Excluding the Rural Population: The Impact of Public Expenditure on Child Malnutrition in Peru

*Gissele Gajate-Garrido**

Why is the urban–rural gap in child malnutrition increasing in Peru despite government efforts to improve the provision of public services? To answer this question, the impact of regional public expenditure in Peru on young children's nutritional outcomes is examined. To account for policy endogeneity, public expenditures are instrumented using unanticipated regional mining revenues. Even after accounting for changes in expenditure composition due to increases in mining revenues, public spending has a significant and positive impact on children's outcomes only in urban areas. However, even in urban areas, barriers exist that diminish the effectiveness of public expenditure, so indigenous and frailer children in these areas do not benefit from public spending. These children face constraints that limit their ability to use public services. This result reveals the paramount importance of initial conditions. In rural areas, possibly because of the lower quantity and quality of public services, there is no positive effect for any children. JEL codes: D13, H51, I12, J13

In the first half of the last decade, Peru grew relatively steadily and quickly, and its public budget expanded. Both the GNP and public expenditure in regions of Peru increased annually by 4 percent on average, whereas regional health expenditures grew by almost 7 percent every year. During this period, the country experienced increased awareness of the importance of early childhood, and its policy agenda featured the announcement of the National Plan of Action for Childhood and Adolescence (PNAI 2002–10). However, child nutrition

*Gissele Gajate-Garrido (corresponding author) is a Research Fellow at the International Food Policy Research Institute (IFPRI); her email address is g.gajategarrido@cgiar.org. The author thanks Dora L. Costa, Pascaline Dupas, John Hoddinott, Naomi Lamoreaux, Arleen Leibowitz, Marc Luppino, the anonymous referees from the World Bank Economic Review, and participants in the UCLA applied micro seminars for thoughtful comments and suggestions. She is also grateful to Javier Escobal and Monica Lizama for providing her with access to the Young Lives survey data and to Milagros Villagarcia and Julio Mejia for providing public expenditure data. The data used in this study com e from Young Lives, a 15-year survey investigating the changing nature of childhood poverty in Ethiopia, India (Andhra Pradesh), Peru, and Vietnam (www.younglives.org.uk). Young Lives is core-funded by UK aid from the Department for International Development (DFID) and co-funded from 2010 to 2014 by the Netherlands Ministry of Foreign Affairs. The views expressed here are those of the author. They are not necessarily those of Young Lives, the University of Oxford, DFID, or other funders. The usual disclaimers apply. A supplemental appendix to this article is available at http://wber.oxfordjournals.org/.

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worsened, and disparities between urban and rural areas widened. This is a serious concern because nutritional deprivation negatively impacts cognitive development (Glewwe et al. 2001; Walker et al. 2005) and hinders human capital formation (Glewwe and Jacoby 1995; Maluccio et al. 2006). By 2005, 30 percent of Peruvian children younger than five years of age endured chronic malnutrition[1], with drastic urban–rural differences. In urban areas, 14 percent of children were malnourished, compared to 46 percent in rural areas. This difference of 32 percentage points represented an increase from 26 percent in 2000[2]. Van de Poel et al. (2007) found that Peru had the largest urban–rural gap in the nutritional levels among 47 developing countries.

This paper aims to determine who benefits from increasing public spending in Peru and to identify potential explanations for the increase in the urban–rural malnutrition gap. I analyze the impact of changes in total regional public expenditure on changes in child nutritional outcomes using longitudinal data from a panel of children who were studied from their first birthday until age six. This approach contrasts with most previous papers in the literature, which perform cross-country analyses (Filmer and Pritchett 1999; Baldacci et al. 2002; Gupta et al. 2003). The use of panel data allows me to control for unobserved household–child heterogeneity.

This study also provides exogenous variation to correct for the potential endogeneity of regional public expenditure. The variation comes from the use of lagged regional mineral extraction multiplied by non-predictable mineral price changes, which I refer to hereafter as unanticipated mining revenues. The instrument is a function of natural resource extractions in each political region of Peru during 2001 and the change in the world prices of these resources between 2002 and 2006. This instrument has a strong impact on public spending because it is directly related to the amount of natural resource royalties that regional governments receive each year. The instrument that I use is the improvement in health input prices, which are typically used in the health economic literature (Schultz 2004), because it is not altered by individual regional migration. Any omitted factors need to fluctuate within regions over time in the same non-linear way as unanticipated revenues in the mining sector to have a confounding effect on child malnutrition. Two possibilities are that (1) regional income increases with increases in unanticipated mining revenues and (2) health outcomes worsen with increases in these revenues. I show that both concerns are unsubstantiated. It is also possible that regional governments changed their patterns of expenditure in response to the amount of royalties received, spending more in sectors that directly influence child health. I verify that changes in the composition of expenditures are not responsible for the differentiated impact of public expenditure.

In addition, this paper differs from the existing literature because it analyzes the potential barriers that diminish the effectiveness of public expenditure. I find

1. Source: 2004–6 Continual Demographic and Family Health Survey (ENDES). This is a nationally representative survey. The percentages belong to children in the same age group in two different points of time.

2. Source: 2004–6 ENDES.

that public expenditure is ineffective and even harmful in rural areas, possibly due to lower quantity and quality of public services in these areas. In urban areas, public spending does have the ability to improve nutritional status. However, in cities, despite the availability of effective public goods and services, demand and efficient use may be limited by the lack of complementary private assets. I confirm that the consumption levels of public goods and services differ depending on child characteristics. The children whom public spending does not help have indigenous mothers and the lowest birth weights.

The remainder of this paper is divided into four sections. The next section briefly describes the link between public spending and child malnutrition. Section two presents the estimation procedure and the conceptual framework. Section three describes the results. Finally, the paper concludes with a discussion of the findings.

Public Spending and Child Malnutrition

This study focuses on the impact of public investment on the nutritional level of children from infancy until early childhood. This period is a particularly important developmental stage for children. Authors such as Knudsen et al. (2006) and Heckman (2007) have emphasized the importance of early experiences, which have a considerable influence on the development of diverse skills as well as on biological processes. These skills and processes determine the mental potential of individuals and, consequently, their ability to achieve strong economic productivity in adulthood.

The causes of stunting are multiple and intertwined[3]. A child's nutritional status results from a process that begins, even before birth. Children with low birth weights, inadequate nutritional intake, and high burdens of disease will become stunted. Furthermore, diseases such as diarrhea and acute respiratory infections can cause a vicious cycle of malnutrition and illness (Ehiri and Prowse 1999). Malnutrition in Peruvian children is caused by food deprivation and infectious diseases, which, in turn, are related to poverty, lack of access to markets, deficient transportation, inadequate health and sanitary infrastructure, and low levels of education (Valdivia 2004; Escobal et al. 2005; Aguiar et al. 2007).

Public goods and services may directly affect a child's nutrition by providing access to health facilities, better sanitary infrastructure, or nutritional programs (McGinnis et al. 2002). In addition, building roads lowers transportation costs, thereby allowing food to reach previously disconnected areas and potentially diversifying or enhancing a child's diet. Building a dam may improve the agricultural productivity of a region and can consequently increase the food supply and ensure food availability. Furthermore, government investments in research and infrastructure may stimulate growth that may lead to greater income-earning opportunities (Fan et al. 2000). Additionally, it is important to measure the impact of

3. A child is stunted if he/she falls two standard deviations below the height-for-age z-score. The z-score is calculated using the World Health Organization Child Growth Standards (WHO 2006).

total public expenditure because bundled public services have been shown to affect welfare more strongly than separate interventions (Escobal and Torero 2002; Chong et al. 2003). Hence, this paper examines the impact of total public expenditure rather than only the effect of increases in public health spending.

The impact of public spending on child nutrition does not depend only on the amount of money spent. The quality of the goods and services provided is crucial to their effectiveness. In Peru, the amounts spent and the quality of expenditure differs considerably between urban and rural areas. Finally, public expenditures will not be effective if households are not able or willing to access public goods and services due to child frailty, language barriers, or lack of economic resources. These concerns are addressed in this study.

Methodology

Public expenditure at a regional level is determined by factors that may simultaneously affect the nutritional levels of children. Maternal characteristics that induce mothers to choose to live in a specific location with a specific level of public expenditure may also affect their ability to care for their children. Moreover, the government may decide to spend more in an area where there is a greater need for public intervention (Rosenzweig and Wolpin 1986). This incentive creates reverse causality[4]. I address this endogeneity problem using an instrumental variable approach. My exogenous variation in public expenditures comes from unanticipated regional mining revenues.

Source of Exogenous Variation: Unanticipated Mining Revenues

Unanticipated mining revenues are composed of revenues from the exploitation of minerals (gold, zinc, lead, silver, iron tin, copper, and molybdenum), oil, and gas. These three are lumped together as "mining resources" in Peruvian national accounts. The Mining Canon Regulations (Supreme Decree No 005-2002-EF) approved in 2002 state that regional and local governments are entitled to all of the mining royalties collected in their region (these are equivalent to 50 percent of the income and rents obtained by the central government from the exploitation of mining activities in their jurisdictions)[5]. At the national level, royalties represented 1.1 percent and 3.5 percent of total regional expenditure in 2002 and 2006, respectively[6]. I use unanticipated mining revenues as an instrument of

4. I conducted a Wu-Hausman F test statistic to test whether public spending was, in fact, exogenous. I was able to reject the null hypothesis (p-value = 0.053). This means that the endogeneity among the regressors would have deleterious effects on OLS estimates.

5. According to the law, the amount of royalties generated in a year is distributed with a delay of a year and a half. This results in a disassociation between the time at which these amounts are generated and when they are spent.

6. These numbers are much larger if Lima is excluded from the calculations (2.7 percent and 7.6 percent, respectively) because, due to the highly centralized nature of the government, public spending in Lima is approximately 20 times the maximum spending in the rest of the regions.

public spending because they determine the magnitude of mining royalties but can be considered exogenous. The instrument uses the extraction levels in each region prior to the new law (2001 volumes) and the changes in the world prices of these resources between 2002 and 2006. By using lagged extraction, identification is driven only by unanticipated price changes rather than by changes in extraction rates, which may have been endogenous to the policy. To show the variation in the instrument, I create a figure comparing the changes between 2002 and 2006 in the value of mineral production in each region (there are 25 regions in Peru). The value is calculated by multiplying the change between 2002 and 2006 in international prices by the amount of minerals produced in each region in 2001. This figure, as well as figures showing the changes in mineral prices and the geographical variation of royalties between 2002 and 2006 (Figures S1.1-S1.5), can be found in the supplemental appendix (available at http://wber.oxfordjournals.org/). These figures illustrate the huge increases in international prices during the period of analysis, the wide geographic variation in the value of royalties across regions, and the variation of the instrument across regions.

The Instrument's Strength

Given the way the law was designed, royalties in Peru have a multiplier effect on public spending. By law, during the period studied in this paper, royalties had to be spent on the maintenance of local infrastructure projects, feasibility studies for investment projects, and scientific and technological research. Furthermore, public funds could only be assigned to regional or local governments for investment projects if they had approved feasibility studies that showed they were economically sound. Producing a feasibility study is a costly activity that can usually only be financed if the authorities have access to external funds, such as royalties. Hence, royalties may allow regional and local governments to hire specialists to produce sound feasibility studies that would increase the probability that their projects would be approved and that they would receive more public funds. In addition, investing in scientific and technological research may result in the development of sounder investment proposals with higher probabilities of being financed and, hence, higher regional public spending. If I run a simple regression of unanticipated mining revenues on changes in public expenditure using region-year data and only controlling for regional debt and a year fixed effect, I find that 100 million soles of additional mining revenues increase total spending by 2.8 million soles[7].

The multiplier effect is even clearer in the size of the parameters found in the first-stage regression for both urban and rural areas, as Table 1 shows. An increase of 100 million soles in the amount of unanticipated mining revenues will increase the level of total expenditure by 1,095 and 635 million soles in rural and urban areas, respectively. Both coefficients are significant at a 1 percent level. The effect is especially large in rural areas, most likely due to the distribution

7. The coefficient is significant at the 10 percent level.

TABLE 1. First Stage Estimation - Impact of Changes in Unanticipated Mining Revenues on Changes in Public Expenditure by Area

Dependent variable:	Public Spending		
	Whole sample IV	Rural IV	Urban IV
Unanticipated mining revenues	8.119	10.952	6.352
	(0.206)***	(0.444)***	(0.201)***
Other controls	YES	YES	YES
Number of observations	1,902	688	1,213
Partial R^2 of excluded instrument	0.454	0.481	0.457
F-test for weak identification	1554	608	995

Notes: The independent variable is the level of unanticipated regional mining revenues. The estimations include regional fixed effects, time fixed effects, and all controls included in the second-stage estimation. Spending measured in 100 million soles. Robust standard errors clustered by region-year in parentheses, * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. These include regional fixed effects and time fixed effects.

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–6.

rule within regions, which favored rural areas[8]. In addition, I assess the strength of the instrument using the first-stage F statistic. Estimators can perform poorly when instruments are weak, resulting in non-normal sampling distributions of IV statistics and unreliable standard IV point estimates, hypothesis tests, and confidence intervals[9]. The null hypothesis is that the instrument is weak. For all of the estimations, the F statistic (at a 5 percent significance level) ensured that the maximal bias of the IV estimator relative to OLS was no larger than 5 percent. This fits the definition of a strong instrument according to Stock et al. (2002).

The Instrument's Validity

Changes in the amount of unanticipated regional mining revenues do not respond to local circumstances. They only depend on the price of minerals in the international market and on the volume of minerals produced prior to the change in the royalties' legislation. Variations in the amount of unanticipated mining revenues do not lead directly to an increase in economic activity in the areas where the resource is located. Indeed, the correlation between the changes in per capita GDP and the changes in unanticipated mining revenues is quite small (0.203)[10], indicating that changes in unanticipated mining revenues cannot

8. See supplemental appendix section S4.3 for more detail on the distribution rule.

9. A set of instruments is defined as weak if the concentration parameter is small enough that inferences based on conventional normal approximating distributions are misleading. The concentration parameter is a unitless measure of the strength of the instruments (Stock et al. 2002; Stock and Yogo 2002). One measure of whether a set of instruments is strong is whether the concentration parameter is sufficiently large.

10. I calculated this correlation using region-year data between 2002 and 2006. In addition, I conducted a regression of changes in unanticipated mining revenues on changes on GDP per capita and found no statistically significant effect of mining revenues on GDP per capita.

affect per capita GDP (or, for that matter health) other than through changes in public expenditures. Furthermore, changes in these revenues have no impact on changes in consumer price indexes for commodities that could affect child well-being, such as food, medicines, and health care, as shown in Table S4.2 in the supplemental appendix[11].

Unanticipated mining revenues are thus arguably unrelated to children's nutritional outcomes provided that an increase in these revenues is uncorrelated with changes in net income per capita, expenditure categories, and migration patterns and that mining does not directly affect child health. First, I verify that increases in mining revenues do not directly increase income per capita by running a panel fixed effects model with region-year data. Changes in these revenues have no statistically significant effect on changes in income per capita (see Table S4.2 in the supplemental appendix).

Second, mining revenues may affect health status directly. Increased mining activities may generate enough additional pollution to worsen the general population's health. However, changes in mining revenues do not have a statistically significant impact on changes in the probability of suffering a chronic illness, nor do they modify the predicted probability of suffering a self-reported life threatening illness[12] (see Tables S4.2 and S4.3 in the supplemental appendix). Finally, I verify that the level of mining revenues do not affect migration patterns and that changes in expenditure composition only explain a small fraction of the impact of total spending. These results and detailed explanations can be found in sections S4.1 and S4.2, respectively, of the supplemental appendix.

Specification

My first stage equation is

$$P_{jt} = \delta_j + \phi_t + \rho_1 Z_{jt} + \rho_2 X^c_{ijt} + \rho_3 \hat{H}^c_{ijt} + \rho_4 X^H_{ijt} + \rho_5 X^C_{ijt} + \rho_6 p^n_{ijt} + \rho_7 X^R_{jt} + \varepsilon_{jt}. \quad (1)$$

P_{jt} is the level of public expenditure in period t and region j, Z_{jt} is the level of unanticipated mining revenues obtained by each region j at time t, δ_j are region fixed effects, and ϕ_t are year fixed effects. I controlled for other regional characteristics that vary over time (X^R_{jt}), the price of the nutritional input (p^n_t)[13], and child (X^c), household (X^H), and community (X^C) characteristics that also vary over time[14]. Child's health status (H^c_t) is a dummy indicating that the child

11. I used data that varied at the region-year level and found no statistically significant effect of changes in mining revenues on changes with either of these consumer price indexes.

12. I tested the effect of mining revenues on the predicted probability of suffering a life-threatening illness for children in the Young Lives Study sample because I use this variable as a control in my main regressions. See the specification subsection for further explanation.

13. The price chosen is the price of rice, the main staple in Peruvian diets. Some of the rice prices were missing, so they were imputed using the province averages to replace the missing values.

14. I did not include maternal characteristics that vary over time because the only one I could control for, maternal education, had coding issues between rounds.

suffered a life-threatening illness[15]. This is an endogenous variable because it is a choice and is likely to be affected by public spending. Hence, I instead use in the regression its predicted value ($\hat{H}^c_{ijt}$), where the predictors of an episode of a serious illness are the intensity of air and water pollution in the community. My second stage equation is

$$N_{jt} = \theta_j + \phi_t + \alpha P_{jt} + \beta_1 X^c_{ijt} + \beta_2 \hat{H}^c_{ijt} + \beta_3 X^H_{ijt} + \beta_4 p^n_{ijt} + \beta_5 X^C_{jt} + \beta_6 X^R_t + \mu_{jt}. \quad (2)$$

where N^c_{ijt} is the height-per-age z-score level for the child and θ_i represents the individual fixed effects. μ_{ijt} represents unobserved attributes related to both the mother and the child, such as resilience, maternal initiative, and determination. I use a first difference approach and cluster the standard errors at the region-year level to account for any variation within region and year[16].

Main Variables

The nutritional status of the child is measured using height z-scores. Height has proven to be an informative long-term indicator of the nutritional status of children. Z-scores are constructed using the new World Health Organization (WHO) international child growth standards. Specifically, the z-scores are defined as the standard for well-nourished children. For example, the height-for-age z-score for a child i in age and gender group c is constructed as

$$Z_{ic} = \frac{(H_{ic} - MedianH_c)}{\sigma_c} \quad (3)$$

where H_{ic} is the measured height of the child and $MedianH_c$ and σ_c are the age- and gender-specific median height and the standard deviation of the height, respectively, of well-nourished children. A risk indicator is falling two standard deviations below this z-score measure. In round one, 18 percent of children in the sample were malnourished, compared with 32 percent in round two. In urban areas, stunting increased from 11 percent to 21 percent between rounds, whereas in rural areas, it increased from 20 percent to 58 percent.

The independent variable of interest used in this study is the level of public expenditure in each region. The total public expenditure is defined as the summation of investment and current expenditure. The unit of measurement is 100 million soles (approximately 33 million dollars). During the period analyzed (2002–6), total per capita government expenditure increased by 34 percent[17].

15. Using acute health conditions instead of minor episodes allowed me to avoid capturing seasonal health problems and to reduce potential biases in reporting health conditions.

16. The clustering level is the region-year. Hence, clusters are defined for non-movers as well as for movers. Thus, there is a cluster for children who lived in Lima in 2002 and stayed in Lima in 2006, and there are different clusters for children who lived in Lima in 2002 but moved to other regions in 2006.

17. Statistics from the Ministry of Economics and Finance (www.mef.gob.pe).

Results

The following section describes the different data sources used in this study and presents the results. It includes explanations of the different pathways through which public spending improves child well-being and the possible exclusion mechanisms at work.

Data

The analysis relies on three main sources of data. I use the Young Lives International Study of Childhood Poverty, which tracks the lives of 2,052 Peruvian children born in the years 2000–1 for 15 years. The first round of data was collected in 2002, and the second round was collected between late 2006 and early 2007. The rate of attrition in the study was small (4.39 percent), and, as Table S3.1 in the supplemental appendix confirms, the only significant differences at a 5 percent level of means are for mother's height and the probability of having an immunization program in the child's community. I also test and discard the hypothesis that attrition can be explained by the spending patterns within regions. This survey includes information about each child as well as the household and the social, economic, and environmental context of the community in which the child resides. These data allow me to control for different aspects in the child's life that may affect his or her nutrition, such as age and household attributes. A description of the design of this study can be found in section S3.1 in the supplemental appendix.

Second, I match these data with statistics at the regional level using the 2002 and 2006 National Household Surveys (ENAHO). These are yearly surveys conducted throughout the entire country to measure living conditions, poverty levels, and the impact of social programs. The ENAHO surveys are representative at both the regional level and the urban–rural level. Finally, I collect information about public expenditure, and I construct the value of unanticipated mining revenues using information from the Ministry of Economics and Finance statistics database.

Descriptive Statistics. The differences between urban and rural areas for both rounds of the survey are illustrated in Table 2. The most remarkable divergences are related to the possession of private assets, such as maternal education and wealth. In addition, community characteristics, such as the size of the population and the probability of living in the highlands, differ greatly. There is differential access to health professionals, such as general physicians, pediatricians, and trained midwives, that persists for the two rounds. The differential access to public health facilities and programs narrows in the second round, with significant increases in rural areas. Finally, children in rural areas have a much worse height z-score and almost three times the probability of being undernourished in comparison to their counterparts in urban areas. Between the two rounds, these differences increase. Child nutrition outcomes and household characteristics

TABLE 2. Descriptive Statistics for Urban and Rural Areas for Both Rounds

Variable	Round 1				Round 2				Difference	
	Urban		Rural		Urban		Rural		Urban	Rural
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	Mean
Prob. of living in the area	65%	48%	35%	48%	69%	46%	31%	46%	4%	−4%
Prob. of being stunted	11%	31%	29%	45%	20%	40%	58%	49%	8%	26%
Z-score (height for age)	−0.49	1.24	−1.31	1.29	−1.20	1.05	−2.18	0.95	−0.67	−0.81
Z-score (weight for age)	0.18	1.13	−0.57	1.13	−0.29	1.04	−1.00	0.79	−0.43	−0.42
Age of child in months	12	3	12	4	65	4	61	4	53	50
Serious illness	0.31	0.46	0.33	0.47	0.19	0.39	0.23	0.42	−0.13	−0.09
Maternal education level	2.18	1.21	1.07	0.78	2.38	1.26	1.21	0.88	0.24	0.21
Number of children younger than 5 yrs	0.35	0.58	0.58	0.64	0.59	0.71	1.11	0.84	0.23	0.48
Household size	5.58	2.32	5.96	2.35	5.25	2.04	6.08	2.05	−0.33	0.00
Household wealth score	1.14	2.26	−2.10	1.16	1.07	2.25	−2.42	1.19	0.10	−0.20
General physician	80%	40%	27%	44%	78%	31%	32%	21%	2%	3%
Pediatrician/gynecologist	50%	50%	4%	19%	39%	36%	3%	11%	−8%	−2%
Midwife in locality	88%	32%	50%	50%	79%	26%	52%	20%	−6%	−2%
Public health center	80%	40%	21%	41%	99%	4%	92%	9%	19%	69%
Immunization	92%	26%	72%	45%	99%	3%	95%	6%	7%	22%
Disease prevention program	93%	25%	78%	41%	99%	3%	95%	6%	6%	16%
Child growth	93%	25%	79%	41%	99%	3%	95%	6%	6%	16%
Highlands	38%	49%	72%	45%	36%	48%	77%	42%	−1%	−2%
Population in locality	6076	3933	2431	3368	21246	24190	1769	4382	17070	−836

Source: Young Lives Study Round 1 and 2.

differ between these areas, according to several authors (Smith et al. 2005; van de Poel et al. 2007; Larrea et al. 2005). One explanation for the nutritional gap may be the high altitude at which most of Peru's rural population lives. In their 2007 study, van de Poel et al. said that child growth retardation could be caused by hypoxia (oxygen shortage), which is common at high altitudes. Similarly, growth retardation could be the result of the highlands diet, which is characterized by low protein and micronutrient intake (Larrea et al. 2005).

The Impact of Regional Public Expenditure on a Child's Z-score

Given the disparities between urban and rural areas, I perform separate estimations of the conditional demand functions for the nutritional level of children for these areas and for the whole sample. The separate estimations measure the impact of changes in total regional expenditure on children living in either urban or rural areas. Hence, the coefficient calculated for urban areas represents how an additional unit of public spending in a region affects the average z-score of children living in an urban area. The results are shown in Table 3. The first column shows the results for simple panel data estimation without instrumenting changes in total public expenditure. The second column provides second-stage estimates for a panel estimation in which changes in total public expenditure are instrumented using changes in unanticipated regional mining revenues. The third and fourth columns display the second-stage panel IV results for the rural and urban samples, respectively.

All specifications include regional and time fixed effects. I control for child's age, child's predicted health status, household characteristics (number of children under five years of age, availability of drinking water in the household, household size, and wealth score), community characteristics (rice price, population size, a dummy for living in the highlands, a dummy for living in an urban area, and a poverty index), and regional variables (debt payments)[18]. According to the simple panel data estimate for the whole sample, changes in total public spending appear to have a negative but not statistically significant effect on changes in a child's nutritional status (the coefficient is equal to -0.052). This result is consistent with the reverse causality hypothesis that the government will spend more in areas where there are pressing social demands. The instrumental variable panel estimation for the whole sample shows a positive but not significant coefficient (0.041)[19]. In contrast, in rural areas, the IV estimation shows a very small, negative (-0.078), and statistically significant impact of public spending. However, in urban areas, conditional on the inclusion of the control variables described above, there is a positive (0.238) and significant impact of changes in public expenditure on changes in a child's nutritional outcome (almost twice the size of a

18. Individual time-invariant variables, such as birth weight, ethnicity, gender, maternal height, and maternal age at birth, were excluded from the estimation because individual fixed effects are included. All of the controls are expressed in changes.

19. I also calculated the instrumental variable pool estimator, which also showed a positive but not significant coefficient (0.535).

TABLE 3. Impact of Changes in Public Expenditure on Changes in a Child's Nutritional Level and Height by Area

Dependent Variable:	Z-score (height for age)				Height (in cm)	
	Panel				Panel	
	Whole sample OLS (1)	Whole sample IV (2)	Rural IV (3)	Urban IV (4)	Rural IV (5)	Urban IV (6)
Total public spending	−0.052	0.041	−0.078	0.238	0.050	0.825
	(0.058)	(0.068)	(0.029)**	(0.127)*	(0.224)	(0.328)**
Other controls	YES	YES	YES	YES	YES	YES
N	1,902	1,902	688	1,214	692	1,218
R^2	0.344					

Notes: The estimations include regional fixed effects, individual fixed effects, and time fixed effects. Controls: child's age, predicted child's health, number of children under 5 years of age in the household, availability of drinking water, household size, wealth score, rice prices in the community, population size, a dummy for living in the highlands, a dummy for being in an urban area, a poverty index, and the level of regional debt payments. For estimations (5) and (6), I include as an additional control the lag value of height. Spending measured in 100 million soles. The instrument for the IV estimation is the amount of unanticipated regional mining revenues. Robust standard errors clustered by region-year in parentheses, * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006 and Ministry of Economic and Finance Budgetary Expenditure for 2000–6.

non-instrumented panel estimation for urban areas[20]). Furthermore, I verify that the difference in the urban and rural coefficients is statistically significant at a 5 percent level. For an increase equal to the average annual change in spending in a region between 2002 and 2006, the average urban child z-score would have increased by 19 percent of a standard deviation. In addition, the coefficient for urban areas is almost six times larger than the one estimated for the whole sample[21]. This magnitude should be understood in the context of a growth curve.

I use growth charts[22] to assess the extent to which increasing public expenditure in urban areas can improve a child's nutritional level. A growth chart consists of a series of percentile curves that show the distribution of height-for-age for boys and girls since birth. Using these tables, a child's height can be compared

20. Simple panel data estimations were performed for urban and rural areas. In rural areas, public spending appears to have a statistically significant at 1 percent and a negative effect on children's stunting (with a coefficient of -.115). In urban areas, there is a small, positive, and statistically significant effect at 1 percent (with a coefficient of 0.141).

21. I performed additional estimations to address the possibility of non-linear effects in spending. I used a logarithmic transformation of the expenditure variable as the independent variable. I found no statistically significant effect of spending for the total sample or for rural areas. As before, I found a statistically significant and positive effect of public expenditure on z-scores in urban areas. According to this estimation, a 1 percent increase in expenditures would increase z-scores by 0.007.

22. Source: World Health Organization.

to the expected height parameters of children of the same age and sex to determine whether the child is growing appropriately. I find that more than 61 percent of the increase in malnutrition disparities between rural and urban areas can be explained by the increase in total public expenditure during the two rounds of the survey (63 percent for boys and 60 percent for girls).

As a robustness check, I estimate the impact of changes in public spending on changes in child height between the two periods[23]. The results are consistent with the ones obtained with z-scores of height for age. In rural areas, there is no statistically significant effect. In urban areas, every increase of 100 million soles in public expenditures increases the average child's height by 0.83 cm. Furthermore, for an increase equal to the average change in public expenditures between survey rounds, a child's height will change by 15.9 cm.

Pathways Through which Public Spending Improves Child Well-Being

The results reinforce the findings of Valdivia (2004) that the expansion in health infrastructure in Peru during the 1990s had a significant causal impact on children's nutrition only in urban areas. Worse health outcomes for the rural population may thus be a consequence of the lack of effectiveness of public services in these areas.

Differences in public services availability between urban and rural areas. The lack of effectiveness of public spending may be related to the differences in the availability of public services between urban and rural areas. The availability of health professionals, health facilities, and programs in a given locality may be pathways through which public spending improves child well-being. To assess these pathways, I estimate IV panel models in which the dependent variable is the change in an access measure at the community level. The community level measures include the change in the probability of accessing a general physician, a pediatrician or gynecologist, a midwife, a child growth control program, and a public health center[24]. The results are presented in Table 4. Changes in public spending only increase access to local health professionals and child growth controls in urban areas. However, in rural areas, public spending does not modify access to local health professionals, but it decreases access to child growth controls while increasing the probability of accessing public health centers. This is not a surprising result because, according to Table 2, public health centers increased dramatically in rural areas during the period of analysis.

23. I include as an additional control the lag value of height, which relaxes the assumption that the coefficient on the lag is equal to 1.

24. These community level measures were obtained from the community survey, so the access to health professionals and facilities is not conditional on health. All of these estimations include regional and time fixed effects. As controls, I use community characteristics (the average household wealth score in the community, population size, a dummy for living in the highlands and a poverty index) and regional variables (average level of education in the region and debt payments). I cluster the standard errors at the region-year level.

TABLE 4. Impact of Changes in Public Spending on Changes in the Probability of Accessing a Health Professional, Program, or Facility in One's Locality (By Area)

	Panel	
Dependent Variable: Availability of . . . in your locality	Rural IV	Urban IV
General physician	−0.049	0.524
	(0.070)	(0.128)***
Pediatrician/Gynecologist	−0.010	0.441
	(0.018)	(0.112)***
Midwife	−0.002	0.330
	(0.048)	(0.132)**
Child growth controls	−0.154	0.222
	(0.051)***	(0.113)*
Public health center	0.178	0.212
	(0.061)***	(0.127)
N	724	1235

Notes: Each coefficient represents a separate regression. Robust standard errors clustered by region−year in parentheses, *significant at 10 percent; **significant at 5 percent; ***significant at 1 percent. Includes the average household wealth score in the locality, the population size, the average educational level in the region, a dummy for belonging to the highlands, a poverty index, the level of regional debt payments, regional fixed effects, and time fixed effects. Spending measured in 100 million soles. The instrument for all IV estimations is the amount of unanticipated mining revenues.

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance (2000–6).

DIFFERENCES IN PUBLIC SPENDING QUALITY BETWEEN URBAN AND RURAL AREAS. High rates of absenteeism and irregular working hours usually characterize poorly monitored public health facilities in rural areas (Devarajan and Reinikka 2004; Chaudhury et al. 2006; Banerjee and Duflo 2011). These limitations could explain the reduced effectiveness of these services. If this is the case, public expenditure should also have a differential effect between urban and rural areas on alternative child health outcomes, such as the probability of suffering a life-threatening illness and weight-for-height z-scores. A more detailed explanation of this alternative hypothesis and a table with the regression results can be found in section S5.1 in the supplemental appendix. The results support the claim that rural areas have less effective public services and that increases in public spending that are mainly directed to health centers may actually worsen child health outcomes.

Exclusions at Work

Disadvantaged groups may profit little from public expenditures if the access to and use of services provided by the government are affected by the possession of private assets (Filmer and Pritchett 1999; Filmer et al. 2000; Filmer 2003; Castro-Leal et al. 1999; O'Donnell 2007; O'Donnell et al. 2007; Thomas et al. 1991). This situation leads to heterogeneous treatment effects. Hence, the

estimates obtained are "local average treatment effects" (LATE) instead of what we should aim to measure, which are the effects of the treatment on the treated (TT) (Heckman and Vitlacyl 1999). The initial results may underestimate the actual impact of increasing public expenditure on those who are able to access the services. Therefore, I also estimate the effect of total public expenditure on the sub-samples defined by child, maternal, and household characteristics[25]. In Table 5, estimates are presented from urban and rural samples to differentiate the effect of a lower quantity and quality supply of public goods and services from the impact of a lack of access to key private assets. A detailed explanation of each of the outcomes analyzed and a further interpretation of these results can be found in the supplemental appendix, section S5.2. In the following subsections, I present a summary of the findings.

The impact of public spending according to child resilience. In urban areas, changes in public expenditure have a statistically significant and positive impact only on changes in the nutritional level of children who are above the 25th birth weight percentile. The coefficient estimate for the sub-sample in the highest percentiles for birth weight is larger than the one for the whole urban sample (0.296 vs. 0.238). These results are consistent with a favorable selection hypothesis[26]. In contrast, in rural areas, changes in public expenditure have a negative impact (significant at the 5 percent level) on children in the higher birth percentiles. There is no statistically significant impact for the non-resilient group in either area. The differential impact across the urban subsamples is statistically significant, but this is not the case for the rural parameters.

The impact of public spending according to child's initial nutrition status. The previous result showed that children with higher birth weights in urban areas are the only ones who benefit from public spending. This result could be explained by a health production function in which poor early life health outcomes magnify over time. If that were the case, one would not expect public spending to play a major role in explaining the widening in the urban–rural malnutrition gap. To test this hypothesis, I divide the children into two groups: those who were malnourished during the first round (with a z-score below -2 S.D.) and those who were not malnourished. The estimates in Table 5 show that changes in public expenditure have a statistically significant and positive impact on changes in the nutritional level only of initially well-nourished children. The coefficient estimate is slightly larger than the one for the whole urban sample (0.283), which attests to the importance of early circumstances. In rural areas, changes in public expenditure only have a statistically significant and negative impact on

25. The instrumental variable in all of the following estimations was tested and proved to be strong.

26. These results may be thought to be driven by the mother's own frailty. To discard this hypothesis, I divided the sample between the children with shorter mothers (belonging to the lowest height quartile) and the children with the tallest mothers. In both urban and rural areas, there was no statistically significant differential impact of public spending between taller and shorter mothers.

TABLE 5. Impact of Changes in Public Expenditure on Changes in a Child's Nutritional Level by Child/Household Characteristics

	Z-score (height for age)					
	Rural IV		Statistically Significant Differential Impact	Urban IV		Statistically Significant Differential Impact
Dependent Variable:	Lowest birth weight quartile	Higher birth weight quartiles		Lowest birth weight quartile	Higher birth weight quartiles	
Total public spending	−0.038	−0.103	No	0.061	0.296	Yes
	(0.041)	(0.043)*		(0.140)	(0.152)*	
N	156	507		257	939	
	Malnourished in 1st round	Not malnourished in 1st round		Malnourished in 1st round	Not malnourished in 1st round	
Total public spending	−0.131	−0.032	No	0.216	0.283	No
	(0.045)**	(0.043)		(0.277)	(0.124)**	
N	196	492		129	1086	
	Indigenous	Not indigenous		Indigenous	Not indigenous	
Total public spending	−0.030	−0.103	No	−0.169	0.346	Yes
	(0.086)	(0.034)***		(0.106)	(0.164)**	
N	375	313		208	1006	
	Poor	Not poor		Poor	Not poor	
Total public spending	−0.079	−0.054	No	0.019	0.239	No
	(0.036)**	(0.040)		(0.292)	(0.114)**	
N	371	317		322	892	

Notes: Robust standard errors clustered by region−year in parentheses, * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. Includes regional fixed effects, individual fixed effects, and time fixed effects and all previous controls in the original regression in Table 3. Spending measured in 100 million soles. The instrument for all IV estimations is the amount of unanticipated mining revenues. The instrument is proved to be strong for every sub-sample.

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–6.

children with worse initial nutritional status. In both areas, the differential impact across the sub-sample is not statistically significant. Hence, initial conditions do not solely explain the results.

THE IMPACT OF PUBLIC SPENDING ACCORDING TO MATERNAL MOTHER TONGUE. An "indigenous" mother tongue can be a barrier with regard to communicating with medical professionals as well as a source of lack of self-confidence. I define as "indigenous" a mother with a mother tongue other than Spanish (the official language) and as "not indigenous" a mother with Spanish as her mother tongue. In rural areas, even though there is a negative and statistically significant effect of changes in public spending for non-indigenous mothers, the differential impact across subsamples is not significant. In urban areas, the impact of changes in public expenditure is positive and significant only for mothers who are not indigenous. This impact is much stronger than for the whole urban sample (0.346). Furthermore, the differential impact of public spending across ethnic groups is statistically significant.

THE IMPACT OF PUBLIC SPENDING ACCORDING TO HOUSEHOLD WEALTH LEVEL. Households with tighter budget constraints are less prone to dedicate time to child-enhancing activities. I define poor households as those with an initial household wealth score below the regional household wealth median[27], which translates to an average income per capita of approximately $2 per day. The poor seem to have worse z-scores due to increases in public spending in rural areas. In urban areas, changes in public expenditure only affect positively (and statistically significantly) the nutritional level of children belonging to "non-poor" households. However, the differential impact across samples is not significant for either area.

DISCUSSION

This paper offers new evidence on the differential impact of public expenditure on child health outcomes in a developing country. In contrast to previous work, it exploits variations in unanticipated mining revenues. This instrumental variable is shown to be unrelated to child nutrition except through public spending. This paper differs from the existing literature because it analyzes the potential barriers that diminish the effectiveness of public expenditure. I provide evidence that changes in public expenditure are ineffective and even harmful in rural areas. A lower quantity and quality of services and the crowding out of private expenditure in those areas are possible explanations for this result. In urban areas, changes in public expenditure appear to positively affect child nutrition. Even there, however, only some children are able to benefit from the consumption of public goods and services. The children whom public expenditure does

27. The regional household wealth median was calculated using the ENAHO surveys.

not help have indigenous mothers and are the ones with the worst initial conditions. The consequence is a regressive distribution of stunting. These findings are consistent with previous studies that indicate an anti-poor bias, represented in this study by indigenous status, of public spending in developing countries (Castro-Leal et al. 1999; O'Donnell et al. 2007; Wagstaff and Watanabe 2000). Public spending is not helping the most destitute children and is thus unable to break the cycle of poverty and malnutrition. This result indicates that disparities in outcomes may widen in the future.

Another finding of this paper is that initial conditions are of paramount importance. Nutrition production varies across age groups, and there are periods in which public expenditure can be more critical than others. Indeed, in urban areas with readily available higher-quality public goods and services, children with low birth weights are not able to benefit from public spending. Hence, governments should focus their efforts on the initial stages of child development.

A limitation of this paper is that the results obtained can only be interpreted as local average treatment effects because this study measures the impact of changes in public expenditure when influenced by mining revenues. Future research should focus on finding other sources of exogenous variation with higher levels of external validity and on exploring how to raise the quality and utilization of health services in rural areas.

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