering the firewood needed to boil water is a significant potential benefit. This benefit would largely flow to women and girls as collection of firewood is typically a female task. The act of boiling itself (once firewood has been collected) is also time-consuming (Clasen et al., 2008). Lighting fires also exposes women and girls to higher risks of respiratory illnesses from indoor air pollution (Naeher et al., 2007; Mengersen et al., 2011).

Our estimates of the time saved from reduced firewood collection associated with decreased water boiling suggest that the reduction in water boiling caused by sanitation improvements saves households an average of 25 minutes daily, or 13 hours monthly, on this task. This frees women and girls up to spend this time on other activities, such as education or child/elder care activities. Our conservative estimate of the value of the time savings associated with not boiling water alone are valued at $7 per household per month (approximately 8% of the median monthly income of households in our sample).

We interpret the observed reduction in water treatment as a rational reaction to improved sanitary conditions and the consequent lower marginal health benefits associated with boiling water, in a context where the costs of this activity remain high - when households perceive community water sources as being cleaner and safer due to better village sanitation, the perceived health benefits of boiling drinking water are reduced and some households decide to stop the practice. The reductions in water

[2]The closest study to ours is Bennett (2012), which studied the substitutability between clean water and household sanitary behavior in the Philippines in a non-experimental setting, finding that the provision of piped water reduced household investment in sanitation.

[3]The child health benefits associated with improved water supply have also been shown to be associated with higher parental investments in education (Gibson and Lawson, 2011).

boiling are an additional important benefit of local environmental improvements, generating economic returns and potentially promoting gender equality.

2 Community-led Total Sanitation (CLTS) with Randomized Financial Incentives

The intervention we exploit combines the randomized allocation of financial incentives for latrine construction with the universal provision of Community-Led Total Sanitation (CLTS).[4] CLTS aims to bring about the community-wide elimination of open defecation through inspiring coordinated community action driven by disgust at open defecation and is currently the most widely practiced intervention for improving rural sanitation in developing countries. It has been implemented in nearly 60 countries, 31 of which have incorporated it as a component of national sanitation strategy or policy (Zuin et al., 2019b).

In the field, CLTS starts with the "triggering event"—a community meeting in which participants are taken through a carefully facilitated set of activities aimed at helping people understand how fecal contamination spreads from exposed excreta to their living environments (including to food and drinking water), leading to the realization that people are digesting small amounts of each other's fecal matter with negative health consequences. Households are then encouraged to build hygienic toilets of their own choosing, at their own expense, while communities are encouraged to aim at achieving Open Defecation Free status. This approach emphasizes the creation of demand for sanitation and new social norms that stigmatize open defecation, in contrast to the traditional approach of supplying sanitation hardware, which has been shown to have had limited success as it failed to stimulate households' demand for sanitation (Sah and Negussie, 2009). CLTS highlights that fecal-borne diseases are mainly transmitted through the consumption of untreated water, increasing the likelihood that households' behavior in relation to water will be influenced by local sanitation.[5]

The intervention took place between March 2015 and October 2016 in 160 villages across 10 districts in two provinces (Champasak and Sekong) in rural southern Lao PDR. Financial incentives for latrine construction were randomly assigned to one of four

[4] Cameron et al. (2021) examine the impact of the financial incentives on toilet construction and child health.

[5] This does not pose a problem for the evaluation as all households—including households in the control group—receive CLTS and its health messaging. The availability of the financial incentives accompanying CLTS is randomized and generates the exogenous variation in sanitation coverage that we exploit in the analysis.

equally sized treatment groups across the 160 villages in our sample: 40 villages per group, stratified by 10 districts, leading to one village per treatment group per district. All villages in both treatment and control groups were universally provided with the CLTS, and the only source of experimental variation is that villages in treatment groups were offered incentives for their latrine construction.

In the first treatment group, villages were assigned to the household incentive scheme. The poorest 30% of households, determined via a score-card system, were given rebates after verified toilet installation, amounting to roughly $20, or 13% of the price of the lowest-priced pour-flush toilet. In the second treatment group, villages were assigned to the village incentive scheme, where a monetary award of between $300 and $500, depending on village population, was offered. This amount was paid to the village administration committee and used at the committee's discretion on any development project, after all households had a hygienic toilet at least 15 meters away from their house, along with evidence of regular use. The remaining treated villages were offered both the household-level rebate and the village-level award. Villages allocated to the control group received CLTS with no financial incentives. Cameron et al. (2021) analyze this experiment and show that targeted incentives alongside CLTS increased the take-up of improved sanitation, with significant health spillovers for children.

3 Data

We use longitudinal household survey data from 2,400 households (15 households per village, and 600 per treatment group) collected in May 2015 and July 2018.[6] The households were randomly sampled from those in each village with at least one child under 2 years of age at baseline. Each interview took approximately 90 minutes. A single respondent (most commonly the spouse of the male household head) was asked a variety of questions on household demographics and sanitation. At the end of the interview, caregivers of children in the target age range (0–2 years old at baseline, 3–5 years old at endline) were asked to consent to their child being measured and weighed.

Our outcome of interest is boiling of drinking water at the household level—specifically, a dummy variable that takes the value of one if the respondent boils water before drinking it, and zero otherwise. 60% of households in our sample treat their drinking water and of these, 98% do so by boiling.

[6] The intervention was only implemented in two villages prior to May 2015 and was only at its very early stages in those villages.

We examine the relationship between better environmental quality (village sanitation coverage) and water boiling. Village latrine coverage is measured using administrative data that is regularly collected by the Provincial Health Department, independently of the research team.

4 Empirical Strategy

4.1 The Relationship between Sanitation Coverage and Water Boiling (OLS)

We begin the analysis of the relationship between village sanitation coverage and water boiling by using OLS regression to estimate regressions of the form:

$$\begin{aligned} Boil_h^{EL} &= \alpha + \beta_1 VillageLatrineCoverage_v^{EL} + \beta_2 X_h^{BL} + \beta_3 V_v^{BL} \\ &\quad + \pi_1 VillageLatrineCoverage_v^{BL} + \pi_2 ToiletOwnership_h^{BL} + \pi_3 Boil_h^{BL} \\ &\quad + \gamma_d + \epsilon_h \end{aligned} \tag{1}$$

where h and v are household and village subscripts, *EL* and *BL* indicate measurements at endline and baseline respectively. Village Latrine Coverage is the percentage of households that own a toilet in each village.[7] Baseline village latrine coverage and baseline household toilet ownership are included to account for baseline differences in initial latrine ownership which may be correlated with a household's water boiling behavior. We also control for baseline water boiling behavior, $Boil_h^{BL}$, and household and village baseline controls, X_h and V_v, respectively. The specific controls included in each specification will be discussed further below. γ_d is a vector of district fixed effects that accounts for the stratified design. Standard errors are clustered at the village level.

4.2 Effect of Sanitation on Water Boiling Behavior (IV estimates)

The adoption of improved sanitation is likely correlated with a potentially large set of variables, some of which are also plausibly correlated with the decision to boil water before drinking. To address this endogeneity concern, we exploit the randomized

[7] We focus on village sanitation coverage, rather than household toilet ownership, as the prevalence of sanitation in a community is what matters most for local environmental quality (Augsburg and Rodriguez-Lesmes, 2018; Bakhtiar et al., 2021; Cameron et al., 2021, 2022; Pakhtigian et al., 2022).

assignment to the different incentives as a source of exogenous variation in village sanitation coverage. We use treatment status (three dummy variables indicating randomization into one of the three treatment groups) as instruments for village sanitation coverage. Because the financial incentives were either offered as a direct subsidy for latrine construction or paid to the village administration committee, they are plausibly exogenous and not directly related to the household level decision-making regarding boiling water. That is, by design, the instruments satisfy the exclusion restriction.

5 Results

5.1 Summary Statistics, Balance Tests and Attrition

Figure 2 presents a comparison of water boiling and latrine coverage rates at both baseline and endline and clearly illustrates an inverse relationship between the two variables. While the share of households that owned a toilet increased from 45% to 62% between baseline and endline, the share of households that boiled water before drinking decreased from 60% to 45%.

In Tables 1 and 2, we present summary statistics of baseline household and village characteristics, respectively. In the vast majority of pair-wise comparisons, we cannot reject the null hypothesis of no difference between treatment and control groups. One exception is that households in villages assigned to receive both incentives were less likely to boil water for drinking and more likely to consume bottled water at baseline, compared to households in villages that received no incentives. These differences are however only weakly statistically significant (p-values = 0.097 and 0.077 respectively). Village latrine coverage at baseline is also weakly higher in villages that received the village reward (T2) than in control villages (p=0.10). Other variables that are unbalanced in some comparisons are the household head's gender and ethnicity, the sex ratio within the household, the number of plots of land owned by the household, the use of firewood for cooking, the distance between the household's latrine and drinking water source, and whether the village had a health care program. Conservatively, we control for all unbalanced baseline variables in the statistical analysis.

Sample attrition was 8%, and we find no evidence of differential attrition by treatment status or by our outcome variable—whether the household boiled water (Table 3).

5.2 OLS and IV Estimates of the Relationship between Village Sanitation Coverage and Water Boiling

The OLS estimates of Equation 1 are presented in Table 4. Column 1 presents the estimates when the only controls included are baseline differences in latrine ownership and water boiling. Column 2 presents the estimates when we additionally include variables that are unbalanced at baseline (discussed above), and in Column 3, we control for all variables listed in Tables 1 and 2.[8]

The estimates suggest that an improvement in village-level sanitation coverage is negatively associated with water boiling: a 1-percentage point increase in village latrine coverage is associated with approximately a 0.14-percentage point decrease in the likelihood of water boiling.

Although the point estimates of the coefficients on village sanitation are stable across the different specifications in Columns 1 to 3, these results do not have a causal interpretation. Many village characteristics could drive a relationship between the two variables. For example, higher socioeconomic status villages may be more likely to have greater sanitation coverage as they can afford to build latrines, and lower water boiling rates as their sources of drinking water may be better quality. Alternatively, more health-seeking households and communities may be more likely to invest in sanitation and to boil water. The OLS estimates thus may be an over- or underestimation of the causal estimate. We turn to instrumental variables estimation to identify the causal impacts.

Panel B, Column 4 of Table 4 presents the first stage results and shows that treatment assignment (the different financial incentives) is strongly predictive of increased village sanitation coverage, with the F-statistic of the Kleibergen-Paap Wald test above the critical values for weak instruments presented in Stock and Yogo (2005) supporting the relevance of the instruments. We likewise fail to reject the overidentification test of all instruments (Hansen J-statistic), supporting exogeneity.

Panel A, Column 4 of Table 4 presents the second stage results. A 10-percentage point increase in village latrine coverage decreases water boiling by about 3.1 percentage points (6.4% relative to our endline sample mean, p-value = 0.062). While both the OLS and the IV regressions support the conclusion that improved sanitation causes households to

[8] We also control for whether the village had a water program or sanitation materials program in the 3 years prior to endline as this could affect both sanitation and water treatment behavior. We restrict the sample to households who do not consume bottled water as whether to boil drinking water is not a consideration for these households. Households who drink bottled water are generally wealthier. The consumption of bottled water increased between baseline and endline but is not affected by treatment status. Results available on request.

reduce water boiling, the IV estimates are larger in magnitude than the corresponding OLS ones. This may reflect that, as discussed above, other things being equal, more health-seeking households and villages are more likely to invest in both sanitation and boiling water, offsetting the effect of a cleaner environment on boiling of water. The IV approach, by eliminating the endogenous effect of sanitation, removes this offsetting effect, resulting in a larger negative coefficient of sanitation on water boiling.

Column 5 in Table 4 presents the reduced form. It shows negative effects on water boiling associated with treatment. The indicator variables for treatment 1 (CLTS + household rebates) and treatment 3 (CLTS + household rebates + village rewards) are statistically significant at the 10% level (p=0.099 and p=0.067, respectively).

6 Costs and Benefits Associated with Reductions in Water Boiling

Estimates from the previous section suggest that increases in the coverage of sanitation reduce water boiling. In this section, we provide a quantification of the costs and benefits associated with this behavior change in terms of child health status and household time use.

6.1 Water Boiling and Child Growth

We examine the association between water boiling and child growth by estimating cross-sectional OLS regressions on the baseline data in the following form:

$$Health_c^{BL} = \alpha + \gamma_1 Boil_h^{BL} + \theta_1 C_c^{BL} + \theta_2 X_h^{BL} + \theta_4 V_v^{BL} + \gamma_d + \epsilon_c \quad (2)$$

where *Health* indicates the child's height-for-age z-score (HAZ)[9] for children aged 0-2 years in our sample, and c (h and v) is the child (household and village) subscript. θ_1 represents a vector of coefficients on controls for the child, including gender, birth order, and age, as well as whether the child is cared for by his/her parents or by others, caregiver's knowledge about the preventability of diseases and the causes of diarrhea, along with their attitudes towards child and adult open defecation. We also control for the same set of household and village controls as in Tables 1 and 2. γ_d is a vector of district fixed effects and ϵ is the error term. Standard errors are clustered at village level.

[9]We used the -zscore06- command in Stata (Leroy, 2011) to estimate height-for-age z-scores.

This analysis is necessarily suggestive, and identifies the correlations between the variables. Our estimates in Table 5, columns (1) to (3) suggest that water boiling is associated with better child health, in terms of height-for-age z-score (HAZ), consistent with the literature, e.g., see a recent meta-analysis by Cohen and J. M. Colford (2017).

These results raise the possibility that the positive health effects of the sanitation intervention are attenuated by the behavioral response that households took in reducing water boiling. To further investigate this, we examine how the relationship between water boiling and child health varies with sanitation coverage (column 4). Recall that most households in our sample collect their drinking water from wells and rivers, so we would expect higher sanitation coverage to be associated with higher water quality.

Figure 3 graphically illustrates the estimates presented in the final column in Table 5. It shows that the positive association between water boiling and child height is weaker when village-level latrine coverage is higher. The association becomes statistically insignificantly different from zero once households live in villages where more than approximately 50% of households own improved sanitation.

This heterogeneity in the effect of water boiling on child's health is also evident when we split the sample based on the threshold of the village sanitation coverage of 50%. The results are presented in Table 6. They are consistent with those presented in Table 5 and show that the positive association between the child growth measure and household water boiling is only apparent in villages where the sanitation coverage is below 50% (Column 1). Once sanitation coverage reaches 50%, the relationship between boiling drinking water and child health becomes statistically insignificant and close to zero in magnitude (column 2). This relationship is mirrored in Figure 4 where there is a clearly nonlinear relationship between village latrine coverage and water boiling: water boiling at endline decreases with latrine coverage until latrine coverage is about 50%.[10]

These findings suggest that there exists a threshold of sanitation coverage, estimated to be 50% of sanitation coverage, beyond which health gains from practicing water boiling become negligible. On this basis, we conclude that the reduction in water boiling is unlikely to be associated with significant health costs in our context, given that, at endline, more than 70% of households in our sample live in villages with a cleaner environment where the importance of treating water is negligible (in contrast to 37% of households at the time of the baseline survey). Instead, it seems to be evidence of an

[10]We cannot conduct the instrumental variables estimation with boiling drinking water as the dependent variable (analogous to Table 4) separately for observations in villages with sanitation coverage above and below 50% at endline, as the instruments lose predictive power in the sub-samples.

informed recalibration, with households changing their behavior in response to improvements in the external environment.

6.2 Time Savings from Water Boiling Reduction

Now, we turn to reflect on what benefits may have resulted from this change in behavior. Building on ex-ante analysis, we focus on the time and energy costs of water boiling, as most households (65%) in our sample collect firewood as a primary energy source for cooking.

To put a value on the benefit of reduced water boiling we use data from the fifth wave of the 2012-2013 Lao Expenditure and Consumption Survey (LECS5) to calculate the number of hours saved in firewood collection and the foregone income associated with this use of time.[11] The Lao Expenditure and Consumption Survey collects data on the time spent on firewood collection irrespective of its purpose, including cooking, animal food preparation, and heating. Rural households that spend time on firewood collection in LECS5 are similar to those in our own data who report burning firewood for cooking across a range of characteristics, including the demographic structure of the household, household heads' gender, age and education and area of agricultural land farmed (Appendix Table A.1).[12] Extrapolating from the LECS5 sample to our own, this analysis suggests that household members spend, on average, three hours per day on firewood collection.

The hours spent on firewood collection specifically for water boiling is calculated by multiplying the total hours households spend on average on firewood gathering each day (3 hours) by the share of firewood used for boiling water (14% based on previous research by Amrose et al. 2015) and produces a figure of 25 minutes per day or 13 hours per month. We then multiply this estimated time use by the Lao PDR national minimum wage to obtain a figure for foregone earnings. At the time of our field work (2015 to 2018), the Lao PDR minimum wage for a standard 206-hour work month (48 hours per week) was KN900,000 ($110) (or KN4,370 per hour).[13] This leads to an estimate of the opportunity cost of collecting firewood for boiling water at KN56,810 ($7) per household per month,

[11] As our survey data do not include information on time use.

[12] An analysis of the determinants of the number of hours spent on firewood collection finds households with a male head, education of primary school level or lower, and a greater number of adult women in the household spend more hours on this task. Time spent on firewood collection seem to (weakly) decrease with education (Appendix Table A.2).

[13] The national minimum wage is lower than the hourly rate in the agriculture sector (KN5,330 per hour according to Lao PDR Statistical Yearbook 2018). Our estimate could however be overstated if most firewood collection is being conducted by young girls who would be unlikely to earn the minimum wage.

which is equivalent to 7.6% of the median value of household monthly income (KN750,000) in our sample.

As in other contexts, there is a clear gender division in who is responsible for firewood collection, with women and girls participating in this activity in 73% households that collect firewood and being solely responsible for firewood collection in 60% of these households, Appendix Table A.3. Table 7 presents some evidence of how individuals might have otherwise allocated their time, had they not had to collect firewood. Time spent on firewood collection is negatively associated with time spent on education (Column 1), and this negative association is almost one-to-one for individuals younger than 18 (Column 2). Individuals who are older than 18 tend to spend their time on children/elder care activities (Column 4). The opportunity cost of firewood collection is maybe then best thought of, not in terms of foregone earnings, but in terms of educational opportunities and time spent in caring activities.

6.3 Other Benefits of Reduced Water Boiling

Reductions in water boiling also potentially generate other societal benefits. These include reductions in the depletion of forests. Rural families in Lao PDR consume approximately 183 kilograms of firewood per month for cooking, with 25.6 kilograms used for boiling drinking water (Tang et al., 2013). This leads to an annual consumption of 0.3 million tons of firewood (0.65 to 1.3 cubic meters per household year), which is a significant factor in the depletion of forests. The reduction in water boiling thus contributes to sustainable forest management. Burning firewood also has a significant impact on the environment in terms of greenhouse gas emissions. Reductions in boiling drinking water means that households are reducing the conversion of large amounts of solid carbon into greenhouse gasses.

Reductions in the burning of firewood may also generate additional health benefits. Burning of firewood is the main energy source in Lao PDR and leads to high concentrations of particulate matter (PM10) and nitrogen dioxide that are about 25 times higher than the World Health Organization's (WHO) 24-hour mean guidelines. The almost 1 hour per day women and girls spend in the household cooking area boiling water exposes them to a higher risk of associated health hazards. Mengersen et al. (2011) find that a wide range of symptoms of respiratory illness in women and children aged 1-4 years in the Lao PDR are positively associated with exposure to indoor cooking. Table A.4 in the appendix shows that in our survey data, having an indoor kitchen and firewood as the main energy source

for cooking is associated with a 6-percentage point (40%) increase in the probability that children under 5 in the household had a cough in the previous seven days.[14]

7 Conclusion

This paper contributes to the sparse literature on behavioral adaptations to a cleaner local environment. We find that improvements in village sanitation coverage, generated by the randomized allocation of financial incentives for latrine construction alongside universal provision of Community-Led Total Sanitation (CLTS), led to a significant reduction in boiling water for drinking.

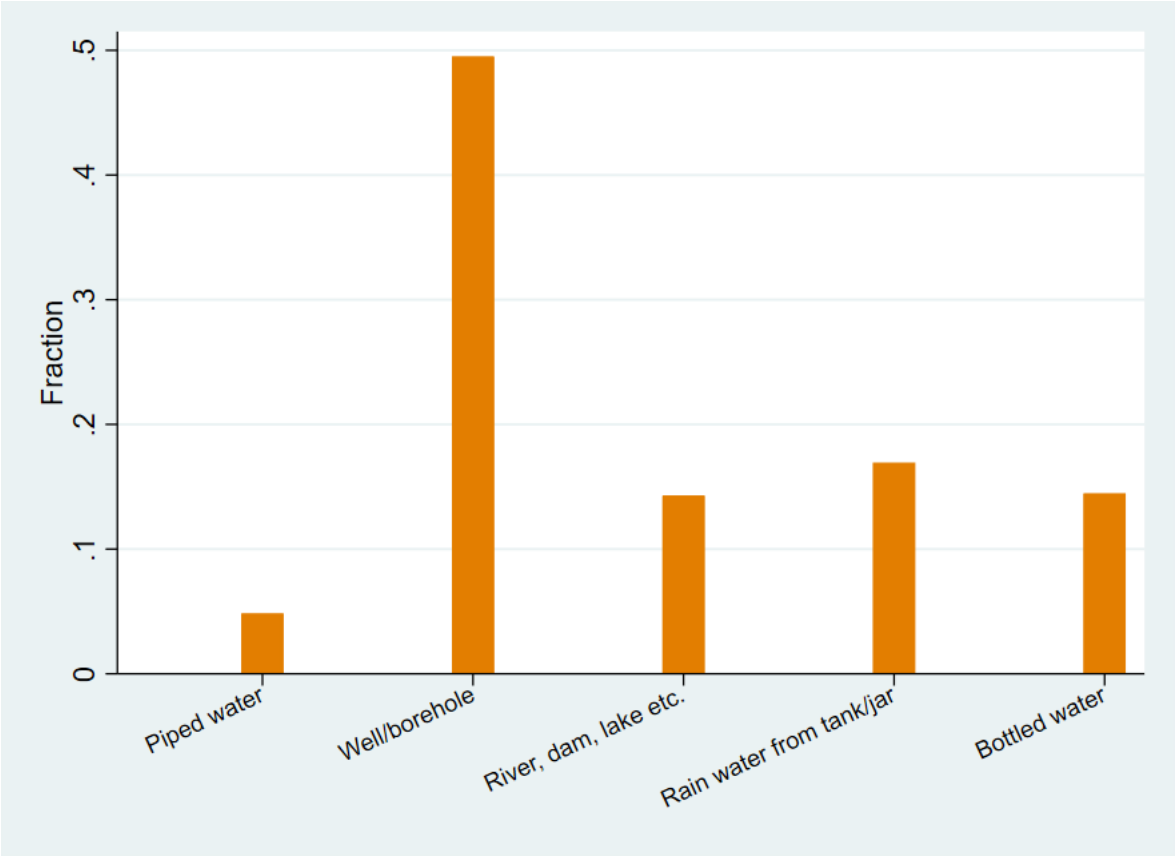
In relation to the costs and benefits associated with reductions in water boiling, our analysis suggests that the link between child health and water treatment becomes negligible when most village households have improved sanitation, a condition prevalent in our endline sample. On that basis, the reduction in water boiling is unlikely to be associated with substantial health costs in our context. Rather, the reduction seems to reflect a rational behavioral response to a cleaner local environment. This change in behavior is an additional benefit of sanitation investments, generating time savings that are disproportionately enjoyed by women and girls in our context.

Our study has powerful implications for cost-benefit analysis of sanitation investments. Governments in developing countries continue to devote resources to increasing hygienic toilet use. The existing literature [e.g., Dickinson et al. (2015)] has shown that latrines are highly cost-effective investments, mainly based on returns to child health, education, and adult time-savings. The findings in this paper suggest that previous studies may have understated the benefits of improved sanitation by not accounting for additional behavioral change flowing from the reduced need for boiled water. In addition to the time-savings of households, reduced burning of firewood for water boiling is likely to generate significant environmental and health benefits. Finally, while gender inequality has deep social roots, our study reveals that improved sanitation has the potential to contribute to gender parity in rural areas by freeing women and girls up from the time-consuming demands of firewood collection.

[14] We do not have data on adult respiratory illness.

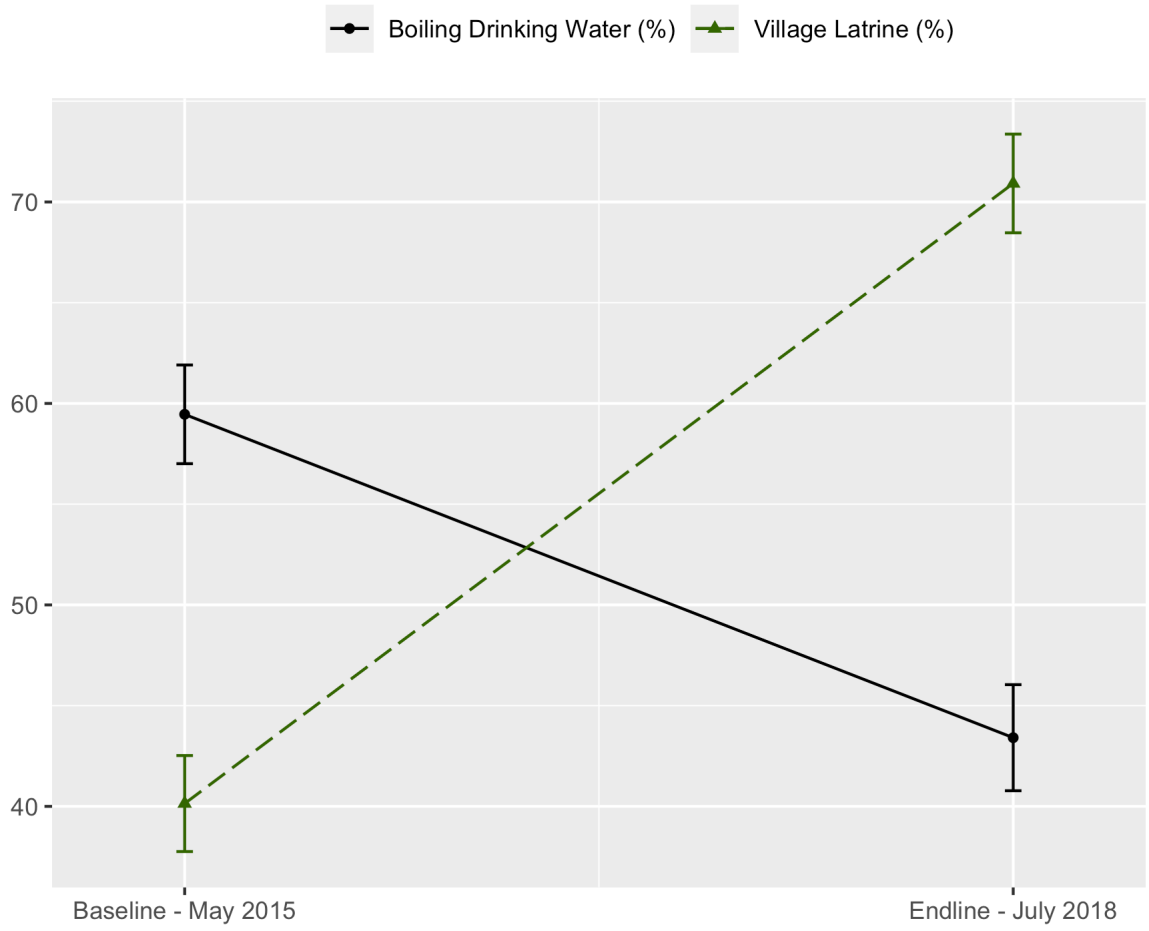
Figures and Tables

Figure 1: Drinking Water Sources in the Lao PDR Survey Sample



Note: The figure plots households' main source of drinking water in the wet season.
Source: Lao Expenditure and Consumption Survey 2012-2013.

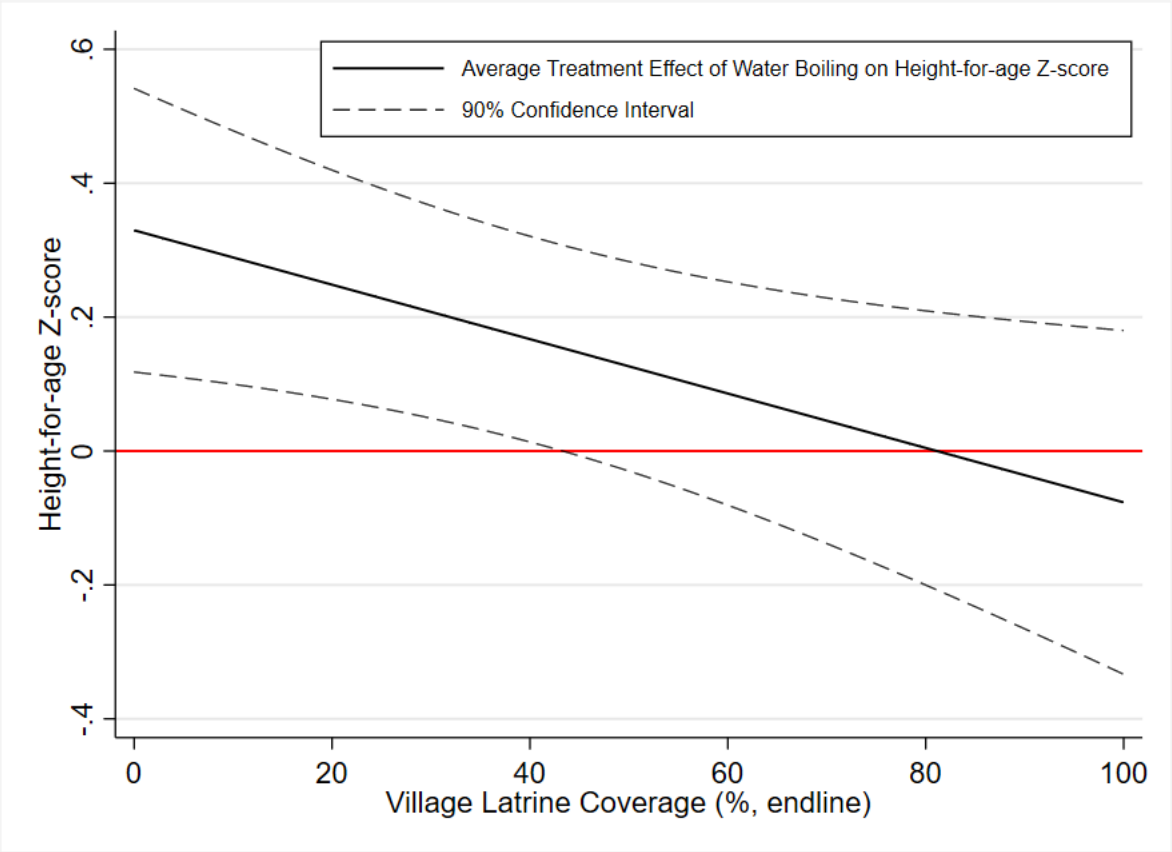
Figure 2: Trends in Village Latrine Coverage and Boiling Water for Drinking



Notes: Water boiling is a dummy variable that takes the value of one if the respondent boils water before drinking and zero otherwise. Village latrine coverage is measured by administrative data that is regularly collected by the Provincial Health Department, independently of the research team.

Source: Authors' calculations.

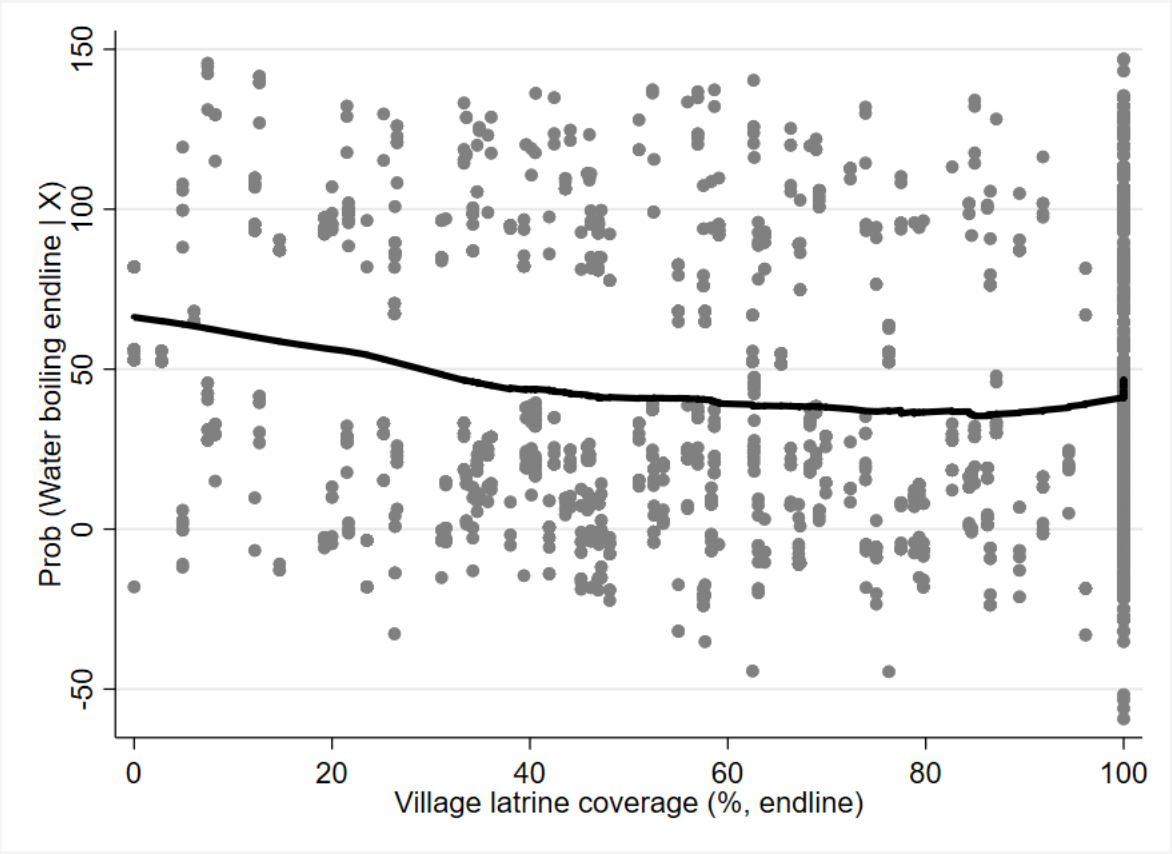
Figure 3: The Relationship Between Water Boiling and Child Growth (height-for-age z-score) as a Function of Village Latrine Coverage



Notes: This figure graphically illustrates the estimates presented in the final column of Table 5. The black line represents the association between boiling drinking water and child health (height-for-age z-score) across different values of latrine coverage at the village level, while the dashed lines indicate the 90% confidence intervals.

Source: Authors' calculations.

Figure 4: Partial Linear Regression of Water Boiling at Endline on Village Latrine Coverage at Endline



Notes: This figure shows a partial linear regression based on Column 2 in Table 4. We use the -plreg- command introduced by Lokshin (2006) and Zuin et al. (2019a). It models endline water boiling as a nonlinear function of village latrine coverage. Each dot represents a household in our sample, while the black curve illustrates the non-linear trend.

Source: Authors' calculations.

Table 1: Balance on Baseline Household Characteristics

N=2400	C	T1	T2	T3	Differences in Means (p-values)					
Intervention:	CLTS	CLTS and Household Rebate	CLTS and Village Reward	CLTS and HH Rebate and V Reward	C vs T1	C vs T2	C vs T3	T1 vs T2	T1 vs T3	T2 vs T3
Household size	6.620	6.672	6.597	7.112	0.895	0.944	0.280	0.850	0.383	0.263
	(0.230)	(0.318)	(0.240)	(0.392)						
No. of children	3.313	3.328	3.260	3.570	0.953	0.823	0.401	0.788	0.448	0.313
	(0.168)	(0.190)	(0.170)	(0.256)						
Head male	0.938	0.903	0.943	0.935	0.082*	0.746	0.846	0.059*	0.157	0.649
	(0.010)	(0.017)	(0.012)	(0.014)						
Head age (years)	40.655	41.443	40.612	41.890	0.576	0.970	0.344	0.527	0.758	0.287
	(0.890)	(1.096)	(0.727)	(0.953)						
Head education (category)	1.308	1.292	1.328	1.263	0.867	0.836	0.650	0.728	0.793	0.537
	(0.064)	(0.077)	(0.073)	(0.076)						
Ethnicity: Lao Tai	0.625	0.733	0.553	0.623	0.241	0.457	0.987	0.053*	0.250	0.482
	(0.068)	(0.062)	(0.068)	(0.073)						
Household sex ratio	0.510	0.520	0.514	0.504	0.281	0.703	0.485	0.464	0.067*	0.262
	(0.007)	(0.006)	(0.006)	(0.007)						
Household dependency ratio	0.255	0.253	0.250	0.246	0.798	0.541	0.284	0.725	0.447	0.724
	(0.007)	(0.007)	(0.007)	(0.005)						
Household income (category)	3.738	3.827	3.767	3.680	0.713	0.904	0.822	0.805	0.576	0.738
	(0.168)	(0.175)	(0.170)	(0.196)						
Poor household	0.253	0.223	0.285	0.293	0.601	0.605	0.541	0.292	0.266	0.900
	(0.043)	(0.038)	(0.044)	(0.050)						
Owns house	0.885	0.860	0.875	0.865	0.414	0.734	0.502	0.618	0.869	0.732
	(0.021)	(0.022)	(0.020)	(0.021)						
House floor area (sq m)	54.705	55.235	50.495	54.648	0.873	0.172	0.987	0.122	0.867	0.207
	(2.358)	(2.330)	(1.967)	(2.632)						

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N=2400	C	T1	T2	T3	Differences in Means (p-values)					
Intervention:	CLTS	CLTS and Household Rebate	CLTS and Village Reward	CLTS and HH Rebate and V Reward	C vs T1	C vs T2	C vs T3	T1 vs T2	T1 vs T3	T2 vs T3
Use firewood for cooking	0.567	0.475	0.682	0.522	0.260	0.134	0.588	0.008***	0.575	0.044**
	(0.057)	(0.058)	(0.051)	(0.060)						
No. plots of land	2.607	2.200	2.608	2.457	0.006***	0.992	0.330	0.012**	0.061*	0.371
	(0.114)	(0.088)	(0.134)	(0.104)						
Owns toilet	0.447	0.442	0.427	0.472	0.934	0.710	0.667	0.807	0.646	0.452
	(0.037)	(0.047)	(0.039)	(0.045)						
Daily open defecation	0.523	0.495	0.532	0.512	0.686	0.901	0.862	0.615	0.820	0.776
	(0.045)	(0.054)	(0.049)	(0.050)						
Dist WC to drinking water ($<$10m)	0.078	0.093	0.100	0.130	0.658	0.526	0.179	0.853	0.359	0.455
	(0.023)	(0.025)	(0.026)	(0.031)						
Dist WC to drinking water ($>$10m)	0.145	0.205	0.118	0.128	0.103	0.401	0.618	0.019**	0.045**	0.764
	(0.023)	(0.029)	(0.022)	(0.025)						
Boils water	66.833	58.667	57.333	55.000	0.220	0.156	0.097*	0.843	0.608	0.745
	(4.644)	(4.751)	(4.785)	(5.352)						
Other water treatment	0.028	0.027	0.027	0.020	0.932	0.931	0.634	1.000	0.636	0.626
	(0.016)	(0.012)	(0.011)	(0.008)						
No water treatment	0.198	0.245	0.255	0.227	0.425	0.303	0.608	0.871	0.767	0.628
	(0.036)	(0.046)	(0.041)	(0.042)						
Drink bottled water	0.105	0.142	0.145	0.203	0.459	0.422	0.077*	0.949	0.287	0.315
	(0.033)	(0.037)	(0.037)	(0.044)						

Notes: Standard errors are clustered at the village level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Source: Authors' calculations.

Table 2: Balance on Baseline Village Characteristics

N=120	C	T1	T2	T3	Differences in Means (p-values)					
Intervention:	CLTS	CLTS and Household Rebate	CLTS and Village Reward	CLTS and HH Rebate and V Reward	C vs T1	C vs T2	C vs T3	T1 vs T2	T1 vs T3	T2 vs T3
Village sex ratio	0.502	0.510	0.502	0.498	0.422	0.975	0.633	0.565	0.165	0.716
	(0.007)	(0.010)	(0.010)	(0.007)						
% Lao Tai	0.625	0.733	0.553	0.623	0.240	0.461	0.986	0.045**	0.208	0.365
	(0.130)	(0.127)	(0.144)	(0.165)						
Distance to city (kms)	18.700	21.925	25.800	24.875	0.379	0.125	0.271	0.261	0.367	0.807
	(2.511)	(3.700)	(4.297)	(5.051)						
Exit road is dirt	0.650	0.575	0.675	0.625	0.449	0.802	0.829	0.462	0.644	0.658
	(0.102)	(0.081)	(0.119)	(0.135)						
Village has river	0.625	0.800	0.675	0.700	0.136	0.582	0.538	0.322	0.396	0.816
	(0.142)	(0.081)	(0.148)	(0.135)						
Connected to public piped water	0.275	0.325	0.275	0.275	0.670	1.000	1.000	0.663	0.613	1.000
	(0.086)	(0.086)	(0.117)	(0.083)						
Has centralized water treatment	0.075	0.075	0.100	0.100	1.000	0.596	0.400	0.617	0.396	1.000
	(0.076)	(0.074)	(0.058)	(0.075)						
Had a water program	0.200	0.150	0.125	0.175	0.422	0.428	0.670	0.679	0.524	0.435
	(0.091)	(0.079)	(0.052)	(0.087)						
Latrine coverage	31.163	39.064	47.536	42.816	0.421	0.098*	0.182	0.119	0.554	0.418
	(6.612)	(7.987)	(5.637)	(7.332)						
Open defecation in pond	0.600	0.725	0.625	0.550	0.262	0.800	0.626	0.362	0.125	0.521
	(0.177)	(0.085)	(0.150)	(0.168)						
Had a sanitation materials program	0.200	0.200	0.125	0.100	1.000	0.245	0.308	0.359	0.373	0.654
	(0.109)	(0.101)	(0.058)	(0.074)						
Had a sanitation information program	0.100	0.075	0.150	0.050	0.702	0.606	0.343	0.393	0.578	0.376
	(0.068)	(0.034)	(0.087)	(0.050)						

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N=120 Intervention:	C CLTS	T1 CLTS and Household Rebate	T2 CLTS and Village Reward	T3 CLTS and HH Rebate and V Reward	Differences in Means (p-values) C vs T1	 C vs T2	 C vs T3	 T1 vs T2	 T1 vs T3	 T2 vs T3
Had a healthcare program	0.175	0.250	0.175	0.250	0.050**	1.000	0.219	0.351	1.000	0.303
	(0.076)	(0.071)	(0.083)	(0.092)						
Had a deworming program	0.950	0.975	0.950	1.000	0.394	1.000	0.201	0.547	0.324	0.146
	(0.036)	(0.024)	(0.031)	(0.000)						
	Mean/(SE)				Pairwise t-test					
Number of observations	40	40	40	40	80	80	80	80	80	80
Number of clusters	10	10	10	10	10	10	10	10	10	10

Notes: Standard errors are in brackets below the means. Standard errors are clustered at the district level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Source: Authors' calculations.

Table 3: Testing for Differential Attrition

	Household was re-interviewed at endline
Treatment group 1	-0.0341
	(0.0311)
Treatment group 2	0.00960
	(0.0258)
Treatment group 3	-0.0301
	(0.0306)
Baseline water boiling (binary)	-0.00181
	(0.0234)
Treatment group 1 * Baseline water boiling	0.0130
	(0.0358)
Treatment group 2 * Baseline water boiling	-0.0264
	(0.0297)
Treatment group 3 * Baseline water boiling	-0.0124
	(0.0344)
Constant	0.963***
	(0.0284)
District fixed effects	Yes
R-squared	0.02
Dependent variable mean values	0.92
Observations	2400

Notes: Standard errors are clustered at the village level. Dependent variable is whether the household was re-interviewed at endline.
Source: Authors' calculations.

Table 4: The Relationship Between Village Latrine Coverage and Water Boiling

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS
Panel A.					
Dependent Variable:	Household boils water for drinking at endline				
Village latrine coverage (%, endline)	-0.13**	-0.12**	-0.14***	-0.31*	
	(0.058)	(0.055)	(0.053)	(0.16)	
Water boiling (binary, baseline)	0.28***	0.28***	0.34***	0.32***	
	(0.037)	(0.039)	(0.091)	(0.090)	
Mean Dep. Variable	62.88	62.88	63.12	63.12	
Panel B:					
Dependent variable:				First Stage Village latrine coverage (EL)	Reduced Form Household boils drinking water (EL)
Treatment group 1				15.38***	-7.18*
				(5.35)	(4.33)
Treatment group 2				14.79**	-3.83
				(5.92)	(4.58)
Treatment group 3				28.10***	-8.68*
				(5.85)	(4.70)
Unbalanced variables at baseline:	No	Yes	Yes	Yes	Yes
Full controls:	No	No	Yes	Yes	Yes
District Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat (p-value)				(<0.01)	
Kleibergen-Paap rk LM stat (F-stat)				7.78	
Hansen J-statistic				0.69	
Hansen J-statistic p-value				0.71	
Mean Dependent variable:				48.27	63.11
Observations	1498	1498	1483	1483	1483

Notes: The unit of observation is a household. The sample is restricted to those households who do not drink bottled water at endline. Household-level variables that are unbalanced at baseline include the gender and ethnicity of the household head, the household sex ratio, the use of firewood for cooking, number of plots of land the household owns, distance from drinking water source to latrine, whether the household boils water before drinking and whether the household drinks bottled water. Village-level variables that are unbalanced at baseline include village latrine coverage and the presence of healthcare programs. Full controls are the full set of variables shown in Tables 1 and 2. All specifications include a control for baseline village latrine coverage. Columns (3) to (5) also include controls for whether the village had a water program or a sanitation materials program in the 3 years prior to endline. The dependent variables in Panel B are: village latrine coverage at endline for the first stage; whether the household boils water for drinking at endline for the reduced form. Standard errors are clustered at the village level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors' calculations.

Table 5: OLS Estimates of the Relationship Between Water Boiling and Child Growth at Baseline

	(1) OLS	(2) OLS	(3) OLS	(4) OLS
Dependent variable:	Baseline Height for age z-score			
Water boiling (BL)	0.0436	0.175**	0.170**	0.330**
	(0.0789)	(0.0842)	(0.0854)	(0.129)
Village latrine coverage (BL)				0.0021
				(0.0018)
Village latrine coverage (BL) x Water boiling (BL)				-0.0041*
				(0.0021)
Household toilet ownership (BL)				-0.0439
				(0.135)
Household toilet ownership (BL) x water boiling (BL)				-0.0126
				(0.148)
Child controls	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	Yes
Village controls	No	No	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes
R-squared	0.30	0.31	0.31	0.31
Dependent variable mean values	-0.63	-0.63	-0.63	-0.63
Observations	2728	2726	2726	2728

Notes: The unit of observation is a child. Controls for the child include gender, birth order, and age, as well as whether the child is cared for by his/her parents or by others, caregiver's knowledge about the preventability of diseases and the causes of diarrhea, along with their attitudes towards child and adult open defecation. Household and village controls are those listed in Tables 1 and 2. Column (4) only includes household and village controls that had a t-statistic >1. Standard errors clustered at the village level are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors' calculations.

Table 6: Sub-Sample Analysis of the Relationship Between Water Boiling and Child Growth

	(1)	(2)
	Sample 1	Sample 2
Baseline village latrine coverage:	$<$50%	$>$50%
	OLS	OLS
Dependent variable:	Height for age z-score	
Boiled drinking water at baseline	0.221**	0.0161
	(0.108)	(0.141)
Child controls	Yes	Yes
Household controls	Yes	Yes
Village controls	Yes	Yes
District fixed effects	Yes	Yes
R-squared	0.33	0.32
Dependent variable mean values	-0.54	-0.79
Observations	1,716	1,010

Notes: Notes: The unit of observation is a child. In our sample, 1,010 households (37% of the total) resided in villages with latrine coverage greater than 50% at baseline, while 1,925 households (71% of the total) lived in villages with latrine coverage greater than 50% at endline. Standard errors clustered at the village level are in parentheses. * p$<$0.10, ** p$<$0.05, *** p$<$0.01.
Source: Authors' calculations.

Table 7: Opportunity Costs of Collecting Firewood

Dependent variable:	(1) Time spent on education	(2) Time spent on education	(3) Time spent caring for dependent family members	(4) Time spent caring for dependent family members
Time spent on firewood collection	-0.310***	-0.112***	-0.176***	-0.196***
	(0.0291)	(0.0241)	(0.034)	(0.040)
Age below 18 (binary)		3.102***		-0.223***
		(0.168)		(0.093)
Time spent on firewood collection * Age below 18		-0.771***		0.087
		(0.0861)		(0.058)
Individual Controls	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.26	0.41	0.09	0.09
Dependent variable mean values (hours per day)	1.1	1.1	1.85	1.85
Observations	2,946	2,946	2,946	2,946

Notes: The unit of observation is an individual. The "dependent family members" in the last two columns include both children and the elderly. Individual controls include gender and the relationship to the household head (head, spouse, parents, children, siblings, other relatives, not relative). Columns (1) and (4) also include a continuous control for the age of the individual. Standard errors clustered at the household level are in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' calculations.

Appendix Tables

Table A.1: Comparison of LECS Data and Survey Data

	Lao Expenditure and Consumption Survey		Survey sample	
	Mean/Std.Dev.	Observations	Mean/Std.Dev.	Observations
Time spent on firewood collection (hours)	2.97	633		
	(3.28)			
Firewood only collected by women and girls (%)	61.77	633		
	(48.63)			
Women and girls participated in firewood collection (%)	73.62	633		
	(44.11)			
Household size (count)	6.21	633	7.02	1567
	(2.55)		(3.58)	
Head male	0.942	633	0.946	1567
	(0.235)		(0.227)	
Number of female household members	3.12	633	3.54	1567
	(1.60)		(2.06)	
Head age (years)	45.87	633	39.49	2400
	(12.44)		(13.20)	
Head's education: Less than primary school	0.246	622	0.189	1567
	(0.431)		(0.008)	
Head's education: Primary school	0.545	622	0.519	1567
	(0.498)		(0.500)	
Head's education: Lower secondary school	0.162	622	0.153	1567
	(0.369)		(0.361)	
Head's education: Upper secondary school	0.024	622	0.078	1567
	(0.154)		(0.268)	
Head's education: Tertiary and vocational	0.023	622	0.031	1567
	(0.148)		(0.176)	
Floor area of house (sq meters)	56.11	633	47.55	2400
	(59.81)		(26.37)	
Agricultural land area	2.20	633	1.84	1567
	(2.45)		(3.13)	

Notes: The unit of observation is a household. The sample for Lao Expenditure and Consumption Survey is rural households who spent time on firewood collection in the last 24 hours (at the time of survey administration). The sample for the survey data is households who report using firewood for cooking. Standard deviations are in parentheses.
Source: Authors' calculations.

Table A.2: Correlates of Household Firewood Collection

	(1)	(2)	(3)	(4)
Dependent Variable: Hours household spends on firewood collection				
Household head characteristics:				
Male	1.068	1.350*	1.072***	1.047***
	(0.659)	(0.759)	(0.255)	(0.227)
Age (years)	0.00331			
	(0.0117)			
Married	-0.567	-0.318		
	(0.573)	(0.771)		
Literate	0.0663			
	(0.410)			
Highest education – primary school	-0.184	-0.128	-0.126	
	(0.415)	(0.273)	(0.275)	
Highest education – lower secondary	-0.651	-0.947**	-0.956**	
	(0.562)	(0.413)	(0.408)	
Highest education – upper secondary and above	-0.232	-0.603	-0.595	
	(0.602)	(0.500)	(0.504)	
Highest education – lower secondary and above				-0.775**
				(0.339)
Ethnicity – Lao Tai	-0.160			
	(0.304)			
No. of household members	0.104			
	(0.105)			
No. of adult female household members	0.265	0.416**	0.412**	0.417**
	(0.207)	(0.159)	(0.156)	(0.153)
No. of female household members under 18 years	0.105			
	(0.131)			
Household owns house	0.118			
	(0.565)			
House floor area (sqm)	0.00245			
	(0.00384)			
House has an indoor kitchen	0.101			
	(0.257)			
Agricultural land area	0.0776			
	(0.104)			
Runs a non-farm business	0.0667			
	(0.400)			
Constant	0.228	0.700	0.674	0.550
	(1.054)	(0.403)	(0.422)	(0.372)
N	672	686	686	686

Notes: We present results from OLS regression. All specifications include provincial fixed effects. Column 1 reports results with the full set of controls shown. Column 2 includes only those independent variables which had a t-statistic > 1 in column 1. Column 3 includes only those independent variables which had a t-statistic > 1 in column 2. Column 4 imposes equality of the household head education category variable coefficients. Standard errors are clustered at the province level and are shown in parentheses. * p<0.10, ** p<0.05, *** p<0.01.
Source: Authors' calculations.

Table A.3: Who Collects Firewood

	%
Type 1: Households that have adults only (N=181)	
Women are solely responsible for firewood collection	60.4
Women participate in firewood collection	72.5
Type 2: Households that have children (<=18 years old), but boys only (N=139)	
Women are solely responsible for firewood collection	45.5
Women participate in firewood collection	59.7
Type 3: Households that have children (<=18 years old), but girls only (N=149)	
Women and girls are solely responsible for firewood collection	69.7
Women and girls participate in firewood collection	79.6
Type 4: Households that have children (<=18 years old), with both boys and girls (N=164)	
Women and girls are solely responsible for firewood collection	70.7
Women and girls participate in firewood collection	82.1

Notes: The unit of observation is a household. The sample is from Lao Expenditure and Consumption Survey where rural households who spent time on firewood collection in the last 24 hours (at the time of survey administration). This table suggests that women and girls are mainly responsible for firewood collection, and hence, they bear most of the associated costs.
Source: Authors' calculations.

Table A.4: Associations Between Using Firewood for Cooking and Children's Respiratory Illness

	(1)	(2)	(3)
Dependent variable: Child aged under 5 years had a cough in the 7 days prior to the survey			
	Marginal Effects		
Firewood is the main energy source for cooking and have an indoor kitchen	0.0644*	0.0656**	0.0639**
	(0.0332)	(0.0325)	(0.0324)
Child controls	Yes	Yes	Yes
Household controls	No	Yes	Yes
Village controls	No	No	Yes
District fixed effects	Yes	Yes	Yes
Dependent variable mean values	0.16	0.16	0.16
Observations	2728	2726	2726

Notes: The unit of observation is a child. We report marginal effects from probit estimation. Child, household and village control variables are the same as in Table 5. All specifications also include controls for firewood being the main energy source for cooking and whether the household has an indoor kitchen. Standard errors clustered at the village level and shown in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Source: Authors' calculations.

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Behavioral Adaptation to Improved Environmental Quality

Evidence from a Sanitation Intervention

This study finds that investing in sanitation not only improved children's health, but also created valuable time-savings for all household members. In 160 villages in the Lao People's Democratic Republic, cash rewards incentivized households to build toilets. Households in areas where sanitation improved, enjoyed a cleaner local environment, and the need to boil water for consumption was lowered. This change saved time, especially for women and girls, who traditionally spend hours collecting firewood and boiling water.

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