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Reducing Child Malnutrition: How Far Does Income Growth Take Us?

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How rapidly will child malnutrition respond to income growth? This article explores that question using household survey data from 12 countries as well as data on malnutrition rates in a cross-section of countries since the 1970s. Both forms of analysis yield similar results. Increases in income at the household and national levels imply similar rates of reduction in malnutrition. Using these estimates and better than historical income growth rates, the article finds that the Millennium Development Goal of halving the prevalence of underweight children by 2015 is unlikely to be met through income growth alone. What is needed to accelerate reductions in malnutrition is a balanced strategy of income growth and investment in more direct interventions.

Great strides have been made in reducing child malnutrition in the past few decades. The prevalence of underweight children under age five in the developing economies was 37.4 percent in 1980. By 2000 this had dropped to 26.7 percent (ACC/SCN 2000). Nevertheless, 150 million children in developing areas remain underweight, and 182 million remain stunted (low height for age). Moreover, progress in reducing prevalence rates has slowed in the past two decades, and in Africa both the number and the prevalence of underweight children have increased. At current trends it is clear that the goal of halving the prevalence of underweight children between 1990 and 2015—one of the indicator targets for the Millennium Development Goals for poverty and hunger—will not be met (ACC/SCN 2000).

What is needed to accelerate reductions in malnutrition to meet this target?[1] It is well accepted that a reduction in income poverty will lead to a reduction in

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[1] We note Maxwell's (1999, p. 93) reminder that "international targets can oversimplify and overgeneralize complex problems . . . and distort public expenditure priorities." But even if one questions the analytical basis of such targets, the general question of how to hasten improvements in nutrition remains a concern.

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malnutrition (Strauss and Thomas 1998). Greater incomes at the household level mean that families can invest more in food consumption, access to clean water and good hygiene, and effective health care. They can also afford more effective child care arrangements. At the community level greater income will eventually lead to better access to and better quality of health care centers and water and sanitation systems. But will moderate income growth alone be enough to meet development targets? If the relationship between income growth and malnutrition reduction is not sufficiently strong, more direct investments will be needed to accelerate declines in malnutrition. Candidates for such investment include nutrition programs such as community-based behavior change initiatives and micronutrient supplementation and fortification (Allen and Gillespie 2001).

The less than perfect correlation between nutritional status and national income levels or national income distribution is often used to distinguish the countries that are atypical or to motivate research to account for this. In places such as Sri Lanka and the Indian state of Kerala, which have achieved better health status than might have been expected given their aggregate income or rates of poverty, this has often happened as a result of public actions that directly affect health or nutrition (Anand and Ravallion 1993). Similarly, but less optimistically, in countries where nutritional status has improved less rapidly than might have been expected given their income growth, this may indicate a need for specific investments in human resources (Alderman and Garcia 1994).

But most studies addressing the causal link between income growth and malnutrition have focused on the response of nutrient *consumption* to changes in income (Strauss and Thomas 1995; Bouis and Haddad 1992). Surprisingly, there has been no systematic multicountry analysis of the causal relationship between income and malnutrition. This article fills that gap. Our goal is to answer this question: How far does moderately rapid income growth take us toward reducing the rate of child malnutrition in line with the Millennium Development Goal? We use an anthropometric measure—low weight for age—of child nutritional status as an outcome of household decisions on health and child care as well as on food consumption. We study the extent to which greater resources at the household as well as the national level explain differences in this crucial outcome.

Using household survey data from 12 countries as well as aggregate data on a set of 61 developing economies, we model the relationship between child underweight and per capita income, proxied by total household consumption per capita in the micro studies and by per capita gross domestic product (GDP) estimated using 1987 purchasing power parity (PPP) rates in the cross-country regressions. We then use the model to predict the declines in malnutrition that can be expected from a sustained 2.5 percent annual increase in per capita income from the date of the survey (in the 1990s) to 2015. Even at this moderately rapid growth rate, in 9 of 12 countries declines in malnutrition rates fall short of the Millennium Development Goal target. We conclude that income growth can play an important part in reducing malnutrition but that it is not enough. We suggest (but cannot prove in this study) that increasing the number and effectiveness of direct nutrition interventions is crucial if nutrition goals are to be met.

I. DATA SETS AND MODELS

In this section we describe the two data sources used to derive estimates of the response of child malnutrition to per capita income growth and outline the models used to generate the results reported in the following section.

The Household Surveys

We investigate how household resources affect the nutritional status of preschool children using household surveys from 12 countries.[2] The countries were selected from those with nationally representative household data for the 1990s to cover a range of locations, spanning four continents. They differ appreciably in their economic situation, including GDP per capita and national rates of malnutrition (table 1).[3] Even so, there is a common thread in the data: in all the countries studied an integrated household survey was undertaken in the 1990s using a multipurpose, modular, living standards survey following a format utilized in more than 20 countries (Grosh and Glewwe 2000). These surveys collect data on children's height and weight as well as information on total expenditures and other socioeconomic conditions of the household.

The measure of nutritional status (N) that we study is weight for age, considered a general indicator of the nutritional status of populations (Alderman 2000; WHO 1995). It is converted into standardized units called z-scores after comparison with the U.S. data chosen as an international reference by the World Health Organization (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. Like most of the literature, we pay particular attention to the proportion of children below two standard deviations from the median for the reference population. We refer to children with a weight-for-age z-score of less than –2 as *underweight*. In the reference population, 2.3 percent have z-scores of less than –2, and 16.0 percent have z-scores of less than –1. These levels might be expected for a normal population and provide a basis for comparison. But because 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 focus on nutritional status, not the probability of malnutrition defined in terms of a z-score of less than –2.

Countries with higher per capita income tend to have less malnutrition (see table 1). But there are exceptions. Although South Africa has the highest income

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[2] The age range was usually 0–60 months. In Kenya the age range was 6–60 months, and in Nepal 0–36 months.

[3] Because of data unavailability, we were unable to cover the half of the world's population that lives in China and India.

TABLE 1. Summary of Household Survey Data Sets

Country	Preschool children included in regressions	Year of sample survey	Maternal height covered	Per capita GDP (U.S. dollars) 1998	Annual percentage change in per capita GDP (PPP)[a]		Child malnutrition rate (percentage of preschool children underweight)		
					1975–99	1990–99	Male	Female	All
Egypt, Arab Rep.	1213	1997	Yes	1290	2.9	2.4	10.3	11.1	10.7
Jamaica	752	1995	No	1680	0.1	–0.6	4.9	5.2	5.0
Kenya	7626	1994	No	330	0.4	–0.3	20.9	18.4	19.7
Kyrgyz Republic	1679	1997	Yes[b]	350	–5.3	–6.4	13.4	13.1	13.3
Morocco	1979	1990–91	Yes	1250	1.4	0.4	14.7	15.4	15.0
Mozambique	3268	1997	No	210	1.3	3.8	23.8	21.7	22.8
Nepal	1560	1996	No	210	1.8	2.3	50.4	45.6	48.1
Pakistan	3076	1991	Yes	480	2.9	1.3	48.4	43.2	45.7
Peru	3075	1997	No	2460	–0.8	3.2	7.5	5.5	6.5
Romania	3625	1994	No	1390	–0.5	–0.5	7.9	4.8	6.4
South Africa	4132	1993	No	2880	–0.8	–0.2	18.2	17.7	18.0
Vietnam	2637	1993	Yes	330	4.8	6.2	39.8	41.5	40.7

[a] Data on real per capita GDP (adjusted for PPP) are from UNDP (2001).

[b] Mother codes were not documented so this data could not be linked to children.

Source: Egypt: Integrated Household Survey (EIHS) conducted under IFPRI Food Security Research Project in Egypt, March–May 1997. Food Consumption and Nutrition Division (FCND), April 2000, Documentation of FCND data sets collected between 1994 and 1999, p. 7. FCND, International Food Policy Research Institute, Washington, D.C. Jamaica: World Bank (2002), "Jamaica Survey of Living Conditions (JSLC) 1998–2000—Basic Information," mimeo, Poverty and Human Resources Division, Development Research Group, World Bank, Washington, D.C., www.worldbank.org/html/prdph/lsms/country/jm/docs/binfo2000.pdf. Kenya: Republic of Kenya (1996), "Welfare Monitoring Survey II—Basic Report," Central Bureau of Statistics, Nairobi, www4.worldbank.org/afr/poverty/pdf/docnav/00643.pdf. Kyrgyz Republic: Kyrgyz Poverty Monitoring Survey 1997 (KPMS), www.worldbank.org/lsms/country/kyrgyz/docs/kyrbif2.pdf. Morocco: Morocco Living Standards Survey 1990/1 (MLSS), www.worldbank.org/lsms/country/mo91/docs/mo91binf.pdf. Mozambique: Safety Net Design and Poverty Monitoring in Mozambique, February 1996 through April 1997, FCND, April 2000, Documentation of FCND data sets collected between 1994 and 1999, p. 23. FCND, International Food Policy Research Institute, Washington, D.C. Nepal: World Bank (2002), "Nepal Living Standards Survey I 1995/96—Survey design and implementation," mimeo, Development Research Group, World Bank, Washington, D.C., www.worldbank.org/lsms/country/nepal/nep96bidr.pdf. Peru: 1997 *Encuesta Nacional de Hogares sobre Medicion de Niveles de Vida* (ENNIV) survey, collected by the Instituto Cuanto. For further details see annex 1 of World Bank (1999). Poverty and Social Development in Peru, 1994–1997. Washington, D.C.: World Bank. Pakistan: World Bank (1985) "Basic Information—Pakistan Household Survey (PIHS) 1991," mimeo, Poverty and Human Resources Division, World Bank, Washington, D.C., www.worldbank.org/html/prdph/lsms/country/pk91/pk91.pdf. Romania: World Bank (1998), "Basic Information—Romania Integrated Household Survey (RIHS)," mimeo, Poverty and Human Resources, Development Research Group, World Bank, Washington, D.C. www.worldbank.org/lsms/country/romania/rm94bid.pdf. South Africa: South Africa Integrated Household Survey,. 1993/4, School of Economics, University of Cape Town, www.worldbank.org/html/prdph/lsms/country/za94/za94data.html. Vietnam: World Bank (2001), "Vietnam Living Standards Survey (VLSS), 1997–98—Basic Information," mimeo, Poverty and Human Resources Division, World Bank, Washington, D.C., www.worldbank.org/lsms/country/vn98/vn98bif.pdf.

in our sample of 12 countries, its malnutrition rates are little better than those in Kenya, whose per capita income is less than an eighth of South Africa's. But our focus with the household data is on the relationships between household resources and nutritional outcomes across households within a given country. As is generally the case, we presume that expenditures reflect a household's long-run income potential. Thus we estimate regressions for nutritional outcomes as a function of the log of per capita household expenditures (Y).

Additional regressors include the education levels of the child's mother and father (or, where parentage is unknown, a proxy).[4] Beyond income earning ability, education captures—though imperfectly—the ability of each parent to obtain and use information about appropriate caring practices and health services for the child. To account for different patterns of malnutrition by age, all the regressions contain six dummy variables for age brackets. In addition, to control for health- and sanitation-related correlates of income that may have an independent effect on nutrition, the regressions include indicators for the type of drinking water and toilet used.[5] Moreover, in countries where there are significant ethnic differences that relate to access to infrastructure—for example, Peru or South Africa—the regressions also include dummy variables for ethnic background.[6] The height of the mother—an indicator of genetic endowment and of growth and development in the womb—is included in the regressions when this information is available. Finally, all models include demographic variables, such as household size and the percentage of household which lies in different age groups.

We undertake two specifications of the model. Model 1 includes expenditures but excludes health, water, and sanitation infrastructure both external and internal to the household.[7] Model 2 controls for the infrastructure in the community that is external to the household (E) by including cluster-level fixed effects.

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[4] If the child's father could not be identified, the education of the most educated adult male in the household was used. In Jamaica and Kenya neither of a child's parents was identified, so the education levels of the household head and his or her spouse were used instead. Education was typically measured in years. For Kenya, however, for which this information was not available, dummy variables for education level were used instead.

[5] Typically the distinction was whether the household had piped drinking water within the dwelling or not and whether it had a flush toilet (see Burger and Esrey 1995 for a discussion of the role of water and sanitation interventions in reducing undernutrition).

[6] However, WHO (1995) advocates using a single international reference for child growth. The reason is that there are few if any ethnic differences in growth patterns of young children, and children from privileged or middle-class families in developing economies generally have height and weight distributions that do not differ from international references.

[7] For both the household survey and the cross-country regressions we log the per capita expenditure variable to minimize the influence of extreme values of per capita expenditure. This also increases the marginal effect of resources on nutrition at lower income levels, because the marginal effect is the estimated coefficient on the log of expenditures divided by the observed level of expenditures. We conduct nonnested tests (Davidson and MacKinnon's *J*-test as outlined in Greene 2000) to determine the appropriateness of this specification compared with a model linear in expenditures. In cases where the test proved conclusive, the log model was favored in seven cases and the linear in two. In 3 of 12 cases the test proved inconclusive.

That is, the model includes a dummy variable for each sample cluster. This dummy variable also picks up the effect of common attitudes and resources in the community or special local circumstances. In addition, model 2 includes the variables for infrastructure within the household (I) through access to piped water and sanitation. The two models can be labeled as follows:

$$N = N(Y) \tag{1}$$

$$N = N(Y, E, I) \tag{2}$$

Model 2 can be considered to give the short-run effect of increasing household income or consumption, holding external infrastructure and internal health infrastructure constant. Over a longer period a household whose income increases may choose to invest in water and sanitation or may have such investments made on its behalf by the public sector. Model 1, for which the short-run interpretation of the coefficient on income is biased to the degree that health and sanitation effects that influence nutritional status are correlated with household income, may better represent the total effect of resources in a long-run scenario.[8]

There are several reasons to suspect the endogeneity of the income variable in both models. The most obvious reason is measurement error in income or in the expenditure variable that we use in lieu of income. As is well known, if random measurement error is present in an explanatory variable, OLS estimates will be biased toward zero. Another potential cause of endogeneity of income is time allocation decisions that affect both income generation through labor supply and child nutrition through child care. Consequently, we estimate the models using both OLS and instrumental variables, both with and without the community fixed effects. Although there are differences in the nature and number of identifying variables in each data set, we use land and livestock holdings as well as other assets and durable goods in per capita terms, where available, as identifying instruments. In all cases we test the strength of our proposed identifying instruments in predicting per capita expenditures (an F-test), whether it is valid to exclude the proposed identifying instruments from the malnutrition equation (a chi-squared test for overidentification), and the significance of the difference between the consistent instrumental variables estimates on income and the efficient OLS estimates (a chi-squared Hausman test).[9]

The Cross-Country Data for 61 Countries, 1970–95

The dependent variable used in the cross-country analysis is the prevalence of children under age five who are underweight for their age—that is, whose weight

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[8] In principle, the education coefficient of model 2 can be used to derive the effect of long-run income growth on nutrition that is mediated by increased parental education that may also be driven by income growth under any assumption of changes in education.

[9] The list of instruments and the full set of results of these tests are available from the authors. Further details on the tests are in Bound and others (1995) and Davidson and MacKinnon (1993).

falls more than two standard deviations below the median for their age. All the data for this variable are survey-based aggregates. Most of the data (75 percent) are from the WHO's *Global Database on Child Growth and Malnutrition* (WHO 1997). These data have been subjected to strict quality control standards.[10] The rest of the data are from ACC/SCN (1993) and World Bank (1997), and we have subjected these data to similar quality checks. We match each weight-for-age survey year with the corresponding year's value of per capita GDP expressed in 1987 U.S. dollars adjusted for PPP. The GDP data are from the World Bank's *World Development Indicators 1998* (1998).[11]

The data set covers 61 developing economies, accounting for more than 80 percent of the developing world's population. Each country has at least two observations, and many have three or four. The total number of country-year observations is 175, spanning the period 1970–95 (Smith and Haddad 2000).[12]

II. RESULTS: WHAT IS THE IMPACT OF INCOME ON MALNUTRITION?

In this section we present the regression results for the effects of income growth at household and national levels on child malnutrition. We describe first the results from the 12 household surveys and then the results from the cross-country analysis.

Household Survey Results: Per Capita Household Income and Child Malnutrition

Table 2 presents estimates of the coefficient of the logarithm of per capita consumption (our proxy for per capita income) for models 1 and 2.[13] It gives both OLS and instrumental variables estimates, with and without mother's height where that variable is available. Several things are worth noting.

First, as expected, the log of per capita household consumption has a positive relationship with the nutritional status of children as measured by weight for age in all the countries studied. All the OLS estimates of model 1 (without controls for infrastructure) differ significantly from zero, as do most of the other estimates.

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[10] The criteria for inclusion in the WHO database are a clearly defined population-based sampling frame, permitting inferences to be drawn about an entire population; a probabilistic sampling procedure involving at least 400 children; use of appropriate equipment and standard measurement techniques; and presentation of data in the form of *z*-scores in relation to the reference population chosen by WHO (1997).

[11] These GDP data are reported only for 1980 to the present. To arrive at comparable PPP GDP per capita figures for the data points in the 1970s, it was necessary to impute growth rates from the data series on GDP in constant local currency units and apply them to countries' 1987 PPP GDPs.

[12] Related work by Smith and Haddad (2002) indicates that instrumenting per capita GDP with the investment share of GDP and the foreign investment share of GDP does not allow us to reject the exogeneity of per capita GDP in the cross-country sample. Thus, we do not instrument per capita GDP in the cross-country regressions.

[13] Table A-1 presents these results in more detail and lists the instruments used. The full set of results for each country is available from the authors.

TABLE 2. Summary of Estimates of the Effect of Per Capita Household Consumption on Weight for Age of Preschool Children, Selected Developing Economies

	Model 1: $N = N(Y)$				Model 2: $N = N(Y, E, I)$			
	OLS with mother's height	IV with mother's height	OLS without mother's height	IV without mother's height	OLS with mother's height	IV with mother's height	OLS without mother's height	IV without mother's height
Egypt, Arab Rep.								
Estimated coefficient[a]	0.1438	0.3600	0.1713	0.4007	0.1652	0.2977	0.1736	0.3176
t-statistic	2.09	2.00	2.47	2.21	1.98	1.30	2.07	1.38
Hausman test[b]	$p = 0.1948$		$p = 0.1698$		$p = 0.5360$		$p = 0.5029$	
Jamaica								
Estimated coefficient			0.257	0.742			0.191	0.411
t-statistic			3.13	3.10			2.11	1.51
Hausman test[b]			$p = 0.027$				$p = 0.393$	
Kenya								
Estimated coefficient[a]			0.137	0.499			0.142	0.417
t-statistic			8.02	7.38			6.36	4.64
Hausman test[b]			$p = 0.000$				$p = 0.01$	
Kyrgyz Republic								
Estimated coefficient[a]			0.2157	0.2893			0.1619	0.3553
t-statistic			3.48	1.68			2.19	1.81
Hausman test[b]			$p = 0.6469$				$p = 0.2882$	
Morocco								
Estimated coefficient[a]	0.4274	0.7174	0.4857	0.7814	0.1879	0.6007	0.2333	0.6330
t-statistic	8.44	9.18	9.62	10.16	2.78	3.86	3.46	4.10
Hausman test[b]	$p = 1.12e–06$		$p = 3.55e–07$		$p = 0.0032$		$p = 0.0040$	
Mozambique								
Estimated coefficient[a]			0.3127	0.4595			0.1860	0.3403
t-statistic			10.68	8.76			3.94	3.62
Hausman test[b]			$p = 0.000746$				$p = 0.05807$	

Nepal								
Estimated coefficient[a]			0.319	0.971			0.204	0.533
t-statistic			6.16	5.15			2.98	2.78
Hausman test[b]			$p = 0.00$				$p = 0.068$	
Pakistan								
Estimated coefficient[a]	0.231	0.471	0.240	0.478	0.075	0.400	0.085	0.405
t-statistic	4.77	3.29	4.96	3.36	1.34	2.25	1.52	2.28
Hausman test[b]	$p = 0.073$		$p = 0.073$		$p = 0.053$		$p = 0.056$	
Peru								
Estimated coefficient[a]			0.2504	1.2001			0.2056	0.8150
t-statistic			5.51	5.38			4.09	3.52
Hausman test[b]			$p = 0.0000139$				$p = 0.0.0069$	
Romania								
Estimated coefficient[a]			0.140	0.180			0.287	0.658
t-statistic			3.28	2.00			2.78	2.89
Hausman test[b]			$p = 0.279$				$p = 0.066$	
South Africa								
Estimated coefficient[a]			0.2089	0.2790			0.1780	0.0807
t-statistic			5.39	1.48			3.45	0.28
Hausman test[b]			$p = 0.7048$				$p = 0.7327$	
Vietnam								
Estimated coefficient[a]	0.265	0.437	0.293	0.471	0.198	0.261	0.105	0.275
t-statistic	6.73	7.02	7.37	7.52	1.76	2.55	1.87	2.67
Hausman test[b]	$p = 0.000$		$p = 0.000$		$p = 0.057$		$p = 0.049$	

Note: The table shows results for the log of per capita expenditure (lnpcxp). Estimates are used in the projections in table 3. IV is instrumental variables.

[a] lnpcxp.

[b] OLS vs. IV (chi squared).

Source: Authors' calculations.

Second, the estimated coefficients on the log of per capita consumption are usually larger in model 1 than in model 2. The exceptions to this are the Arab Republic of Egypt and Romania. The general pattern is consistent with the interpretation that model 1 captures the long-run effect of income on malnutrition.

Third, the instrumental variables estimates are, without exception, larger than the OLS estimates. The differences range from 29 percent in Romania to 500 percent in Peru. These differences are consistent with a high degree of measurement error on the per capita consumption variable.

Fourth, the instrumental variables estimates differ significantly from zero and differ significantly at the 5 percent level from the OLS estimates for 8 of the 12 countries. OLS estimates are preferred to the instrumental variables estimates for 3 of the 12 countries. For the Kyrgyz Republic and South Africa we cannot generate significant instrumental variables estimates for either model 1 or 2. For Romania instrumental variables estimates can be generated that differ significantly from zero, but the Hausman test fails to reject the equality of OLS and instrumental variables estimates even at the low threshold of 20 percent, arbitrarily selected to take into account the low power of the test. For the remaining country, Egypt, we selected the instrumental variables estimate (0.36) rather than the lower OLS estimate (0.14) for the subsequent projections even though the Hausman test only rejected the equality of the estimates at the 19 percent level.

Fifth, the estimated coefficients on the log of per capita consumption are larger in the absence of mother's height. The differences (in our preferred specifications) range from 1 percent in Pakistan to 11 percent in Egypt. These differences are consistent with the hypothesis that failing to control for mother's height will lead to a bias due to omitted variables (Alderman 2000). The bias appears modest in the four cases in which we can test for this, however.

Sixth, if we focus on our preferred estimates of model 1 (table 2), the mean coefficient is 0.54—implying that doubling household income will increase weight for age by half a standard deviation from the median for the reference population. The median coefficient is 0.47. But the coefficients vary widely across countries, from 0.14 for Romania to 1.20 for Peru.

The results reported in table 2 are based on regressions that have nutritional status as a dependent variable. Though this approach uses more information in the data sets than one focusing on the probability of crossing a threshold, it does not allow us to directly infer the effect of income growth on malnutrition rates. Under the assumption of a neutral distribution of income growth, however, it is relatively straightforward to simulate expected change in the prevalence of malnutrition between the year of a survey and 2015 (the reference point for the Millennium Development Goals) using the coefficients in table 2.

Table 3 shows the expected proportional reduction in malnutrition after sustained per capita income growth of 2.5 percent a year, using the estimates in table 2 (all from model 1, the long-run specification). Because we force income growth to be the same across countries, any differences in the effect of this growth reflect the size of the estimated coefficient on income and the density of the dis-

Table 3. Projected Child Malnutrition Rate with 2.5 Percent Annual Growth in Per Capita Income from the 1990s to 2015, Selected Developing Economies

Country	Estimated coefficient on log of per capita expenditure from model 1	Child malnutrition rate in survey year (percentage of preschool children underweight)	Projected child malnutrition rate in 2015 (percentage of preschool children underweight)	Change in child malnutrition rate (percent)	Arc elasticity
Egypt, Arab Rep.	0.3600[a]	10.80	8.00	–25.95	–0.464
Jamaica	0.7415[a]	5.05	2.26	–55.26	–0.865
Kenya	0.4994[a]	19.63	11.38	–42.02	–0.618
Kyrgyz Republic	0.2157[b]	13.28	11.44	–13.90	–0.248
Morocco	0.7174[a]	13.79	6.11	–55.68	–0.670
Mozambique	0.4595[a]	23.04	16.43	–28.69	–0.513
Nepal	0.9710[a]	48.08	25.99	–45.94	–0.767
Pakistan	0.4705[a]	45.73	34.67	–24.18	–0.299
Peru	1.2001[a]	7.32	2.70	–63.11	–1.127
Romania	0.1396[b]	6.40	5.54	–13.36	–0.197
South Africa	0.2089[b]	18.02	15.54	–13.79	–0.191
Vietnam	0.4372[a]	40.65	28.13	–30.78	–0.427

[a] Instrumental variables estimate.

[b] OLS estimate.

Source: See table 1.

tribution of the nutritional status of the population slightly below the cutoff for malnutrition at a *z*-score of –2. The assumed growth rate for per capita income is relatively optimistic. Only 3 of the 12 countries achieved this growth rate over the 1990s, although another 2 came close (see table 1). Over the 25-year period ending in 1999, again only three countries achieved 2.5 percent per capita growth. The cross-country data set confirms that the income growth rates used in our simulations are optimistic. Based on all observations available (61 countries, 175 observations), the mean growth in per capita GDP between the earliest and latest years for each country averages just 1 percent a year. In the countries for which we have observations for all three decades, growth averaged only 0.65 percent a year.

For only 3 of the 12 countries—Jamaica, Morocco, and Peru—does per capita income growth of 2.5 percent result in a halving of the malnutrition rate by 2015. Among the 12 countries, these 3 rank first, third, and sixth, respectively, by lowest initial rate of malnutrition, although there is no statistically significant correlation between the initial malnutrition rate and the projected decline across the 12 countries. The relative decline ranges from 13 percent in Romania to 63 percent in Peru, averaging 34 percent (the median decline is 30 percent).

These projected declines are likely to be on the high end for several reasons. First, by using estimates from model 1, we assume that as a household's income improves, so does the health and sanitation infrastructure to which the household has access, both internally and externally. If we assume that infrastructure and community fixed factors do not improve (basing our estimates on model 2), sustained growth of 2.5 percent would reduce malnutrition by an average 27.4 percent by 2015.[14] Second, we assume that every household experiences the same rate of income growth, an assumption that forces growth to be broadly based. Third, we assume fairly robust growth of per capita income. If we assume a more modest rate of, for example, 1.25 percent a year (achieved by only half the 12 countries in 1990–99), none of the 12 countries would meet the target of halving malnutrition rates by 2015. Fourth, by using the estimated coefficients from the log specification on per capita consumption, regardless of what the nonnested tests conclude, we force the estimated effect of income on nutrition to be relatively large for poorer households (which tend to contain proportionately more underweight children).

Before looking at the effect of GDP growth on cross-country regressions, we discuss the coefficients of the auxiliary variables included in the household regressions to reduce the bias due to missing variables, such as parental education and the infrastructure terms, focusing our attention on model 2.

Parental characteristics are often important determinants of anthropometric status (table 4). This is particularly true for mother's height, which had a positive and significant relationship with the child's nutrition in all the countries for which this information was available. Years of parental education are positive and significant determinants of anthropometric status in just over a third of all cases. The lack of significance may be surprising given the conventional wisdom, although it mirrors the findings of Sahn and others (1999) based on Demographic and Health Surveys for nine African countries.[15] The estimates of the coefficients are almost always positive and, taken together, make it unlikely that their true value is zero. On average, an extra year of maternal education raises z-scores by around 1.3 percent of a standard deviation of nutritional status. Paternal education generally has a somewhat smaller effect (averaging 0.7 percent of a standard deviation), though it varies by country. On average, giving mothers and fathers an extra six years of schooling each would raise weight for age by 12 percent of a standard deviation. Compare this with the 54 percent average change predicted from doubling income.

In all cases the age bracket variables for the child were jointly significant and in most cases individually so. The anthropometric data show no evidence of bias against girls, even in countries where it is commonly suspected, such as Nepal and Pakistan (see also Harriss 1995). z-Scores are almost always higher on average for girls than for boys, although the differences are often statistically insignificant.

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[14] With estimated coefficients from model 2, the malnutrition rate would decline by 16.03 percent in Egypt, 15.79 percent in Jamaica, 36.10 percent in Kenya, 11.66 percent in the Kyrgyz Republic, 49.81 percent in Morocco, 22.70 percent in Mozambique, 27.20 percent in Nepal, 19.11 percent in Pakistan, 45.33 percent in Peru, 58.19 percent in Romania, 7.76 percent in South Africa, and 19.56 percent in Vietnam.

[15] In one specification parental education variables were significant determinants of height for age in only 11 of 32 cases studied by Sahn and others (1999, table 14A).

Table 4. Coefficients on Parental Characteristics, Selected Developing Economies

Country	Father's education	Mother's education	Mother's height
Egypt, Arab Rep.	–0.0106 (1.29)	0.0019 (0.20)	0.0240 (3.50)
Egypt, Arab Rep.	–0.01049 (1.27)	0.0033 (0.34)	
Jamaica	0.0052 (0.24)	0.0165 (1.15)	n.a.
Kenya	0.0016 (0.35)	0.0144 (3.77)	n.a.
Kyrgyz Republic	0.0024 (0.14)	0.0580 (2.99)	n.a.
Morocco	0.0006 (0.01)	–0.0358 (0.15)	0.0270 (4.97)
Morocco	0.0076 (0.13)	–0.038 (0.16)	
Mozambique	0.0023 (0.28)	0.0261 (2.24)	n.a.
Nepal	0.0212 (2.76)	0.0146 (1.20)	n.a.
Pakistan	0.0198 (2.68)	0.0311 (2.79)	0.0060 (2.38)
Pakistan	0.0218 (2.97)	0.0308 (2.76)	
Peru	–0.0165 (2.53)	0.0284 (3.47)	n.a.
Romania	0.0480 (2.63)	–0.0185 (–0.89)	n.a.
South Africa	0.0167 (1.48)	0.0049 (0.62)	n.a.
Vietnam	–0.0042 (–0.53)	0.0182 (2.10)	0.0253 (6.15)
Vietnam	–0.0048 (–0.61)	0.0190 (2.17)	

Note: The dependent variable is weight for age (z-score) preschool children. The coefficients are OLS estimates from model 2. n.a., Not available.

Source: Authors' calculations.

Cross-Country Results: Per Capita GDP and Child Malnutrition

Table 5 presents the mean prevalence of malnutrition in our cross-country sample, both for all the countries and for the subsample for which we have observations in each decade. We report both unweighted cross-country means and means weighted by country population. Comparisons of trends in malnutrition rates over time are complicated by our lack of observations for China in the 1970s and India in the 1980s. But the data do illustrate the cross-sectional variation of malnutrition with national income.

Figure 1 plots the predicted negative relationship between smoothed malnutrition rates and per capita GDP based on the smoothed regression routine for each decade. The association between GDP and nutrition has been fairly constant; the line for the 1970s runs parallel to those for the next two decades. At any given level of GDP in the 1980s or 1990s, a country could expect a lower rate of malnutrition than in the 1970s. That is, even in countries with stagnant economies, the expected rate of malnutrition in the 1980s was lower than that in the 1970s. Plausible candidates that may account for this change between the 1970s and 1980s include improvements in technology that are not strongly related to income or investment in the countries in the sample, such as the promotion of oral rehydration salts and mass immunization. In addition, the average price of food was higher in the 1970s. Though it is also true that the average education of women (as well as men) improved in the period, this is less likely to be an explanation, because (as will be discussed) the 1970s imply higher malnu-

Table 5. Mean Child Malnutrition Rate in Cross-Country Data

	Mean child malnutrition rate (percentage of preschool children underweight)		
Decade	Unweighted	Population weighted	Observations
All countries			
1970s	29.18	50.8	30
1980s	24.23	29.0	74
1990s	23.80	28.5	71
All	24.90		175
Countries with observations in all decades			
1970s	27.07	33.9	18
1980s	20.69	26	27
1990s	19.65	24.5	22
All	22.06		67

Source: WHO (1997).

trition even in regressions that control for education. Moreover, the improvement in education continued and indeed accelerated in many countries into the 1990s, but the curve for that decade is not appreciably below that for the 1980s.

Table 6 reports models of malnutrition rates as a function of the log of per capita GDP, female secondary school enrollment, access to safe water, and decade dummy variables. The models do not explore how different structures of GDP growth influence malnutrition, although the fixed effects results do have some control for such differences. The OLS results (without the variable for access to safe water) are analogous to model 1 (column 1 of table 6), and the country fixed effects estimates (with the variable for access to safe water) are analogous to model 2 (column 2).[16]

The decline in malnutrition rates over time suggested in figure 1 is confirmed by the negative signs of the dummy variables for the 1980s and 1990s (significant at 5 percent for the 1980s only in the model 2 specification) relative to the 1970s. Model 1 estimates indicate a negative and significant effect of per capita GDP on malnutrition rates. By dividing the coefficient of the logarithm by the

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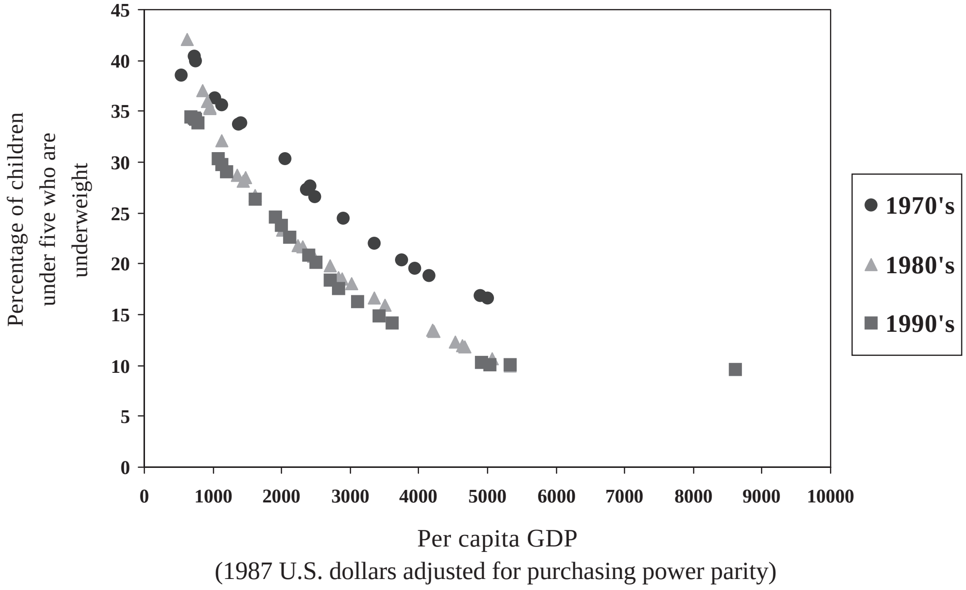
[16] Although Pritchett and Summers (1996) present evidence that GDP can be treated as exogenous in cross-country health regressions, we explored potential concerns about measurement error in the explanatory variables using a procedure suggested by Griliches and Hausman (1986). For the 36 countries with more than two observations, we generated two sets of fixed-effects estimates by differencing out the fixed effects in two different ways. First, we differenced observations $t1$ and $t2$; second, we differenced the first and last observations. The two sets of estimates were similar, especially for log per capita GDP (–6.13, $t = 1.29$ in the first case, and –6.91, $t = 1.91$ in the second). Because attenuation bias does not worsen appreciably with shorter periods between observations, we conclude that measurement error in the explanatory variables does no major violence to our findings on the size of the estimated coefficient on the log of per capita GDP (Johnston and DiNardo 1997). This approach also partially addresses a concern about the education variables that are generally less useful in time series of aggregate data than in household data (Krueger and Lindhal 1999), though the longer the interval, the less of a concern this is.

FIGURE 1. Fitted Relationship between Child Malnutrition Rate and Per Capita gdp in Developing Economies, 1970s, 1980s, and 1990s



Note: The ksm command in Stata (V7) with only per capita GDP as an explanatory variable was used to generate the smoothed curve. A bandwidth of 0.8 was used.

Source: Authors' calculations.

mean rate of malnutrition in the sample countries reported in table 5, we derive an elasticity at the mean of –0.51, comparable to the mean (–0.53) of the arc elasticities reported in table 3 from the survey-based estimates. As expected, the inclusion of fixed effects and the variable for access to safe water in model 2 leads to a smaller estimate of the effect of income growth. In column 2 of table 6 the coefficient on per capita GDP drops to 59 percent of its value in column 1. This general result holds for fixed effects estimation with the variable for access to safe water and without it (not reported here). It suggests that there are many time-invariant unobservable factors that are positively associated with both high (low) income and low (high) malnutrition, biasing the OLS estimates upward.

The estimated coefficient on the log of per capita GDP in column 2 of table 6 implies that 2.5 percent annual growth in per capita GDP between 1995 and 2015 would reduce the malnutrition rate by 8 percentage points, or 32 percent of the initial rate (compared with 34 percent, the mean relative decline for the 12 survey countries). The results refute a hypothesis that per capita GDP growth fails to improve the nutritional status of the most vulnerable. This improvement in nutrition related to GDP growth may be a direct effect of economic growth on the income of households with malnourished members (presumably the poor) or an indirect effect of this growth on the infrastructure of the country—or a combination of the two.

Table 6. OLS and Country Fixed Effects Regressions, Cross-Country Data

Explanatory variable	(1) OLS	(2) Country fixed effects
Log of per capita GDP	–12.673	–7.44
	(8.00)**	(2.89)**
Female secondary school enrollment	–0.011	–0.088
	(0.19)	(1.13)
Percentage of households with access to safe water		–0.055
		(1.18)
Decade = 1980s	–4.411	–4.07
	(1.77)	(2.66)*
Decade = 1990s	–6.385	–4.18
	(2.52)*	(2.19)*
Constant	124.220	89.80
	(11.24)**	(4.92)**
Observations	175	175
Countries	61	61
R^2	0.45	0.43

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Note: The dependent variable is the prevalence of preschool children who are underweight for their age (z-score less than –2). The numbers in parentheses are the absolute value of t-statistics.

Source: Authors' calculations.

The percentage reductions in malnutrition rates estimated using the survey data are remarkably similar to those estimated using the cross-country data. Of course, there is no automatic correspondence between the household regressions and the cross-country results. For one thing, income growth rates estimated using the national accounts data in the cross-country regressions do not closely track those estimated using survey data on household expenditures (Deaton 2001). In addition, the rate of income growth for the households at risk of malnutrition may differ from the national average, depending on whether inequality is increasing or declining. Moreover, the cross-country results might be biased downward because of mismeasurement in PPP. Conversely, one might expect the cross-country results to give higher income elasticities than those based on household survey data, because the second are conditioned on time-varying as well as time-invariant country-level factors. For example, if all households in a survey are subject to the same national health system, household-level estimates of income effects will not include the indirect effects on the performance of the system from rising national income. Thus, it is reassuring that our main results on the expected effect of income growth are fairly robust to the alternative source of income data.

Our cross-country estimates have not yet explicitly addressed income distribution. This omission is important for two reasons. First, it is plausible that the inequality in a country affects the allocation of resources to basic health and similar services. Second, for our cross-country model to be consistent with the semi-logarithmic specification at the household level, we need to accommodate the fact that the per capita GDP variable is not equivalent to the average of the logarithm of income. We cannot re-create that average with the aggregate data available. However, the misspecification of the income variable when the true model is semi-logarithmic is explicitly related to Theil's inequality measure. This, too, is unavailable with the aggregate data, but a related measure is found in the Gini coefficients in the Deininger and Squire Data Set on income inequality (World Bank 2002). Although this is not the perfect correction for using per capita GDP in a model based on a logarithmic income response, it serves as a conditioning variable to reduce any error in the per capita GDP variable, though it does so imprecisely. Because the Gini coefficient variable picks up the aggregation bias as well as the possible causal relationship between inequality and the effect of income growth on nutrition, there is no clear expectation for the sign.

From the Deininger and Squire Data Set it is clear that inequality measures change over time and thus are not adequately controlled for in the fixed-effects estimates. Merging that data set's self-declared "high-quality" data on the Gini coefficient by country and year into our data set reduces the number of observations from 175 to 96 and the number of usable observations (those for countries with more than one observation) to 79 (or 31 countries). Table 7 presents regressions similar to those in table 6—but on this much smaller data set—both with and without the Gini coefficient variable. This variable does not differ significantly from zero at the 5 percent level in either the OLS or the country fixed effects specification. But it does have a negative coefficient. Importantly, introducing the Gini coefficient does not substantially alter the size of the estimated coefficient on the log of per capita GDP.

III. CONCLUSIONS

Both the cross-country and the household-level results show that sustained income growth could lead to a sizable reduction in malnutrition in the next decade or so. Even with no change in community and household infrastructure, rates of malnutrition (low weight for age) are projected to decline by an average of around 27 percent by 2015 if countries can achieve per capita income growth of 2.5 percent a year. Allowing community and household infrastructure to change over time increases the effect of the growth to a 34 percent reduction in national malnutrition rates. Cross-country regressions imply similar reductions. The cross-country estimates add another dimension, showing that historical patterns of income distribution are consistent with income growth leading to marked improvements in nutrition.

Although these results are encouraging, others are disturbing. First, only 3 of the 12 countries sustained per capita income growth of more than 2.5 percent a year in the 1990s. Second, even if all 12 countries had 2.5 percent growth over the approximately 20-year period ending in 2015, only 3 would meet the target

Table 7. OLS and Country Fixed Effects Regressions with Gini Coefficient, Cross-Country Data

Explanatory variable	OLS	OLS including Gini coefficient	Country fixed effects	Country fixed effects including coefficient Gini
Log of per capita GDP	–17.216	–15.196	–10.165	–9.242
	(7.35)**	(5.53)**	(2.09)*	(1.94)
Female secondary school enrollment	–0.038	–0.039	0.027	–0.005
	(0.44)	(0.47)	(0.25)	(0.05)
Percentage of households with access			–0.119	–0.146
to safe water		(1.80)	(2.20)*	
Decade = 1980s	–6.302	–7.025	–4.368	–4.159
	(1.71)	(1.89)	(1.93)	(1.88)
Decade = 1990s	–10.230	–11.143	–4.494	–3.975
	(2.60)*	(2.81)**	(1.57)	(1.41)
Gini coefficient		–0.302		–0.342
		(1.38)		(1.80)
Constant	165.400	163.766	113.283	123.911
	(9.74)**	(9.67)**	(3.20)**	(3.54)**
Observations	79	79	79	79
Countries	31	31	31	31
R^2	0.56	0.57	0.54	0.56

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Note: The dependent variable is the prevalence of preschool children who are underweight for their age (z-score less than –2). The numbers in parentheses are the absolute value of t-statistics. The table includes only countries with more than one observation for the Gini coefficient.

Source: Authors' calculations.

of reducing malnutrition rates by half. Third, among the countries that will not meet that target even with sustained growth of 2.5 percent a year are those with the highest current malnutrition rates—Nepal, Pakistan, and Vietnam. Fourth, even if all economies managed to grow at a pace that would halve malnutrition rates by 2015, each year a different cohort of preschool children—particularly those under 36 months of age—would be irreversibly harmed.[17] Do we need to wait this long for malnutrition rates to be halved?

Though income growth can take us a long way toward meeting the target for malnutrition, it is unlikely by itself to ensure that outcome. What will it take to meet this target—and at a more rapid pace? There are many effective nutrition and health interventions that could accelerate reductions in malnutrition in the short run (Allen and Gillespie 2001). Some of these interventions—particularly vitamin A supplementation for children under age five, iron supplementation for

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[17] Moreover, even if the target is met in countries with high initial malnutrition rates, this is no cause for complacency: these countries will still be home to many undernourished preschool children.

pregnant women, and some types of nutrition education and behavior change initiatives—are more cost-effective than others (Gillespie and Haddad 2001). Impact evaluations and other project-level assessments have shown that such instruments are effective. The long-run income estimates based on the survey data allow for improvements in health-related infrastructure, but only at a "business as usual" rate. Unfortunately, because of data constraints, it is impossible to compare the cost-effectiveness of current health infrastructure captured by the surveys with that of the "best practice" set of nutrition interventions, especially when the health infrastructure is broadly defined and can fall within other sectors, such as education, infrastructure, and agriculture.

Income growth is also part of this balanced strategy. Sustained per capita income growth will go a long way toward halving child malnutrition rates by 2015. Indeed, in the absence of income growth, the effect of direct nutrition interventions is likely to be hampered despite their potential.

Even so, we can echo the conclusions of Berg (1981) and Reutlinger and Selowsky (1976), who note that malnutrition would persist in the face of rapid income growth in the absence of additional measures to address malnutrition directly, whatever those measures might be. Our results point to the crucial importance of pursuing a balanced strategy to accelerate reductions in malnutrition, though by themselves the results do not identify which investments are more effective in which environment (see Gillespie and others 1996, for example).

Appendix Table A-1. Full Results on the Effect of Per Capita Consumption, Selected Developing Economies

	Model 1: $N = N(Y)$				Model 2: $N = N(Y, E, I)$			
	OLS with mother's height	IV with mother's height	OLS without mother's height	IV without mother's height	OLS with mother's height	IV with mother's height	OLS without mother's height	IV without mother's height
Egypt, Arab Rep.								
Estimated coefficient[a]	0.1438	0.3600	0.1713	0.4007	0.1652	0.2977	0.1736	0.3176
t-statistic	2.09	2.00	2.47	2.21	1.98	1.30	2.07	1.38
F-test on significance of identifying instruments	$F(10,1188) = 20.45$ $(p = 0)$		$F(10,1189) = 20.72$ $(p = 0)$		$F(10,1061) = 16.17$ $(p = 0)$		$F(10,1062) = 16.24$ $(p = 0)$	
Overidentification test[b]	6.31 ($df = 9$) (pass)		6.31 ($df = 9$) (pass)		3.158 ($df = 9$) (pass)		3.518 ($df = 9$) (pass)	
Hausman test, OLS vs. IV[b]	$p = 0.1948$		$p = 0.1698$		$p = 0.5360$		$p = 0.5029$	
Instruments (10)	Per capita values of animals owned (and × rural-urban dummy variable), acres owned (and × rural-urban dummy variable), other savings and bank deposits, other property not in use, durable goods, household enterprise, and agricultural machinery (tractors, threshers) (and × rural-urban dummy variable)							
Jamaica								
Estimated coefficient[a]			0.257	0.742			0.191	0.411
t-statistic			3.13	3.10			2.11	1.51
Relevance test			$F(6,730) = 17.02$ $(p = 0)$				$F(6,716) = 14.53$ $(p = 0)$	
Overidentification test[b]			0.752 ($df = 6$) (pass)				0.075 ($df = 6$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.027$				$p = 0.393$	
Instruments (5)	Log per capita value of durable goods, log per capita unearned income, log per capita rooms, 1—receive food stamps, 1—applied for food stamps, 1—own house							
Kenya								
Estimated coefficient[a]			0.137	0.499			0.142	0.417
t-statistic			8.02	7.38			6.36	4.64
Relevance test			$F(6,7603) = 92.29$ $(p = 0)$				$F(6,6481) = 73.24$ $(p = 0)$	
Overidentification test[b]			6.01 ($df = 5$) (pass)				1.53 ($df = 5$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.00$				$p = 0.01$	
Instruments (6)	Log per capita cattle, 1—no cattle, log per capita number of rooms in house, 1—household head is commercial farmer, 1—household head is in business, 1—iron roof							

Kyrgyz Republic								
Estimated coefficient[a]			0.2157	0.2893			0.1619	0.3553
t-statistic			3.48	1.68			2.19	1.81
F-test on significance of identifying instruments			$F(6,1657) = 41.0$ ($p = 0$)				$F(6,1602) = 44.13$ ($p = 0$)	
Overidentification test[b]			2.351 ($df = 5$) (pass)				0.672 ($df = 5$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.6469$				$p = 0.2882$	
Instruments (6)	Per capita values of durable goods, livestock, business owned, housing and properties owned, other assets and savings, and land							
Morocco								
Estimated coefficient[a]	0.4274	0.7174	0.4857	0.7814	0.1879	0.6007	0.2333	0.6330
t-statistic	8.44	9.18	9.62	10.16	2.78	3.86	3.46	4.10
F-test on significance of identifying instruments	$F(5,1956) = 291.38$ ($p = 0$)		$F(5,1957) = 304.76$ ($p = 0$)		$F(5,1814) = 86.72$ ($p = 0$)		$F(5,1815) = 87.93$ ($p = 0$)	
Overidentification test[b]	7.718 ($df = 4$) (pass)		8.1139 ($df = 4$) (pass)		4.35 ($df = 4$) (pass)		2.97 ($df = 4$) (pass)	
Hausman test, OLS vs. IV[b]	$p = 1.12e{-}06$		$p = 3.55e{-}07$		$p = 0.0032$		$p = 0.0040$	
Instruments (5)	1—own cooker, 1—own refrigerator, 1—own stove with gas, 1—own color TV, 1—own black and white TV							
Mozambique								
Estimated coefficient[a]			0.3127	0.4595			0.1860	0.3403
t-statistic			10.68	8.76			3.94	3.62
F-test on significance of identifying instruments			$F(16,3279) = 92.26$ ($p = 0$)				$F(16,2513) = 53.20$ ($p = 0$)	
Overidentification test[b]			19.28 ($df = 15$) (pass)				21.90 ($df = 15$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.000746$				$p = 0.05807$	
Instruments (16)	Per capita land area (ha), per capita livestock value, 1—own refrigerator, 1—own fan, 1—own sewing machine, 1—own loom, 1—own iron, 1—own radio, 1—own TV, 1—own color TV, 1—own air conditioner, 1–own clock, 1–own telephone, 1—own car, 1—own motor bike, 1—own bicycle							
Nepal								
Estimated coefficient[a]			0.319	0.971			0.204	0.533
t-statistic			6.16	5.15			2.98	2.78
Relevance test			$F(6,1539) = 23.22$ ($p = 0$)				$F(6,1539) = 30.32$ ($p = 0$)	
Overidentification test[b]			5.14 ($df = 5$) (pass)				9.04 ($df = 5$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.00$				$p = 0.068$	
Instruments (6)	Log value of consumer durables, log per capita land value, log per capita livestock value, log per capita value of farm enterprise assets, log per capita value of nonfarm enterprise, 1—electric lighting							

(*continued*)

Table A-1. (*continued*)

	Model 1: $N = N(Y)$				Model 2: $N = N(Y, E, I)$			
	OLS with mother's height	IV with mother's height	OLS without mother's height	IV without mother's height	OLS with mother's height	IV with mother's height	OLS without mother's height	IV without mother's height
Pakistan								
Estimated coefficient[a]	0.231	0.471	0.240	0.478	0.075	0.400	0.085	0.405
t-statistic	4.77	3.29	4.96	3.36	1.34	2.25	1.52	2.28
Relevance test	$F(6,3051) = 66.61$ ($p = 0$)		$F(8,3052) = 62.26$ ($p = 0$)		$F(6,2759) = 51.26$ ($p = 0$)		$F(6,2760) = 51.34$ ($p = 0$)	
Overidentification test[b]	8.613 ($df = 6$) (pass)		8.305 ($df = 6$) (pass)		0.615 ($df = 6$) (pass)		0.308 ($df = 6$) (pass)	
Hausman test, OLS vs. IV[b]	$p = 0.073$		$p = 0.073$		$p = 0.053$		$p = 0.056$	
Instruments (6)	Log per capita land in ha, log per capita rooms, 1—mud floor, 1—iron roof, 1—no land, 1—missing data on housing							
Peru								
Estimated coefficient[a]			0.2504	1.2001			0.2056	0.8150
t-statistic			5.51	5.38			4.09	3.52
F-test on significance of identifying instruments			$F(4,3055) = 66.23$ ($p = 0$)				$F(4,2680) = 67.22$ ($p = 0$)	
Overidentification test[b]			0.0001 ($df = 3$) (pass)				0.0001 ($df = 3$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.0000139$				$p = 0.0.0069$	
Instruments (4)	Per capita values of durable goods (and squared term) and house (and squared term)							
Romania								
Estimated coefficient[a]			0.140	0.180			0.287	0.658
t-statistic			3.28	2.00			2.78	2.89
Relevance test			$F(10,3597) = 107.95$ ($p = 0$)				$F(10,1216) = 31.97$ ($p = 0$)	
Overidentification test[b]			13.77 ($df = 9$) (pass)				2.175 ($df = 9$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.279$				$p = 0.066$	
Instruments (10)	Log per capita value of consumer durables; log per capita value of domestic currency savings; wage earners as proportion of household size; log per capita own house value; log per capita private rent; log per capita public rent; dummy variables for private renting, for public renting, and for missing monetary information on housing							

South Africa								
Estimated coefficient[a]			0.2089	0.2790			0.1780	0.0807
t-statistic			5.39	1.48			3.45	0.28
F-test on significance of identifying instruments			*F*(5,4108) = 36.02 ($p = 0$) ($p = 0$)				*F*(5,3755) = 24.67 ($p = 0$) ($p = 0$)	
Overidentification test[b]			5.372 ($df = 4$) (pass)				0.0001 ($df = 4$) (pass)	
Hausman test, OLS vs. IV[b]			$p = 0.7048$				$p = 0.7327$	
Instruments (5)	Wage earners per household, per capita land owned (hectares), per capita value of vehicle, per capita value of other machinery (such as motorized pumps), per capita value of other immovable assets (such as land not in use)							
Vietnam								
Estimated coefficient[a]	0.265	0.437	0.293	0.471	0.098	0.261	0.105	0.275
t-statistic	6.73	7.02	7.37	7.52	1.76	2.55	1.87	2.67
Relevance test	*F*(4,2616) = 441.64 ($p = 0$)		*F*(4,2617) = 447.10 ($p = 0$)		*F*(4,2317) = 244.98 ($p = 0$)		*F*(4,2318) = 245.35 ($p = 0$)	
Overidentification test[b]	7.120 ($df = 4$) (pass)		7.120 ($df = 4$) (pass)		0.791 ($df = 4$) (pass)		0.791 ($df = 4$) (pass)	
Hausman test, OLS vs. IV[b]	$p = 0.000$		$p = 0.000$		$p = 0.057$		$p = 0.049$	
Instruments (4)	Log per capita value of durable goods, log per capita land in ha, log per capita value of livestock, 1—no land							

Note: The table shows results for the log of per capita expenditure (lnpcxp). The dependent variable is weight for age (*z*-score) of preschool children. Estimates are used in the projections in table 3. IV is instrumental variables.

[a] lnpcxp.

[b] Chi-squared.

Source: Authors' calculations.

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