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The Interaction of Public Assets, Private Assets and Community Characteristics and its Effect on Early Childhood Height-for-Age in Peru

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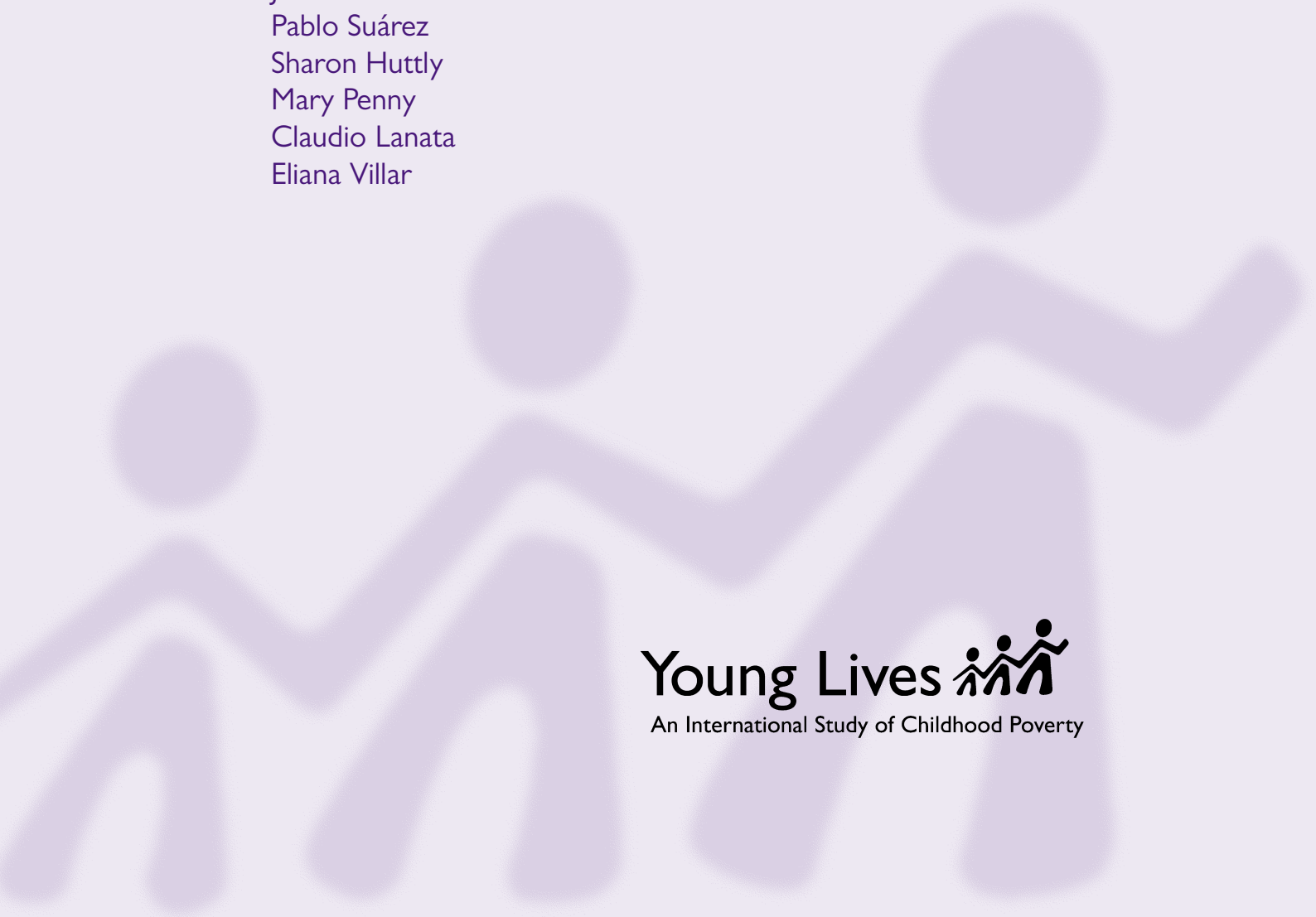

Young Lives
An International Study of Childhood Poverty

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Preface

This paper is one of a series of working papers published by the Young Lives project, an innovative longitudinal study of childhood poverty in Ethiopia, India (Andhra Pradesh State), Peru and Vietnam. Between 2002 and 2015, some 2,000 children in each country are being tracked and surveyed at 3-4 year intervals from when they are 1 until 14 years of age. Also, 1,000 older children in each country are being followed from when they are aged 8 years.

Young Lives is a joint research and policy initiative co-ordinated by an academic consortium (composed of the University of Reading, the London School of Hygiene and Tropical Medicine, London South Bank University and the South African Medical Research Council) and Save the Children UK, incorporating both inter-disciplinary and North-South collaboration.

Young Lives seeks to:

- Produce long-term data on children and poverty in the four research countries
- Draw on this data to develop a nuanced and comparative understanding of childhood poverty dynamics to inform national policy agendas
- Trace associations between key macro policy trends and child outcomes and use these findings as a basis to advocate for policy choices at macro and meso levels that facilitate the reduction of childhood poverty
- Actively engage with ongoing work on poverty alleviation and reduction, involving stakeholders who may use or be impacted by the research throughout the research design, data collection and analyses, and dissemination stages
- Foster public concern about, and encourage political motivation to act on, childhood poverty issues through its advocacy and media work at both national and international levels.

As a working paper, this publication represents work in progress and the authors welcome comments from readers to contribute to further development of these ideas.

The project received financial support from the UK Department for International Development and this is gratefully acknowledged.

For further information and to download all our publications, visit www.younglives.org.uk

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Acknowledgements

This project would not have been possible without the extreme effort and professionalism of the field teams and local helpers, under the supervision of Sofía Madrid. The authors also wish to thank Héctor Verástegui for his database management assistance.

Abstract

Child health in general and long-term nutritional status in particular are related to family characteristics and assets (including maternal education) and community characteristics (including access to public services), as well as to child-specific characteristics. Public policy has a crucial role in increasing the likelihood that a child can access high quality healthcare as well as a set of other public services that have an effect on health status. However, access to these public services may have different effects depending on how it interacts with specific community and family characteristics, in particular the education of the mother or caregiver. In Peru, despite a dramatic increase in investment in health during the last decade, particularly in primary care centres, and improved targeting of public health investment, there is still a large degree of inequality and leakage. In addition, there is evidence that the productivity of healthcare establishments is on average low, and variability very high, with lower productivity observed in rural areas. Access to water and sewerage also shows considerable variability. In many cases, access to and use of services such as health facilities, water and sanitation, electricity, roads, etc, is determined by the possession of private assets. Efficient use of these services appears to be related to key assets such as education.

This paper uses Young Lives (YL) data to explore the interaction of private assets, such as education, with public services, some of them provided at the community level and some of them at the household level. In particular, we have explored how mother's education interacts with access to clean water and sewerage, availability and quality of health facilities, proximity to paved or engineered roads, and access to electricity. Using cross tabulations between these variables and anthropometric outcomes, and regression analyses that account for the clustered nature of the data, the paper focuses on the direct and indirect impact of maternal education on height-for-age z-scores (HAZ), after controlling for other covariates including inherited factors, family and child characteristics, and community characteristics, some of which can be influenced by public policies.

As in many other studies, mother's education was found to have a positive effect on long-term nutritional status, as measured by HAZ. HAZ is clearly associated with mother's education and the data suggest a non-linear relationship, ie, more important in earlier years. The results clearly establish that mother's education is an important independent determinant of child nutritional status. Moreover, there are indirect effects of education operating through other variables such as the number and spacing of siblings and initial birth weight. An auxiliary regression that only includes education shows that at least half the effect of education is direct, while the remainder operates through wealth and family demographics. In addition, the level of mothers' education at the community level also matters.

Differences in nutritional status according to service access are seen in both urban and rural areas. Only in the case of those mothers who are more educated does access to services not make a significant difference to nutritional status. These findings are maintained when covariates are controlled for. Although these are only cross correlations, they suggest potential substitutability between education – a private asset – and public service facilities, the availability of which depends, even if they are inside the household, on the existence of a public network. Our results thus endorse the concept that investment in public services is even more necessary in areas with low maternal education.

Introduction

Child health is related to family characteristics and assets, particularly mother's education; to the overall community environment, including access to publicly provided services; and to child characteristics. Public policy has a crucial role in increasing many children's chances of accessing high quality healthcare and a set of other public services that have an effect on health status. But access to public assets will have different effects depending on how it interacts with specific family characteristics and private assets, in particular education, and community characteristics.

Despite a dramatic increase in investment in health in Peru during the last decade, particularly in primary care centres, and improved targeting of public health investment, there is still a large degree of inequality and leakage. In addition, there is evidence that productivity of healthcare establishments is on average low, and variance very high, with lower productivity observed in rural areas, and presumably also lower quality. Access to water and sewerage also shows considerable variability. Data from the latest Peruvian Living Standards Measurement Study – LSMS (Instituto Cuánto, 2000) show that the percentage of households that own a toilet or septic tank is 84 per cent in urban areas and only 22 per cent in rural areas.

In all cases, access to and use of services such as health facilities, water and sanitation, electricity, roads, etc, is determined by the possession of private assets. Moreover, efficient use of these services appears to be related to assets such as education. The context, and the availability of more than one asset, matter in many cases. Escobal and Torero (2002), in the case of rural areas, and Chong, Hentschel and Saavedra (2003), provide evidence for Peru that bundling of public services matters, and the effect on welfare of having access to two or more services together is proportionally higher than when the effect of each one is measured separately. There is also evidence that other types of community effects may matter. Alderman, Hentschel and Sabates (2001) show that in Peru female education at the neighbourhood level has a positive effect on nutrition beyond the effect of the individual caregiver's own education. This is consistent with the existence of externalities in education (ie, community-level impacts) that justify more aggressive public investment.

Anthropometric measures are key indicators of child growth and health. Child growth is a measure of a physiological process that depends on the child's nutrition both in utero and post-natally and is modulated by many factors which include genetics, child illness, the care the child receives (including healthcare), maternal behaviour such as tobacco and alcohol consumption, and economic, health or emotional shocks suffered during pregnancy and during the lifetime of the child (Barber and Gertler, 2002).

Maternal education affects child health and standard of living. Education may have both a direct effect on health (Strauss, 1990; Barrera, 1990) and an effect through many indirect channels. Education directly influences use of and choice of healthcare options and affects the demand for health inputs if, for instance, schools provide health information or if they change women's attitudes towards modern health practices. Education may also increase the ability to comply with treatments suggested by healthcare providers or to take advantage of publicly available information (another channel through which education affects health) (Thomas, Strauss and Henriques, 1991). Mother's education may affect waste and rubbish disposal, and non-breast-milk caloric intake, which in turn are related to diarrhoeal

infections (Glewwe, 1999). Education may also affect health through a reduction in the number of pregnancies and the number of children, which allows more resources to be devoted to the surviving children (Kravdal, 2003).

How robust are these effects? Some studies have focused on health knowledge as the key variable behind maternal education. According to some of these studies, like that of Kovsted, Pörtner and Tarp (2002) using information on children in Guinea Bissau, the effect of maternal education on malnutrition almost disappears when health knowledge is taken into account. Block (2002) obtains a similar result for Indonesia where maternal education was found to contribute to child micronutrient status through its effect on nutrition knowledge (for which schooling is not the primary choice).

Desai and Alva (1998), using a panel of countries, show that the effect of maternal education on child health vanishes in most, but not all, cases when partner education, access to public services and place of residence are controlled for. Of the 24 countries studied, the only places where the relationship with maternal education remained after controlling for other covariates were Liberia, Sri Lanka and several Latin American countries including Peru. Victora et al (1992), using data from the Pelotas Birth Cohort[1] study, found that the relationship between maternal education and height-for-age was very robust while the relationship with birth weight and perinatal mortality disappeared after controlling for confounding variables such as family income and the education of the partner.

Nevertheless, the literature has consistently shown that mother's education plays an important role in child wellbeing even after controlling for a number of factors, including the initial conditions (birth weight, mother's height); sex of the child; age of the mother; socio-economic characteristics of the household (asset endowment); and the characteristics of the partner/husband (education level, occupation). Few variables have shown such a strong relationship. One policy implication may simply be to increase expenditure on education, especially for females. However, if we do not fully understand the channels through which education affects the long-term nutritional status of children, policy proposals may lack focus.

Another set of factors that greatly determine child health are community characteristics. Public policy has a crucial role in determining access to high quality healthcare and a set of other public services that have an effect on health status. Family choices also affect the amount, quality and type of prenatal and curative healthcare accessed, but these choices will be conditioned by the availability and quality of public goods and by community characteristics. For instance, Strauss (1990) and Wolfe and Behrman (1986) have explored the importance of community variables, such as water and sewerage systems, for child growth and health.

Access to health facilities, and the quality of these facilities and of the staff, may determine whether children experience appropriate management of common infectious diseases, in particular in poor settings where inadequate or marginal nutritional intake interacts with childhood infections to negatively impact on growth. This is especially important in settings where poor sanitation facilitates faecal-oral transmission of diarrhoeal and parasitic illnesses (Grantham-McGregor, Fernald and Sethuraman, 1999), important causes of infant mortality in poorer countries. Thomas, Lavy and Strauss (1996) show that healthcare facilities explain a significant proportion of the variance in child nutritional status. They also find some evidence of the importance of medical personnel and the availability of medicines at the community level. Finally, they find that the availability of immunisation

[1] The Pelotas Birth Cohort study is a longitudinal study started in Pelotas, southeast Brazil in 1982. It recruited 5,914 newborns who have been followed periodically ever since. More information is available at www.scielo.br/pdf/csp/v19n5/17797.pdf

programmes, childbirth services and child growth monitoring programmes are correlated with child height.

However, access to public assets will have different effects depending on how it interacts with specific family characteristics and private assets, in particular education, and community characteristics. Thomas, Strauss and Henriques (1991) show, using Brazilian data, that there are significant interactions between maternal education and availability of community services, indicating that education and public services or health services can be complements or substitutes, depending on the setting (urban/rural) and the types of service.

This paper uses the Young Lives (YL) data set obtained from a stratified (urban and rural) nationwide clustered sample of Peruvian children aged between 6 and 18 months. Using anthropometric outcomes, it explores the interaction of private assets such as education with public services, some of them provided at the community level and some of them at the household level. In particular, we explore interactions with access to clean water, sewerage, electricity and improved roads, and availability of health facilities. In addition, we look at the role of the level of education achieved by the mothers in the community, as this may work as a positive or negative externality, given the mother's own education.

Methods

The Peru YL data set consists of a nationwide sample of 1,980 children aged between 6 and 17.9 months at enrolment. Children were enrolled for the first phase of the project between August and December 2002. The sample was distributed between 20 sentinel sites in urban and rural districts; each site included 100 children between 6 and 17.9 months. In brief, all 1,818 districts of Peru were ranked according to their poverty level. Eliminating the wealthiest five per cent, a sample of districts was taken across the poverty spectrum. Within each district sampled, a random dwelling was selected and then all dwellings nearby were systematically checked to identify children of the relevant age. In a few cases, after covering the whole community or even the whole district, there were fewer children than required, so children living in contiguous communities and districts were surveyed. A detailed description of the data set and sampling procedure can be found in Escobal et al (2003).

Information at the community level comes from several sources. First we used a community (town) census that was developed in 2001. The census questionnaire included questions on population and on road access. We complemented this information with a YL community questionnaire and a survey carried out with headteachers by the Ministry of Education. Health services information was obtained from the 1999 Health Census provided by the Ministry of Health (MINSA, 2000).

All children were weighed and their length measured. The outcome indicator used here is height-for-age, a measure of chronic nutritional status of a child. Using the NCHS (1977) reference population, z-scores (HAZ) were computed. Children with a HAZ of less than –2 were classified as stunted in growth (ie, with chronic malnutrition).

In order to rank the children according to wealth, an index was constructed. This wealth index is a simple average of three components: housing quality, consumer durables and access to public services. Housing quality is itself a simple average of the following indicators: rooms per person and quality of floor, roof and wall. Consumer durables are proxied by the number of durables available in the household. Finally, public services is a simple average of dummy variables reflecting access to drinking water, electricity, a toilet and fuel.

Maternal education was measured as the stage of schooling completed and the number of years of schooling received. A community level of maternal education was also derived as an aggregate variable, defined as the median years of schooling of the mothers surveyed in the community.

Public and community services were measured in four different ways. First, public services *availability* at household level considers if a household has access to piped water, a connection to a sewerage system, and electricity. Second, public services *supply* at community level reflects whether these services are supplied in the community where the household lives – irrespective of whether they are available at the individual household level. Third, improved roads is measured by a dummy variable which indicates whether or not the main access road to the community is a paved or engineered road. Finally, access to health services is proxied by a dummy variable which indicates whether or not there is a health centre in the community where the child lives.

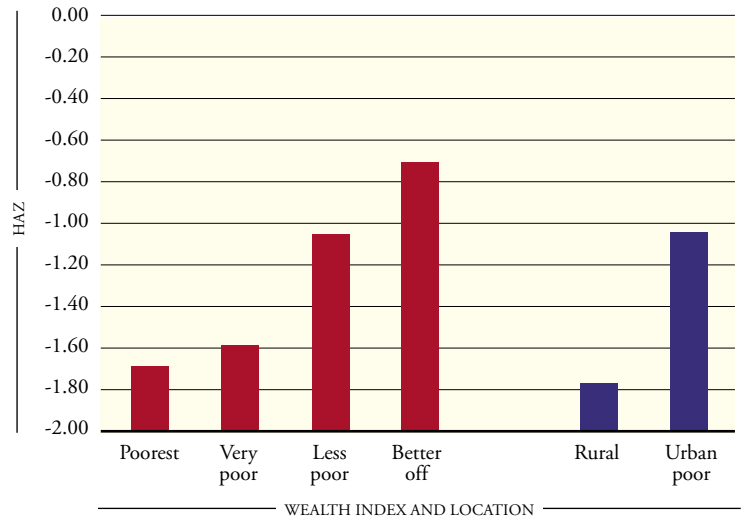
Data analyses were conducted using Stata version 8 (StataCorp, 2003). Mean HAZ were compared using Students' t-test. For multivariate analysis, a series of regression models were fitted, the details of which are given in Appendix A.

Results

Nutritional status

Overall, 25 per cent of the Peru YL children were classified as stunted (HAZ < -2). This is consistent with national results that rank Peru as having the second highest chronic malnutrition rate in South America and the fifth in Latin America (de Onis, Frongillo and Blössner, 2000). This short stature is related to chronic nutritional deficiency and/or previous acute malnutrition, which affects the child's growth and, eventually, limits his or her intellectual capacity. Stunting was more prevalent among rural children than among urban children (39.2 per cent vs. 18.2 per cent). These figures are very similar to those reported in the Peru national Demographic and Health Surveys (DHS) for children of the same age range. Graph 1 shows the mean HAZ according to wealth index and rural/urban location.

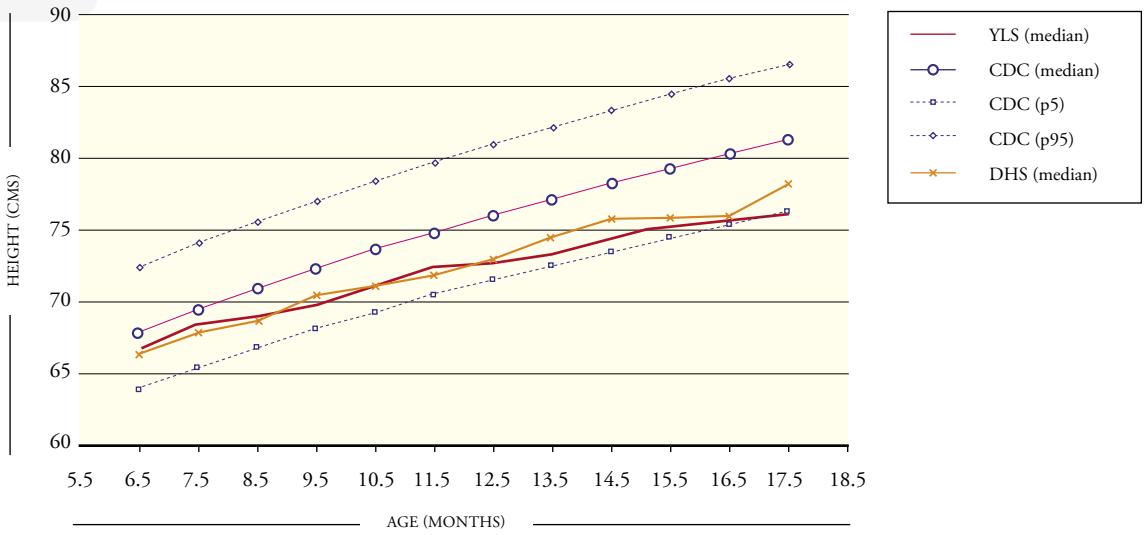
Graph 1: Mean height-for-age z-score by wealth index and location



Source: Own estimations based on YL data

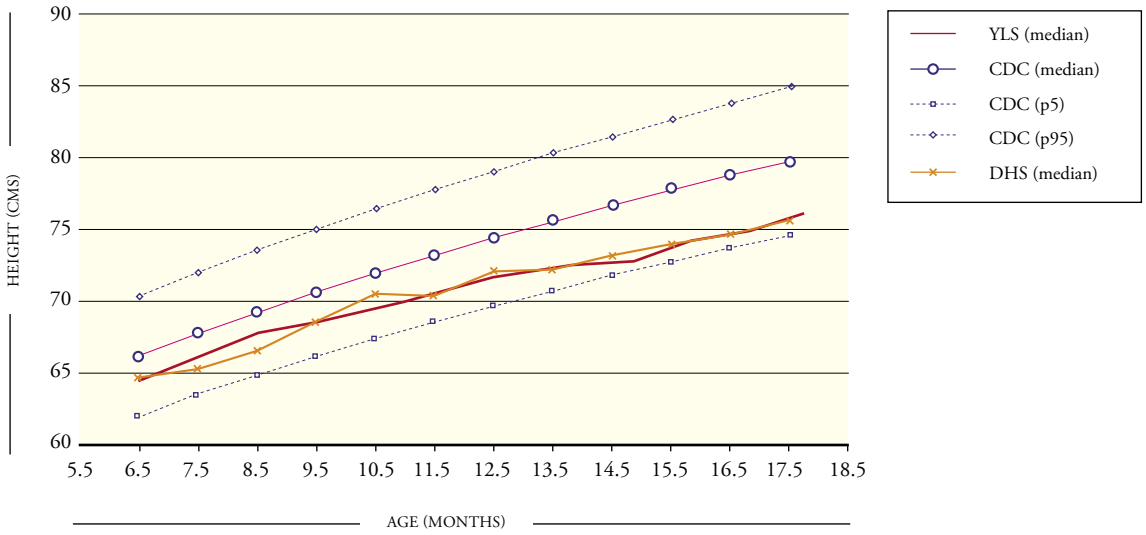
During the first six months of life, Peruvian children receive a good supply of nutrients, almost exclusively from breastfeeding. Height deficits become more noticeable after this age. Graphs 2 and 3 show height-for-age values for boys and girls using the YL data, the CDC reference values and data from the 2000 Demographic and Health Surveys (DHS) obtained from INEI (2001). It can be observed that Peruvian children's median height in the 6 to 18 month interval, according to both YL and DHS data, converges towards the CDC's 5th percentile as age increases. Additionally, the height-for-age deficit increases faster for boys than for girls.

Graph 2: Boys' height-for-age



Source: YLS 2002, DHS 2000, CDC 2000

Graph 3: Girls' height-for-age

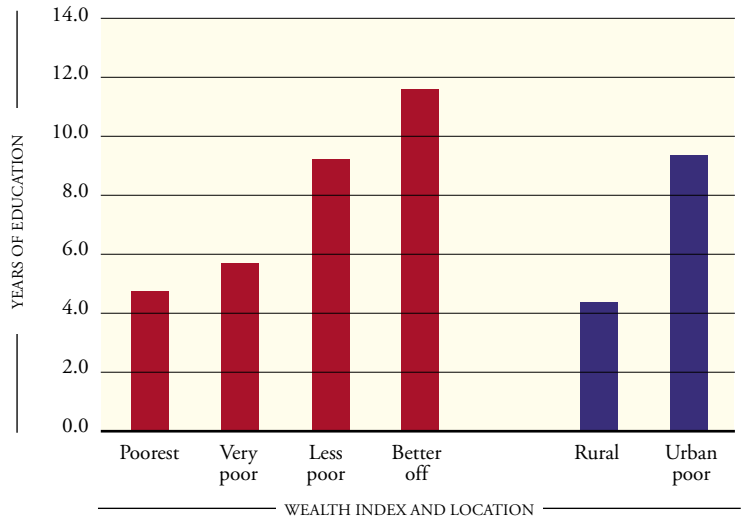


Source: YLS 2002, DHS 2000, CDC 2000

Maternal education

Although Peru has a high formal education level, educational inequality is also quite high. As seen in Graph 4, there is dramatic inequality in women's education between urban and rural areas and between wealth groups.

Graph 4: Mean mother's years of education by wealth index and location

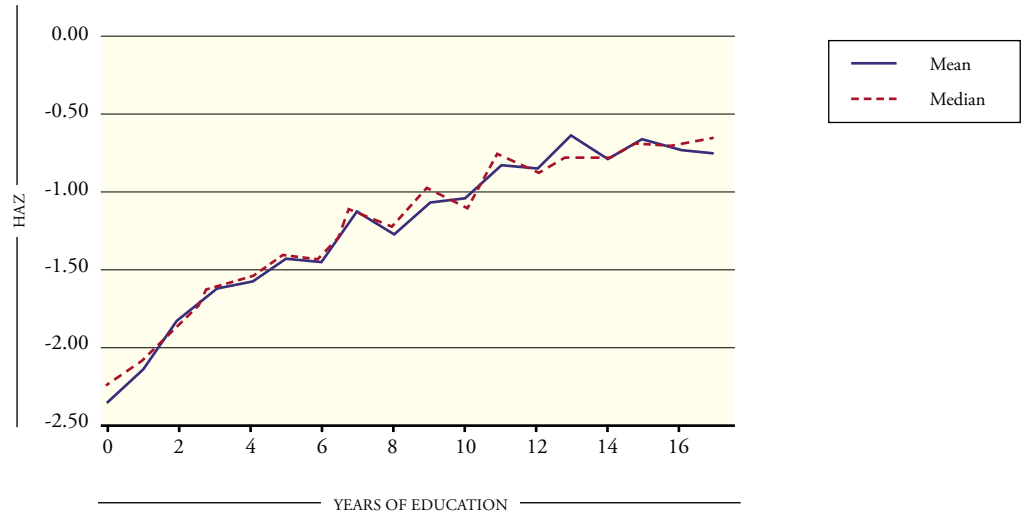


Source: YLS 2002

Maternal education and child HAZ

Standardised height is clearly correlated with maternal education, and the data suggest a non-linear relationship (Graph 5). The marginal contribution of education is greater for the first years of schooling (basic education) than for higher levels of education. However, this marginal contribution is positive across the schooling range.

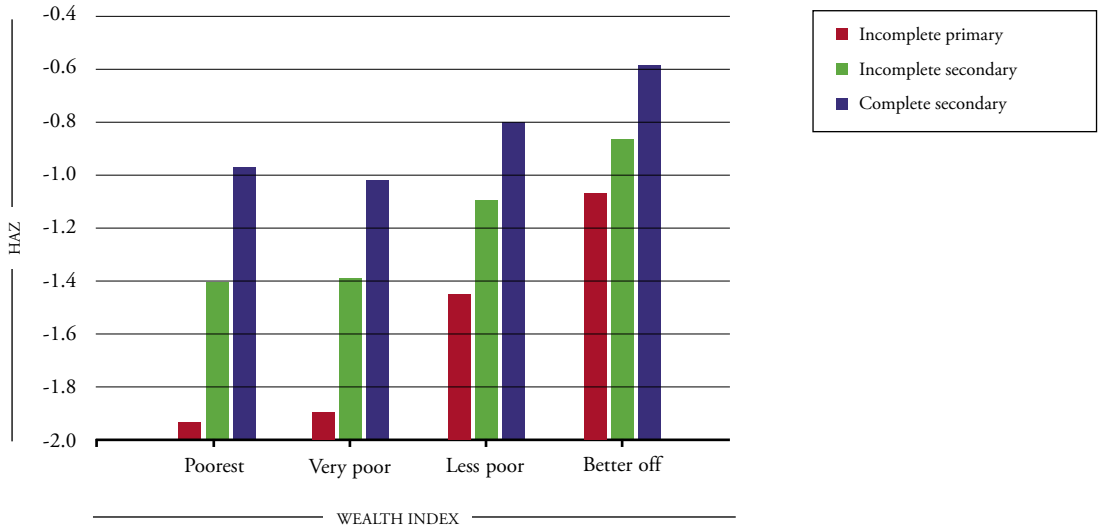
Graph 5: Mean and median height-for-age z-score by mother's years of education



Source: YLS 2002

Mother's education and family wealth are correlated and each has a strong relationship with nutritional status. Moreover, for a given education level, height-for-age increases with the family's wealth, as can be observed in Graph 6. The same occurs with variables such as family income, the possession of consumer durable assets – although only up to a certain level – child's birth weight, mother's height and community size.

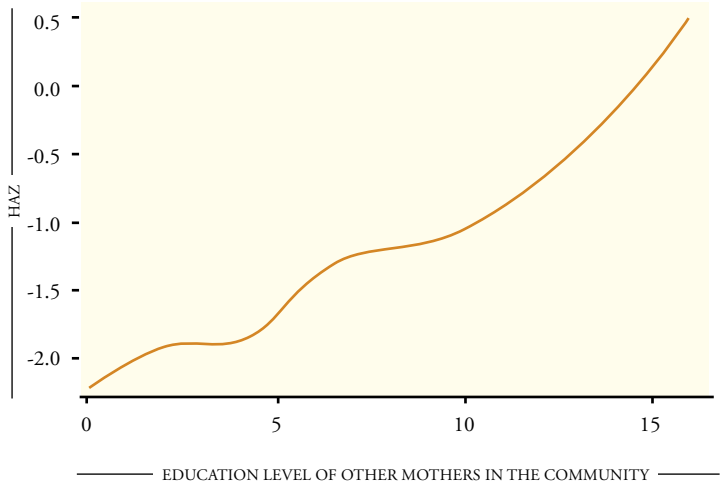
Graph 6: Mean height-for-age z-score by wealth index and mother's education



Source: YLS 2002

The importance of mother's education is also seen at a collective community level. As Graph 7 shows, HAZ is correlated with the education of other mothers in the community. This variable probably reflects both the socio-economic status of the community and the general knowledge of neighbouring mothers. The latter might benefit a mother, for example by facilitating the provision of information about how to improve her child's health.

Graph 7: Height-for-age z-score by education of other mothers in the community

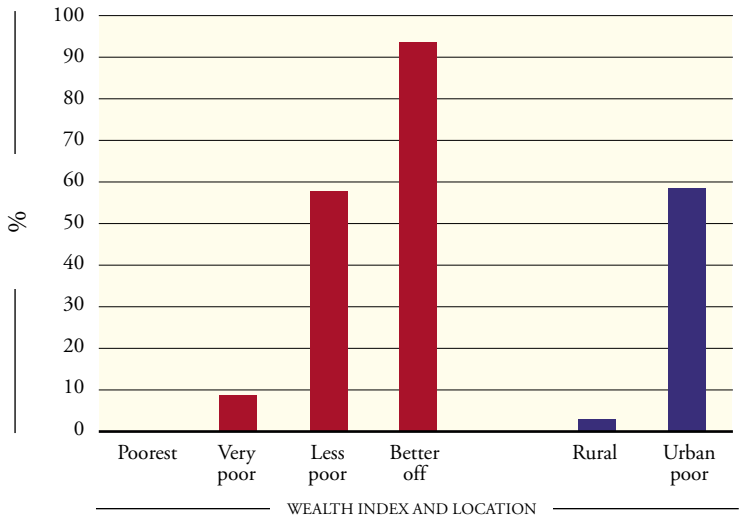


Source: YLS 2002

Public goods and services

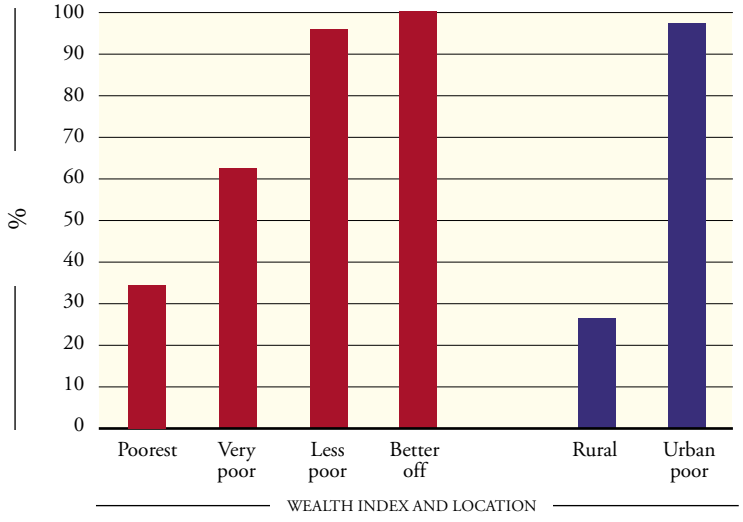
We will focus mainly on the four groups described under 'Methods': public services *availability* (households having piped water, a sewerage system and electricity); public services *supply* (households living in a community with piped water, sewerage and electricity); paved or engineered road access; and health services access. As can be seen in Graphs 8 to 11, there are indeed important differences in the provision of public goods and services in Peru according to wealth groupings and rural/urban areas.

Graph 8: Public services availability (%) by wealth index and location



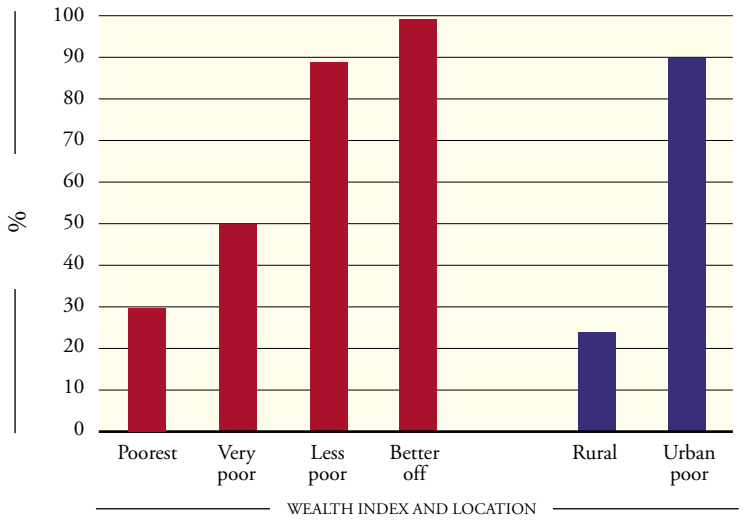
Source: YLS 2002

Graph 9: Public services supply (%) by wealth index and location



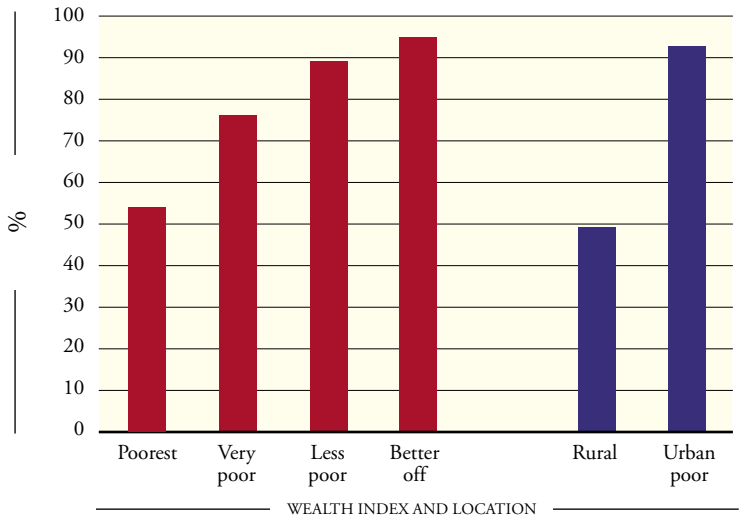
Source: YLS 2002

Graph 10: Paved or engineered road access (%) by wealth index and location



Source: YLS 2002

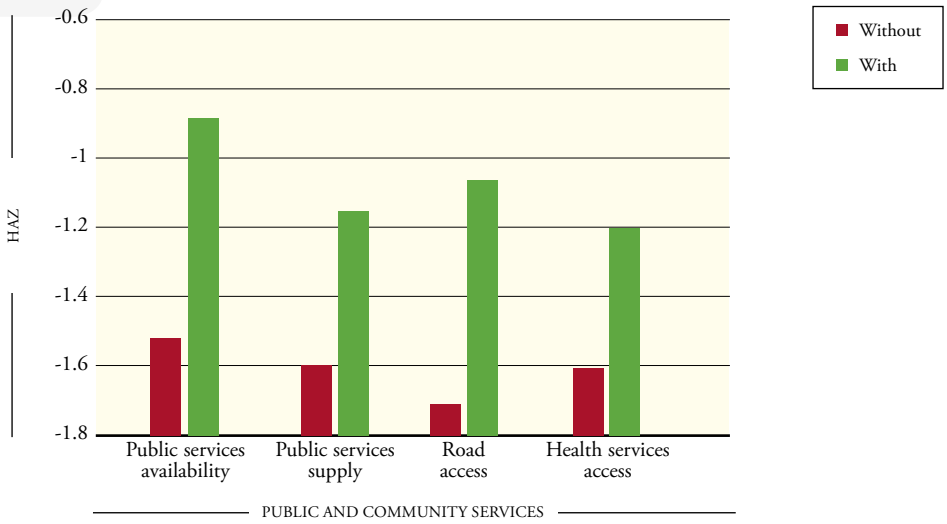
Graph 11: Health services supply (%) by wealth index and location



Source: YLS 2002

Public assets and community characteristics also seem to be correlated with nutritional status. As shown in Graph 12, children from households without access to public and community services have lower HAZ than those who do.

Graph 12: Mean height-for-age z-score by public and community services access



Source: YLS 2002

Public services, education (private asset) and nutritional status

We now consider the private asset of maternal education in conjunction with these public assets and the impact on child HAZ. As can be observed in Tables 1 to 4, there is evidence that within maternal education levels, anthropometric outcomes significantly differ depending on the availability and supply of public and community services. Table 1 shows that services availability at the household level significantly affects HAZ where mothers are less educated but not for more educated mothers. A similar finding occurs with respect to living in a community with access to a paved or engineered road (Table 3). In contrast, when we observe what happens with public and health services supply in the community, we find that both seem to have an impact on HAZ only among children living in households with more educated mothers (Tables 2 and 4).

Table 1
Mother's education and availability of public services
(Mean height-for-age z-score)

Education level achieved	Public services availability	
	No	Yes
Incomplete primary or no formal education	-1.96	-1.66 ***
Incomplete secondary	-1.41	-1.17 **
Complete secondary	-0.83	-0.78

**** significant at 5%; *** significant at 1%**
Source:YLS 2002

Table 2
Mother's education and public services supply
(Mean height-for-age z-score)

Education level achieved	Public services availability	
	No	Yes
Incomplete primary or no formal education	-1.79	-1.86
Incomplete secondary	-1.44	-1.20 **
Complete secondary	-1.09	-0.76 **

**** significant at 5%**
Source:YLS 2002

Table 3
Mother's education and paved or engineered road access
(Mean height-for-age z-score)

Education level achieved	Public services availability	
	No	Yes
Incomplete primary or no formal education	-1.99	-1.58 ***
Incomplete secondary	-1.48	-1.16 ***
Complete secondary	-0.96	-0.77

***** significant at 1%**
Source:YLS 2002

Table 4
Mother's education and health services access
(Mean height-for-age z-score)

Education level achieved	Public services availability	
	No	Yes
Incomplete primary or no formal education	-1.86	-1.81
Incomplete secondary	-1.40	-1.23
Complete secondary	-1.24	-0.73 ***

***** significant at 1%**
Source:YLS 2002

We then explored services supply and availability in more detail. Results are presented below for sewerage services; similar investigation of piped water and electricity did not show any consistent or significant findings. We compared the effect on HAZ of living in a community where a sewerage system is not supplied, living in a place where it is supplied but is not available to the household, and living in a household that has the service. In Table 5 we show how this relates to HAZ and how it is affected by the interaction with mother's education level. We find a significant difference between those children living in households without the service and those who have it. This difference tends to be smaller – and not even significant – within households where the mother is more educated.

Table 5
Mother's education and mismatch between household availability and community supply of sewerage
(Mean height-for-age z-score)

Mother's education level achieved	Community without sewerage	Community has sewerage, household doesn't	Household has sewerage	Tests of significance		
	(1)	(2)	(3)	(1)/(2)	(2)/(3)	(1)/(3)
Incomplete primary	-1.77	-1.98	-1.32	*	***	***
Incomplete secondary	-1.48	-1.38	-1.04		***	***
Complete secondary	-1.19	-0.85	-0.74	*		**
Total	-1.58	-1.54	-0.90		***	***

*** significant at 10%; ** significant at 5%; *** significant at 1%**

Source:YLS 2002

Since there are so many other determinants of child nutritional status that could explain the findings observed above, it is important to control for these other factors to confirm these initial findings. Regression analyses were employed to achieve this.

Regression analyses

As detailed in Appendix B, our analysis is based on height-for-age z-score (HAZ). Regressions of the HAZ on a set of child, parental, family and community characteristics (including mother's education and access to community and public services) are reported in Tables B1 to B3 in Appendix B. Table B1 shows the regression estimations considering public services *availability* at household level (ie, electricity, piped water and sewerage in the household) as explanatory factors for HAZ. Table B2 is similar but considers public services *supply* at community level (ie, electricity, piped water and sewerage in the community). Tables B1 and B2 show results with and without adjustment for the average level of maternal education in the community. Finally, Table B3 considers the interaction of sewerage access and supply as a factor explaining HAZ.

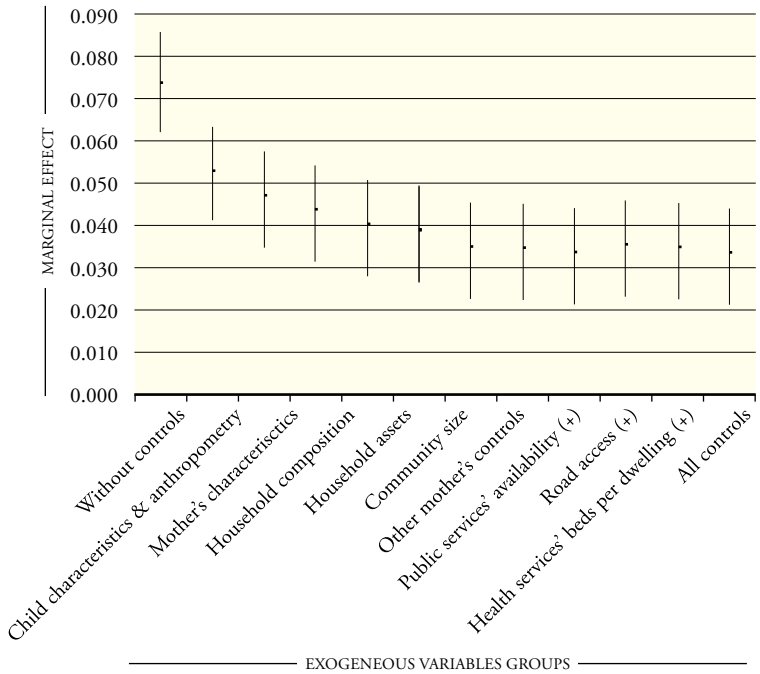
The covariates included in these regressions are:

- Child's sex
- Child's age
- Birth weight
- Mother's height
- Siblings with less than two years' age difference
- Other children between 0 and 5 years
- Other household members
- Presence of a partner in household
- (Mother's age)/100
- Mother's ethnicity
- Durable assets
- Community size
- Community price differences (food price index)

As seen in Tables B1-B3, there are many significant associations between HAZ and the above covariates. However, the main focus of this paper is on maternal education and public services and these findings are discussed here.

Graph 13 shows results from a series of regression models that demonstrate the impact of maternal education on HAZ, adjusting for various individual, household and community characteristics. As we have shown, maternal education has a positive effect on HAZ. Some of this effect is indirect, that is, it is mediated through other factors. Nevertheless, it retains an independent impact. An auxiliary regression which only includes education shows that at least half of the effect of education is direct, while the remainder operates through wealth and family characteristics.

Graph 13: Impact of mother's education on height-for-age z-score (under different specifications)



Note: The categories are added one by one to the previous specification, from left to right, except the ones with (+) which are considered separately.

Source: YLS 2002

Next we investigated the effect of the community level of maternal education (as seen in Graph 7) controlling for other covariates. Tables B1 and B2 show that the level of maternal education in the community – measured as the median level of education of other[2] mothers living in the community – continued to have a robust and significant impact on HAZ, over and above that of the individual mother, after adjusting for covariates. This variable could be reflecting both the socio-economic status of the community and the positive externalities that living in a community with more educated women can have on a particular child.

Turning to public services and community characteristics, it is interesting to compare our previous results (Tables 1 to 4) with the regression estimates in Tables B1-B3. Some of these results remain (ie, are robust) while others do not, once we control for other covariates.

Table B1 shows that children living in households with piped water, a sewerage system and electricity have higher HAZ but that this effect tends to be smaller in families where the child's mother is more educated (ie, as in Table 1). Table B2, on the other hand, shows that public services supply (ie, community availability) has no impact on HAZ once other covariates are adjusted for. This apparently contradictory result can be explained by looking at Table B3. This table shows that children living in areas that have sewerage facilities but do not have these facilities in their household are, on average, worse off than other children, even compared to those living in communities without sewerage facilities. Nonetheless, children living in communities without this facility also show lower HAZ than those living in households with sewerage systems. The results suggest that this is a key facility if households are to attain better child health. The significance of the interaction term shown in Table B3 also suggests that the impact of sewerage facilities tends to be smaller in more educated families (as expected from Table 5).

The impact on HAZ of having access to a paved or engineered road and its relationship with maternal education is less clear (Tables B1-B2). The impact appears not to depend on the level of maternal education (as was seen in Table 3) and the inclusion of other services access in the model appears to diminish its effect. Similarly, the impact of health services availability (as seen in Table 4) is no longer evident once other factors are taken into account.

2 Excluding the individual in question.

Discussion and conclusions

Our results show clearly that no matter how much we control for other covariates the impact of mother's education on child wellbeing remains robust. In fact 50 per cent of the impact of education cannot be accounted for by socio-economic variables such as assets and other covariates. Thus we can be very confident that there is a direct channel from mother's education to child welfare that goes beyond the capability of generating income and it is probably related to usage of education to directly access health/nutrition information. This result is consistent with the results of Desai and Alva (1998), who highlight Peru as one of the few countries they analysed where the direct impact of mother's education remained significant after controlling for typical confounders.

In addition, our results show there is an important non-linear association between mother's education and child wellbeing. This pattern is very robust once we control for a whole series of covariates.

The marginal benefit of an additional year of education is larger for those mothers with basic educational skills than for mothers with higher educational attainment. However, this marginal contribution of an additional year is positive for the whole schooling range. It even remains positive after eight years of schooling. This finding suggests that the years of education required is greater than those needed to obtain literacy skills, so we can deduce that the need for this education might be related to the need to develop more complex skills.

We have also found that the average level of maternal education in the community where the mother is located also plays an important role in increased child wellbeing. Here we found very significant results that remained when we included all of our controlling variables. This externality effect may be related to people sharing health knowledge that may benefit the nutritional status of the child.

Finally, the simulations performed using the random effect econometric model confirm what we had already seen in the simple cross tabulation results: the impact of public services (in this case sewerage facilities) is larger in those households where less educated mothers live. In other words, education may be working as a substitute in more educated households. If this is true, the need for public services provision in those areas where clusters of uneducated woman are found may be even greater than we initially thought. Analysis of how different public services affect child health can contribute to public policies oriented towards improving access and reducing inequality in the provision of services and in child health, which will in the long run also contribute, probably substantially, to reduced inequalities in the labour market and in overall welfare.

Although we have estimated the direct impact of mother's education on child wellbeing (measured by the improvement of the HAZ), the data are cross-sectional and we are not able to disentangle the specific channels through which maternal education may affect child health outcomes. Some of the most common channels referred to in the literature include the following:

- Directly transmitting health/nutrition information through education
- Teaching numeracy/literacy allowing caregivers to improve information-acquiring capabilities
- Exposing the future mother to new environments and making her more receptive to modern medical treatment
- Enhancing self-confidence, allowing better interaction within the family and with health professionals
- Helping to build social networks allowing health and nutritional information to be gathered through community or other reference groups.

For example, the existence of an externality effect (more educated mothers within the community improves the HAZ beyond the effect of the education of the child's own caregiver) may suggest that sharing health and reproductive behaviour knowledge may be just one of the multiple channels though which this interaction may operate. However, to fully explore the relative importance of these different channels we will need a full longitudinal database. Due to the restriction of only the first round of this longitudinal study having been completed so far we have limited ourselves to measuring the overall impact of mother's education and hypothesising what some of the important channels might be.

Once the YL project has collected at least two rounds of data, an assessment can be made of which of these channels might be operating in Peru.

What are the key policy messages we should highlight from these results? First, the obvious message is that improving the education of females is a crucial element for improving child nutrition. This is important, considering the existing inequalities in schooling in Peru. According to the latest National Household Survey (INEI, 2001), women with children five years old or younger coming from the poorest quintile have an average of 5.7 years of schooling. This average increases to 12.2 when we look at women from the richest quintile of the income distribution. Furthermore, 5 per cent of women with children of this age have not attended school at all, while 40 per cent only attended primary and just 20 per cent have some tertiary education. In terms of policy, this implies the need to improve programmes that aim to reduce education gaps and increase the schooling average. In the short term, this education gap also calls for the need to implement training programmes in order to substitute uneducated women's lack of nutrition-related knowledge. This recommendation is reinforced by the fact that, as our results show, a community's overall level of mothers' education also has an effect on nutrition. Education or training programmes should be designed to reach the majority or the whole of a community, in order to take advantage of these additional externalities.

In areas where low educated mothers are concentrated, as in some of the poorest rural sentinel sites the YL project has covered, the expansion of key public services such as sewerage facilities and improved road networks might serve as a substitute for the lack of maternal education. The need to improve the targeting of public infrastructure expenditure toward these areas can also be justified on the grounds of supplementing the lack of maternal education and bringing closer a large array of public services that might help improve the health status of children.

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Appendix A: Model and empirical strategy

We will approach the modelling of child health by integrating a child health production function with a household level utility maximisation process. This allows for the determination of a reduced form for a demand for child health. The household maximises utility subject to total income. Utility depends on household consumption of goods and services, c; leisure, l; and child health, θ, given household characteristics, μ_h. ν captures unobserved heterogeneity in preferences:

$$U = U(c, l, \theta; \mu_h, \nu)$$

subject to $p_c * C + p_a * a = w(T-l) + N$

where p_c is a vector of consumption prices, w is the individual salary, T is total available time, N is non-labour income. The production of health depends on investments made at home; health services and inputs bought outside the home, a; the prices of these inputs, p_a; and initial health and inherited characteristics. The first two are in turn determined by the characteristics of the child him/herself, by household characteristics and by environmental characteristics. Specifically, we model the production function of child health, the biomedical process that converts specific investments into health (Barber and Gertler, 2002) as

$$\theta_i = h(\theta_i^o, a, \mu_i, \mu_f, \mu_c, \varepsilon)$$

Child health depends on initial child health, H_i^o; a set of inputs bought outside the home, a; household characteristics, μ_f; child characteristics, μ_i; and community characteristics, μ_c. ε is a random child-specific error. The reduced form for the demand for health will then include exogenous individual, family and community characteristics, initial health, and price of consumption goods and inputs:

$$H_i = h(H_i^o, p_a, p_c, w, \mu_i, \mu_f, \mu_c, N, \varepsilon)$$

where H stands for the specific anthropometric outcomes used to assess child health. Instead of a total income specification, we are including as determinant of H non-labour income, N, which is presumably exogenous. The effect of total value of the time endowment of the household is captured by w. This specification takes into account that time devoted to labour activities is jointly determined with time devoted to leisure, and, in the case of the child's caregiver, with time devoted to childcare.

At the methodological level, our aim is to estimate

$$H_i = h(H_i^o, p_a, p_c, w, \mu_i, \mu_f, \mu_c, N, \varepsilon)$$

where H_i are the anthropometric or health outcomes for child i; H_i^o is the set of health inputs bought outside the home; μ_i, μ_f and μ_c are the covariates relevant at the child, household and community levels; N is the non-labour income; and (p_a, p_c, w) is the vector of relevant prices and wages. Finally, ε is a random child-specific error.

It is important to note that in several cases some of the household-specific variables may have some degree of endogeneity. In such cases we will proceed to instrumentalise such variables. For example, total household income may be jointly determined with health, and we may need to use assets as an instrument. If we want to add a household-specific factor such as 'cleanliness status' we may also need to instrumentalise it (we can use for example the price of soap or detergents).

As pointed out by Thomas, Lavy and Strauss (1996), there may be non-observable cluster-specific factors that will render least square coefficient estimates that, although consistent, may not be efficient. That is, the variance-covariance matrix estimates will not be consistent. Considering the clustered nature of our data, non-observables may have strong correlation within clusters:

$$E(\varepsilon_{ic}\varepsilon_{jd}) = \sigma^2\delta_{cd}[(1-\rho_c)\delta_{ij}+\rho_c]$$

where δ is the Kronecker delta, ρ_c is the intra-cluster correlation of disturbances for cluster c, and errors are assumed to have a constant common variance σ^2. Note that in our case we will estimate variance-covariance estimates under the assumption that intra-cluster correlation of disturbances (ρ_c) differs from cluster to cluster. This is a much more flexible assumption than the typical equi-correlated error assumption used in the literature.

The typical household survey has very few observations per cluster. For example, Peruvian LSMS clusters located in the capital, Lima, have only 6 observations, while the other clusters have 12 observations per cluster. With this limited number of households per cluster, ρ_c cannot be precisely estimated. This is not the case, however, with the survey we plan to use in this study. By design, this survey has 100 observations per cluster, allowing us to have enough intra-cluster variance to drop the assumption of ρ being constant across clusters.

The importance of this departure from the typical equi-correlated error assumption is twofold. On the one hand, it will improve the efficiency of coefficient estimates, allowing us to better assess whether or not certain community characteristics do affect health outcomes. On the other hand, by testing the constancy of ρ_c across clusters, we can check whether or not community-specific non-observables affect health outcomes across clusters differently.

The procedure we will employ to estimate the corrected variance-covariance matrix is that of jackknifed least square estimates under the proper assumption that the errors are independent between clusters but are correlated within clusters. Although we will explore the properties and robustness of bootstrapping following Thomas, Lavy and Strauss (1996), we should note that, in general, the jackknife will provide estimators with less bias and variance than the bootstrap when samples are clustered.

One might ask how different our results would be if instead of estimating our model by ordinary least squares (OLS) with clustered errors we proceeded to estimate it under the assumption that the data were panel-level heteroskedastic. Although both estimates are correct, they do have different asymptotic properties. If we assume that the disturbances have different variance for each cluster and are constant within clusters, panel estimates (ie, random effect estimators) will be more efficient than a cluster-based estimation. In addition, as noted by Williams (2000), the cluster-based estimation proposed here is robust to any type of correlation within the observations of each cluster (community).

Estimation of interaction terms

We determine the extent to which there are any significant interactions between household socio-economic characteristics and community level variables by estimating

$$H_i = \alpha + \beta_1 X_i + \beta_2 X_h + \beta_3 FI_h + \gamma \hat{X}_c + \delta (X_h * \hat{X}_c) + \eta_i$$

where X_i, X_h and X_c are the vectors of individual, household and community-level characteristics and FI_h is the full income of household h. If the functional relationship between these correlates and health is linear, then δ would indeed summarise the interaction between household-specific and community level variables. If such is the case, a positive and significant value for δ will suggest complementarities between household-specific and community level variables and a negative and significant value for δ will suggest that these variables are substitutes.

Appendix B

Table B1: HAZ determinants (controlling for public services availability)

	(1) Controlling for other mothers' education	(2) Not controlling for other mothers' education
Child is a boy	-0.170 (0.045)***	-0.173 (0.046)***
Child's age / 100	-0.290 (0.021)***	-0.289 (0.021)***
Birth weight (kg)	0.437 (0.048)***	0.443 (0.048)***
Mother's height	0.046 (0.004)***	0.046 (0.005)***
Siblings with less than two years' age difference	-0.157 (0.080)*	-0.155 (0.080)*
Other children (0-5 years) in the household	-0.093 (0.036)**	-0.092 (0.036)**
Household members six years old or over	0.008 (0.012)	0.008 (0.012)
Mother's years of schooling	0.037 (0.015)**	0.047 (0.015)***
Mother has a partner living with her	-0.054 (0.066)	-0.050 (0.066)
Mother's age / 100	5.662 (2.461)**	5.856 (2.465)**
Square of (mother's age / 100)	-11.300 (4.190)***	-11.518 (4.197)***
Mother's mother tongue is Spanish	0.043 (0.075)	0.090 (0.074)
Durable assets	0.035 (0.062)	0.039 (0.062)
Food price index	0.003 (0.003)	0.003 (0.003)
Community has 400 or fewer dwellings	-0.317 (0.155)**	-0.415 (0.161)**
Community has between 401 and 2,000 dwellings	-0.254 (0.171)	-0.372 (0.180)**
Community has more than 2,000 dwellings (excluding Lima)	-0.429 (0.147)***	-0.425 (0.162)***
Community's air reported as polluted	-0.174 (0.078)**	-0.149 (0.079)*
Household only has piped water	0.040 (0.085)	0.031 (0.085)
Household only has sewerage	-0.063 (0.279)	-0.025 (0.279)
Household only has electricity	-0.055 (0.121)	-0.049 (0.122)
Household only has piped water and sewerage	0.095 (0.187)	0.121 (0.187)
Household only has piped water and electricity	-0.048 (0.097)	-0.043 (0.098)
Household only has sewerage and electricity	0.270 (0.198)	0.289 (0.197)
Household has piped water, sewerage and electricity	0.418 (0.170)**	0.462 (0.168)***
(Household has piped water, sewerage and electricity) x (mother's education)	-0.028 (0.015)*	-0.030 (0.015)**
Community has paved or engineered road access	0.067 (0.136)	0.196 (0.131)
(Community has paved or engineered road access) x (mother's education)	-0.005 (0.016)	-0.015 (0.016)
Community has healthcare centre	-0.095 (0.121)	-0.076 (0.123)
(Community has healthcare centre) x (mother's education)	0.014 (0.015)	0.015 (0.016)
Median of education of other mothers living in the community	0.043 (0.015)***	
Constant	-9.578 (0.843)***	-9.443 (0.857)***
Observations	1,975	1,975
Number of communities	150	150

Standard errors in parentheses
*** significant at 10%; ** significant at 5%; *** significant at 1%**

Table B2: HAZ determinants (controlling for public services supply)

	(1) Controlling for other mothers' education	(2) Not controlling for other mothers' education
Child is a boy	0.545 (0.126)***	0.565 (0.127)***
Child's age / 100	0.655 (0.062)***	0.657 (0.063)***
Birth weight (kg)	-0.969 (0.137)***	-0.979 (0.137)***
Mother's height	-0.087 (0.013)***	-0.088 (0.013)***
Siblings with less than two years' age difference	0.485 (0.202)**	0.477 (0.202)**
Other children (0-5 years) in the household	0.149 (0.095)	0.146 (0.096)
Household members six years old or over	-0.015 (0.032)	-0.011 (0.032)
Mother's years of schooling	-0.062 (0.037)*	-0.086 (0.037)**
Mother has a partner living with her	-0.100 (0.179)	-0.118 (0.180)
Mother's age / 100	-7.370 (6.369)	-8.453 (6.406)
Square of (mother's age / 100)	16.282 (10.746)	17.719 (10.815)
Mother's mother tongue is Spanish	-0.083 (0.178)	-0.235 (0.182)
Durable assets	-0.557 (0.208)***	-0.556 (0.211)***
Food price index	-0.006 (0.006)	-0.007 (0.007)
Community has 400 or fewer dwellings	1.114 (0.350)***	1.339 (0.388)***
Community has between 401 and 2,000 dwellings	1.033 (0.360)***	1.321 (0.409)***
Community has more than 2,000 dwellings (excluding Lima)	1.359 (0.287)***	1.341 (0.352)***
Community's air reported as polluted	0.602 (0.148)***	0.538 (0.167)***
Household only has piped water	-0.170 (0.195)	-0.153 (0.200)
Household only has sewerage	0.046 (0.709)	-0.113 (0.726)
Household only has electricity	0.615 (0.295)**	0.584 (0.301)*
Household only has piped water and sewerage	-0.055 (0.468)	-0.137 (0.480)
Household only has piped water and electricity	0.043 (0.226)	0.016 (0.239)
Household only has sewerage and electricity	-0.576 (0.640)	-0.671 (0.647)
Household has piped water, sewerage and electricity	-0.496 (0.443)	-0.739 (0.453)
(Household has piped water, sewerage and electricity) x (mother's education)	0.058 (0.042)	0.069 (0.042)
Community has paved or engineered road access	-0.266 (0.303)	-0.631 (0.300)**
(Community has paved or engineered road access) x (mother's education)	0.028 (0.042)	0.059 (0.043)
Community has healthcare centre	0.442 (0.268)*	0.430 (0.281)
(Community has healthcare centre) x (mother's education)	-0.042 (0.036)	-0.054 (0.039)
Median of education of other mothers living in the community	-0.108 (0.034)***	
Constant	13.351 (2.246)***	13.378 (2.313)***
Observations	1,975	1,975
Number of communities	150	150

Standard errors in parentheses
*** significant at 10%; ** significant at 5%; *** significant at 1%**

Table B3: HAZ determinants (controlling for access and supply mismatch of public services)

	(1)	(2)	(3)
Child is a boy	-0.166 (0.045)***	-0.167 (0.045)***	-0.167 (0.045)***
Child's age / 100	-0.289 (0.021)***	-0.289 (0.021)***	-0.289 (0.021)***
Birth weight (kg)	0.435 (0.048)***	0.435 (0.048)***	0.435 (0.048)***
Mother's height	0.046 (0.004)***	0.046 (0.004)***	0.045 (0.004)***
Siblings with less than two years' age difference	-0.152 (0.080)*	-0.150 (0.080)*	-0.150 (0.080)*
Other children (0-5 years) in the household	-0.092 (0.036)**	-0.092 (0.036)**	-0.092 (0.036)**
Household members six years old or over	0.006 (0.012)	0.007 (0.012)	0.007 (0.012)
Mother's years of schooling	0.021 (0.009)**	0.020 (0.009)**	0.052 (0.010)***
Mother has a partner living with her	-0.056 (0.066)	-0.054 (0.066)	-0.055 (0.066)
Mother's age / 100	5.359 (2.448)**	5.401 (2.446)**	5.451 (2.447)**
Square of (mother's age / 100)	-10.783 (4.168)***	-10.860 (4.165)***	-10.968 (4.165)***
Mother's mother tongue is Spanish	0.027 (0.075)	0.030 (0.076)	0.027 (0.076)
Durable assets	0.040 (0.059)	0.037 (0.059)	0.035 (0.060)
Food price index	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)
Community has 400 or fewer dwellings	-0.329 (0.157)**	-0.319 (0.157)**	-0.321 (0.158)**
Community has between 401 and 2,000 dwellings	-0.283 (0.176)	-0.280 (0.177)	-0.275 (0.178)
Community has more than 2,000 dwellings (excluding Lima)	-0.444 (0.154)***	-0.442 (0.155)***	-0.442 (0.156)***
Community's air reported as polluted	-0.171 (0.078)**	-0.167 (0.078)**	-0.168 (0.079)**
Community without sewerage	-0.203 (0.113)*		0.243 (0.135)*
Community has sewerage but household does not	-0.438 (0.131)***	-0.219 (0.113)*	
Household has sewerage	0.244 (0.111)**		0.443 (0.138)***
(Community without sewerage) x (mother's education)			-0.034 (0.019)*
(Community has sewerage but household does not) x (mother's education)	0.032 (0.013)**	0.033 (0.013)***	
(Household has sewerage) x (mother's education)			-0.031 (0.014)**
Median of education of other mothers living in the community	0.045 (0.014)***	0.043 (0.014)***	0.044 (0.014)***
Constant	-9.115 (0.845)***	-9.351 (0.836)***	-9.575 (0.845)***
Observations	1,975	1,975	1,975
Number of communities	150	150	150

Standard errors in parentheses
*** significant at 10%; ** significant at 5%; *** significant at 1%**

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Young Lives is an international longitudinal study of childhood poverty, taking place in Ethiopia, India, Peru and Vietnam, and funded by DFID. The project aims to improve our understanding of the causes and consequences of childhood poverty in the developing world by following the lives of a group of 8,000 children and their families over a 15-year period. Through the involvement of academic, government and NGO partners in the aforementioned countries, South Africa and the UK, the Young Lives project will highlight ways in which policy can be improved to more effectively tackle child poverty.

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