Do Piped Water And Flush Toilets Prevent Child Diarrhea in Rural Philippines?

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Note to readers

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Abstract

Like in other developing countries, diarrhea in the Philippines continues to be among the top causes of infant mortality and morbidity. In pursuit of its Millenium Development Goals, the Government of the Philippines commits to reduce the child deaths and to provide water and sanitation services to more rural households by 2015. Applying propensity score matching on the 1993, 1998, 2003 and 2008 rounds of the National Demographic and Health Survey, the incidence of diarrhea among under-5 children is found lower by as much as 4.5 percent in households with access to piped water and 10 percent in those with their own flush toilets than in comparable households. These underscore the need to ensure at the point of use the quality of drinking water from piped or other improved sources, and the provision of improved and own sanitation facilities.

Key words: child health, impact, Philippines, sanitation, water

Introduction

In many developing countries, diarrheal diseases remain a scourge of children. According to the World Health Organization[1], diarrheal diseases account for the deaths of around 1.8 million people every year. In the WHO's Southeast Asia Region and Western Pacific Region, it was responsible for 20.1% and 12%, respectively, of all deaths among children below five years old in 2000. In 2008, it accounted for 13% and 4% of all child deaths in the same regions. To prevent these cases, the WHO advocates better access to improved water supply and sanitation facilities, and better hygiene practices. Some evidence of the impact of these facilities and practices are found in many countries[2], more recently in rural India[3,4], Senegal[5], and in rural Pakistan[6]. However, the health impacts and cost-effectiveness of these interventions vary across countries[7,8,9]. Thus, in this paper, we assess the impact of household water supply and sanitation facilities on child health in rural Philippines, where most Filipinos live and their living conditions are relatively poorer[10].

According to the Philippine Department of Health[11], around 928 for every 100,000 population each year during the period 2000-2004 had acute watery diarrhea. By 2007, still around 640 out of 100,000 Filipinos had the same health problem. In 2003 and 2004, out of every 1,000 live births, 0.5-0.6 infants died due to diarrheal diseases. By preventing child diarrhea, the Government of the Philippines thus advances towards its Millenium Development Goal of reducing by two-thirds the death rate of under-5 children by 2015.

Also as part of its MDG commitments, the government aims to halve the proportion of population with no access to safe drinking water and basic sanitation facilities by 2015 (NEDA, 2010). Based on the 2007 Annual Poverty Indicators Survey (APIS), only two of every ten families have no access to safe drinking water while one of ten families has no sanitary toilet.

Recently, the national government and local government units together jumpstarted a program to improve household access to water and sanitation facilities in the poorest areas, including 200 *barangays* (villages) in Metro Manila and 200 municipalities elsewhere, where less than half has water supply. If water supply and sanitation facilities can prevent child diarrhea as well, then public investments in them are further justified.

Methods

Figure 1[8] illustrates how bacteria and other diarrhea-causing microorganisms may enter a child's body through the water she drinks, the food she eats, or from putting "dirty" fingers, toys and other foreign objects in her mouth. Furthermore, the unsanitary disposal of stool may contaminate unprotected water supply or foods. Failure to wash hands adequately, especially before eating or cooking, may also lead to unhealthy ingestion. Thus, to prevent child diarrhea, households must have access to safe water supply and sanitary toilet facilities, practice basic hygiene.

[Insert Figure 1 here.]

Ideally, the impact of improved water and sanitation facility or hygiene practice should be measured as the change in the health status (or diarrhea condition) of each child before and after the intervention. Since only observational data are available, we propose instead to estimate the impact by taking the differences in the average health status of two sets of children with the same characteristics, but one set having access to the desired water sources or sanitation facilities while the other has none. Specifically, we match each "treated"child with one or several "untreated" or "control" children with the same pre-treatment characteristics using propensity scores.

Defined as the conditional probability of receiving treatment given a set of pre-treatment characteristics ***X*** [13], propensity scores have the property that if the outcome is independent of treatment status after conditioning on ***X***, then the outcome remains independent of treatment status after conditioning on the propensity scores defined over X.[14] Moreover, matching using a propensity score, which is a scalar, more practical than exact covariate matching when samples are limited.

We matched each treated unit to control units using nearest-5 neighbors (NN5) and kernel matching algorithms. In the NN5-matching, we set the caliper sizes to 0.001, 0.01, 0.02 and 0.03 to increase the number of potential matches and thereby reduce the bias in the impact estimate. In the kernel matching, we set the bandwidth to 0.03 and 0.05 to improve the variance of the impact estimates. Following similar studies[3,4,5,6], the average treatment effect on the treated (ATT)[15] – the difference in the average health statuses of the treated children and the matched control (untreated) children – is our estimator of the impact of the water supply or sanitation intervention. We estimate the propensity score using logit regressions, and the ATT using PSMATCH2[16] routine in STATA.

Data

Table 1 shows the sample sizes of the four rounds of the Philippines National Demographic and Health Surveys[17] (NDHS), our main source of the observational data. In each year, more than half of the total samples of households, children below 5 years old and women of reproductive age (15-49 years old) live in rural areas. The proportion of under-5 children with diarrhea (all cases, and for the two week-period prior to the interview) in rural areas is higher than for the country as a whole. The share of under-5 children in rural areas with access to water piped into their yard or dwelling fell from around 40% in 1993 to below 20% since then. On the upside, the proportion with access to own flush toilets has steadily risen in rural areas from 34.3% to 58.1% in 1993 and 2008, respectively. While these proportion s are consistenly lower than the national rates, the concerned children presumably are less vulnerable to diarrheal diseases than those without similar water and toilet facilities.

Balance diagnostics

Following convention[15, 18], we check if the treated and matched control units have the same pre-treatment characteristics. Table 2 and Table 3 show the after-matching means of the covariates used in the logit regressions for piped water and flush toilets, respectively. In general, the percentage reductions in the differences in the covariate means are significant. Also, the bottom row of each table shows the means and standard deviations of the standardized bias, a summary measure of the differences in the covariates[18]. In all cases, both the means and standard deviations fall below 4, indicating that the paired units have become more similar after matching.

[Insert Table 2 and Table 3 here.]

Further, Figure 1 and Figure 2 show the distribution of the matched units along the common support for piped water and own flush toilet, respectively. As required, the propensity scores of the paired units overlap at values $0<p(\boldsymbol{X})<1$.

[Insert Figure 1 and Figure 2 here.]

Impact estimates

Table 4 shows for each survey year the ATT estimates of piped water and own flush toilet. The impact estimates for piped water are all negative except in 1998. However, save for the estimate using NN5(0.001)-matching, the rest of the estimates for 1993, 1998 and 2003 are not statistically significant from zero. In contrast, the estimates for 2008 are all statistically significant. At p<0.01, the impact of piped water could be as much as a 4.5-percent reduction in the incidence of diarrhea. At p<0.05, the reduction could be as much as 2.9% in 2008 and 3.2% in 2003. Still at a lower level of significance (p<0.10), the impact could be as much as two percent in 1993.

The magnitudes of the ATT estimates for own flush toilet are much bigger in 2008. The contribution of own flush toilets to the prevention of child diarrhea range from 3.4% to 10% in 2008. In 2003, it ranges from 2.5% to 3%. These are all statistically signficant at p<0.05. These toilet facilities however have no differential impact in the years 1993 and 1998.

[Insert Table 4 here.]

Discussion

The estimates reveal that in recent years (2008 and 2003) piped water and own flush toilets helped prevent diarrhea in under-5 children in rural Philippines. The effect of piped water could be due to local water utilities complying with quality control and other regulatory standards. According to water utility managers in both urban areas (East Zone of Metro Manila and Los Banos in Laguna) and rural areas (Baliwag in Bulacan and Indang in Cavite) that we interviewed, they filter and treat with chlorine the water before they pump it to household connections. They also regularly send water samples to accredited labarotories for microbial and other tests. Moreover, they monitor and repair pipes for leakages. When requested, local water districts also lend their technical expertise to other community-operated water systems. They promptly respond to such requests and customer complaints partly because municipal mayors or provincial governors appoint members of the board of directors of local water districts.

In the rural areas, many households still do not have access to piped water and they rely mostly on dug wells and springs. These households are the most vulnerable to bacterial contamination, especially during typhoons and floods. Likewise, these households are likely to have substandard toilet facilities. In-house pipes may be leaky or pump wells may be too close to septic tanks, latrines or sewers. It is noted that local governments often weakly enforce the Building Code that enables households with flush toilets on the surface but still unsanitary septic tanks underneath. Even more vulnerable are households with shared toilet facilities that deteriorate faster with heavy use and poor maintenance. The rural health officials in the aforementioned places linked the diarrhea incidence among their patients to the food or water ingested. Nonetheless, they claimed that most of their patients practice basic hygiene.

Data from the NDHS serve further caution. Alarmingly, a big percentage of the samples treat their water presumably to make it even safer for drinking. Among those with access to improved water sources and piped water in 1998, 26% and 39% respectively treated their drinking water. In 2003, the corresponding figures rose to 50% and 57%. In 2008, the rates are 44% and 49%. These facts, together with increasing proportion of bottled water users (about 17% in 2008), point to the possible worsening quality of piped water and other improved sources at the point of use.

Conclusion

In sum, piped water and flush toilets had their desired impact on child health in 2003 and 2008. As the government expands its investments in water and sanitation infrastructure, it serves well however to re-evaluate what it considers as safe water and sanitation facilities. For one, the government classifies as improved water sources both community water systems and protected wells, and as sanitatry facilities both flush toilets (either owned or shared) and closed pits. While these any of these water and sanitation facilities may have been effective before, our results favor investments in higher quality facilities – piped water and own flush toilets.

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Figure Legends

Figure 1. Mechanisms through which bacteria may enter a child's body; adapted from Waddington et al[8].

Figure 2. Histograms of matched sub-samples along common support for Piped water, based on NN5 (0.001) matching. (a) 1993. (b) 1998. (c) 2003. (d) 2008.

Figure 3. Histograms of matched sub-samples along common support for Flush toilet (own), 1993-2008; based on NN5 (0.001) matching. (a) 1993. (b) 1998. (c) 2003. (d) 2008.

Tables

Table 1. Sample sizes of the National Demographic and Health Surveys, Philippines

Samples	1993		1998		2003		2008	
	Total	Rural	Total	Rural	Total	Rural	Total	Rural
Number of women of reproductive age (15-49 years old)	15,029	7,121	13,983	7,253	13,633	6,197	13,594	6,832
Number of households	12,995	6,864	12,407	7,214	12,586	6,403	12,469	6,925
Number of households with children below 5 years old	5,795	3,116	5,240	3,150	4,920	2,585	4,712	2,663
Number of children below 5 years old	9,195	5,041	8,083	5,004	7,145	3,854	6,572	3,777
Under-5 children by diarrhea condition*	8,770[a]	4,795[a]	7,669[b]	4,740[b]	6,825[b]	3,612[b]	6,327[a]	3,535[a]
	100%	100%	*100%*	100%	*100%*	100%	*100%*	100%
No	7,871	4,292	7,065	4,337	6,076	3,208	5,756	3,213
	89.7%	89.5%	*92.1%*	91.5%	*89.0%*	88.8%	*91.0%*	90.9%
Yes	908	503	604	403	749	404	571	322
	10.3%	11.5%	*7.9%*	8.5%	*11.0%*	11.2%	*9.0%*	9.1%
Under-5 children with access to piped water (into yard or dwelling)*	4,311	1,190	2,183	736	2,286	683	1,615	700
	46.9%	*37.9%*	*27.0%*	*14.7%*	*32.5%*	*18.0%*	*25.2%*	*19.0%*
Under-5 children with access to flush toilet (own)	3,932	1,731	3,680	1,774	3,837	1,613	4,444	2,136
	42.7%	*34.3%*	*45.5%*	*35.5%*	*54.5%*	*42.6%*	*69.4%*	*58.1%*

Notes:
*Sub-samples limited to dejure members of households.
Source: National Demographic and Health Survey (various rounds). Authors' calculations.

Table 2. Means of the covariates after NN5 (0.001)-matching: Piped water, 1993-2008

Covariates	1993			1998			2003			2008		
	Treated (*N*= 1599)	Control (*N*= 2902)	% reduction |bias|	Treated (*N*= 625)	Control (*N*= 4016)	% reduction |bias|	Treated (*N*= 578)	Control (*N*= 2953)	% reduction |bias|	Treated (*N*= 616)	Control (*N*= 2842)	% reduction |bias|
Age of household head	37.90	37.92	98.9	38.64	38.62	98.3	39.91	39.21	77.5	40.58	39.83	43.4
If h. head finished high school	0.46	0.48	87.1	0.64	0.67	91.7	0.51	0.53	90.6	0.60	0.60	99.1
If mother is married	0.91	0.92	69.2	0.90	0.91	92.7	0.85	0.85	77.4	0.80	0.80	-19.2
Wealth quintile 1 (Poorest)	0.35	0.34	94.1	0.20	0.21	98.5	0.18	0.18	98.5	0.20	0.19	93.5
Ethnicity: Tagalog	0.17	0.17	99.5	0.14	0.15	89.6	0.16	0.18	76.5	0.19	0.22	73
Ethnicity: Cebuano	0.19	0.20	95.8	0.25	0.28	57	0.33	0.34	92.2	0.31	0.33	50.6
Ethnicity: Ilonggo	0.12	0.10	-239.1	0.05	0.05	80.6	0.07	0.05	61.1	0.05	0.03	68.3
Ethnicity: Bicolano	0.09	0.07	11.7	0.12	0.13	77	0.06	0.06	75.1	0.05	0.04	39
Reigion: Catholic	0.81	0.81	7.2	0.77	0.79	27.9	0.79	0.82	58.3	0.77	0.79	64.1
Religion: Iglesia Ni Kristo	0.03	0.02	40.7	0.03	0.02	-29.5	0.02	0.02	-1053.6	0.04	0.03	76.7
Religion: Islam	0.03	0.04	97	0.08	0.09	40.2	0.04	0.03	85.2	0.02	0.01	92.4
Ilocos Region	0.14	0.14	98.3	0.10	0.10	89.1	0.07	0.07	94.9	0.04	0.04	83.2
Cagayan Region	0.09	0.10	88.7	0.02	0.03	90	0.03	0.02	84.4	0.03	0.03	75.9
Central Luzon Region	0.11	0.11	97.6	0.07	0.05	-66.5	0.07	0.07	73.9	0.07	0.08	-142.2
Bicol Region	0.09	0.08	50.8	0.14	0.14	90.6	0.07	0.06	73.5	0.05	0.05	96
Western Visayas Region	0.08	0.07	76.7	0.04	0.04	94.6	0.06	0.04	58.7	0.03	0.03	92.4
Central Visayas Region	0.02	0.01	95.3	0.03	0.02	88.5	0.08	0.09	7.6	0.09	0.11	50.7
Eastern Visayas Region	0.06	0.06	65.1	0.06	0.06	89.9	0.07	0.08	83.4	0.06	0.08	22.1
Zamboanga Peninsula Region	0.02	0.02	97.6	0.08	0.10	-1989	0.08	0.08	77.9	0.05	0.04	61.6
Northern Mindanao Region	0.05	0.05	83.1	0.06	0.05	-1611.5	0.09	0.08	79.4	0.09	0.08	81.2
Davao Region	0.03	0.04	97.5	0.04	0.04	59.3	0.02	0.02	95.2	0.07	0.06	-235.5
SOCCSKARGEN Region	0.08	0.09	85.5	0.05	0.04	28	0.02	0.03	94.8	0.04	0.03	59.2
Cordillera Administrative Region	0.05	0.05	93.9	0.11	0.09	61.3	0.10	0.10	98.1	0.13	0.11	87.9
ARMM Region	0.02	0.02	94.3	0.07	0.07	94.8	0.03	0.02	87	0.00	0.00	99.3
CARAGA Region	0.03	0.03	46.3	0.05	0.04	68.1	0.06	0.06	-157.8	0.09	0.09	92.2
MIMAROPA Region	0.04	0.05	76.7	0.04	0.02	-26.9	0.08	0.11	-31.2	0.04	0.03	80.7
Standardized bias												
Mean		2.31			3.64			3.32			3.77	
Standard deviation		1.85			2.72			2.74			2.29	
Pseudo *R*-squared (logit)		0.1916			0.1810			0.1533			0.1726	

Table 3. Means of the covariates after NN5 (0.001)-matching: Flush toilet (own), 1993-2008

Variables	1993			1998			2003			2008		
	Treated (*N*= 1381)	Control (*N*= 3055)	% reduction |bias|	Treated (*N*= 1480)	Control (*N*= 3024)	% reduction |bias|	Treated (*N*= 1243)	Control (*N*= 2051)	% reduction |bias|	Treated (*N*= 1497)	Control (*N*= 1467)	% reduction |bias|
Age of household head	39.22	39.15	98.4	39.38	39.47	97.9	38.64	38.70	98.5	40.87	39.16	63.8
If h. head finished high school	0.48	0.48	98.2	0.52	0.53	96.1	0.52	0.50	91.7	0.51	0.55	84.9
If mother is married	0.91	0.92	61	0.89	0.89	-273.5	0.87	0.87	96.3	0.80	0.80	91.3
Wealth quintile 1 (Poorest)	0.25	0.23	95.7	0.30	0.28	95.4	0.22	0.22	99.1	0.23	0.23	99.5
Ethinicity: Tagalog	0.16	0.16	90.9	0.14	0.11	58.3	0.14	0.14	95.2	0.12	0.13	95.3
Ethnicity: Cebuano	0.30	0.31	92.7	0.27	0.29	73.2	0.29	0.30	61.2	0.28	0.29	-8.3
Etnicity: Ilonggo	0.08	0.09	94.3	0.08	0.07	43.5	0.09	0.08	53.7	0.10	0.10	69.6
Ethnicity: Bicolano	0.10	0.09	-94.8	0.08	0.09	74	0.09	0.08	76.4	0.08	0.07	78
Religion: Catholic	0.84	0.85	83.5	0.80	0.83	65.1	0.81	0.80	91.5	0.79	0.80	97.8
Religion: Iglesia Ni Kristo	0.03	0.03	38.2	0.03	0.02	70	0.03	0.03	41.1	0.02	0.03	-36.1
Religion: Islam	0.01	0.01	97	0.04	0.03	94.1	0.03	0.04	93	0.04	0.03	97.9
Ilocos Region	0.12	0.13	96.3	0.07	0.06	89.3	0.05	0.05	89	0.05	0.07	66.6
Cagayan Region	0.04	0.03	86.1	0.09	0.10	85.7	0.06	0.08	69.6	0.05	0.04	-80.4
Central Luzon Region	0.11	0.14	51.1	0.08	0.06	66.6	0.06	0.06	98.4	0.05	0.05	91.1
Bicol Region	0.11	0.10	-140.9	0.10	0.11	-50.2	0.10	0.09	-351.3	0.10	0.10	34.6
Western Visayas Region	0.05	0.04	91	0.04	0.05	74.5	0.07	0.06	72.2	0.08	0.06	-11
Central Visayas Region	0.04	0.04	95.2	0.07	0.07	88.2	0.07	0.06	-49.1	0.06	0.06	21.9
Eastern Visayas Region	0.07	0.07	64.3	0.09	0.09	57.8	0.10	0.09	24.8	0.07	0.07	84.1
Zamboanga Peninsula Region	0.08	0.10	6.7	0.05	0.05	94.8	0.05	0.06	66	0.05	0.04	34.7
Northern Mindanao Region	0.07	0.07	-369.7	0.07	0.06	81.9	0.06	0.06	-10.1	0.06	0.06	23
Davao Region	0.06	0.05	-408.4	0.05	0.05	-14.9	0.04	0.03	-54.2	0.06	0.08	0.4
SOCCSKSARGEN Region	0.06	0.06	50.7	0.07	0.08	26.4	0.06	0.08	34.6	0.06	0.07	49.8
Cordillera Administrative Region	0.03	0.03	41.1	0.04	0.04	86.1	0.06	0.06	80.7	0.06	0.07	71.5
ARMM Region	0.01	0.01	98.2	0.03	0.03	98.4	0.03	0.03	99.6	0.02	0.02	99.5
CARAGA Region	0.04	0.03	81.8	0.08	0.08	98.9	0.06	0.07	47.5	0.08	0.08	98.8
MIMAROPA Region	0.03	0.03	95.3	0.02	0.01	72.5	0.06	0.06	95.2	0.06	0.07	23.9
Standardized bias												
Mean		2.69			2.9			2.92			3.79	
Standard deviation		2.67			2.41			2.39			3.76	
Pseudo *R*-squared (logit)		0.2428			0.2007			0.2221			0.2757	

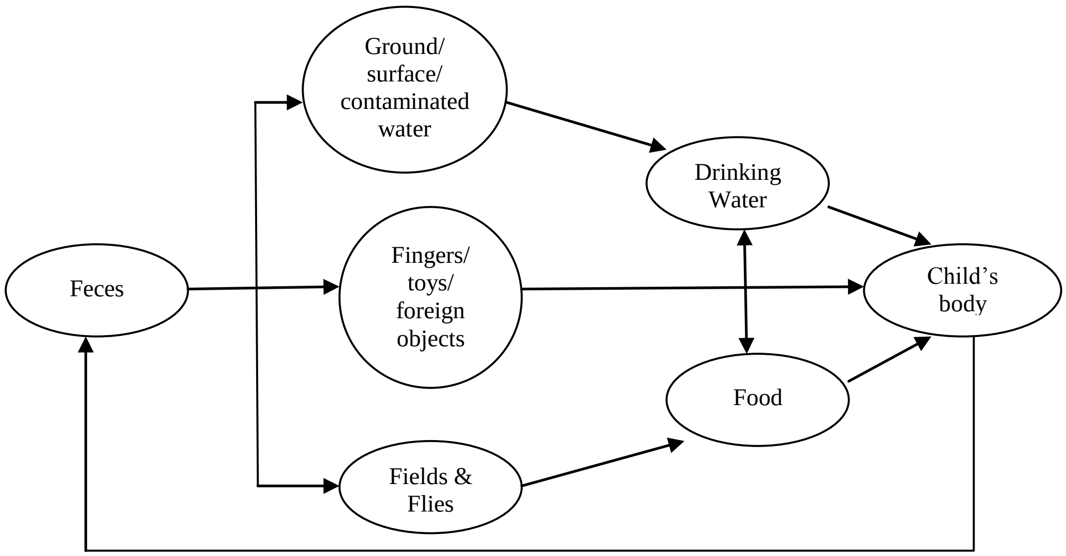
Table 4. Impact estimates, 1993-2008

Treatment/ matching algorithm	1993		1998		2003		2008	
	ATT	Std. errors	ATT	Std. errors	ATT	Std. errors	ATT	Std. errors
Piped water								
NN5 (0.001)	-0.020[c]	0.014	0.012	0.015	-0.032[b]	0.018	-0.029[b]	0.017
NN5 (0.01)	-0.015	0.013	0.008	0.015	-0.014	0.017	-0.040[a]	0.015
NN5 (0.02)	-0.009	0.013	0.012	0.015	-0.012	0.017	-0.045[a]	0.015
NN5 (0.03)	-0.013	0.013	0.013	0.015	-0.015	0.017	-0.042[a]	0.015
Kernel (0.03)	-0.002	0.012	0.014	0.013	-0.010	0.015	-0.028[b]	0.013
Kernel (0.05)	-0.001	0.012	0.014	0.013	-0.005	0.015	-0.018[b]	0.013
Own flush toilet								
NN5 (0.001)	-0.017	0.016	-0.010	0.013	-0.025[c]	0.016	-0.034[b]	0.018
NN5 (0.01)	-0.013	0.014	-0.003	0.012	-0.026[b]	0.015	-0.100[a]	0.020
NN5 (0.02)	-0.012	0.014	-0.001	0.012	-0.027[b]	0.015	-0.090[a]	0.019
NN5 (0.03)	-0.015	0.014	-0.005	0.012	-0.030[b]	0.015	-0.087[a]	0.019
Kernel (0.03)	-0.015	0.013	0.002	0.011	-0.028[b]	0.014	-0.073[a]	0.018
Kernel (0.05)	-0.016	0.013	0.002	0.011	-0.027[b]	0.014	-0.068[a]	0.018

Notes:
[a] significant at 1%.
[b] significant at 5%.
[c] significant at 10%.

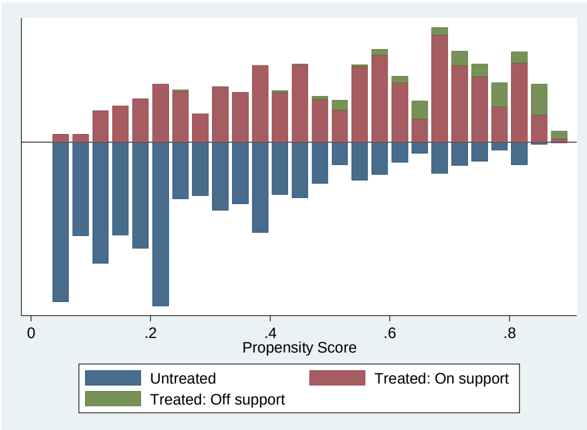
Figures

Figure 1. Mechanisms through which bacteria may enter a child's body.

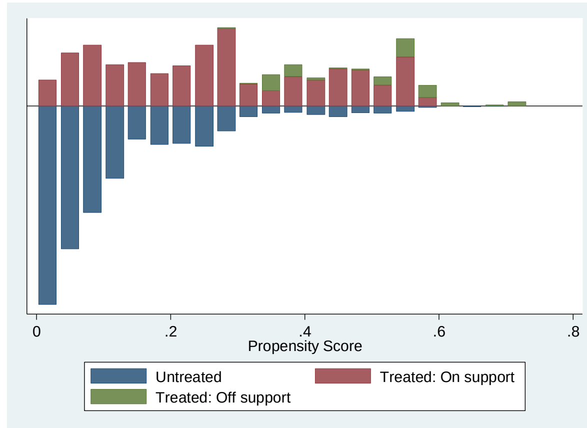


Adapted from Waddington et al..(2009).

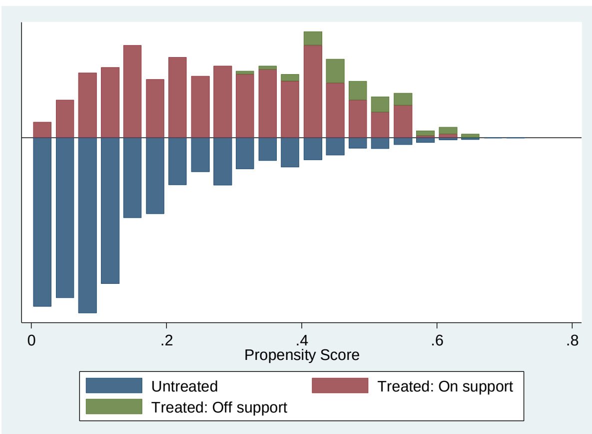
Figure 2. Histograms of matched sub-samples along common support: Piped water, 1993-2008



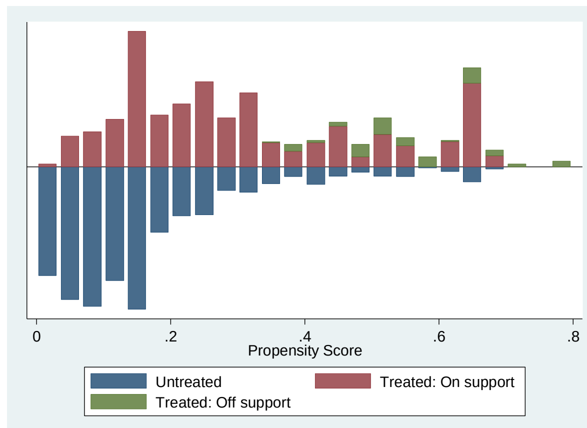
a. 1993



b. 1998

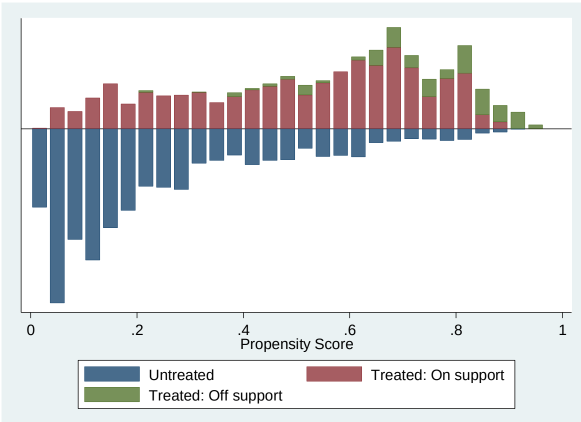


c. 2003

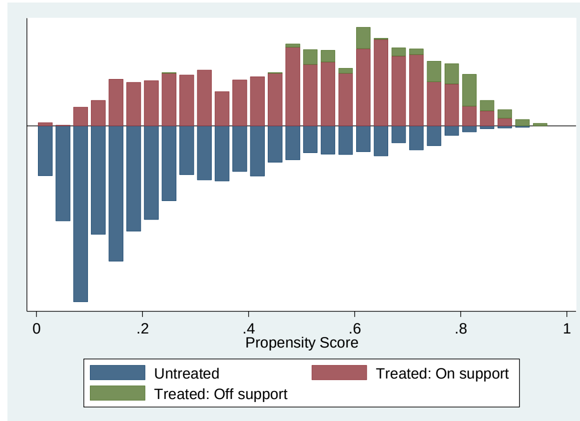


d. 2008

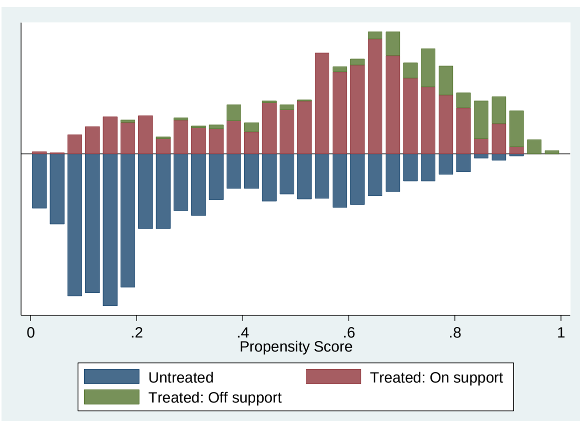
Figure 3. Histograms of matched sub-samples along common support: Flush toilet (own), 1993-2008



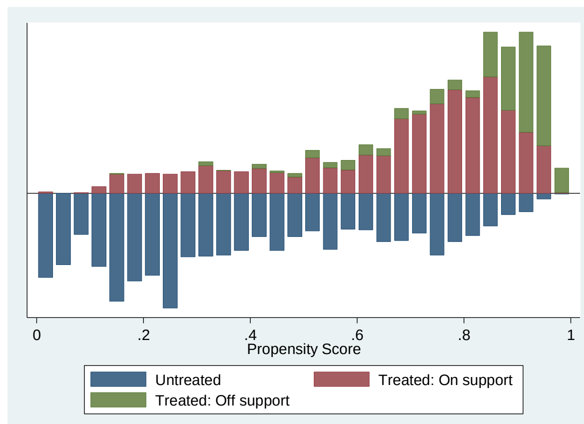
a. 1993



b. 1998



c. 2003



d. 2008