The Hidden Role of Piped Water in the Prevention of Obesity in Developing Countries. Experimental and Non-Experimental Evidence.

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Abstract

Child obesity in developing countries is growing at an alarming pace. This study investigates whether expanding access to piped water at home can contribute to stopping this epidemic. It exploits experimental data from Morocco and longitudinal data from the Philippines and finds that access to piped water at home reduces childhood BMI and obesity rates. This study further shows that the effect seems to be generated by a reduction in the consumption of food prepared outside the home. Finally, the study shows that the effect of access to piped water on healthy nutritional status is hidden, when access to piped water at home reduces diarrhea prevalence since this in turn increases BMI.

1 Introduction

As of 2010, there were 43 million children worldwide age 5 or younger overweight or obese. Of these, 35 million live in developing countries (Harvard, 2018). In

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Morocco, the overweight rate for children under five years of age is one of the highest in the world, surpassing the US and Mexico (WHO, 2016). Obesity can seriously deteriorate children heart, lungs, muscles and bones, kidneys and digestive tract, and hormones that control blood sugar and puberty. It increases the likelihood of adult obesity, and with that increases the risk of cardiovascular diseases and unemployment. This study investigates whether access to drinking water can contribute to the fight against the obesity epidemic in developing countries. Previous studies have shown important benefits associated with access to drinking water, including reduced morbidity and mortality mainly from waterborne diseases (Galiani, Gertler and Schargrodsky, 2005; Gamper-Rabindran, Khan and Timmins, 2010; Duflo, Galiani and Mobarak, 2012), but to the best of my knowledge, no study has investigated whether access to piped water at home reduces body weight and obesity rates.

Conceptually, there are reasons to believe that access to drinking water can have an important effect on obesity prevalence. Households disconnected from water supply networks suffer a higher cost for drinking water, cooking and of washing dishes. This cost typically has two components: the first component is more time and effort to obtain water; instead of simply opening the tap in their houses, they must walk with buckets and spend considerable time fetching water. The second component of the cost is a higher likelihood of becoming infected with waterborne pathogens; water from public sources are typically less clean than piped water at home. This higher costs of drinking water, cooking and washing dishes might, in turn, affect body weight in a couple of ways. First of all, the physical activity of walking and fetching water might affect weight negatively. However, the burden of collecting water is typically concentrated on adults, in particular, adult women, not on children. Second, higher costs for drinking water, cooking and washing dishes might induce people to substitute toward eating food outside the home including snacks, soft drinks, fast food, and street vendors' food and this substitution in food might lead to a weight increase.

The two implicit conditions for this subsitution in food and increase in wieght to happen is, first, that families without piped water at home do have enough money and do have access to snacks, soft drinks, fast food or street-vendors food. This, of course, is not the case in many rural areas and among extremely poor individuals in developing countries. However, lack of access to piped water at home is far from being a problem unique to extremely poor individuals and from rural areas; one in every three urban dwellers in developing countries does not have piped water at home (UnitedNations, 2015). Meanwhile, western food companies are targeting developing countries as the richest nations are shrinking their demand (Jacobs and Richtel, 2017; Euromonitor-International, 2010; Deogun, 1999).

The second condition is that food outside the home has more calories than home-made food or that eating food outside the home leads people to consume more food in total. Typically, food prepared outside the home in most areas of the world has high sugar and fat content, such at widely available deep-fried foods, and sugar and fat are among the highest contributors of calories. Additionally, consuming food prepared outside the home is less time-consuming than preparing and consuming food at home, this lower cost might lead to a larger number of meals per day. Finally, food outside the home might be less satiating than food inside the home. For example, there is important evidence that drinking water facilitates weight loss by increasing the sensation of fullness, which in turn leads to a lower meal energy intake (Dennis et al., 2010; Stookey et al., 2008), while liquid carbohydrates show little compensatory dietary response, meaning that individuals who consume more liquid carbohydrates, like soft drinks, do not offset the corresponding increase in calorie intake by reducing their consumption of another caloric food (DiMeglio, Mattes et al., 2000).

In general, previous studies agree that the obesity epidemic has resulted from a change in the type of food consumed rather than solely on an increase in the amount of food consumed. Cutler, Glaeser and Shapiro (2003) argue that the switch from individual to mass preparation lowered the time price of food consumption and have led to increased quantity and variety of the foods consumed. They use the example of the consumption of potatoes, which has increased greatly in the US over the last decades, but almost exclusively in the form of potato chips and french fries, which are typically prepared outside the home and usually not in baked, boiled or mashed form. Other studies have shown how the prices of food typically prepared outside the home like pizza and sodas have fallen over the last decades while the real price of fruits and vegetables has rather increased (Cawley, 2015; Wendt and Todd, 2011). In the particular case of developing countries with poor drinking water access, Ritter (2018) finds soda prices experienced a sharp decrease in the late 1990s in Peru and that households without piped water at home were especially responsive, increasing their consumption of soda and their obesity rates, while reducing diarrhea prevalence, suggesting that they were substituting contaminated water with soda.

In principle, then, it seems plausible that if families get access to piped water at home they will reduce their consumption of food outside the home, and this might reduce their obesity rates. However, it is not easy to test this claim empirically. Access to drinking water at home can have two simultaneous effects: it might reduce the consumption of food outside the home, and thereby reduce BMI, but it might also reduce diarrhea prevalence, and a reduction in diarrhea prevalence has the opposite effect on BMI (Kremer et al., 2011). Thus, if we do not disentangle these two effects, it might seem like access to drinking water has no effect on the nutritional status of individuals, as measured by BMI. This conclusion, however, would be misleading; an individual that maintains a normal BMI (greater than 18 and smaller than 25) by offsetting the effect of consuming high-calorie snacks and street food with chronic diarrhea is likely significantly less healthy than an individual that achieve a normal BMI by consuming fewer high-calorie snacks and street food.

This study examines the effect of access to piped water at home on BMI and obesity rates, exploiting both experimental and non-experimental data. The experimental data comes from a social experiment carried out by Devoto et al. (2012) in the city of Tangiers, Morocco. They found that households are willing to pay a substantial amount of money to have a private tap at home. They also find that connection to piped water at home increased time spent in leisure and social activities, improved social integration and reduced conflict. Interestingly, the experiment did not have any effects on diarrhea prevalence, since both treatment and control group had access to a nearby public tap with clean water, and Devoto et al. (2012) did not examine effects on BMI or obesity rates. This context is ideal for the analysis of the present paper because it allows me to estimate the causal effect on BMI through the potential effect on the consumption of food outside the home isolated from the potential offsetting effect of diarrhea on BMI. This estimation is relevant not only as an empirical exercise but also for public policy recommendations; there have been great advances worldwide in improving water quality at the source but access to piped water at home is still very limited (Duflo, Galiani and Mobarak, 2012). Moreover, some studies suggest it is not clear that it is socially profitable (Fewtrell et al., 2005; Devoto et al., 2012; Bennett, 2012); these cost and benefit analyses, however, do not include the potential effect of access to piped water at home on obesity rates.

The non-experimental data comes from the Cebu Longitudinal Health and Nutrition Survey, a cohort of Filipino women and their children from the Metropolitan Cebu area. This data is ideal because it contains information regarding the children's daily diets, allowing me to investigate potential channels through which access to piped water at home might reduce childhood BMI. Additionally, Cebu is poorer and more rural and has much lower childhood obesity than the city of Tangiers, thus, the exploitation of this data allows me to test the external validity of the experiment in Morocco.

Results from the experiment in the city of Tangiers show that access to piped water at home decreased BMI by 0.24 standard deviations and obesity rates by 16 percentage points, or 68%, among children age 0 to 5 . Results from the longitudinal analysis of Cebu, also show that access to piped water at home decreased BMI among children age 10 to 19 by 0.26 standard deviations, but only among those individuals with little or no exposure to contaminated water, while the effect of access to piped water on BMI through diarrhea is positive and large enough to "hide" the effect of access to piped water on BMI through the reduction in consumption. These results might seem large, however, back-of-envelop calculations show my highest point estimate of the increase in BMI requires approximately an increase of only 111 calories per day. Furthermore, results from this analysis confirm the hypothesis that access to piped water at home reduces consumption of food outside the home by approximately 41 grams per day or 16%. A Chebakia (a typical street cookie from Morocco), for example, weights 20 grams and has 85 calories and a Ginabot strip (deep-fried swine intestines, common street food in the Philippines) has 160 calories.

Obesity, in particular, childhood obesity, is increasing at an alarming pace. Very few interventions have thus far proven to be effective in the fight against this epidemic (Cawley, 2015). This study shows that access to piped water at home has additional social benefits and that it can play an important role in the fight against obesity.

2 Experimental Evidence

2.1 Setting and Experimental Design

This study exploits an experiment carried out by Devoto et al. (2012) in the city of Tangiers, north urban area of Morocco. The original purpose of the experiment was to estimate the effect of households' connection to the drinking water network on several well-being indicators including water-borne diseases, time use, social integration, and mental well-being. The intervention consisted of information about and assistance with the application for a loan to finance the connection to the water network. The loan was offered by Amendis, the local water provider, as part of a program that sought to increase access to the water and sanitation network. The connection to the water network was at full cost, but the loan was interest-free. The treatment encouraged take-up of the loan by providing information and a marketing campaign, pre-approving the loan and offering the collection of the down-payment at home, saving them the trip to the branch office (Devoto et al., 2012).

Devoto et al. (2012) selected a sample of 845 households from three zones of the city of Tangiers. The households selected had no water connection at home but had a public tap in their neighborhoods. The randomization was done at a "cluster" level, where a cluster was defined as two adjacent plots or two plots facing each other on the street or up to one house apart. It was stratified by location, water source, the number of children under five, and the number of households within the cluster. This study works with a subsample, since anthropometric indicators were taken only from children ages 0 to 7 (in the Endline). The resulting number of observation in the Endline is 344, corresponding to 126 clusters and 191 households in the treatment group and 105 clusters and 153 households in the control group. Data were collected before the intervention in August 2007 (hereafter "Baseline"), and 5 months after the water connection (6 months after the intervention), in August 2008 (hereafter "Endline").

2.2 Balance Check

Table 1 shows the balance check in the baseline from the subsample used in this study. BMI is calculated by the ratio of weight in kilograms divided by the square of height in meters. Definitions of anthropometric indicators follow the World Health Organization (WHO) 2006 standards. BMI-for-age is age- and sex-specific and represents the (standardized and adjusted) deviation of a child's BMI from the median value of a reference population selected by WHO. Overweight and obese children are defined as those with BMI-for-age greater than one and two standard deviations, respectively. Underweight children are those with BMI-for-age lower than negative two standard deviations. One inconvenient of the data is that the number of children with anthropometric indicators in the Baseline is less than half of that in the Endline, and the number is in fact too small to detect significant differences. Fortunately, the most important outcome variable, obesity rate, seems actually higher for the treatment group than for the control group.

In terms of household variables, we do have the same number of observations in the baseline and Endline. We can see only two significant differences between the treatment and control group. One is in the number of children age 7 or less. We can see, however that the difference in the Endline of the number of children age 7 or less (that is our sample of interest) is not significantly different. The second difference is in an assets indicator. This indicator was constructing following Devoto et al. (2012)'s strategy and should reflect differences in wealth or income. However, in Devoto et al. (2012)'s sample there is no difference in this indicator, and in our sample, there is no significant difference in any other income or wealth indicator. Nevertheless, I control all our regressions for these two variables to control for those imbalances and in 11of the Appendix I show the estimations including several other control variables.

It is important to notice that by sample design no household in either group had access to piped water at home but all households have access to piped water from a public tab. The average distance to water is 142 meters. This distance might not seem too large, but just not having the water in the convenience of home might make a significant difference. In particular, for mothers, who are typically the ones in charge of teching water and cooking.

Morocco has one of the highest rates of childhood obesity in the world according to the WHO. This sample is not the exemption: 22% of the children age 0 to 5 were obese in the baseline. Finally, I would like to mention that weight was measured two times in this sample, and I work with the average of these two measurements of weight in order to calculate BMI and BMI-for-age.

2.3 Empirical Strategy

This section estimates intent-to-treat effects (ITT) and local average treatment effects (LATE). The ITT estimator captures the effect of being selected for treatment (but not necessarily treated). This effect is estimated from the following specification:

$$Y_{i,j} = \beta_o + \beta_1 T_j + \beta_2 X_{i,j} + \varepsilon_{i,j}$$

where $Y_{i,j}$ stands for BMI or for the obesity dummy for child i in cluster j, T_j stands for whether the cluster j was selected to the treatment, $X_{i,j}$ stands for baseline control variables i in cluster j, and $\varepsilon_{i,j}$ stands for the error term. All the regressions have standard errors clustered at the cluster level.

The LATE estimator captures the effects of actually having received the treatment, using the selection to the treatment as an instrumental variable. The first stage estimates the effect of being selected for the treatment on the probability of being connected to the water network from the following specification:

$$C_{i,j} = \beta_2 + \beta_3 T_j + \beta_4 X_{i,j} + \varepsilon_{i,j}$$

where $C_{i,t}$ stands for whether the child lives in a house connected to the water network.

The second stage estimates the effect of being connected to the water network on some outcome from the following specification:

$$Y_{i,j} = \beta_o + \beta_1 \hat{C}_{i,j} + \beta_2 X_{i,j} + \varepsilon_{i,j}$$

where $\hat{C}_{i,j}$ stands for the predicted probability of being connected to the water network estimated in the first stage.

Under the assumption of constant treatment effect, β_1 could be interpreted as the average treatment effect. In the absence of such assumption, this estimator should be interpreted as the effect of access to the water network on weight outcomes of children of the "complier" households. That is, households that were encouraged by the intervention to connect to the water network but would not have done so in the absence of the intervention. Again, all the regressions have standard errors clustered at the cluster level.

2.4 Results - Experimental Evidence

As explained above this intervention relied on an encouragement design as opposed to a direct intervention. Hence, the first question we need to assess is whether the intervention increased water connection significantly. Table 2 shows that, in fact, the intervention successfully encouraged water connections; 82% of the treatment group got connected to the water network, while only 20% of the control group did. It is also important to confirm with our sample the results of Devoto et al. (2012) that there was no effect on diarrhea prevalence. Table 3 shows that in fact, there was no significant effect on diarrhea prevalence. Thus, the estimates on BMI and obesity rates are not going to be affected by changes in diarrhea prevalence.

Figure 1 shows the effect of the treatment in the distribution of BMI-for-age. It is apparent from the graph that there are fewer obese children (BMI-for-age of 2 or more) in the treatment group than in the control group. It is also apparent from the graph that there is a higher concentration of children with normal weight (BMI-for-age between -1 and 1) and that there is not much difference in the left-tail of the distribution. Finally, it seems from the graph that the control group has larger extreme values in particular on the right side of the distribution. The results, however, are robust to further trimming the data, even when dropping all the observations with BMI-for-age 3 or larger, as we can see in Table 10 of the Appendix.

Table 4 presents the effect of the treatment on BMI-for-age and obesity rates. For an easier interpretation of my results, after calculating overweight, obesity and underweight, I standardized BMI-for-age so that it represents the standardized deviation of a child's BMI from the median value of my sample, rather than from the median value of a reference population. In all regressions I control for the number of children age 7 or less and the assets indicator that were the variables that were not balanced in the baseline. In Table 11 of the Appendix I show my estimations controlling additionally for age, sex, family income, distance to public water source, connection to public tap, connection to neighbor's tap, and whether the water looks clear. We can see that the results are basically the same.

The first columns show the Intention the Treat estimates and the second columns show the 2SLS estimates. Panel A shows that 5 months after the water connection children of the treatment group have average BMI-for-age lower than children of the control group by 0.15 standard deviations, although the difference is not statistically significant. As expected, the 2SLS or LATE estimates are larger in magnitude.

Table 4 also presents the effect of the treatment on obesity rates. The first column shows that 5 months after the water connection, 22% of the children of the control group are obese, while only 12% of the children of the treatment group are obese, and this difference is statistically significant. According to the LATE estimator, the effect of being connected to the water network reduced the probability of being obese by 16 percentage points.

One concern about these estimations is the possibility that the results in BMI and obesity rates could be spuriously generated by the small number of observations. Therefore, as a mean to increase the reliability of the results, I test the following hypothesis: if my results reflect the effect of the program, the effect should be smaller for households that before the program were connected to the public tap either through a hose or an informal pipe, since they already had running water at home. On the contrary, if the true effect of the program would be zero, it shouldn't be any different for people that before the program were connected to the public tap either through a hose or an informal pipe. Panel B of Table 4 shows that the effects of the program on BMI and obesity rates come mostly from households that before the program were not connected to the public tap. In this case, both the effect on BMI and well as the effect on obesity rate are statistically significant for the base population, that is for individuals before the program were not connected to the public tap either through a hose or an informal pipe. These results also help to discard an alternative theory about the mechanism; the effect on BMI and obesity rates could be driven by a reduction of income for the treatment group, since they have to repay the loan, while the control group does not. Moreover they are paying for water now, while the control group obtain water from the public taps for free. If this alternative story would be true, we should not expect any different for people that before the program were connected to the public tap either through a hose or an informal pipe, since there is no statistically difference in their take-up of the loans, as we can see in Table 12 of the Appendix.

Magnitude of the Estimates and Back-of-Envelop Calculation

Many people belief that it requires a significant change in calories to obtain a change in the obesity rate of a society. This belief, however, is incorrect. As Cutler, Glaeser and Shapiro (2003) illustrated, only an increase of 100 to 150 calories in the daily consumption of food, like three Oreo cookies or one can of Pepsi, could explain the 100% increase in obesity rate (10-12 pounds on the average American) in the US between 1965 and 1995. Hall et al. (2011) make a more precise calculation and arrives at a very similar estimation: it takes approximately 100 calories to gain 10 pounds. It is also common that obesity rates change proportionally more than average weight of the population. Cutler, Glaeser and Shapiro (2003) argue that part of the explanation relies on self-control problems, since people with self-control problems are more likely to be overweight initially and are more likely to respond to further improvements in food technology. Ritter (2018) also finds proportionally larger results on obesity rates than on average BMI. Finally, another common misbelief is that it takes a long period of time to gain weight. Hall et al. (2011), however, estimate that 65% of the effect on weight of a change in diet happens by 1 year and 95% happens by 3 years. Thus, it really takes a few calories and a short period of time to see large effects on BMI and, in particular, on obesity rates. Moreover, if changes in consumption are not permanent, the long-term effect could be smaller in magnitude than the short term effect. In this study, the highest point estimate corresponds to an increase of 80% in obesity rate, 0.4 standard deviations of BMI-for-age and 3 pounds. Applying Hall et al 2011's rule of thumb and assuming after 5 months 27% of the effect has happened, such an increase in weight would require an increase of 111 calories per day, less calories than 1 and a half Chebakia (a Moroccan street cookie). Thus, my estimated effects are large but not implausible. Moreover, it is important to remember that the LATE estimates capture the effect of access to the water network on the likelihood of being obese of children of the "complier" households. Since the intervention consisted in information and assistance with the loan, but no difference in the loan conditions, those in the pool of households who connected to the network as a consequence of the intervention may not have been very educated but had enough money to repay the loan. This pool of households might have particularly large effects, insofar as low-educated households are less aware of the detrimental consequences of childhood obesity, and households with enough money to repay the loan can also probably afford to buy high-caloric food prepared outside the home. Thus, my estimated Local Treatment Effect (LATE) might be significantly higher than the average treatment effect of connecting to the water network.

3 Non-Experimental Evidence

3.1 Data and Summary Statistics

This section exploits data from the Children of the Cebu Longitudinal Health and Nutrition Survey. This study follows a cohort of Filipino women and their children from the Metropolitan Cebu area who were born between May 1, 1983, and April 30, 1984 . After the baseline, they surveyed children's anthropometric indicators and diet diaries in 1991, 1994, 1998, 2002, 2005. I work with data until 2002, since the WHO standards that are used to calculate the BMI-for-age are comparable only up to age 19 and there are no children age 19 or younger in the year 2005. Additionally, information about whether children had piped water at home, our main explanatory variable, was collected only since 1991, and since I use lagged variables to estimate the effect on BMI, I am not able to estimate the effect on BMI for the year 1991. Finally, the first round of food diaries in 1991 differs from the following diaries, which means I am also not able to use the food diaries from 1991.

Table 5 shows the summary statistics of my sample. Children are 15 years old and weight 40 kilos on average. The overweight rate is only 4%, there are no obese children and 13% of children are underweight. This represents a very different context from Tangiers. However, this is unsurprising given that this sample is more rural, poorer, only around half of the households in this sample live within walking distance of a store, only 17% has access to piped water at home and 38% has access to piped water either inside or outside the house. 40% of women fetched water and spent 116 minutes doing so in the week previous to the baseline. Women at that time, however, were pregnant, so these numbers might be underestimating the real percentage and time of women fetching water regularly.

Table 5 also shows, as we would expect, that children with piped water at home have higher family incomes, live in more populated areas, eat more food outside the home, drink more sodas and are more likely to be overweight.

3.2 Model and Empirical Strategy

This section exploits the longitudinal feature of the data to apply a Fixed Effect Model at the individual level. The estimations with this dataset by itself do not provide enough robust evidence that access to piped water at home has a causal effect BMI, given that this empirical strategy does not control for potential omitted variables that change whithin child over time. However, this simple strategy will provide important complementary evidence to the experiment in Morocco in two main ways: first by investigating the potential channels through which access to piped water at home might reduce childhood BMI, in particular, if it reduces the consumption of food prepared outside the home, and second, by increasing its external validity.

The effect on food consumption is estimated from the following specification:

$$Y_{i,t} = \beta_o + \beta_1 Water_{i,t} + \beta_2 X_{i,} + \alpha_i + \phi_t + \varepsilon_{i,t}$$

where $Y_{i,t}$ stands for the consumption of food outside the home or other type of consumption of child i in year t, $Water_{i,t}$ stands for whether the child i had piped water at home in year t, $X_{i,t}$ stands for control variables of child i inyear t, α_i and ϕ_t stand for child and year fixed effect, respectively, and $\varepsilon_{i,t}$ stands for the error term. Control variables include: household's income, number of children living in the house and fixed effects of the barangay where the child currently lives. The same child can live in several barangays across rounds, because this survey follows the children and their families even if they move. All the regressions have standard errors clustered at the household level.

The effect on standardized BMI-for-age and overweight rate is estimated from the following specification:

$$Y_{i,t} = \beta_o + \beta_1 Water_{i,t-1} + \beta_2 Water_{i,t-1} Diarrhea_{i,s} + \beta_3 X_{i,t-1} + \alpha_i + \phi_t + \varepsilon_{i,t}$$

In this case, I use lagged variables to capture the accumulated effect on BMI. Rounds in this survey happen every 3-4 years, thus by using lagged explanatory variables, the estimated effect correspond to the long-term effect of access to piped water on BMI, according to Hall et al. (2011). We also know that access to water can reduce diarrhea prevalence and this in turn can increase BMI. Unfortunately, there is no data on diarrhea prevalence in all rounds. Thus, in order to control, at least imperfectly, for this off-setting effect, this specification controls for the interaction of access to piped water at home and whether the child or the child's mother experienced at least one episode of diarrhea in the 3 months preceding the baseline, s. Thus, β_1 now should capture the effect access to piped water on children, who were exposed to no or little contaminated water; that is the effect on BMI due only to a reduction in the consumption of food outside the home and soft drinks, while

β_2 should capture the differential effect of access to piped water on children that were exposed to contaminated water; that is, the additional and off-setting effect on BMI through reduction in diarrhea prevalence. If my predictions are correct, β_1 should be negative and β_2 should be positive.

3.3 Results

Table 6 shows the results on food eaten outside the home, soft drinks, home-made food, and milk. The simple correlation between piped water at home and the quantity of food eaten outside the house is positive due to several third factors that are positively correlated with both variables. The first obvious group of variables are those related to time-invariant characteristics of the children, such as wealth, parents' education, and knowledge about nutrition. The first column shows the results from a FE model without any additional control variable. As we can see, controlling for time-invariable characteristics of the children eliminates the apparent positive effect on food eaten outside the house. A second important third factor correlated with both variables is time. In the last decades, there has been an increase in the consumption of food outside the house in many developing countries, in particular in the consumption of snacks and fast food, both for families/individuals with and without piped water at home. Simultaneously, there has been an increase in the number of households with access to piped water at home. In order to control for these simultaneous increases, column 2 includes year fixed effects, and as we would expect, our coefficient of interest grows in absolute terms and becomes statistically significant. This data set follows individuals that move; for this reason, column 3 includes fixed effects of the barangay, where they currently live. Areas with greater access to piped water have typically better access to food outside the home. If individuals move to these areas, we will see an increase in the likelihood of access to both of these things. Again we observe an increase in the magnitude of the estimate. Column 4 controls for income. Naturally, income is positively correlated with having access to piped water and with eating food outside the house, thus controlling for income increases the magnitude and the significance of our estimated coefficient. Column 5 controls for the number of children living in the house. It is not clear how this control variable should affect the estimates, but changes in the number of children could affect both the demand for piped water and the demand for food outside the home, so it is important to control for it. According to this estimation, access to piped water at home decreases the consumption of food outside the home on average by approximately 41 grams per day, which represents a decrease of 16%. Finally, column 6 explores heterogenous effects. As we would expect, the effect is larger, 45 grams per day, on those children who had access to potentially contaminated water at home in the first round, since access to piped water not only reduced their cost in term of fetching water but also in terms of the likelihood of contracting waterborne diseases. A very similar pattern can be observed in the estimation of the effect of piped water at home on soda consumption. In this case, the effect is only statistically significant for those children who had access to potentially contaminated water at home in the first round. For them, access to piped water at home decreases the consumption of soda by approximately 18 milliliters per month, which represents an increase of 30%.

Table 7 shows the effect on home-made food and milk. Here we see that access to piped water at home has no significant effect on these consumptions. These results are reassuring in several ways. First of all, it enables us to discard the alternative hypothesis that access to piped water at home might be correlated with a decrease in income or another omitted variable that decreases all types of consumption. Second, our story predicts that access to piped water at home should generate a decrease in soft drinks because it generates an increase in the consumption of water, not on milk. Finally, it is important to note a couple of things related to effect in consumption of home-made food. First of all, although the effect on the quantity in grams of home-made food is not statistically significant, the effect on the percentage of home-made food that children consume is positive and statistically significant, as we can see in Table 8. According to Column 5, access to piped water at home increases the consumption of home-made food by approximately 3 percentage points or 5%. Second, while the effect on consumption of home-made food, is positive it is not as large in magnitude as the decrease in food outside the home. Thus access to piped water at home generated a substitution away from food outside the home toward home food but this substitution does not seem to be completely offset (although this difference is not statistically significant). Thus, there should be an effect on weight resulting from a change in the quality of food, but probably also in the quantity of food, although we find a negative but not significant effect on the total quantity of food consumed.

Table 9 shows the results on standardized BMI-for-age and overweight rate (results on obesity rates are omitted, given that rates are close to 0 for this population). The first column shows the effect of a simple fixed effect strategy, and we can see that the difference in BMI within children with and without piped water at home is positive. The second column includes additionally year fixed effects. We can see that including these fixed effects eliminates the significance of the positive correlation between access to piped water at home and BMI. Column 3 includes the interaction of piped water at home and instances in which the child's mother experienced diarrhea in the baseline. We can see that the effect of access to piped water at home on BMI in the absence of diarrhea is negative and the additional effect of access to piped water through diarrhea on BMI-for-age is positive. Column 4 includes barangay fixed effects and the effect of piped water on BMI becomes statistically significant. Column 5 controls additionally for income, and column 6 controls additionally for the number of children in the household. According to our last and preferred estimate, access to piped water at home *reduces* BMI-for-age by around 0.26 standard deviations but *increases* BMI-for-age by around 0.32 standard deviation through its reduction on diarrhea prevalence. Note that we have seen previously that this group of children reduce their consumption of food outside the home actually more than children with access to potentially clean water. Thus the net effect of diarrhea on BMI is probably even larger than this estimate. Table 9 also shows that the same pattern for the estimations of the effect of access to piped water at home on child overweight rate. However, none of the estimations are statistically significant. Note that it is not the case that the results on average BMI are driven by changes on the rate of underweight; as we can see in Table 13 of the Appendix, there is no statistically significant effect on underweight rate.

4 Conclusions

This study investigates whether expanded access to piped water at home can contribute to the fight against obesity in developing countries. It exploits experimental data from the city of Tangiers, Morocco and longitudinal data from the city of Cebu, the Philippines. Results from the experiment in the city of Tangiers show that access to piped water at home decreased BMI and obesity rates among children age 0 to 5. Results from the longitudinal analysis in Cebu, a very different context with zero childhood obesity also provides evidence that access to piped water at home decreased BMI among children age 10 to 19. Furthermore, results from this analysis confirm the hypothesis that access to piped water at home reduces the consumption of food outside the home, and that the effect of access to piped water on BMI through diarrhea is positive and large enough to "hide" the effect of access to piped water on BMI through the reduction in consumption.

This study suggests that access to piped water at home might play an important role in the fight against obesity in developing countries. It also provides evidence that programs that facilitate water access at home can have important health benefits, even in areas with access to clean water. This result is especially relevant given that, while there have been great advances in improved water sources worldwide, access to piped water at home is still very limited. Finally, this paper contributes to a better understanding of the demand and willingness to pay for piped water at home; Devoto et al. (2012) found that households are willing to pay a substantial amount of money to have a private tap at home, which was somewhat puzzling, since they did not find any productive or monetary benefit from it. Nevertheless, this paper finds that access to piped water reduces the consumption of food prepared outside the house, and this might generate some monetary savings, in addition to the health benefits of reducing childhood obesity.

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Figure 1: Effect of the Treatment on BMI-for-Age Children Age 0-7

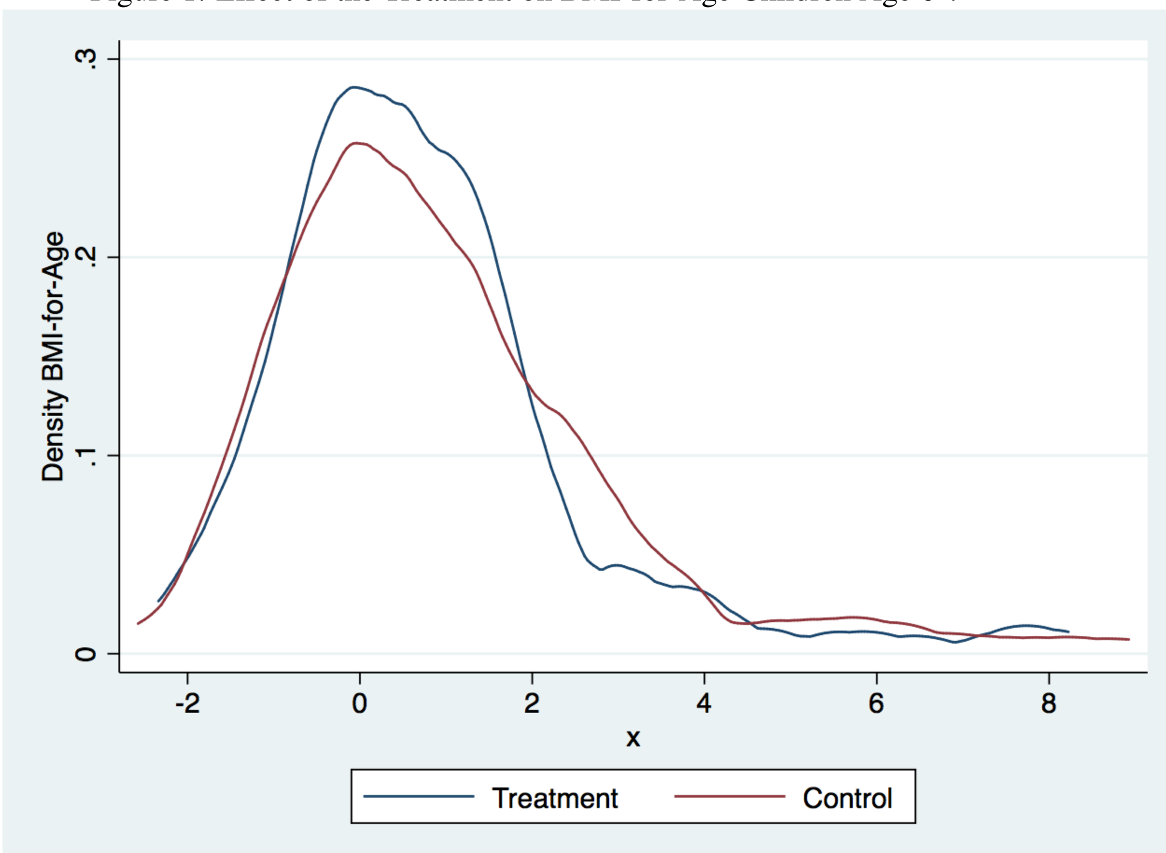

Table 1: Balance Check - Experimental

	Obs.	Treatment	Control	P-Value (T=C)
Age	159	2.7	3.0	0.21
Female	159	53%	59%	0.47
Weight	159	13.7	14.2	0.35
Height	159	90.3	92.3	0.40
BMI	159	16.7	16.9	0.67
BMI-for-age	159	0.9	1.0	0.69
Underweight	159	1%	0%	0.38
Overweight	159	37%	40%	0.71
Obesity	159	26%	17%	0.19
Num. members	344	5.7	5.9	0.39
Num. children <=7	344	1.6	1.9	0.01
Num. children <=7 (Endline)	344	1.8	1.9	0.23
Head male	344	92%	88%	0.22
Head age	344	41.2	40.7	0.73
Head married	344	92%	93%	0.69
Head no education	344	29%	33%	0.37
Assets score	344	0.0	0.4	0.03
Head income	344	1,189	1,173	0.89
Family income	315	4.5	4.7	0.27
Num. rooms per person	342	0.7	0.6	0.23
Piped water at home	344	0%	0%	0.12
Piped water anywhere	344	100%	100%	0.36
Chlorine in water	103	69%	61%	0.39
Clear water	344	99%	99%	0.70
Water use in the last 7 days (liters)	328	448.5	462.9	0.88
Distance to water (mts)	344	152.4	137.7	0.35
Connection to neighbors' tap	344	20%	22%	0.80

Table 2: First Stage Results - Experimental Data

	Piped Water at Home
	coef/se
Treatment	0.617***
	(0.056)
Mean Control Group	0.196
Number of observations	344
R2	0.376

Note: Control variables include number of kids age 7 or younger and assest quintile. Standard errors are clustered at cluster level.
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 3: Results on Diarrhea Prevalence - Experimental Data

	Diarrhea Prevalence
	coef/se
Treatment	0.005
	(0.109)
Mean Control Group	0.219
Number of observations	309
R2	0.064

Note: Control variables include number of kids age 7 or younger and assest quintile. Standard errors are clustered at cluster level.
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Results on BMI-for-Age and Obesity Rates - Experimental Data

Panel A. Simple Treatment Effect

	Std. BMI for Age		Obesity Rate	
	ITT	**2SLQ**	**ITT**	**2SLQ**
	coef/se	**coef/se**	**coef/se**	**coef/se**
Treatment	-0.150	-0.243	-0.101**	-0.164**
	(0.124)	(0.201)	(0.047)	(0.078)
Mean Control Group	0.043	0.073	0.216***	0.242***
Number of observations	344	344	344	344
R2	0.026	0.020	0.034	.

Panel B. Heterogeneous Treatment Effect

	Std. BMI for Age		Obesity Rate	
	ITT	**2SLQ**	**ITT**	**2SLQ**
	coef/se	**coef/se**	**coef/se**	**coef/se**
Treatment	-0.248*	-0.411*	-0.120**	-0.198**
	(0.132)	(0.221)	(0.049)	(0.085)
Treatment x public tap	0.584*	0.965	0.116	0.197
	(0.355)	(0.615)	(0.130)	(0.213)
Public tap	-0.197	-0.379	-0.034	-0.071
	(0.236)	(0.327)	(0.094)	(0.124)
Mean Control Group	0.065	0.121	0.218***	0.249***
Number of observations	344	344	344	344
R2	0.038	0.004	0.038	.

Note: Control variables include number of kids age 7 or younger and assest quintile.
Standard errors are clustered at cluster level.
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 5: Summary Statistics - Longitudinal Data

	Total		Piped Water at Home	
			With	Without
	Obs.	Mean	Mean	Mean
Age (in years)	5,377	15.03	15.51	14.96
		(2.99)	(3.01)	(2.98)
Male (%)	5,377	52%	55%	52%
		(0.50)	(0.50)	(0.50)
Height (in cm)	5,377	147.54	151.63	146.87
		(13.03)	(12.09)	(13.06)
Weight (in kg)	5,377	40.05	43.49	39.49
		(11.29)	(11.60)	(11.14)
Body Mass Index (BMI)	5,377	17.99	18.57	17.89
		(2.77)	(3.01)	(2.72)
BMI-for-age	5,377	-0.89	-0.75	-0.91
		(0.97)	(1.06)	(0.96)
Overweight (%)	5,377	4%	6%	3%
		(0.18)	(0.23)	(0.18)
Obesity (%)	5,377	0%	0%	0%
		(0.00)	(0.00)	(0.00)
Underweight (%)	5,377	13%	11%	13%
		(0.33)	(0.32)	(0.34)
Diarrhea (%)	5,377	86%	86%	86%
		(0.35)	(0.35)	(0.35)
Urban (%)	5,636	72%	96%	67%
		(0.45)	(0.19)	(0.47)
Piped water at home (%)	5,636	17%	100%	0%
		(0.38)	(0.00)	(0.00)
Piped water anywhere (%)	5,636	38%	100%	25%
		(0.49)	(0.00)	(0.43)
Mother fetched water 1st. Round (%)	5,636	40%	28%	42%
		(0.49)	(0.45)	(0.49)
Min. p/week m. fetched water 1st. Round	3,583	115.74	101.01	118.20
		(105.80)	(84.98)	(108.70)
No store at a walking distance (%)	5,636	61%	49%	64%
		(0.49)	(0.50)	(0.48)
Standardized family income	5,636	0.28	0.89	0.15
		(1.10)	(1.39)	(0.98)
Food outside the home (grs/day)	5,636	281.78	362.66	264.78
		(260.60)	(287.02)	(251.45)
Home-made food (grs/day)	5,583	649.62	658.44	647.76
		(331.91)	(339.50)	(330.29)
Soft drinks (mls/day)	5,636	64.46	91.03	58.86
		(122.77)	(141.94)	(117.59)
Milk (mls/day)	5,631	2.92	4.33	2.63
		(9.75)	(12.08)	(9.16)

Table 6: Results on Consumption (1) - Longitudinal Data

	Food outside the home (grs/day)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Piped water inside home or yard	4.335	-27.985	-39.342**	-40.836**	-41.334**	-44.555**
	(16.523)	(17.098)	(18.014)	(18.002)	(17.995)	(19.377)
Piped water inside home or yard x no diarrhea						20.994
						(51.299)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE			X	X	X	X
Income				X	X	X
Number of children					X	X
Number of observations	5,636	5,636	5,636	5,636	5,636	5,636
R2	0.000	0.076	0.116	0.117	0.118	0.118

Note: *** p<0.01, ** p<0.05, * p<0.1

	Soft drinks (mls/day)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
HH has piped water inside home or yard	11.252	-10.196	-12.291	-12.904	-12.666	-17.525*
	(8.856)	(8.675)	(9.017)	(9.020)	(9.030)	(9.596)
Piped water inside home or yard x no diarrhea						31.980
						(26.661)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE			X	X	X	X
Income				X	X	X
Number of children					X	X
Number of observations	5,636	5,636	5,636	5,636	5,636	5,636
R2	0.001	0.130	0.157	0.158	0.159	0.159

note: *** p<0.01, ** p<0.05, * p<0.1

Table 7: Results on Consumption (2) - Longitudinal Data

	Home-made food (grs/day)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
HH has piped water inside home or yard	51.539**	0.351	7.504	8.996	6.762	-1.577
	(20.093)	(18.860)	(20.235)	(20.209)	(20.102)	(22.522)
Piped water inside home or yard x no diarrhea						54.430
						(45.959)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE			X	X	X	X
Income				X	X	X
Number of children					X	X
Number of observations	5,583	5,583	5,583	5,583	5,583	5,583
R2	0.002	0.132	0.161	0.162	0.167	0.167

note: *** p<0.01, ** p<0.05, * p<0.1

	Milk (mls/day)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
HH has piped water inside home or yard	0.981	0.699	0.411	0.364	0.328	0.246
	(0.681)	(0.693)	(0.721)	(0.721)	(0.723)	(0.775)
Piped water inside home or yard x no diarrhea						0.560
						(2.035)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE			X	X	X	X
Income				X	X	X
Number of children					X	X
Number of observations	5,631	5,631	5,631	5,631	5,631	5,631
R2	0.001	0.004	0.042	0.043	0.046	0.046

note: *** p<0.01, ** p<0.05, * p<0.1

Table 8: Results on Consumption (3) - Longitudinal Data

	Home-made food (%)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
HH has piped water inside home or yard	0.009	0.020	0.031**	0.032**	0.032**	0.029*
	(0.013)	(0.014)	(0.015)	(0.014)	(0.014)	(0.016)
Piped water inside home or yard x no diarrhea						0.020
						(0.040)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE			X	X	X	X
Income				X	X	X
Number of children					X	X
Number of observations	5,540	5,540	5,540	5,540	5,540	5,540
R2	0.000	0.018	0.065	0.066	0.067	0.067

note: *** p<0.01, ** p<0.05, * p<0.1

	Total food (grs/day)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
HH has piped water inside home or yard	58.579**	-24.551	-29.211	-28.608	-29.972	-45.206
	(25.389)	(24.418)	(25.925)	(25.960)	(26.099)	(28.799)
Piped water inside home or yard x no diarrhea						100.107
						(65.179)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE			X	X	X	X
Income				X	X	X
Number of children					X	X
Number of observations	5,581	5,581	5,581	5,581	5,581	5,581
R2	0.002	0.210	0.231	0.231	0.234	0.235

note: *** p<0.01, ** p<0.05, * p<0.1

Table 9: Results on Body Mass Index and Overweight Rate- Longitudinal Data

	Standardized BMI-for-age					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Piped water inside home or yard (lag)	0.133***	0.030	-0.160	-0.252**	-0.247**	-0.263***
	(0.046)	(0.047)	(0.097)	(0.100)	(0.100)	(0.099)
Piped water inside home or yard x diarrhea (lag)			0.219**	0.294**	0.296***	0.319***
			(0.110)	(0.115)	(0.114)	(0.114)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE				X	X	X
Income					X	X
Number of children						X
Number of observations	5,377	5,377	5,377	5,377	5,377	5,377
R2	0.003	0.100	0.101	0.138	0.138	0.145

Note: *** p<0.01, ** p<0.05, * p<0.1

	Overweight Rate					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Piped water inside home or yard (lag)	0.017	0.014	-0.017	-0.015	-0.015	-0.016
	(0.012)	(0.012)	(0.015)	(0.019)	(0.019)	(0.020)
Piped water inside home or yard x diarrhea (lag)			0.036*	0.038	0.039	0.040
			(0.020)	(0.024)	(0.024)	(0.025)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE				X	X	X
Income					X	X
Number of children						X
Number of observations	5,377	5,377	5,377	5,377	5,377	5,377
R2	0.001	0.003	0.003	0.042	0.042	0.045

Table 10: Sensitivity Analysis -Results on Obesity Rates - Experimental Data

	Obesity Rates				
	No Trim. coef/se	**BMI-for-Age <6** coef/se	**BMI-for-Age <5** coef/se	**BMI-for-Age <4** coef/se	**BMI-for-Age <3** coef/se
treatment Assigned to Treatment Group	-0.101**	-0.098**	-0.086**	-0.092**	-0.072**
	(0.047)	(0.044)	(0.043)	(0.040)	(0.034)
Mean Control Group	0.216	0.189	0.172	0.161	0.104
Number of observations	344	333	329	324	308
R2	0.034	0.046	0.042	0.052	0.036

Note: Control variables include number of kids age 7 or younger and assest quintile. Standard errors are clustered at cluster level.
note: *** p<0.01, ** p<0.05, * p<0.1

Table 11: Results on BMI-for-Age and Obesity Rates- More Control Variables - Experimental Data

Panel A. Simple Treatment Effect

	Std. BMI for Age		Obesity Rate	
	ITT	**2SLQ**	**ITT**	**2SLQ**
	coef/se	**coef/se**	**coef/se**	**coef/se**
Treatment	-0.159	-0.258	-0.101**	-0.164**
	(0.112)	(0.184)	(0.044)	(0.074)
Mean Control Group	0.043	0.073	0.216***	0.242***
Number of observations	344	344	344	344
R2	0.257	0.243	0.196	0.145

Panel B. Heterogeneous Treatment Effect

	Std. BMI for Age		Obesity Rate	
	ITT	**2SLQ**	**ITT**	**2SLQ**
	coef/se	**coef/se**	**coef/se**	**coef/se**
Treatment	-0.242**	-0.402*	-0.116**	-0.192**
	(0.122)	(0.210)	(0.046)	(0.081)
Treatment x public tap	0.485*	0.826*	0.086	0.161
	(0.290)	(0.486)	(0.111)	(0.184)
Public tap	-0.227	-0.372	-0.042	-0.067
	(0.216)	(0.279)	(0.078)	(0.102)
Mean Control Group	0.065	0.121	0.218***	0.249***
Number of observations	344	344	344	344
R2	0.264	0.237	0.198	0.144

Note: Control variables include number of kids age 7 or younger, assest quintile, age, sex, family income, distance to public water source, connection to public tap, connection to neighbor's tap, and whether the water looks clear. Standard errors are clustered at cluster level.
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 12: First Stage Results - Het. effects - Experimental Data

	Piped Water at Home
	coef/se
Treatment	0.614***
	(0.064)
Treatment x public tap	0.023
	(0.155)
Public tap	-0.001
	(0.103)
Mean Control Group	0.202
Number of observations	344
R2	0.376

Note: Control variables include number of kids age 7 or younger and assest quintile. Standard errors are clustered at cluster level.
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 13: Results on Underweight Rate- Longitudinal Data

	Underweight Rate					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Piped water inside home or yard (lag)	-0.029	-0.002	-0.007	0.001	0.000	0.002
	(0.019)	(0.018)	(0.040)	(0.049)	(0.049)	(0.047)
Piped water inside home or yard x diarrhea (lag)			0.005	-0.002	-0.002	-0.004
			(0.045)	(0.055)	(0.055)	(0.053)
Individual FE	X	X	X	X	X	X
Year FE		X	X	X	X	X
Barangay FE				X	X	X
Income				X	X	X
Number of children						X
Number of observations	5,377	5,377	5,377	5,377	5,377	5,377
R2	0.001	0.030	0.030	0.060	0.060	0.065

Note: *** p<0.01, ** p<0.05, * p<0.1