Closing the Rural-Urban Gap in Child Malnutrition: Evidence from Paraguay, 1997-2012

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Closing the Rural-Urban Gap in Child Malnutrition: Evidence from Paraguay, 1997-2012

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Abstract

Between 1997 and 2012, Paraguay achieved not only remarkable improvements in child nutrition, but also a surprising elimination of the rural-urban differential in child height-for-age Z score (HAZ) and stunting. Our decomposition analysis, applied to four rounds of Paraguayan National Household Surveys, allows us to directly infer not only the contributions of changes in determinants of child nutritional status to the improvements in child nutritional status in rural and urban areas, but also their contribution to closing the rural-urban gap. We find that while common determinants of child nutritional status such as income, maternal education, sanitation, and access to piped water are strongly associated with improvements in child nutrition, they have contributed little to reducing the rural-urban gap (10%, $p<0.05$). Improvements in health care utilization, family planning, and demographics have been the main drivers in closing the rural-urban gap in child nutritional status in Paraguay (32%, $p<0.05$). The results highlight the potential need for multipronged nutritional strategies that consider the distinct needs of rural and urban communities.

Keywords: Nutrition Policy, Height-for-Age, Stunting, Rural-Urban Disparities, Latin America

JEL Codes: I12, I15, I18

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1 Introduction

Numerous studies document the existence of various health disparities between rural and urban areas (Liu et al. 2013; Paciorek et al. 2013; Pong et al. 2009; Van de Poel et al. 2007). Yet, little is known about rural-urban differences in child nutrition and health, how these differences change over time, and especially the role played in this change by different demographic and socio-economic factors. This in spite of the fact that, as Van de Poel et al. (2007) so eloquently put it, "understanding the *nature* and the *causes* of rural-urban disparities is essential in contemplating the health consequences of the rapid urbanization taking place throughout the developing world and in targeting resources appropriately to raise population health."

In this study, we analyze the factors associated with changes in the rural-urban differential, or rather the rural-urban gap, in child nutritional status in Paraguay, a country that between 1997 to 2012 managed to eliminate the rural-urban gap in child malnutrition. Table 1 summarizes the changes in two indicators of child nutritional status in Paraguay during this period: height-for-age z-scores (HAZ) and stunting prevalence.[1] This table makes immediately clear the striking reduction of the rural-urban gap in child HAZ and stunting.[2] The rural-urban gap in HAZ scores decreased by 0.29 standard deviation (almost 64%) over the period, reaching a difference of only 0.16 in 2012, a difference that was no longer statistically significant. Even more remarkably, the rural-urban gap in stunting decreased by 9.45 percentage points (almost 120%), and reversed by 2012 with urban children more likely to be stunted than rural children.

We hypothesize that improvements in a number of drivers of child nutritional status commonly found in the existing literature and available in the Paraguayan household surveys

[1] HAZ scores are calculated using the 2006 World Health Organization growth standards (WHO 2006; Vidmar et al. 2013). Stunting prevalence is defined as the percentage of the population of children under 5 with a HAZ score < -2. The underlying child anthropometric data come from several rounds of Paraguayan household surveys, described in more detail in the Data and Methods section.

[2] Our study is partially based on Ervin (2016), who documented the closing of the rural-urban gap in child nutrition in Paraguay.

Table 1. Changes in mean HAZ and stunting prevalence: 1997 to 2012

Sample	Mean HAZ			HAZ	Stunting (%)			Stunting
	National	Rural	Urban	RU Gap	National	Rural	Urban	RU Gap
1997	−0.77	−0.99	−0.53	−0.45***	14.4	18.26	10.26	8.00***
2000	−0.80	−1.07	−0.50	−0.57***	17.31	22.66	11.62	11.04***
2005	−0.85	−1.03	−0.70	−0.33***	18.34	23.10	14.42	8.68***
2012	−0.49	−0.57	−0.41	−0.16	11.28	10.50	11.95	−1.45
Change[a]	0.29***	0.41***	0.12	0.29**	−3.18*	−7.76***	1.69	−9.45***
% Change[a]	−37.05	−41.79	−23.34	−63.58	−21.98	−42.50	16.52	−118.09

Notes: [a]From 1997 to 2012. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Significance tests of changes based on village-clustered robust standard errors. Height-for-age Z score is denoted as HAZ. Stunting (%) is defined as the percentage of the population of children under 5 with a HAZ score <-2. "RU Gap" denotes Rural-Urban Gap. Statistics calculated with sample weights. Source: Authors' calculations.

can explain a significant part of the closing of the rural-urban gap in child nutrition in Paraguay. In addition to the well-known effects of income on nutrition (Behrman and Deolalikar 1987; Haddad et al. 2003; Headey 2013; Heltberg 2009; Smith and Haddad 2000), there is a growing number of studies that link nutrition outcomes to education (Glewwe 1999; Headey 2013), demography and family planning (Behrman 1988; Horton 1988; Rutstein 2005), gender empowerment (Lépine and Strobl 2013; Imai et al. 2014; Malapit et al. 2015), improved sanitation (Freeman et al. 2017), and health service utilization (Headey 2013). The basis for including such factors in our analysis is the UNICEF (1990) framework, updated by Black et al. (2013), which has become the foundation of a large literature investigating the drivers of improvements in child nutrition outcomes (Headey et al. 2015; Headey and Hoddinott 2015; Zanello et al. 2016; Headey et al. 2017).

Our study seeks to contribute to a growing literature analyzing improvements in child nutritional status in countries that have achieved rapid and/or significant reductions in child stunting and improvements in child stature (Liu et al. 2013; Headey et al. 2015; Zanello et al. 2016).[3] However, we extend these studies to investigate rural-urban differences in child nutritional status and the factors associated with changes in the rural-urban gap in child nutrition. Paciorek et al. (2013) investigated changes in rural and urban child nutrition in 141 countries, but their analysis used regional aggregates and did not explore the effect of changes

[3]Liu et al. (2013) investigate the significant decline in rural and urban health and nutritional disparities in China over 1989-2006; Headey et al. (2015) analyze the factors associated with rapid reduction in the rate of child undernutrition in Bangladesh during 1997-2011; and, Zanello et al. (2016) analyze Cambodia's success in reducing stunting during 2000-2014.

in socioeconomic determinants on changes in rural and urban child nutrition. Furthermore, in contrast to other studies that employ decomposition techniques to investigate national and/or regional improvements in child nutrition (Spears 2013; Cavatorta et al. 2015; Headey et al. 2015; Vyas et al. 2016; Zanello et al. 2016), we extend the decomposition to directly infer the contributions of changes in determinants of child nutritional status to the closing of the rural-urban gap.[4]

Table 2 summarizes the changes in mean determinants of child nutritional status included in our analysis.[5] These include education variables (maternal and paternal education), sanitation variables (proportion of households with piped water, proportion of households with flush toilet, and proportion of households with dirt floor), health services utilization variables (proportion of children born in hospital, proportion of children with health insurance, and proportion of children with delayed vaccines), and family planning and feeding practice variables (proportion of children breastfed at birth, birth interval between children, birth order, and the proportion of households with caretakers under the age of 20). Table 2 shows improvements in nearly every determinant for rural households, while only eight of the thirteen determinants improved for urban households. Importantly, Table 2 also documents significant reductions in rural-urban gaps across most of the determinants. Income growth, reductions of houses with dirt floors, a shortening of birth order, and improvements in nearly all health-care utilization variables were all much faster in rural areas compared to urban areas.[6]

[4]A handful of local studies analyzed the nutritional status of children under the age of 5 conditional on socio-economic characteristics and area of residence (Sanabria et al. 2000; Sanabria and Sánchez Bernal 2001; Sanabria 2003; Morinigo et al. 2015). A small literature has also analyzed the nutritional situation of indigenous children and children of afro-descent (Echagüe et al. 2016; Sánchez Bernal et al. 2017). Finally, Acevedo et al. (2004) investigated the prevalence and epidemiological characteristics of severe forms of malnutrition. However, none of these studies investigated rural-urban differences in child nutrition, nor changes in the rural-urban gap.

[5]Definition of these is provided in Table A1 in Appendix A.

[6]Additional descriptive statistics for the determinants of child nutrition disaggregated by year and rural/urban area can be found in Tables A3, and A4 in Appendix A. It is worth taking a moment to discuss apparently disparate and unequal evolution in the mean determinants of child nutrition, nutritional indicators (both HAZ and stunting which deteriorated between 1997 and 2005 and only started to improve in 2005), and the rural-urban gap in both nutritional indicators, as documented in these two tables. There are two forces in play that need to be considered. The first one has to do with economic growth (and income): the

Table 2. Changes in mean determinants of child nutrition by area in Paraguay, 1997 to 2012

Variable	Rural Mean 1997	Rural Mean 2012	Change 1997-2012	Urban Mean 1997	Urban Mean 2012	Change 1997-2012	Change RU Gap
Income[a]	3.896	6.125	2.229***	10.818	10.596	−0.222	2.451**
Maternal education	5.316	7.779	2.464***	8.528	10.404	1.876***	0.588
Paternal education	5.264	7.203	1.940***	8.434	10.098	1.664***	0.276
Piped water	0.104	0.417	0.313***	0.494	0.757	0.263***	0.050
Flush toilet	0.170	0.442	0.272***	0.670	0.879	0.209***	0.063
Dirt floor	0.551	0.358	−0.192***	0.114	0.078	−0.036	−0.156**
Delayed vaccines	0.566	0.374	−0.193***	0.464	0.363	−0.102***	−0.091*
Health insurance	0.053	0.143	0.090***	0.284	0.297	0.013	0.077**
Born hospital	0.470	0.877	0.407***	0.762	0.965	0.203***	0.204***
Breastfed at birth	0.705	0.849	0.144***	0.778	0.817	0.038	0.105**
Birth interval	3.337	4.724	1.388***	4.044	4.965	0.920***	0.467
Birth order	3.690	2.692	−0.998***	2.894	2.391	−0.502***	−0.496**
Caretaker under 20	0.041	0.034	−0.007	0.024	0.011	−0.013*	0.006

Notes: [a]In one hundred thousand 2011 constant Paraguayan Guaranís. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Significance tests of changes based on village-clustered robust standard errors. "RU Gap" denotes Rural-Urban Gap. Statistics calculated with sample weights. Source: Authors' calculations.

We identify two broad sources of nutritional change that likely played important roles in the observed improvements in the nutritional determinants: strong economic growth and notable policy changes. Over the period of our study, the Paraguayan economy underwent dramatic changes, spurred by rapid and inclusive economic growth, policy reforms, and increases in social spending (World Bank 2010, 2014). These changes translated into income growth that was especially pro-poor.[7] The poverty rate in Paraguay fell from 40.6% in 1997 to 31.4% in 2012, while the Gini index fell from 54.9 to 47.6 over the same period(World Bank 2010).[8]

high growth achieved in Paraguay during the period starting in 2003 started off with a slow recovery from the 1997-2002 period of low growth (World Bank 2014). The average real per capita household income, an important determinant of child nutrition, continued to decrease well into 2005, even as the economy was already growing. Furthermore, this period was also characterized by moderate reduction in extreme poverty and persistently high inequality, especially in urban areas. It is thus not surprising to see the child nutritional outcomes deteriorating over the period (and possibly well beyond 2005 for urban areas). At the same time, despite the developments at the macro levels, the (mean) determinants of child (excl. income) experienced improvements year-over-year during the 1997-2012 period, albeit to a different degree, both in rural and urban areas, resulting in differential evolution of rural-urban gap; see also the following footnote. As a result, we see that the rural-urban gap started to improve already in 2000.

[7]The disproportionate increase in rural income relative to urban income is due to two factors: first, a strong job creation coupled with a large increase in average agricultural incomes, and, second, a significant movement towards wage employment both agriculture (larger farms) and non-agriculture (mostly construction, transport and public and private services) generating alternative sources of income which could be more profitable and stable (World Bank 2010, 2014). In addition, non-labor incomes (including family transfers and public transfers from social programs such as Tekoporã and Adultos Mayores, discussed further in the text) have played an important role.

[8]Several studies have shown a negative association between inequality and anthropometric outcomes (Larrea and Kawachi 2005; Hong 2007; Undurraga et al. 2016).

Coinciding with rising incomes was an increase in social spending and the creation of major nutritional and social assistance programs. In 2005, the government of Paraguay created the Integrated Nutritional Food Program (also known as PANI), along with the conditional cash transfer programs, Tekoporã and Abrazo. PANI provides nutritional assistance and support to children and pregnant women at risk of malnutrition.[9] The conditional cash transfer programs seek to eliminate the intergenerational transmission of poverty by improving child health and education by providing monetary assistance conditional on hospital check-ups, vaccinations, and school enrollment and attendance.[10] While these programs expanded over the period of our study, by all accounts they remain small.[11]

A number of important policy changes also took place over the period of our analysis. In 2008, the Paraguayan government began emphasizing primary health care as the focal point of the national health system (WHO 2012). Accompanying this was an increase in health expenditures from 3% to 3.8% of GDP and the development of a network of family health units, which offered free access to health services to more than two million people and expanded rapidly into rural areas.[12] At the same time, health campaigns emphasized sexual health, leading to an increased awareness of safe sex and contraception among adolescents and young adults. Contraceptive use increased to 80% by 2008, while the fertility rate significantly decreased.[13] Paraguay also made significant progress in infrastructure development, especially

[9]Additional information about the PANI program can be found at the website of the National Institute for Diet and Nutrition (Instituto Nacional de Alimentación y Nutrición, or INAN), which runs the PANI program (available in Spanish).

[10]Additional information about the Tekoporã program is available at the website of the Secretariat for Social Action (SAS) and on the Abrazo program at the website of the National Secretariat for Children and Adolescents (SNNA).

[11]World Bank (2010) estimates showed that Tekoporã and Pro País (another, smaller social program) together disbursed Gs. 120,000 million in 2009, or 0.172 percent of GDP, barely above one tenth of the sum necessary to eradicate extreme poverty if there were perfect targeting.

[12]The number of family health units - staffed by health teams made up of a physician, a registered nurse, a nurse's aide, and community health workers - has continually increased. As of the end of 2010, there were 503 units serving approximately 2,012,000 people (or 22.8% of the population). By 2011, the number of units increased by 40%, covering a total of 2,467,000 people.

[13]Analysis of the 2008 National Demographic Survey shows that, while only 53% of women in urban areas and 33.5% in rural areas used contraceptive in 1990, by 2008 contraceptive use reached 80% in urban areas and 79% in rural areas (CEPEP 2009). Fertility rate decreased from 4.3 children during the 1995 to 1998 period to 2.5 children during the 2005 to 2008 period.

in access to clean water and sanitation. Adoption of a subsidized community-led service management system helped improve water access so that by the end of 2012, 73% of the country's rural population had access to safe water, compared with just 26% in 1997. Similarly, rural households with flush toilets increased from 23% to 76% over the same period. Finally, education reforms in 1994 expanded mandatory and free education from 6 to 9 years, contributing to increases in educational attainment.

Our study provides evidence that many of the positive developments that took place in Paraguay over the period of our study likely had a positive effect on improving child nutrition within rural and urban areas. Indeed, many of the key factors commonly found in existing studies of child nutritional improvements, such as income growth, improved access to safe water and advanced sanitation, and higher maternal education, are all strongly related to improvements in child nutrition status. However, and surprisingly, they have not been the key factors associated with closing of the rural-urban gap in child nutritional status in Paraguay. Health care utilization, family planning, and demographics have contributed to approximately 35% (30%) of the reduction in the rural-urban gap in child stature (stunting), while income, maternal education, and access to piped water and flush toilet account for about 21% (6%) of the same reduction. The importance of health care utilization, family planning and demographics in closing the rural-urban gap in child malnutrition is robust to a number of alternative specifications. Our models tend to perform very well at explaining both nutritional change over time and the closing of the rural-urban gap, accounting for 66% (48%) of the reduction in the rural-urban gap in child stature (stunting).

2 Data and Methods

We use data collected from the only known household surveys in Paraguay that collect child anthropometric data and are comparable across survey rounds. These are the Permanent Household Surveys (EPH) of 1997-98, 2000-01, 2005, and the Household Income and Expenditure Survey (EIG) of 2011-12.[14] All surveys are nationally and sub-nationally representative and contain modules on household demographics, household amenities, income and asset holdings, as well as child anthropometrics and caring practices for children under 5 years of age.[15] All definitions of the intermediate determinants used in this study are provided in Table A1 in Appendix A. The corresponding descriptive statistics can be found in Table A2 (Appendix A).

After restricting our sample to children under the age of 5, for which anthropometric data are available, we obtain a sample of 10,118 children, of which 2,672 children (57% rural and 42% urban) come from the 1997-1998 round, 4,006 children (49% rural and 51% urban) come from the 2000-2001 round, 1,699 children (50% rural and 50% urban) come from the 2005 round, and 1,741 children (42% rural and 58% urban) come from the 2011-2012 round.[16]

To investigate the relationship between child nutritional outcomes and the intermediate determinants, we employ linear regression models and linear probability models.[17] We represent this relationship as

$$N_{i,t} = \boldsymbol{\beta} \boldsymbol{X}_{i,t} + \varepsilon_{i,t}. \tag{1}$$

The vector of coefficients $\boldsymbol{\beta}$ can be consistently estimated by Equation 1 if the error term, $\varepsilon_{i,t}$, is uncorrelated with the explanatory variables. Omitted variable bias and simultaneity bias are two potential challenges to estimating consistent coefficients.

[14]We note that the acronyms EPH and EIG are from the Spanish names of surveys. These are the Encuesta Permanente de Hogares and Encuesta de Ingresos y Gastos, respectively. The datasets are publicly available from the http://www.dgeec.gov.py. The Multiple Indicator Cluster Survey (MICS 2016), released by UNICEF in late 2017, also contains child anthropometric and health data for Paraguay. However, due to different survey design (incl. missing information on income and child insurance) and sampling methodologies (incl. additional stratification based on the presence of children under 5), this survey is not directly comparable to the Paraguayan household surveys, and hence is not used in this study.

[15]The EIG is identical to the EPH, but contains additional modules on household consumption, expenditure, and subjective wellbeing. To investigate whether the additional modules may have affected responses, we compared means of all the variables common to the EIG 2011/2012 and the EPH 2011 (DGEEC 2012), such as income, parental education, household characteristics, amenities, and composition, and found no statistical differences in any of the variables. See Table A7 in Appendix A.

[16]Appendix B examines the potential impact of rural-urban migration on child nutritional status.

[17]All analyses were performed in STATA™ 14.2 for Windows.

Omitted variable bias may occur when confounding factors are not adequately controlled for in the analysis. Important omitted explanatory variables could include access to markets and food prices, healthcare facilities, and additional infrastructure or environmental characteristics that affect child health and nutrition. To deal with potential omitted variables, we include a full set of indicators for each location and survey year in Equation 1, which has the benefit of controlling for every factor common to children in the region during the survey year.[18] Unfortunately, the household survey data don't include information on participation in food or conditional cash transfer programs and, thus, we were unable to control for these programs.[19]

Simultaneity bias may occur when dependent variables and explanatory variables are jointly determined. This is most likely to be the case with fertility decisions and health investments (Becker 1960). However, income may also be partly determined by child nutritional status if, for example, household members base their work decisions in part on the nutritional status of the children. In principle, if instrumental variables are available, they can be used to remove simultaneity bias. A shortcoming of our study is that we could not find suitable instruments. Thus, we note that Equation 1 provides an explanation of child nutritional status in a statistical sense, without necessarily clarifying the causal effects. We also estimate additional alternative models that exclude potentially endogenous variables.

An additional assumption of Equation 1 is that the linear functional form is correctly specified. To this end, we used graphical, non-parametric methods to explore non-linear relationships between HAZ and continuous explanatory variables. Most continuous explanatory variables exhibit approximate linear relationships. However, we adopted a flexible specification of monthly child age dummies to capture the growth faltering process that malnourished populations undergo until around two years of age (Shrimpton et al. 2001; Rieger and Trommlerová 2016), which we observe in our data. Specifications of log income

[18] We also explore fixed effects models at the village-survey level (see Table C4 in Appendix C). But due to similar results and for parsimony, we preferred indicators for departments and survey years.

[19] The authors held two high-level meetings with the National Institute of Food and Nutrition (INAN) to explore the availability of administrative data that could be used to link the food program to child nutritional outcomes. INAN officials confirmed that such information is not available.

and log birth interval were chosen to better capture observed non-linear relationships. When estimating models of stunting, we chose a dichotomous indicator for income (Income>400,000 Guaranís, approximately equal to the poverty line), because children in households with less than 400,000 Guaranís per capita exhibited a noticeable increase in stunting, but above this level additional income increases were not associated with reduced stunting.[20] Finally, we explored non-linear probability models of stunting and observed similar estimated marginal effects between linear and non-linear models. Ultimately, we preferred the linear probability model, due to its ease of interpretation.[21]

Once we have estimated Equation 1, we perform a decomposition analysis of the changes in rural and urban nutritional status and determine the contribution of individual determinants to changes in the rural-urban gap. Under the assumption that the vector of coefficients $\boldsymbol{\beta}$ is area and time invariant and the expectation of the error term $\varepsilon_{i,t}$ is zero, the expected change in the rural-urban gap over the time period of our sample is given by the equation

$$\begin{aligned}
\Delta \text{GAP} &= \text{GAP}_{2012} - \text{GAP}_{1997} \\
&= (\bar{N}^R_{t=2012} - \bar{N}^U_{t=2012}) - (\bar{N}^R_{t=1997} - \bar{N}^U_{t=1997}) \\
&= \boldsymbol{\beta}\left(\bar{\boldsymbol{X}}^R_{t=2012} - \bar{\boldsymbol{X}}^U_{t=2012}\right) - \boldsymbol{\beta}\left(\bar{\boldsymbol{X}}^R_{t=1997} - \bar{\boldsymbol{X}}^U_{t=1997}\right) \\
&= \boldsymbol{\beta}\left(\bar{\boldsymbol{X}}^R_{t=2012} - \bar{\boldsymbol{X}}^R_{t=1997}\right) - \boldsymbol{\beta}\left(\bar{\boldsymbol{X}}^U_{t=2012} - \bar{\boldsymbol{X}}^U_{t=1997}\right) \\
&= \Delta \bar{N}^R - \Delta \bar{N}^U
\end{aligned} \tag{2}$$

where bars represent sample means and superscripts R and U indicate rural and urban areas. Equation 2 shows that the expected change in the gap can be decomposed into either the expected changes in rural and urban areas over time or into the expected changes in the rural-urban gaps observed in the individual years. Due to the rapid increase in rural nutrition over this time period, as an intermediate step, we investigate factors associated with nutritional improvements in rural and urban areas over time and relate changes in these

[20] See Table A9 in Appendix A for regression results of stunting using the continuous income variable.

[21] See Table A8 in Appendix A.

factors to the change in the rural-urban gap. Finally, summing over k intermediate factors, we can rewrite Equation 2 in summation notation as

$$\begin{aligned}\Delta\text{GAP} &= \sum_k \beta_k \left[(\bar{x}^R_{k,t=2012} - \bar{x}^U_{k,t=2012}) - (\bar{x}^R_{k,t=1997} - \bar{x}^U_{k,t=1997})\right] \\ &= \sum_k \Delta\text{GAP}_k.\end{aligned} \tag{3}$$

The contribution of an individual intermediate determinant, j, to the change in the overall rural-urban gap is then provided by

$$\phi_j = \frac{\Delta\text{GAP}_j}{\Delta\text{GAP}}. \tag{4}$$

Equation 2 is derived assuming the coefficients in $\boldsymbol{\beta}$ are time and area invariant. If the coefficients are not time and area invariant, then an Oaxaca-Blinder type decomposition is necessary to decompose changes in the rural-urban gap into changes in the means of the determinants and changes in the coefficients across time and area (Oaxaca 1973; Blinder 1973; Jann 2008). If there is a high-degree of parameter stability across time and area, then such a decomposition is equivalent to Equation 2. Existing studies have found a high degree of parameter stability in similar explanatory variables of child HAZ across time and area (Headey et al. 2015; Srinivasan et al. 2013). Nevertheless, we investigate parameter stability with a series of statistical tests to test for differences in the coefficients on the intermediate determinants of interest across time and area (Chow 1960) and find a high degree of parameter stability. We discuss this further in Appendix C.

3 Results and Discussion

Table 3 reports the main regression results for child HAZ and stunting using ordinary least squares (OLS) and linear probability models (LPM), respectively. The pooled results are based on estimating Equation 1 on the pooled sample of all survey rounds from 1997 to 2012, while urban and rural results are based on the urban and rural sub-samples of the pooled data. All regressions include a number of controls for child demographics, characteristics of household adults, and location-year indicators, which are omitted from Table 3 for brevity.

Table 3. Regression models of child HAZ and stunting by region in Paraguay

Model:	OLS[a]			LPM[b]		
	HAZ	HAZ	HAZ	Stunted	Stunted	Stunted
Variable	Pooled	Rural	Urban	Pooled	Rural	Urban
Income[c]	0.068**	0.054	0.099**	−0.036***	−0.022	−0.060***
	(0.029)	(0.039)	(0.041)	(0.013)	(0.017)	(0.019)
Maternal education	0.032***	0.025***	0.034***	−0.004***	−0.005*	−0.003
	(0.006)	(0.010)	(0.008)	(0.002)	(0.003)	(0.002)
Paternal education	0.003	0.013	−0.009	−0.000	−0.004	0.003*
	(0.006)	(0.009)	(0.008)	(0.002)	(0.003)	(0.002)
Piped water	0.095*	0.161**	0.041	−0.005	−0.010	0.004
	(0.056)	(0.082)	(0.074)	(0.014)	(0.024)	(0.018)
Flush toilet	0.156***	0.023	0.267***	−0.010	0.023	−0.044*
	(0.059)	(0.070)	(0.088)	(0.016)	(0.020)	(0.024)
Dirt floor	−0.153***	−0.210***	−0.057	0.059***	0.056***	0.063**
	(0.051)	(0.060)	(0.097)	(0.017)	(0.020)	(0.032)
Delayed vaccines	−0.068*	−0.066	−0.086	0.020*	0.026*	0.015
	(0.037)	(0.045)	(0.058)	(0.010)	(0.014)	(0.014)
Health insurance	0.162***	0.245***	0.121*	−0.044***	−0.052***	−0.043***
	(0.055)	(0.094)	(0.064)	(0.012)	(0.019)	(0.015)
Born hospital	0.181***	0.143***	0.245***	−0.047***	−0.040**	−0.057***
	(0.040)	(0.051)	(0.067)	(0.013)	(0.018)	(0.020)
Breastfed at birth	0.078	−0.027	0.183***	−0.028**	−0.004	−0.046**
	(0.050)	(0.066)	(0.070)	(0.013)	(0.018)	(0.019)
ln(Birth interval)	0.171***	0.181***	0.144***	−0.042***	−0.061***	−0.021**
	(0.027)	(0.037)	(0.038)	(0.008)	(0.013)	(0.010)
Birth order	−0.041***	−0.032*	−0.062***	0.009*	0.011*	0.009
	(0.014)	(0.018)	(0.020)	(0.005)	(0.007)	(0.007)
Caretaker under 20	−0.320***	−0.358***	−0.272	0.007	0.018	−0.010
	(0.103)	(0.125)	(0.165)	(0.036)	(0.048)	(0.043)
Female	0.083**	0.075*	0.094*	−0.020**	−0.005	−0.035**
	(0.033)	(0.042)	(0.048)	(0.009)	(0.012)	(0.014)
Head Guaraní	−0.039	−0.046	−0.071	0.009	0.004	0.024
	(0.057)	(0.095)	(0.069)	(0.015)	(0.028)	(0.018)
Head bilingual	−0.032	−0.177	0.002	0.013	0.031	0.017
	(0.059)	(0.121)	(0.064)	(0.014)	(0.031)	(0.016)
Head other language	0.452***	0.490***	0.261*	−0.073***	−0.097**	−0.020
	(0.116)	(0.150)	(0.142)	(0.026)	(0.038)	(0.036)
Observations	10118	5068	5050	10118	5068	5050
Adjusted R^2	0.196	0.212	0.163	0.098	0.112	0.089

Notes: [a]OLS is Ordinary Least Squares. [b]LPM is linear probability model. [c]Income is the natural log of income in the OLS HAZ models and an indicator of Income>400,000 Guaranís in the LPM stunted models. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. See Table A6 in Appendix A for results without sample weights. Source: Authors' calculations.

We first discuss the results of estimation of the OLS HAZ model. As the parameter estimates (including their signs and magnitudes) show a high level of agreement between rural and urban sub-samples, we focus our discussion generally only on the pooled samples.

The average marginal effect of income on HAZ suggests that a 300,000 Guaraní increase in real monthly per capita income ($60 USD at an exchange rate of 5,000 Guaranís per USD) is associated with a 0.09 standard deviation increase in the predicted HAZ score.[22] In elasticity terms, a 10% increase in real income yields approximately a 1% increase in the predicted HAZ score. For maternal education, we find that an extra year of schooling adds a 0.03 standard deviation to predicted HAZ score. This suggests that a child whose mother has completed 9 years of schooling (equivalent to the 9 years of obligatory Basic School education in Paraguay) could be expected to be around 0.29 standard deviations taller than a child whose mother had not attended school. The estimated parameter on paternal education is small and typically not statistically significant at conventional levels.

In terms of infrastructure variables, we find that the presence of flush toilet as well as the presence (or absence) of dirt floor in the household are both strongly associated with linear growth outcomes. In particular, whereas a flush toilet improves HAZ score by approximately 0.16 standard deviations, a dirt floor yields a 0.15 standard deviation deterioration in child's height. It is of note that, at the rural/urban level, a flush toilet is only significant in urban areas, whereas a dirt floor is only significant in rural areas. The latter result suggests the possible role of dirt floors as indirect measures of pathogen prevalence and transmission in the child nutrition outcomes in rural areas (Cattaneo et al. 2009).[23] At the same time, the fact that a dirt floor turns out to be insignificant in the urban sample may be due to a relatively low percentage of urban households with dirt floors (7.8% in 2012; see Table 2), resulting in lower probability of disease transmission. In contrast to sanitation, we find only a marginally significant effect of piped water on growth outcomes. Additionally, we note that piped water,

[22] In the OLS HAZ model, income is transformed to the natural log of income. The average marginal effect is calculated as the mean of $\frac{\hat{\beta}_{inc}}{x_{inc}}$, where $\hat{\beta}_{inc}$ is the estimated parameter on the natural log of income and x_{inc} is untransformed observed income. The increase in real monthly per capita income of 300.000 Guaranís is equivalent to about one fifth of the minimum salary of 1,658,232 Guaranís as of April 2011.

[23] Dirt floor may be a proxy for extreme poverty. To investigate this possibility, we ran regressions by income levels and found the presence of dirt floor to be strongly associated with lower child HAZ within income groups (see Table A10 in Appendix A).

flush toilet, and dirt floors are strongly correlated (tetrachoric correlations greater than 0.80). Thus, it may be appropriate to view these variables jointly. Joint significance tests of piped water, flush toilets , and dirt floors soundly reject the null hypothesis (F=10.46, p<0.01).

Turning to health variables, we find that child health insurance status and whether a child was born in the hospital are both robust and highly significant predictors of HAZ, adding 0.16 and 0.18 standard deviations to predicted HAZ, respectively. We do not find a significant association between beginning breastfeeding on the first day of birth and HAZ scores in the pooled sample; however, the variable is highly significant in urban sample, predicting a relatively large impact on HAZ score of 0.18 standard deviations. Finally, being up-to-date with vaccines is significantly related to higher child HAZ scores, although only at the 10% level of significance.

All three family planning and demographic variables, which include birth intervals, birth order, and teenage caretakers, yield highly statistically significant coefficients. In particular, birth order, or rather the addition of child, is associated with a 0.04 decrease in child HAZ scores. This suggests that a child born into a family with three siblings will have, on average, a HAZ score of 0.12 lower than a child born into a family with one sibling. The average marginal effect of birth interval suggests that a one year increase in preceding birth interval yields a 0.06 standard deviation increase in HAZ score. Finally, children in households with caretakers under the age of 20 have predicted HAZ scores that are 0.32 lower than children in households with older caretakers.

Female children are statistically taller than males. This finding is consistent with a number of other studies and likely the result of a biological rather than a social phenomenon (Rieger and Trommlerová 2016). Children of Guaraní speakers, both monolingual and bilingual, have lower HAZ scores, on average, than children of monolingual Spanish speakers, but this effect is not statistically significant at conventional levels. A household head speaking a language other than Spanish and/or Guaraní was associated with a higher HAZ score, presumably owing to differences in child caring practices and genetic histories.

The results of the LPM models for child stunting are very similar to the results from the OLS HAZ models.[24] A monthly household income per capita greater than 400,000 Guaranís and maternal education are both associated with a reduction in child stunting. As for the infrastructure variables, we again find a highly significant association between the presence of dirt floor and the growth outcome, although here the coefficient on dirt floor is also significant in urban areas. However, in contrast to the results from the OLS HAZ model, neither the coefficient on piped water, nor the coefficient on flush toilet are statistically significant at conventional levels, although both are associated with a reduction in stunting. All health variables, including beginning breastfeeding on the first day at birth (which was not significant in the OLS HAZ model), now show significant positive associations with stunting. The family planning and demographic variables also show a similar impact on stunting, although both birth order and having a caretaker under 20 years of age are no longer statistically significant at conventional significance levels. Finally, the impact of the remaining variables on stunting (female child and language of the household head) is again similar to their impact on HAZ score.

We now turn to the second part of the analysis that allows us to relate the changes in the determinants of nutritional improvements in rural and urban areas to the corresponding changes in the rural-urban gap.[25]

Table 4 presents the decomposition results of child HAZ from 1997 to 2012. The largest driver of higher HAZ score in rural areas was maternal education, which was associated with 18.9% of the total improvement in rural HAZ. A similarly large improvement in rural HAZ (18%) was associated with an increase in hospital births. In addition, the following factors played an important role in statistically explaining the predicted change in HAZ score (ordered from the largest to the smallest impact): an increase in birth intervals, improvements in flush toilets, a decrease in the number of children (birth order), increased income, improvements in

[24]Note that a positive parameter on HAZ and a negative parameter on stunting indicate an improvement in child HAZ and a reduction (improvement) in stunting, respectively.

[25]Appendix C presents the results of the tests for individual and joint significance of parameters across time and area and provides evidence of parameter stability in these dimensions.

piped water, reductions in houses with dirt floors, and expansions in child health insurance. We note that, when considered jointly, demographic variables (birth interval and birth order) and health variables (hospital births and health insurance), were associated with even larger shares of the improvement in HAZ in rural areas (23% and 22%, respectively) than maternal education. Overall, statistically significant determinants accounted for 98% of the total change in HAZ in rural areas.

Table 4. Decomposing the sources of change in child HAZ in Paraguay, 1997 to 2012

Variable	Rural Change in HAZ	Urban Change in HAZ	Rural-Urban Gap Change in HAZ	Share of Gap Change (%) in HAZ
ln(Income)	0.035**	0.006	0.029**	10.091
Maternal education	0.078***	0.059***	0.018	6.263
Paternal education	0.005	0.005	0.001	0.348
Piped water	0.030*	0.025*	0.005	1.740
Flush toilet	0.042**	0.033**	0.010	3.479
Dirt floor	0.029*	0.006	0.024	8.351
Delayed vaccines	0.013	0.007	0.006	2.088
Health insurance	0.015**	0.002	0.012*	4.175
Born hospital	0.074***	0.037***	0.037***	12.874
Breastfed at birth	0.011	0.003	0.008	2.784
ln(Birth interval)	0.055***	0.031***	0.023**	8.003
Birth order	0.041***	0.021**	0.020**	6.959
Caretaker under 20	0.002	0.004	−0.002	−0.696
Predicted[a]	0.430	0.239	0.191	
Observed	0.412	0.125	0.287	
Observed 95% CI	(0.220, 0.604)	(0.042, 0.291)	(0.033, 0.542)	
Share Explained[b] (%)	104.381	191.885	66.458	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. Village-clustered robust standard errors obtained using the delta method on the OLS HAZ pooled regression coefficients in Table 3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Height-for-age Z scores is denoted as HAZ. Statistics calculated with sample weights. Source: Authors' calculations.

The results for the urban areas are largely similar to the ones for the rural areas. Maternal education is the single largest factor associated with higher HAZ scores, explaining 47% of the total improvement in this child nutrition indicator. Increases in hospital births, houses with flush toilets, longer birth intervals, and access to piped water, and a decrease in the number of children (birth order) were also associated with increases in HAZ in urban areas. Statistically significant determinants accounted for 0.206 standard deviation increase in HAZ score in urban areas. This is larger than the observed increase in HAZ of 0.125 standard deviation observed in urban areas, but within the 95% confidence interval.

Finally, we turn to the results of the analysis of changes in the rural-urban gap in child HAZ. We highlight two important findings. First, the model accounts for just over two-thirds of the reduction in the rural-urban gap in child HAZ over the period of the study. And second, a rapid increase in hospital births in rural areas relative to urban areas stands out as the single most important factor associated with the reduction in rural-urban gap (12.9%). Rapid increase in income and similarly rapid improvements in family planning and demographic variables (an increase in birth interval and a decrease in the number of children) emerge as the second and third most important set of factors. It is worth noting that the (statistically significant) family planning and demographic factors are jointly associated with 15% of the reduction in rural-urban gap, highlighting their importance compared to income. Finally, an increase in child health insurance was also associated with the reduction in the rural-urban gap, although only marginally. Overall, statistically significant determinants accounted for 35% of the reduction in rural-urban gap in child HAZ.

Table 5 presents the decompositions results for stunting. It is evident that many of the results for stunting are similar to child HAZ. However, in contrast to HAZ, improvements in access to piped water and flush toilets were not statistically related to reductions in stunting. In rural areas, the largest drivers of reduced stunting were hospital births, longer birth intervals, reductions in houses with dirt floors, and increases in years of maternal education. These four determinants accounted for 68% of the total decrease in stunting in rural areas. In urban areas, the largest drivers of reduced stunting were births in hospitals, longer birth intervals, increases in years of maternal education, and birth order. These four determinants were associated with a 3% reduction in the expected stunting prevalence in urban areas. Similar to HAZ in urban areas, while this prediction is lower than the observed reduction, it falls within the 95% confidence interval on the observed stunting prevalence.

In terms of closing the rural-urban gap in stunting, the complete model explains just over 47% of the rural-urban gap reduction. Statistically significant and rapid increases in rural areas relative to urban areas in hospital births, reductions in housing with dirt floors,

Table 5. Decomposing the sources of change in stunting in Paraguay, 1997 to 2012

Variable	Rural Change in Stunting	Urban Change in Stunting	Rural-Urban Gap Change in Stunting	Share of Gap Change (%) in Stunting
I(Income>400,000)[c]	−0.007**	−0.002	−0.004	4.230
Maternal education	−0.010**	−0.008**	−0.002	2.115
Paternal education	−0.001	−0.001	0.000	0.000
Piped water	−0.001	−0.001	0.000	0.000
Flush toilet	−0.003	−0.002	−0.001	1.058
Dirt floor	−0.011**	−0.002	−0.009*	9.518
Delayed vaccines	−0.004*	−0.002*	−0.002	2.115
Health insurance	−0.004***	−0.001	−0.003*	3.173
Born hospital	−0.019***	−0.009***	−0.010***	10.575
Breastfed at birth	−0.004*	−0.001	−0.003	3.173
ln(Birth interval)	−0.013***	−0.008***	−0.006**	6.345
Birth order	−0.009*	−0.005	−0.005	5.288
Caretaker under 20	0.000	0.000	0.000	0.000
Predicted[a]	−0.086	−0.042	−0.045	
Observed	−0.078	0.017	−0.095	
Observed 95% CI	(-0.126, -0.030)	(-0.030, 0.064)	(-0.162, -0.027)	
Share Explained[b] (%)	110.800	−247.913	47.589	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. [c]Indicator function equals 1 if statement in parentheses is true. Village-clustered robust standard errors obtained using the delta method on the LPM Stunted pooled regression coefficients in Table 3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Stunted is defined as HAZ <-2. Statistics calculated with sample weights. Source: Authors' calculations.

longer birth intervals, and expansions in health insurance coverage accounted for 30% of the rural-urban gap reduction.

To conclude this section, we present the results of several robustness analyses. Tables D1 and D2 in Appendix D present the decomposition results from omitting potentially endogenous child health care utilization, family planning and demographic variables from estimation of Equation 1 and the decomposition. As anticipated, the estimated coefficient on income is about twice as large after omitting these variables. The estimated coefficients on the other determinants remain relatively unchanged; see Table D3 in Appendix D. A similar impact is observed on the decomposition results. Income accounts for approximately 20% of the reduction in the rural-urban gap in child HAZ and a little under 10% of the reduction in the rural-urban gap in stunting after removing child health and fertility variables. A reduction in houses with dirt floors is the only other important factor associated with closing of the rural-urban gap in child nutrition, with education, sanitation, and piped water not having a statistically significant effect. The explanatory power of these models in explaining reductions in the rural-urban gap is reduced by over 20%.

Another endogeneity concern is household income. Tables D4 and D5 in Appendix D present the decomposition results excluding income, as well as child health care utilization, family planning and demographic variables. The contribution of education, piped water, flush toilets, and dirt floors are are nearly identical to the results just discussed (Tables D1 and D2), with maternal education and dirt floors accounting for the lion's share of the reduction in the rural-urban gap in child nutritional status. The explanatory power of these models in statistically explaining the reductions in the rural-urban gap is now reduced by over 35%.

Next we investigated decompositions over the 2000 to 2012 period and the 2005 to 2012 period. The results of these decompositions are found in Tables D6, D7, D8, and D9 in Appendix D. Compared to the 1997 to 2012 period, we see income accounting for a lower share of the reduction in the rural-urban gap in child nutritional status. Births in hospitals and maternal education, followed by family planning and demographic, and water and sanitation variables continue to account for the largest shares of the reduction in the rural-urban gap in child nutritional status.

Finally, to further investigate parameter stability, we performed an Oaxaca decomposition, on the rural and urban changes in child nutrition from 1997 to 2012. A summary of the results of the Oaxaca decompositions is found in Table D10 in Appendix D. The results were nearly identical to the results presented in Table 4 and Table 5 based on the linear decomposition of Equation 2. Changes in determinants accounted for all of the observed change in child nutrition, suggesting a high degree of parameter stability. Likewise, we observed similar patterns in the share of the total rural and urban change explained by individual factors. We take this as further support for our main findings based on the linear decomposition.

4 Conclusion

Paraguay achieved a striking reduction in the rural-urban gap in child HAZ and stunting between 1997 to 2012. Our study shows that while the well-documented determinants of child nutritional status, such as income, maternal education, sanitation, and access to piped water, are strongly associated with the improvements in child nutrition, they have contributed little to reducing the rural-urban gap in child nutrition in Paraguay. Statistically significant improvements in health care utilization, family planning, and demographics appear to be the main factors associated with closing the rural-urban gap in child nutrition. This suggests that improving health care utilization and promoting family planning initiatives may go a long way in reducing disparities in child nutritional status.

Our findings further highlight that despite rapid improvements in many of the key drivers of child nutritional status highlighted in the existing literature, such as income (Behrman and Deolalikar 1987; Haddad et al. 2003; Headey 2013; Heltberg 2009; Smith and Haddad 2000), education (Glewwe 1999; Headey 2013), demography and family planning (Behrman 1988; Horton 1988; Rutstein 2005), improved sanitation (Freeman et al. 2017), and health service utilization (Headey 2013), persistent gaps in important determinants of child nutritional status continue to exist across rural and urban areas in Paraguay. For example, while the rural-urban gap in vaccines, hospital births, demographics, and feeding practices has virtually been closed, large gaps in income, education, and access to water and sanitation remain. To be sure, in 2012, rural mothers completed 2.6 years of schooling less than urban mothers. Furthermore, children born in rural areas were still 34% and 44% less likely than children born in urban areas to have access to piped water and flush toilets, respectively.

These findings have potentially important implications for the design and implementation of health and economic policies. In addition to long-term development projects to improve piped-water and sanitation coverage and policy reforms to improve the education system, the government should build on the success of health care in rural areas and continue to expand access and promote demand for quality health services and family planning programs in both rural and urban areas. However, the focus on infrastructure and education cannot be underestimated as continued disparities in access to education and services may risk undoing the progress made in other areas.

An additional finding of our analysis is that the closing of the rural-urban gap in child nutrition was partly driven by slow improvements in child nutrition in urban areas relative to rural areas. For example, while child HAZ in rural areas increased significantly by 0.41 standard deviations from 1997 to 2012, progress was slower in urban areas, where child HAZ improved by only 0.12 standard deviations (an improvement that was not statistically significant). A deeper understanding of the factors that determined the disparate developments between child nutritional status in rural and urban areas would be key to designing nutritional strategies in these areas.

Finally, our study suffers from several shortcomings. First, despite being able to account for a relatively large share of the change in the rural-urban gap in child nutritional status (over 66% for HAZ and 47% in stunting), a portion of the change in the rural-urban gap in child nutritional status remains unexplained. It is possible that, despite their relatively small size, social and nutrition programs implemented by the Paraguayan government after 2005 played a non-trivial role in explaining this residual change. Although we control for participation in social and food program at the regional level by including a complete set of rural, department, and year indicators, we were not able to control for participation in the existing food and nutrition programs at the household or individual level due to a lack of data. Limited assessments of changes in the nutritional profile of Paraguay's largest food and nutritional assistance program (PANI) suggest a significant and positive effect of the program on reducing the prevalence of malnutrition in children under 5 years of age (Lezcano and Sanabria 2010; Sanchez Bernal et al. 2017b). Exploring the role of social and food programs on improving child nutritional status in Paraguay further should be a priority for future research.

Finally, while the decompositions explain the closing of the rural-urban gap in child nutritional status in a statistical sense, additional research is needed to understand the causal effects of child health and nutrition policies in Paraguay. If nutrition and social programs are targeted through health services, being born in a hospital, for example, could absorb at least part of the positive impact of the nutritional assistance program on child health outcomes and our estimated effect of births in hospitals on child nutrition could be overly optimistic. An understanding of the causal effects of these health and nutrition policies is necessary to support an objective evaluation of the existing programs, as well as to ensure that new programs are developed that provide large net economic benefits.

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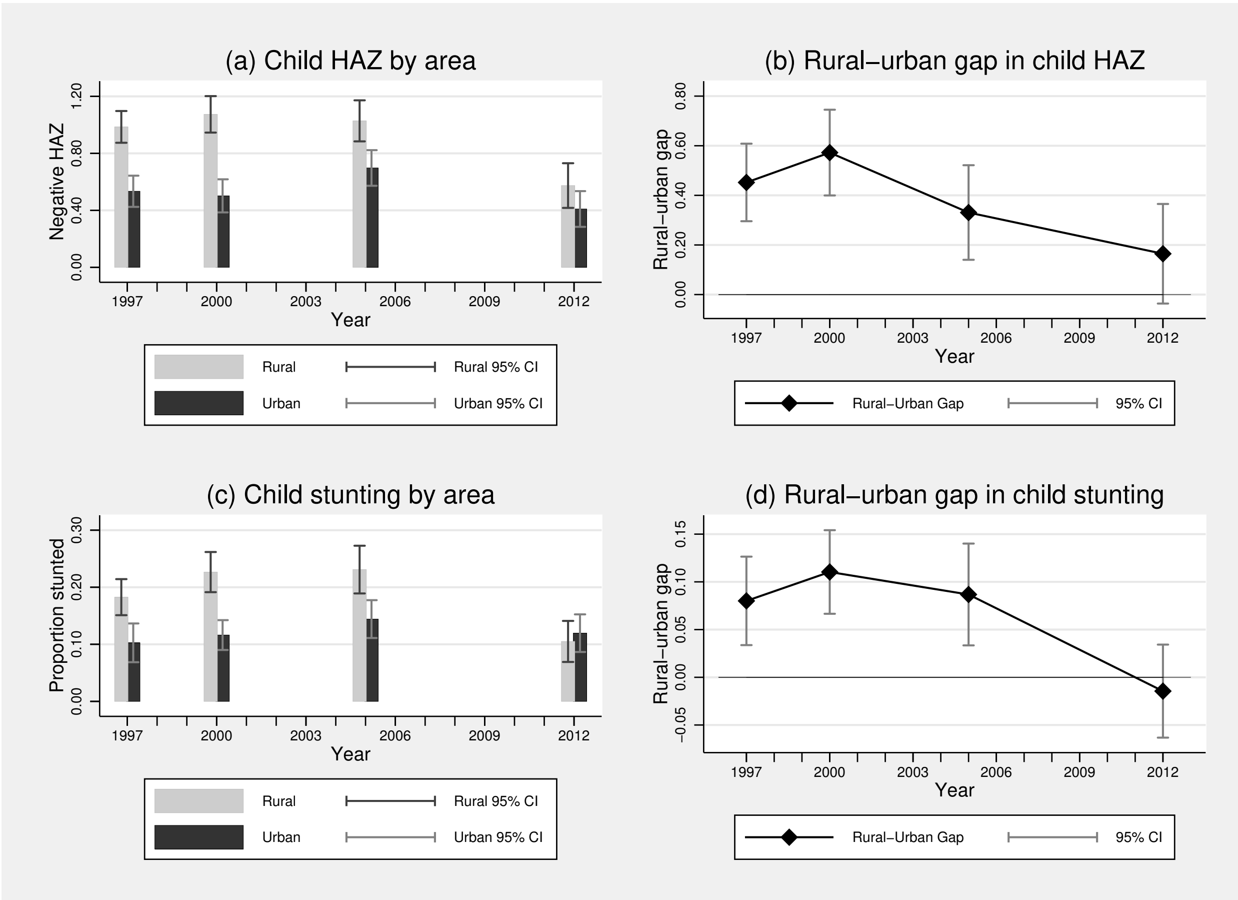
Appendix A

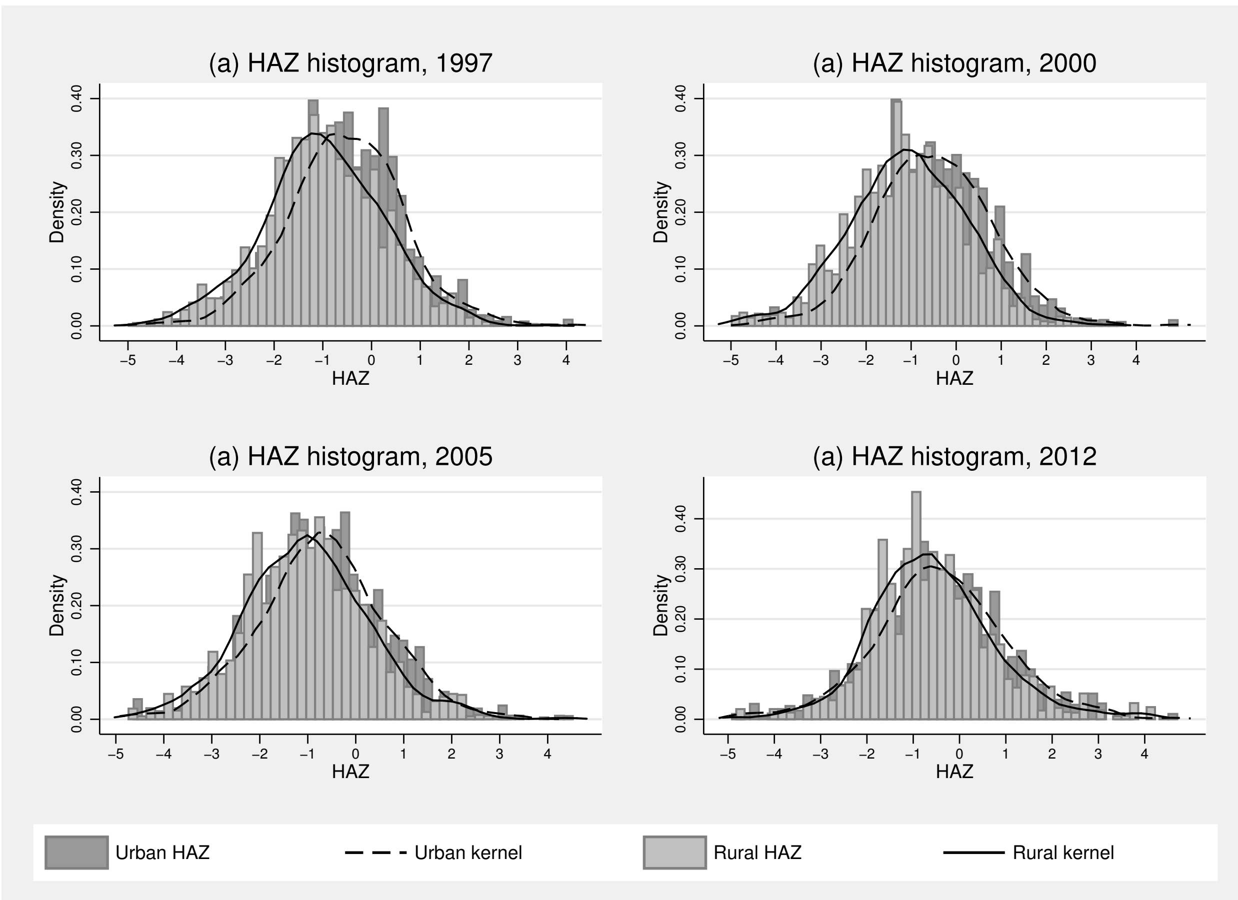
In Appendix A we present a number of descriptive statistics and alternative regression results.

Fig A1. Rural-urban gap in child HAZ and stunting in Paraguay, 1997 to 2012



Notes: Height-for-age Z score denoted as HAZ. Stunted is defined as an indicator variable of HAZ <-2. CI denotes confidence interval based on village-clustered robust standard errors. Statistics calculated with sample weights. Source: Authors' calculations.

Fig A2. Distribution of child HAZ in Paraguay by year



Notes: Height-for-age Z score is denoted as HAZ. Kernel density estimates are based on Epanechnikov kernel function. Statistics are calculated with sample weights. Source: Authors' calculations.

Table A1. Variable definitions.

Variable Name	Definition
HAZ	Dependent Variable. Standardized height-for-age Z score for children younger than 5 (WHO 2006).
Stunted	Dependent Variable. Indicator variable=1 if HAZ<-2.
Income	Household monthly income per capita in 2011 constant Paraguayan Guaraní.
Maternal education	Maximum years of schooling achieved by any female adult (16+) household member.
Paternal education	Maximum years of schooling achieved by any male adult (16+) household member.
Piped water	Indicator variable=1 if house has piped water.
Flush toilet	Indicator variable=1 if house has a flush toilet.
Dirt floor	Indicator variable=1 if house has a dirt floor.
Delayed vaccines	Indicator variable=one if child is delayed with vaccines BCG, MMR, or OPV based on national immunization schedule[a] (UNICEF 2014).
Health insurance	Indicator variable=1 if child has health insurance.
Born hospital	Indicator variable=1 if child was born in a hospital or clinic.
Breastfed at birth	Indicator variable=1 if child began to breastfeed on day of birth.
Birth interval	The time between a birth and the subsequent birth in years.
Birth order	Order of birth compared to siblings within the household.
Caretaker under 20	Indicator variable=1 if oldest female[b] household member is younger than 20 years old.
Head Guaraní	Indicator variable=1 if head of the household speaks monolingual Guarani
Head Spanish (reference)	Indicator variable=1 if head of the household speaks monolingual Spanish.
Head bilingual	Indicator variable=1 if head of the household speaks bilingual Spanish and Guaraní.
Head other language	Indicator variable equals one if head of the household speaks a language other than Spanish or Guarani.
Age	Child's age in months.
Female	Indicator variable=1 if child is female.
Twin	Indicator variable=1 if child is a twin.
Only child	Indicator variable=1 if child is an only child.
First born	Indicator variable=1 if child is the first born child.
Female adult present	Indicator variable=1 if at least one female adult (16+) is present in the household.
Male adult present	Indicator variable=1 if at least one male adult (16+) is present in the household.
Years	Indicator variables for the surveys beginning in 1997, 2000, 2005 and 2012
Rural	Indicator variable=1 if area is rural.
Departments	Indicator variables for departments of Asunción, San Pedro, Caaguazú, Itapúa, Alto Paraná, Central, and Rest (a representative grouping of the remaining departments).

Notes: [a]Delayed vaccines are defined as not receiving the Bacillus CalmetteGuérin (tuberculosis) (BCG) vaccine at birth, being four months delayed on any dose of the scheduled oral poliovirus vaccines (OPV), and/or not receiving any dose of the measles, mumps, and rubella (MMR) vaccine by the age of two. [b]If female adult not present in household, age of male adult was used. Source: Authors' calculations.

Table A2. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
HAZ	10118	−0.723	1.321	−4.984	4.918
Stunted	10118	0.152	0.359	0	1
Income[a]	10118	7.178	14.186	0	803.264
Maternal education	10103	7.821	4.019	0	18
Paternal education	9800	7.603	4.088	0	18
Piped water	10118	0.428	0.495	0	1
Flush toilet	10118	0.519	0.500	0	1
Dirt floor	10118	0.274	0.446	0	1
Delayed vaccines	10118	0.451	0.498	0	1
Health insurance	10118	0.191	0.393	0	1
Born hospital	10118	0.747	0.435	0	1
Breastfed at birth	10118	0.828	0.378	0	1
Birth interval	7960	4.053	3.099	0	15
Birth order	10118	3.017	1.829	1	12
Caretaker under 20	10118	0.025	0.155	0	1
Head Guarani	10118	0.552	0.497	0	1
Head Spanish	10118	0.180	0.384	0	1
Head bilingual	10118	0.232	0.422	0	1
Head other language	10118	0.036	0.186	0	1
Age	10118	30.791	17.211	0.066	59.959
Female	10118	0.492	0.500	0	1
Twin	10118	0.020	0.140	0	1
Only child	10118	0.160	0.366	0	1
First born	10118	0.222	0.416	0	1
Female adult present	10118	0.996	0.06	0	1
Male adult present	10118	0.912	0.283	0	1
Year 1997	10118	0.285	0.452	0	1
Year 2000	10118	0.260	0.439	0	1
Year 2005	10118	0.208	0.406	0	1
Year 2012	10118	0.247	0.431	0	1
Rural	10118	0.492	0.500	0	1
Dept Asunción	10118	0.074	0.261	0	1
Dept San Pedro	10118	0.085	0.279	0	1
Dept Caaguazú	10118	0.091	0.288	0	1
Dept Itapúa	10118	0.097	0.296	0	1
Dept Alto Paraná	10118	0.112	0.315	0	1
Dept Central	10118	0.267	0.442	0	1
Dept Rest	10118	0.274	0.446	0	1

Notes: [a]In one hundred thousand 2011 constant Paraguayan Guaraní. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. Statistics are calculated with survey weights. Source: Authors' calculations.

Table A3. Mean determinants of child nutrition in Paraguay, 1997-2012

	National Mean				Change
Variable	**1997**	**2000**	**2005**	**2012**	**1997-2012**
HAZ	−0.771	−0.797	−0.847	−0.485	0.286***
	(0.042)	(0.054)	(0.049)	(0.050)	(0.065)
Stunted	0.145	0.173	0.183	0.113	−0.031*
	(0.012)	(0.013)	(0.014)	(0.013)	(0.017)
Income[a]	7.185	6.541	6.359	8.528	1.343**
	(0.352)	(0.374)	(0.655)	(0.463)	(0.582)
Maternal education	6.842	7.281	8.212	9.189	2.347***
	(0.151)	(0.158)	(0.177)	(0.173)	(0.229)
Paternal education	6.760	7.282	7.809	8.774	2.014***
	(0.149)	(0.150)	(0.192)	(0.262)	(0.301)
Piped water	0.289	0.361	0.497	0.600	0.310***
	(0.017)	(0.027)	(0.025)	(0.030)	(0.034)
Flush toilet	0.408	0.463	0.553	0.677	0.269***
	(0.022)	(0.026)	(0.026)	(0.032)	(0.039)
Dirt floor	0.343	0.31	0.211	0.208	−0.136***
	(0.024)	(0.026)	(0.020)	(0.034)	(0.042)
Delayed vaccines	0.518	0.471	0.432	0.368	−0.150***
	(0.015)	(0.015)	(0.018)	(0.021)	(0.026)
Health insurance	0.162	0.173	0.209	0.226	0.063***
	(0.012)	(0.013)	(0.017)	(0.015)	(0.019)
Born hospital	0.609	0.697	0.787	0.924	0.315***
	(0.018)	(0.018)	(0.018)	(0.011)	(0.021)
Breastfed at birth	0.740	0.859	0.904	0.832	0.092***
	(0.018)	(0.012)	(0.010)	(0.014)	(0.022)
Birth interval	3.653	3.693	4.228	4.848	1.195***
	(0.092)	(0.089)	(0.113)	(0.120)	(0.151)
Birth order	3.312	3.251	2.900	2.530	−0.781***
	(0.085)	(0.100)	(0.064)	(0.057)	(0.102)
Caretaker under 20	0.033	0.022	0.020	0.022	−0.011
	(0.006)	(0.003)	(0.004)	(0.008)	(0.010)

Notes: [a]In one hundred thousand 2011 constant Paraguayan Guaraní. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. Statistics are calculated with sample weights. Source: Authors' calculations.

Table A4. Mean determinants of child nutrition by area in Paraguay, 1997-2012

Variable	Rural Mean				Urban Mean			
	1997	2000	2005	2012	1997	2000	2005	2012
HAZ	−0.986	−1.074	−1.028	−0.574	−0.534	−0.501	−0.697	−0.409
	(0.057)	(0.065)	(0.074)	(0.080)	(0.056)	(0.059)	(0.064)	(0.064)
Stunted	0.183	0.227	0.231	0.105	0.103	0.116	0.144	0.120
	(0.016)	(0.018)	(0.021)	(0.018)	(0.017)	(0.013)	(0.017)	(0.017)
Income[a]	3.896	3.861	4.131	6.125	10.818	9.396	8.196	10.596
	(0.337)	(0.392)	(0.2)	(0.656)	(0.534)	(0.508)	(1.172)	(0.525)
Maternal education	5.316	5.715	6.656	7.779	8.528	8.949	9.498	10.404
	(0.152)	(0.182)	(0.204)	(0.244)	(0.197)	(0.264)	(0.238)	(0.213)
Paternal education	5.264	5.998	6.597	7.203	8.434	8.688	8.802	10.098
	(0.137)	(0.193)	(0.228)	(0.409)	(0.213)	(0.195)	(0.279)	(0.185)
Piped water	0.104	0.159	0.257	0.417	0.494	0.577	0.695	0.757
	(0.015)	(0.031)	(0.027)	(0.045)	(0.026)	(0.032)	(0.031)	(0.026)
Flush toilet	0.170	0.212	0.281	0.442	0.670	0.730	0.778	0.879
	(0.021)	(0.033)	(0.029)	(0.049)	(0.028)	(0.027)	(0.027)	(0.021)
Dirt floor	0.551	0.504	0.380	0.358	0.114	0.102	0.072	0.078
	(0.033)	(0.034)	(0.032)	(0.059)	(0.016)	(0.017)	(0.016)	(0.023)
Delayed vaccines	0.566	0.526	0.429	0.374	0.464	0.413	0.434	0.363
	(0.022)	(0.023)	(0.025)	(0.039)	(0.019)	(0.018)	(0.026)	(0.022)
Health insurance	0.053	0.080	0.089	0.143	0.284	0.273	0.308	0.297
	(0.009)	(0.012)	(0.019)	(0.019)	(0.02)	(0.021)	(0.025)	(0.023)
Born hospital	0.470	0.544	0.664	0.877	0.762	0.860	0.888	0.965
	(0.024)	(0.026)	(0.029)	(0.02)	(0.021)	(0.016)	(0.018)	(0.011)
Breastfed at birth	0.705	0.838	0.924	0.849	0.778	0.881	0.888	0.817
	(0.028)	(0.019)	(0.011)	(0.022)	(0.019)	(0.014)	(0.015)	(0.017)
Birth interval	3.337	3.338	4.045	4.724	4.044	4.105	4.387	4.965
	(0.120)	(0.108)	(0.152)	(0.166)	(0.131)	(0.127)	(0.167)	(0.172)
Birth order	3.690	3.684	3.215	2.692	2.894	2.789	2.641	2.391
	(0.131)	(0.149)	(0.102)	(0.086)	(0.093)	(0.088)	(0.078)	(0.071)
Caretaker under 20	0.041	0.026	0.026	0.034	0.024	0.017	0.015	0.011
	(0.010)	(0.005)	(0.007)	(0.016)	(0.006)	(0.004)	(0.005)	(0.004)

Notes: [a]In one hundred thousand 2011 constant Paraguayan Guaraní. Village-clustered robust standard errors are in parentheses. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. Statistics are calculated with sample weights. Source: Authors' calculations.

Table A5. Changes in child nutritional status and mean (transformed) determinants by area in Paraguay, 1997 to 2012

Variable	Rural Mean 1997	Rural Mean 2012	Change 1997-2012	Urban Mean 1997	Urban Mean 2012	Change 1997-2012	Change RU Gap
HAZ observed	−0.986	−0.574	0.412	−0.534	−0.409	0.125	0.287
	(0.057)	(0.080)	(0.098)	(0.056)	(0.064)	(0.085)	(0.130)
HAZ predicted[a]	−0.986	−0.574	0.412	−0.534	−0.409	0.125	0.287
	(0.030)	(0.044)	(0.053)	(0.026)	(0.023)	(0.035)	(0.063)
Stunted observed	0.183	0.105	−0.078	0.103	0.120	0.0170	−0.095
	(0.016)	(0.018)	(0.024)	(0.017)	(0.017)	(0.024)	(0.034)
Stunted predicted[a]	0.183	0.105	−0.078	0.103	0.120	0.017	−0.095
	(0.007)	(0.008)	(0.011)	(0.005)	(0.005)	(0.007)	(0.013)
ln(Income)	12.340	12.853	0.513	13.440	13.523	0.084	0.429
	(0.076)	(0.104)	(0.128)	(0.048)	(0.042)	(0.064)	(0.143)
I(Income>400,000)[b]	0.300	0.478	0.178	0.723	0.784	0.061	0.117
	(0.027)	(0.051)	(0.057)	(0.025)	(0.021)	(0.032)	(0.066)
Maternal education	5.316	7.779	2.464	8.528	10.408	1.880	0.583
	(0.152)	(0.244)	(0.286)	(0.197)	(0.213)	(0.29)	(0.407)
Paternal education	5.260	7.123	1.863	8.430	10.056	1.626	0.238
	(0.137)	(0.431)	(0.451)	(0.21)	(0.179)	(0.276)	(0.529)
Piped water	0.104	0.417	0.313	0.494	0.757	0.263	0.050
	(0.015)	(0.045)	(0.047)	(0.026)	(0.026)	(0.037)	(0.059)
Flush toilet	0.170	0.442	0.272	0.670	0.879	0.209	0.063
	(0.021)	(0.049)	(0.053)	(0.028)	(0.021)	(0.035)	(0.064)
Dirt floor	0.551	0.358	−0.192	0.114	0.078	−0.036	−0.156
	(0.033)	(0.059)	(0.067)	(0.016)	(0.023)	(0.029)	(0.073)
Delayed vaccines	0.566	0.374	−0.193	0.464	0.363	−0.102	−0.091
	(0.022)	(0.039)	(0.045)	(0.019)	(0.022)	(0.028)	(0.053)
Health insurance	0.053	0.143	0.090	0.284	0.297	0.013	0.077
	(0.009)	(0.019)	(0.021)	(0.020)	(0.023)	(0.030)	(0.037)
Born hospital	0.470	0.877	0.407	0.762	0.965	0.203	0.204
	(0.024)	(0.020)	(0.031)	(0.021)	(0.011)	(0.024)	(0.039)
Breastfed at birth	0.705	0.849	0.144	0.778	0.817	0.038	0.105
	(0.028)	(0.022)	(0.036)	(0.019)	(0.017)	(0.025)	(0.044)
ln(Birth interval)	1.020	1.339	0.319	1.183	1.367	0.184	0.135
	(0.026)	(0.028)	(0.038)	(0.026)	(0.026)	(0.037)	(0.053)
Birth order	3.690	2.692	−0.998	2.894	2.391	−0.502	−0.496
	(0.131)	(0.086)	(0.156)	(0.093)	(0.071)	(0.117)	(0.195)
Caretaker under 20	0.041	0.034	−0.007	0.024	0.011	−0.013	0.006
	(0.010)	(0.016)	(0.019)	(0.006)	(0.004)	(0.007)	(0.020)

Notes: [a]Prediction based on pooled regression model including all control variables. [b]Indicator function equals 1 if statement in parentheses is true. Village-clustered robust standard errors are in parentheses. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. "RU Gap" denotes Rural-Urban Gap. Statistics calculated with sample weights. Source: Authors' calculations.

Table A6. OLS regression results without sample weights

Dep. Variable: HAZ	(1) Pooled	(2) Rural	(3) Urban
Income[a]	0.101***	0.091***	0.124***
	(0.020)	(0.027)	(0.030)
Maternal education	0.028***	0.031***	0.025***
	(0.005)	(0.007)	(0.006)
Paternal education	0.003	0.013*	−0.005
	(0.005)	(0.007)	(0.006)
Piped water	0.120***	0.165**	0.095*
	(0.042)	(0.069)	(0.053)
Flush toilet	0.099**	−0.047	0.220***
	(0.043)	(0.063)	(0.058)
Dirt floor	−0.151***	−0.208***	−0.028
	(0.038)	(0.045)	(0.075)
Delayed vaccines	−0.076***	−0.099***	−0.068*
	(0.026)	(0.036)	(0.038)
Health insurance	0.129***	0.197***	0.096**
	(0.039)	(0.072)	(0.047)
Born hospital	0.132***	0.070*	0.217***
	(0.033)	(0.041)	(0.055)
Breastfed at birth	0.089***	0.013	0.168***
	(0.035)	(0.046)	(0.051)
ln(Birth interval)	0.186***	0.186***	0.177***
	(0.021)	(0.029)	(0.029)
Birth order	−0.023**	−0.018	−0.038**
	(0.011)	(0.014)	(0.017)
Caretaker under 20	−0.279***	−0.336***	−0.215*
	(0.079)	(0.099)	(0.130)
Female	0.117***	0.112***	0.120***
	(0.024)	(0.032)	(0.034)
Head Guaraní	−0.102**	−0.113	−0.113**
	(0.046)	(0.087)	(0.057)
Head bilingual	−0.053	−0.178*	−0.031
	(0.043)	(0.098)	(0.048)
Head other language	0.264***	0.334***	0.105
	(0.080)	(0.114)	(0.135)
Observations	10118	5068	5050
Adjusted R^2	0.184	0.182	0.153

Notes: OLS is Ordinary Least Squares. [a]Income is the natural log of income. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated without sample weights. Source: Authors' calculations.

Table A7. Comparison of mean determinants of child HAZ between EPH 2011 and EIG 2011/12 (Standard Errors in Parentheses).

	National		Urban		Rural	
Variable	**EPH 2011**	**EIG 2011/12**	**EPH 2011**	**EIG 2011/12**	**EPH 2011**	**EIG 2011/12**
Advanced sanitation	0.679	0.687	0.885	0.887	0.450	0.443
	(0.020)	(0.028)	(0.018)	(0.019)	(0.034)	(0.047)
Caretaker under 20	0.027	0.022	0.017	0.011	0.037	0.035
	(0.005)	(0.007)	(0.005)	(0.004)	(0.009)	(0.015)
Child age	2.090	1.964	2.033	1.919	2.153	2.019
	(0.036)	(0.036)	(0.049)	(0.048)	(0.054)	(0.055)
Child birth interval	4.868	4.949	5.050	5.043	4.681	4.846
	(0.128)	(0.142)	(0.162)	(0.173)	(0.196)	(0.230)
Child birth order	2.466	2.482	2.258	2.327	2.699	2.673
	(0.062)	(0.054)	(0.066)	(0.069)	(0.106)	(0.082)
Child female	0.494	0.484	0.523	0.475	0.462	0.496
	(0.015)	(0.015)	(0.018)	(0.02)	(0.023)	(0.022)
Child firstborn	0.324	0.311	0.351	0.348	0.295	0.264
	(0.013)	(0.014)	(0.018)	(0.019)	(0.019)	(0.019)
Child health insurance	0.231	0.238	0.363	0.320	0.085	0.138
	(0.016)	(0.015)	(0.023)	(0.023)	(0.019)	(0.019)
Child twins	0.014	0.018	0.012	0.024	0.015	0.010
	(0.004)	(0.007)	(0.005)	(0.011)	(0.007)	(0.006)
Dirt floor	0.170	0.196	0.056	0.072	0.298	0.348
	(0.017)	(0.030)	(0.013)	(0.02)	(0.03)	(0.055)
Income per capita[a]	825.696	890.951	1036.680	1120.572	590.400	609.857
	(64.973)	(48.031)	(82.463)	(65.134)	(100.396)	(59.895)
Maternal education	9.371	9.390	10.933	10.632	7.624	7.871
	(0.161)	(0.155)	(0.197)	(0.204)	(0.225)	(0.238)
Paternal education	9.012	9.000	10.621	10.345	7.280	7.319
	(0.155)	(0.238)	(0.202)	(0.183)	(0.189)	(0.408)
Only child	0.248	0.255	0.280	0.295	0.211	0.206
	(0.013)	(0.014)	(0.018)	(0.019)	(0.019)	(0.019)
Piped water inside	0.590	0.616	0.777	0.777	0.381	0.419
	(0.020)	(0.027)	(0.021)	(0.023)	(0.031)	(0.044)
Rural area	0.473	0.450	0	0	1	1
	(0.017)	(0.027)	(0)	(0)	(0)	(0)
Household members	5.530	5.556	5.381	5.539	5.696	5.577
	(0.099)	(0.090)	(0.114)	(0.119)	(0.164)	(0.140)

Notes: [a]Income in thousand constant 2012 Guaranís. Source: Authors' calculations.

Table A8. Comparison of Average Marginal Effects and Discrete Changes for Probability Models

Dep. Variable: Stunted	**(1) LPM[a]**	**(2) Probit**	**(3) Logit**
Income[b]	−0.036***	−0.034***	−0.034***
Maternal education	−0.004***	−0.005***	−0.005***
Paternal education	−0.000	−0.000	−0.000
Piped water	−0.004	−0.008	−0.011
Flush toilet	−0.010	−0.013	−0.014
Dirt floor	0.059***	0.044***	0.043***
Delayed vaccines	0.020*	0.020**	0.021**
Health insurance	−0.044***	−0.067***	−0.071***
Born hospital	−0.047***	−0.038***	−0.033***
Breastfed at birth	−0.028**	−0.034**	−0.032**
ln(Birth interval)	−0.042***	−0.041***	−0.041***
Birth order	0.009*	0.006	0.006
Caretaker under 20	0.007	0.010	0.011
Female	−0.020**	−0.017*	−0.017*
Head Guaraní	0.009	0.014	0.012
Head bilingual	0.013	0.019	0.017
Head other language	−0.073***	−0.073***	−0.077***
Observations	10118	10118	10118

Notes: [a]LPM is linear probability model. [b]Income is an indicator of Income>400,000 Guaranís in the LPM stunted models. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Stunted is defined as an indicator variable of HAZ<-2. The table excludes a number of controls common to all models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. Source: Authors' calculations.

Table A9. LPM Model of Stunting with Continuous Income Variable

Dep. Variable: Stunted	**(1) Pooled**	**(2) Rural**	**(3) Urban**
ln(Income)	−0.011	−0.016	−0.011
	(0.009)	(0.012)	(0.011)
Maternal education	−0.004***	−0.005*	−0.003*
	(0.002)	(0.003)	(0.002)
Paternal education	−0.000	−0.004	0.003
	(0.002)	(0.003)	(0.002)
Piped water	−0.006	−0.011	0.002
	(0.015)	(0.024)	(0.018)
Flush toilet	−0.013	0.024	−0.051**
	(0.016)	(0.021)	(0.024)
Dirt floor	0.061***	0.053***	0.071**
	(0.017)	(0.020)	(0.032)
Delayed vaccines	0.020*	0.026*	0.016
	(0.010)	(0.015)	(0.014)
Health insurance	−0.046***	−0.052***	−0.046***
	(0.012)	(0.019)	(0.015)
Born hospital	−0.047***	−0.039**	−0.059***
	(0.013)	(0.018)	(0.020)
Breastfed at birth	−0.029**	−0.005	−0.046**
	(0.013)	(0.018)	(0.019)
ln(Birth interval)	−0.043***	−0.061***	−0.023**
	(0.008)	(0.013)	(0.010)
Birth order	0.010*	0.010	0.010
	(0.005)	(0.007)	(0.007)
Caretaker under 20	0.009	0.016	−0.003
	(0.035)	(0.048)	(0.045)
Female	−0.020**	−0.004	−0.035**
	(0.009)	(0.012)	(0.014)
Head Guaraní	0.009	0.002	0.023
	(0.015)	(0.029)	(0.018)
Head bilingual	0.011	0.029	0.014
	(0.014)	(0.031)	(0.016)
Head other language	−0.071***	−0.092**	−0.020
	(0.026)	(0.040)	(0.038)
Observations	10118	5068	5050
Adjusted R^2	0.098	0.112	0.085

Notes: LPM is linear probability model. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Stunted is defined as an indicator variable of HAZ<-2. The table excludes a number of controls common to all models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. Source: Authors' calculations.

Table A10. OLS HAZ Regression by Income Levels

	(1)	(2)	(3)
Dep. Variable: HAZ	**High Income[a]**	**Medium Income[b]**	**Low Income[c]**
ln(Income)	0.066	0.341**	0.101*
	(0.067)	(0.159)	(0.056)
Maternal education	0.035***	0.024**	0.030***
	(0.009)	(0.011)	(0.011)
Paternal education	0.002	−0.013	0.023**
	(0.008)	(0.012)	(0.011)
Piped water	0.130	0.169*	−0.148
	(0.087)	(0.088)	(0.103)
Flush toilet	0.139	0.135	0.255**
	(0.098)	(0.089)	(0.100)
Dirt floor	−0.287*	−0.210**	−0.162**
	(0.165)	(0.090)	(0.064)
Delayed vaccines	−0.085	−0.073	−0.071
	(0.061)	(0.064)	(0.051)
Health insurance	0.148**	0.200*	−0.082
	(0.066)	(0.105)	(0.243)
Born hospital	0.270***	0.211***	0.106*
	(0.085)	(0.081)	(0.055)
Breastfed at birth	0.193**	−0.030	0.055
	(0.081)	(0.088)	(0.081)
ln(Birth interval)	0.163***	0.135***	0.181***
	(0.051)	(0.047)	(0.042)
Birth order	−0.009	−0.066**	−0.050***
	(0.032)	(0.026)	(0.018)
Caretaker under 20	−0.208	−0.435**	−0.345***
	(0.176)	(0.201)	(0.133)
Female	0.056	0.132**	0.078*
	(0.059)	(0.058)	(0.047)
Head Guaraní	−0.044	0.070	−0.140
	(0.080)	(0.104)	(0.142)
Head bilingual	−0.019	0.049	−0.186
	(0.073)	(0.113)	(0.170)
Head other language	0.604***	0.447*	0.204
	(0.151)	(0.238)	(0.230)
Observations	3484	2763	3871
Adjusted R^2	0.118	0.169	0.209

Notes: OLS is Ordinary Least Squares. [a]High Income>600,000 PYG per capita, [b]Medium is 300,000 to 600,000 PYG per capita, [c]Income<300,000 PYG per capita. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated without sample weights. Source: Authors' calculations.

Appendix B

In this section, we examine the potential impact of rural-urban migration on child nutritional status over 1997-2012. During this period, the proportion of households with children under the age of 5 with a household head that was born in a rural area and currently resides in an urban area increased by 5.45%. This increase was statistically significant at the 5% significance level. The migration pattern in the other direction (urban to rural) was small and not statistically significant.

Analysis of the impact of urbanization, or migration from rural to urban areas, requires the knowledge of the head of household's area of birth; this information is available for 9,599 of the 10,118 children in our sample. Controlling for the migration status of the household head in our regressions of HAZ and stunting, we found that the estimated coefficients on migration status were small, not statistically significant, and did not affect other parameter estimates in any meaningful way. Thus, rather than exclude over 500 observations from our analysis, we opted to omit controls for migration status.

To test whether childrens nutritional status was systematically related to whether the household heads immigration status was unknown, we included an indicator variable for unknown migration status. See Table B1. The results show that none of the indicators of migration are statistically significant, nor alter the other parameters in a meaningful way. Additionally, we investigated the migration status of the household head by year and area. See Table B2 In urban areas the percentage of household heads with children under 5 that have migrated from rural areas increased by 7 percentage points (from 31.55 to 38.55). How migration affects child health in Paraguay is unknown. The variables included in our model will account for different factors, such as higher incomes and better access to goods and services, that migrants may be able to obtain, but, given our data and that migration decisions are endogenous, we do not explore this further.

Table B1. OLS regression models of child HAZ by region in Paraguay including migration status

Dep. Variable: HAZ	(1) Pooled	(2) Rural	(3) Urban
Income[a]	0.067**	0.054	0.098**
	(0.029)	(0.038)	(0.041)
Maternal education	0.032***	0.025***	0.035***
	(0.006)	(0.010)	(0.008)
Paternal education	0.003	0.014	−0.009
	(0.006)	(0.009)	(0.008)
Piped water	0.097*	0.160*	0.044
	(0.056)	(0.082)	(0.074)
Flush toilet	0.157***	0.026	0.268***
	(0.059)	(0.069)	(0.088)
Dirt floor	−0.155***	−0.209***	−0.059
	(0.051)	(0.060)	(0.097)
Delayed vaccines	−0.067*	−0.065	−0.087
	(0.037)	(0.044)	(0.059)
Health insurance	0.162***	0.253***	0.120*
	(0.055)	(0.095)	(0.065)
Born hospital	0.181***	0.143***	0.245***
	(0.040)	(0.051)	(0.067)
Breastfed at birth	0.079	−0.027	0.182***
	(0.050)	(0.066)	(0.070)
ln(Birth interval)	0.171***	0.179***	0.143***
	(0.027)	(0.037)	(0.038)
Birth order	−0.041***	−0.032*	−0.062***
	(0.014)	(0.018)	(0.020)
Caretaker under 20	−0.320***	−0.356***	−0.272
	(0.103)	(0.124)	(0.165)
Female	0.083**	0.074*	0.094*
	(0.033)	(0.042)	(0.048)
Head Guaraní	−0.050	−0.045	−0.081
	(0.059)	(0.101)	(0.071)
Head bilingual	−0.038	−0.177	−0.006
	(0.060)	(0.124)	(0.065)
Head other language	0.455***	0.365*	0.324**
	(0.136)	(0.190)	(0.165)
Migr rural to urban	0.037		0.027
	(0.054)		(0.055)
Migr urban to rural	−0.053	−0.029	
	(0.085)	(0.084)	
Migr status unknown	−0.020	0.158	−0.091
	(0.106)	(0.176)	(0.127)
Observations	10118	5068	5050
Adjusted R^2	0.196	0.212	0.163

Notes: OLS is Ordinary Least Squares. [a]Income is the natural log of income. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. Source: Authors' calculations.

Table B2. Mean migration status of household head by area and year (percent)

Year	National Rural to urban	Urban to rural	Unknown
1997	14.99	5.79	5.00
2000	18.77	4.55	6.09
2005	20.07	5.02	5.20
2012	20.72	7.03	2.39
Year	**Rural** **Rural to urban**	**Urban to rural**	**Unknown**
1997		11.03	7.09
2000		8.82	6.72
2005		11.12	5.36
2012		15.21	2.53
Year	**Urban** **Rural to urban**	**Urban to rural**	**Unknown**
1997	31.55		2.70
2000	38.77		5.42
2005	36.62		5.07
2012	38.55		2.27

Notes: Means are calculated with sample weights on the sample of households with children under the age of 5. Source: Authors' calculations.

Appendix C

In Appendix C we explore parameter stability. In order to decompose the individual contribution of changes in the determinants of child nutritional status to the change in rural and urban child nutritional status and the change in the rural-urban gap in child nutrition using Equation 2, we first need to establish evidence of parameter stability across time and area. We estimate specifications of Equation 1 that allow the parameters on the determinants of child nutritional status to vary by year and region and perform individual and joint tests for significant differences in parameter values compared to the remaining pooled sample parameter estimates.

Table C1 summarizes the results of the test for individual and joint significance of parameters across time and area. The full results of these regressions are found in Tables C2 and C3 further below. Similar to existing studies, we find scant evidence of significant differences in parameters across time and area (Headey et al. 2015; Srinivasan et al. 2013). Some parameter instability is seen on paternal education, which had a positive and statistically significant relationship with child HAZ in rural areas in the 1997 and 2000 survey rounds. However, this effect was no longer observed after 2000. Signs of parameter instability are also observed on piped water, dirt floor, hospital births, breastfed at birth, and birth order variables, but no systematic patterns emerge. A Wald test of joint significance of the area-time varying parameters returned mixed results. Joint statistical tests rejected the hypothesis of parameter stability for urban areas in 2012, and rural areas in 1997, 2000, and 2012. We interpret this as evidence of random variation in year to year samples rather than as of any structural differences across time and space. Thus, we believe a simple linear decomposition based on Equation 2 is appropriate. However, as a robustness check, we perform Oaxaca-Blinder decompositions on the change in child nutrition in rural and urban areas.

We further explored parameter stability with a village-year fixed effects model and found further evidence in support of parameter stability. See Tables C5 and C6.

Table C1. Summary of parameter instability: Are area-time varying parameters statistically different than pooled estimates?

	Rural				Urban			
Variable	**1997**	**2000**	**2005**	**2012**	**1997**	**2000**	**2005**	**2012**
ln(Income)	No	No	No	No	No	No	No	No
Maternal education	No	No	No	No	No	No	No	No
Paternal education	**Yes**	**Yes**	No	No	No	No	No	No
Piped water	No	No	No	No	No	No	**Yes**	No
Flush toilet	No	No	No	No	No	No	No	No
Dirt floor	No	**Yes**	No	No	**Yes**	No	No	No
Delayed vaccines	No	No	No	No	No	No	No	No
Health insurance	No	No	No	No	No	No	No	No
Born hospital	**Yes**	No	No	No	No	No	No	No
Breastfed at birth	No	**Yes**	No	No	No	No	No	**Yes**
ln(Birth interval)	No	No	No	No	No	No	No	No
Birth order	No	No	No	No	No	**Yes**	No	No
Caretaker under 20	No	No	No	No	No	No	No	No
Joint Significance?[a]	**Yes**	**Yes**	No	**Yes**	No	No	No	**Yes**

Notes: [a]Joint significance is based on a Wald test of the null hypothesis that all area-time varying parameters are jointly equal to zero. Significance tests based on regression models can be found in Tables C2 and C3 further below. Source: Authors' calculations.

Table C2. Regression models of child HAZ and time-area parameter stability, rural areas

Model:	OLS Rural HAZ			
Variable	**1997**	**2000**	**2005**	**2012**
	Time-area Varying Parameters			
$\boldsymbol{D}_{a,t}\times$ln(Income)	−0.056	−0.031	0.034	0.029
$\boldsymbol{D}_{a,t}\times$Maternal education	0.001	−0.002	−0.002	−0.028
$\boldsymbol{D}_{a,t}\times$Paternal education	0.037*	0.040*	−0.002	−0.028
$\boldsymbol{D}_{a,t}\times$Piped water	−0.040	−0.025	0.245	0.086
$\boldsymbol{D}_{a,t}\times$Flush toilet	−0.126	−0.024	−0.254	−0.212
$\boldsymbol{D}_{a,t}\times$Dirt floor	−0.002	−0.296*	0.107	−0.068
$\boldsymbol{D}_{a,t}\times$Delayed vaccines	−0.040	−0.080	−0.099	0.152
$\boldsymbol{D}_{a,t}\times$Health insurance	0.284	0.162	0.332	−0.215
$\boldsymbol{D}_{a,t}\times$Born hospital	−0.232*	−0.049	0.005	0.163
$\boldsymbol{D}_{a,t}\times$Breastfed at birth	0.018	−0.293*	0.046	−0.202
$\boldsymbol{D}_{a,t}\times$ln(Birth interval)	0.098	−0.002	−0.061	0.031
$\boldsymbol{D}_{a,t}\times$Birth order	0.022	0.033	0.009	−0.016
$\boldsymbol{D}_{a,t}\times$Caretaker under 20	−0.188	−0.042	0.103	0.166
Joint Significance?[a]	**Yes**	**Yes**	**No**	**Yes**
	Pooled Parameters			
ln(Income)	0.081**	0.074*	0.065*	0.065*
Maternal education	0.031**	0.032**	0.032**	0.035**
Paternal education	−0.001	−0.001	0.003	0.006
Piped water	0.095	0.109	0.072	0.074
Flush toilet	0.169**	0.152*	0.174**	0.196**
Dirt floor	−0.152*	−0.090	−0.167**	−0.155**
Delayed vaccines	−0.062	−0.063	−0.057	−0.089*
Health insurance	0.146*	0.149**	0.148**	0.184**
Born hospital	0.231**	0.181**	0.179**	0.160**
Breastfed at birth	0.077	0.119*	0.076	0.102
ln(Birth interval)	0.155**	0.172**	0.177**	0.167**
Birth order	−0.048**	−0.046**	−0.042**	−0.039**
Caretaker under 20	−0.270*	−0.305**	−0.329**	−0.369**
Observations	10118	10118	10118	10118
R^2	0.209	0.210	0.208	0.211

Notes: [a]Joint significance is based on a Wald test of the null hypothesis that all time-area varying parameters are jointly equal to zero. OLS denotes Ordinary Least Squares. Each model is estimated as $N_{i,t} = \boldsymbol{\beta X}_{i,t} + \boldsymbol{\gamma X}_{i,t}\boldsymbol{D}_{a,t} + \varepsilon_{i,t}$, $\forall a \in$ {rural, urban} and $t \in$ {1997, 2000, 2005, 2012}, where $\boldsymbol{D}_{a,t}$ is an indicator variable for area, a, and survey year, t. The vector of coefficients, $\boldsymbol{\gamma}$, contains the time-area varying parameters and the vector of coefficients, $\boldsymbol{\beta}$, contains the pooled parameters. Village-clustered robust standard errors are in parentheses. * $p < 0.05$, ** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. Source: Authors' calculations.

Table C3. Regression models of child HAZ and time-area parameter stability, urban areas

Model:	OLS Urban HAZ			
Variable	**1997**	**2000**	**2005**	**2012**
	Time-area Varying Parameters			
$\boldsymbol{D}_{a,t}\times$ln(Income)	0.062	−0.062	0.084	0.012
$\boldsymbol{D}_{a,t}\times$Maternal education	0.001	0.006	0.023	−0.024
$\boldsymbol{D}_{a,t}\times$Paternal education	0.008	0.001	−0.026	−0.003
$\boldsymbol{D}_{a,t}\times$Piped water	0.128	−0.072	−0.353*	0.026
$\boldsymbol{D}_{a,t}\times$Flush toilet	0.074	0.094	0.287	0.120
$\boldsymbol{D}_{a,t}\times$Dirt floor	0.361*	0.358	−0.099	−0.353
$\boldsymbol{D}_{a,t}\times$Delayed vaccines	−0.053	0.043	0.012	0.026
$\boldsymbol{D}_{a,t}\times$Health insurance	−0.125	−0.164	−0.108	0.191
$\boldsymbol{D}_{a,t}\times$Born hospital	−0.232*	0.128	0.073	−0.030
$\boldsymbol{D}_{a,t}\times$Breastfed at birth	0.051	−0.033	0.068	0.332*
$\boldsymbol{D}_{a,t}\times$ln(Birth interval)	−0.022	−0.025	0.069	−0.104
$\boldsymbol{D}_{a,t}\times$Birth order	−0.010	−0.074*	0.014	−0.001
$\boldsymbol{D}_{a,t}\times$Caretaker under 20	−0.358	0.020	0.139	0.468
Joint Significance?[a]	**No**	**No**	**No**	**Yes**
	Pooled Parameters			
ln(Income)	0.058	0.073*	0.060*	0.068*
Maternal education	0.031**	0.030**	0.028**	0.035**
Paternal education	0.002	0.003	0.007	0.004
Piped water	0.070	0.114*	0.138*	0.087
Flush toilet	0.146*	0.142*	0.123*	0.147*
Dirt floor	−0.196**	−0.181**	−0.148**	−0.128*
Delayed vaccines	−0.059	−0.072	−0.068	−0.070
Health insurance	0.190**	0.194**	0.171**	0.119*
Born hospital	0.174**	0.169**	0.178**	0.181**
Breastfed at birth	0.067	0.082	0.077	0.025
ln(Birth interval)	0.174**	0.175**	0.165**	0.183**
Birth order	−0.039**	−0.032*	−0.042**	−0.043**
Caretaker under 20	−0.276**	−0.314**	−0.327**	−0.359**
Observations	10118	10118	10118	10118
R^2	0.209	0.209	0.209	0.210

Notes: [a]Joint significance is based on a Wald test of the null hypothesis that all time-area varying parameters are jointly equal to zero. OLS denotes Ordinary Least Squares. Each model is estimated as $N_{i,t} = \boldsymbol{\beta X}_{i,t} + \boldsymbol{\gamma X}_{i,t}\boldsymbol{D}_{a,t} + \varepsilon_{i,t}$, $\forall a \in$ {rural, urban} and $t \in$ {1997, 2000, 2005, 2012}, where $\boldsymbol{D}_{a,t}$ is an indicator variable for area, a, and survey year, t. The vector of coefficients, $\boldsymbol{\gamma}$, contains the time-area varying parameters and the vector of coefficients, $\boldsymbol{\beta}$, contains the pooled parameters. Village-clustered robust standard errors are in parentheses. * $p < 0.05$, ** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. Source: Authors' calculations.

Table C4. Village Fixed Effects Regression Results

Dep. Variable: HAZ	(1) Pooled	(2) Rural	(3) Urban
Income[a]	0.056	0.068*	0.061
	(0.036)	(0.040)	(0.058)
Maternal education	0.026***	0.016	0.033***
	(0.008)	(0.011)	(0.011)
Paternal education	−0.002	0.007	−0.012
	(0.008)	(0.010)	(0.011)
Piped water	0.093	0.158	0.068
	(0.076)	(0.096)	(0.105)
Flush toilet	0.187**	0.048	0.281**
	(0.077)	(0.088)	(0.117)
Dirt floor	−0.209***	−0.278***	0.009
	(0.061)	(0.067)	(0.127)
Delayed vaccines	−0.060	−0.103**	−0.027
	(0.043)	(0.048)	(0.073)
Health insurance	0.165**	0.243*	0.129*
	(0.070)	(0.124)	(0.077)
Born hospital	0.144***	0.141**	0.153*
	(0.049)	(0.060)	(0.080)
Breastfed at birth	0.023	−0.070	0.109
	(0.058)	(0.074)	(0.086)
ln(Birth interval)	0.176***	0.196***	0.144***
	(0.029)	(0.039)	(0.040)
Birth order	−0.026	−0.024	−0.036
	(0.017)	(0.020)	(0.028)
Caretaker under 20	−0.248**	−0.397***	−0.068
	(0.110)	(0.134)	(0.197)
Female	0.057	0.044	0.071
	(0.036)	(0.044)	(0.057)
Head Guaraní	−0.042	0.095	−0.113
	(0.077)	(0.137)	(0.091)
Head bilingual	−0.034	0.027	−0.040
	(0.078)	(0.171)	(0.083)
Head other language	0.296*	0.385*	0.296
	(0.174)	(0.219)	(0.234)
Observations	10118	5068	5050
Adjusted R^2	0.141	0.175	0.127

Notes: Village is identified as the primary sampling unit. Fixed effects are unique to the village and survey year. [a]Income is the natural log of income. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators). Statistics are calculated with sample weights. Source: Authors' calculations.

Table C5. Fixed Effects regression models of child HAZ and time-area parameter stability, rural areas

Model:	FE Rural HAZ			
Variable	**1997**	**2000**	**2005**	**2012**
	Time-area Varying Parameters			
$\boldsymbol{D}_{a,t}\times$ln(Income)	0.096	−0.055	−0.032	0.015
$\boldsymbol{D}_{a,t}\times$Maternal education	0.010	0.001	0.001	−0.054*
$\boldsymbol{D}_{a,t}\times$Paternal education	−0.007	0.043*	0.025	−0.012
$\boldsymbol{D}_{a,t}\times$Piped water	0.134	0.003	0.064	0.191
$\boldsymbol{D}_{a,t}\times$Flush toilet	−0.236	0.035	−0.141	−0.289
$\boldsymbol{D}_{a,t}\times$Dirt floor	−0.138	−0.192	0.186	−0.116
$\boldsymbol{D}_{a,t}\times$Delayed vaccines	0.006	−0.140	−0.109	−0.003
$\boldsymbol{D}_{a,t}\times$Health insurance	0.557*	0.261	0.093	−0.239
$\boldsymbol{D}_{a,t}\times$Born hospital	−0.334**	0.129	0.094	0.103
$\boldsymbol{D}_{a,t}\times$Breastfed at birth	0.168	−0.340*	−0.273	−0.118
$\boldsymbol{D}_{a,t}\times$ln(Birth interval)	0.118	0.042	−0.112	−0.014
$\boldsymbol{D}_{a,t}\times$Birth order	0.011	0.058*	−0.020	−0.046
$\boldsymbol{D}_{a,t}\times$Caretaker under 20	−0.386	0.145	−0.040	−0.246
Joint Significance?[a]	**Yes**	**Yes**	**No**	**Yes**
	Pooled Parameters			
ln(Income)	0.040	0.071	0.059	0.051
Maternal education	0.025**	0.024**	0.026**	0.035**
Paternal education	−0.000	−0.007	−0.004	−0.000
Piped water	0.102	0.109	0.089	0.050
Flush toilet	0.206*	0.165*	0.198*	0.247**
Dirt floor	−0.184**	−0.157*	−0.232**	−0.195**
Delayed vaccines	−0.062	−0.043	−0.049	−0.064
Health insurance	0.144*	0.138	0.158*	0.199**
Born hospital	0.206**	0.104	0.131*	0.134**
Breastfed at birth	−0.010	0.077	0.040	0.037
ln(Birth interval)	0.157**	0.168**	0.184**	0.177**
Birth order	−0.027	−0.039*	−0.026	−0.022
Caretaker under 20	−0.184	−0.266*	−0.251*	−0.218
Observations	10118	10118	10118	10118
R^2	0.144	0.146	0.142	0.145

Notes: Village is identified as the primary sampling unit. Fixed effects are unique to the village and survey year.[a]Joint significance is based on a Wald test of the null hypothesis that all time-area varying parameters are jointly equal to zero. Each model is estimated as $N_{i,t} = \boldsymbol{\beta X}_{i,t} + \boldsymbol{\gamma X}_{i,t}\boldsymbol{D}_{a,t} + \boldsymbol{\omega_{v,t}} + \varepsilon_{i,t}$, $\forall a \in$ {rural, urban} and $t \in$ {1997, 2000, 2005, 2012}, where $\boldsymbol{D}_{a,t}$ is an indicator variable for area, a, and survey year, t and $\boldsymbol{\omega_{v,t}}$ is a village-survey year fixed effect. The vector of coefficients, $\boldsymbol{\gamma}$, contains the time-area varying parameters and the vector of coefficients, $\boldsymbol{\beta}$, contains the pooled parameters. Village-clustered robust standard errors are in parentheses. * $p < 0.05$, ** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), and indicators for whether a female and male adults are present in the household. Statistics are calculated with sample weights. Source: Authors' calculations.

Table C6. Fixed Effects regression models of child HAZ and time-area parameter stability, urban areas

Model:	FE Urban HAZ			
Variable	**1997**	**2000**	**2005**	**2012**
	Time-area Varying Parameters			
$\boldsymbol{D}_{a,t}\times$ln(Income)	0.062	−0.038	−0.007	−0.030
$\boldsymbol{D}_{a,t}\times$Maternal education	−0.003	0.01	0.035	−0.020
$\boldsymbol{D}_{a,t}\times$Paternal education	0.002	−0.007	−0.02	−0.015
$\boldsymbol{D}_{a,t}\times$Piped water	0.082	−0.142	−0.243	0.227
$\boldsymbol{D}_{a,t}\times$Flush toilet	0.228	−0.075	0.485*	0.093
$\boldsymbol{D}_{a,t}\times$Dirt floor	0.398	0.374*	0.112	−0.243
$\boldsymbol{D}_{a,t}\times$Delayed vaccines	−0.049	0.106	0.025	0.130
$\boldsymbol{D}_{a,t}\times$Health insurance	−0.012	−0.169	−0.127	0.187
$\boldsymbol{D}_{a,t}\times$Born hospital	−0.113	0.229	0.057	−0.422
$\boldsymbol{D}_{a,t}\times$Breastfed at birth	0.159	−0.02	0.055	0.310
$\boldsymbol{D}_{a,t}\times$ln(Birth interval)	−0.038	−0.038	0.028	−0.065
$\boldsymbol{D}_{a,t}\times$Birth order	0.029	−0.098*	0.058	0.001
$\boldsymbol{D}_{a,t}\times$Caretaker under 20	0.111	−0.05	0.231	0.477
Joint Significance?[a]	**No**	**Yes**	**No**	**No**
	Pooled Parameters			
ln(Income)	0.052	0.063	0.054	0.059
Maternal education	0.026**	0.024**	0.022*	0.029**
Paternal education	−0.002	−0.000	0.001	−0.000
Piped water	0.085	0.127	0.119	0.064
Flush toilet	0.155	0.197*	0.141	0.190*
Dirt floor	−0.242**	−0.244**	−0.217**	−0.190**
Delayed vaccines	−0.053	−0.072	−0.065	−0.071
Health insurance	0.173*	0.202*	0.181*	0.133
Born hospital	0.158**	0.123*	0.142**	0.155**
Breastfed at birth	0.002	0.030	0.022	−0.014
ln(Birth interval)	0.181**	0.179**	0.173**	0.183**
Birth order	−0.027	−0.039*	−0.026	−0.022
Caretaker under 20	−0.029	−0.014	−0.030	−0.027
Observations	10118	10118	10118	10118
R^2	0.142	0.144	0.142	0.143

Notes: Village is identified as the primary sampling unit. Fixed effects are unique to the village and survey year.[a]Joint significance is based on a Wald test of the null hypothesis that all time-area varying parameters are jointly equal to zero. Each model is estimated as $N_{i,t} = \boldsymbol{\beta}\boldsymbol{X}_{i,t} + \boldsymbol{\gamma}\boldsymbol{X}_{i,t}\boldsymbol{D}_{a,t} + \boldsymbol{\omega_{v,t}} + \varepsilon_{i,t}$, $\forall a \in$ {rural, urban} and $t \in$ {1997, 2000, 2005, 2012}, where $\boldsymbol{D}_{a,t}$ is an indicator variable for area, a, and survey year, t and $\boldsymbol{\omega_{v,t}}$ is a village-survey year fixed effect. The vector of coefficients, $\boldsymbol{\gamma}$, contains the time-area varying parameters and the vector of coefficients, $\boldsymbol{\beta}$, contains the pooled parameters. Village-clustered robust standard errors are in parentheses. * $p < 0.05$, ** $p < 0.01$. Height-for-age Z score is denoted as HAZ. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), and indicators for whether a female and male adults are present in the household. Statistics are calculated with sample weights. Source: Authors' calculations.

Appendix D

In Appendix D we present the main robustness analyses discussed in the paper.

Table D1. Decomposing the sources of change in child HAZ in Paraguay excluding child health and fertility variables, 1997 to 2012

Variable	Rural Change in HAZ	Urban Change in HAZ	Rural-Urban Gap Change in HAZ	Share of Gap Change (%) in HAZ
ln(Income)	0.066***	0.011	0.056***	19.485
Maternal education	0.085***	0.065***	0.020	6.959
Paternal education	0.013	0.011	0.002	0.696
Piped water	0.039**	0.033**	0.006	2.088
Flush toilet	0.043**	0.033**	0.010	3.479
Dirt floor	0.040**	0.008	0.032*	11.134
Predicted[a]	0.286	0.161	0.126	
Observed	0.412	0.125	0.287	
Observed 95% CI	(0.220, 0.604)	(0.042, 0.291)	(0.033, 0.542)	
Share Explained[b] (%)	69.426	129.262	43.842	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. Village-clustered robust standard errors were obtained using the delta method on the OLS HAZ pooled regression coefficients in Table D3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Height-for-age Z scores are denoted as HAZ. Statistics are calculated with sample weights. Source: Authors' calculations.

Table D2. Decomposing the sources of change in stunting in Paraguay excluding child health and fertility, 1997 to 2012

Variable	Rural Change in Stunting	Urban Change in Stunting	Rural-Urban Gap Change in Stunting	Share of Gap Change (%) in Stunting
I(Income>400,000)[c]	−0.010***	−0.004*	−0.007*	7.403
Maternal education	−0.013***	−0.010***	−0.003	3.173
Paternal education	−0.003	−0.003	0.000	0.000
Piped water	−0.004	−0.003	−0.001	1.058
Flush toilet	−0.003	−0.002	−0.001	1.058
Dirt floor	−0.014**	−0.003	−0.0120*	12.691
Predicted[a]	−0.047	−0.025	−0.024	
Observed	−0.078	0.017	−0.095	
Observed 95% CI	(-0.126, -0.030)	(-0.030, 0.064)	(-0.162, -0.027)	
Share Explained[b] (%)	60.554	−147.567	25.381	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. [c]Indicator function equals 1 if statement in parentheses is true. Village-clustered robust standard errors were obtained using the delta method on the LPM Stunted pooled regression coefficients in Table D3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Stunted is defined as HAZ<-2. Statistics are calculated with sample weights. Source: Authors' calculations.

Table D3. Regression models of child HAZ and stunting in Paraguay excluding child health and fertility variables

Model:	OLS[a]	LPM[b]
	HAZ	Stunted
Variable	Pooled	Pooled
Income[c]	0.129***	−0.059***
	(0.028)	(0.013)
Maternal education	0.035***	−0.005***
	(0.006)	(0.001)
Paternal education	0.007	−0.002
	(0.006)	(0.002)
Piped water	0.125**	−0.012
	(0.058)	(0.015)
Flush toilet	0.159***	−0.010
	(0.061)	(0.016)
Dirt floor	−0.208***	0.074***
	(0.052)	(0.017)
Female	0.079**	−0.019**
	(0.033)	(0.009)
Head Guaraní	−0.073	0.020
	(0.057)	(0.015)
Head bilingual	−0.032	0.016
	(0.060)	(0.014)
Head other language	0.475***	−0.085***
	(0.118)	(0.027)
Observations	10118	10118
Adjusted R^2	0.179	0.084

Notes: [a]OLS is Ordinary Least Squares. [b]LPM is linear probability model. [c]Income is the natural log of income in the OLS HAZ model and an indicator of Income>400,000 Guaraní in the LPM stunted model. Village-clustered robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. The regression table excludes a number of controls common to all regressions models: child demographics (female, twin, only child, first born, and monthly age indicators), indicators for whether a female and male adults are present in the household, and a complete set of department-area-year indicators. Statistics are calculated with sample weights. Source: Authors' calculations.

Table D4. Decomposing the sources of change in child HAZ in Paraguay excluding child health, fertility, and income variables, 1997 to 2012

Variable	Rural Change in HAZ	Urban Change in HAZ	Rural-Urban Gap Change in HAZ	Share of Gap Change (%) in HAZ
Maternal education	0.102***	0.078***	0.024	8.362
Paternal education	0.024**	0.021**	0.003	1.045
Piped water	0.046**	0.038**	0.007	2.439
Flush toilet	0.052***	0.040***	0.012	4.181
Dirt floor	0.048**	0.009	0.039*	13.589
Predicted[a]	0.272	0.186	0.085	
Observed	0.412	0.125	0.287	
Observed 95% CI	(0.220, 0.604)	(0.042, 0.291)	(0.033, 0.542)	
Share Explained[b] (%)	66.019	148.800	29.616	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. Village-clustered robust standard errors were obtained using the delta method. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Height-for-age Z scores are denoted as HAZ. Statistics are calculated with sample weights. Source: Authors' calculations.

Table D5. Decomposing the sources of change in stunting in Paraguay excluding child health, fertility, and income variables, 1997 to 2012

Variable	Rural Change in Stunting	Urban Change in Stunting	Rural-Urban Gap Change in Stunting	Share of Gap Change (%) in Stunting
Maternal education	−0.016***	−0.012***	−0.004	3.173
Paternal education	−0.004	−0.004	−0.001	1.058
Piped water	−0.005	−0.004	−0.001	1.058
Flush toilet	−0.005	−0.004	−0.001	1.058
Dirt floor	−0.016**	−0.003	−0.013*	13.684
Predicted[a]	−0.046	−0.027	−0.02	
Observed	−0.078	0.017	−0.095	
Observed 95% CI	(-0.126, -0.030)	(-0.030, 0.064)	(-0.162, -0.027)	
Share Explained[b] (%)	58.974	−158.824	21.052	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. Village-clustered robust standard errors were obtained using the delta method. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Stunted is defined as HAZ<-2. Statistics are calculated with sample weights. Source: Authors' calculations.

Table D6. Decomposing the sources of change in child HAZ in Paraguay, 2000 to 2012

Variable	Rural Change in HAZ	Urban Change in HAZ	Rural-Urban Gap Change in HAZ	Share of Gap Change (%) in HAZ
ln(Income)	0.033**	0.006	0.019*	4.657
Maternal education	0.065***	0.046***	0.019	4.657
Paternal education	0.003	0.004	−0.001	−0.245
Piped water	0.025*	0.017*	0.008	1.961
Flush toilet	0.036**	0.023**	0.013	3.186
Dirt floor	0.022	0.004	0.018	4.412
Delayed vaccines	0.010	0.003	0.007	1.716
Health insurance	0.010**	0.004	0.006	1.471
Born hospital	0.060***	0.019***	0.041***	10.049
Breastfed at birth	0.001	−0.005	0.006	1.471
ln(Birth interval)	0.052***	0.027***	0.025***	6.127
Birth order	0.041***	0.016**	0.024**	5.882
Caretaker under_20	−0.002	0.002	−0.004	−0.980
Predicted[a]	0.356	0.173	0.181	
Observed	0.500	0.092	0.408	
Observed 95% CI	(0.298, 0.703)	(-0.079, 0.263)	(0.143, 0.673)	
Share Explained[b] (%)	71.200	188.043	44.363	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. Village-clustered robust standard errors obtained using the delta method on the OLS HAZ pooled regression coefficients in Table 3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Height-for-age Z scores is denoted as HAZ. Statistics calculated with sample weights. Source: Authors' calculations.

Table D7. Decomposing the sources of change in stunting in Paraguay, 2000 to 2012

Variable	Rural Change in Stunting	Urban Change in Stunting	Rural-Urban Gap Change in Stunting	Share of Gap Change (%) in Stunting
I(Income>400,000)[c]	−0.007**	−0.003*	−0.004	3.200
Maternal education	−0.010**	−0.008**	−0.002	1.600
Paternal education	0.000	0.000	0.000	0.000
Piped water	−0.001	−0.001	0.000	0.000
Flush toilet	−0.003	−0.001	−0.001	0.800
Dirt floor	−0.009*	−0.001	−0.007	5.600
Delayed vaccines	−0.003	−0.001	−0.002	1.600
Health insurance	−0.003**	−0.001	−0.002	1.600
Born hospital	−0.016***	−0.005***	−0.011***	8.800
Breastfed at birth	0.000	0.002	−0.002	1.600
ln(Birth interval)	−0.013***	−0.07***	−0.006**	4.800
Birth order	−0.009*	−0.004*	−0.006	4.800
Caretaker under 20	0.000	0.000	0.000	0.000
Predicted[a]	−0.071	−0.028	−0.043	
Observed	−0.121	0.003	−0.125	
Observed 95% CI	(-0.172, -0.071)	(-0.039, 0.045)	(-0.190, -0.059)	
Share Explained[b] (%)	58.678	933.333	34.400	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. [c]Indicator function equals 1 if statement in parentheses is true. Village-clustered robust standard errors obtained using the delta method on the LPM Stunted pooled regression coefficients in Table 3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Stunted is defined as HAZ <-2. Statistics calculated with sample weights. Source: Authors' calculations.

Table D8. Decomposing the sources of change in child HAZ in Paraguay, 2005 to 2012

Variable	Rural Change in HAZ	Urban Change in HAZ	Rural-Urban Gap Change in HAZ	Share of Gap Change (%) in HAZ
ln(Income)	0.020*	0.029**	−0.009	−5.422
Maternal education	0.035***	0.007	0.018	10.843
Paternal education	0.002	0.004	−0.002	−1.205
Piped water	0.015	0.006	0.009	5.422
Flush toilet	0.025*	0.016**	0.009	5.422
Dirt floor	0.003	−0.001	0.004	2.41
Delayed vaccines	0.0004	0.005	−0.001	−0.602
Health insurance	0.009*	−0.002	0.011	6.627
Born hospital	0.039***	0.014***	0.025***	15.060
Breastfed at birth	−0.006	−0.006	0.000	0.000
ln(Birth interval)	0.024***	0.018**	0.007	4.217
Birth order	0.021**	0.010*	0.011	6.627
Caretaker under 20	−0.003	0.001	−0.004	−2.410
Predicted[a]	0.188	0.123	0.57	
Observed	0.454	0.288	0.166	
Observed 95% CI	(0.241, 0.667)	(0.111, 0.465)	(-0.111, 0.443)	
Share Explained[b] (%)	41.410	42.708	34.337	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. Village-clustered robust standard errors obtained using the delta method on the OLS HAZ pooled regression coefficients in Table 3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Height-for-age Z scores is denoted as HAZ. Statistics calculated with sample weights. Source: Authors' calculations.

Table D9. Decomposing the sources of change in stunting in Paraguay, 2005 to 2012

Variable	Rural Change in Stunting	Urban Change in Stunting	Rural-Urban Gap Change in Stunting	Share of Gap Change (%) in Stunting
I(Income>400,000)[c]	−0.005*	−0.002	0.003	−2.970
Maternal education	−0.005**	−0.004*	−0.001	0.990
Paternal education	0.000	0.000	0.000	0.000
Piped water	−0.001	0.000	0.000	0.000
Flush toilet	−0.003	−0.001	−0.001	0.990
Dirt floor	−0.001	0.000	−0.002	1.980
Delayed vaccines	−0.001	−0.001	0.000	0.000
Health insurance	−0.002*	0.000	−0.003	2.970
Born hospital	−0.010***	−0.004**	−0.006**	5.941
Breastfed at birth	0.002*	0.002*	0.000	0.000
ln(Birth interval)	−0.006***	−0.004**	−0.002	1.980
Birth order	−0.005*	−0.005	−0.003	2.97
Caretaker under 20	0.000	0.000	0.000	0.000
Predicted[a]	−0.036	−0.022	−0.015	
Observed	−0.126	−0.025	−0.101	
Observed 95% CI	(-0.181, -0.071)	(-0.071, 0.022)	(-0.174, -0.029)	
Share Explained[b] (%)	28.571	88.000	14.851	

Notes: [a]Predicted change is the sum of the change associated with each determinant and does not include changes in control variables. [b]Share explained is the share of the total change explained by the predicted change in percent. [c]Indicator function equals 1 if statement in parentheses is true. Village-clustered robust standard errors obtained using the delta method on the LPM Stunted pooled regression coefficients in Table 3 and the (transformed) mean estimates in Table A5 in Appendix A. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CI denotes confidence interval. Stunted is defined as HAZ <-2. Statistics calculated with sample weights. Source: Authors' calculations.

Table D10. Summary of Oaxaca decomposition of rural and urban changes in child HAZ and stunting in Paraguay, 1997 to 2012

Component	**Rural HAZ**	**Rural HAZ**	**Urban Stunting**	**Urban Stunting**
Sample 1997	−0.574**	−0.409**	0.105**	0.120**
	(0.085)	(0.064)	(0.016)	(0.014)
Sample 2012	−0.986**	−0.534**	0.183**	0.103**
	(0.048)	(0.048)	(0.016)	(0.015)
Change 1997-2012	0.412**	0.125	−0.078**	0.017
	(0.098)	(0.080)	(0.022)	(0.021)
Endowments[a]	0.407**	0.264**	−0.114**	−0.043**
	(0.079)	(0.056)	(0.020)	(0.016)
Coefficients[b]	0.081	−0.079	−0.024	0.049
	(0.136)	(0.092)	(0.032)	(0.027)
Interaction[c]	−0.076	−0.060	0.061	0.011
	(0.146)	(0.086)	(0.032)	(0.026)

Notes: This is a three-fold decomposition. [a]Endowments measures the change in child nutrition associated with changes in the determinants. [b]Coefficients measures the change in child nutrition associated with changes in the coefficients in the 1997 and 2012 model. [c]Interaction accounts for differences in endowments and coefficients that exist simultaneously between the the 1997 and 2012 models. See Jann Jann (2008) for more details. Decomposition based on ordinary least squares and linear probability models. Village-clustered robust standard errors in parentheses. Height-for-age Z score is denoted as HAZ. Stunted is defined as an indicator variable of HAZ<-2. Statistics calculated with sample weights. Source: Authors' calculations.

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