Policy Research Working Paper 9054

Children Need Clean Water to Grow

E. Coli Contamination of Drinking Water and Childhood Nutrition in Bangladesh

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WORLD BANK GROUP
Water Global Practice
November 2019

Policy Research Working Paper 9045

Abstract

Water, sanitation, and hygiene interventions are increasingly recognized as essential for improving nutritional outcomes in children. Emerging literature describes the negative effects of poor sanitation on child growth. However, limited evidence has shown a link between water quality and nutritional outcomes. Similar to poor sanitation, it is plausible that water contaminated with E. coli could affect the nutritional status of children through various possible biological pathways, such as repeated episodes of diarrhea, environmental enteropathy, parasites, or other mechanisms that inhibit nutrient uptake and absorption. This study explores the relationship between contaminated water and stunting prevalence among children younger than age five years, using unique cross-sectional data from the 2012–13 Bangladesh Multiple Indicator Cluster Survey, which was one of the first nationally representative surveys to include water quality testing for E. coli. E. coli contamination in drinking water is measured at household and source points. Stunting is measured using height-for-age z-scores for children under five, where a child is considered stunted when he or she is two or more standard deviations below the median of the World Health Organization reference population. The results of multiple probit regression models indicate a 6 percent increase in the prevalence of stunting in children who are exposed to highly contaminated drinking water at household point compared with those exposed to low-to-medium contamination. When contamination is measured at the source level, the association is greater, with a 9 percent increase in the likelihood of stunting when exposed to a high level of contamination.

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Children Need Clean Water to Grow: E. Coli Contamination of Drinking Water and Childhood Nutrition in Bangladesh

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Key words: fecal contamination, early childhood development, water quality, health, Bangladesh

JEL Code: C13; I14; Q57

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This work was made possible by the Swedish International Development Cooperation Agency as part of the WASH Poverty Diagnostics Initiative. The findings, interpretations, and conclusions expressed in this paper do not necessarily reflect the views of the World Bank, its Board of Executive Directors, or the governments they represent.

1. Introduction

Since 1990, Bangladesh experienced a 20 percentage point increase in access to drinking water sources that are considered "improved" by global standards, with current access at 98 percent (WHO/UNICEF 2017). The transition from unimproved sources such as ponds, rivers, open wells, and other unprotected water to improved water infrastructure is considered as an important stride in Bangladesh's development and is thought to have significantly lowered the disease burden of waterborne illness and infant mortality rates (Field et al 2011). Although the water that Bangladeshis consume is safer today than in recent decades, it is still plagued by widespread fecal contamination. A nationally-representative cross-sectional survey on water quality estimates that 56 percent of all improved water sources are contaminated with *Escherichia coli* (E. coli) bacteria (UNICEF 2016).

Poor water quality is a stubborn barrier to reducing preventable enteric infections and sometimes chronic ailments that debilitate and kill children. Exposure to fecal contaminants in drinking water has mostly been linked to diarrheal diseases, which are a leading cause of child mortality in low-income countries like Bangladesh. Systematic reviews and meta-analyses on the effectiveness of water, sanitation, and hygiene (WASH) interventions conclude that point-of-use water treatment is among the most effective WASH interventions for reducing diarrheal disease (Fewtrell et al 2005; Clasen et al 2007; Gruber et al 2014; Wolf et al 2018). Massive increases in water and sanitation coverage and delivery of oral rehydration therapy are likely to have lowered child deaths from diarrheal diseases globally (Victora et al 2000; Askeer et al 2017).

However, good quality water could have additional benefits for child well-being, such as improving nutritional outcomes including stunted growth, a measurement of low height-for-age and marker of chronic undernutrition. Observational studies have shown the effects of poor sanitation, particularly high rates of open defecation, on rates of stunting in a number of countries (Spears et al 2013; Heady et al 2016; Rah et al 2015; Chambers et al 2013). However, a systematic review evaluating the effectiveness of WASH on improving nutrition concluded that improvements in microbial water quality were among the most effective WASH interventions (Dangour et al 2013). Though the causes of undernutrition are multifaceted and include factors such as caretaking practices, food security, access to health care, and various social determinants, the contribution of specific WASH conditions to rates of childhood undernutrition warrants further study.

Using household survey data collected by the United Nations Children's Fund (UNICEF), this analysis attempts to observe the effect of various levels of E. coli contamination of drinking water on the prevalence of stunting in children under 5. Such an effect would be consistent with the biological plausibility that exposure to fecal contaminants can interrupt critical growth periods of children through the onset of enteric infections. Further, the effect can be attributed to quantifiable levels of E. coli bacteria that children could arguably have regular exposure to through drinking water.

We present results from our econometric analysis, where we regress levels of E. coli contamination of drinking water at the household source and consumption on the probability of being stunted, as measured by height-for-age z-scores that are two standard deviations below the World Health Organization (WHO) reference population. After controlling for a range of demographic, social, and economic characteristics of households, the results from the probit regression models suggest that E. coli contamination at both the source and consumption point are significantly and positively associated with stunting status, where the likelihood of stunting is higher for children exposed to increasing risk levels of E. coli contamination.

The results indicate a 6 percentage point increase in the prevalence of stunting in children (n=817) who are exposed to highly contaminated (>100 cfu in 100ml) drinking water at household point compared to those exposed to low-to-medium contamination (1-100 cfu in 100ml). When contamination is measured at the source level (n=1,293), the association is greater with a 9 percentage point increase in the likelihood of stunting when exposed to a high level of contamination. The results leave important implications on the necessity of addressing water quality in WASH interventions as consistent with the new Sustainable Development Goal (SDG) targets as well as future research questions on the synergies between WASH and nutrition.

The paper continues in four sections. Section 2 provides a background on environmental fecal contamination in less developed countries and summarizes evidence on the links between WASH interventions and nutrition outcomes. Next, section 3 describes the data used for the analysis and the methods for building the probit regression models, and section 4 presents the results. Finally, section 5 discusses the findings and policy implications of the presented analysis.

2. Background: Environmental fecal contamination and its effects on nutrition

In Bangladesh, over a third of all children under five are estimated to be stunted, making the country a priority for the Scaling Up Nutrition (SUN) movement. Stunting is prevalent throughout all Bangladeshi households, regardless of wealth, though rates are highest among the poorest: nearly half of all children living in the bottom 40 percent of households are stunted (World Bank 2018). The consequences of chronic undernutrition during childhood include poorer health status from weakened immunity, impaired physical and cognitive development, lower educational attainment, and reduced lifetime earnings and productivity into adulthood (Victora et al 2008, Guerrant et al 2013). Improving nutritional outcomes is a vital strategy for poverty reduction and economic growth.

The causes of undernutrition are multifaceted, but the most immediate pathways are considered to be insufficient dietary intake and disease. Other underlying causes include food insecurity, poor caregiving practices, limited access to health services, and unsanitary conditions (UNICEF 1990). WASH may particularly contribute to undernutrition when it cannot prevent high fecal pollution of the environment and guarantee safe access to services. Exposure to inadequate WASH could indicate a higher risk of contracting diarrheal diseases, parasitic enteric infections, mosquito-borne illnesses, and environmental enteric dysfunction (EED), all of which can influence nutritional outcomes.

For example, diarrheal diseases mediate the WASH and nutrition relationship because they may cause children to lose their appetite, divert energy to fighting off the illness, or have malabsorption and expel nutrients during episodes (Ngure et al 2014). Moreover, in low-income countries, the highest incidence of diarrheal diseases is noted to occur in the first two years of life, commonly referred to by nutrition experts as the "first 1,000 days," the most critical and vulnerable stage of growth and development of children (Alderman et al 2014).

Parasitic enteric infections from soil-transmitted helminths (STH) such as hookworm, whipworm, and roundworm and mosquito-borne illnesses such as malaria, dengue, and yellow fever can also be linked to poor WASH and nutrition. These illnesses can cause anemia, loss of appetite, and weakened immunity (Ngure et al 2014). Stagnant water offers breeding grounds for disease-carrying mosquitos, while high loads of STH are found soil, water, and sometimes food in areas of high fecal pollution. Young children are particularly at risk due to unique outdoor playing and eating (e.g. geophagia) behaviors. Pregnant mothers may also be vulnerable to infections, which can impair their nutritional status and endanger the health and development of the children. Mothers with hookworm infections are at higher risk for pre-term delivery and low-birth weight of children, which increases the odds of childhood undernutrition (Dreyfuss et al 2000).

EED is the newest hypothesized disease link between WASH and nutrition. The hypothesis suspects that chronic exposure to feces could inflame the gut and cause physical intestinal deformations, where the impaired gut cannot absorb or retain essential nutrients needed for healthy development (Humphrey 2009; Ngure et al 2014). More importantly, those children affected with EED may not exhibit symptoms of enteric infection such as episodes of diarrhea. However, victims of EED may be at high risk for vaccine failure, reduced immunity, and growth faltering. EED is difficult to diagnose due to its complex pathogenesis and limitations in testing methods; however, EED is suspected to be most prevalent in areas of poor WASH (Guerrant et al 2013).

Much of the literature on WASH and nutrition derives from observational studies, particularly on the correlation between poor sanitation on nutrition outcomes. There are limited experimental studies that have evaluated the effectiveness of WASH interventions on improving nutritional outcomes. Further, the few experimental evaluations that exist have shown mixed results on the ability of traditional WASH to improve growth. For example, a couple of randomized controlled trials (RCTs) have evaluated improved sanitation for promoting childhood nutrition. In rural Indonesia, it was found that a sanitation marketing intervention reduced diarrheal prevalence and improved growth in wealthier households that did not have sanitation at baseline (Cameron et al 2013). Pickering and colleagues (2015) found that community-led total sanitation interventions did not reduce diarrheal disease incidence but did improve child growth. However, two RCTs on pit latrine building campaigns to eradicate open defecation in rural India showed that increased latrine coverage had minimal impact on disease outcomes including diarrhea and undernutrition, though both areas still had notably high rates of open defecation (Clasen et al 2014; Patil et al 2014). Nevertheless, a meta-analysis of observational and experimental studies found that sanitation interventions overall had a positive effect on at least height-for-age (Freeman et al 2017).

There have been fewer experimental evaluations on the effectiveness of improvements in household microbial water quality on improving childhood nutrition, but there is some promising evidence for potential impact. Indicators of E. coli in household drinking water are associated with diarrheal disease and are an appropriate marker of fecal contamination (Gruber et al 2014). Systematic reviews have found that point-of-use water treatment is among the most effective WASH interventions to reduce diarrheal disease incidence (Fewtrell et al 2005; Clasen et al 2007; Wolf et al 2018). Further, a meta-analysis examined 14 studies on various WASH interventions (improved microbiological quality of drinking water, water quantity and supply, sanitation coverage, handwashing, and child feces disposal) and found that interventions with solar disinfection of water, provision of soap, and improvement of water quality) had some benefit on the linear growth of children under 5 (Dangour et al 2013). However, two recently published RCTs evaluating the effectiveness of chlorination tablets in rural Bangladesh and Kenya found that the water quality intervention had no impact on diarrheal disease incidence or anthropometric measures (Luby et al 2018; Null et al 2018). The conclusions of these studies do not necessarily imply that there is no link between contaminated water and nutrition, but more likely that the interventions did not effectively limit exposure to feces in a sustainable manner. Further research is needed in understanding the relationship between pathways and quantities of fecal exposure and nutritional status of children.

3. Methodology

3.1 Data

We use cross-sectional data from the 2012-13 MICS survey for Bangladesh, a nationally representative survey with various indicators on household characteristics across urban and rural regions of Bangladesh. The 2012-2013 MICS is the first and latest national representative survey that provides water quality data on E. coli contamination in drinking water sources in Bangladesh. Globally, there are very few other data sets that examine microbial water quality indicators on a national scale. We particularly examine indicators on E. coli contamination in drinking water and childhood stunting. The independent variables include E. coli contamination at point-of-source (e.g. water quality results from the household's main reported source of drinking water) and E. coli contamination at point-of-consumption (water quality results from a cup of drinking water prepared by a household member). The dependent variable, childhood stunting, is based on linear growth measure of height-for-age z-scores that are two standard deviations below the WHO reference population.

3.2 Empirical Strategy

This analysis uses a probit regression model to determine the probability of stunting when children are exposed to E. coli in drinking water at varying risk levels and different collection points (source and consumption).

Specification (1) uses a probit model to examine the link between stunting and E. coli contamination at the consumption level for 817 children under five. The dependent variable is stunting as a dichotomous variable. In specification (1.1), the primary explanatory variable is E. coli contamination, a binary variable that compares no detected E. coli (<1 cfu in 100 ml) to any detected E. coli (>1cfu in 100 ml) in the household sample. Specification (1.2) uses an E. coli variable that compares a low and medium level of contamination (0-10 cfu in 100 ml) to a high level (11-200 cfu in 100 ml). Other covariates in specifications (1.1) and (1.2) include characteristics of the following: child (whether he/she has ever been breastfed, sex, age), mother (education), household (location, size, wealth quintile, type of sanitation facility, type of drinking water source, water treatment, and handwashing), and community (sanitation ratio).

Specification (2) uses a similar probit model to determine the likelihood of stunting when exposed to E. coli at source point for 1,292 children under five. This differs from specification (1) in that it examines the relationship between stunting and E. coli in water, prior to any intervention (e.g. water treatment or storage) that may affect contamination. Specification (2.1) uses a binary E. coli variable with 0 indicating low contamination (<1 cfu in 100 ml) at source and 1 indicating some contamination (>1cfu in 100 ml). Specification (2.2) disaggregates the E. coli risk levels with 0 indicating a low or medium level of contamination (0-10 cfu in 100 ml) and 1 indicating a high level (11-200 cfu in 100 ml) of E. coli at source.

In specification (2), if the tested household relies on piped water, the result from the E. coli test is applied to all households within the cluster that also uses piped water as the primary source. This is based on the assumption that if one piped source is contaminated, then all households in the vicinity using that piped connection have the same level of contamination, since the water is most likely coming from a centralized source. This rule was not applied to tested households with tube wells and other sources of water.[1] This assumption allows an increase in sample size, which can improve the robustness of the analysis.

The inclusion of household and community variables in the analysis causes child variables to cluster, particularly since the sample contains several children who are siblings (Zenger 1993, Liang

[1] The piped water category includes piped into dwelling, piped into compound, yard or plot, piped to neighbor, and public tap/standpipe. Other sources include protected well, protected spring, unprotected well, unprotected spring, cart with small/tank drum, and surface water (river, stream, dam, lake).

and Zeger, 1993). Thus, standard errors are corrected using the Huber and White matrix for village-level clustering.

4. Results

4.1 Descriptive Statistics

Table 1 shows the weighted mean values of the variables in specification (1). About 42 percent of the children in the sample are stunted which is slightly higher than the most recent estimate of the national rate of 36 percent from 2014. About 43 percent of the households use water that is contaminated at the source point, while 62 percent are contaminated at the household point. This is indicative that child, maternal and household characteristics influence contamination between collection at source and consumption at the household points.

When disaggregated by type of water source, E. coli contamination at both source and household points is higher in piped water and other sources compared to tube wells (Annex Figure 1). Among households with piped water, there is little difference in E. coli contamination between collection points. This indicates that E. coli at source is a significant determinant of contamination at the household point when the primary source of drinking water is piped water.

There is a substantial increase in contamination from 40 percent at the source to 61 percent at the household point when tube wells are the main source of drinking water. Again, the difference in contamination between collection points can be attributed to child, maternal, and household characteristics instead of source contamination.

Household water treatment is one way to reduce the level of contamination between collection points. However, among users of piped and tubewells that reported treating water, contamination did not significantly decrease from source to consumption point. It should be noted that the portion of households that treat water is too small (4 percent) to make a conclusive statement on its impact on E. coli contamination and thus, stunting too.

Piped water is more prevalent in urban areas (20%) compared to rural areas (2%). In rural areas, the majority (93 percent) of the households use tubewells. When disaggregated by risk levels, urban households are twice as likely to have very high levels of E. coli (>100 cfu in 100 ml) compared to rural areas (Figure 2). The difference is greater when comparing E. coli at source point in urban versus rural areas (Annex 2).

Table 1: Weighted sample mean values of variables in specification (1)

Category	Variable	Type	Obs	Mean	Std. Dev.
Outcome	Stunting	Dummy	816	0.42	0.49
E. Coli Contamination	High E. Coli Cont. at HH Point	Dummy	816	0.39	0.49
	Some E. Coli Cont. at HH Point	Dummy	816	0.62	0.48
	High E. Coli Cont. at Source Point	Dummy	816	0.18	0.39
	Some E. Coli Cont. at Source Point	Dummy	816	0.43	0.49
Water Treatment Practices	Household Practices Appropriate Water Treatment	Dummy	816	0.06	0.23
Water Source	**Water Sources (Household Point)**				
	Unimproved Water Sources	Dummy	816	0.01	0.14
	Improved Sources; Tube Wells	Dummy	816	0.91	0.29
	Improved Sources; Piped Water	Dummy	816	0.08	0.26
Child's Characteristics	Child's Age	Continuous	816	29.79	17.53
	Child's Age (log)	Continuous	816	3.08	0.98
	Child's Age Squared (log)	Continuous	816	6.16	1.96
	Female Child	Dummy	816	0.47	0.50
	Child Ever Breastfed	Dummy	816	0.99	0.12
Mother's Characteristics	**Mother's Education**				
	No Education	Dummy	816	0.38	0.49
	Primary or Some Secondary	Dummy	816	0.52	0.50
	Secondary or Higher	Dummy	816	0.10	0.30
Community Characteristics	Community Improved Sanitation Ratio	Continuous	816	0.51	0.23
HH Characteristics	**Sanitation Status**				
	Unimproved Sanitation	Dummy	816	0.23	0.42
	Improved Sanitation; Shared	Dummy	816	0.24	0.42
	Improved Sanitation; Private	Dummy	816	0.53	0.50
	Household size	Continuous	816	5.37	1.93
	Household Size (log)	Continuous	816	1.62	0.34
	Urban Household	Dummy	816	0.19	0.39
	Wealth Quintile				
	First Quintile	Dummy	816	0.23	0.42
	Second Quintile	Dummy	816	0.20	0.40
	Middle Quintile	Dummy	816	0.18	0.38
	Fourth Quintile	Dummy	816	0.21	0.41
	Richest Quintile	Dummy	816	0.18	0.38
	Floor is made of Earth or Dung	Dummy	816	0.74	0.44
	Functioning handwashing stand	Dummy	816	0.30	0.46
	Unsafe Disposal of Child Feces	Dummy	816	0.15	0.36

Of the 816 children under five, 341 (42 percent) are stunted. Among the stunted children, 62 percent are exposed to E. coli in their drinking water, while 36 percent are stunted without any exposure. Annex Figure 3 shows that stunting rates are largely driven by E. coli contamination at the household point and not wealth, i.e., the difference in stunting rates between the bottom 40 and top 60 segments of the population is small.

Annex Figure 4 compares stunting rates and contamination in different age groups. Stunting is found to be most prevalent in the 24-60 month group, which includes children who are more likely to drink contaminated water than younger children who are exclusively breastfed. In addition, children in that age group are mobile and develop mouthing behavior that expose them to more pathogens (George et al 2015, Tulve 2002).

4.2 Fecal contamination effects on nutrition

Table 2 presents results from specification (1) which examines the likelihood of stunting in different age groups when exposed to E. coli contamination at the household point. In the 6-23 month group, contamination does not have a significant correlation with stunting. This could be because children at this age group are more likely to be exclusively breastfeeding. In this category, households with flooring that is made of earth and mother's education have the strongest association with stunting. In both (1.1a) and (1.2a), a child with a mother who completed secondary education is 27 percentage points less likely to be stunted compared to a child whose mother has no education. Children in this age group from households whose floor is made of earth are 26 percentage points more likely to be stunted. Children in this age group would have begun crawling and could have been exposed to contaminated soil within the household. As mentioned earlier, children in this age group are also known to inadvertently consume contaminated soil (e.g. geophagia) which in turn lead to higher risk of stunting (George et al 2015).

In the 24-60 month group, E. coli increases the likelihood of stunting by 13 percentage points, only when it is at a high risk level (1.2d). The significance of contamination in this age category can be attributed to the fact that children aged 24-60 months are more likely to drink water. Variables that have significant and negative associations with stunting include breastfeeding and being in the topmost wealth quintile. A child between 24 and 60 months who has been breastfed is over 27 percentage points less likely to be stunted than one who has not. Wealth reduces the probability of stunting by 26 percentage points, but only when the household is in the topmost quintile.

In the overall sample, a high level of E. coli at household point increases the probability of stunting by 6 percentage points (1.2d). Mother's completion of secondary education and breastfeeding significantly decrease the incidence of stunting by 13 and 28 percentage points, respectively. In addition, improved sanitation and water treatment have a strong correlation with lower stunting. Appropriate water treatment decreases the likelihood of stunting by around 22 percentage points while improved sanitation that is private lowers stunting by 11 percentage points. As discussed before, water treatment is not a common practice in Bangladesh and was not effective in reducing contamination in households that use piped water and tube wells. Here, the significance of water treatment might reflect a greater hygiene awareness, education level, or wealth in the household and not necessarily the effectiveness of the practice.

Table 3 shows results from specification (2) which examines the likelihood of stunting when exposed to E. coli at the source point. In the 24-60 month group, the likelihood of stunting increases from 6 percentage points (2.1d) to 10 percentage points (2.2d) when the contamination variable is re-defined from some contamination to high contamination. Similarly, in the 0-60 month group, the incidence of stunting almost doubles from 5 percentage points in (2.1e) to 9 percentage points in (2.2e). Improved sanitation, mother's education and breastfeeding are strongly correlated with lower stunting for the 24-60 month group and the total sample. Mother's completion of secondary education has the highest correlation with an over 25 percentage point decrease in the likelihood of stunting.

In both specifications, exposure to high levels of E. coli, breastfeeding, being in the topmost quintile, improved sanitation, and mother's education have the most significant relationship with stunting for the 0-60 months age group. Being in the topmost wealth quintile is also significant in both specifications but only in the age group 23 to 60 months.

Annex Figures 6 and 7 present the predicted probabilities of stunting from specifications (1.1e) and (1.2e) as well as (2.1e) and (2.2e). The predicted probabilities show a consistent trend across all four specifications: children from the poorest quintile are most likely to be stunted if they are exposed to

E. coli contamination both at the household point or at the source point compared to children in the richest quintile who are exposed to E. coli contamination.

Table 2: Specification 1 – Correlates of stunting with exposure to E. Coli contamination at household point (N=816 children)

Dependent Variable: Stunting	6 to 23 months		6 to 60 months		12 to 60 months		24 to 60 months		0-60 months	
	(1.1a)	(1.2a)	(1.1b)	(1.2b)	(1.1c)	(1.2c)	(1.1d)	(1.2d)	(1.1e)	(1.2e)
High E. Coli Contamination at HH (=1)		-0.050		0.064*		0.069*		0.125***		0.062*
		(0.059)		(0.037)		(0.039)		(0.045)		(0.035)
Some E. Coli Contamination at HH (=1)	-0.032		-0.002		-0.007		0.010		-0.001	
	(0.060)		(0.036)		(0.038)		(0.044)		(0.035)	
Appropriate water treatment (=1)	-0.236**	-0.233**	-0.212**	-0.208**	-0.207**	-0.202**	-0.188	-0.173	-0.219***	-0.217***
	(0.110)	(0.112)	(0.086)	(0.085)	(0.095)	(0.094)	(0.120)	(0.119)	(0.079)	(0.079)
Water Sources										
Tube Wells	-0.181	-0.195	-0.093	-0.060	-0.092	-0.056	-0.055	0.011	-0.112	-0.083
	(0.188)	(0.188)	(0.096)	(0.099)	(0.099)	(0.102)	(0.112)	(0.115)	(0.085)	(0.087)
Piped Systems	-0.114	-0.110	0.064	0.087	0.083	0.109	0.106	0.159	0.011	0.033
	(0.267)	(0.268)	(0.135)	(0.136)	(0.137)	(0.139)	(0.152)	(0.155)	(0.127)	(0.127)
(baseline: Unimproved Water)										
Log of Child Age	-1.559	-1.529	1.368***	1.401***	2.306***	2.357***	-0.550	-0.079	0.174**	0.182**
	(1.099)	(1.099)	(0.332)	(0.330)	(0.628)	(0.629)	(2.390)	(2.378)	(0.082)	(0.082)
Log of Child Age Squared	0.370*	0.363*	-0.210***	-0.215***	-0.348***	-0.356***	0.047	-0.016	-0.021	-0.022
	(0.217)	(0.217)	(0.053)	(0.053)	(0.094)	(0.094)	(0.326)	(0.325)	(0.016)	(0.016)
Female Child (=1)	0.024	0.027	0.021	0.021	0.016	0.017	0.019	0.020	0.013	0.013
	(0.058)	(0.058)	(0.035)	(0.035)	(0.037)	(0.037)	(0.044)	(0.043)	(0.033)	(0.033)
Child was ever breastfed (=1)	-0.023	-0.023	-0.297***	-0.301***	-0.301***	-0.308***	-0.273**	-0.282**	-0.281**	-0.284**
	(0.217)	(0.211)	(0.105)	(0.104)	(0.108)	(0.107)	(0.115)	(0.114)	(0.112)	(0.111)
Mother's Education										
Primary Education	-0.037	-0.033	-0.038	-0.037	-0.046	-0.043	-0.049	-0.042	-0.039	-0.037
	(0.066)	(0.066)	(0.040)	(0.040)	(0.043)	(0.043)	(0.049)	(0.048)	(0.038)	(0.038)
Secondary Education or Higher	-0.272***	-0.274***	-0.146**	-0.145**	-0.134*	-0.133*	-0.078	-0.077	-0.135*	-0.132*
	(0.102)	(0.101)	(0.072)	(0.071)	(0.078)	(0.078)	(0.093)	(0.091)	(0.070)	(0.070)
(baseline: No Education)										
Community Improved Sanitation Ratio	-0.065	-0.048	0.084	0.079	0.090	0.085	0.112	0.111	0.104	0.103
	(0.158)	(0.159)	(0.093)	(0.092)	(0.098)	(0.097)	(0.112)	(0.111)	(0.087)	(0.086)

Sanitation Status										
Improved Sanitation, Shared	-0.098	-0.096	-0.090*	-0.092*	-0.118**	-0.118**	-0.088	-0.091	-0.079	-0.080
	(0.086)	(0.086)	(0.053)	(0.053)	(0.056)	(0.056)	(0.065)	(0.064)	(0.050)	(0.050)
Improved Sanitation, Private	-0.159**	-0.158**	-0.099*	-0.096*	-0.113**	-0.109**	-0.073	-0.067	-0.112**	-0.109**
	(0.077)	(0.077)	(0.051)	(0.051)	(0.055)	(0.055)	(0.064)	(0.063)	(0.049)	(0.049)
(baseline: Unimproved Sanitation)										
Log Household Size	-0.138	-0.137	-0.067	-0.073	-0.040	-0.045	-0.038	-0.051	-0.035	-0.041
	(0.101)	(0.101)	(0.057)	(0.057)	(0.060)	(0.060)	(0.071)	(0.070)	(0.054)	(0.054)
Household in Urban Areas (=1)	-0.125	-0.128	-0.018	-0.023	-0.005	-0.011	0.022	0.013	-0.012	-0.015
	(0.095)	(0.095)	(0.056)	(0.056)	(0.058)	(0.058)	(0.066)	(0.066)	(0.053)	(0.053)
Wealth Index										
Second Quintile	0.005	0.007	-0.041	-0.046	-0.055	-0.060	-0.077	-0.085	-0.011	-0.014
	(0.078)	(0.078)	(0.053)	(0.053)	(0.056)	(0.056)	(0.066)	(0.066)	(0.050)	(0.050)
Third Quintile	-0.041	-0.041	-0.005	-0.008	-0.011	-0.017	0.033	0.029	0.009	0.006
	(0.084)	(0.083)	(0.055)	(0.055)	(0.059)	(0.059)	(0.068)	(0.067)	(0.052)	(0.052)
Fourth Quintile	-0.018	-0.021	-0.045	-0.049	-0.032	-0.038	-0.040	-0.053	-0.034	-0.037
	(0.090)	(0.090)	(0.061)	(0.061)	(0.065)	(0.064)	(0.075)	(0.074)	(0.058)	(0.058)
Richest Quintile	0.205	0.199	-0.155*	-0.159*	-0.169*	-0.175**	-0.278***	-0.287***	-0.129	-0.133*
	(0.136)	(0.135)	(0.082)	(0.082)	(0.087)	(0.087)	(0.093)	(0.091)	(0.079)	(0.079)
(baseline: First Quintile)										
HH's Floor is made of Earth, Dung (=1)	0.262***	0.260***	0.141**	0.139**	0.162***	0.158***	0.114*	0.107	0.124**	0.122**
	(0.089)	(0.089)	(0.060)	(0.060)	(0.060)	(0.060)	(0.068)	(0.067)	(0.056)	(0.056)
Functioning Handwashing Station (=1)	-0.020	-0.018	-0.028	-0.032	-0.005	-0.011	-0.010	-0.019	-0.029	-0.033
	(0.061)	(0.061)	(0.039)	(0.039)	(0.042)	(0.042)	(0.050)	(0.050)	(0.037)	(0.037)
Unsafe Disposal of Child Feces (=1)	-0.052	-0.049	0.002	-0.003	0.020	0.013	0.063	0.062	0.027	0.025
	(0.064)	(0.064)	(0.054)	(0.054)	(0.060)	(0.061)	(0.085)	(0.085)	(0.050)	(0.050)
Observations	234	234	742	742	667	667	508	508	816	816
Pseudo R2	0.181	0.182	0.0902	0.0932	0.0870	0.0904	0.0789	0.0898	0.0810	0.0839
Model VIF	-	-	-	-	-	-	-	-	3.03	3.03
Goodness of Fit Test	3.34	3.94	6.71	8.19	6.07	5.69	2.49	5.67	5.42	9.32

Standard Errors are Robust Clustered at Household Level

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

Table 3: Specification 2 – Correlates of stunting with exposure to E Coli contamination at source point (N=1292 children)

Dependent Variable: Stunting	**6 to 23 months**		**6 to 60 months**		**12 to 60 months**		**24 to 60 months**		**0-60 months**	
	(2.1a)	(2.2a)	(2.1b)	(2.2b)	(2.1c)	(2.2c)	(2.2d)	(2.2d)	(2.1e)	(2.2e)
High E. Coli Contamination at Source (=1)		0.022		0.077**		0.076**		0.099**		0.094***
		(0.059)		(0.035)		(0.038)		(0.047)		(0.034)
Some E. Coli Contamination at Source (=1)	-0.015		0.046		0.043		0.062*		0.051*	
	(0.048)		(0.028)		(0.030)		(0.036)		(0.027)	
Appropriate water treatment (=1)	0.091	0.082	0.009	0.003	0.020	0.012	-0.042	-0.051	0.010	0.000
	(0.077)	(0.078)	(0.052)	(0.052)	(0.056)	(0.056)	(0.066)	(0.067)	(0.051)	(0.051)
Water Sources										
Tube Wells	-0.071	-0.053	-0.002	0.018	-0.008	0.014	0.027	0.055	-0.024	0.001
	(0.169)	(0.168)	(0.087)	(0.088)	(0.092)	(0.093)	(0.099)	(0.101)	(0.082)	(0.083)
Piped Water	-0.083	-0.067	0.028	0.043	0.027	0.042	0.088	0.105	-0.005	0.013
	(0.176)	(0.175)	(0.091)	(0.091)	(0.097)	(0.097)	(0.105)	(0.105)	(0.086)	(0.086)
(baseline: Unimproved Water)										
Log of Child Age	-0.281	-0.281	1.419***	1.433***	2.043***	2.066***	-0.368	-0.605	0.144**	0.151**
	(0.836)	(0.832)	(0.261)	(0.260)	(0.508)	(0.509)	(1.837)	(1.842)	(0.068)	(0.067)
Log of Child Age Squared	0.119	0.119	-0.216***	-0.219***	-0.308***	-0.312***	0.024	0.055	-0.015	-0.017
	(0.165)	(0.164)	(0.041)	(0.041)	(0.076)	(0.076)	(0.250)	(0.251)	(0.013)	(0.013)
Female Child (=1)	-0.046	-0.047	-0.004	-0.002	-0.009	-0.006	0.015	0.017	-0.009	-0.006
	(0.047)	(0.046)	(0.026)	(0.026)	(0.028)	(0.028)	(0.033)	(0.033)	(0.025)	(0.025)
Child was ever breastfed (=1)	-0.082	-0.088	-0.191**	-0.186**	-0.201**	-0.196**	-0.223**	-0.211**	-0.214***	-0.208**
	(0.170)	(0.170)	(0.080)	(0.081)	(0.083)	(0.083)	(0.090)	(0.093)	(0.082)	(0.083)
Mother's Education										
Primary Education	-0.031	-0.030	-0.070**	-0.072**	-0.088**	-0.090**	-0.089**	-0.093**	-0.062*	-0.064**
	(0.057)	(0.057)	(0.034)	(0.034)	(0.037)	(0.037)	(0.042)	(0.042)	(0.032)	(0.032)
Secondary Education or Higher	-0.301***	-0.297***	-0.272***	-0.271***	-0.287***	-0.286***	-0.247***	-0.246***	-0.255***	-0.253***
	(0.064)	(0.065)	(0.046)	(0.045)	(0.050)	(0.050)	(0.060)	(0.060)	(0.044)	(0.044)
(baseline: No Education)										
Community Improved Sanitation Ratio	-0.077	-0.073	0.055	0.075	0.073	0.093	0.115	0.141*	0.072	0.095
	(0.110)	(0.111)	(0.066)	(0.066)	(0.070)	(0.071)	(0.083)	(0.085)	(0.064)	(0.064)

<u>Sanitation Status</u>										
Improved Sanitation, Shared	-0.080	-0.084	-0.079*	-0.074*	-0.098**	-0.095**	-0.075	-0.070	-0.076*	-0.071*
	(0.070)	(0.070)	(0.043)	(0.043)	(0.047)	(0.047)	(0.055)	(0.055)	(0.041)	(0.040)
Improved Sanitation, Private	-0.136**	-0.136**	-0.130***	-0.130***	-0.141***	-0.143***	-0.124**	-0.126**	-0.137***	-0.137***
	(0.066)	(0.067)	(0.044)	(0.044)	(0.047)	(0.047)	(0.055)	(0.055)	(0.042)	(0.042)
(baseline: Unimproved Sanitation)										
Log Number of Household Members	-0.167**	-0.167**	-0.045	-0.048	-0.030	-0.033	0.009	0.008	-0.033	-0.038
	(0.071)	(0.070)	(0.040)	(0.040)	(0.042)	(0.042)	(0.051)	(0.051)	(0.038)	(0.038)
Household in Urban Areas (=1)	-0.019	-0.022	0.027	0.022	0.044	0.039	0.045	0.039	0.034	0.028
	(0.060)	(0.060)	(0.038)	(0.038)	(0.041)	(0.041)	(0.048)	(0.048)	(0.037)	(0.037)
<u>Wealth Index (Excluding Floor Material)</u>										
Second Quintile	-0.036	-0.040	-0.089*	-0.086*	-0.088*	-0.085*	-0.122**	-0.116**	-0.055	-0.052
	(0.073)	(0.074)	(0.046)	(0.046)	(0.050)	(0.050)	(0.058)	(0.058)	(0.043)	(0.043)
Third Quintile	-0.096	-0.100	-0.036	-0.037	-0.029	-0.030	0.014	0.016	-0.027	-0.028
	(0.074)	(0.075)	(0.049)	(0.049)	(0.053)	(0.052)	(0.061)	(0.061)	(0.046)	(0.045)
Fourth Quintile	-0.070	-0.071	-0.047	-0.044	-0.029	-0.026	-0.042	-0.036	-0.037	-0.034
	(0.081)	(0.082)	(0.052)	(0.052)	(0.055)	(0.055)	(0.063)	(0.063)	(0.049)	(0.048)
Richest Quintile	0.074	0.072	-0.099	-0.095	-0.098	-0.092	-0.180**	-0.171**	-0.086	-0.080
	(0.104)	(0.105)	(0.065)	(0.064)	(0.070)	(0.069)	(0.078)	(0.077)	(0.061)	(0.060)
(baseline: First Quintile)										
HH's Floor is made of Earth, Dung (=1)	0.124	0.128*	0.094**	0.101**	0.104**	0.110**	0.076	0.084	0.080*	0.089**
	(0.078)	(0.077)	(0.047)	(0.047)	(0.051)	(0.051)	(0.056)	(0.057)	(0.044)	(0.044)
Functioning Handwashing Station (=1)	-0.048	-0.050	0.001	-0.001	0.020	0.019	0.030	0.029	0.006	0.003
	(0.049)	(0.049)	(0.031)	(0.031)	(0.034)	(0.034)	(0.041)	(0.040)	(0.030)	(0.030)
Unsafe Disposal of Child Feces (=1)	-0.089	-0.089	-0.036	-0.034	-0.022	-0.019	0.010	0.015	-0.012	-0.008
	(0.056)	(0.056)	(0.045)	(0.045)	(0.051)	(0.051)	(0.070)	(0.070)	(0.042)	(0.042)
Observations	372	372	1,185	1,185	1,069	1,069	813	813	1,292	1,292
Pseudo R2	0.177	0.178	0.101	0.102	0.088	0.089	0.094	0.095	0.085	0.088
Model VIF	-	-	-	-	-	-	-	-	4.14	4.17
Goodness of Fit Test	13.53*	17.48*	1.66	2.54	4.28	10.63	5.80	8.97	5.89	3.36

Standard Errors are Robust Clustered at Household Level

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

4.3 Robustness Checks

Coefficient Stability, E. Coli Contamination

Annex Table 8 examines the robustness of the E. coli contamination coefficients found in specifications (1.2d), (I.2e), (2.2d) and (2.2e) following suggestions from Oster (2014) building on Altonji et al (2005) who previously developed a method to investigate the coefficients' sensitivity to potential omitted variable bias. The estimates produced in Annex 6 are calculated using the Stata module *psacalc* introduced in Oster (2014). Since the bounding method can only be implemented on linear models, linear probability model equivalents for each of the probit specifications found in (1.2d), (I.2e), (2.2d) & (2.2e) are estimated. The marginal effect, standard error and model R-squared (in square brackets) for each of the specification are reported in column (5).

First, as suggested by Oster (2014) we hypothetically increase each model's R-squared in column (5) by a factor of 2.2 and examine the changes on each of the model's coefficient. In other words, we are asking what would become of our coefficients of interest – E. coli contamination – if we include unobserved variables that increase the current R-squared by a factor of 2.2. If the coefficients estimated in column (5) (and by extension, column (2)) do not change signs or become zero, they are then considered to be robust to omitted variable bias.

The results are shown in columns (7) to (10). For all the specifications, the changes in the coefficients are not modest and not of concern. For example, if E. coli contamination is specified to be high at the household point, it reduces marginally from 13 percentage points to 12 percentage points for the age group 24-60 months and from 6 percentage points to 5 percentage points for the age group 0-60 months when we increase the model R-squared by a factor of 2.2. Furthermore, if E. coli contamination is specified to be high at the source point, the coefficients actually move away from zero for both age groups. This further indicates that the unobserved variables for these two specifications do not confound the effects of E. coli contamination at the source level. These coefficients were computed under the assumption that the unobservables were as important as the controlled variables already included in the model.

Column (11) presents the bias adjusted coefficients for each specification under the assumption that the unoservables are 1.5 times as important as the observables - a situation that is unlikely given that we have extensively included variables that have been found to be important predictors of both stunting and water contamination. Still, the results do not pose any concern given that the adjusted coefficients under such assumption do not change sign or are reduced to zero, which further indicates that the coefficients are robust to omitted variable bias.

Second, as suggested by Altonji et al (2005), we compute the ratios of the impact of omitted variable(s) relative to the included controlled variables that are needed to fully explain away the effects of E. coli contamination on stunting for the specifications. The results in column (12) show that across all four specifications, it appears that the unobserved variables must be at least 5 times as important for the outcome than the included control variables to fully explain away the effects of E. coli contamination. This is a strong indication that it is very unlikely that this analysis has missed including important unobserved variable(s). The negative signs reported here simply imply that the unobservables would be negatively correlated to the controlled variables at the same time.

Coefficient Sensitivity to Selection Bias

One concern in moving from specification (1) to specification (2) is whether the observed changes in the significance among other controlled variables, if any, are in fact driven by the increased number of observations or by extension, the disproportionate selection to having missing household E. coli contamination measurement. This is important because any significant degree of selection could yield in a selection bias in the resulting estimations through specifications (1) and (2) earlier. Annex Tables 7 and 8 address this.

Annex Table 7 investigates the potential selection among the observations that have missing household E. coli contamination measurement. Households that practice appropriate water treatment are significantly more likely to have a missing household E. coli contamination measurement and household whose floor is made of earth is significantly less likely to have a missing household E. coli contamination measurement. This is concerning given the fact that both variables are found to be significantly correlated to stunting as discussed earlier. While urban households as well as households in the richest quintile are also more likely to have missing household E. coli contamination measurements, those are not of concern since both variables are not found to be correlated with incidences of stunting among children especially in the 0-60 month group.

Annex Table 8 further confirms this. Annex 8 reports the marginal effects of the covariates that are found to be significantly correlated to incidences of stunting in specifications (1.1e), (1.2e), (2.1e) and (2.2e) earlier and compares them to the corresponding marginal effects produced when the same regression is estimated for the sample of children who are missing household E. coli contamination measurements. It is observed that within the sample of children whose households are missing household E. coli contamination measurements, there were no significant correlation between stunting and appropriate water treatment. This may have changed the effect of water treatment on stunting from being significant to non-significant from specification (1) to (2). Still, as mentioned earlier, it should be noted that the portion of households that treat water is too small (4 percent) to make a conclusive statement on its impact on E. coli contamination and that the significance of water treatment in specification (1) might reflect a greater hygiene awareness in the household and not necessarily the effectiveness of the practice.

While there is also selection among households who have floors that are made of earth as shown in Annex Table 7, this seems not to have affected the coefficients in specifications (1) and (2). Other variables such as wealth index, breastfeeding, child's age, improved sanitation and mother's education were not affected by the missing values.

5. Discussion

We find that detection of E. coli in drinking water is significantly related to the prevalence of stunting in children under five in some cases. At the consumption point, high E. coli presence (10-200 cfu/100 ml) compared to low E. coli (0-10 cfu/100 ml) presence increases the probability of stunting by 6 percentage points. However, at the source point (before any treatment interventions), any presence of E. coli increases the probability by 5 percentage points. When comparing high E. coli presence (10-200 cfu/100 ml) to low E. coli presence (0-10 cfu/100 ml), the probability increases to 9 percentage points. Though the consumption-point is likely a better indicator of direct exposure through drinking water, the source-point may be a proxy indicator of E. coli contamination in the environment before any drinking water treatment interventions take place. For example, water sources that are highly contaminated with E. coli could be more likely in areas with high E. coli pollution in the environment. Microbial water quality was not significantly related to stunting among children in the 6-23 month age group. This could be related to specific caretaking and behaviors of young infants.

Furthermore, E. coli contamination in drinking water affects nutritional status of children in both poor and rich households. However, the effects are most obvious in poorer households most likely because they have fewer coping mechanisms such as access to health services, better food security, and other caretaking resources. In rural/poor areas, household characteristics (such as mother's education, hygiene, sanitation, income) play a greater role in high E. coli at consumption point. In rich/urban households, source contamination (piped) is the major determinant of E. coli at consumption point.

Safe water treatment also had significant and large effects on stunting prevalence; however, we surprisingly did not find that water treatment effectively reduced the presence of E. coli from source to consumption point. Nevertheless, these results should be interpreted with caution since safe water treatment practices are limited to only 4 percent of the sample. It could be likely that water treatment is a measurement of overall hygiene awareness and caretaking practices.

In addition to microbial water quality, we find other significant correlates of stunting, including breastfeeding, mother's education, wealth status, and sanitation access, and flooring material. These results are in line with the notion that the causes of undernutrition are multifaceted and additionally show potentially important pathways of fecal exposure including dirt floors and access to improved sanitation.

Overall, the analysis has a number limitations and the results should be interpreted with caution. First, this is a cross-sectional study, where data were collected at one point in time. Therefore, we cannot infer any causality between variables. Further, the reported levels of E. coli contamination in drinking water do not necessarily translate to a child's true exposure to feces. Stunting is most likely manifested through chronic exposure to fecal contaminants. Water quality varies by seasons, and we do not have information on levels of E. coli from other exposure pathways. Future studies should focus on more rigorous assessment of exposure and health and nutritional outcomes to better show causal inference.

6. Conclusion

Reducing fecal contamination of drinking water sources is a main objective of the WASH sector, yet traditional interventions have had mixed success in maintaining good water quality and thus improving health outcomes. A chief criticism of global WASH policy, including the "JMP Drinking

Water and Sanitation Ladders" was that indicators focused too strongly on types of infrastructure technology rather than the ability to improve disease environments. However, the new WASH targets under Sustainable Development Goal – 6 (SDG-6) moves from the provision of simple water and sanitation infrastructure to sustaining "safely managed" services that better target the primary pathways for transmission of waterborne diseases. For example, the "safely managed water" target aims to provide universal coverage of improved water sources that are 1) free of priority bacteria and contaminants; 2) located on household premises; and 3) regularly available without frequent interruptions of service.

Our results support a departure from simple infrastructure provision and the overall direction of the SDGs. Further, we provide new evidence for the synergies between WASH and nutrition. Programming and research should explore interventions that can sustainably limit fecal exposure through primary pathways such as drinking water.

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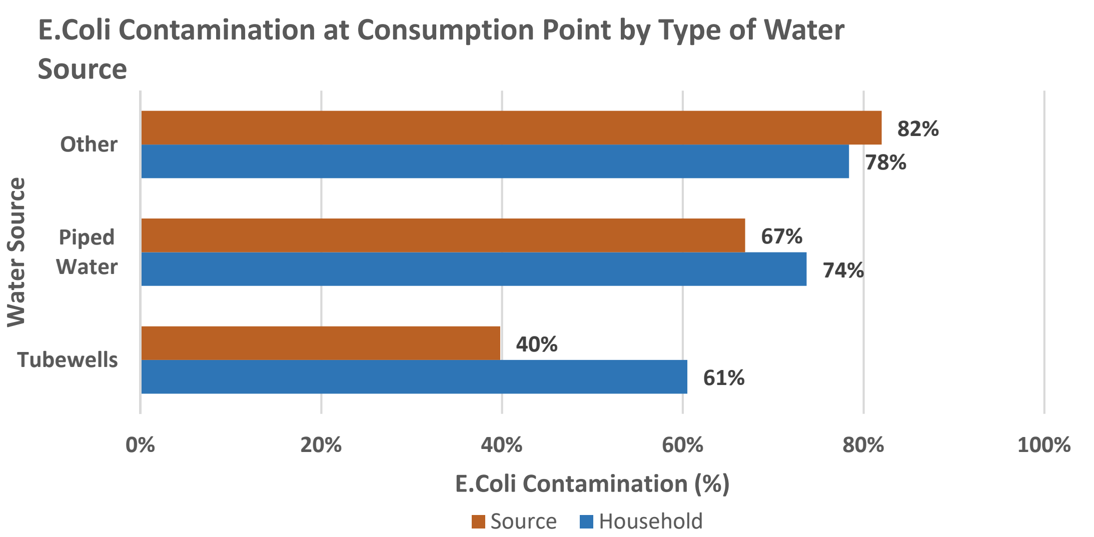
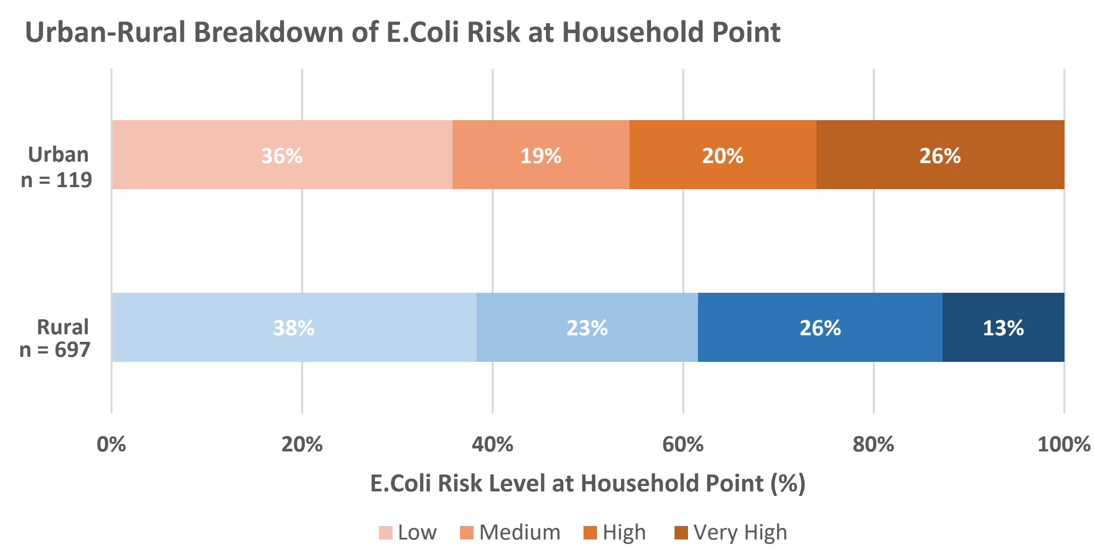
8. Annex

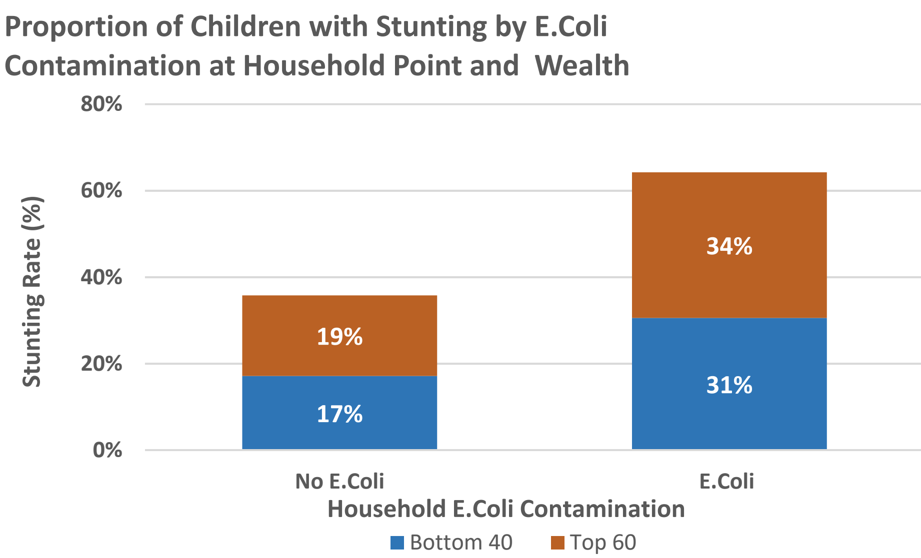
Annex Figure 1: Proportion of households with E.Coli contamination at source and household points, by type of drinking water source



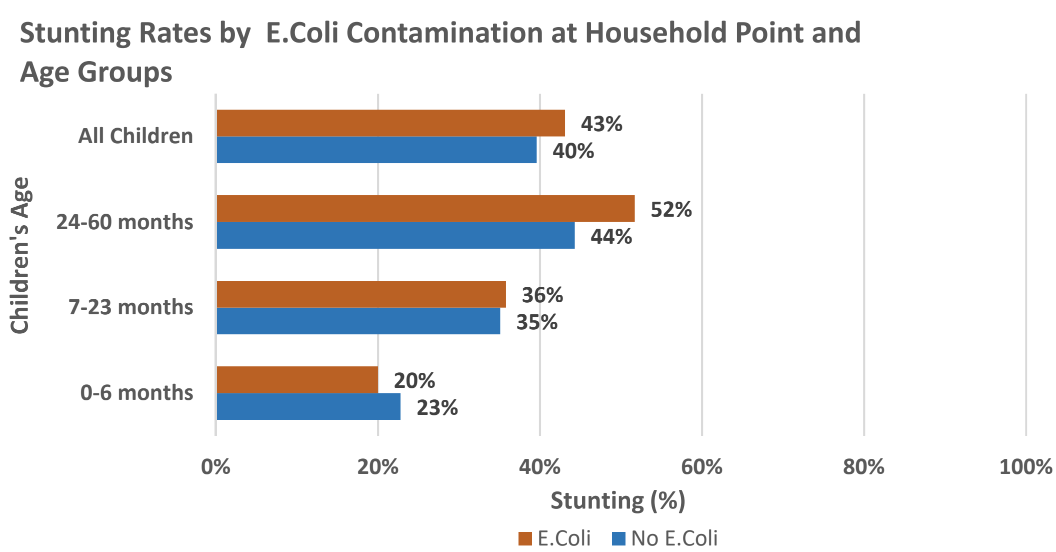
Annex Figure 2: Urban-rural breakdown of E. Coli risk level at household point



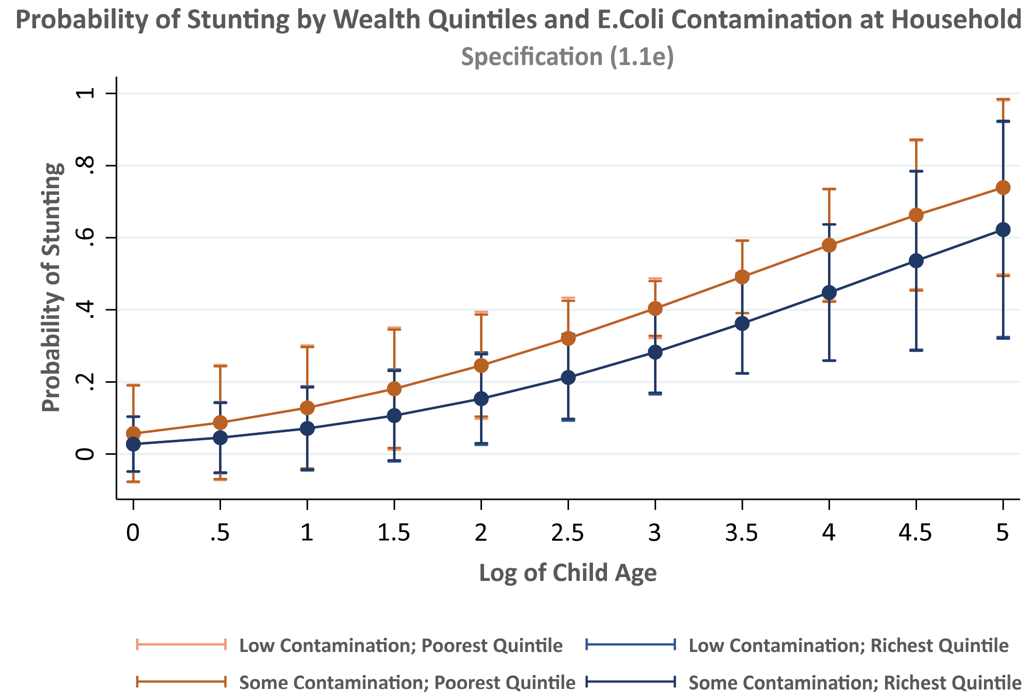
Annex Figure 3: Proportion of children with stunting by E. Coli contamination at household point and wealth

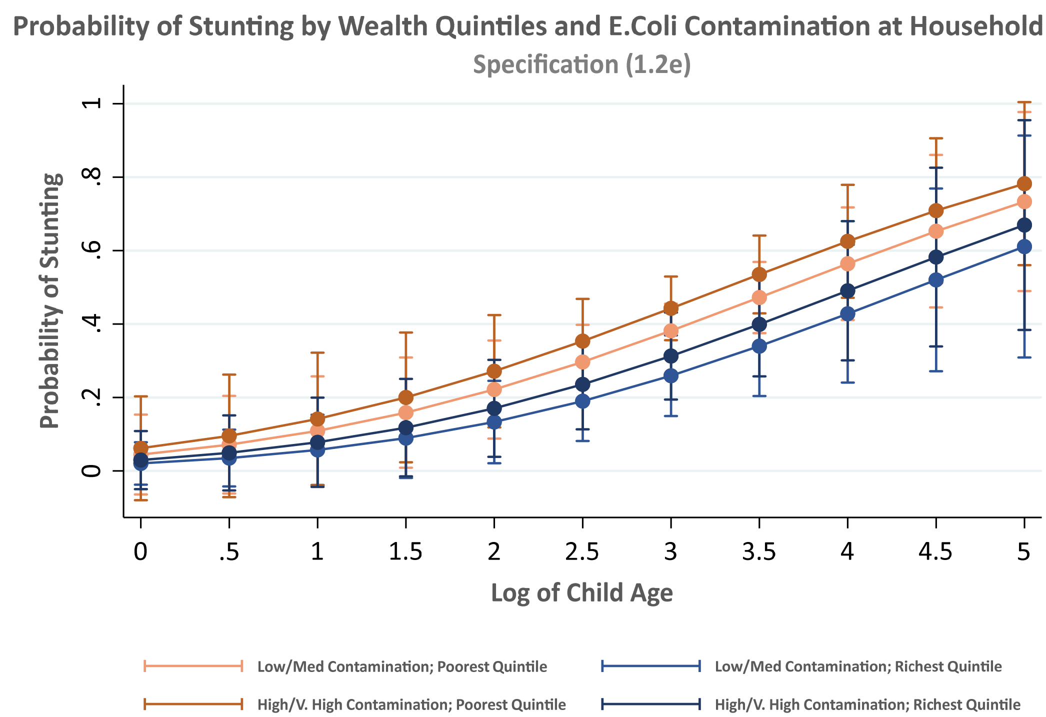


Annex Figure 4: Proportion of children with stunting by E. Coli contamination at household point and age group

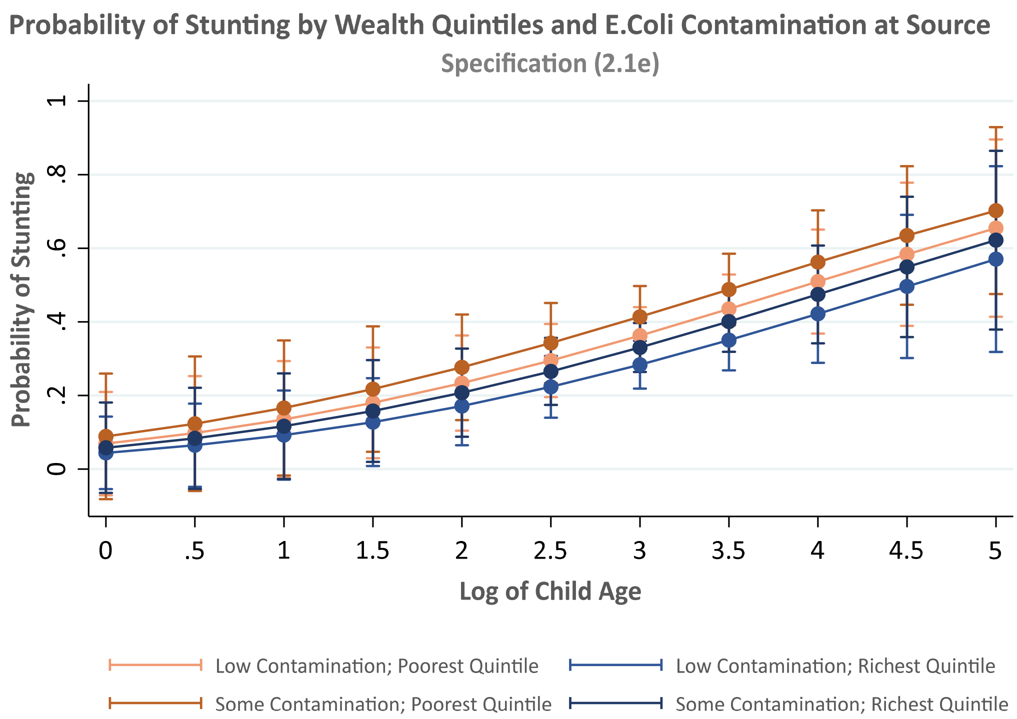


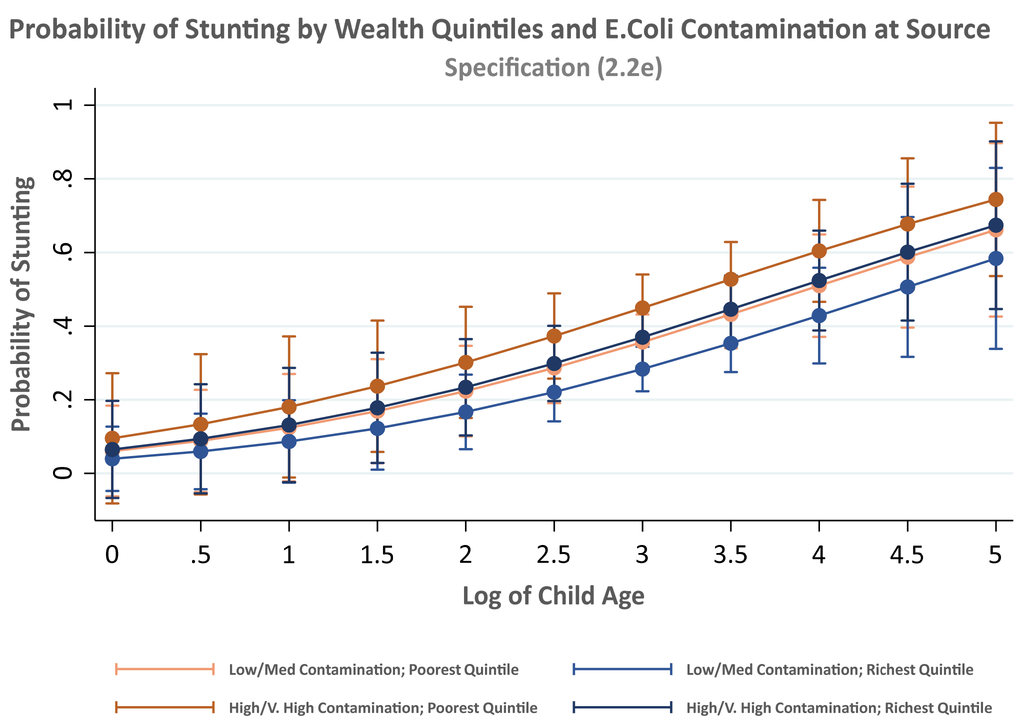
Annex 6: Predicted Probabilities of Stunting by Wealth Quintiles and E.Coli Contamination at Household Point; Specifications (1.1e) and (1.2e)





Annex 7: Predicted Probabilities of Stunting by Wealth Quintiles and E.Coli Contamination at Source; Specifications Point (2.1e) and (2.2e)





Annex 8: Coefficient Stability – Robustness to Omitted Variable Bias

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Treatment Variable	**Sample**	**Controlled Marginal Effect (Probit)**	**Uncontrolled Effect (LPM)**	**Controlled Effect (LPM)**	**95% CI**	**Adjusted Coefficient 2.2*(R2)**	**Identified Set**	**Exclude Zero**	**Within 95% CI?**	**Bias adjusted coefficients (Delta = 1.5)**	**Delta**
High E.Coli Contamination at HH Point	24-60 months	0.125***	0.133	0.127***	[0.036,0.219]	0.117	[0.117,**0.127**]	Yes	Yes	0.111	4.796
	[n = 508]	(0.045)	(0.455)	(0.046)							
		[0.090]	[0.017]	[0.113]							
	All children	0.062*	0.066*	0.059*	[-0.011,0.129]	0.050	[0.050,**0.059**]	Yes	Yes	0.045	4.670
	[n= 816]	(0.035)	(0.036)	(0.036)							
		[0.084]	[0.004]	[0.102]							
High E.Coli Contamination at Source Point	24-60 months	0.099**	0.063	0.096**	[0.005,0.189]	0.191	[**0.094,**0.191]	Yes	No	0.343	-6.216
	[n = 813]	(0.047)	(0.043)	(0.047)							
		[0.095]	[0.003]	[0.122]							
	All children	0.094***	0.059*	0.091***	[0.024,0.157]	0.164	[**0.091**,0.164]	Yes	No	0.243	-4.743
	[n= 1,292]	(0.034)	(0.032)	(0.034)							
		[0.088]	[0.003]	[0.109]							

Annex 9: Selection to missing Household E. coli measurement

Dependent Variable: Missing Household E. coli measurement	
HH practices appropriate water treatment (=1)	0.128**
	(0.051)
Log of Child Age	0.029
	(0.047)
Log of Child Age Squared	-0.003
	(0.009)
Female Child (=1)	0.021
	(0.023)
Child was ever breastfed (=1)	-0.084
	(0.072)
Mother's Education	
Mother Completed Primary Education	-0.030
	(0.028)
Mother Completed Secondary Education	-0.030
	(0.041)
(baseline: No education)	
Improved Sanitation Ratio within Cluster	-0.012
	(0.067)
Sanitation Status	
Improved Sanitation, Shared	0.013
	(0.036)
Improved Sanitation, Private	0.015
	(0.038)
(baseline: Unimproved Sanitation)	
Log Household Size	-0.020
	(0.036)
Household in Urban Areas (=1)	0.258***
	(0.029)
Wealth Index (Excluding Floor Material)	
Second Quintile	0.080*
	(0.046)
Third Quintile	0.037
	(0.047)
Fourth Quintile	0.073
	(0.052)
Richest Quintile	0.151**
	(0.068)
(baseline: First Quintile)	
Household's Floor is made of Earth, Dung (=1)	-0.153***
	(0.057)
Functioning Handwashing Station (=1)	-0.018
	(0.030)
Unsafe Disposal of Child Feces (=1)	-0.051
	(0.042)
Observations	1,292
Pseudo R2	0.304

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

Annex 10: Coefficient Sensitivity to Specifications

Dependent Variable: Stunting	(1.1e)	(1.2e)	(2.1e)	(2.2e)	Missing Observations
Appropriate water treatment (=1)	-0.219***	-0.217***	0.010	0.000	0.061
	(0.079)	(0.079)	(0.051)	(0.051)	(0.053)
Log of Child Age	0.174**	0.182**	0.144**	0.151**	0.128
	(0.082)	(0.082)	(0.068)	(0.067)	(0.123)
Child was ever breastfed (=1)	-0.281**	-0.284**	-0.214***	-0.208**	-0.091
	(0.112)	(0.111)	(0.082)	(0.083)	(0.111)
Mother's Education					
Primary Education	-0.039	-0.037	-0.062*	-0.064**	-0.150***
	(0.038)	(0.038)	(0.032)	(0.032)	(0.055)
Secondary Education	-0.135*	-0.132*	-0.255***	-0.253***	-0.391***
	(0.070)	(0.070)	(0.044)	(0.044)	(0.060)
(baseline: No Education)					
Sanitation Status					
Improved Sanitation, Shared	-0.079	-0.080	-0.076*	-0.071*	-0.123*
	(0.050)	(0.050)	(0.041)	(0.040)	(0.068)
Improved Sanitation, Private	-0.112**	-0.109**	-0.137***	-0.137***	-0.202***
	(0.049)	(0.049)	(0.042)	(0.042)	(0.074)
(baseline: Unimproved Sanitation)					
Wealth Index (Excluding Floor Material)					
Second Quintile	-0.011	-0.014	-0.055	-0.052	-0.276***
	(0.050)	(0.050)	(0.043)	(0.043)	(0.079)
Third Quintile	0.009	0.006	-0.027	-0.028	-0.266***
	(0.052)	(0.052)	(0.046)	(0.045)	(0.084)
Fourth Quintile	-0.034	-0.037	-0.037	-0.034	-0.130
	(0.058)	(0.058)	(0.049)	(0.048)	(0.089)
Richest Quintile	-0.129	-0.133*	-0.086	-0.080	-0.165*
	(0.079)	(0.079)	(0.061)	(0.060)	(0.098)
(baseline: First Quintile)					
Household's Floor is made of Earth, Dung (=1)	0.124**	0.122**	0.080*	0.089**	0.046
	(0.056)	(0.056)	(0.044)	(0.044)	(0.067)
Observations	816	816	1,292	1,292	476
Pseudo R2	0.081	0.084	0.085	0.088	0.150

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