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How important is improving food availability for reducing child malnutrition in developing countries?

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Abstract

Do increases in the food supply per person in a country, i.e., national food availability, contribute substantially to reductions in malnutrition among its children? This paper sets out to answer this controversial question using panel data from 63 developing countries over 1970–1996. This paper gives evidence in support of a statistically significant and strong positive impact of national food availability on child nutrition, finding that increased food supplies have resulted in significant reductions in malnutrition since the 1970s despite population increases over the period. However, per-capita food supplies have a declining marginal impact: their effect is quite strong for countries with very low food availability (e.g., most countries in sub-Saharan Africa and South Asia), but weak or non-existent for those with high levels (e.g., most countries in the Near East and North Africa). Further, non-food factors, such as women's education and status and the quality of health environments, are also important determinants of children's nutritional status. Depending on the state of food availability in any particular geographic area and relative costs, these factors may merit greater priority in policies to reduce malnutrition.

Keywords: National food availability; Child malnutrition; Nutrition policy

1. Introduction

To what extent do increases in the food available per person at a national-level contribute to reductions in child malnutrition? This question has generated a wide range of responses (Haddad et al., 1997). At one extreme are those who take it for granted that such increases will lead to higher food intakes for young children in households and, consequently, improved nutritional status. It is true that the developing countries with the highest per-capita dietary energy supplies (DES) — the standard measure of national food availability — tend to have the lowest child malnutrition rates (see Fig. 1). Further, looking historically, over 1970–1995 the developing country per-capita DES increased by 22% (from 2092 to 2559 kcal), while the percent of malnourished children declined considerably, from 46.5 to 31% (Smith and Haddad, 2000).

At the other extreme are those who have little faith in the ability of increases in aggregate food availability to improve child nutrition. These peoples' arguments are bolstered by the fact that over two-thirds of malnourished children live in countries with adequate food supplies to meet their populations' dietary energy requirements (Smith et al., 1999). They point to problems of poverty and food access and to non-food

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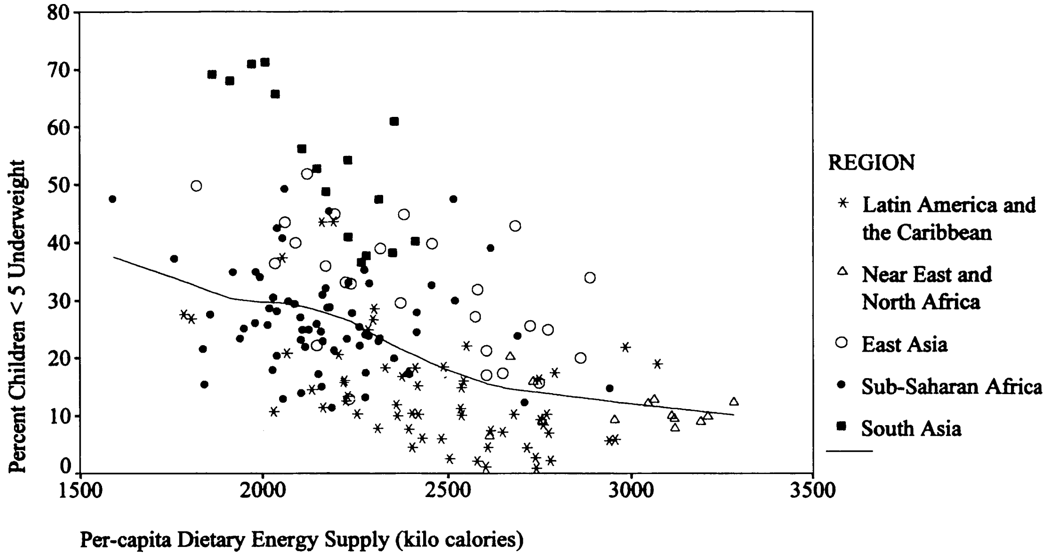

Fig. 1. Plot of underweight prevalence by per-capita DES.

factors, such as children's health and the quality of their care, as more crucial constraints to improved child nutrition. [1]

Micro-studies of the impact of new productivity-enhancing agricultural technologies — a primary means for increasing food availability — do not find negative impacts on child nutrition, but neither do they find large positive impacts (von Braun and Kennedy, 1994). In some cases increased incomes from raised productivity improve households' ability to purchase food, but either the requisite health and sanitation inputs are not purchased (Bouis and Haddad, 1990; von Braun et al., 1989) or women — generally the main caretakers of children — lose control of the newly commercialized crop (von Braun and Webb, 1989), thus reducing the impact of the income increase on child nutrition. The few cross-country regression studies relying on national-level data have yielded mixed conclusions (ACC/SCN, 1993; Gillespie et al., 1996; Frongillo et al., 1997), largely due to differences in specifications and estimation methods (Smith and Haddad, 2000).

Yet, for a number of reasons, estimates of the impact of national food availability on child malnutrition are critical for effective policy formulation and implementation with the goal of improving food security and nutritional status in developing countries. At the 1996 World Food Summit, 186 countries agreed to reduce the numbers of undernourished people in the developing countries by half by 2015, reflecting a larger goal of eventually eliminating food insecurity and malnutrition across the globe. One of the commitments made focuses on maintaining "adequate and reliable food supplies at the ... national, regional and global levels ... " (FAO, 1996, p. 3). Credible estimates will allow assessment of whether the efforts of governments to meet this commitment in the face of growing populations are likely to improve the nutritional health of the most vulnerable group, young children. They also allow us to determine the efficacy of investing in increasing food supplies compared to other means of improving child nutrition, for example, improving women's education or access to safe water.

[1] The challenge to the "food scarcity" view of global food and nutrition issues and push to focus on food access at the household and individual level was given prominence by Lappé et al. (1977) in their popular book *Food First* and academic credence by Sen (1981). The belief that food access is the root cause of food insecurity in developing countries is now widely accepted (El Obeid et al., 1999). See Gittinger et al. (1987) for an in-depth discussion of the issues. The awareness of non-food factors in the etiology of child nutrition among social scientists is more recent (Haddad et al., 1998).

Finally, they will aid in assessing the importance of the role of agriculture in strategies to reduce malnutrition in a global context. In most developing countries agricultural production is the main means through which food supplies are increased, whether through direct production of food for consumption in country or by providing the foreign exchange and effective demand for food imports. Sustainable increases in agricultural productivity is one of the goals of a number of international institutions such as the United Nations Food and Agriculture Organization, the International Fund for Agricultural Development, the 16 research institutes under the umbrella of the Consultative Group on International Agricultural Research, and the World Bank. It is also an integral part of the strategies of many bilateral development agencies and non-governmental organizations (FAO, 1995; IFAD, 1997; CGIAR, 1996; World Bank, 1998; USAID, 1999; CARE, 1999). Are these institutions' investments in agriculture likely to help reduce malnutrition as envisioned?

With these aims in mind, this paper investigates the relationship between countries' per-capita DES and child underweight prevalences using country fixed-effects regression and data from 1970 to 1996 for 63 developing countries. The next two sections lay out the data and empirical methods employed. After reporting the estimates, we measure the contribution of increases in per-capita DES over 1970–1995 to the reductions in child underweight prevalences over the period. We then identify the developing countries and regions where further increases should (and should not) be prioritized to reduce child malnutrition the most quickly over the next 20 years.

2. Variables, data and estimation procedure

A number of conceptual issues arise in the choice of empirical specification for analysis of child nutrition using national data. Of greatest importance among these is the choice of appropriate independent variables. In addition to food availability, child nutrition is determined by a complex web of factors ranging from a country's political and ethnic make-up to child feeding practices and exposure to pathogens. To avoid major endogeneity problems, it is necessary to identify factors influencing child nutrition at roughly the same level of causality as food availability. The UNICEF conceptual framework for child growth and malnutrition (UNICEF, 1998) helps to do so by separating causal factors into three levels: immediate determinants, underlying determinants, and basic determinants.

The most immediate determinants of a child's nutritional status are the child's dietary intake and health status. The role of the former is to provide the essential nutrients for child growth and development. The state of a child's health affects her or his appetite and the absorption of nutrients in food eaten, which strongly affect nutritional status. On the other hand, the most basic determinants, which lie at the deepest level of causality, are factors such as countries' natural resource bases, political systems, and national incomes. National food availability lies at an intermediate level of causality between these two, among child nutrition's "underlying determinants". It influences children's nutrient intakes through enhancing food security at the household level. It is a necessary condition for food security but of course not sufficient, because households must also have adequate resources to acquire the available food on a sustainable basis before achieving food security. Other underlying determinants are the quality of care for children and their mothers (e.g. feeding, immunizations, and prenatal and birthing care) and the quality of households' health environments. [2]

Based on these conceptual considerations and data availability, in addition to food availability we include as explanatory variables three additional variables. The first two, women's education and women's status relative to men, are believed to strongly influence both the quality of care for mothers and children and food security. The third, safe water access, is a proxy indicator of health environment quality. Ideally a measure of poverty would be included. However, at this time insufficient data exists to do so.

The dependent variable of the analysis (denoted CM) is the prevalence of children under five who are

[2] In the UNICEF conceptual framework the three underlying determinants of child nutritional status are considered to be food security, care for mothers and children, and health environment quality. Here, we classify national food availability as an underlying (rather than basic) determinant because of its close conceptual association with food security and the strong influence upon it of basic determinants such as income growth and agro-ecological conditions.

underweight for their age, i.e., whose weight falls more than two standard deviations below the median for their age using international reference standards. This measure represents a synthesis of stunting (long-term growth faltering) and wasting (acute growth disturbance). The large majority of the underweight data, 75%, are from the World Health Organization's *Global Database on Child Growth and Malnutrition* (WHO, 1997). These data have been subjected to strict quality control standards.[3] Other sources are ACC/SCN (1993, 1996) and World Bank (1997). All of the data were subjected to tests for potentially erroneous values and, subsequently, several observations were discarded from the latter source (see Smith and Haddad, 2000).

The measure employed for food availabilities, daily per-capita DES, is derived from food balance sheets compiled by FAO using country-level data on the production and trade of food commodities. Given information on seed rates, wastage, stock changes, and types of other utilization of food commodities (e.g. animal feed) a supply account is prepared for each commodity in terms of the weight available for human consumption each year. Total dietary energy available per-capita is then estimated by converting the weights of each commodity into energy values, aggregating across commodities, and dividing by population size. The data employed are obtained from the FAOSTAT database (FAO, 1998). While these data are subject to error (see Svedberg, 1999), they are a reasonably close representation of the variability across countries in DES.

The measure of women's education employed is female gross secondary school enrollment rates (denoted FEMSED) from UNESCO (1998). For women's relative status we employ a ratio of female life expectancy at birth to male life expectancy at birth (denoted LFEXPRAT) as a proxy. The life expectancy data are from World Bank (1997). For safe water access we use a measure of the percentage of countries' population with access to an adequate amount of uncontaminated water. The data are from UNICEF (various years) and (WHO, 1996).[4]

Data for the explanatory variables are matched for each country by the year in which underweight data are available, giving an unbalanced panel. The total number of country-year observations is 179. The countries covered, classified by region, are listed in Table 1. Overall, the sample covers 53% of the developing countries (88% of the 1995 population). The variables employed, their definitions, and sample summary statistics are given in Table 2.

Econometrically, we employ a country fixed-effects (FE) or one-way error components model (Baltaji, 1995) as follows:

$$M_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,it} + \mu_i + v_{it}, \quad v_{it} \sim N(0, \sigma^2),$$
$$i = 1, \ldots, 63, \; t = 1, \ldots, \tag{1}$$

where X_{it} are the explanatory variables, i denotes countries, t denotes time, α is a scalar and β is a $K \times 1$ vector of parameters. The μ_i are unobservable country-specific, time-invariant effects, and v_{it} is a stochastic error term. In addition to removing any bias in the parameter estimates introduced by unobserved, time-invariant factors that may be correlated with the included explanatory variables, the fixed-effects approach controls for measurement errors and non-comparabilities in the data due to definitional and measurement differences at the country level (Ravallion and Chen, 1997). The actual estimating equation is obtained by transforming the observations into deviations from the country-specific averages:

$$CM_{it} - \overline{CM}_i = \sum_{k=1}^{4} \beta_k (X_{k,it} - \bar{X}_{k,i}) + (\mu_i - \bar{\mu}_i) + (v_{it} - \bar{v}_i). \tag{2}$$

Since the μ_i terms are time-invariant, $(\mu_i - \bar{\mu}_i) = 0$, and they drop out of the model. Unbiased and consistent estimates of the β_k can be obtained using ordinary least-squares (OLS) estimation assuming the error term is not correlated with the explanatory variables. We undertake a number of specification

[3] The inclusion criteria are: (1) a clearly defined population-based sampling frame, permitting inferences to be drawn about an entire population; (2) a probabilistic sampling procedure involving at least 400 children; (3) use of appropriate equipment and standard measurement techniques; and (4) presentation of data in the form of z-scores in relation to the NCHS/WHO reference population (WHO, 1997).

[4] For the interested reader, further discussion of the merits and demerits of these measures can be found in Smith and Haddad (2000, pp. 19–25).

Table 1
Regional, country and population coverage

Region	Number of countries	Regional coverage (in terms of number of countries) (%)	Number of observations	Countries (with years in parentheses)
South Asia	5	71	16	Bangladesh (1982, 1985, 1989, 1996), India-rural (1977, 1991), Nepal-rural (1975, 1995), Pakistan (1977, 1985, 1990, 1995), Sri Lanka (1977, 1980, 1987, 1993)
SSA	26	58	65	Benin (1987, 1996), Burkina Faso (1987, 1992), Cameroon (1977, 1991), Comoros (1991, 1995), Congo, Rep. (1977, 1987), Congo, Dem. Rep. (1975, 1986, 1989, 1994), Côte d'Ivoire (1986, 1994), Ethiopia-rural (1983, 1992), Ghana (1987, 1993), Guinea (1980, 1995), Kenya-rural (1982, 1987), Lesotho (1976, 1981, 1994), Madagascar (1983, 1992, 1995), Malawi (1981, 1992, 1995), Mauritania (1981, 1987, 1990), Mauritius (1985, 1995), Niger (1985, 1992), Nigeria (1990, 1993), Rwanda (1976, 1992), Senegal (1986, 1992), Sierra Leone (1974, 1977, 1990), Tanzania (1987, 1991, 1996), Togo (1976, 1988), Uganda (1977, 1988, 1995), Zambia (1972, 1985, 1988, 1992, 1996), Zimbabwe (1984, 1988, 1994)
East Asia	8	57	26	China (1987, 1992, 1995), Indonesia (1978, 1987, 1995), Laos (1984, 1994), Malaysia (1983, 1986, 1990, 1995), Myanmar (1980, 1983, 1990, 1995), Philippines (1973, 1982, 1987, 1993), Thailand (1982, 1987, 1990), Vietnam (1980, 1987, 1994)
NENA	5	31	14	Algeria (1987, 1992, 1995), Egypt (1978, 1988, 1992, 1995), Jordan (1975, 1990), Morocco (1987, 1992), Tunisia (1974, 1988, 1994)
Latin America and the Caribbean (LAC)	19	68	58	Bolivia (1981, 1989, 1993), Brazil (1975, 1989, 1996), Chile (1978, 1982, 1986, 1995), Columbia (1977, 1986, 1989, 1995), Costa Rica (1978, 1982, 1989, 1994), Dominican Republic (1986, 1991), El Salvador (1988, 1993), Guatemala (1977, 1980, 1987, 1995), Guyana (1971, 1981, 1993), Haiti (1978, 1990, 1994), Honduras (1982, 1987, 1993), Jamaica (1978, 1985, 1989, 1993), Mexico-rural (1974, 1979, 1989), Nicaragua (1980, 1993), Panama (1980, 1992), Peru (1975, 1984, 1991, 1996), Trinidad and Tobago (1976, 1987), Uruguay (1987, 1992), Venezuela (1981, 1987, 1990, 1994)
Total	63	57 (88% of total developing world population)[a]	179	

[a] This percentage is calculated from countries' 1995 populations.

tests to gauge the accuracy of the estimates and their applicability across the developing-country regions.

3. Empirical results

The results are presented in Table 3. For reference, those obtained from a fully linear specification are given in column (1). All coefficients are negative and statistically significant. No significant interactions between the independent variables were found. However, the coefficient on a quadratic term for DES is significant and positive, indicating that while food availability works to reduce child malnutrition it has a declining marginal effect (column (2)). The turning point in the quadratic curve is at 2727 kcal, which

Table 2
Variable definitions and sample summary statistics

Variable	Definition	Mean	Standard deviation	Minimum	Maximum
Child malnutrition (CM)	Percent of children with weight-for-age less than 2 standard deviations from the mean according to NCHS/WHO standards	24.6	15	0.9 (Chile, 1995)	71.3 (India, 1977)
Per-capita DES	Daily per-capita DES (kcal)	2360	331	1592 (Ethiopia, 1992)	3284 (Egypt, 1995)
Access to safe water (SAFEW)	Percent of population with access to safe water	56.2	23.7	6 (Ethiopia, 1983)	100 (Mauritius, 1985)
Female secondary enrollments (FEMSED)	Gross female secondary school enrollment rate (%)	33.8	22.5	2.5 (Uganda, 1977)	88 (Uruguay, 1992)
Female to male life expectancy ratio (LFEXPRAT)	Ratio of female life expectancy at birth to male life expectancy at birth	1.062	0.03	0.97 (Nepal, 1975)	1.15 (El Salvador, 1988)

falls well within the developing-country range. The result suggests that after reaching about 2700 kcal, further increases in per-capita DES work to *worsen* child malnutrition, an intuitively implausible result.

To test whether the quadratic upturn is in fact implied by the data rather than "forced" on it by the functional form, we fitted the curve as a linear spline. An extensive grid search was undertaken to locate the knot combinations yielding the smallest sum of squared residuals. The best fitting function was a three-segment spline with optimal knots at 2300 and 3120 kcal. Next, with the lower knot anchored at 2300, a spline function with the second knot at 2727 kcal was estimated. The coefficient on the third segment of the spline was positive but insignificant ($t = 1.0$). We concluded that the upturn implied by the quadratic

Table 3
Country fixed-effects estimation results[a]

Explanatory variable	Specification		
	Linear (1)	Quadratic DES (2)	Linear spline DES (3)
Per-capita DES	−0.0081 (2.48)**	−0.067 (3.00)***	
DES-squared		1.24E−05 (2.66)***	
DES spline			
DES $\leq$ 2300 ($n = 93$)			−0.0170 (3.41)***
2300 < DES $\leq$ 3120 ($n = 83$)			−0.0024 (2.16)**
DES > 3120 ($n = 3$)[b]			0.0405 (1.35)
Access to safe water (SAFEW)	−0.085 (2.14)**	−0.072 (1.84)*	−0.076 (1.95)*
Female secondary enrollments (FEMSED)	−0.167 (2.64)***	−0.232 (3.51)***	−0.220 (3.41)***
Female-to-male life expectancy ratio (LFEXPRAT)	−93.45 (2.25)**	−74.89 (1.83)*	−71.8 (1.74)*
R^2	0.943	0.947	0.947

[a] The dependent variable is the prevalence of children underweight. Coefficients of the fixed-effects terms are not reported. An F-test of the joint significance of the fixed effects terms strongly rejects the null hypothesis that they have no impact on child underweight rates. Absolute values of t-statistics are in parentheses.

[b] The choice of spline segments is the result of a grid search with minimum sum of squared residuals as the criterion. The coefficient on the third segment remains positive and statistically insignificant even when the cut-off point is lowered considerably (making the number of data points sufficient for the estimation of a significant coefficient).

* Significant at 10% levels.

** Significant at 5% levels.

*** Significant at 1% levels.

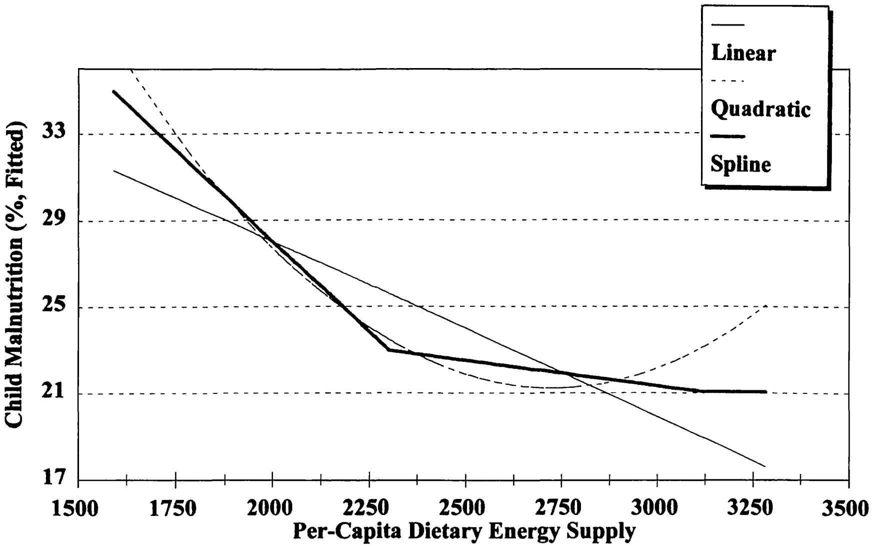

Fig. 2. Plot of child underweight prevalence with per-capita DES: linear, quadratic and spline curves.

function is not substantiated by the data and chose the spline-generated estimates as preferred. These are reported in Table 3, column (3). The first and second segments of the spline have negative and significant slopes, with the second having a much smaller slope than the first. The coefficient of the third segment is not statistically significant. The coefficients of the three non-food explanatory variables are statistically significant and negative. Note that the quadratic and spline specifications differ little in terms of overall fit and in the coefficients on the non-DES explanatory variables. However, their shape differs substantially at high levels of DES as illustrated in Fig. 2.

A number of specification tests were performed.[5] To test for endogeneity of DES,[6] we undertook a Hausman–Wu instrumental variables test (Davidson and Mackinnon, 1993) employing fertilizer use per hectare of arable land and irrigated land per-capita as the instrument set. This set passed both relevance (Bound et al., 1995) and over-identification (Davidson and Mackinnon, 1993) tests. The Hausman–Wu test results indicate that aggregate food availability per person is not endogenous to child underweight prevalences and that the coefficient estimates are not seriously biased by measurement error problems. We thus proceed under the assumption that we have identified a causal, rather than merely associative, relationship between child malnutrition and national food availability. The second test, a Ramsey RESET test (Kennedy, 1992), indicates that the estimates are not plagued by any serious omitted variable bias. Additionally, we undertook a Chow F-test for parameter stability across the developing-country regions. This test revealed no significant differences in the estimated coefficients among the regions.

The numbers in Table 4 help to evaluate how substantial, in a practical sense, the estimated effect of national food availability is and how it compares to the effects of the other determinants. Column (2) reports elasticities. The full sample elasticity for DES is estimated using a weighted average of regression coefficients for each segment with weights the proportion of the data points in each. It implies that a 1% increase in the developing-country DES would lead to a 0.95%

[5] The tests were performed using the quadratic specification because using the linear spline requires multiple time consuming re-estimations of the spline curve with little change in the test results given the similar coefficient estimates.

[6] DES may be correlated with the error term due to a number of potential sources of endogeneity including: (1) reverse causality (e.g., food supply-augmenting food aid may be purposefully allocated to countries with high prevalences of child malnutrition), (2) the simultaneous determination of child malnutrition and DES by some third unobserved variable, and (3) measurement error.

Table 4
The absolute and relative strength of impact of food availability on child underweight rates

	Sample (or segment) mean (1)	Elasticity[a] evaluated at sample mean (2)	Developing Country range[b] (3)	Increase in variable needed to reduce prevalence of child malnutrition by 1% point[c] (4)	Number in (4) as a percent of developing country range (5)
Per-capita DES, full sample	2360	−0.949	1522–3605	101	4.9
DES ≤ 2300	2106	−1.150		59	2.8
2300 < DES ≤ 3120	2613	−0.343		425	20.4
DES > 3120	3230	0		–	–
Population with access to safe water (SAFEW)	56.2	−0.174	1–100	13.1	13.2
Female secondary enrollments (FEMSED)	33.8	−0.302	0.5–100	4.6	4.6
Female-to-male life expectancy ratio (LFEXPRAT)	1.0624	−3.092	0.97–1.12	0.0139	9.3

[a] Estimated percent change in CM resulting from a 1% increase in the explanatory variable based on the estimates of Table 3, column (3). The segment elasticities for DES are evaluated at the DES and CM means of the sample data falling into the segments.

[b] The end-points of the ranges are for the following countries and years (minimum, maximum): SAFEW (Gabon, 1970 and Barbados, 1990s), FEMSED (Mauritania, 1970 and Bahrain, 1993); LFEXPRAT (Nepal, 1975, maximum: Brazil, 1996 and El Salvador, 1993). DES (Ethiopia, 1977 and Turkey, 1995).

[c] Calculated as 1 divided by the regression coefficients of Table 3, column (3).

reduction in the prevalence of CM, almost a unitary elasticity. The story for the different spline segments differs considerably. The elasticity for the lowest segment is greater than 1, that along the middle segment is substantially less than 1, and the last segment has zero elasticity.

Among the four underlying determinants, LFEXPRAT (the measure of women's status) has by far the largest elasticity, at 3.1, DES has the next highest elasticity, followed by FEMSED and access to safe water. However, since the variables are measured in units with different ranges, their elasticities are not fully comparable. Variable ranges, based on the minimum and maximum values observed among developing countries over 1970–1995, are in column (3). Column (4) gives the increase in each variable needed to reduce the prevalence of CM by 1 percentage point. Finally, the numbers in column (5), which give those in (4) as a percent of the range, allow a scale-neutral comparison of the relative strengths of impact of the determinants.

The required increase in DES needed to reduce the underweight rate by 1% point is 101 kcal. This is only 4.9% of its range, indicating that increased national food availability has a substantial impact on child nutrition from an absolute stand point. By contrast, the required increase in LFEXPRAT is 9.3% of its range. The only variable that surpasses DES in terms of strength of impact seen from this perspective is FEMSED, with a required increase that is 4.6% of its range. The variable with the weakest impact, relatively speaking, is access to safe water. Note that for countries falling into the low DES segment (≤2300) DES is ranked first among the determinants and FEMSED second. For those in the medium and high (>3120) segments, however, FEMSED is ranked first and DES last after all other determinants.

4. Implications for policy: past contributions, future priorities

In this section, we further draw out the implications of the empirical results by asking (1) how much of the total reduction in the developing country child underweight rate from 1970 to 1995 can be attributed to

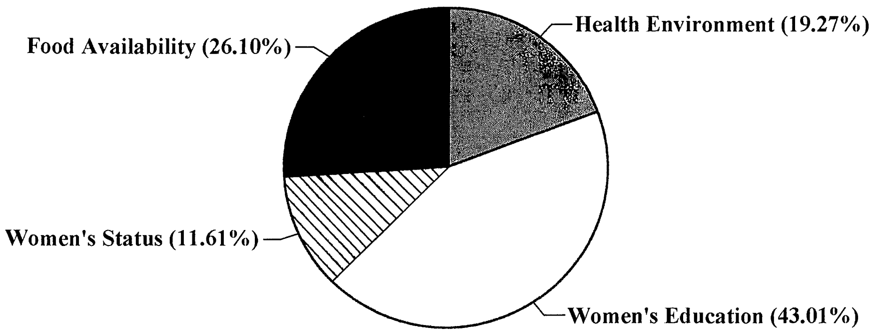

Fig. 3. Estimated contributions of food availability and other determinants to reductions in child malnutrition, 1970–1995.

increases in food availability; and (2) where increasing food availability should be prioritized to bring about the fastest future reduction in the rate.

To answer the first question, we start with the fixed-effects parameter estimates of Table 3, column (3) to formulate a predicting equation for the change in child underweight prevalence over 1970–1995. The underlying levels equation is

$$\begin{aligned}\widehat{CM}_t = {} & 140 - 0.076 \times \text{SAFEW}_t - 0.220 \times \text{FEMSED}_t \\ & -71.8 \times \text{LFEXPRAT}_t - 0.017 \times \text{DES1}_t \\ & -0.002 \times \text{DES2}_t + 0.0 \times \text{DES3}_t + \hat{\mu},\end{aligned}$$

where DES1, DES2, and DES3 are the spline segments, and $\hat{\mu}$ is the fixed-effect term. This latter term is wiped out using a first-difference transformation as follows:

$$\begin{aligned}\Delta\widehat{CM} &= \widehat{CM}_{1995} - \widehat{CM}_{1970} \\ &= -0.076 \times \Delta\text{SAFEW} - 0.220 \times \Delta\text{FEMSED} \\ &\quad -71.8 \times \Delta\text{LFEXPRAT} - 0.017 \times \Delta\text{DES1} \\ &\quad -0.002 \times \Delta\text{DES2} + 0.0 \times \Delta\text{DES3}.\end{aligned}$$

The estimated percent contribution of DES to the total change in the underweight rate ($\Delta\widehat{CM}$) is calculated as

$$\frac{-0.076 \times \Delta\text{DES1} - 0.002 \times \Delta\text{DES2}}{\Delta\widehat{CM}} \times 100$$

For information on how the four determinants have actually changed over the entire period and for 5-year intervals, the data set is expanded to include all available data for the years 1970, 1975, 1980, 1985, 1990 and 1995.

The total estimated reduction ($\Delta\widehat{CM}$) is 15.9 percentage points. Fig. 3 shows that increases in countries' per-capita DESs have made a substantial contribution to this reduction (4.14 percentage points), just over a quarter of the total.[7] This contribution is a combined result of both the strong effect of national food availability and fairly substantial increases in it over the period. The only other underlying determinant that surpasses DES in contribution is women's education, which contributed to 43% of the reduction.

For a historical perspective, Fig. 4 traces out the estimated contributions of the determinants for 5-year intervals. Corresponding to the world food crisis of the 1970s, per-capita food availability declined over 1970–1975, leading to a slight *increase* in child malnutrition. As the Green Revolution picked up in the late 1970s, the developing countries saw substantial increases in food availability. In the 1975–1980 and 1980–1985 periods food availability increases made by far the greatest contribution to reductions in malnutrition. Despite continued increases in per-capita DES in the late 1980s and early 1990s, the contribution — both absolute and relative to the other determinants — leveled off, partly due to a continual decline in strength of impact.

Looking to the future, in which countries and regions should increasing food availability be a priority

[7] This number is quite close to the actual reduction, which is approximately 15.5 percentage points (Smith and Haddad, 2000).

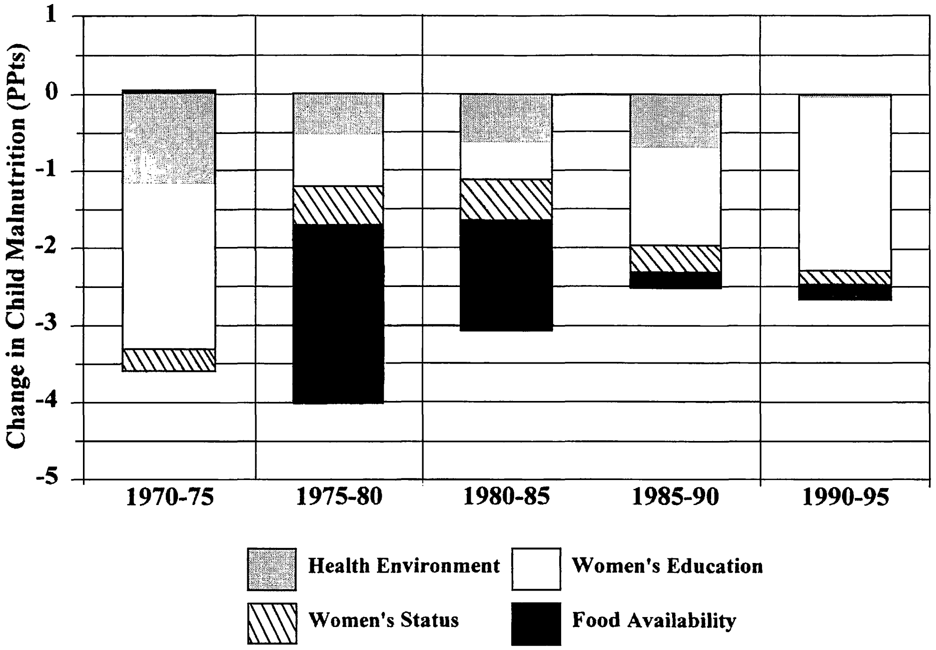

Fig. 4. Estimated contributions of food availability and other determinants to reductions in child malnutrition for 5 year periods, 1970–1995.

in the quest to reduce child malnutrition? Using our regression estimates, Table 5 classifies the developing countries into three groups based on the strength of impact of food availability on child malnutrition (in 1995): a "high impact" group (with DES below 2300 kcal), a "medium impact" group (between 2300 and 3120 kcal), and a "low impact" group (above 3120 kcal). Most of the countries in South Asia and sub-Saharan Africa (SSA) fall into the high impact group. Some, however, among which are countries with very high prevalences of child malnutrition (e.g., Pakistan, Mauritania) fall into the medium impact group. Most countries in the low impact group are from Near East and North Africa (NENA). In these countries, further increases in food availability are unlikely to lead to improvements in children's nutritional status.

The country classification of Table 5 helps to identify, first, the relative priorities for investing in increased food availability across the developing-country regions and, second, the emphasis that should be placed on it relative to the other determinants considered in this paper. Column (2) of Table 6 gives calculations of the absolute increase in each region's 1995 DES needed to bring about a reduction in the child malnutrition rate of 1 percentage point. The region in which the smallest increase would be required, only 75 kcal, is SSA. The same reduction in child malnutrition would require a slightly greater increase in South Asia, 94 kcal. A very large increase would be required in NENA, 333 kcal. Based on these numbers, the regions where investment in increasing food availability would have the greatest pay off in terms of reducing child malnutrition are SSA and South Asia. These are also the regions with the highest child malnutrition rates (column (1)).

In prioritizing food availability across all four of the underlying determinants, two criteria must be taken into account. The first is their relative strength of impact, gauged for DES by the figures reported in column (3) and for the other determinants by the figures in Table 4, column (5) (which do not differ by region). The second important criteria to take into account is how close each determinant is to its desired level, which limits its scope for reducing

Table 5
Classification of 109 developing countries by strength of impact of food availability on child malnutrition[a]

	High impact (DES[b] less than 2300)	Medium impact (DES between 2300 and 3120)	Low impact (DES greater than 3120)
South Asia	Afghanistan, Bangladesh, Nepal, Sri Lanka	Pakistan, India, Maldives	
SSA	Ethiopia, Somalia, Eritrea, Burundi, Mozambique, Comoros, Congo, Democratic Republic, Central African Republic, Chad, Djibouti, Angola, Zambia, Niger, Zimbabwe, Madagascar, Kenya, Tanzania, Sierra Leone, Rwanda, Malawi, Liberia, Lesotho, Togo, Namibia, Congo, Guinea, Sao-Tome and Principe, Mali, Cameroon, Burkina Faso, Botswana, Uganda, Gambia	Côte d'Ivoire, Sudan, Benin, Guinea-Bissau, Senegal, Swaziland, Gabon, Nigeria, Ghana, Mauritania, Mauritius	
East Asia	Cambodia, Mongolia, Laos	Thailand, Philippines, North Korea, Vietnam, Myanmar, China, Brunei, Malaysia, Macau, Indonesia	South Korea
Near East/North Africa	Yemen, Iraq	Saudi Arabia, Jordan, Iran, Kuwait, Algeria, Tunisia	Morocco, Libya, Egypt, Lebanon, Syria, United Arab Emirates, Cyprus, Turkey
Latin America/Caribbean	Haiti, Bolivia, Peru, Guatemala	Nicaragua, Dominican Republic, Honduras, Cuba, Venezuela, Ecuador, Guyana, Panama, Bahamas, Paraguay, El Salvador, Surname, Jamaica, Trinidad and Tobago, Chile, Colombia, Uruguay, Belize, Costa Rica, Brazil, Dominica, Argentina	Mexico, Barbados

[a] The country classifications are based on cut-offs determined by the two knots of a three-segment linear spline function for DES in a regression on underweight prevalence (see Table 3, column (3)). The DESs are for 1995. Data source: FAO (1998).
[b] Per-capita dietary energy supply measured in kilocalories.

child malnutrition in the medium-to-long term. The desired level of DES is 3100 kcal, and column (4) shows how far each region is from reaching it in percentage terms. Similar numbers for the other determinants are reported in Smith and Haddad (2000).[8]

Ranking the determinants on these criteria, the top policy priorities for future reductions in child malnutrition in each developing region are listed in column (5). In South Asia and SSA food availability increases compete with women's education for top priority. In East Asia, women's education is the top priority, with food availability second. In NENA and LAC, food availability is not a top priority at all. Note that the above prioritization is undertaken in the absence of crucial cost-side information. The costs of alternative investments are likely to differ substantially, and each may differ across regions. The identified priorities are offered as only part of the information base that can be used by a policy decision maker who should also rely on her or his understanding of relative costs.

[8] The desirable level of DES is assumed to be 3100 kcal. This is an intermediate level between 2770 (a level at which FAO claims 2.5% of a country's population would be undernourished) and 3360 (of Western Europe) that is close to 3120, the level past which we have estimated that further increases in DES have no impact on child nutrition. The desirable levels of the other variables are assumed to be: FEMSED, 100; SAFEW, 100; and LFEXPRAT, 1.1.

Table 6
Priority setting for the future: regional comparison of the strengths and potential impacts of food availability on child malnutrition (1995)[a]

Region	Underweight rate (1995) (1) (%)	Increase in DES needed to reduce prevalence of child malnutrition by 1% point (2) (kcal)	Number in (2) as a percent of developing-country range (3) (%)	Percent DES is below its desirable level (4) (%)	Priorities for future child malnutrition reductions (among underlying determinants) (5)
South Asia	49.3	94	4.5	−24.0	(1) Increase food availability; (1) increase women's education
SSA	31.1	75	3.6	−31.1	(1) Increase food availability; (1) increase women's education
East Asia	22.9	188	9.0	−12.3	(1) Increase women's education; (2) increase food availability; (2) improve women's relative status
Near East/North Africa	14.6	333	16.0	2.3	(1) Increase women's education; (2) improve women's relative status
Latin America/ Caribbean	9.5	234	11.2	−10.4	(1) Increase women's education; (2) improve women's relative status; (2) improve health environment

[a] See Table 4 for calculation methods. The rankings are based on two criteria: (1) most potent impact on malnutrition relative to its existing range (given for DES in column (2)); and (2) most potential for impact based on increases to desirable level (given for DES in column (4)). The top priorities are based on the first- and second-highest ranked determinants chosen under each criteria. The number in column (3) is calculated using the shortfall of all countries listed in Table 5.

5. Conclusion

Using a panel data set comprising 63 developing countries, this paper gives evidence in support of a statistically significant and strong positive impact of national per-capita food availability on child nutritional status. The results confirm that efforts to increase food supplies have resulted in substantial reductions in malnutrition among young children over the last three decades. They also affirm the important role of agriculture in strategies to reduce child malnutrition.

While substantiating a strong impact on child malnutrition for the developing countries as a whole, the paper finds the national food availability has a declining marginal effect. Thus, as per-capita food supplies are increased in any country, they become an increasingly blunt tool for reducing malnutrition. The effect is very strong for countries with per-capita DES below 2300 kcal. Between 2300 and 3120 kcal it is still significant, but not as strong. Above 3120 kcal, further increases in per-capita food availability are likely to have little impact. Furthermore, while food availability is indeed an important determinant of child nutritional status, non-food factors, such as women's education and status and health environment quality are also important due to their influence on children's dietary intakes and health status. In any particular country, these factors may take priority in strategies to reduce child malnutrition either because they have a stronger impact or they are far from desirable levels.

SSA and South Asia should be the focus of future efforts to increase national food availability. These are the regions with the highest child malnutrition rates. They are also the regions where improvements in food availability have had a strong impact in reducing child malnutrition. Moreover, food availability remains far from desirable levels. In East Asia, the NENA, and Latin America and the Caribbean, child malnutrition is likely to be reduced faster by investing in other underlying factors, such as improvements in education access and quality for girls.

Given land constraints, improvements in food availability must come from sustainable improvements in productivity. This will involve increased resource allocation to agricultural research and natural resource management. But this is not enough. To increase agriculture's contributions to reducing child malnutrition, it will be necessary to alter the way in which extra resources are allocated. In particular, there is a need to expand participatory approaches and to focus more on regions where the malnourished live. An increased focus on crop qualities such as micronutrient content (Bouis, 2000), and on cooking and storage qualities that improve nutrition impact will help too, as will a perspective on crops that enhance the livelihoods of the poorest families in rural areas, whether food or non-food crops (Haddad, 2000; Hazell and Haddad, 2000), and institutional arrangements that protect the ability of mothers to provide adequate care for their children (Paolisso et al., 2000).

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