Socioeconomic and Demographic Factors Are Associated with Worldwide Patterns of Stunting and Wasting of Children[1,2]

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ABSTRACT We estimated the variability among nations in the prevalence of stunting and wasting, evaluated which national factors are associated with stunting and wasting and examined the relationship of stunting with wasting. The World Health Organization Global Database on Child Growth, a comprehensive conceptual model and a database of national factors were used with variance components and regression analyses. There was substantial variability among nations and among provinces within nations. Most national variability for stunting (76%) and wasting (66%) was explained by national factors and geographic region. Higher energy availability, female literacy and gross product were the most important factors associated with lower prevalence of stunting. The association of health expenditures and stunting differed by region. Higher immunization rate and, for Asia only, energy availability were the most important factors associated with lower prevalence of wasting. Regional differences in the relationship between stunting and wasting were accounted for by national factors. Some factors associated with stunting and wasting differ at the national level. Child malnutrition within a household is greatly influenced by issues at national and provincial levels, and intervention should be considered at all three levels. J. Nutr. 127: 2302–2309, 1997

KEY WORDS: • *stunting* • *wasting* • *malnutrition* • *humans* • *children*

The variability in child growth across nations is due much more to social, demographic and economic factors than to genetics (Beaton et al. 1990, Frongillo and Hanson 1995, Osmani 1992). However, little more than this is understood.

Cross-national studies of developing nations have observed that the prevalence of stunting, wasting and underweight among preschool children differed in the various regions of the world, with the lowest prevalence in Latin America and the highest in Asia (de Onis et al. 1993, Victora 1992). Furthermore, the association between stunting (i.e., low height-for-age) and wasting (i.e., low weight-for-height) differed by geographic region. This implies that deficits in weight and height result, at least in part, from different causes. Unresolved issues included why different patterns of growth occur across nations and why the patterns differ for height and weight.

The purpose of this paper is to answer the following three questions: *1*) How variable is the prevalence of stunting and wasting among and within nations? *2*) Which factors explain differences in stunting and wasting among nations? *3*) What is the relationship between stunting and wasting, before andafter adjustment for national factors, and are there regional differences in this relationship?

MATERIALS AND METHODS

Conceptual model. The conceptual model (**Fig. 1**) used for this study is adapted from Jonsson (1995), UNICEF (1990) and also includes ideas from Caldwell (1993) and Young (1994). According to this model, three levels of factors affect child growth: immediate causes, underlying causes and basic causes. There are two immediate causes: adequate dietary intake and health; no data were available for these concepts for most nations and thus they were not included in this study. There are three underlying causes: food security, maternal and child care, and health services and environment. There are four basic causes: formal and nonformal institutions, political and ideological factors, economic structure and potential resources.

Data sources and variable definitions. Data on the prevalence of stunting and wasting were taken from the October 1993 version of the *WHO Global Database on Child Growth* (de Onis and Blössner 1996, de Onis et al. 1993). This database covers 90% of the total population of children < 5 y old in developing nations and is based upon nationally representative cross-sectional data. Prevalence of stunting and wasting was defined as the percentage of children > 2 SD below the median value of the WHO/NCHS international reference. There is a shift in whole Z-score distributions for height and weight in poor environmental conditions, whereas standard deviations across populations are usually constant within 0.2 SD units from the expected value of 1.0 (WHO 1995). Therefore, the results reported in this paper for prevalence also reflect what would have resulted if population means had been analyzed.

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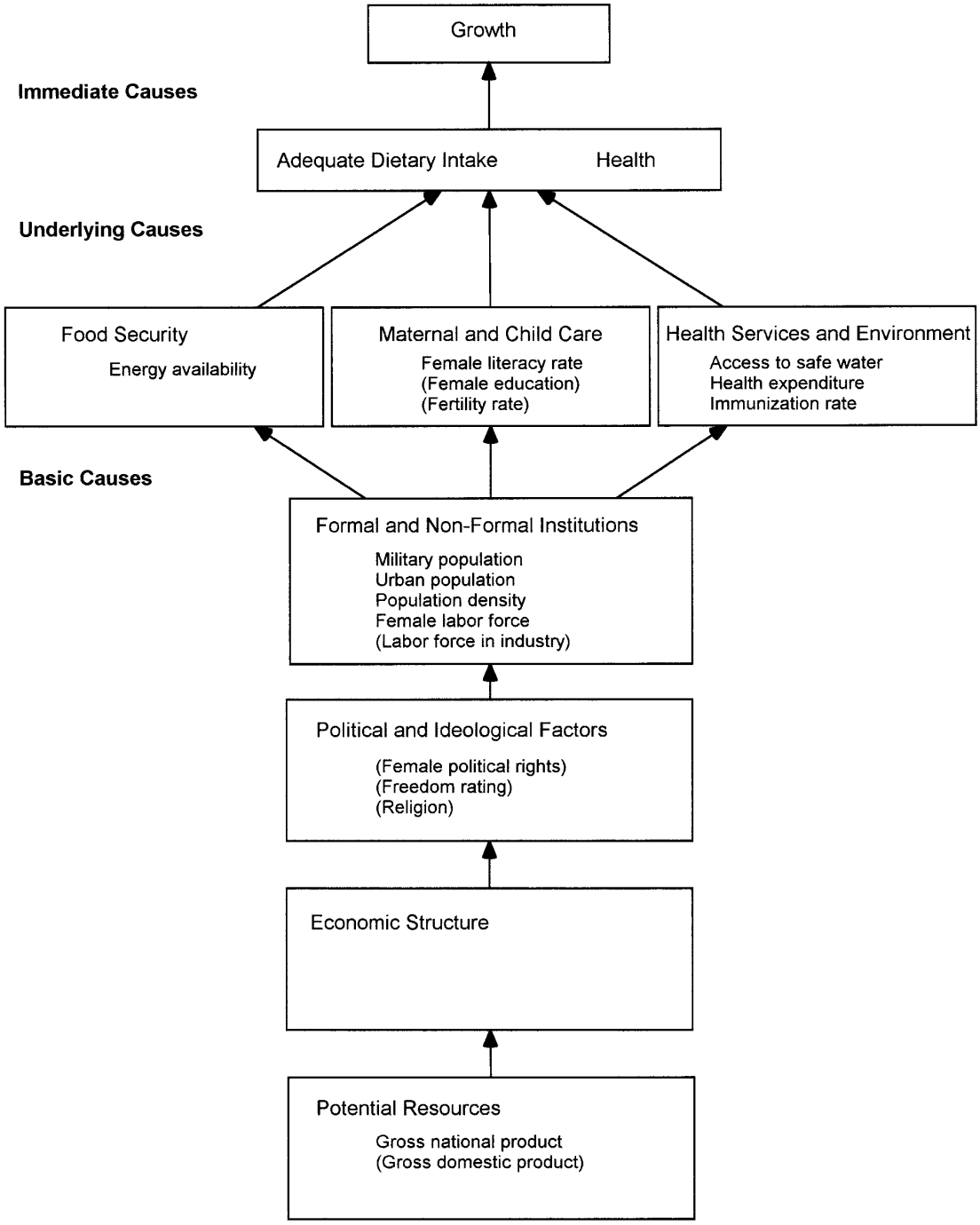

FIGURE 1 Conceptual model for relationships of national factors to child growth. Variables in parentheses were not included in regression analyses.

Nations included in the analysis were restricted to those with nationally representative studies of children (both sexes) < 5 y of age, done after 1980. Nations were grouped according to the United Nations (UN) regional classification (United Nations 1993). Due to scarcity of data, Oceania was not included in the analyses. In all, 70 nations were included in the main analyses from three regions:

1. Africa: Algeria, Burundi, Cameroon, Cape Verde, Congo, Côte d'Ivoire, Djibouti, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe
2. Asia: Bangladesh, Bhutan, China, India, Iraq, Jordan, Kuwait, Laos, Mongolia, Myanmar, Oman, Pakistan, Philippines, Sri Lanka, Thailand, Viet Nam, Yemen
3. Latin America: Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Venezuela

For the analyses comparing variability within nations to that among nations, those nations with provinces or districts (hereafter referred to as provinces) comprising the national data were used, resulting in 237 provinces from 45 nations.

National factors were taken from two secondary sources, the Human Development Report (United Nations Development Programme

TABLE 1

Descriptive statistics for national factors and prevalences of stunting and wasting used in analyses of worldwide patterns of child growth[1]

Variable	Q1[2]	Mean	Q3	SD
Food security				
Energy availability (% need)[a]	94.0	104.1	114.0	13.9
Maternal and child care				
Female literacy rate (% males)[a]	34.0	58.4	83.0	26.7
Health services and environment				
Access to safe water (% pop)[a]	44.8	59.8	77.0	23.6
Health expenditure (log % GNP)[a]	0.3	0.7	1.2	0.7
Immunization rate (% pop)[a]	62.0	72.5	86.0	18.1
Formal and nonformal institutions				
Military population (% working age)[b]	3.1	8.8	10.4	9.6
Urban population (% pop)[b]	24.0	40.3	52.0	21.1
Population density (pop/hectare)[a]	0.2	1.0	1.2	1.5
Female labor force (% males)[a]	21.7	30.1	40.0	11.7
Potential resources				
Gross national product (log)[a]	5.7	6.5	7.1	1.0
Prevalences				
Stunting (% of pop)[c]	20.7	30.3	39.6	14.9
Wasting (% of pop)[c]	2.3	5.9	8.5	4.4

[1] Sources for variables used in analyses: [a] United Nations Development Programme 1990 and 1993. [b] Hoover Institute 1989. [c] World Health Organization 1993.

[2] Q1 refers to first quartile and Q3 to third quartile; pop, population; GNP, gross national product.

1990 and 1993) and a computerized database entitled Nation3 (Hoover Institute on War, Revolution and Peace 1989). The primary sources for both were official, nationally representative data. Data were matched by year to the extent possible.

Following are definitions of the concepts included in the conceptual model (Fig. 1), and descriptions of the variables used to measure each concept. Frongillo and Hanson (1995) provide a more complete discussion of these. Sources for the variables used in analyses are given in **Table 1**.

Food security at the national level is the energy available from food; it was estimated as the daily caloric supply as a percentage of requirements (i.e., caloric equivalent of net food supplies per capita divided by average number of calories required to sustain a person per capita times 100). Maternal and child care refers to the services and activities to provide adequate nutrition and proper health care to women and children. The factors used to measure this concept were females in primary school as percentage of enrolled males, female literacy rate and fertility rate. For health services and environment, the factors were as follows: the percentage of the population with access to safe water, the natural logarithm of government health expenditure as percentage of gross national product and the average percentage of 1-y-old children immunized against four antigens.

We defined formal and nonformal institutions as the socioeconomic and demographic structure of society. This concept was measured by the following five factors: military population as percentage of working age population, urban population as percentage of total population, population density (people per hectare), females in the labor force as percentage of males in the labor force and the percentage of the labor force working in industry.

Political factors reflect structure at the national level, whereas ideological factors are wider and relate to the beliefs of a society. These were measured using a female political rights rating, a summary freedom rating and the percentage of the population belonging to primary and secondary religions. The two religion variables were combined into one summed measure.

Economic structure is the distribution of productive assets, combined with external economic dependency. We attempted to measure this concept by the percentage of income distributed to the top 20% of the population, but this variable was available for only two thirds of the nations and was therefore not included. Potential resources are the total wealth or production and resources of the nation. This concept was measured using the natural logarithm of gross national product per capita.

A total of 3.2% of the values of the national factors were missing and had to be imputed using multiple regression. A shrinkage estimator was used to ensure that the imputed values would not be extreme and potentially influential in subsequent regressions (Lehmann 1982).

Statistical analyses. Although the prevalence of stunting and wasting was somewhat positively skewed, we report analyses on the prevalences rather than on their transformations. Prevalence is epidemiologically more relevant, because differences in prevalence that are attributable to differences in national factors can be readily seen. Analyses without and with logarithmic transformations of the prevalence yielded similar results.

Through ANOVA components, we estimated variability among nations and among provinces within nations using restricted maximum likelihood (SAS/STAT Version 6.09, SAS Institute, Cary, NC). The variance among individuals within provinces was estimated assuming that a hypothetical sample of 100 individuals was sampled from a given province and nation with average prevalence, the variance expected from the binomial distribution. The hypothetical sample size of 100 was chosen because it is a typical sample size for a small survey and because the mean of a sample of 100 approximately follows the normal distribution. All other analyses used nation as the unit of analysis.

The three factors used to measure maternal and child care were found to be highly related, on the basis of correlation and factor analyses. Consequently, only female literacy rate was used to represent this concept. Preliminary analyses found that percentage of the labor force in industry, as well as the political and ideological factors, were never significant in the models, and they were therefore excluded. Minimal decreases in explained variance were noted with these deletions. All of the continuous variables used in the analysis were centered at their mean to obtain meaningful parameters in the presence of polynomial and interaction terms, and to reduce the likelihood of multicollinearity.

Two multiple linear regression models were run to determine how well region and national factors explained prevalence of stunting and wasting. The first model included only region. The second model included region and the underlying and basic causes. Polynomial terms for the food, care and health factors were used up to a cubic term to allow for curvature in the relationships; none of the cubic terms were significant, however; therefore, only linear and quadratic terms were used in the model. Two-way interactions of the food, care and health factors with gross national product and region were examined using forward stepwise regression (SYSTAT version 5.03, SYSTAT, Evanston, IL). The noninteractive terms were all forced into the models, so that only interactive terms could be deleted if not important. The final model included only the interactions found to be important. To diagnose potential regression problems (i.e., the estimation of too many parameters or the presence of values excessively influential in determining the effects), collinearity, residuals and leverage statistics were examined. We found no evidence of these potential regression problems.

Because the presence of polynomials and interactions makes interpretation of the second model somewhat complex, we calculated interquartile effects, i.e., the effects on prevalence of differences from the first quartile to the third quartile for each factor, with other factors held at their means. Thus, these interquartile effects correspond to differences in prevalence across the middle one half of a factor's distribution.

To examine the relationship between wasting and stunting, and to evaluate whether region made a difference in this relationship,

TABLE 2

Estimates of components of variances for the prevalences of stunting and wasting for 237 provinces from 45 nations

	Stunting	Wasting
Variances (square of prevalence as percentage)		
Among nations	141.0	18.0
Among provinces within nations	102.6	7.3
Among individuals within provinces[1]	21.0	5.6
Ratios		
Among nations/Among individuals	6.7	3.2
Among provinces/Among individuals	4.9	1.3
Among nations/Among provinces	1.4	2.5

[1] The variances shown for among individuals within provinces refer to the sampling variability expected for a hypothetical sample of 100 individuals.

stunting and its interaction with region were added to the two models described above for wasting.

RESULTS

Descriptive statistics and sources for the factors used in the analyses are given in Table 1. There were 70 nations available for analyses of stunting and wasting, with 33, 17 and 20 from Africa, Asia and Latin America, respectively.

The variances among nations for stunting and wasting were 1.4 and 2.5 times those found among provinces within nations, respectively (**Table 2**). The variances among nations for stunting and wasting were 6.7 and 3.2 times the variances among individuals within provinces for a hypothetical sample of 100 individuals, respectively.

UN region alone explained 15 and 22% of the variability among nations for stunting and wasting, respectively. For this model, the prevalence of stunting in Asia was 5.5 percentage units higher, and in Latin America was 9.8 units lower, than in Africa; the prevalence of wasting in Asia was 1.5 percentage units higher, and in Latin America was 3.8 lower, than in Africa.

Factors measuring region, food security, maternal and child care, health services and environment, institutions, potential resources and interactions explained 78 and 66% of the variability for stunting and wasting, respectively. The regression coefficients for this model are presented in **Table 3**. After adjustment for national factors, the prevalence of stunting was highest in Asia and lowest in Africa, whereas the prevalence of wasting was highest in Asia and lowest in Latin America. This ordering of UN regions for stunting was different than that seen in the model with region only, whereas the ordering for wasting was not different.

For stunting, the effects of energy availability (**Fig. 2**) and female literacy (**Fig. 3**) were curvilinear; these curvilinear effects were approximated by polynomials. Energy availability had a large negative effect on prevalence when there was little energy available but no effect when energy was abundant. For example, a difference in prevalence of 6 percentage units is associated with a change in energy availability from 85 to 95. In contrast, the negative effect of female literacy rate on prevalence was large only at higher values of literacy. Health expenditures had a curvilinear relationship; for Latin America, health expenditures had a large negative effect on prevalence at low health expenditures but no effect at high expenditures, whereas for Africa and Asia, health expenditures had a positive effect over its range. Gross national product was also a significant covariate.

For wasting, the effect of energy was significant only for Asia. Female literacy had a curvilinear relationship, such that there was a large effect at low literacy values and no effect at high literacy rates. Immunization and military population were also significant factors.

As measured by the interquartile effects (**Table 4**), higher energy availability, higher female literacy, higher health expenditures for Latin America, lower health expenditures for Africa and Asia and higher gross product were related to lower prevalence of stunting, with effects ranging from 2 to 11 percentage units. For wasting, higher energy availability for Asia and higher immunization rate were related to lower prevalence, with effects of about 3.

The relationship between wasting and stunting is shown in **Figure 4,** with regions identified by symbols. The prevalences of stunting and wasting are linearly related; the corresponding correlation coefficient was 0.4, indicating considerable spread around the line. The regression of wasting on region, stunting and their interaction explained 37% of the variability in wasting. In this model, Africa and Latin America had slopes close to zero, whereas Asia had a much larger, significant slope of 0.21. At the mean stunting prevalence (30.3%), the prevalence of wasting was 0.17 percentage units higher in Asia than in Africa and 3.72 percentage units lower in Latin America than in Africa. When national factors were added to the model, 67% of the variability in wasting was explained; the slopes between wasting and stunting were near zero for each region and were no longer significantly different among the three regions. At the mean stunting prevalence, the prevalence of wasting was 3.03 percentage units higher in Asia than in Africa and 4.61 percentage units lower in Latin America than in Africa. Thus, national factors explained almost all of the differences in slopes across regions. Also, the prevalence of wasting relative to that of stunting was higher in Asia than in Africa when adjusting for national factors, but was about equal for these two regions when not adjusting for those factors.

DISCUSSION

This study systematically addressed the factors associated with differential patterns of growth at the national level. Previous studies have demonstrated relationships between the prevalence of underweight and several national factors such as gross national product, infant mortality rate, energy intake per capita, female education, governmental social support, child population, food sources of energy, distribution of income, access to safe water, female literacy rate and region (ACC/SCN 1992 and 1993, Haaga et al. 1985). Other studies have shown relationships between height and national economic measures, including income distribution (Clarke 1992, Steckel 1983). A recent cross-national study analyzed variability in patterns of growth in height and weight among nations and factors associated with it (Frongillo and Hanson 1995). In that study, national data on the height and weight of children, sex, eth-

TABLE 3

Regression coefficients, standard errors and P-values from the multiple linear regression models for the prevalences of stunting and wasting in 70 nations[1]

	Stunting			Wasting		
	Coefficient	SEM	*P*-value	Coefficient	SEM	*P*-value
Constant	23.388	2.523	0.000	5.084	0.664	0.000
Energy availability	−0.290	0.089	0.002	0.042	0.034	0.223
Energy availability^2	0.011	0.005	0.022	—	—	—
Female literacy rate	−0.180	0.065	0.007	−0.008	0.023	0.715
Female literacy rate^2	−0.003	0.002	0.087	0.002	0.001	0.008
Safe water	−0.040	0.063	0.530	0.033	0.024	0.172
Health expenditure	5.078	1.872	0.009	0.031	0.597	0.958
Health expenditure^2	2.840	1.473	0.059	—	—	—
Immunization rate	−0.022	0.064	0.734	−0.103	0.023	0.000
Military population	−0.124	0.175	0.482	−0.135	0.062	0.033
Urban population	0.050	0.086	0.560	0.015	0.031	0.625
Population density	1.294	0.803	0.113	0.392	0.314	0.217
Female labor force	0.060	0.119	0.613	−0.044	0.043	0.311
Gross national product	−7.855	1.652	0.000	−0.865	0.597	0.153
Asia	14.732	3.583	0.000	3.623	1.288	0.007
Latin America	8.348	3.600	0.024	−3.951	1.296	0.004
Health expenditure* Latin America	−8.552	3.935	0.034	—	—	—
Energy availability* Asia	—	—	—	−0.209	0.083	0.015

[1] Regression coefficients for Asia and Latin America are relative to Africa. Units for variables are as given in Table 1. * Variables except Asia and Latin America have been centered at the mean given in Table 1.

nicity, and 14 social, economic, health, education and political factors were combined from three secondary sources. Substantial variability in growth patterns among nations was seen in comparison with the variability within nations. Regression models with national factors explained a large percentage of this variability. The factors associated with height, weight, and weight adjusted for height were somewhat different. The growth data used were limited in their lack of national representation and in the existence of 123 studies from only 44 nations, including developed nations.

In this study of 70 developing nations using nationally representative data, the variability among nations in the prevalence of stunting and wasting was substantial in comparison with the variability among provinces within nations and in comparison with the variability among individuals within provinces for a hypothetical sample of 100 individuals. These results are similar to those reported by Frongillo and Hanson (1995) for height and weight data, although the ratios of national- to individual-level variances were much larger in that study (73 to 197 for samples of 100 individuals) than those found in this study.

National factors explained the majority of the variability among nations, reducing the standard deviation for stunting in the regression analyses from 15 to 8 percentage

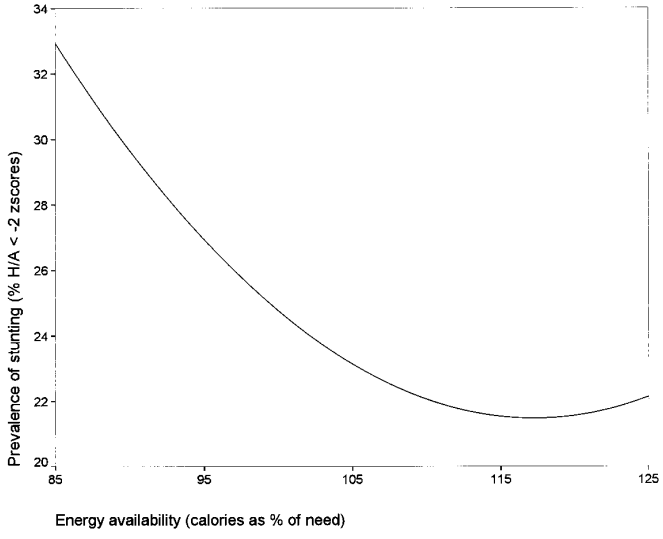

FIGURE 2 Relationship of energy availability to stunting, with other national factors constant at their mean. H/A, height for age.

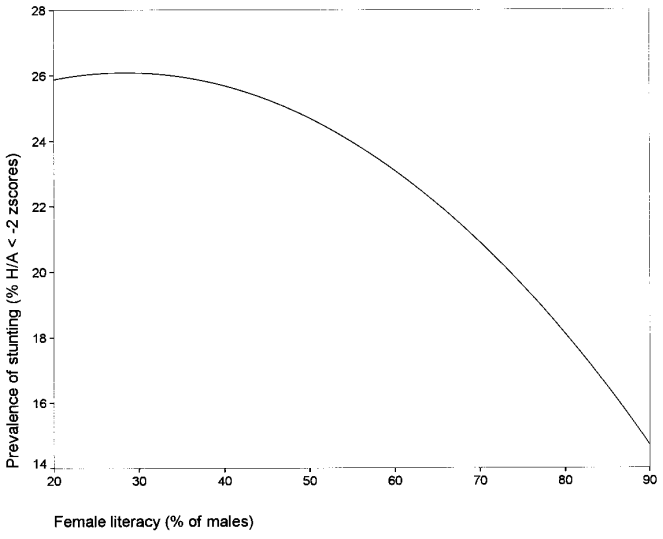

FIGURE 3 Relationship of female literacy to stunting, with other national factors constant at their mean. H/A, height for age.

TABLE 4

Interquartile effects for the relationships between national factors and stunting and wasting, derived from the coefficients estimated in multiple linear regressions[1]

Variable	Stunting	Wasting
Energy availability	−5.84	—
Africa and Latin America	—	0.84
Asia	—	−3.34
Female literacy rate	−8.88	−0.39
Safe water	−1.29	1.05
Health expenditure	—	0.03
Africa and Asia	4.68	—
Latin America	−1.97	—
Immunization rate	−0.53	−2.48
Military population	−0.91	−1.00
Urban population	1.41	0.43
Population density	1.30	0.40
Female labor force	1.04	−0.76
Gross national product	−11.02	−1.21

[1] Interquartile effects are the effects on prevalence of differences from the first quartile to the third quartile for each factor, with other factors held at their means. Regionally specific interquartile effects are shown for variables that had significant interactions with region, i.e., health expenditure for stunting and energy availability for wasting. Otherwise, the reported interquartile effects are applicable to all three regions.

units and for wasting from 4.4 to 2.8. That some variability was left unexplained is probably due to inadequacies in the measures of national factors available and used. Inadequacy of measurement is a likely explanation for the fact that political and ideological factors were never significant in the models. Regional differences in prevalence of stunting and wasting were very similar to those reported by Victora (1992). Even after accounting for national factors, regional differences in prevalence persisted, although the ordering of regions changed for stunting. The differences in prevalence of stunting between Asia and Africa and between Latin America and Africa were 14.7 and 8.3, respectively (Table 3). The corresponding differences in prevalence of wasting were 3.6 and −4.0, respectively (Table 3). These regional differences likely result from a combination of environmental factors not accounted for by our models (e.g., diet quality) and perhaps to a small degree from ethnic differences. The extent to which ethnic differences are an important component of these regional differences cannot be determined with available data (Frongillo and Hanson 1995). Ramalingaswami et al. (1996) have suggested three possible reasons why Asia has higher rates of malnutrition than does Africa or Latin American: poor care afforded to girls and women by husbands and elders, all-round poor hygiene, and practices related to breast feeding and the timing of introduction of complementary foods. The national factors that we used may have only partially accounted for the first two of these reasons and did not account for the third reason at all.

The regression models evaluated the effects of factors while adjusting for other factors. Thus, given the hierarchical order of determination implied by the conceptual framework, the models did not evaluate total effects of factors. The relationships of energy availability, female literacy and gross national product with stunting were in the expected direction. The direction and magnitude of the relationship with health expenditures differed by region. In Africa and Asia, health expenditures were related up to a point to a lower prevalence of stunting, after which larger health expenditures were related to higher prevalence. One possible explanation for this is that excessive allocation of resources to health services, perhaps due to misallocation to services that are not cost-effective, is detrimental (World Bank 1993). A second possible explanation is that funds for health care are allocated most where people are doing the worst, a form of reverse causality (Shen 1994). The plausibility of this explanation is uncertain in light of the literature on "the inverse care law," which suggests that the availability of good health care tends to vary inversely with the need of the population served (Hart 1971). A third possible explanation is that funds for health care are only one component of a health system that affects delivery of services to the population and health outcomes; the other components are resources, organization and management (Roemer 1991). The direction of the relationships of energy availability, female literacy and immunization rate with wasting were also in the expected direction, although for energy availability only in Asia. This larger effect of energy availability in Asia than in the other two regions was previously found by Haaga et al. (1985). The effect of military population was small and negative, meaning that greater military population was associated with lower stunting and wasting. The explanation for this direction is not apparent.

Although the prevalence of stunting and wasting were somewhat related, these two anthropometric measures contribute different information about nations. Victora (1992) found that the relationship of wasting to stunting differed across broad geographic regions of the world and stated that the reasons for these differences were little understood. We found similar results in this study for the relationship of wasting to stunting, but then further found that these differences were eliminated when the social, demographic and economic factors of nations were taken into account.

The unit of analysis in this study for the regression analyses was the nation. The strong relationships between prevalence and national factors reflect how nations differ and

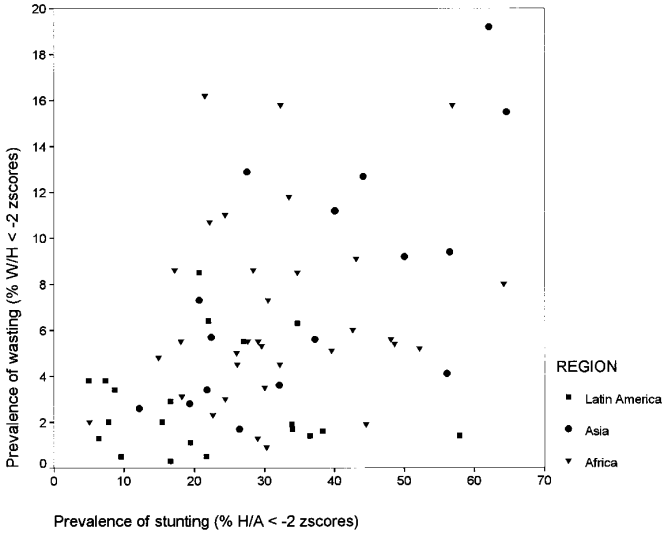

FIGURE 4 Relationship between stunting and wasting for 70 nations, not accounting for national factors. H/A, height for age; W/H, weight for height.

have implications for policies and programs at the national level. These relationships observed at the national level, however, may not hold at the provincial level and should not be taken to imply that processes within nations are necessarily similar. For example, food security at the national level, as measured by the supply of food energy, has a strong link to both stunting and wasting. Food security at the household level, composed of the four components of quantity, quality, certainty and acceptability (Radimer et al. 1992), may be related to stunting and wasting in different ways. Similarly, the relationships observed at the national level may not hold at the individual level.

Implications. Victora (1992) concluded that stunting and wasting must have at least some different causes. Our results support this conclusion. We found that energy availability was associated with both stunting and wasting, although for wasting it was so only for Asia. Female literacy, health expenditures and gross national product were associated with stunting, whereas immunization was associated with wasting. Overall, more of the variability of stunting could be explained than that of wasting. At the individual level, it has also been thought that stunting and wasting have different causes. Some possible causes of stunting at the individual level are micronutrient deficiencies, inadequate protein intake, prenatal nutrition, maternal size and parasitic infection, whereas wasting may be due primarily to insufficient energy intake and repeated infections (Gorstein et al. 1994). Understanding these causes at the individual level should be an objective of further research on the biological and social processes that affect development. Studies should use longitudinal designs with measurements close in time and monitor height, weight, diet, illness, care and other variables.

It is valuable to examine the prevalence of stunting and wasting for specific nations, before and after adjustment for a comprehensive set of national factors. This has been done previously to determine whether nations were doing better or worse than expected on the basis of single factors, particularly gross product (UNICEF 1994). For example, India (top right point in Fig. 4) had a higher prevalence of wasting than Bangladesh (point just below and to the right of India in Fig. 4). After accounting for national factors, region and stunting, the predicted prevalence of wasting for Bangladesh was 20 and for India was 11. Thus, the prevalence of wasting observed for Bangladesh was actually lower than expected based on national factors, region and stunting, whereas the reverse was true for India. The explanation for why certain nations have higher or lower prevalence than expected on the basis of the models may be due in part to factors specific to each nation, and perhaps factors that are not easily quantified. It would be valuable for researchers with in-depth knowledge of specific nations to help determine these possible factors. Strategies for improvement of child well-being may differ depending upon the factors operating in a specific nation.

The large variability among nations, and among provinces, in the prevalence of stunting and wasting means that whether or not children are malnourished is as much or more a consequence of factors at the national and provincial levels as it is a consequence of individual household circumstances. The implication of this result is that, although interventions at the household level are clearly important, interventions at the national and subnational level are also important because of determining effects on the conditions faced by households (World Bank 1993).

To help determine policy directions for nations that aim to reduce stunting and wasting, three tasks should be undertaken: *1*) identify which national factors are related to stunting and wasting, *2*) consider whether these factors are amenable to change and *3*) determine whether changing these factors will actually result in reductions in stunting and wasting. This paper has provided information about the first task. Higher energy availability, higher female literacy, higher immunization rates and higher gross product were the most important factors associated with lower prevalence of stunting and wasting. Because of the strong associations of female literacy with female education, higher female education would also be expected to be associated with lower prevalence.

Each of these factors is amenable to change, and there is considerable evidence in broad terms that changes in national factors result in improvements in child well-being (World Bank 1993). However, from one nation to another, changes in different factors will produce the most improvement, depending on the current status of those various factors (World Bank 1993). Improvement in any of the factors identified by this study requires quite different governmental actions. Specific research is required that assists governments in making cost-effective choices as to which factors to change.

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