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Infrastructure Services and Early Childhood Development in Latin America and the Caribbean: Water, Sanitation, and Garbage Collection*

Lenin H. Balza Jorge Cuartas Nicolas Gomez-Parra Tomás Serebrisky

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Abstract

Access to essential infrastructure services such as water, sanitation, and garbage collection can considerably affect children's environment and may play a significant role in shaping early childhood developmental and health outcomes. Using data from the Multiple Indicator Cluster Surveys (MICS) and the Demographic and Health Surveys (DHS) for 18 countries in Latin America and the Caribbean (LAC), we show a significant positive association between access to water and sanitation and early childhood development, as well as reduced instances of stunting. In addition, we identify a negative association between access to improved garbage collection services and the rates of stunting and underweight among children under five. Our findings are robust after using alternative measures for access and controlling for individual, maternal, and household factors, alongside considerations of household wealth and caregiver's stimulation activities. Similarly, the economic relevance of the relationship is highlighted by the substantial gap relative to the size of the vulnerable groups, persisting even after adjusting for confounding variables. Our results also suggest that households may be able to lessen the potential impact of pollutants through mitigation measures such as treating water to make it safe for consumption, using handwashing cleansers, and storing household trash in lidded containers. The current findings underscore the importance of investing in basic infrastructure services as a critical component of comprehensive strategies to enhance early childhood development and health in low- and middle-income countries. We emphasize the importance of considering the quality and type of infrastructure services alongside their availability. Future research should incorporate more complete and detailed data to improve understanding of the causal relationship between water, sanitation, and garbage collection and early childhood development, as well as the mechanisms underlying the observed associations.

JEL codes: H41, I15, J13, Q53.
Keywords: Early childhood development, Water and sanitation access, Waste management infrastructure, Low- and middle-income countries, Mitigation strategies.

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1 Introduction

More than 250 million children younger than five living in low- and middle-income countries are at risk of not reaching their developmental potential due to adversity and lack of nurturing care (i.e., good health, adequate nutrition, early learning opportunities, safety and security, and responsive caregiving) (Black et al., 2017; Lu et al., 2020; McCoy et al., 2022). This is concerning as early childhood development (ECD) strongly predicts educational trajectories, future health, and economic and social well-being throughout an individual's lifespan (Black et al., 2017; Heckman, 2006). Indeed, brain development and the acquisition of foundational skills are highly sensitive to environmental input early in life (Sheridan and Nelson, 2009). Early experiences – positive or negative – thus have enormous long-term consequences for individual and societal welfare (Black et al., 2017; Cunha and Heckman, 2007; Knudsen et al., 2006).

Extensive evidence has shown that ECD is particularly sensitive to various nutritional, health, and psychosocial factors, including the home environment, access to learning opportunities, and exposure to violence (Attanasio et al., 2020; Cuartas, 2021, 2022; Cuartas et al., 2020, 2021; Jeong et al., 2017; McCoy et al., 2016; Salhi et al., 2021; Wolf and McCoy, 2019). While there is extensive literature within the field of public health assessing the impact of the physical environment (in particular, the relation between water, sanitation, and hygiene with nutrition) on ECD (Danaei et al., 2016; Sania et al., 2019), the bulk of this research has focused on stunting as an outcome and not child development specifically. Stunting has often been used as a proxy for child development, though recent evidence suggests that it is an inadequate proxy (Sania et al., 2019; Perumal et al., 2018). In this context, relatively little effort has been made to integrate developmental science with environmental health (Trentacosta et al., 2016). This work is nonetheless important as climate change, industrialization and poor basic infrastructure access have increased several specific environmental risks that may be particularly influential early in life. These are especially pronounced in low- and middle-income countries (LMICs), where millions of children lack access to clean water sources, improved sanitation, and adequate waste management (McCoy et al., 2022). Indeed, poor water, sanitation, and garbage disposal represent particular risks for children as they consume more water, food, and air relative to their body weight than adults, while their metabolism is less capable of coping with contaminants and their brain architecture is more sensitive to pollutants (Trentacosta et al., 2016).

Inadequate or polluted water, poor sanitation, and garbage disposal can affect ECD through at least three mechanisms. First, poor hygiene, polluted water, and inadequate sanitation and waste management can lead to biological changes affecting the metabolic system with downstream consequences on children's weight and nutrition (Heindel and Schug, 2014). Second, ingesting pollutants and microbial contaminants can disrupt the normal development and pruning of synapses in key areas of the brain (e.g., the prefrontal cortex), impacting brain structure and function and consequently cognition, social-emotional development, and behavior (Walker et al., 2011).

Handwashing and combined water, sanitation, handwashing, and nutrition interventions might improve child motor development (Stewart et al., 2018).[1] Finally, pollution and the lack of clean water, adequate sanitation, and waste management sources can be a major source of stress for families, which can affect their behavior and the type and quality of care that they provide to children (Bornstein et al., 2015). In sum, evidence supports hypothesizing that inadequate water, sanitation, and garbage disposal can impact childhood health and development, with downstream consequences for lifelong individual and societal outcomes.

Consistent with these findings, investing in improved water, sanitation, and waste management infrastructure can be a key strategy for promoting positive health and developmental outcomes early in life (Acuff and Kaffine, 2013). Environmental problems such as odors and air and water pollution are caused by poor waste management and may be exacerbated as the climate crisis deepens (Janmaimool, 2017; Vaccari et al., 2019). Poor waste management increases the risk of severe diseases, like dysentery and jaundice (Rathnamala et al., 2021). However, budget and financial constraints, socioeconomic factors, and negative attitudes towards waste management make it difficult to invest in waste management infrastructure in LMICs (Al-Khatib et al., 2016; Vaccari et al., 2019; Şchiopu et al., 2007; Manga et al., 2019; Wang et al., 2018; Keser et al., 2012; Rathnamala et al., 2021). Furthermore, these policies are hard to target as responsibility for the generation of solid waste is shared across industry, households, and government (Abdulredha et al., 2018; Yamamoto and Kinnaman, 2022; Hamilton et al., 2013; Agyei-Mensah and Oteng-Ababio, 2012).

Addressing environmental infrastructure gaps is crucial for enhancing ECD in Latin America and the Caribbean (LAC) region (Günther and Lahoti, 2021; Schady, 2015; Korc and Hauchman, 2021). While LAC has made significant strides in enhancing access to clean water, sanitation remains a pressing concern, especially in rural areas (Alvarez, 2019; Jeuland et al., 2013). Similarly, the region has made significant progress in waste management, with an average solid waste collection rate higher than the global average. Yet, challenges persist in achieving consistent and equitable waste management services across different areas. The region grapples with variations in service quality and frequency, as well as a low level of municipal planning in solid waste management (Grau et al., 2015). These infrastructural challenges not only pose immediate health risks, but also could have long-term implications on cognitive and physical development. The region's unique socio-economic dynamics, coupled with its diverse topography and climate, further accentuate these challenges. Vulnerable areas often are characterized by limited state presence and investment. Families in these locations often lack the resources or knowledge to adopt mitigative measures, exacerbating the health and developmental risks for children. In stark contrast, urban centers, despite better infrastructure, grapple with challenges posed by rapid urbanization and population density, often leading to overburdened facilities (Sparkman and Sturzenegger, 2016).

[1] However, modestly improved sanitation practices do not necessarily enhance child health outcomes, underscoring the complexity of achieving health benefits through interventions (Patil et al., 2014).

This paper aims to provide evidence on the potential positive effects of improved water, sanitation, and waste management infrastructure on ECD in LAC. Our findings can help provide important evidence to support targeted investments that benefit the environment, local populations, and young children. In particular, we seek to address the following research questions. First, does access to improved water, sanitation, and waste management impact young children's health and development? Second, to what extent do the links between access to improved water, sanitation, and waste disposal vary across countries, when controlling for individual and household characteristics, such as maternal education, wealth, health status, stimulation behaviors, and the availability of certain assets and goods (e.g., hand cleansers, refrigerators, access to bottled water, and lidded containers)?

We use two main data sources to examine these questions. First, we employ UNICEF's Multiple Indicators Cluster Surveys (MICS) from Belize, Costa Rica, Cuba, El Salvador, Guyana, Honduras, Jamaica, Panama, Paraguay, Dominican Republic, Saint Lucia, Suriname, Trinidad and Tobago, and Uruguay, which include information on access to improved water and sanitation and on child health, and development. We also use the Demographic and Health Surveys (DHS) from Bolivia, Colombia, Dominican Republic, Guyana, Nicaragua, and Peru, which provide information on child health and nutrition, and household waste management. We conducted a thorough multivariate statistical analysis, utilizing linear probability models to explore the correlations between infrastructure access and developmental and health outcomes, while taking advantage of the differences in infrastructure between countries. To mitigate potential endogeneity concerns, especially the confounding effect of household wealth, we incorporated control variables in our models. We further validated our findings by incorporating the stimulation index, which is a widely recognized predictor of ECD. Additionally, we used categorical variables to analyze access to water and sanitation, and applied a propensity score matching approach to the data. Despite these variations, our results remain consistent.

The findings of our paper significantly emphasize the core associations between access to improved water, sanitation, waste management, and the developmental and health outcomes in young children. Children in households with better access to these facilities are more likely to be developmentally on track and less prone to stunting. Notable variability in these associations across countries calls for further exploration of other environmental factors affecting children's health and development. Additionally, improved garbage collection services are linked with reduced rates of stunting and underweight among children under five. We also explore mitigating behaviors that households can adopt amid inadequate access to clean water and sanitation facilities. Our findings advocate for promoting household water treatment practices and using lidded containers for waste as provisional solutions towards universal access to water and sanitation. Examining predicted rates of stunting and underweight among children who have experienced recent illness episodes highlights potential underlying mechanisms affecting child development, emphasizing the health channel.

Our findings resonate with and extend the existing literature, marking an advancement in comprehending the infrastructure-health nexus. Gao et al. (2021), using a sample of more than 88,000 children aged 26-59 months in 20 countries in Sub-Saharan Africa, found a positive association between a composite index of improved housing (including access to better water sources and sanitation facilities) and early childhood development. In addition, Schady (2015) highlights the disparities in water and sanitation infrastructure access in LAC. It outlines the public health implications of inadequate facilities, linking microbial ingestion to health adversities such as diarrhea, a significant factor in under-five mortality in developing regions. While existing evidence substantiates the relationship between improved infrastructure and reduced child mortality, a further need exists to conduct new evaluations to assess the impact on child morbidity, nutritional status, and development. There is a lack of well-identified evidence within the LAC region, advocating for comprehensive evaluations to understand the multi-dimensional benefits of improved water and sanitation access for children over time (Schady, 2015; Günther and Lahoti, 2021). To the best of our knowledge, our paper is the first to explore the independent relationships between access to water, sanitation, and waste management, and their impact on ECD and health outcomes in LAC using between-country heterogeneity. We particularly emphasize the inclusion of waste management as part of access to basic infrastructure. This disaggregated information is critical for understanding specific early childhood developmental and health outcomes that may be impacted by physical environment features and for informing future investments in infrastructure to promote positive developmental trajectories from a young age.

The remainder of this paper is organized as follows. In section 2 we summarize the methodology, including the measurement tools and estimation method. Section 3 describes the data used to assess the links between access to improved water sources, sanitation, and garbage disposal and early childhood developmental and health outcomes. Section 4 summarizes the results. We conclude with a general discussion and implications for future research and practice.

2 Methodology: Measurement and estimation

In this paper, we consider two main outcome variables: (1) child development and (2) child health/nutrition. We use the early childhood development index (ECDI) (Loizillon et al., 2017) as a measure of young children's development. The ECDI is a 10-item parent-reported scale that aims to assess the basic developmental skills of children aged 3-5 years in four developmental domains: social-emotional, literacy-numeracy, approaches to learning, and physical. The social-emotional domain consists of three items asking whether the child (1) gets along well with other children, (2) kicks, bites, or hits other children or adults, and (3) is easily distracted. Two items cover literacy-numeracy: (1) whether the child can identify or name at least ten letters of the alphabet, and (2) whether the child can read at least four simple words. Approaches to learning is measured by two items: (1) whether the child follows simple instructions and (2) whether, when given something to

do, the child is able to do it independently. Finally, the physical domain includes the following two items: (1) whether the child can pick up a small object with two fingers and (2) whether the child is often too ill to play.

The ECDI is one of the most robust measures of child development used globally and, specifically, across LAC. It serves as an important policy indicator, as the lack of comparable child development indicators has constituted a barrier to monitoring progress, ensuring accountability, and investing effectively in ECD (Engle et al., 2007). The ECDI is highly policy-relevant as it is an interim measure for reporting on Sustainable Development Goal indicator 4.2.1 (UNICEF et al., 2020). This indicator measures the percentage of children who are developmentally on track in health, learning, and psychosocial well-being, classified by gender (United Nations, 2015). Following UNICEF guidelines (Loizillon et al., 2017) and prior research (Cuartas et al., 2021; Lu et al., 2020), we consider a child to be "on track" if they meet the criteria for being developmentally on track in at least three of the four domains of the ECDI. The domains include literacy-numeracy, physical, social-emotional, and learning. Each domain has specific criteria that must be met for the child to be considered on track in that domain. For instance, a child is on track in the literacy-numeracy domain if they can identify or name at least ten letters of the alphabet or can read at least four simple words. Similarly, other domains have their respective criteria for assessing if a child is developmentally on track. Figure 1 shows the percentage of children with ECDI on track for all MICS rounds in LAC.[2]

To measure child health and nutrition, we use information on children's anthropometry, using Seca digital scales to measure weight and Shorr measuring boards for height. We follow World Health Organization standards (WHO, 2009) and classify children aged 0-5 years with a height-for-age z-score (HAZ) lower than 2 standard deviations below the median score as stunted, and those with a weight-for-height z-score (WHZ) lower than 2 standard deviations below the median as underweight.[3] Figure 2 shows how these indicators have progressed in LAC over the past two decades.

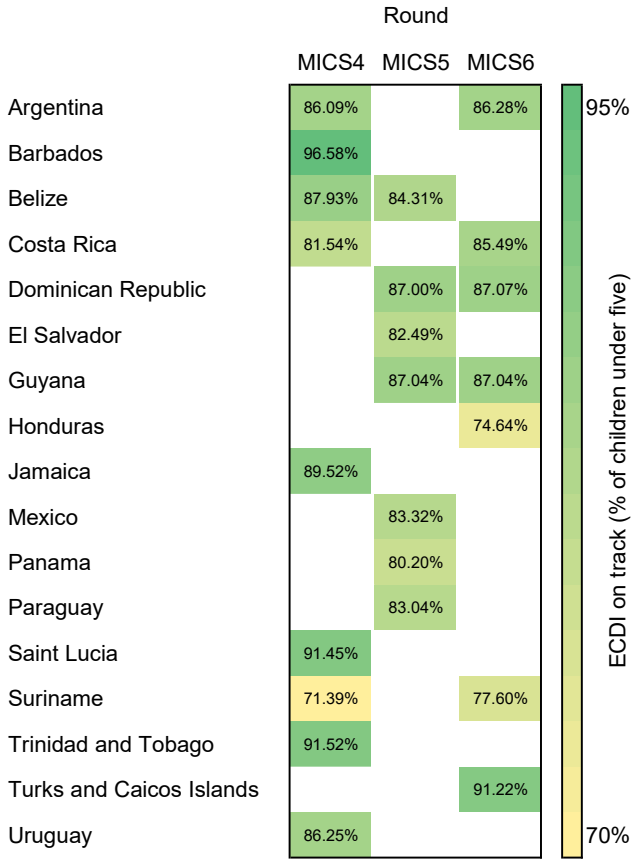
Our predictor of interest is access to adequate water, sanitation, and garbage disposal in the dwelling. Children are considered to have access to adequate water if their main source of drinking water comes from a protected and treated source. This includes water piped directly into the dwelling, yard, or plot, public taps or standpipes, tubewells or boreholes, protected wells, protected springs, and treated water from public water treatment plants. Additionally, packaged bottled water and water from water kiosks also are considered adequate sources.[4] Tanker-trucks, carts with small tanks or drums, and other packaged water like sachet water are also considered reliable

[2]Many other global population measures of ECD exist, such as the Assessment of Early Childhood Development (AIM-ECD), the Model of Early Learning and Development (MODEL), the Caregiver-Reported Early Development Instruments (CREDI), and the Global Scale for Early Development (GSED). In this paper, we focus on ECDI only.

[3]As mentioned previously, nutritional factors such as stunting and underweight are seen as inputs to child development, not outcomes of child development itself (Sania et al., 2019; Danaei et al., 2016). However, they are considered outcomes in this analysis to comprehensively assess the impacts on child health and development.

[4]In the case of Panama, specific water treatment plant options have been recoded to be included under piped water, acknowledging them as treated water options.

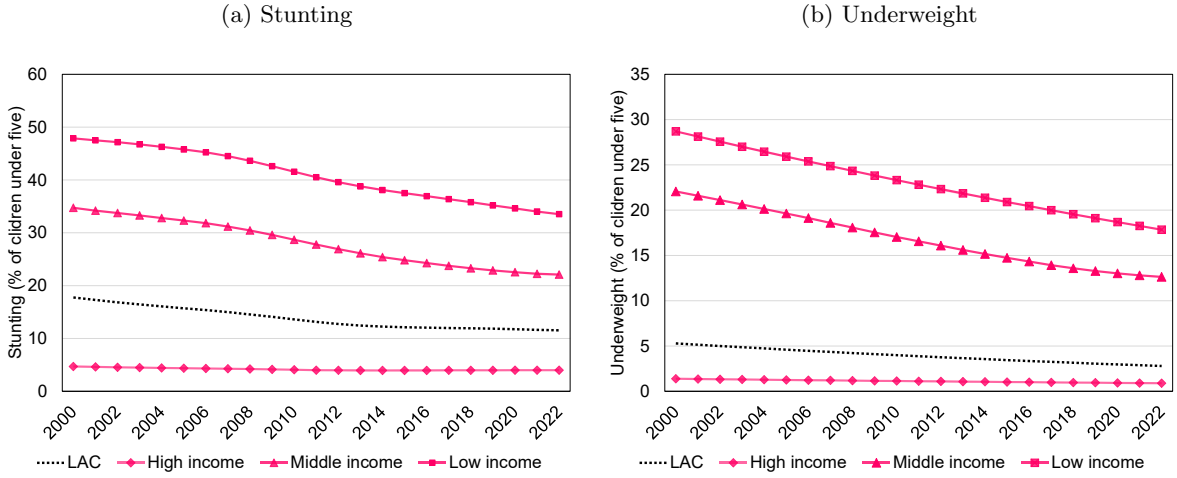
Figure 1: Percentage of children with early childhood development index on track in LAC



Notes: This heatmap visualizes the percentage of children with early childhood development index (ECDI) on track across various countries in Latin America and the Caribbean (LAC), as captured in different rounds of the Multiple Indicator Cluster Surveys (MICS). The rounds 4, 5, and 6 correspond to three different periods: 2009-2012, 2012-2016, and 2017-2019, respectively. The colors represent the percentage of children on track, with darker shades indicating higher percentages. Each column corresponds to a different MICS round, while each row represents a specific country. The percentages presented are weighted statistics calculated at the child level to ensure national representativeness. These statistics may vary from the ones in Sections 3 and 4 as they do not incorporate such weighting and final samples differ for data analysis purposes.

sources of safe drinking water (WHO, 2019). On the other hand, sources such as unprotected wells and springs, rainwater collection, surface water from rivers, dams, and lakes, and other unspecified or unknown sources are categorized as inadequate. Regarding sanitation, children are considered to have access to adequate sanitation if their dwellings have private sanitation facilities such as flush or pour-flush toilets connected to a piped sewer system or septic tank, various types of pit latrines (including ventilated improved pit latrines and those with slabs), and composting toilets. Inadequate sanitation includes the use of shared or public-use facilities, flush or pour-flush toilets that dispose waste elsewhere, pit latrines without slabs or open pits, hanging latrines, and practices of open defecation. Last, we also add garbage collection, including details about household storage practices and quality of service. In general, non-collected garbage disposal includes open dumping or burning of waste.

Figure 2: Trends in stunting and underweight: LAC and global income groups



Notes: This figure illustrates the progression of stunting and underweight prevalence among children under five years old in the Latin America and Caribbean (LAC) region against global income groups, as defined by the World Bank. Panel (a) delineates the percentage of children exhibiting stunting, characterized by a height for age more than two standard deviations below the median of the international reference population. Simultaneously, panel (b) portrays the prevalence of underweight children, defined by a weight for age significantly below the international standard. The figure highlights existing nutritional disparities and trends over time. The data for this visualization are sourced from the World Development Indicators.

Finally, the data include demographic, socioeconomic, and contextual information that we use as covariates in our models. This includes information on children's age and sex, mothers' education, household composition, and wealth quintiles, as measured by a principal component index of basic dwelling characteristics and asset ownership.[5] In addition, we use a stimulation index as a control variable, which summarizes caregivers' engagement in six different play/learning activities with children, following prior research showing associations between these activities and young children's cognitive, social-emotional, and motor development (Cuartas et al., 2023).[6] The index is a categorical variable ranging from 0 to 6, based on whether anyone in the household engaged in these activities with the child in the last three days. It includes stimulation from any caregiver, not just the mother, thus capturing a broader range of interactions. Specifically, the MICS asks whether anyone in the household engaged in the activities with the child, and the responses are recoded so that a higher score indicates greater stimulation. For instance, there is a reading component indicating whether anyone in the household read books to the child in the last three days. Similar items include telling stories, singing songs, taking the child outside, playing with the child, and spending time naming, counting, or drawing things.

[5]We do not directly calculate the wealth index as it is already accessible in both the MICS and DHS data sets.

[6]The inclusion of a stimulation covariate is informed by evidence that caregivers' stimulation significantly impacts early child development. See Cuartas et al. (2023) and Jeong et al. (2016).

In our empirical analysis, we employ a linear probability model to investigate the relationship between access to basic infrastructure services and child health and developmental outcomes. The model is specified as follows:

$$y_{ict} = \beta_0 + \beta_1 \cdot \text{access}_{ict} + \gamma_{ctr} + \mathbf{X}_{ict}\beta + \epsilon_{ict}$$

where y_{ict} represents the developmental and health outcome of interest for child i in country c and year t. These outcomes encompass binary indicators for ECDI, stunting, and underweight status. access_{ict} is a binary variable capturing access to essential infrastructure, including water, sanitation, and garbage collection, for child i in country c and year t. γ_{ctr} denotes country-year-region fixed effects, controlling for unobserved heterogeneity across regions within countries over time. $\mathbf{X}_{ict}$ is a vector of covariates incorporating individual characteristics of the child, maternal characteristics, and household characteristics. β represents the vector of coefficients associated with the covariates and ϵ_{ict} is the error term. We cluster the standard errors at the country-year level to account for within-group correlation, recognizing that observations within the same survey may not be independent and thus could exhibit correlation in their unobserved influences on the health and developmental outcomes.

This model allows us to estimate the average correlation of having access to infrastructure on children's developmental and health outcomes, accounting for observed characteristics and fixed effects. We include additional controls in various model specifications to mitigate potential endogeneity issues and to provide robustness checks. Specifically, we control for household wealth and maternal education, acknowledging their significant roles in child development and health.

3 Data

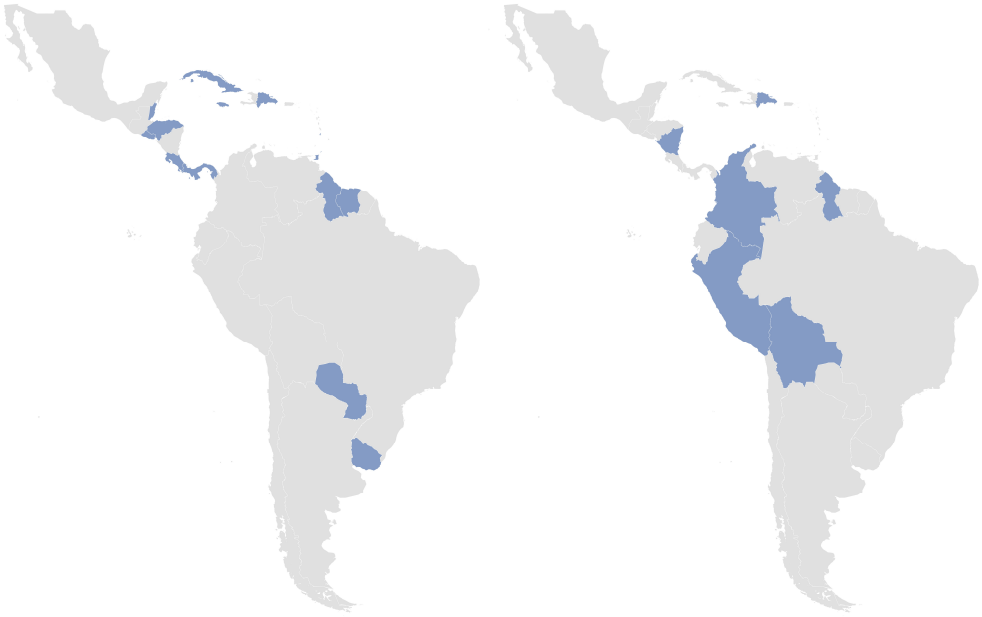
To assess the links between crucial basic services such as water, sanitation, and garbage collection and ECD and child health, we employ data from the Multiple Indicators Cluster Survey (MICS) and the Demographic and Health Surveys (DHS). In total, we use data for 18 countries and 36 surveys for the period 1991-2019 –see Figure 3 for the geographical coverage of our analyses and Appendix Table A1 for sample sizes in each country and outcome.

The MICS is a household survey designed to provide comparable information on the well-being of children and women, primarily in low- and middle-income countries. All MICS surveys follow a two-stage cluster sampling protocol, based on probabilistic, random samples of households with children under the age of five from enumeration areas drawn from national censuses. These surveys include questionnaires about the household (e.g., dwelling characteristics and access to goods and services), women (e.g., background characteristics and maternal health), and children under five (e.g., development, and learning environment).

Figure 3: Countries available in MICS and DHS for our analysis

(a) MICS

(b) DHS



Notes: This figure presents the total geographic coverage of the surveys used in our analyses. In Figure 3a, we show the 14 countries (22 surveys) we used from The Multiple Indicators Cluster Survey (MICS): Belize, Costa Rica, Cuba, El Salvador, Guyana, Honduras, Jamaica, Panama, Paraguay, Dominican Republic, Saint Lucia, Suriname, Trinidad and Tobago, and Uruguay. In Figure 3b, we present the six countries (14 surveys) used from the Demographic and Health Surveys (DHS): Bolivia, Colombia, Dominican Republic, Guyana, Nicaragua, and Peru. Statistics for these samples are available in Appendix Tables A3, A4, and A5.

We use MICS data from a total of 22 surveys in 14 countries, although we use different samples to study different outcomes.[7] Appendix Table A3 presents descriptive statistics that offer a general overview of the ECDI as well as data on access to improved water sources and sanitation infrastructure for a sample of 19 surveys with almost 38,000 child-mother dyads. We find that, on average, 83% of children are on track in overall development, with 28% on track in literacy/numeracy, 99% in physical development, 82% in socio-emotional development, and 97% in learning.[8] Access to sanitation and water infrastructure services is 91% and 90%, respectively. The average child in the ECDI sample is 48 months old and belongs to a household of five to six members, with one to two children under the age of five. The gender distribution in the sample is relatively balanced, with female children comprising 49% of the sample.

The sample used to analyze health outcomes consists of around 67,000 child-mother dyads in 17 surveys; additional information on the sample is provided in Appendix Table A4. The findings indicate a 12% incidence of stunting and 3% of underweight among children under the age of five with 87% access to water and 90% access to sanitation services. These statistics suggest that

[7] This approach is adopted due to the substantial variation in the number of observations when comparing developmental outcomes with health outcomes across the datasets.

[8] Please note that all statistics in Sections 3 and beyond are unweighted.

although many children in the study region are developing as expected according to the ECDI, significant challenges remain in terms of critical developmental skills, health outcomes, and access to infrastructure services.

Figure 4 shows access to water and sanitation services by country using the ECDI sample.[9] These figures suggest significant disparities in access to these infrastructure services persist for households with children under five. While MICS data indicate high overall level of access to these services in LAC, a substantial number of households with children under five still do not have access. Notably, Guyana, Panama, Paraguay, and Suriname lag far behind the region in terms of access to water and sanitation, while Uruguay and Jamaica perform significantly better. This variation in access between countries is crucial for our paper as it provides sufficient variance of infrastructure access for our analyses. Thus, the use of multiple surveys allows us to capture the full range of variation in access to water and sanitation services, despite the high overall rates of access in the region.

In addition, the data in Figure 4 also reveal interesting patterns in access to water and sanitation services in each country. For instance, in Cuba, while access to water is almost universal, about 10% of households with children under five still lack access to adequate sanitation services. Access to sanitation services is likewise significantly lower than access to water services in Panama. These nuances in access to different types of infrastructure services are crucial to consider when designing policies and interventions to improve the well-being of children and women in the region. Although access to water and sanitation services is highly correlated, this does not necessarily mean these services are always connected. In some cases, households may have access to clean water but not adequate sanitation facilities, and vice versa. On average, 3% of children lack access to both water and sanitation, 13% lack access to one of them, and 84% have access to both (Appendix Table A3).

Figure 5 presents a detailed analysis of the relationship between access to water and sanitation services and early childhood development and health, as measured by three distinct indicators (one per panel): (a) the overall ECDI on track, (b) stunting, and (c) underweight. In each panel, the indicator is compared between children who have access to both water and sanitation services and those who do not.[10]

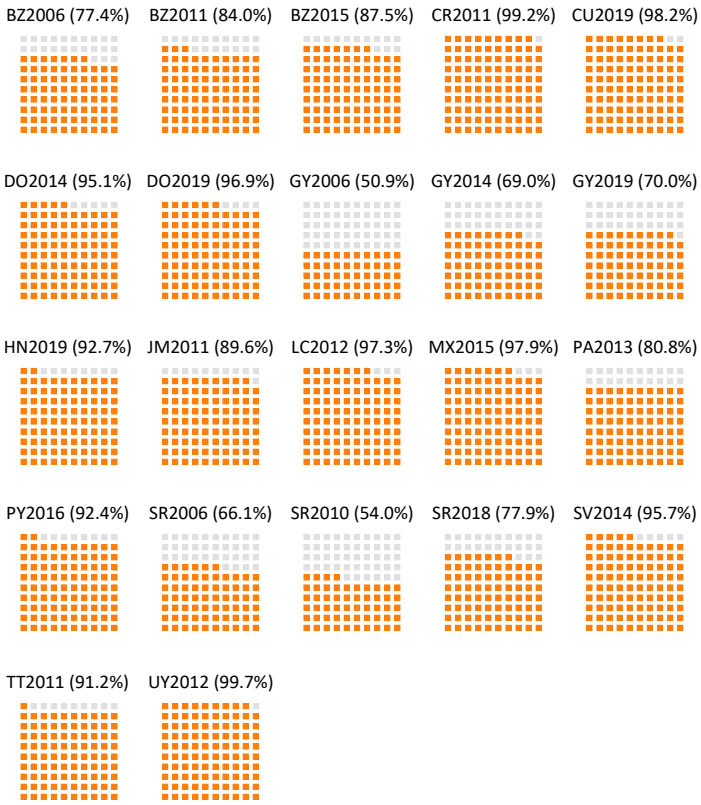
Panel A shows that in most countries, children with access to water and sanitation services are more likely to be on track developmentally as measured by the ECDI compared to those without access. For instance, in countries like Guyana, Mexico, Panama, and Suriname, a large difference in early childhood development between children with and without infrastructure access is visible. Suriname has the lowest percent of children with ECDI on track compared to all other groups, which is concerning. In 2010, this percentage was at 59.60% for children without access. However, this figure has improved significantly since then, as of 2018. Similar patterns are observed for

[9] Statistics are not significantly different when using the health sample.

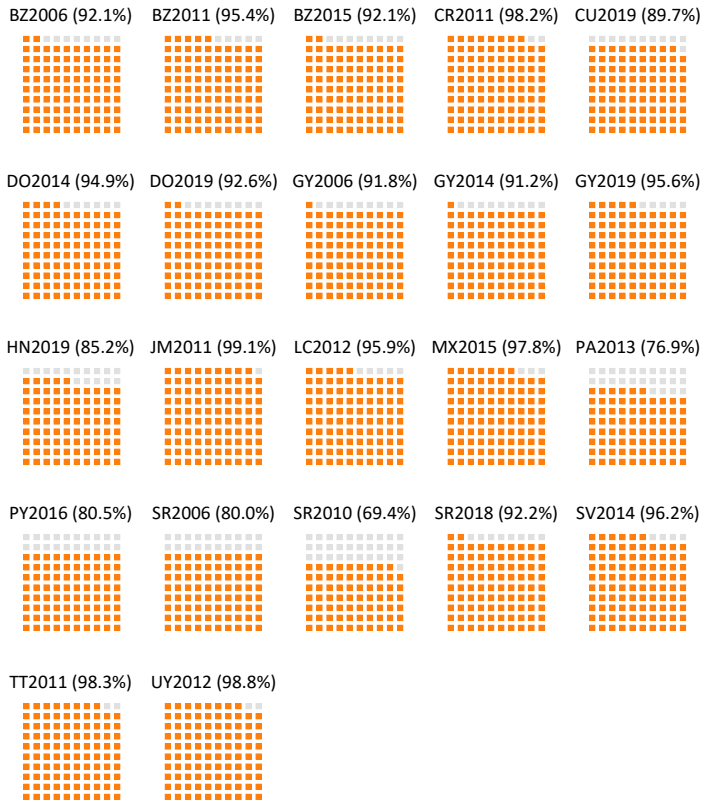
[10] As mentioned before, the number of surveys included for each indicator varies due to differences in data collection across surveys.

Figure 4: Access to water and sanitation infrastructure by survey

(a) Water access (dummy)

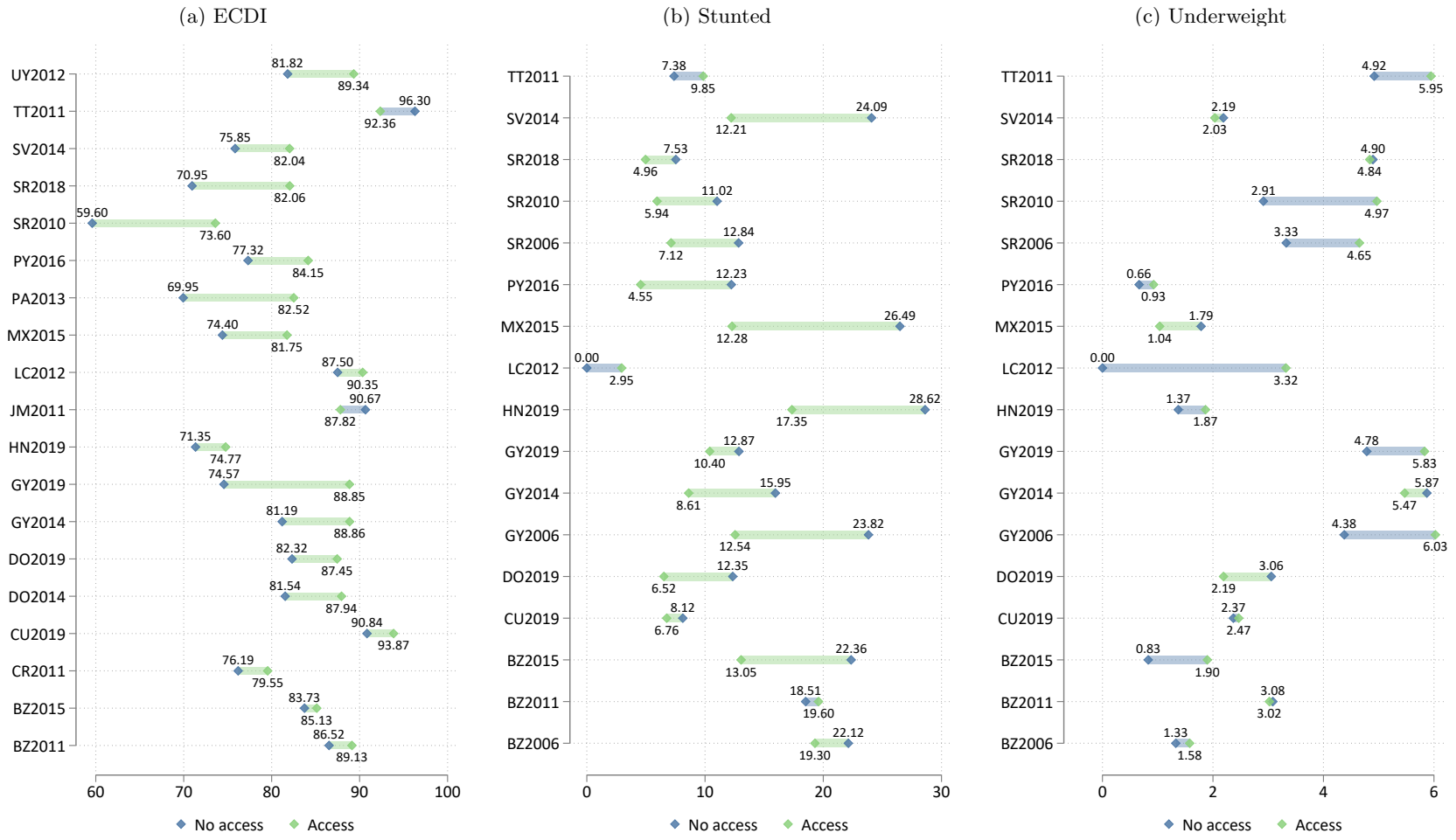


(b) Sanitation access (dummy)



Notes: This figure shows the percentage of children who have access to water and sanitation services in their homes across different countries in Latin America and the Caribbean (LAC). Data were obtained from the Multiple Indicators Cluster Survey (MICS) for Belize (BZ), Costa Rica (CR), Cuba (CU), Dominican Republic (DO), El Salvador (SV), Guyana (GY), Honduras (HN), Jamaica (JM), Mexico (MX), Panama (PA), Paraguay (PY), Saint Lucia (LC), Suriname (SR), Trinidad and Tobago (TT), and Uruguay (UY). We present statistics for water access in Figure 4a, and sanitation access in Figure 4b. Statistics correspond to simple national averages from each survey.

Figure 5: Developmental and health outcomes by survey and access to both water and sanitation



Notes: This chart displays the percentage of children who are considered developmentally on track according to the early childhood development index (ECDI), as well as the rates of stunting and underweight. Figures for each of these categories are shown in Figure 5a, Figure 5b, and Figure 5c, respectively. Statistics are unweighted averages calculated separately for each survey for children with and without access to infrastructure services. Data were obtained from the Multiple Indicators Cluster Survey (MICS) for Belize (BZ), Costa Rica (CR), Cuba (CU), Dominican Republic (DO), El Salvador (SV), Guyana (GY), Honduras (HN), Jamaica (JM), Mexico (MX), Panama (PA), Paraguay (PY), Saint Lucia (LC), Suriname (SR), Trinidad and Tobago (TT), and Uruguay (UY).

sanitation access, with a higher percentage of children with access to sanitation being on track with ECDI in most countries. In nearly all countries, the difference in the percentage of children who are developmentally on track is significant between those who do and do not have access.

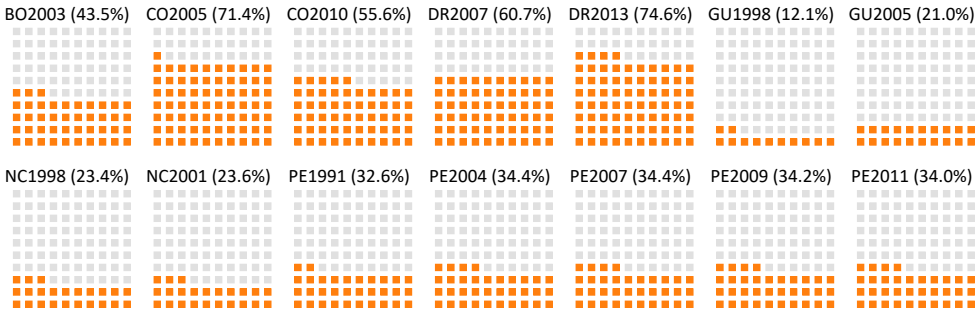
The data also show in Panel B that the percentage of children with stunting is higher among those without access to infrastructure in most countries, except Trinidad and Tobago and Saint Lucia. The largest absolute difference is found in Honduras, Mexico and El Salvador, between those with and without access, while Guyana in 2019 has the smallest difference. In Panel C, we provide descriptive information about underweight, which displays greater variation between countries compared to ECDI and stunting. Generally, children with access to both services report higher incidence of underweight than those without access. However, there is a remarkably low incidence of underweight across all countries in general.

Overall, the results presented in Figure 5 indicate that access to water and sanitation services might be linked to early childhood development outcomes, with children who have access to these services generally having better ECDI scores and experiencing lower rates of stunting. We try to explore the particular low incidence of underweight across countries during the empirical models.

We employ data from the Demographic and Health Surveys (DHS) to examine households' garbage management in LAC. DHS surveys are nationally representative household surveys that collect data on various aspects of health, including reproductive health, child health, and nutrition. They cover both low- and middle-income countries, enabling comparative analyses across different contexts. Moreover, these surveys provide detailed information on garbage collection, such as type and frequency, which is relevant for our hypothesis that children's health outcomes are negatively affected by higher exposure to residential waste.

As shown in Figure 6, we retrieved garbage collection data from 14 surveys with a total of 118,597 mother-child dyads. Access to garbage collection services varies significantly across countries. In Guyana, for instance, access to garbage collection was low at 12.1% in 1998, rising to 21% in 2005. Meanwhile, Nicaragua reported a low access rate of around 23% in both 1998 and 2001. The Dominican Republic showed progress, with the percentage of access increasing from 60.7% in 2007 to 74.6% in 2013. Notably, access to garbage collection services is steady in Peru across multiple surveys from 1991 to 2011. Even over two decades, the percentage of access to garbage collection services remained almost stagnant, hovering around 34%. Additional statistics for the pooled sample of countries/surveys are available in Appendix Table A5.

Figure 6: Access to garbage collection by survey



Notes: This figure presents the percentage of children whose households had access to garbage collection services across different surveys. Data were obtained from the Demographic and Health Surveys (DHS) for Bolivia (BO), Colombia (CO), Dominican Republic (DR), Guyana (GU), Nicaragua (NC), and Peru (PE). These data only include countries for which garbage collection information is available from the DHS surveys. Statistics represent unweighted averages.

Figure 7 presents differences in stunting and underweight by the availability of garbage collection across surveys. The largest difference in stunting between children with and without garbage collection services is observed in Guyana (1998), at 30.98% and 62.72%, respectively, while the smallest difference in stunting was observed in the Dominican Republic (2013), at 7.49% and 10.1% respectively.

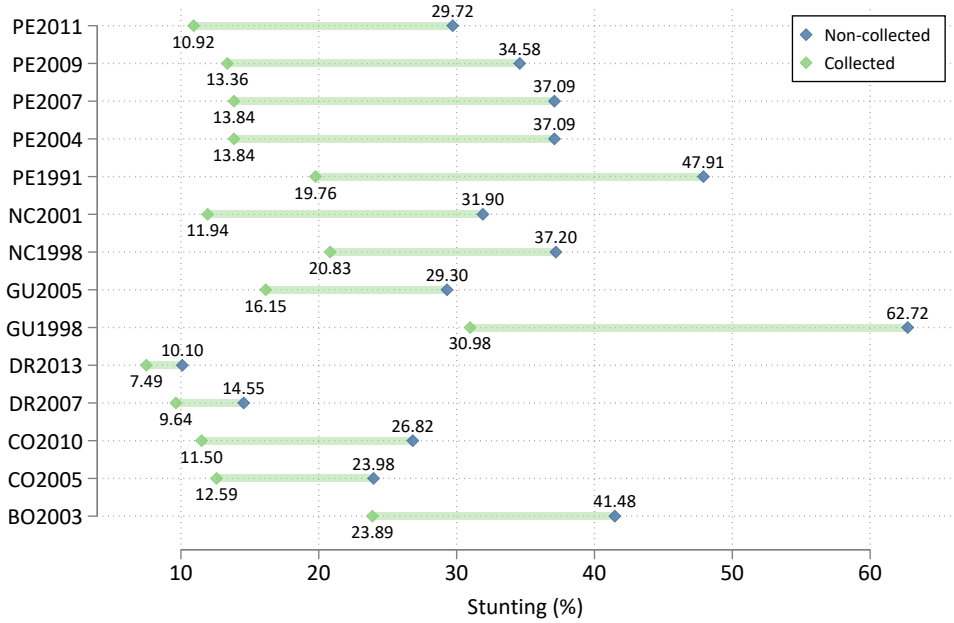
Similarly, children with access to garbage collection services are less frequently underweight than those without access. The largest difference in underweight children between those with and without garbage collection services was observed in Guyana (1998), at 9.36% and 21.25% respectively. The smallest difference in underweight children was observed in the Dominican Republic (2013), at 3.14% and 4.8% respectively. In general, these statistics support our hypothesis that children's health outcomes may be negatively affected by higher exposure to residential waste, highlighting the importance of investing in efficient waste management systems for promoting better health and early childhood development outcomes.

4 Results

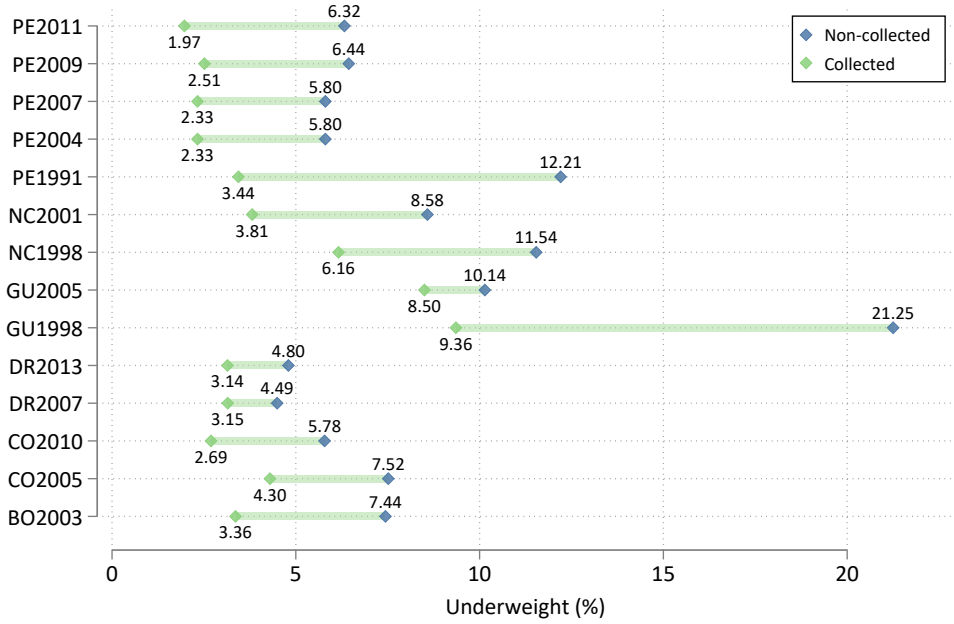
In this section, we provide evidence of the potentially significant role that access to basic infrastructure services, such as water, sanitation, and garbage collection, plays in early childhood health and development. Specifically, the MICS data demonstrate a strong link between access to water and sanitation and children's likelihood of being on track in their development according to the ECDI, as well as a lower likelihood of stunting. In addition, the DHS data highlight a negative association between access to improved garbage collection services and rates of stunting and underweight among children under five.

Figure 7: Stunting and underweight by type of garbage disposal system

(a) Stunting



(b) Underweight



Notes: This figure presents the percentage of children with stunting and underweight across different surveys by access to garbage collection. Data were obtained from the Demographic and Health Surveys (DHS) for Bolivia (BO), Colombia (CO), Dominican Republic (DR), Guyana (GU), Nicaragua (NC), and Peru (PE). The data presented here only include countries for which garbage collection information is available from the DHS surveys. Statistics represent unweighted averages.

Water and sanitation infrastructure using the MICS: We present the results of the linear probability models that explore the association between access to water and sanitation and various developmental and health outcomes. These outcomes include binary indicators for being on track in the ECDI, as well as stunting and underweight status in children. The data utilized for this analysis originate from 22 surveys conducted across 14 different countries. It is important to note that the specific countries and surveys included in the analysis vary based on the model and health outcome in question, as not all outcomes are available across all surveys.[11]

Table 1: Access to infrastructure and the relationship with the ECDI

Dependent variable	ECDI (dummy)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Water access (dummy)	0.039***	0.041***	0.027**	0.019*				
	(0.010)	(0.010)	(0.010)	(0.010)				
Sanitation access (dummy)					0.059***	0.058***	0.037***	0.029***
					(0.009)	(0.008)	(0.008)	(0.008)
R2-squared	0.039	0.051	0.059	0.063	0.040	0.052	0.060	0.063
Mean of outcome	0.834	0.834	0.834	0.834	0.834	0.834	0.834	0.834
N	37964	37964	37964	37964	37964	37964	37964	37964
Surveys	19	19	19	19	19	19	19	19
Controls								
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes

Notes: This table presents results from a linear probability model for the correlation between child development indicators and access to water and sanitation infrastructure. The analysis sample is composed from 19 surveys included in The Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A3. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

In Table 1, we analyze the association between access to water and sanitation, and a child's developmental progress as captured by the ECDI. The models, spanning columns 1 to 8, reveal a consistent positive association. For instance, the model in column 1, accounting for country-region-year fixed effects, suggests that access to water correlates with a 3.9% increase in the likelihood of a child being developmentally on track according to the ECDI. This relationship persists even when additional control variables are introduced, including child, mother, and household characteristics. The coefficients for water and sanitation access slightly diminish but remain significantly positive,

[11]The sample across the different models and outcomes is not harmonized due to substantial variations in the number and type of observations when comparing Tables 1 and 2. Despite this, the results remain consistent and robust when using the same sample, as evidenced by the findings presented in Appendix Table A6.

emphasizing the robustness of these findings. Children with water access exhibit a 1.9% to 4.1% higher likelihood of optimal development, while sanitation access corresponds to a 2.9% to 5.8% increase.

In Appendix Table A7, we refine this analysis, dissecting the ECDI into its constituent sub-domains: learning, socio-emotional development, physical development, and literacy/numeracy. The models reveal that water access predominantly benefits learning, socio-emotional development, and literacy/numeracy, with associations as high as 7.6%, 1.5%, and 1.9% respectively. Sanitation access echoes these benefits, particularly enhancing learning (9.0%), socio-emotional development (2.0%), and literacy/numeracy (3.4%). The physical development sub-domain, while showing a positive trend, does not reach statistical significance, possibly due to short-term measurement limitations or variability in physical development milestones.

In Table 2, we explore the associations between access to water and sanitation and health outcomes, particularly stunting and being underweight in children. The analysis reveals a noteworthy correlation: access to water is associated with a 1.3% to 3.8% reduction in the likelihood of stunting and a 0.3% decrease in the probability of a child being underweight. These associations are further strengthened with access to sanitation, which is correlated with a 4.8% to 8.1% decrease in the likelihood of stunting and a 0.3% reduction in being underweight. Although the percentage changes might seem modest, they are significant when considered in relation to the baseline prevalence of these health outcomes, thus highlighting their potential relevance for public health efforts.

We tested additional models that include wealth to mitigate endogeneity issues and obtain more accurate estimates. Specifically, wealth may predict both access to improved sanitation facilities as well as developmental and health outcomes, leading to issues of selection or omitted variable bias. By controlling for wealth, we can account for the possibility that wealthier individuals are more likely to have better sanitation facilities while also simultaneously enjoying better health outcomes due to other factors that are correlated with wealth. These results are shown in Appendix Table A8. In our baseline model, we have opted not to include wealth due to the construction of the wealth index, which integrates proxies related to infrastructure access. This integration could potentially obscure the independent effects of water and sanitation access.[12]

The estimates in Appendix Table A8 show that even after controlling for household wealth, water and sanitation access are both positively associated with on-track ECDI scores and negatively associated with stunting and underweight. However, only sanitation is statistically significant. We confirm that the coefficients of the wealth quintile dummy variables show that children from richer households are more likely to be developmentally on track and have lower rates of stunting and underweight than those from poorer households. Previously, all our models control for maternal education in order to separate out the impact of maternal education on child developmental and health outcomes. Indeed, maternal education is linked to better hygiene, nutrition, and healthcare-

[12]See Appendix Table A2 for additional details about the construction of the wealth index.

Table 2: Access to infrastructure and the relationship with health outcomes

Dependent variable	Stunted (dummy)				Underweight (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Water access (dummy)	-0.038***	-0.038***	-0.026**	-0.013	-0.003	-0.003	-0.003	-0.003
	(0.012)	(0.012)	(0.010)	(0.008)	(0.003)	(0.003)	(0.003)	(0.003)
R2-squared	0.044	0.050	0.060	0.068	0.014	0.017	0.017	0.017
Mean of outcome	0.116	0.116	0.116	0.116	0.027	0.027	0.027	0.027
N	67248	67248	67248	67248	67248	67248	67248	67248
Surveys	17	17	17	17	17	17	17	17
Controls								
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Sanitation access (dummy)	-0.081***	-0.081***	-0.061***	-0.048***	-0.003	-0.003	-0.002	-0.002
	(0.011)	(0.011)	(0.010)	(0.007)	(0.002)	(0.002)	(0.002)	(0.002)
R2-squared	0.047	0.053	0.062	0.069	0.014	0.017	0.017	0.017
Mean of outcome	0.116	0.116	0.116	0.116	0.027	0.027	0.027	0.027
N	67248	67248	67248	67248	67248	67248	67248	67248
Countries	17	17	17	17	17	17	17	17
Controls								
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes

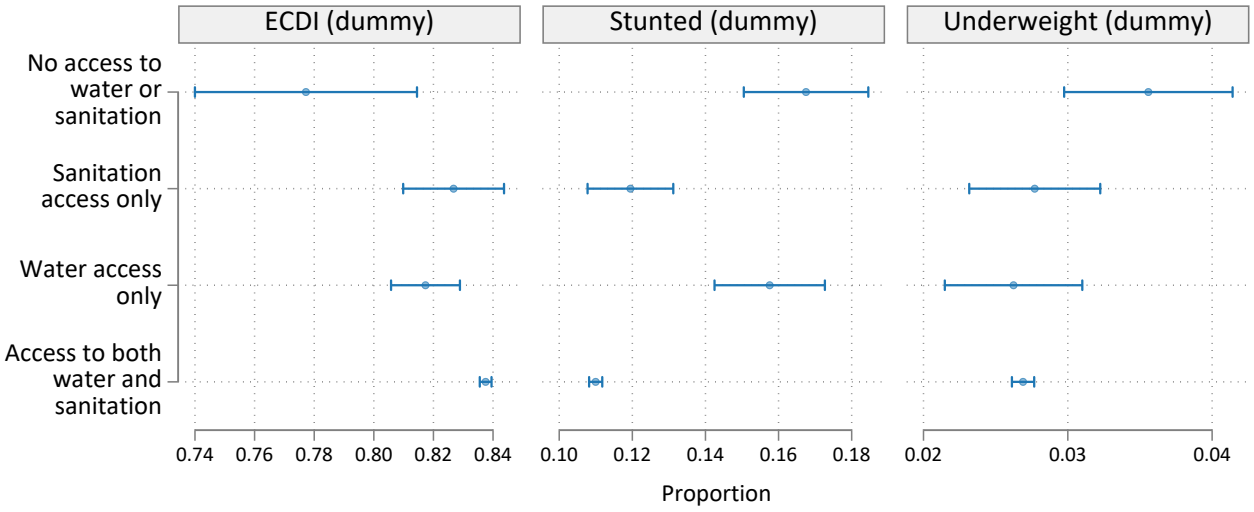
Notes: This table presents results from a linear probability model for the correlation between child development indicators and access to water and sanitation infrastructure. The analysis sample is composed from the surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A4. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

seeking behavior for children, and may influence household wealth and investment in water and sanitation infrastructure. Lastly, we also tested the robustness of the results to the inclusion of the stimulation index, which is a strong predictor of ECD (Cuartas et al., 2023), obtaining consistent estimates.

Recognizing the inherent interconnectedness of sanitation and water in determining health and developmental outcomes, it becomes essential to investigate not just their individual influences, but also their combined effects. The results of these interactions are illustrated in Figure 8. By including an interaction term between sanitation and water, we aim to distinguish whether their joint influence amplifies or diminishes the outcomes observed when they act independently. The

results for ECDI indicate a positive association with both water and sanitation access. Children with access to both water and sanitation have a predicted 83.8% likelihood of being on track in ECDI, which is higher compared to those with access to only water (81.7%), only sanitation (82.7%), or neither (77.7%). When it comes to stunting children with access to both water and sanitation have the lowest likelihood of being stunted, at 11.00%. Those without access to either have a higher likelihood of 16.75%, Similar trends are observed for children with access to only water (15.76%) or only sanitation (11.95%). The pattern continues for underweight, an indicator of acute malnutrition. Children with access to both water and sanitation have a likelihood of 2.69%, the lowest among the groups. Those without access to either are at a higher likelihood of 3.56%. Access to water only results in a likelihood of 2.62%, while sanitation only shows a likelihood of 2.77%.

Figure 8: Predicted developmental and health outcomes by infrastructure access



Notes: The coefficient plot visually displays the predictive margins for three distinct health and development outcomes in children: being on track according to the early childhood development index (ECDI), being stunted, and being underweight. The figure categorizes the results based on the children's access to water and sanitation, delineating four scenarios: "No access to water or sanitation", "Water access only", "Sanitation access only", and "Access to both water and sanitation". The predictive margins are calculated from the linear probability models in Appendix Table A9. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Confidence intervals are represented by capped lines and set at 90%.

In order to mitigate the negative impacts of inadequate access to clean water and sanitation facilities, households may adopt various behaviors or attitudes that promote health and well-being. These practices, ranging from treating water to enhance its safety for consumption, to ensuring the availability of soap or cleansers for handwashing, play a crucial role in safeguarding health, particularly in contexts where access to water and sanitation infrastructure is limited. As shown in Figure 9a, water treatment emerges as a significant mitigating factor, especially for developmental outcomes. Promoting household water treatment practices could be a viable interim solution while

working towards universal access to water and sanitation. The data also suggest that the availability of a cleanser might play a mitigating role, particularly in relation to ECDI and stunting (see Figure 9b).

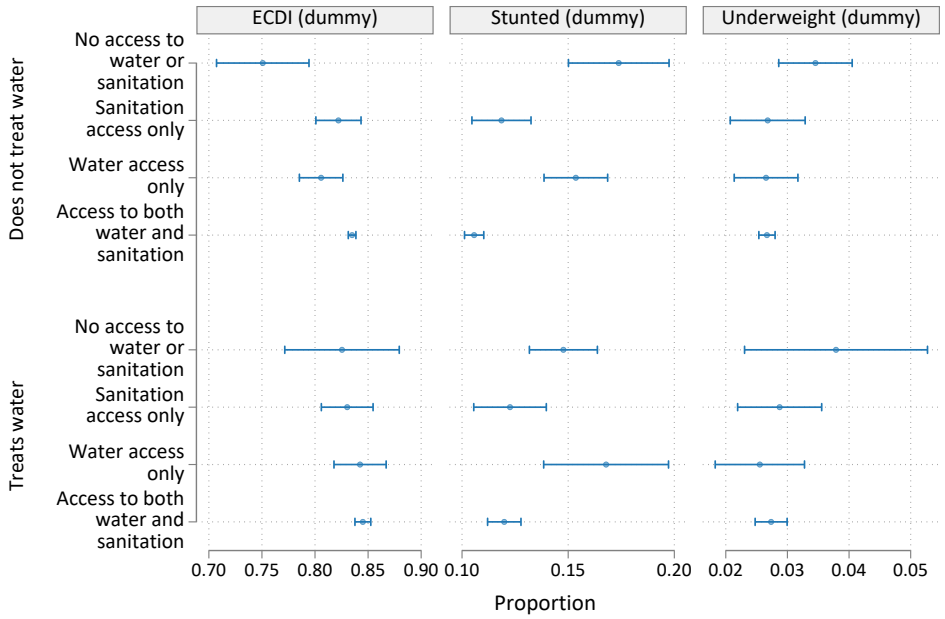
The robustness of our results is reinforced through a series of additional analyses. First, we confirm our results through the application of a preferential within propensity score matching approach (Arpino and Cannas, 2016), as demonstrated in Appendix Table A13, providing further confidence in the validity and reliability of our findings. Second, we extend further our analyses with the results presented in Tables A11 and A12. By employing a categorical variable for both water and sanitation access, rather than relying on binary indicators, we explore the correlation of different types of access. Our findings interestingly highlight the significant role of packaged water in mitigating the adverse effects associated with other forms of water access. This observation could be indicative of the unreliable quality of piped water sources in some Latin American countries and the lack of appropriate storage options, underscoring the potential need for alternative safe drinking water solutions. On the sanitation front, flush systems stand out as particularly beneficial, showcasing greater effectiveness in promoting health and developmental outcomes when compared to both hygienic non-flush methods and unsanitary systems, as well as in comparison to a complete lack of sanitation facilities. These findings underline the necessity to recognize and address the varying impacts of different types of water and sanitation access. They also emphasize the importance of considering the quality and type of water and sanitation services alongside their availability.

The data from the MICS compellingly illustrate the positive relationship that investments in water and sanitation infrastructure can have on the development and health of young children. This relationship holds strong even when taking into account various individual, maternal, and household factors, alongside considerations of household wealth and stimulation activities. To get more into this association, we expand the data analyses to include information on residential waste collection systems. Such data would provide a more comprehensive understanding of how waste management infrastructure services impact early childhood development. Since exposure to waste can affect the quality of an individual's environment, this additional information may enhance the accuracy of the relationship between infrastructure services and early childhood development.

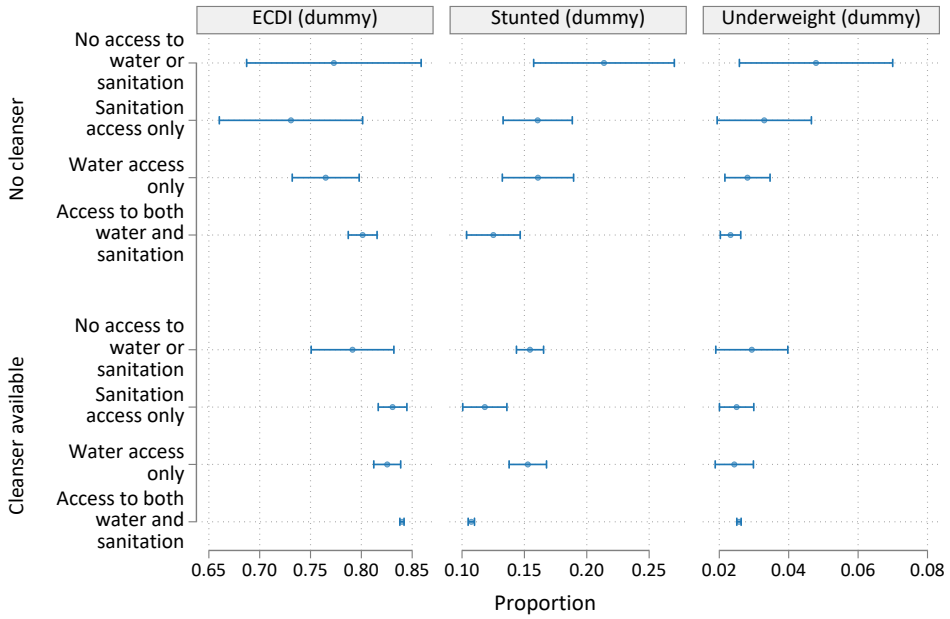
Residential waste management infrastructure using the DHS: Table 3 presents the results of the linear probability model to assess the correlation between garbage collection and child health indicators, specifically stunting and underweight. Our analysis begins with a simple correlation using year-country-region fixed effects, which is then extended by introducing additional controls, including children, mother and household characteristics. Controlling for household characteristics allows us to account for the potential impact of socio-economic status on the relationship between garbage collection and health indicators, as discussed previously.

Figure 9: Predicted developmental and health outcomes by mitigation behavior and infrastructure access

(a) Treats water



(b) Cleanser available to wash hands



Notes: The coefficient plot visually displays the predictive margins for three distinct health and development outcomes in children: being on track according to the early childhood development index (ECDI), being stunted, and being underweight.The results are categorized based on the household's adoption of mitigation behaviors such as treating water before consumption to make it safe (Figure 9a) and having hand cleanser available at home (Figure 9b). The figure then presents estimations according to the children's access to water and sanitation, outlining four scenarios: "No access to water or sanitation", "Water access only", "Sanitation access only", and "Access to both water and sanitation". The predictive margins are calculated from the linear probability models in Appendix Table A10. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Confidence intervals are represented by capped lines and set at 90%.

Table 3: Access to waste management infrastructure and the relationship with health outcomes

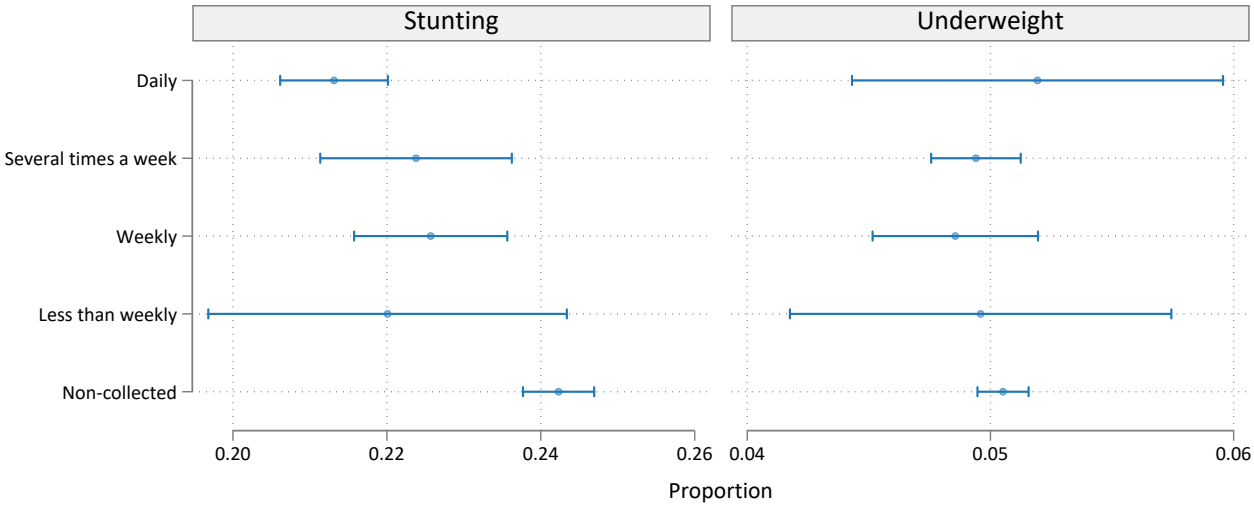
Dependent variable	Stunted (dummy)				Underweight (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Garbage collection (dummy)	-0.134***	-0.134***	-0.091***	-0.028***	-0.032***	-0.032***	-0.020***	-0.004*
	(0.012)	(0.012)	(0.008)	(0.005)	(0.004)	(0.004)	(0.003)	(0.002)
R2-squared	0.123	0.145	0.165	0.181	0.034	0.038	0.044	0.049
N	118598	118598	118598	118598	118598	118598	118598	118598
Surveys	14	14	14	14	14	14	14	14
Mean of outcome	0.251	0.251	0.251	0.251	0.060	0.060	0.060	0.060
Controls								
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to water and sanitation infrastructure. The analysis sample is composed from fourteen surveys included in the Demographic and Health Surveys (DHS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

The results indicate a statistically significant association between access to improved garbage collection services and child development indicators. Children under five with access to improved garbage collection services have a 13.4% and 3.2% lower probability of stunting and underweight, respectively, in the most straightforward model. These coefficients are lower, however, when additional control variables are included. Specifically, results from the model including all covariates show a statistically significant association between improved garbage collection and the health outcomes. Overall, the coefficients for stunting range from -0.134 to -0.028, while those for underweight range -0.032 to -0.004, representing approximately as much as 50% of the mean of the dependent variable in each case. Our results remain consistent when controlling for wealth and interacting it with access to garbage collection, however, children from poorer households are more likely to suffer from stunting -see Appendix Figure A1.

We also analyze a sub-sample of surveys that include the frequency with which garbage collection services are provided. In particular, we distinguish between households that benefit from garbage collection daily, several times a week, weekly, and less than weekly. The results in Figure 10 show that children living in households with daily garbage collection have lower rates of stunting compared to those living in households where garbage is not collected. The main differences appear to stem from the gap between these two groups.

Figure 10: Predicted stunting and underweight with changes in frequency of garbage collection

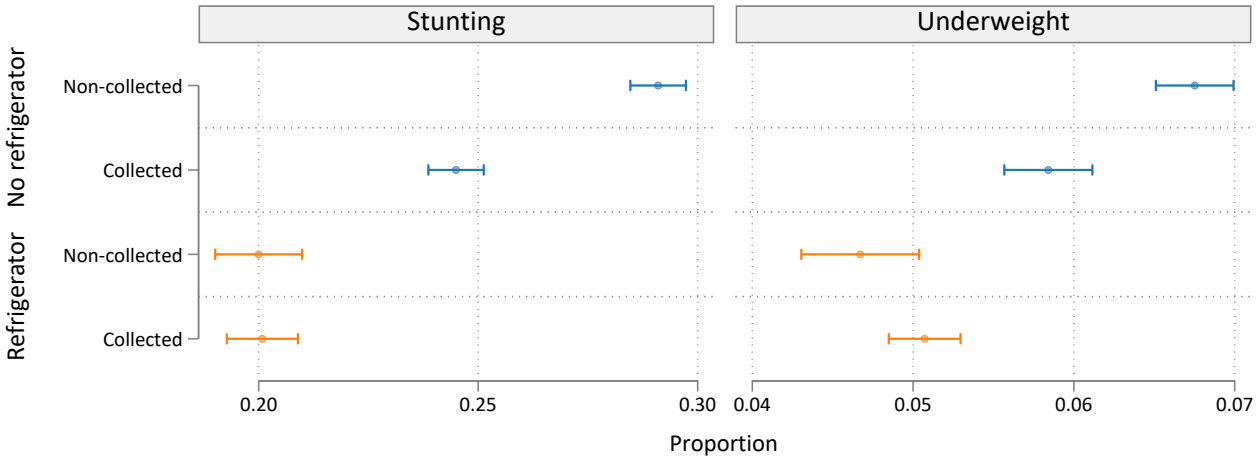


Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are categorized based on the household's wealth quintile. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A15. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

In Appendix Figure A2, we present the findings of an analysis that examines the potential interaction between garbage collection and access to electricity, water, and sanitation services in relation to child development indicators. Specifically, the figure shows predicted average rates of stunting and underweight for children under five, listed separately for households with and without access to these services and improved garbage collection. The data indicate that access to improved garbage collection is consistently associated with lower stunting rates across different infrastructure scenarios, regardless of electricity, water, or sanitation services availability. Households with access to all three services (electricity, water, and sanitation) and garbage collection have substantially lower stunting rates than households without adequate garbage collection. This finding suggests that waste management infrastructure plays a distinct and essential role in reducing stunting, even when other services are present.

We further analyze the predicted rates of stunting and underweight in households with and without access to garbage collection, looking at certain household behaviors that could reduce children's environmental exposure to waste-related impacts. In particular, we consider households with and without a refrigerator, which could potentially minimize food spoilage and the associated health risks. We then examine the use of bottled drinking water, which may reduce the likelihood of water contamination from improper waste disposal. Finally, we investigate whether households store their garbage in lidded containers before disposal, a practice that could mitigate the spread of disease-carrying vectors and decrease children's exposure to harmful waste.

Figure 11: Predicted stunting and underweight in households with refrigeration ownership and type of garbage collection

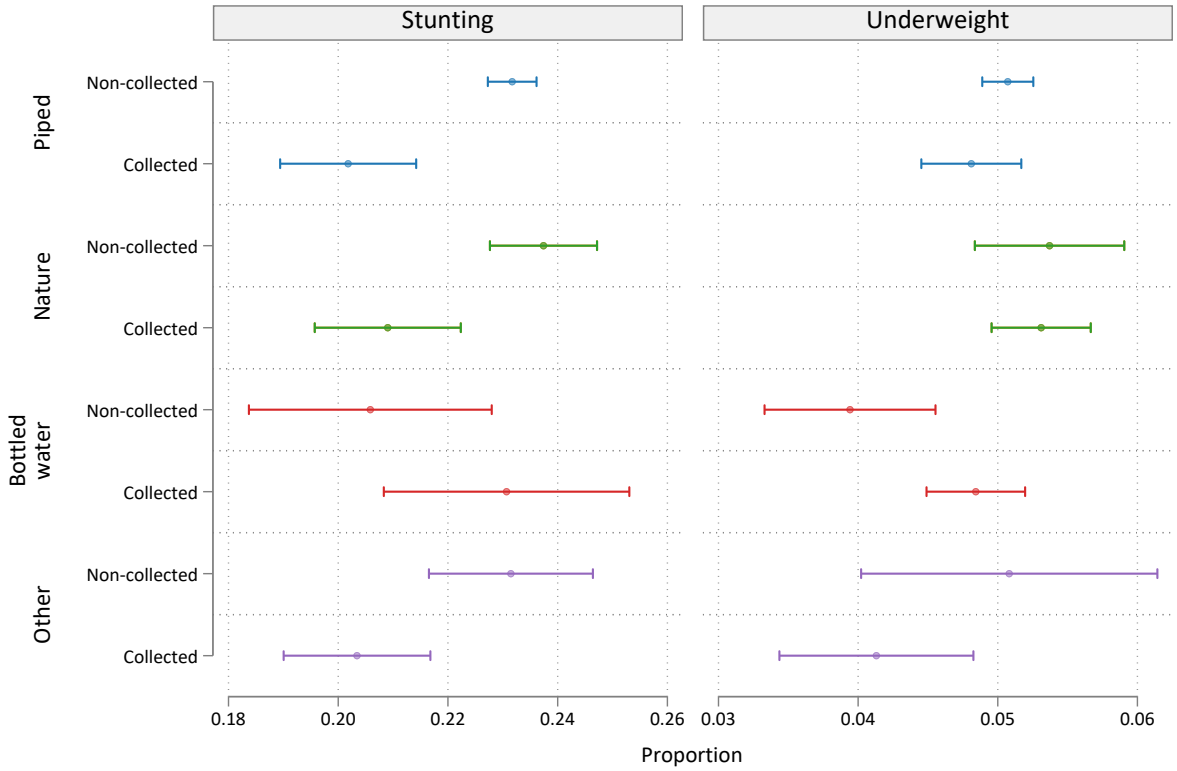


Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are categorized based on the household's ownership of refrigerators. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A17. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

As shown in Figure 11, no differences are detectable in the likelihood of stunting or underweight between children in households with refrigerators, regardless of whether the households have garbage collection. But, among children in households without a refrigerator, those who are without garbage collection have higher rates of stunting (4.60 percentage points) and underweight (0.91 percentage points). In Figure 12, we show the variation in rates of stunting and underweight based on households' main source of drinking water and availability of garbage collection. The results indicate that households without garbage collection have higher rates of stunting than households with garbage collection when these households use piped or natural sources as their main source of drinking water, although the latter estimate is more imprecise due to the small number of households that rely on natural sources. We found no detectable differences in the association between garbage collection and the prevalence of underweight according to the main source of drinking water.

Figure 13 reveals that households that store waste in lidless containers had the biggest gap in stunting by garbage collection access. Specifically, we observe that households using lidless containers had a predicted stunting rate of 27.99% when garbage was not collected, compared to 23.71% when garbage was collected. Similar differences remain for households that store their waste in vessels other than covered containers, such as plastic bags. These findings suggest that the use of lidded containers for waste can have significant benefits for promoting healthy child development. By reducing exposure to potential pollutants and promoting sanitary waste management practices,

Figure 12: Predicted stunting and underweight in households by source of drinking water and type of garbage collection

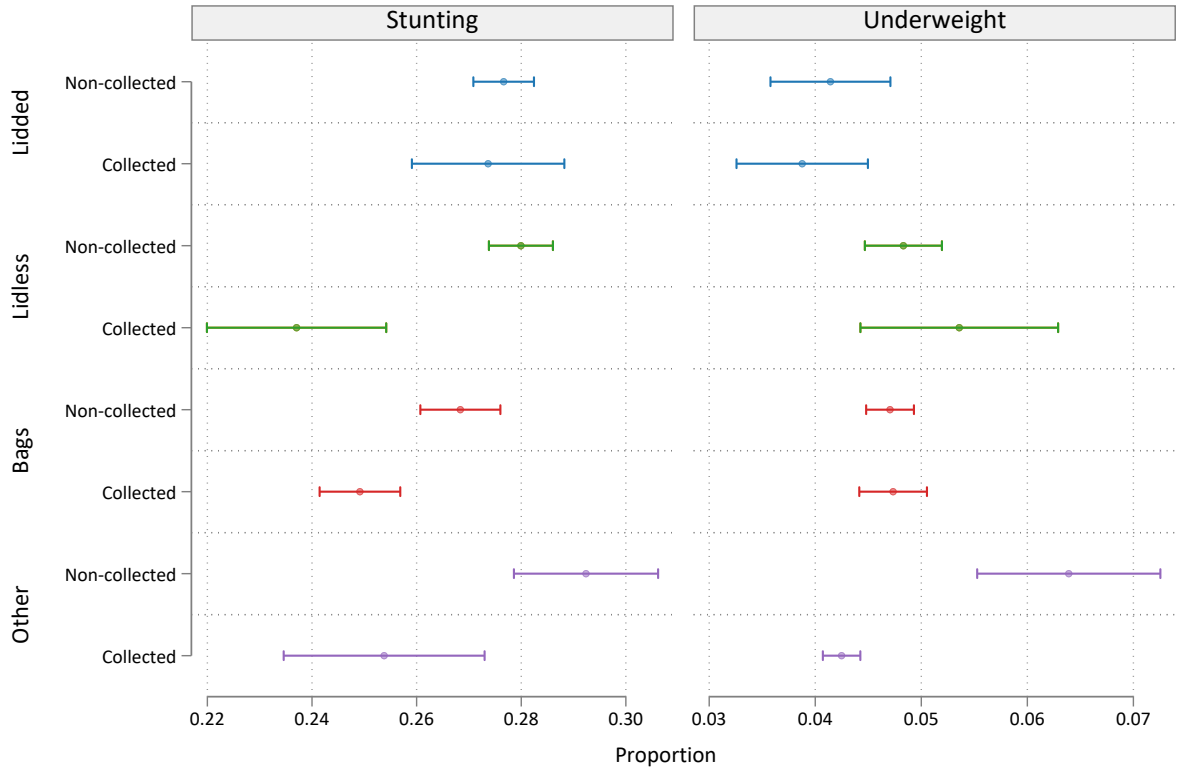


Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are categorized based on the household's source of drinking water. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A18. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

households can help protect their children. Furthermore, these results highlight the importance of targeted policy interventions aimed at promoting the use of lidded containers for waste among households in the region.

We further extend our analyses to look more closely at the relationship between child health and waste management by examining the predicted rates of stunting and underweight among children who have experienced recent illness. Our findings are summarized in Figure 14. Specifically, we consider instances of child diarrhea, cough, and fever, as reported by households during the survey period. This analysis sheds light on the potential mechanisms underlying the observed effects on child development, particularly emphasizing the health channel. Examining the interplay between recent episodes of illness and the development indicators may help elucidate the significance of waste management improvements in mitigating adverse health outcomes among children.

Figure 13: Predicted stunting and underweight in households using lidded containers for waste by type of garbage collection

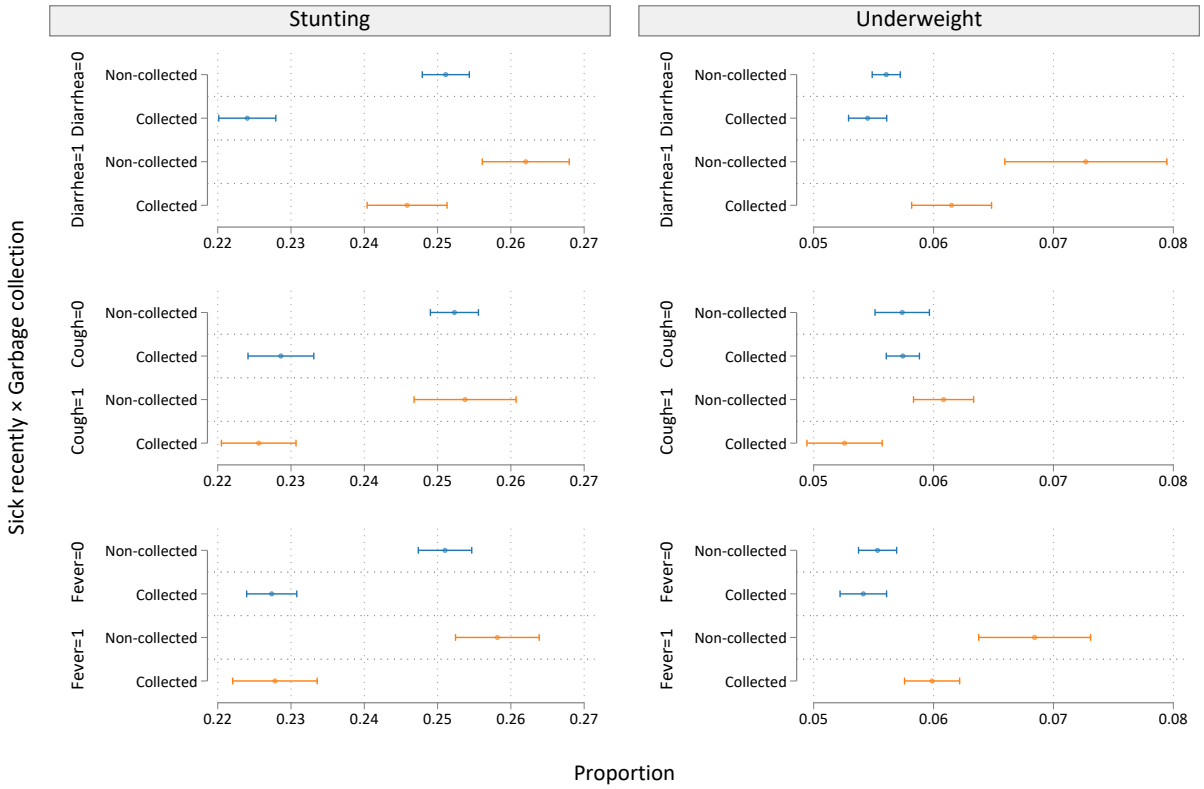


Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are organized according to the type of garbage containers used by households prior to collection. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A19. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

We find that children living in households with garbage collection have a 2.4 percentage point lower likelihood of being stunted than children in households without garbage collection, independently of recent illness episodes. This result is consistent with the general trend observed throughout the paper. However, the interaction terms between garbage collection and recent illness episodes (diarrhea, cough, or fever) are negative and significant for underweight, indicating that the presence of these illnesses may be one of the channels for the negative relationship between garbage collection and the likelihood of being underweight.

Our findings highlight the importance of considering both long-term and short-term indicators of child health when assessing the impact of waste management practices. While stunting serves as a consistent long-term marker of developmental issues, underweight status may be more challenging to identify due to its transient nature and sensitivity to recent illness episodes. As our analysis shows, the effects of poor waste management on children's underweight status may be exacerbated by a recent illness, making it crucial to address both immediate and long-term health concerns. In

Figure 14: Predicted stunting and underweight for recently sick children by type of garbage collection



Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are organized based on recent illness episodes such as diarrhea, cough, and fever in children. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A20. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

light of these insights, targeted policy interventions that address waste management and sanitation infrastructure, with a particular focus on households with children who have experienced recent episodes of illness may be effective. This approach will help mitigate the negative impacts of poor waste management on stunting as well as underweight status, thereby promoting improved child health and development outcomes.

5 Conclusion

This paper provides insights into the link between access to essential infrastructure services and early childhood development (ECD) in Latin America and the Caribbean (LAC). Our findings show that access to water, sanitation, and garbage collection can significantly impact children's developmental and health outcomes. Specifically, we document that access to water and sanitation is strongly associated with a higher likelihood of being developmentally on track as measured by the

early childhood development index, and with fewer instances of stunting and underweight. Additionally, the results reveal a negative association between improved garbage collection services and rates of stunting and underweight among children under five. Our findings hold strong even when taking into account various individual, maternal, and household factors, alongside considerations of household wealth and stimulation activities.

Our findings are consistent with prior evidence (Piper et al., 2017; WaterAid, 2016; Schady, 2015; Gao et al., 2021), and have important implications for policymakers in the region. First and foremost, the expansion of piped water and sanitation services is crucial for improving child outcomes. This expansion aligns with evidence indicating that improvements in water infrastructure can substantially reduce child mortality, with greater effects among socioeconomically disadvantaged groups. It is essential, however, to recognize the complexity of separating the effects of improved water from that of improved sanitation, as the magnitude of the relationship of clean water with child outcomes is often different than that of improved sanitation.

A key dimension of our analysis that merits significant emphasis is the differential impact of types of access to infrastructure, a crucial aspect considering the Sustainable Development Goals (SDGs) have elevated standards for what constitutes adequate access to water and sanitation. Our analysis underscores the pivotal role of alternatives to piped water in either mitigating or exacerbating the effects of water quality received by households. This is especially pertinent in contexts where piped water sources may be unreliable, highlighting the need for alternative safe drinking water solutions. Regarding sanitation, flush systems demonstrate substantial benefits, promoting health and developmental outcomes more effectively than both hygienic non-flush methods and unsanitary systems, even in the absence of sanitation facilities. These findings stress the need to recognize and address the varying impacts of different types of water and sanitation access, emphasizing the necessity for specific measurements of quality and access to essential infrastructure. There exist challenges in accurately measuring real household access, a critical consideration for policy and infrastructure development.

We underscore the importance of investing in waste management infrastructure as a critical but often overlooked component of comprehensive strategies to enhance early childhood development in low- and middle-income countries. This is particularly critical in light of previous work (Lu et al., 2020; McCoy et al., 2022) and our descriptive observations of persistent inequities in access to basic water, sanitation, and waste disposal services in LAC. By ensuring that all households have access to all basic services that promote good health and foundational skill development, policymakers can improve the developmental trajectories and well-being of children across the region and maximize the beneficial impact of other investments (including early childhood care and education and parenting programs) while promoting sustainable economic development for years to come.

Our paper also highlights the need for targeted policy interventions aimed at improving household practices in the region. The literature focuses on infrastructure hardware rather than on interventions that modify household behaviors and mitigation measures (Schady, 2015; Rupasinghe et al., 2021). For example, households could be encouraged to protect their environment from potential pollutants through mitigation measures such as storing waste in lidded containers or participating in community-based recycling programs. Similarly, strategies like handwashing, and treating water hold promise, but their effectiveness often relies on behavioral changes. Policymakers could consider implementing public education campaigns to raise awareness of the importance of proper household practices for healthy child development. Parenting and ECD programs delivered through home visits and community meetings have been expanding in LAC and offer a potential means of providing information and support related to hygiene practices and the protection of children from environmental hazards (Leer and Lopez-Boo, 2019).

Importantly, our findings suggest that households in the region can reap significant economic benefits from investments in water, sanitation, and waste management infrastructure and their downstream benefits for child health and development. Indeed, recent simulation studies estimate that stunting alone causes learning and economic losses with a total cost of approximately $176.8 billion per birth cohort globally and $44.7 billion in Latin America (Fink et al., 2016), while the cost of not investing in critical interventions to promote ECD in LAC countries such as Guatemala, Nicaragua, Colombia, Peru, Ecuador, and Chile ranged from 0.05% to 3.6% of their gross domestic product (Richter et al., 2017). The cost of inaction is therefore substantial and has meaningful impacts on individual and societal outcomes. By promoting ECD and reducing rates of stunting and underweight among young children, practices to improve water, sanitation, and waste management can lead to lower healthcare costs for families, maximize the impact of subsequent interventions, and promote higher levels of educational attainment and workforce productivity over time. There is also a necessity for a multi-sector approach. We underline the need to jointly address a range of factors –environmental, nutritional, health-related– to enhance early childhood development effectively (Rupasinghe et al., 2021; Vargas-Baron et al., 2019; Black et al., 2017).

Looking ahead, much remains to be learned about the complex relationship between access to infrastructure and early childhood development in LAC. Future research could explore the specific mechanisms through which access to essential infrastructure services affects child health outcomes, as well as the potential role of cultural and social factors in shaping household practices in the region. Additionally, further studies could explore the long-term economic benefits of investing in infrastructure for promoting healthy child development and sustainable economic growth.

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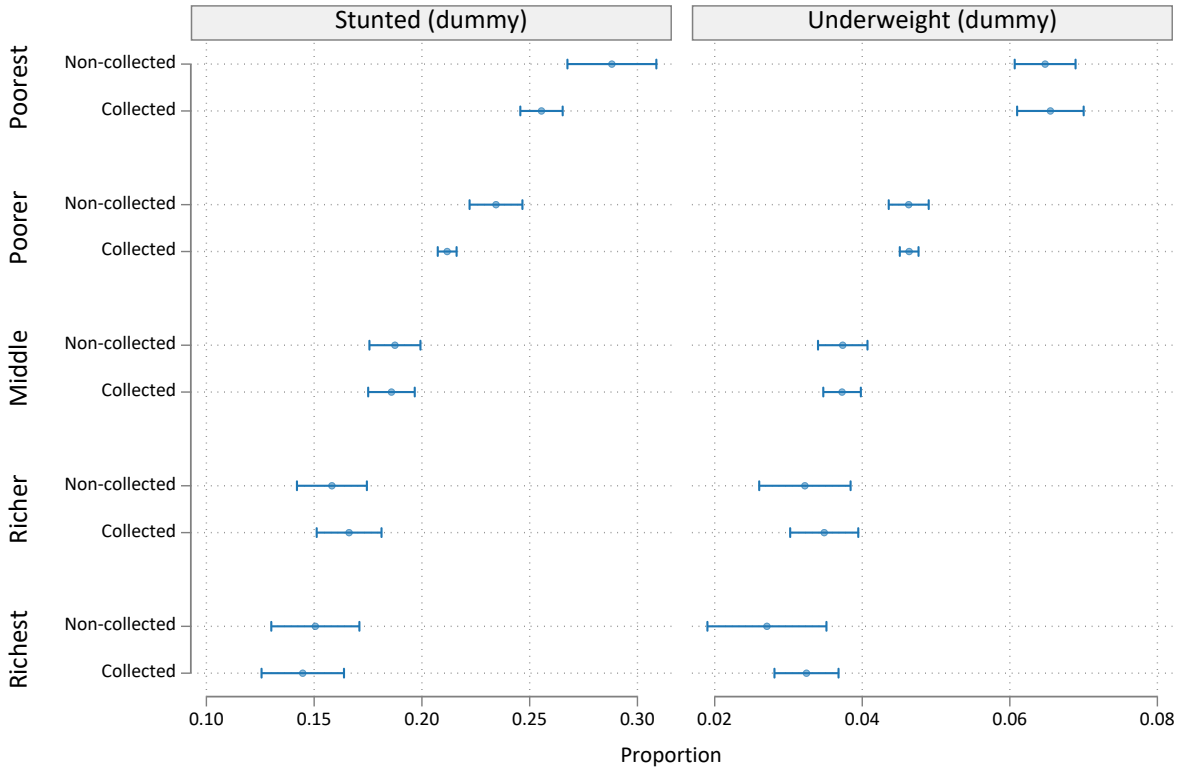
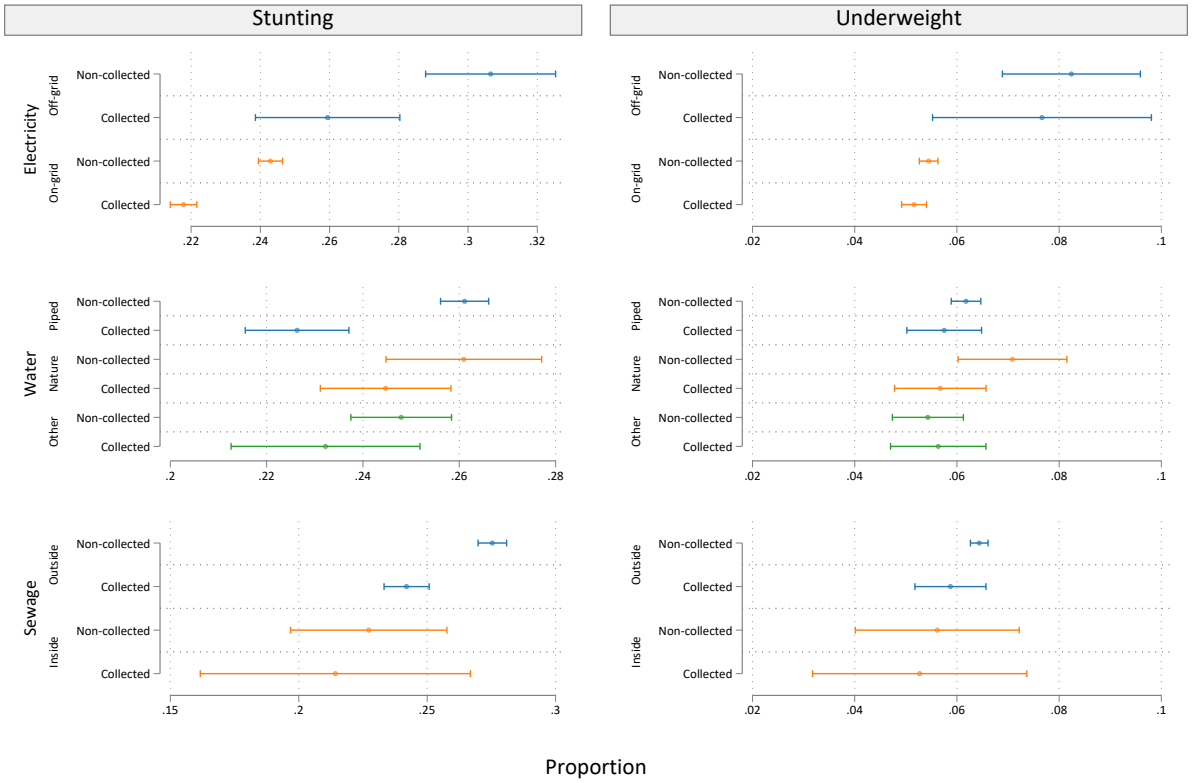
Appendix

Figure A1: Predicted health outcomes by wealth quintile and type of garbage collection



Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are categorized based on the household's wealth quintile. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A14. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

Figure A2: Predicted stunting and underweight with different household infrastructure access by type of garbage collection



Notes: The coefficient plot visually displays the predictive margins for two distinct health outcomes in children: being stunted, and being underweight. The results are categorized based on the household's wealth quintile. The figure then presents estimations according to the children's access to garbage collection. The predictive margins are calculated from the linear probability models in Appendix Table A16. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Confidence intervals are represented by capped lines and set at 90%.

Table A1: Sample size by dataset and outcome

MICS						DHS		
ECDI			Health			Health		
Country	Year	N	Country	Year	N	Country	Year	N
Belize	2006	796	Belize	2011	785	Bolivia	2003	9,165
	2011	1,945		2015	1,090	Colombia	2005	12,480
	2015	2,537	Costa Rica	2011	906		2010	24,560
Cuba	2019	5,252	Cuba	2019	2,316	Dominican Republic	2007	9,221
Dominican Republic	2019	8,396	Dominican Republic	2014	7,781		2013	3,116
El Salvador	2014	7,337		2019	3,404	Guyana	1998	3,982
Guyana	2006	2,462	El Salvador	2014	2,986		2005	1,684
	2014	3,335	Guyana	2014	1,307	Nicaragua	1998	6,935
	2019	2,782		2019	1,184		2001	6,008
Honduras	2019	8,464	Honduras	2019	3,616	Peru	1991	7,757
Mexico	2015	8,065	Jamaica	2011	666		2004	7,990
Paraguay	2016	4,614	Mexico	2015	3,352		2007	7,990
Saint Lucia	2012	291	Panama	2013	2,305		2009	9,199
Suriname	2006	2,248	Paraguay	2016	1,830		2011	8,510
	2010	3,301	Saint Lucia	2012	122			
	2018	4,225	Suriname	2010	1,265			
Trinidad and Tobago	2011	1,198		2018	1,772			
			Trinidad and Tobago	2011	525			
			Uruguay	2012	752			

Notes: This table shows the sample sizes for each country, grouped by outcome and dataset. The dataset used in the analysis are the Multiple Indicators Cluster Surveys (MICS) and the Demographic Health Surveys (DHS).

Table A2: Description of variables

Variable	Description
Panel A: MICS Variables	
Age	Age in months (0-59 months).
ECDI	Early Childhood Development Index (ECDI) measures the development of children aged 3-5 years across four domains: social-emotional, literacy-numeracy, approaches to learning, and physical. More details about the index in Loizillon et al. (2017).
Household members	Number of members in the household.
Household members ≤ 5	Number of household members less than 5 years old.
Mother's education	Categorical variable for mother's education level: none, primary, secondary, or higher education.
Sanitation access	Children are considered to have access to adequate sanitation if their dwellings have private sanitation facilities such as flush or pour-flush toilets connected to a piped sewer system or septic tank, various types of pit latrines (including ventilated improved pit latrines and those with slabs), and composting toilets. Inadequate sanitation includes the use of shared or public-use facilities, flush or pour-flush toilets that dispose waste elsewhere, pit latrines without slabs or open pits, hanging latrines, and practices of open defecation.
Sex	Sex categories: male and female.
Stunting	Dummy variable indicating if a child's height-for-age z-score (HAZ) is less than -2 standard deviations, following the World Health Organization (WHO) standard (WHO, 2009).
Stimulation index	Categorical index ranging from 0 to 6. It summarizes caregivers' engagement in six different play/learning activities with children, such as reading, telling stories, singing songs, taking the child outside, playing, and spending time on activities like naming, counting, or drawing. The index is constructed from MICS data, which asks whether anyone in the household engaged in these activities with the child in the past three days. Responses indicating the activity did not occur were coded as 1, while responses indicating the activity did occur were coded as 0. Missing values were treated as missing. The index was then created by summing the recoded variables, resulting in a score that reflects the number of activities the child did not experience, with a higher score indicating lower stimulation. More details about this index can be found in Cuartas et al. (2023).
Underweight	Dummy variable indicating if a child's weight-for-height z-score (WHZ) is less than -2 standard deviations, following the WHO standard (WHO, 2009).

Water access	Children are considered to have access to adequate water if their main source of drinking water comes from a protected and treated source. This includes water piped directly into the dwelling, yard, or plot, public taps or standpipes, tubewells or boreholes, protected wells, protected springs, and treated water from public water treatment plants. Additionally, packaged bottled water and water from water kiosks are also considered as adequate sources. Tanker-trucks, carts with small tanks or drums, and other packaged water like sachet water are also considered reliable sources of safe drinking water (WHO, 2019). In the case of Panama, specific water treatment plant options have been recoded to be included under piped water, acknowledging them as treated water options. On the other hand, sources such as unprotected wells and springs, rainwater collection, surface water from rivers, dams, and lakes, and other unspecified or unknown sources are categorized as inadequate.
Wealth	Wealth index by quintiles in each country. More details about the construction of the index in Martel (2016).
Panel B: DHS Variables	
Age	Age in months (0-59 months).
Area	Categorical variable for urban and rural areas.
Cohort	Year of birth.
Container	Categorical variable for garbage storage in the household: lidded, lidless, plastic bags, and other.
Electricity	Dummy variable indicating if the household has electricity. This variable is only available for a set of 5 countries.
Frequency of collection	Categorical variable for garbage collection frequency: daily, several times a week, weekly, less than weekly, and not collected.
Garbage collection	Dummy variable indicating if a household has garbage collection.
Household characteristics	Set of variables accounting for differences in household wealth. In particular, electricity, sewage, piped drinking water, and ownership of appliances, such as refrigerators.
Household income	Characterization of households as low or high income based on access to services, ownership of appliances, and mother's education.
Mother-level controls	Set of variables including mother's education and mother's head of household status. Mother's education refers to a categorical variable according to the interquartile range of the country distribution in years of education. Mother's head of household status indicates whether the mother is head of household or not.
Region	Categorical variable for administrative level 2 divisions in each country.
Refrigerator	Dummy variable indicating if the household owns a refrigerator.
Sewage	Dummy variable indicating if the dwelling has an indoor toilet.
Sex	Sex categories: male and female.
Sick	Categorical variable indicating if the child has recently been sick with diarrhea, cough, fever, or has not been feeling sick recently.

Stunting	Dummy variable indicating if a child's height-for-age z-score (HAZ) is less than -2 standard deviations, following the WHO standard (WHO, 2009).
Underweight	Dummy variable indicating if a child's weight-for-height z-score (WHZ) is less than -2 standard deviations, following the WHO standard (WHO, 2009).
Water access	Categorical variable for drinking water sources: piped, natural, and other. Other includes bottled water, which can be disaggregated for a subset of surveys.
Wealth	Wealth index by quintiles in each country. More details about the construction of the index in Martel (2016).

Notes: This table presents the description of variables used in the analysis of the correlation between child development indicators and access to infrastructure services. In this study, we employ data from the Multiple Indicators Cluster Survey (MICS) and the Demographic and Health Surveys (DHS) to assess the links between these basic services and ECD and child health. In total, we used data for 18 countries and 36 surveys for the 1991-2019 period.

Table A3: MICS statistics for ECDI analysis

Variable	Type	N	μ	σ	Min	Max
Outcomes and access to infrastructure						
ECDI						
Total	dummy	37,964	0.834	0.372	0.000	1.000
Learning	dummy	37,964	0.970	0.170	0.000	1.000
Literacy/numeracy	dummy	37,964	0.275	0.447	0.000	1.000
Physical	dummy	37,964	0.985	0.123	0.000	1.000
Socio-emotional	dummy	37,964	0.815	0.388	0.000	1.000
Water access	dummy	37,964	0.903	0.296	0.000	1.000
Sanitation access	dummy	37,964	0.913	0.282	0.000	1.000
Water access × Sanitation access	categorical					
0×0		37,964	0.029	0.166	0.000	1.000
1×0		37,964	0.059	0.235	0.000	1.000
0×1		37,964	0.069	0.253	0.000	1.000
1×1		37,964	0.844	0.363	0.000	1.000
Water access	categorical					
Piped water		37,559	0.439	0.496	0.000	1.000
Tubewell or borehole		37,559	0.011	0.106	0.000	1.000
Protected well/spring		37,559	0.034	0.181	0.000	1.000
Unprotected sources		37,559	0.073	0.260	0.000	1.000
Transported water		37,559	0.015	0.123	0.000	1.000
Packaged water		37,559	0.407	0.491	0.000	1.000
Surface water		37,559	0.020	0.139	0.000	1.000
Sanitation access	categorical					
Flush systems		37,795	0.718	0.450	0.000	1.000
Hygienic non-flush		37,795	0.199	0.399	0.000	1.000
Unsanitary systems		37,795	0.030	0.171	0.000	1.000
No facilities		37,795	0.052	0.223	0.000	1.000
Controls						
Age in months	number	37,964	47.645	6.863	35.000	59.000
Cohort	categorical					
2005		37,964	0.006	0.076	0.000	1.000
2006		37,964	0.033	0.180	0.000	1.000
2007		37,964	0.049	0.216	0.000	1.000
2008		37,964	0.051	0.219	0.000	1.000
2009		37,964	0.121	0.326	0.000	1.000
2010		37,964	0.190	0.393	0.000	1.000
2011		37,964	0.141	0.349	0.000	1.000
2012		37,964	0.071	0.256	0.000	1.000
2013		37,964	0.029	0.167	0.000	1.000

Table A3: MICS statistics for ECDI analysis

Variable	Type	N	μ	σ	Min	Max
2014		37,964	0.069	0.253	0.000	1.000
2015		37,964	0.150	0.357	0.000	1.000
2016		37,964	0.091	0.287	0.000	1.000
Electricity	dummy	37,964	0.919	0.272	0.000	1.000
Female	dummy	37,964	0.492	0.500	0.000	1.000
Hands cleanser available	dummy	31,466	0.922	0.267	0.000	1.000
Household members	number	37,964	5.297	2.246	2.000	32.000
Household members ≤ 5	number	37,964	1.478	0.711	1.000	9.000
Mother's education	categorical					
Less than primary		37,964	0.051	0.219	0.000	1.000
Primary		37,964	0.309	0.462	0.000	1.000
Lower secondary		37,964	0.104	0.306	0.000	1.000
Upper secondary		37,964	0.048	0.214	0.000	1.000
Secondary		37,964	0.321	0.467	0.000	1.000
Tertiary/higher/university		37,964	0.163	0.370	0.000	1.000
Vocational/technical		37,964	0.000	0.010	0.000	1.000
Other		37,964	0.001	0.036	0.000	1.000
Stimulation index	categorical	37,951	4.140	1.966	0.000	6.000
Urban area	dummy	37,964	0.470	0.499	0.000	1.000
Water treated for safe drinking	dummy	37,907	0.285	0.451	0.000	1.000
Wealth index quintiles	categorical					
Poorest		37,964	0.313	0.464	0.000	1.000
Second		37,964	0.217	0.412	0.000	1.000
Middle		37,964	0.185	0.388	0.000	1.000
Fourth		37,964	0.157	0.364	0.000	1.000
Richest		37,964	0.128	0.334	0.000	1.000

Notes: This table presents descriptive statistics for the variables from the UNICEF's Multiple Indicators Cluster Survey (MICS). The analysis sample is composed from twelve surveys. In particular, Argentina 2011, Belize 2015, Costa Rica 2018, Dominican Republic 2014, El Salvador 2014, Guyana 2014, Haiti 2016, Jamaica 2011, Mexico 2015, Panama 2013, Paraguay 2016, and Uruguay 2012.

Table A4: MICS statistics for health analysis

Variable	Type	N	μ	σ	Min	Max
Outcomes and access to infrastructure						
Stunting	dummy	67,248	0.116	0.320	0.000	1.000
Underweight	dummy	67,248	0.027	0.163	0.000	1.000
Water access	dummy	67,248	0.866	0.341	0.000	1.000
Sanitation access	dummy	67,248	0.902	0.297	0.000	1.000
Water access × Sanitation access	categorical					
0×0		67,248	0.037	0.188	0.000	1.000
1×0		67,248	0.061	0.239	0.000	1.000
0×1		67,248	0.098	0.297	0.000	1.000
1×1		67,248	0.805	0.396	0.000	1.000
Water access	categorical					
Piped water		66,279	0.459	0.498	0.000	1.000
Tubewell or borehole		66,279	0.014	0.119	0.000	1.000
Protected well/spring		66,279	0.044	0.206	0.000	1.000
Unprotected sources		66,279	0.104	0.306	0.000	1.000
Transported water		66,279	0.013	0.114	0.000	1.000
Packaged water		66,279	0.340	0.474	0.000	1.000
Surface water		66,279	0.024	0.155	0.000	1.000
Sanitation access	categorical					
Flush systems		66,928	0.694	0.461	0.000	1.000
Hygienic non-flush		66,928	0.214	0.410	0.000	1.000
Unsanitary systems		66,928	0.038	0.191	0.000	1.000
No facilities		66,928	0.055	0.227	0.000	1.000
Controls						
Age in months	number	67,248	30.355	17.049	0.000	59.000
Cohort	categorical					
2001		67,248	0.010	0.102	0.000	1.000
2002		67,248	0.017	0.128	0.000	1.000
2003		67,248	0.017	0.130	0.000	1.000
2004		67,248	0.016	0.124	0.000	1.000
2005		67,248	0.019	0.137	0.000	1.000
2006		67,248	0.019	0.135	0.000	1.000
2007		67,248	0.020	0.141	0.000	1.000
2008		67,248	0.022	0.146	0.000	1.000
2009		67,248	0.038	0.191	0.000	1.000
2010		67,248	0.055	0.229	0.000	1.000
2011		67,248	0.075	0.264	0.000	1.000
2012		67,248	0.080	0.271	0.000	1.000
2013		67,248	0.087	0.282	0.000	1.000

Table A4: MICS statistics for health analysis

Variable	Type	N	μ	σ	Min	Max
2014		67,248	0.094	0.292	0.000	1.000
2015		67,248	0.130	0.336	0.000	1.000
2016		67,248	0.097	0.296	0.000	1.000
2017		67,248	0.082	0.275	0.000	1.000
2018		67,248	0.079	0.270	0.000	1.000
2019		67,248	0.041	0.199	0.000	1.000
Electricity	dummy	67,248	0.903	0.296	0.000	1.000
Female	dummy	67,248	0.492	0.500	0.000	1.000
Hands cleanser available	dummy	59,142	0.931	0.253	0.000	1.000
Household members	number	67,248	5.442	2.348	2.000	32.000
Household members ≤ 5	number	67,248	1.499	0.731	1.000	9.000
Mother's education	categorical					
Less than primary		67,248	0.047	0.211	0.000	1.000
Primary		67,248	0.286	0.452	0.000	1.000
Lower secondary		67,248	0.158	0.364	0.000	1.000
Upper secondary		67,248	0.071	0.256	0.000	1.000
Secondary		67,248	0.303	0.459	0.000	1.000
Tertiary/higher/university		67,248	0.130	0.337	0.000	1.000
Vocational/technical		67,248	0.000	0.013	0.000	1.000
Other or non-standard curriculum		67,248	0.002	0.042	0.000	1.000
Stimulation index	categorical	36,760	4.240	1.934	0.000	6.000
Urban area	dummy	67,248	0.506	0.500	0.000	1.000
Water treated for safe drinking	dummy	67,171	0.308	0.462	0.000	1.000
Wealth index quintiles	categorical					
Poorest		67,248	0.313	0.464	0.000	1.000
Second		67,248	0.215	0.411	0.000	1.000
Middle		67,248	0.186	0.389	0.000	1.000
Fourth		67,248	0.161	0.368	0.000	1.000
Richest		67,248	0.126	0.331	0.000	1.000

Notes: This table presents descriptive statistics for the variables from the UNICEF's Multiple Indicators Cluster Survey (MICS). The analysis sample is composed from twelve surveys. In particular, Argentina 2011, Belize 2015, Costa Rica 2018, Dominican Republic 2014, El Salvador 2014, Guyana 2014, Haiti 2016, Jamaica 2011, Mexico 2015, Panama 2013, Paraguay 2016, and Uruguay 2012.

Table A5: DHS statistics

Variable	Type	N	μ	σ	Min	Max
Outcomes and waste management						
Stunting	dummy	118,597	0.251	0.434	0.000	1.000
Underweight	dummy	118,597	0.060	0.237	0.000	1.000
Garbage collection	dummy	118,597	0.442	0.497	0.000	1.000
Controls						
Age in months	number	118,597	29.770	17.216	0.000	59.000
Cohort	categorical					
1986		118,597	0.000	0.021	0.000	1.000
1987		118,597	0.012	0.110	0.000	1.000
1988		118,597	0.014	0.116	0.000	1.000
1989		118,597	0.013	0.112	0.000	1.000
1990		118,597	0.012	0.111	0.000	1.000
1991		118,597	0.014	0.116	0.000	1.000
1992		118,597	0.000	0.020	0.000	1.000
1993		118,597	0.010	0.100	0.000	1.000
1994		118,597	0.017	0.130	0.000	1.000
1995		118,597	0.018	0.134	0.000	1.000
1996		118,597	0.019	0.138	0.000	1.000
1997		118,597	0.029	0.167	0.000	1.000
1998		118,597	0.021	0.143	0.000	1.000
1999		118,597	0.028	0.166	0.000	1.000
2000		118,597	0.043	0.203	0.000	1.000
2001		118,597	0.043	0.204	0.000	1.000
2002		118,597	0.049	0.217	0.000	1.000
2003		118,597	0.068	0.252	0.000	1.000
2004		118,597	0.074	0.263	0.000	1.000
2005		118,597	0.088	0.283	0.000	1.000
2006		118,597	0.108	0.311	0.000	1.000
2007		118,597	0.100	0.300	0.000	1.000
2008		118,597	0.086	0.280	0.000	1.000
2009		118,597	0.072	0.258	0.000	1.000
2010		118,597	0.038	0.192	0.000	1.000
2011		118,597	0.013	0.111	0.000	1.000
2012		118,597	0.006	0.075	0.000	1.000
2013		118,597	0.003	0.058	0.000	1.000
Cough	dummy	118,445	0.376	0.484	0.000	1.000
Diarrhea	dummy	118,450	0.161	0.368	0.000	1.000
Electricity	dummy	118,597	0.757	0.429	0.000	1.000
Female	dummy	118,597	0.492	0.500	0.000	1.000
Fever	dummy	110,652	0.256	0.436	0.000	1.000
Garbage container	categorical					
Lidded		42,199	0.135	0.342	0.000	1.000
Lidless		42,199	0.359	0.480	0.000	1.000

Table A5: DHS statistics

Variable	Type	N	μ	σ	Min	Max
Bags		42,199	0.382	0.486	0.000	1.000
Other		42,199	0.123	0.328	0.000	1.000
Refrigerator		118,597	0.350	0.477	0.000	1.000
Household members	number	118,597	5.962	2.531	2.000	30.000
Household members ≤ 5	number	118,597	1.732	0.859	0.000	10.000
Mother's education quartiles	categorical					
Low		118,597	0.280	0.449	0.000	1.000
Interquartile range		118,597	0.561	0.496	0.000	1.000
Top		118,597	0.159	0.366	0.000	1.000
Mother is head of household	dummy	118,597	0.096	0.294	0.000	1.000
Toilet is inside dwelling	dummy	118,597	0.357	0.479	0.000	1.000
Urban area	dummy	118,597	0.552	0.497	0.000	1.000
Water access	categorical					
Piped water source		118,597	0.616	0.486	0.000	1.000
Nature sources		118,597	0.252	0.434	0.000	1.000
Other		118,597	0.132	0.338	0.000	1.000

Notes: This table presents descriptive statistics for the variables from the Demographic and Health Surveys (DHS). The analysis sample is composed from fourteen surveys. In particular, Bolivia (2003), Colombia (2005, and 2010), Dominican Republic (2007, and 2013), Guyana (1998, and 2005), Nicaragua (1998, and 2001), and Peru (1991, 2004, 2007, 2009, and 2011). Variable definitions are available in Appendix Table A2.

Table A6: Access to infrastructure and the relationship with developmental and health outcomes: harmonizing the sample

Dependent variable	ECDI (dummy)				Stunted (dummy)				Underweight (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Water access (dummy)	0.041***	0.042***	0.030**	0.023	-0.040**	-0.040**	-0.028**	-0.013	-0.001	-0.001	-0.002	-0.002
	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)	(0.011)	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)
R2-squared	0.044	0.057	0.065	0.068	0.066	0.069	0.082	0.089	0.021	0.023	0.023	0.023
Mean of outcome	0.824	0.824	0.824	0.824	0.109	0.109	0.109	0.109	0.023	0.023	0.023	0.023
N	25599	25599	25599	25599	25599	25599	25599	25599	25599	25599	25599	25599
Surveys	14	14	14	14	14	14	14	14	14	14	14	14
Controls												
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Sanitation access (dummy)	0.052***	0.051***	0.032***	0.025***	-0.077***	-0.077***	-0.056***	-0.043***	-0.002	-0.002	-0.002	-0.002
	(0.008)	(0.008)	(0.008)	(0.008)	(0.016)	(0.016)	(0.013)	(0.010)	(0.002)	(0.002)	(0.002)	(0.002)
R2-squared	0.044	0.058	0.065	0.068	0.069	0.072	0.083	0.091	0.021	0.023	0.023	0.023
Mean of outcome	0.824	0.824	0.824	0.824	0.109	0.109	0.109	0.109	0.023	0.023	0.023	0.023
N	25599	25599	25599	25599	25599	25599	25599	25599	25599	25599	25599	25599
Surveys	14	14	14	14	14	14	14	14	14	14	14	14
Controls												
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: This table presents results from a linear probability model for the correlation between the early childhood development index (ECDI) and access to water and sanitation infrastructure. The analysis sample is composed from fourteen surveys included in the Multiple Indicator Cluster Surveys (MICS). The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A7: Access to infrastructure and the relationship with the developmental components of the ECDI

Dependent variable	ECDI learning (dummy)				ECDI physical (dummy)				ECDI socio-emotional (dummy)				ECDI literacy/numeracy (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Water access (dummy)	0.076***	0.078***	0.054***	0.039**	0.004	0.004	0.003	0.003	0.014*	0.015*	0.009	0.006	0.018**	0.019**	0.013*	0.008
	(0.015)	(0.015)	(0.015)	(0.015)	(0.003)	(0.003)	(0.004)	(0.003)	(0.008)	(0.008)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)
R2-squared	0.159	0.197	0.215	0.218	0.008	0.009	0.010	0.011	0.042	0.049	0.052	0.055	0.023	0.026	0.033	0.035
Mean of outcome	0.275	0.275	0.275	0.275	0.985	0.985	0.985	0.985	0.815	0.815	0.815	0.815	0.970	0.970	0.970	0.970
N	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964
Surveys	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Controls																
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)
Sanitation access (dummy)	0.090***	0.088***	0.050***	0.035***	0.004	0.004	0.003	0.002	0.020**	0.019**	0.010	0.006	0.034***	0.034***	0.025***	0.020**
	(0.009)	(0.009)	(0.006)	(0.007)	(0.003)	(0.003)	(0.003)	(0.003)	(0.009)	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)
R2-squared	0.159	0.197	0.215	0.218	0.008	0.009	0.010	0.011	0.042	0.049	0.052	0.055	0.025	0.028	0.033	0.036
Mean of outcome	0.275	0.275	0.275	0.275	0.985	0.985	0.985	0.985	0.815	0.815	0.815	0.815	0.970	0.970	0.970	0.970
N	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964	37964
Countries	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Controls																
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Mother level	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Household characteristics	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: This table presents results from a linear probability model for the correlation between the sub-components of the early childhood development index (ECDI) and access to water and sanitation infrastructure. The analysis sample is composed from 19 surveys included in The Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A3. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A8: Access to infrastructure and the relationship with developmental and health outcomes: wealth and stimulation

Dependent variable	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)
	(1)	(2)	(3)	(4)	(5)	(6)
Water access (dummy)	0.017	-0.009	-0.001	0.011	-0.002	-0.003
	(0.010)	(0.007)	(0.003)	(0.010)	(0.008)	(0.003)
R2-squared	0.067	0.090	0.022	0.065	0.072	0.018
Mean of outcome	0.834	0.117	0.026	0.834	0.116	0.027
N	37951	36760	36760	37964	67248	67248
Countries	19	17	17	19	17	17
Controls						
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Children level	Yes	Yes	Yes	Yes	Yes	Yes
Mother level	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Stimulation index	Yes	Yes	Yes	No	No	No
Wealth quintiles	No	No	No	Yes	Yes	Yes
	(7)	(8)	(9)	(10)	(11)	(12)
Sanitation access (dummy)	0.024***	-0.051***	-0.004	0.018*	-0.032***	-0.003
	(0.007)	(0.013)	(0.003)	(0.009)	(0.007)	(0.002)
R2-squared	0.067	0.092	0.022	0.065	0.073	0.018
Mean of outcome	0.834	0.117	0.026	0.834	0.116	0.027
N	37951	36760	36760	37964	67248	67248
Surveys	19	17	17	19	17	17
Controls						
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Children level	Yes	Yes	Yes	Yes	Yes	Yes
Mother level	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Stimulation index	Yes	Yes	Yes	No	No	No
Wealth quintiles	No	No	No	Yes	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child development and health indicators and access to water and sanitation infrastructure including wealth and stimulation factors as controls. The analysis sample is composed from multiple surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A9: Access to infrastructure and the relationship with developmental and health outcomes: interactions between water and sanitation

	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)
	(1)	(2)	(3)
Water access (dummy)	0.040	-0.010	-0.009*
	(0.026)	(0.016)	(0.005)
Sanitation access (dummy)	0.050*	-0.048***	-0.008**
	(0.025)	(0.011)	(0.003)
Water access × Sanitation access	-0.029	0.000	0.009
	(0.029)	(0.016)	(0.005)
R2-squared	0.063	0.069	0.018
Mean of outcome	0.834	0.116	0.027
N	37964	67248	67248
Countries	19	17	17
Controls			
Country-region-year FE	Yes	Yes	Yes
Children level	Yes	Yes	Yes
Mother level	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child development and health indicators and access to water and sanitation infrastructure including interactions between water and sanitation. The analysis sample is composed from multiple surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A10: Access to infrastructure and the relationship with developmental and health outcomes: mitigation behaviors

Dependent variable	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)
	(1)	(2)	(3)	(4)	(5)	(6)
Water access (dummy)	0.055*	-0.020	-0.008	-0.008	-0.053	-0.020
	(0.028)	(0.019)	(0.005)	(0.067)	(0.033)	(0.015)
Sanitation access (dummy)	0.071***	-0.055***	-0.008*	-0.042	-0.053	-0.015
	(0.024)	(0.015)	(0.004)	(0.057)	(0.039)	(0.016)
Water access × Sanitation access	-0.042	0.007	0.008	0.079	0.017	0.010
	(0.029)	(0.018)	(0.005)	(0.072)	(0.043)	(0.019)
Treats water (dummy)	0.077*	-0.029	0.003			
	(0.038)	(0.017)	(0.010)			
Water access × Treats water	-0.038	0.040	-0.004			
	(0.046)	(0.026)	(0.013)			
Sanitation access × Treats water	-0.066*	0.030	-0.001			
	(0.036)	(0.019)	(0.010)			
Water access × Sanitation access × Treats water	0.040	-0.030	0.003			
	(0.049)	(0.025)	(0.013)			
Cleanser to wash hands (dummy)				0.011	-0.049	-0.018
				(0.035)	(0.029)	(0.018)
Water access × Cleanser to wash hands				0.042	0.051*	0.015
				(0.048)	(0.024)	(0.020)
Sanitation access × Cleanser to wash hands				0.082*	0.017	0.011
				(0.045)	(0.041)	(0.020)
Water access × Sanitation access × Cleanser to wash hands				-0.103*	-0.026	-0.004
				(0.057)	(0.045)	(0.023)
R2-squared	0.064	0.069	0.017	0.065	0.067	0.017
Mean of outcome	0.834	0.116	0.027	0.834	0.114	0.026
N	37907	67171	67171	31466	59141	59141
Countries	19	17	17	17	14	14
Controls						
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Children level	Yes	Yes	Yes	Yes	Yes	Yes
Mother level	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child development and health indicators and access to water and sanitation infrastructure including interactions with mitigation behaviors such as treating water for safe consumption and having hands cleanser available. The analysis sample is composed from multiple surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A11: Access to infrastructure and the relationship with developmental and health outcomes: decomposing water access

Dependent variable	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)
	(1)	(2)	(3)
Piped water sources (base category)			
Tubewell or borehole	-0.051**	0.010	0.000
	(0.021)	(0.010)	(0.005)
Protected well/spring	-0.011	0.014	-0.002
	(0.007)	(0.009)	(0.002)
Unprotected sources	-0.016	0.000	0.002
	(0.012)	(0.010)	(0.003)
Transported water sources	-0.021	-0.001	0.012**
	(0.013)	(0.017)	(0.004)
Packaged water	0.009**	-0.036***	-0.001
	(0.004)	(0.009)	(0.003)
Surface water	-0.053*	0.030**	0.003
	(0.029)	(0.012)	(0.005)
R2-squared	0.064	0.069	0.017
Mean of outcome	0.834	0.116	0.027
N	37559	66279	66279
Countries	19	17	17
Controls			
Country-region-year FE	Yes	Yes	Yes
Children level	Yes	Yes	Yes
Mother level	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child development and health indicators and access to water when decomposing the main water access binary indicator in sub-categories. The analysis sample is composed from multiple surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A12: Access to infrastructure and the relationship with developmental and health outcomes: decomposing sanitation access

Dependent variable	ECDI (dummy)	Stunted (dummy)	Underweight (dummy)
	(1)	(2)	(3)
Flush systems (base category)			
Hygienic non-flush	-0.025***	0.026***	-0.002
	(0.007)	(0.007)	(0.002)
Unsanitary systems	-0.039***	0.048***	-0.001
	(0.011)	(0.007)	(0.004)
No facilities	-0.043***	0.076***	0.002
	(0.013)	(0.013)	(0.003)
R2-squared	0.063	0.070	0.018
Mean of outcome	0.834	0.116	0.027
N	37795	66928	66928
Countries	19	17	17
Controls			
Country-region-year FE	Yes	Yes	Yes
Children level	Yes	Yes	Yes
Mother level	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child development and health indicators and access to sanitation when decomposing the main sanitation access binary indicator in sub-categories. The analysis sample is composed from multiple surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Tables A3 and A4. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A13: Access to infrastructure and the relationship with developmental and health outcomes: a within preferential propensity score matching approach

Dependent variable	ECDI (dummy)	Literacy (dummy)	Physical (dummy)	Soc.-emo. (dummy)	Learning (dummy)	Stunted (dummy)	Underweight (dummy)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Water and sanitation access (dummy)	0.034**	0.059***	0.009	0.025	0.004	-0.024***	-0.002
	(0.015)	(0.010)	(0.009)	(0.019)	(0.006)	(0.007)	(0.006)
R2-squared	0.120	0.253	0.068	0.114	0.053	0.084	0.052
Mean of outcome							
N	60415	60392	60407	60396	60396	107832	107832
Countries	19	19	19	19	19	17	17
Controls							
Country-region-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Children level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mother level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child development and health indicators and access to water when implementing a within preferential propensity score matching approach as proposed by Arpino and Cannas (2016) when having clustered standard errors. The analysis sample is composed from multiple surveys included in the Multiple Indicator Cluster Surveys (MICS). The countries that have been included in this analysis and their respective original sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls account for the mother's education level. Household characteristics controlled for are urban residency status, access to electricity, total household size, and the number of household members who are under five years of age. Variable definitions are available in Appendix Table A2. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A14: Access to waste management infrastructure and the relationship with health outcomes: wealth

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Garbage collection (dummy)	-0.033**	0.001
	(0.011)	(0.003)
Garbage collection × Poorer (vs. poorest)	0.010	-0.001
	(0.012)	(0.003)
Garbage collection × Middle (vs. poorest)	0.031**	-0.001
	(0.011)	(0.003)
Garbage collection × Richer (vs. poorest)	0.041***	0.002
	(0.011)	(0.005)
Garbage collection × Richest (vs. poorest)	0.027*	0.005
	(0.013)	(0.006)
R2-squared	0.154	0.030
N	93916	93916
Surveys	10	10
Mean of outcome	0.218	0.047
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes
Wealth quintiles	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including interactions with wealth quintiles. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A15: Access to waste management infrastructure and the relationship with health outcomes: frequency of garbage collection

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Daily (base category)		
Several times a week	0.011	-0.003
	(0.009)	(0.005)
Weekly	0.013	-0.003
	(0.009)	(0.005)
Less than weekly	0.007	-0.002
	(0.013)	(0.007)
Non-collected	0.029***	-0.001
	(0.005)	(0.005)
R2-squared	0.152	0.032
N	64361	64580
Countries	8	8
Mean of outcome	0.234	0.050
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including a variable that measures the frequency of garbage collection. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A16: Access to waste management infrastructure and the relationship with health outcomes: interactions with other infrastructure services

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Garbage collection (dummy)	-0.043**	-0.002
	(0.019)	(0.016)
Garbage collection × Electricity	-0.002	-0.004
	(0.019)	(0.015)
Garbage collection × Nature (vs. piped water sources)	0.034	-0.012
	(0.023)	(0.016)
Garbage collection × Other (vs. piped water sources)	-0.036	0.012
	(0.041)	(0.027)
Garbage collection × Electricity × Nature	-0.012	0.021
	(0.030)	(0.018)
Garbage collection × Electricity × Other	0.075*	-0.011
	(0.042)	(0.024)
Garbage collection × Sewage	-0.085*	-0.001
	(0.040)	(0.016)
Garbage collection × Electricity × Sewage	0.115**	0.003
	(0.047)	(0.016)
Garbage collection × Other × Sewage	0.347***	-0.033
	(0.060)	(0.100)
Garbage collection × Electricity × Nature × Sewage	-0.134	-0.069
	(0.181)	(0.073)
Garbage collection × Electricity × Other × Sewage	-0.357***	0.040
	(0.062)	(0.096)
R2-squared	0.182	0.049
N	118597	118597
Countries	14	14
Mean of outcome	0.251	0.060
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including interactions with access to other infrastructure services such as electricity, water, and sewage. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A17: Access to waste management infrastructure and the relationship with health outcomes: refrigeration as a mitigation factor

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Garbage collection (dummy)	-0.046***	-0.009***
	(0.006)	(0.003)
Garbage collection × Refrigerator (dummy)	0.047***	0.013***
	(0.008)	(0.004)
R2-squared	0.182	0.049
N	118597	118597
Countries	14	14
Dep. Var. Mean	0.251	0.060
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including interactions with the ownership of a refrigerator. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The countries that have been included in this analysis and their respective sample sizes can be found in Appendix Table A1. The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A18: Access to waste management infrastructure and the relationship with health outcomes: bottled water as a mitigation factor

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Garbage collection (dummy)	-0.030***	-0.003
	(0.009)	(0.002)
Garbage collection × Nature (vs. piped water sources)	0.002	0.002
	(0.011)	(0.004)
Garbage collection × Bottled water (vs. piped water sources)	0.055***	0.012*
	(0.013)	(0.005)
Garbage collection × Other (vs. piped water sources)	0.002	-0.007
	(0.015)	(0.008)
R2-squared	0.166	0.036
N	92507	92507
Countries	10	10
Dep. Var. Mean	0.220	0.050
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including interactions with the source of drinking water. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A19: Access to waste management infrastructure and the relationship with health outcomes: lidded containers as a mitigation factor

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Garbage collection (dummy)	-0.003	-0.003
	(0.008)	(0.006)
Garbage collection × Lidless (vs. lidded)	-0.040	0.008
	(0.021)	(0.007)
Garbage collection × Bags (vs. lidded)	-0.016	0.003
	(0.010)	(0.007)
Garbage collection × Other (vs. lidded)	-0.036*	-0.019
	(0.015)	(0.011)
R2-squared	0.170	0.038
N	42199	42199
Countries	5	5
Dep. Var. Mean	0.269	0.048
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including interactions with garbage container types prior to collection. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard error are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A20: Access to waste management infrastructure and the relationship with health outcomes: health channels

Dependent variable	Stunted (dummy)	Underweight (dummy)
	(1)	(2)
Garbage collection (dummy)	-0.024***	0.003*
	(0.004)	(0.002)
Garbage collection × Diarrhea (dummy)	0.011*	-0.010*
	(0.006)	(0.005)
Garbage collection × Cough (dummy)	-0.004	-0.008**
	(0.007)	(0.003)
Garbage collection × Fever (dummy)	-0.007	-0.007**
	(0.005)	(0.003)
R2-squared	0.172	0.049
N	110647	111124
Countries	13	13
Dep. Var. Mean	0.241	0.057
Controls		
Country-region-year FE	Yes	Yes
Children level	Yes	Yes
Mother level	Yes	Yes
Household characteristics	Yes	Yes

Notes: This table presents results from a linear probability model for the correlation between child health indicators and access to waste management infrastructure including interactions with recent child illness episodes such as diarrhea, cough, and fever. The analysis sample is composed from surveys included in the Demographic and Health Surveys (DHS). The analysis controls for fixed effects at the country-region-year level. Additional controls at the child level include age (in months), birth cohort, and sex. Mother-level controls take into account the mother's education level and whether she is the head of the household. Household characteristics include urban residency status, access to electricity, water, sewage, total household size, and number of members under five years old. Variable definitions are available in Appendix Table A2 and summary statistics in Appendix Table A5. Survey clustered standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).