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With the Help of One's Neighbors

Externalities in the Production of Nutrition in Peru

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Public and private investments in education and infrastructure (such as water and sanitation infrastructure) for one household carry over to neighboring households. Shared knowledge has a significant impact on children's nutrition in rural areas. There is a direct link between the caregivers' education and their children's health status and an additional impact from living near neighbors with more education.

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Summary findings

Both public and private resources contribute to children's nutritional status. And investments by one household may improve health in other neighborhood households by improving the sanitation environment and increasing shared knowledge.

Alderman, Hentschel, and Sabates measure the externalities of investments in nutrition by indicating the impact of women's education in Peruvian neighborhoods on children's nutrition in other households, after controlling for those households' education and income. They find that in rural areas this shared knowledge has a significant impact on nutrition. The coefficient of an increase in the average education in the neighborhood is appreciably larger than the coefficient of education in isolation. That is, educating women in rural areas improves all children's nutritional status even for those whose caregivers are themselves not educated.

In both urban and rural areas, they observe externalities from investments in sanitation made by neighboring households. They do not find the same externalities in the case of investments only in the household water supply.

There is a direct link between the caregivers' education and their children's health status. Education transmits information about health and nutrition. It teaches numeracy and literacy, which help caregivers read labels and instructions. By exposing caregivers to new environments, it makes then receptive to modern medical treatment. It gives women the confidence to participate in decisionmaking within a household, and it gives men and women the confidence to interact with health care professionals.

This paper—a joint product of Poverty, Development Research Group and the Poverty Division, Poverty Reduction and Economic Management Network—is part of a larger effort in the Bank to better understand the impact of public services. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Patricia Sader, room MC3-556, telephone 202-473-3902, fax 202-522-1153, email address psader@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at halderman@worldbank.org, jhentschel@worldbank.org, or rsabates@students.wisc.edu. June 2001. (19 pages)

With the Help of One's Neighbors:

Externalities in the Production of Nutrition in Peru

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1. Introduction

The nutritional status of children reflects the interplay of household level decisions regarding food, health, and childcare. These decisions are conditioned, in part, by a household's access to health and sanitation services as well as its ability to make optimal use of its own and community resources. A number of empirical studies have explored the contribution of such community resources to nutritional status as well as the role education plays in reducing malnutrition.[1] Most often these investigations are framed, implicitly, if not explicitly, in terms of individual resources and public goods.

This current study amplifies such approaches by recognizing an additional contribution to child health through externalities of the investments of other households in the neighborhood, hence the importance of individual resources of *other* households on the nutritional status of children. In particular, we look at the contribution to nutrition outcomes attributed to the education, water and sanitation investments of neighborhood members that is additional to the impact of a household's own assets. [2]

Consider first the different possible contributions of education on the nutritional status of children. In addition to the indirect impact of education on nutrition through increased household income, schooling may influence nutrition by four channels establishing a direct link between education of the caregiver and their children: (i) it transmits information about health and nutrition, (ii) it teaches numeracy and literacy, thereby assisting care givers in acquiring information including reading labels and instructions on medicines, (iii) by exposing individuals to new environments it makes them receptive to modern medical treatment and (iv) it imparts self confidence which enhances women's role in intra-household decision making and all individuals in their interaction with health care professionals.

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1. See, for example, Thomas, Lavy, and Strauss (1996), Alderman and Garcia (1994) and Barrera (1990).
2. See, also, Stephens, (1995), Hughes and Dunleavy (2000), Hoque et al (1999) and Shi (2000).

Glewwe (1999) tests the relative role of the first three of these and finds that the health knowledge itself contributes the most to child health in Morocco. However, he also observes that this is not part of the school curriculum. Indeed, specific information important to health care may be obtained from interaction with ones neighbors. The others pathways by which education may contribute to child health are more directly associated with formal schooling, but enhanced receptivity to modern medical approaches may also occur via diffusion by neighbors. Similarly, an illiterate caregiver may prevail upon her neighbor to explain the instructions that come on the label of a medicine. Thus, the schooling of some individuals may contribute to health over a wider net than does the individual's immediate household.

Basu and Foster (1998) have formalized a definition of proximate literacy that is in keeping with this view that knowledge commonly associated with formal schooling can be transmitted by interaction with others who have obtained this schooling. Recently, Gibson (2001) has shown empirically that externalities from literacy may be appreciable within a family. The current study takes the measurement of externalities one step further by asking if these externalities are inter-household as well.

In a similar vein, it is possible that investments in water and sanitation by some individuals will have an impact across the wider neighborhood. Clearly investments in household sanitation have the potential to reduce the bacterial count in the air and soil of the neighborhood and, thus, indirectly benefit their neighbors. It is less clear that individual investments in water supply assist other households since the link to the community environment is weaker. While access to uncontaminated water at home may improve nutrition due to the reduction in its price and the attendant increase of the quantity used for cleaning as much as due to any increase in the quality of water that is drunk (Burger and Esrey, 1994), the impact on the bacterial count in the neighborhood should be relatively small. A possible externality could arise, however, if families with access to quality water share this source with neighbors that do not have such access. Even in such circumstances, households may permit access to their own water source for small amounts of drinking water but be less willing to provide larger quantities (e.g., for bathing).

There is little empirical work on the impact of such access to basic services or education at the neighborhood level, i.e., at potential positive (or negative) externalities in the production of child health. One exception is Hughes and Dunleavy (2000) who examine the influence of community provision of basic services such as water and sanitation as well as community female education in a reduced form mortality hazard model for children under the age of five in India. They do not find a synergy between water supply and sanitation facilities in the sense that the mortality hazard for a household with both a private water supply and private toilet facilities is not significantly different from what would be expected by combining the separate effects of water and sanitation. Moreover, community access to toilets alone has no significant impact on child mortality rates and the same is true for community access to water (alone) in rural areas. However, when sanitation and water access *at the community level* are combined, a joint externality effect emerges which is statistically significant.

Another study that is closely related to the analysis presented here is Gragnolati (2000). He examines the determinants of children's growth in rural Guatemala, specifically considering the importance of a number of community variables that might be associated with child anthropometry. Gragnolati finds that the proportion of households with piped water connections is positively associated with children's nutritional status. Surprisingly, the height of rural Guatemalan children is inversely associated with the proportion of households (per community) with flush toilets.

Our approach , however, differs from Gragnolati's in an important respect. Gragnolati treats *own* access to basic water and sanitation services as endogenous to child health, i.e., parents decide on both child health and access to basic services jointly. To accommodate this, he does not include individual access to basic services in his model. In such formulation, it is not possible to distinguish the *additional* impact of the investments of the other households in the community, separate from own access to such services. As this is the primary focus of the current paper, it is necessary that we include both household and neighborhood infrastructure in the regressions reported.

2. Model and Estimation Approach

We assume that the nutritional status of a child is produced in a household through the combination of nutrients (F, food), health (H), and child care (C). This can be represented by a nutritional status production function, which is conditional on unobserved child specific characteristics including genetic potential (e), as well as on observed neighborhood environmental conditions, (E), and unobserved community effects, (ε);

(1) $N_i = N(F_i, H_i, C_i, E, e_i, \varepsilon)$.

In principle, such a production function can be estimated (Rosenzweig and Schultz, 1988). However, the fact that the inputs are based on household choices which reflect the household's assessment of the unobservable (to the researcher) child and community specific characteristics makes this approach dependent on the ability to accurately identify and estimate input demand functions. An alternative approach is to begin with the assumption that a household maximizes utility based on its consumption of goods (G), leisure (L) and the nutritional status of the members of the household (or, more generally, the human capital of its members).

(2) $U = u(G,L,N)$

A household maximizes this subject to the production function expressed in equation 1 as well as its budget constraint. This results in an equation for nutritional status that is analogous to a commodity demand equation. Thus,

(3) $N_i = n(Y_i, S_i, E, \varepsilon, \mu_i)$.

This equation reflects both the production technology and the household's demand for health along with its resource envelope (Y for financial resources and S for schooling or human capital). In this equation μ_i represents random error including unobserved individual endowments (e_i) as well as measurement error. The inputs of nutrients and health are not included in this quasi–reduced form equation.[3] Instead, the equation includes factors which determine the level at which such inputs are used as well as the efficiency by which they are

3. This is a quasi-reduced form since the equation includes income rather than the assets that produce it.

combined. While prices are elements of the household's budget constraint, they generally do not vary over a community. Moreover, since the data used in this study (discussed below) come from a cross-sectional household survey, community prices do not vary over time. Thus, the price vector which conceptually belongs in a reduced form equation for nutrition, such as equation 3, gets subsumed into the unobserved community effects, ε.

3. Data

The Andean nation of Peru has been a nation of contrasts. The country is sharply divided in three different climatic zones – the Amazonian jungle region in the East; the central, largely rural and indigenous highlands spanning the center of the country from North to South; and the Pacific Coast in the West with almost half of the urban population of the whole nation living in- and around the capital Lima. While poverty and malnutrition rates have decreased substantially over the past years in Peru, they still remain at quite alarming levels. In 1997, about half of the population was poor and about every fourth child was malnourished. Key social indicators are presented in table 1.

Differences between living conditions of the population in rural and urban areas indeed remains striking. Malnutrition levels in rural Peru are more than three times as high as in urban areas; for the severe poverty rate the factor is 2.5. Similarly, access to basic services such as electricity, sanitation and water is highly tilted in favor of towns and cities. In 1997, only every tenth Peruvian in the countryside had access to a flush toilet while eight out of ten Peruvians in cities commanded such service.

Table 1. Basic Social Indicators, Peru 1994 and 1997

	National		*Urban*		*Rural*	
	1994	1997	1994	1997	1994	1997
Malnutrition rate	30.0	23.8	17.4	12.2	44.7	37.3
Literacy rate	87.6	90.2	92.3	94.3	77.4	82.1
Poverty rate	53.5	49.0	46.1	40.4	67.0	64.7
Severe poverty rate	18.8	14.8	12.9	9.3	29.5	24.5
Electricity connection	68.8	73.7	93.7	97.4	23.2	30.3
Sanitation connections	48.2	58.6	73.4	84.3	2.4	11.6
Water, public network	65.0	72.8	84.9	89.0	28.8	43.1

Source: World Bank (1999, p.10)

To investigate what is the impact of these services on nutrition, we use data from the 1997 round of the Peru Living Standards Measurement Study. This survey was a multi-purpose, modular, living standards survey following a format utilized in over twenty countries (Grosh and Glewwe, 2000). While many of the variables such as infrastructure and total expenditures are based on household data, the analysis is performed on individual observations of child heights for children sixty months of age or less.[4] The total sample is 2,154 children below the age of five were recorded in the survey, more or less equally divided by gender and among urban and rural populations (see appendix table 1).

The measure of nutritional status used in the study is height for age. This is considered a measure of long-run nutritional deprivation, (Alderman, 2000; WHO, 1995). This measure is converted into standardized units (Z scores) after comparison with the US data chosen as an international reference by the WHO. The Z scores are derived after subtracting the age- and gender-specific means from the reference data and after dividing by the corresponding standard deviation. In the reference population 2.3 percent have a Z score below –2, while 16.0 percent are below –1 Z score. These levels might be expected for a normal population, and provide a basis for comparison.

Commonly, rates of malnutrition in a population are based on the percentage of children below the age of 5 whose z-score is two standard deviations below the reference value. This is the measure of malnutrition reported in table 1. However, as there is no sharp difference in risk of mortality or functional impairment at this or any other commonly used cutoff level (Pelletier, 1994), the regressions reported below focus on nutritional status itself and not the probability of malnutrition defined in terms of a Z score below –2. That is, the dependent variable is the Z score for height for age.

Of central importance to this paper is the definition of the neighborhood variables. In all cases we derive the value of the variables from non-self means. These are derived by summing the variable of interest over the sample cluster and then subtracting the observation for the household and dividing this difference by the number of households in

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4. See Annex 1 of World Bank (1999) for a detailed description of the household survey and the method of aggregation and deflating expenditures to obtain a consistent welfare indicator across households.

the cluster minus one. There are 371 clusters in the sample. Thus, clusters are relatively small. This implies that the non-self estimates are less precise than might be preferred. However the errors in variable problem should bias any parameters towards zero and, thus, towards an inappropriate failure to reject the null hypothesis (that is, towards finding that community effects are not important, when, in fact, they are). This will strengthen our case in the event that we find significant neighborhood effects in the empirical part of the paper.

We use the following definitions of 'good' water and sanitation sources. For water, both access to the public water net within the house and within the building qualifies as 'good' water access. All other options—well, public standpipe, river, truck—are left out of the definition since the likelihood of contamination of water from such sources is considerably higher. Regrettably, such definitions can, obviously, capture the quality of water and sanitation services only imprecisely since even a supposedly 'good' source of water—like the public net with an in-house connection—can dispense contaminated water.

Similarly, for sanitation facilities we include *exclusive* use for household members (either through the public net or using a septic tank) as constituting access to 'good' sanitation. These facilities are assumed to reduce the risk of unhygienic treatment of human waste as well as limiting exposure of the waste to flies that can transmit bacteria. Shared use of hygienic facilities and open disposal of the human waste (in canals, roads or the open field) are excluded from this definition.

The provision of water and sanitation services in urban Peru is very different than in rural area. As shown in table 2, almost three-quarters of the children below the age of five in our urban sample live in houses with both proper water and proper sanitation access as defined above. The last quarter is quite evenly split between the three remaining possibilities: having access to only water, having access to only sanitation or neither. The rates of access to water is for the children in our sample is approximately the same rate as for households in the urban population overall (see table 1) while the access to sanitation is slightly higher. In rural areas, about 60 percent of children in our sample lived in families who had no access to water or sanitation services as defined above. Less than ten percent lived in households with two services while more than a quarter had only water services. Extremely few households (4 percent) had sanitation services alone.

Table 2. Access to Household Sanitation and Water for Urban and Rural Peru

Rural Areas	
With no infrastructure	587
With only water	259
With only sanitation	41
With water & sanitation	87
Total Rural Children	974
Urban	
With no infrastructure	120
With only water	114
With only sanitation	77
With water & sanitation	799
Total Urban Children	1,100

As is discussed further below, the fact that the overwhelming majority of urban households have both quality sanitation and access to water needs to be considered when assessing the impact of the infrastructure of the remaining households in the neighborhood. Similarly the analysis needs to accommodate the fact that there are comparatively few rural observations with good sanitation yet also do not have direct access to piped water. The analysis that follows first classifies services in terms of having none, one or two. We do this to get a perspective on potential returns from combining services at the household as well as at the community level. Such returns of combining services would exist if we were to find that the positive impact of having combined water and sanitation services on nutritional outcome is larger than twice the impact of having one service alone. Such argument could also be made at the community level. However, we also address the question of the impact of sanitation and of water supply by including these services as regressors explicitly This differs somewhat from the classification in terms of the amount of services. Thus, the two approaches complement each other.

For the analysis of the amount of services we classify 191 urban observations with one service and 799 with two while we classify 913 as having water and 976 as having sanitation. For the rural population, 346 observations are classified with water and 128 with sanitation while 300 have one service and 87 have two.

4. Results

Our first estimations start from the standard literature model of the production of nutrition, i.e., without the inclusion of possible neighborhood externality effects. The first two columns of table 3 present results of this standard approach to modeling nutritional status and find, reassuringly, that the results are consistent with the wider literature.

For example, as is generally observed, heights (standardized for age) decline over the first year of life and then more or less levels off with little catch up. Also, income is an important explanatory variable even after accounting for the positive effects of maternal education. Indeed, the magnitude of the coefficient of the logarithm of expenditures is relatively large compared to that estimated for other low and middle income countries (Alderman et al., 2000), but not unprecedented.

As expected, household's own access to sanitation or water supply improves the nutritional status of children living in the household; and having both has a more favorable impact than having only one. Here, we find indeed that having two services has more than double the impact of having one service alone which would point towards the potential existence of returns of combining services to exist.

Also, as anticipated, the indigenous population is at a disadvantage even after controlling for income, education, and infrastructure for which the population is at a disadvantage. This may reflect social exclusion or differential access to services we cannot capture here (e.g., consistently worse quality of water). Or it may be due to a correlation of ethnicity and altitude; the latter is known to influence anthropometric status (Haas et al., 1982). These are not mutually exclusive hypotheses.

Table 3. Regressions Explaining Child Heights

	Pooled			Urban	Rural
Variables	*Column 1*	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Constant	-3.449***	-3.640***	-3.888***	-4.215***	-2.974***
	(.460)	(.451)	(.865)	(1.216)	(1.223)
Urban		.523***	.333***		
		(.094)	(.103)		
Male	.040	.042	.039	.056	.009
	(.061)	(.061)	(.060)	(.080)	(.088)
Age 7-12 months	-.530***	-.534***	-.529***	-.325	-.770***
	(.167)	(.163)	(.163)	(.249)	(.200)
Age 13-18 months	-1.192***	-1.190***	-1.207***	-1.167***	-1.275***
	(.137)	(.134)	(.135)	(.184)	(.202)
Age 19-24 months	-1.425***	-1.442***	-1.460***	-1.328***	-1.624***
	(.142)	(.140)	(.141)	(.201)	(.186)
Age 25-36 months	-1.174***	-1.187***	-1.213***	-1.179***	-1.287***
	(.122)	(.119)	(.120)	(.171)	(.167)
Age 37-48 months	-1.197***	-1.216***	-1.239***	-1.302***	-1.168***
	(.117)	(.115)	(.115)	(.161)	(.167)
Age 49-60 months	-1.456***	-1.473***	-1.474***	-1.412***	-1.604***
	(.117)	(.115)	(.115)	(.161)	(.165)
Indigenous	-.438***	-.314***	-.279**	-.211	-.252**
	(.124)	(.125)	(.124)	(.632)	(.123)
Logarithm of income	.345***	.374***	.334***	.297***	.391***
per capita	(.064)	(.062)	(.071)	(.098)	(.101)
Male education in years	-.011	-.018**	-.021***	-.015	-.030**
	(.009)	(.009)	(.009)	(.011)	(.015)
Female education in	.089***	.074***	.056***	.056***	.052***
years	(.010)	(.011)	(.012)	(.016)	(.017)
Has sanitation *or* water	.190**	.105	.173	.139	.171
supply	(.093)	(.091)	(.138)	(.204)	(.185)
Has *both* sanitation and	.502***	.211***	.211	.299	-.103
water supply	(.079)	(.090)	(.162)	(.193)	(.277)
Non-self neighborhood			-.118	-.269	-.021
percentage with one type of infrastructure			(.165)	(.339)	(.213)
Non-self neighborhood			-.031	-.012	.016
percentage with both types of infrastructure			(.198)	(.272)	(.332)
Non-self average			.041	.217	-.188
logarithm of expenditures			(.138)	(.205)	(.175)
Non-self female			.070***	.008	.171***
education			(.023)	(.030)	(.035)
R-square	.267	.280	.285	.189	.214
Number of observations	2084	2084	2084	1110	974

Robust standard errors in parentheses. *** significant at 1 percent level. ** significance at 5 percent level.

The absence of a significant gender effect is consistent with results covering populations outside of south and west Asia. The only coefficient in column one that is unexpected is the negative, albeit insignificant, impact of male education. One can speculate that this is related to the shifting of consumption patterns to status goods, but we have no direct evidence. In any case, the magnitude is comparatively small compared to the positive impact of an additional year of schooling for women.

Column two in table 3 includes a dummy variable for the urban population. This specification dominates the former; we include both to illustrate the difference in the coefficients of sanitation and or water supply when the urbanization variable is included. Much of what is attributed to a household's own sanitation or water in the first column is absorbed into the dummy variable in the second. Nevertheless, the effect of having both forms of infrastructure remains statistically significant from zero. However, controlling for regional variation does have an impact on the size of the parameters; the returns to combining services at the household level disappear.

The variables of prime interest in this study, i.e., the non-self cluster means for both the infrastructure variables as well as female education, are introduced in the specification reported in column three. The education of other women in the neighborhood has a positive impact on the nutrition of a child, even after controlling for the education and consumption of the household itself.[5] Indeed, the coefficient of an increase in the average education in the neighborhood being appreciable larger than the coefficient of education in isolation.

However, at first glance, there is little encouragement for the hypothesis that the prevalence of sanitation and water services in the neighborhood influences the nutritional status of a child. According to these results, no evidence can be found for our hypothesis of neighborhood externalities in the production of child nutrition in Peru. Indeed, the percentage of households having one type of infrastructure seems to have a negative influence relative to the percentage having either none or both. Again, however, the coefficient of the variable is not significantly different from zero.

The results look equally unsupportive of this hypothesis when the regressions are run separately for the urban and rural sub-samples as shown in columns four and five. The majority of the point estimates for the coefficients in the sector regressions are the same as in the pooled regressions although some precision is lost. This is especially the case with the variables representing relatively small cells such as the variable for the urban indigenous population and the few rural households with both types of infrastructure. The fact that the neighborhood education of women is significant only in rural areas is consistent with the results reported by Hughes and Dunleavy (2000) who found that a high proportion of women with middle school education or beyond significantly lowers mortality hazards only in rural areas of India.

However, the regression specifications in table 3 do not take into account the fact that the average level of infrastructure in rural communities differs appreciably from that in urban areas. If the impact of externalities varies according to the level of the household's own investments then the specification for rural areas may need to differ from that for urban communities. That is, to correctly assess the externalities we would have to limit our sample to only those households that have a common sanitary environment. Table 4 presents a few variations from this perspective.

In column one of table 4 we confine the sample to the 799 urban observations with both types of infrastructure (water and sanitation) within their household. This regression can not include own infrastructure since, by design, there is no variation within the sub-sample. Both coefficients of neighborhood infrastructure are now significantly positive in this specification, although there is no difference between having one and having both in the neighborhood. Thus, the key finding in this regression is that once one has taken into account the sanitary environment within the household, there is an additional impact if the neighbors have similar access to such services. We do not, however, find evidence of returns to combining services at the community level.

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5. The impact of the average of education of men in the community is not significant and we do not include the variable in this or other models reported in the tables.

Table 4. Regressions Results Allowing Parameters to Vary According to Existing Infrastructure

	Restricted urban[a]	*Restricted rural*[b]	*Urban*	***Rural***	*Urban*	*Rural*
Variables	*Column 1*	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*
Constant	-5.597***	-2.749**	-4.449***	-2.961***	-4.217***	-3.014***
	(1.452)	(1.633)	(1.202)	(1.218)	(1.191)	(1.214)
Male	.062	-.023	.060	-.000	.060	.004
	(.084)	(.109)	(.081)	(.087)	(.080)	(.087)
Age 7-12 months	-.322	-.924***	-.318	-.776***	-.320	-.770***
	(.236)	(.237)	(.249)	(.200)	(.248)	(.200)
Age 13-18 months	-1.011***	-1.387***	-1.168***	-1.273***	-1.164***	-1.261***
	(.202)	(.241)	(.184)	(.202)	(.183)	(.201)
Age 19-24 months	-1.007***	-1.696***	-1.319***	-1.632***	-1.318***	-1.603***
	(.217)	(.234)	(.201)	(.185)	(.200)	(.184)
Age 25-36 months	-.978***	-1.368***	-1.178***	-1.298***	-1.170***	-1.289***
	(.189)	(.190)	(.172)	(.167)	(.171)	(.168)
Age 37-48 months	-1.147***	-1.260***	-1.300***	-1.178***	-1.301***	-1.183***
	(.179)	(.186)	(.162)	(.167)	(.159)	(.167)
Age 49-60 months	-1.245***	-1.904***	-1.410***	-1.617***	-1.406***	-1.615***
	(.175)	(.189)	(.162)	(.164)	(.159)	(.166)
Indigenous	-.217	-.342***	-.226	-.260**	-.215	-.231**
	(.672)	(.144)	(.630)	(.123)	(.636)	(.123)
Logarithm of income per capita	.304***	.200	.296***	.393***	.290***	.369***
	(.090)	(.125)	(.099)	(.101)	(.099)	(.101)
Male education in years	-.018	-.017	-.014	-.030**	-.015	-.030**
	(.012)	(.018)	(.011)	(.015)	(.011)	(.015)
Female education in years	.050***	.044**	.057***	.053***	.056***	.056***
	(.017)	(.023)	(.016)	(.018)	(.016)	(.018)
Has sanitation *or* water supply			.117	.177**		
			(.190)	(.108)		
Has *both* sanitation and water supply			-1.032	-.077		
			(.650)	(.142)		
Interaction of household has neither type of infrastructure with neighborhood average for one type				.030		
				(.288)		
Interaction of household has neither type of infrastructure with neighborhood average for *both* types				2.449**		
				(1.122)		
Interaction of household has both types of infrastructure with neighborhood average for one type			1.544**			
			(.850)			
Interaction of household has both types of infrastructure with neighborhood average for both types			1.411**			
			(.638)			
Non-self neighborhood percentage with one type of infrastructure	1.559**	.076				
	(.864)	(.285)				
Non-self neighborhood percentage with both types	1.425**	2.435**				
	(.648)	(1.166)				

of infrastructure						
Non-self average logarithm of expenditures	.235	-.026	.241	-.193	.196	-.171
	(.189)	(.219)	(.206)	(.174)	(.207)	(.177)
Non-self female education	.006	.184***	.002	.170***	.008	.171***
	(.032)	(.042)	(.031)	(.035)	(.030)	(.035)
Water supply					.114	.255
					(.240)	(.221)
Sanitation					.186	-.135
					(.165)	(.167)
Neighborhood water supply					-.270	.414
					(.249)	(.666)
Neighborhood sanitation					.471**	1.108**
					(.232)	(.559)
Neighborhood water supply squared						-.584
						(.687)
Neighborhood sanitation squared						-1.317**
						(.604)
R-square	.167	.256	.191	.217		.220
Number of observations	799	587	1110	974		974

Robust standard errors in parentheses. *** significant at 1 percent level. ** significant at 5 percent level.
[a] Sample restricted to households with both types of infrastructure.
[b] Sample restricted to households with neither type of infrastructure.

An analogous argument can be made regarding the rural population. Since few households in the rural areas command both types of infrastructure, the regression in column two can not be specified exactly as with the urban regression. Thus, for the rural population we confine the sample to that subset of the rural population which has neither water nor sanitation infrastructure (587 observations). In this regression we find that those rural households with neither sanitation nor piped water benefit from being located near households with both of these. We note, however, that we only observe an important neighborhood effect for a combination of water and sanitation; the coefficient of having one type of neighborhood infrastructure is not significant in column two.[6]

Another way to allow for the fact that the impact of neighborhood access is mediated by the household's own investment is to use the full urban sample but to limit the parameter estimates to only those households that have a given level of infrastructure supply. We do this in a specification for urban areas by interacting the neighborhood averages of water and sanitation with a dummy variable for households with both types of infrastructure (column three). As indicated, for those who have both a secure water supply and good sanitation, the nutrition of children improves with the average level of infrastructure access within the neighborhood. As we also include the average consumption of the neighborhood, this impact of infrastructure is distinct from the overall effect (not significant) of being in a well off neighborhood.[7]

Similarly, the rural regression in column four of table 4 interacts the neighborhood infrastructure with a dummy variable for those who do *not* have access to either type of infrastructure within their own home. As with column two, this specification confirms that the infrastructure of neighbors affects those rural households who have neither assured water or sanitation in their homes.

While we are able to distinguish the impact of neighborhood infrastructure according to the level of the most common household infrastructure provision, we cannot repeat this for all possible combinations. The share of the urban population with neither sanitation nor good water is too small to run a regression with that sub-sample. Similarly, too few rural residents have both types of infrastructure to run a rural regression analogous to the urban regression in column three.[8]

We explore one further variation of the initial specification. Columns 5 and 6 of table 4 indicate the results of explicitly distinguishing the role of sanitation and of water supply. As mentioned, this differs a bit from the question of whether the impact of

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6. We also explored whether the impact of the education of other women in the community differs according to the level of the education of women in the household. The coefficient for the interaction (not illustrated here) was not significant.

7. This specification includes the full urban sample. Since the other coefficients in common with the restricted sample regression (column one in table 4) differ little in magnitude from the results in column one this provides some assurance that selectivity does not affect the results.

8. However, we are able to explore the sensitivity of the results in table 4 by seeing if the results change is we reclassify the infrastructure variables. For example, if we redefine the categories of rural infrastructure into having i) either no infrastructure in the household or only sanitation water, ii) having only water or iii) having both water and sanitation. As indicated in table 2, this involves shifting 41 households. Estimating this model (not reported in table 4) has the effect of reducing the coefficient of having one type of infrastructure [that is, water] by 10% in a regression analogous to that in column 2. As the standard error increases by 4%, the coefficient becomes statistically significant at only the 10% level. However, the impact of the percentage of the community members with both types remains unaffected.

services is cumulative since the groups having water may also have sanitation. In this specification there is no apparent impact of having infrastructure in one's own household, in either urban or rural neighborhoods. Nevertheless, in both urban and rural areas neighborhood sanitation remains important. However, the coefficient on neighborhood water supply is not significant in either sample. In the urban regression the inclusion of quadratic terms renders all of the infrastructure variables insignificant. Hence, the results reported are for a linear specification.

However, there appear to be diminishing returns to the impact of sanitation in the rural area. These diminishing returns are such that if the squared term is not included, the coefficient of neighborhood sanitation is not significant. This specification is not reported nor are alternative specifications that included the interaction of neighborhood sanitation and neighborhood water supply since this variable also was not significant. As specified in column six, the quadratic implies that the marginal impact of additional neighborhood sanitation declines (rather than levels off). It is zero when over 40% of the rural community have improved sanitation in the household. This value, however, is more than two and a half times the average in the sample and would therefore imply that positive neighborhood externalities in sanitation will continue to exist for the foreseeable future.

5. Conclusions

This study has three principal conclusions. First, there are appreciable externalities in the investment in household level infrastructure that carry over to neighboring households. This is most apparent in the case of female education in rural areas where the overall education of the neighborhood has a positive impact on nutritional status regardless of the education of the child's own caregiver. Similarly, we find that water and sanitation investments (or both) in the neighborhood appear to influence a child's health after controlling for the immediate family environment in both urban and rural areas although clearly not in an additive manner. In urban areas having both does not have any more impact than having one while in rural areas those households in our sample which benefit from the infrastructure in the neighborhood only do so when both are present.

However, our second main finding indicates that when we distinguish the type of services rather than the number of service we find that the provision of sanitation in the neighborhood dominates both sanitation in the household and water supply *per se*. This may explain why households with no infrastructure derive no measurable impact from only one service (columns 2 and 4, table 4) since in our rural sample having one service usually means having water supply but not sanitation.

Our third conclusion is that context matters. The impact of the neighborhood infrastructure differs not only between rural and urban but also at different levels of average neighborhood infrastructure. According to the results presented here, the positive externalities for rural sanitation would be highest at low levels of neighborhood access to sanitation and they would level off with increasing service provision. Such positive externalities exist until about half of the neighborhood has access to sanitation.

Context also matters in another way. A household's ability to benefit from investments of their neighbors in water and sanitation varies with its own access to such services. In urban areas, households with their own infrastructure benefit most from high neighborhood availability. In contrast, in rural areas where the average level of infrastructure is low, households with no infrastructure benefit the most. As mentioned, this is likely due to the availability in sanitation. Further work using larger samples with greater intra- and inter-community variability will likely yield additional insights regarding the interaction of services at the household level and at the community level.

Appendix Table 1. Means and Standard Deviation for the Variables in this Study

	Pooled		*Rural*		*Urban*	
Height for Age Z Score	-1.117	(1.511)	-1.604	(1.488)	-0.690	(1.398)
Male	0.504	(0.500)	0.495	(0.500)	0.512	(0.500)
Age 0-6 months	0.109	(0.312)	0.114	(0.318)	0.105	(0.307)
Age 7-12 months	0.097	(0.296)	0.104	(0.305)	0.091	(0.288)
Age 13-18 months	0.092	(0.289)	0.093	(0.291)	0.091	(0.288)
Age 19-24 months	0.090	(0.286)	0.081	(0.273)	0.097	(0.296)
Age 25-36 months	0.200	(0.400)	0.202	(0.402)	0.197	(0.398)
Age 37-48 months	0.202	(0.402)	0.199	(0.400)	0.205	(0.404)
Age 49-60 months	0.210	(0.407)	0.206	(0.405)	0.213	(0.409)
Indigenous	0.082	(0.274)	0.161	(0.368)	0.012	(0.108)
Logarithm of income per capita	7.474	(0.556)	7.307	(0.515)	7.621	(0.550)
Female education in years	7.356	(3.948)	5.182	(3.104)	9.264	(3.610)
Male education in years	7.127	(3.986)	5.424	(3.344)	8.622	(3.904)
Has *neither* sanitation or water supply	0.339	(0.474)	0.603	(0.490)	0.108	(0.311)
Has sanitation or water supply	0.236	(0.424)	0.308	(0.462)	0.172	(0.378)
Has *both* sanitation and water supply	0.425	(0.494)	0.089	(0.285)	0.720	(0.449)
Urban	0.533	(0.499)				
Non-self female education	7.469	(2.690)	5.345	(1.618)	9.333	(1.963)
Non-self average logarithm of expenditures	7.649	(0.338)	7.486	(0.289)	7.792	(0.314)
Non-self neighborhood percentage with *neither* type of infrastructure	0.320	(0.402)	0.580	(0.425)	0.092	(0.181)
Non-self neighborhood percentage with one type of infrastructure	0.246	(0.303)	0.329	(0.367)	0.173	(0.208)
Non-self neighborhood percentage with both types of infrastructure	0.434	(0.426)	0.091	(0.231)	0.735	(0.316)
Number of observations	2,084		974		1,110	

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