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Characteristics and Determinants of Child Nutritional Status in Nepal

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Characteristics and determinants of child nutritional status in Nepal[1,2]

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ABSTRACT Herein, we examine characteristics and determinants of child malnutrition in the districts of Bara and Rautahat of the Terai region of Nepal. The sample studied consists of 510 rural children ranging in age from 3 to 10 yr. The Nepali children were found to have one of the highest reported prevalences of stunting (65% were <90% National study for Health Statistics median height for age). The study children were also 1 to 1.5 kg lighter when compared to US children of the same height. Fat deposits, as measured by anthropometric variables and Hb levels were also very low. Multiple regression analysis showed that age, district of residence, household income, breast-feeding, and several specific food items were significant predictors of nutritional status. Association with other factors such as caste and parental schooling, were not evident in multiple regressions. Boys were as likely to be malnourished as girls. Prolonged breast-feeding was associated with greater fat stores, but with reduced stature and low Hb values. Both landholdings and household income were found to be positively and significantly associated with almost all measures of nutritional status. *Am J Clin Nutr* 1983;39:74–86.

KEY WORDS Nutritional status, anthropometry, growth, socioeconomic status

Introduction

Nepal is one of the poorest nations of the world. For example, the reported average per capita income was only $140/yr as of 1980 (1). Infant mortality has been estimated to be about 165 per thousand for the Terai region of Nepal using 1974 child survivorship data (2). Other development indicators are as follows: adult literacy is 19% (1977 estimate), life expectancy at birth is 44 yr (1980 estimate), 9% of the population has access to safe water (1975 estimate), and the average per capita daily supply of food energy is 2002 cal or 89% of the requirement (1977 estimate) (1).

Data on health and nutrition in Nepal are limited. The first comprehensive health survey was carried out in 1965 by the University of Hawaii (3). Dietary but no anthropometric data were collected in this clinically oriented study. Recently, the Centers for Disease Control (CDC) and the United States Agency for International Development assisted the government of Nepal in carrying out a national nutrition survey on children that included anthropometry and Hb determinations (4).

The objective herein to report on the analysis of health and nutrition data obtained as part of a World Bank research project undertaken in the Terai region of Nepal. The data are regional in scope but their richness allows for an in-depth characterization of the growth pattern of Nepalese children and for the identification of some of the key determinants of nutritional status in this population.

Methods

This research was approved by the Bureau of Planning Commission of His Majesty's Government of Ne-

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pal. The data reported herein were obtained from a survey of rural households in two of Nepal's 75 administrative districts. The districts, Bara and Rautahat, are located in the Nepal Terai, a flat, fertile area straddling the border between Nepal and the Indian states of Bihar and Uttar Pradesh. The sample studied is a random sample of 15% of the households in six panchayats of Bara (of 109 panchayats in the district) and six panchayats of Rautahat (of 132). The households chosen for study were interviewed on four separate occasions beginning in October 1977 as part of a World Bank Study of education, agricultural productivity, and rural development. Each survey varied in content and emphasis but was based on essentially the same households and individuals. This report is largely limited to the data collected during the most recent survey carried out from December 1980 to January 1981 and includes 510 children ranging in age from 3 to 10 yr of age (0 to 7 yr in 1977, the first survey year). The 1980 to 1981 survey emphasized nutrition data collection and included anthropometry and hemoglobin determinations as well as dietary frequency questions.

The population of the Bara/Rautahat research site is composed primarily of middle- and low-caste Hindu households from the business, farming, and occupational castes. Muslims constitute 10% of the population of Bara and 14% of that of Rautahat, but Muslim households were not included in the sample. Household caste was coded as high caste (5.0%), middle caste (59.6%), and low caste (35.4%). The caste of a household, it should be noted, designates its ancestral affiliation and occupational status (eg, middle caste as "business" and "farming" castes) but does not necessarily correspond to actual economic activity or occupational status today. In fact, all of the households were subsistence farm households.

Four anthropometric measures were collected following standard techniques: height, weight, arm circumference, and triceps skinfold. Height was measured to the nearest millimeter with a locally constructed wooden measuring board, and weight was measured to within 0.1 kg using a portable beam balance scale. The Harpenden skinfold caliper was used to measure triceps skinfold, and the Zerfas insertion tape to measure arm circumference, both to the nearest mm. Subroutines obtained from the Centers for Disease Control (CDC) were used to generate percent of median values and Z scores for weight, height, and weight for height. These calculations use data from the National Center for Health Statistics (NCHS) as the reference or standard (5). Arm muscle area and arm fat area were calculated as recommended by Frisancho (6).

Capillary blood was collected by finger prick and analyzed in the field. Blood was put directly on a slide, stirred with a reagent, and the slide inserted into a reading chamber (method of American Optical Company). Values were not corrected for altitude since the Terai, unlike the rest of Nepal, is only slightly above sea level.

Mothers were asked by trained Nepalese field workers about their children's diarrheal and respiratory illnesses during the preceding week and about the frequency of consumption of major foods during the same period. Information about the duration of breast-feeding and the timing of the introduction of solid foods was also obtained for each child. Socioeconomic and other data including age and sex structure of the family, caste, land ownership, agricultural production, and level of schooling were obtained through standardized questionnaires. Written birth records were not generally available for the children. Although mothers were reasonably confident in stating the ages of young children, the field workers did assist some by reference to annual festivals and important local events.

An attempt was made to reduce the number of agricultural production variables by creating a crude measure of household income. The variable named "crop production value" (CRPVL) was computed as the sum of the outputs of the paddy and wheat crops weighted by the respective farmgate prices of these two cereals. Virtually every farm (91%) cultivated paddy in the 1980 growing season, and a smaller number (62%) cultivated wheat. Paddy and wheat together accounted for 1.0 ha of land usage that year on the "typical farm" out of a total of 1.3 ha available.

Fifty-six food items were included in the dietary questionnaire. To reduce the number of variables in the analyses, the 10 most variable items (eg, largest variance) were selected. This procedure excludes foods that are consumed either only occasionally (eg, seasonal fruits) or very frequently (eg, rice). Only six of the 10 "high variance" dietary variables were included in the final regression equations since earlier analyses showed that the other four consistently failed to be significant predictors of any measure of nutritional status. The dietary variables were recoded for the purposes of this analysis into three categories: 1 = not eaten last week, 2 = eaten occasionally last week, 3 = eaten daily.

All data were scanned for outliers and a small percentage (less than 1%) of cases with inconsistent or improbable values were deleted. A core sample of 510 cases was available for the analysis. These 510 cases had complete data for height, weight, age, sex, district, crop value, and for weaning, dietary, and disease variables. However, there were some missing values for other variables which resulted in our using just 461 cases in the final regression equations. The SPSS software package was used for all analyses.

Results

Description of sample

Sample sizes, means, and SDs for height, weight, arm circumference, triceps skinfold, and Hb are shown in **Table 1**, separately for boys and girls, and for eight age groups. Age 3 includes children 36 to 47 months of age, age 4 includes the range 48 to 59 months, etc. Because the majority of children have ages that are multiples of 12 months, the average age of each group is close to the starting month (eg, 36.6 months for group 36 to 47, 48.8 months for group 48 to 59, etc).

Z scores for weight for height, weight, and

TABLE 1
Means and SDs for anthropometric measures in nepalese boys and girls (n = 510)

Age	Sample size	Ht (cm)		Wt (kg)		Arm circumference (cm)		Triceps skinfold (mm)		HB (g/100 ml)	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
yr											
Males											
3	16	87.2	5.9	11.9	1.3	13.9	1.0	3.8	0.8	11.3	1.8
4	20	92.5	7.4	13.0	2.0	14.1	1.0	3.7	0.8	12.2	2.1
5	46	95.7	7.3	13.8	2.2	14.0	1.1	3.4	0.7	11.7	1.7
6	48	101.4	8.0	15.2	2.1	14.0	1.0	3.1	0.6	11.5	1.5
7	43	108.4	6.0	16.4	2.0	14.1	0.8	2.7	0.5	11.9	1.6
8	38	114.3	8.4	18.4	2.8	14.5	1.0	2.6	0.6	11.8	1.8
9	34	116.6	5.2	19.2	2.5	14.8	1.0	2.4	0.4	11.6	1.8
10	14	124.5	7.8	23.2	3.9	16.1	1.2	2.6	0.6	11.5	1.7
Females											
3	17	87.4	4.2	11.1	1.4	13.4	0.9	3.9	0.7	10.7	1.6
4	31	92.1	5.9	12.7	1.8	13.8	0.9	3.5	0.6	10.7	1.8
5	58	94.7	8.1	13.3	2.5	13.9	1.0	3.4	0.7	11.0	1.4
6	42	99.9	7.8	14.3	2.4	13.7	0.9	3.0	0.7	11.0	1.7
7	47	107.4	9.4	16.1	3.2	14.3	1.1	2.8	0.6	10.6	1.9
8	24	110.1	8.9	16.8	2.3	14.1	0.6	2.7	0.7	11.1	1.7
9	22	115.6	8.4	18.8	3.1	15.1	1.0	2.6	0.4	11.7	1.5
10	10	123.1	8.4	20.8	3.0	14.9	0.9	2.5	0.4	11.1	2.4

height are shown in **Figure 1**. The average Z score ($n = 510$) was −2.74 for height, −2.26 for weight, and −0.92 for weight for height. In a well-nourished sample, Z scores for all three measures would approach zero. There are no statistically significant differences in Z score values associated with sex. The age pattern in Z score values shown in Figure 1 seems to indicate progressive stunting until about 5 yr of age with the situation stabilizing or slightly improving thereafter.

Frisancho (6) has recently published norms for arm circumference, triceps skinfold, and upper arm fat and muscle areas. These data come from the same population as the NCHS norms for height and weight. At present, no subroutines are available to the public for calculating Z score values. In **Figures 2 and 3**, the NCHS 50th and 5th percentiles and the Nepalese means are plotted for triceps and arm circumference respectively for the sample of boys (sample sizes as in Table 1). The pattern in girls was found to be similar.

Means for arm muscle and fat area are plotted against mean height for the Nepalese sample in **Figure 4**. For comparison, the 50th and 5th percentiles of arm muscle and fat area are plotted against median heights in the case of the NCHS sample. Relative to height, the average arm muscle area of Nepalese children is somewhat low in comparison with the NCHS norms but well within the normal distribution (ie, between the 50th and 5th percentiles). This is in marked contrast to arm fat area, in which case Nepalese values are substantially below the NCHS 5th percentile. As would be expected from these relationships, the percentage of arm area which is muscle is considerably greater in the Nepalese sample than in the NCHS sample. As was the case for other figures, patterns for girls were similar to those for boys.

Hb values of the Nepalese children are very low when compared to US sea level norms given by Dallman and Siimes (7). For Nepalese girls, mean values fall below the 3rd US percentile while for boys they vary between the 3rd and the 10th percentile. Also, Hb values do not rise with age in the Nepalese sample as is observed in the US population (see Table 1).

Factors influencing nutritional status

Regressions were carried out for both Z scores and percentages of median values for height, weight, and weight for height. Since similar results were obtained for both types

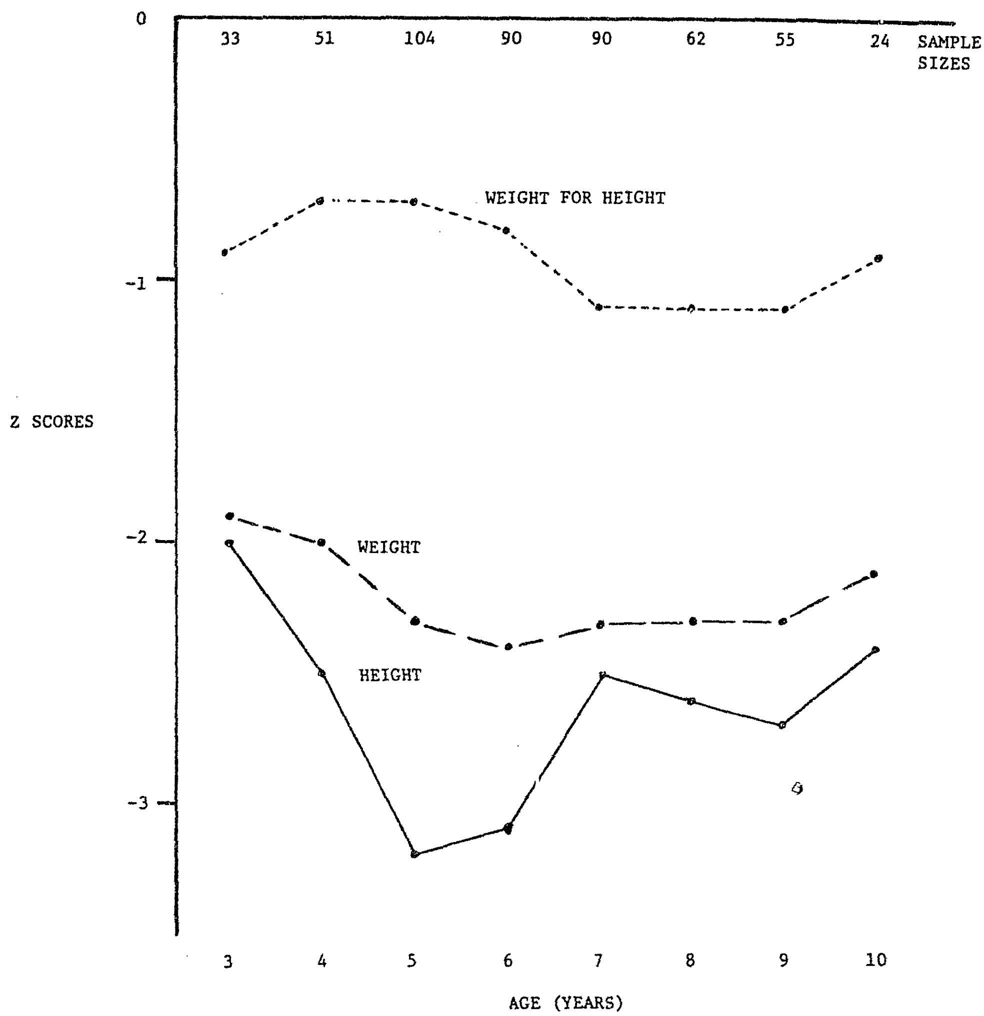

FIG 1. Anthropometry Z scores in Nepalese children.

of dependent variables and since percentages of median values have been used more often in previous studies, results for the Z score regressions are not reported here. Variable definitions, sample sizes, and mean and SDs for dependent, background, dietary, and morbidity variables used in the multiple regressions are given in **Table 2**. Mean percentages of median values are 88 for height, 73 for weight, and 93 for weight for height. Families had access to very limited amounts of land and their total agricultural production was very low. Only 26% of fathers and 7% of mothers had ever been to school. Mothers reported that children were breast-fed for nearly 3 yr on average and solids were not introduced until about 18 months. Eighteen percent of the children were reported to have had diarrhea the previous week and 41% were said to have had respiratory infections.

Most of the independent variables are significantly related to one or more of the dependent variables in the expected direction as shown in **Table 3**. Greater values for the variables LAND and CRPVL are associated with better growth as measured by all of the anthropometric variables except triceps skinfold and fat area. Increased parental age and schooling are associated with im-

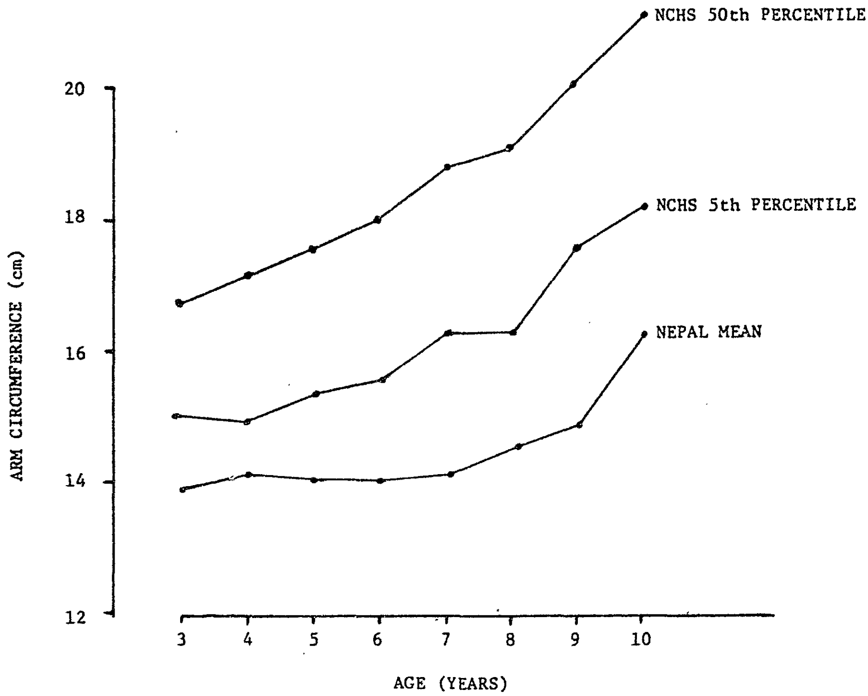

FIG 2. Arm circumference: males.

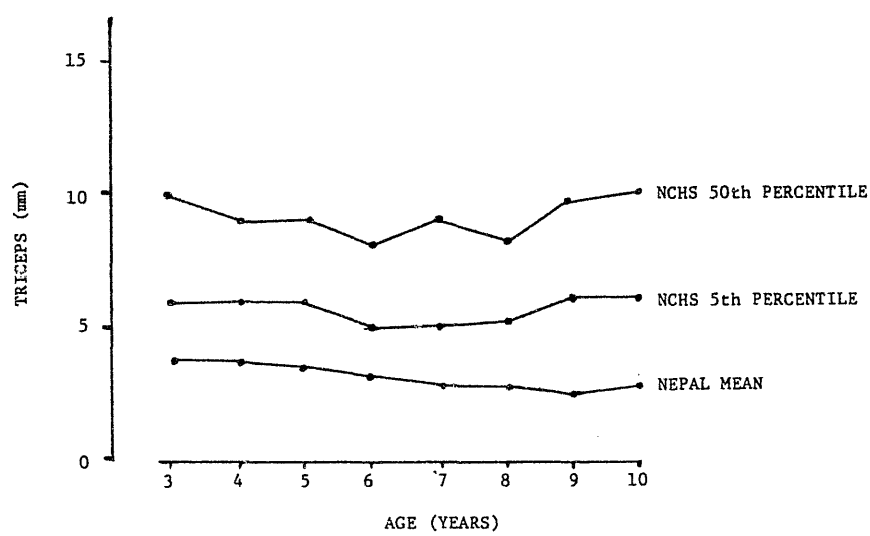

FIG 3. Triceps skinfold: males.

proved growth, and caste is related to growth in the expected direction, with high caste status being associated with greater fatness, and low caste with smaller heights and weights. No significant associations with diarrhea are observed, and except for a positive association with triceps and fat area, there is no association for respiratory illnesses. A history of prolonged breast-feeding is associated with shorter heights and months of exclusive breast-feeding (ie, late introduction of solids) is associated with

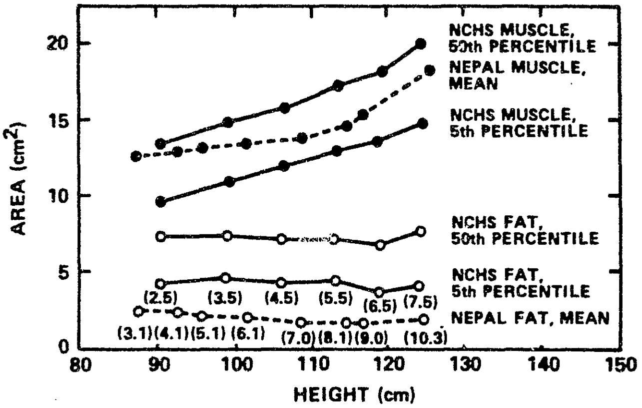

FIG 4. Arm muscle and arm fat area plotted on height for males (ages in parentheses).

TABLE 2
Variable definitions, means, and SDs
for variables used in multiple regressions
(n = 461)

	Variable description	Mean	SD
Dependent variables			
HA	Percent of NCHS median ht for age	88.47	6.43
WA	Percent of NCHS median wt for age	73.22	11.89
WH	Percent of NCHS median wt for ht for age	92.97	8.44
AC	Arm circumference (cm)	14.19	1.07
TRICEPS	Triceps skinfold (mm)	3.04	0.75
MAREA	Muscle area (mm^2)/10	138.41	231.60
FAREA	Fat area (mm^2)/10	20.54	51.72
HB	(g/dl)	11.32	1.77
Background variables			
AGE	Age of child (mo)	76.67	22.41
AGESQ	Age of child squared	6,379.18	3,578.17
SEX	1 = male, 2 = female	1.49	0.50
DISTRICT	1 = Bara, 2 = Rautahat	1.56	0.50
CRPVL	Value of crop output (100 Rs)	23.96	32.92
LAND	Land Owned (Bighas)*	2.07	3.78
MOAGE	Age of mother (yr)	33.80	8.11
HICST	High caste (1 = high, 0 = others)	0.05	0.23
LWCST	Low caste (1 = low, 0 = others)	0.36	0.48
MOSCH	Mother ever been to school (1 = yes, 0 = no)	0.07	0.25
FASCH	Father ever been to school (1 = yes, 0 = no)	0.26	0.44
Dietary variables			
MBF	Months of breast-feeding	34.19	11.26
MEBF	Months of exclusive breast-feeding	18.20	7.73
BRICE	Beaten rice last wk (1 = none, 2 = some, 3 = daily)	1.83	0.69
ROTI	Roti last week (1 = none, 2 = some, 3 = daily)	1.52	0.61
PPEAS	Pigeon peas last wk (1 = none, 2 = some, 3 = daily)	1.34	0.64
SWPOT	Sweet potatoes last wk (1 = none, 2 = some, 3 = daily)	2.15	0.61
Sugar	Sugar or molasses last wk (1 = none, 2 = some, 3 = daily)	1.87	0.74
TURNIP	Turnips last week (1 = none, 2 = some, 3 = daily)	1.93	0.63
Morbidity variables			
RESP	Respiratory infection last wk (1 = yes, 0 = no)	0.41	0.49
DIARR	Diarrhea last wk (1 = yes, 0 = no)	0.18	0.39

* 1 Bigha = 1.6 acres = 0.6 ha.

TABLE 3
Significant correlations between dependent and independent variables (n = 461)

Variables		Ha (% of median ht)	Wa (% of median wt)	Wh (% of median W/H)	AC (arm circumference)	TRICEPS (triceps skinfold)	MAREA (muscle area)	FAREA (fat area)	HB
Background									
AGE			−0.297*	−0.226*	0.356*	−0.559*	0.470*	−0.432*	0.089†
SEX					−0.077†		−0.089†		−0.220*
DISTRICT		−0.112‡	−0.137‡			−0.258*		−0.252*	
CRPVL	Crop output value	0.157*	0.169*		0.214*		0.205*	0.083†	0.094†
LAND	Land	0.142*	0135*		0.199*		0.201*		
MOAGE	Mother's age				0.176*	−0.101†	0.196*		0.080†
HICST	High caste					0.109‡		0.109‡	
LWCST	Low caste	−0.092†	−0.116‡						
MOSCH	School (mother)	0.080†	0.088†		0.103†		0.099†		0.084†
FASCH	School (father)	0.078†	0.078†		0.093†		0.090†		
Dietary									
MBF	Mos. breast fed	−0.096†							
MEBF	Mos. only breast			0.107†		0.154*		0.139*	−0.106†
BRICE	Beaten rice	0.098†	0.137‡	0.087†	0.130‡	0.105*	0.108‡	0.139‡	
ROTI	Roti				0.089†			0.083†	
PPEAS	Pigeon peas		0.080†	0.102†	0.135‡		0.119‡	0.102†	
SWPOT	Sweet potatoes		0.077†						
SUGAR	Sugar/molasses	0.124‡	0.115‡			0.155*		0.150*	
TURNIP	Turnips								
Morbidity									
RESP	Respiratory								
DIARR	Diarrhea								−0.078†

* $p < 0.001$.
† $p < 0.05$.
‡ $p < 0.01$.

TABLE 4
Determinants of anthropometry and Hb (n = 461)

Variables	HA		WA		WH		AC		TRICEPS		MAREA		FAREA		Hb	
	b	t	b	t	b	t	b	t	b	t	b	t	b	t	b	t
Background																
Age	−0.216	2.64*	−0.171	1.18	−0.118	1.10	−0.025	1.98†	−0.048	6.20‡	−2.783	1.08	−3.251	5.65‡	0.007	0.29
AGESQ	0.001	2.51†	0.000	0.03	0.000	0.27	0.000	3.29‡	0.000	3.81‡	0.047	2.92*	0.014	3.95‡	−0.000	0.16
SEX	−0.460	0.77	−0.094	0.09	0.672	0.86	−0.039	0.43	0.066	1.18	−11.882	0.63	3.472	0.83	−0.774	4.70
DISTRICT	−1.058	1.49	−2.442	1.95†	−0.736	0.79	−0.112	1.03	−0.330	4.96‡	−2.459	0.11	−22.785	4.58‡	0.182	0.93
CRPVL	0.015	1.34	0.035	1.76	−0.016	1.10	0.005	2.94*	0.000	0.63	1.004	2.86*	0.011	1.39	0.003	1.07
MOAGE	0.088	2.33†	0.193	2.76†	0.046	0.89	0.012	2.03†	0.002	0.64	2.476	1.99†	0.315	1.14	0.012	1.09
HICST	−1.341	0.90	−1.569	0.59	0.621	0.32	−0.132	0.58	0.208	1.48	−43.000	0.91	11.823	1.13	0.154	0.38
LWCST	−0.690	1.06	−1.499	1.30	−0.085	0.10	0.045	0.45	0.040	0.65	4.881	0.24	2.932	0.64	−0.124	0.69
MOSCH	1.389	0.94	3.494	1.33	1.053	0.54	0.364	1.60	0.123	0.89	70.064	1.50	11.574	1.11	0.166	0.41
FASCH	0.469	0.58	−0.395	0.27	−1.621	1.52	−0.006	0.05	−0.127	1.66	7.197	0.28	−8.585	1.50	0.013	0.05
Dietary																
MBF	−0.068	2.44†	−0.059	1.19	0.056	1.53	0.003	0.79	0.005	1.75	0.432	0.49	0.338	1.71	−0.003	0.34
MEBF	−0.026	−.62	−0.019	0.26	0.058	1.07	−0.006	0.87	0.008	1.98†	−1.624	1.25	0.418	1.44	−0.025	2.18†
BRICE	0.202	0.41	0.942	1.07	0.639	0.99	0.041	0.55	0.031	0.67	7.008	0.45	3.113	0.89	0.082	0.60
ROTI	−1.055	2.07†	−1.170	1.30	0.692	1.04	0.121	1.54	0.046	0.95	22.538	1.40	4.323	1.21	0.134	0.96
PPEAS	−0.121	0.23	0.943	0.99	1.330	1.90	0.132	1.60	0.068	1.36	23.234	1.38	6.536	1.74	0.059	0.40
SWPOT	−0.631	1.21	−1.061	1.15	−0.217	0.32	−0.005	0.05	0.032	0.65	−2.800	0.17	1.080	0.46	0.053	0.37
SUGAR	0.923	1.91	0.646	0.75	−0.663	1.05	−0.017	0.23	−0.031	0.68	0.046	0.00	−2.516	0.74	−0.003	0.00
TURNIP	−0.240	0.48	−1.147	1.31	−0.980	1.51	−0.225	2.96†	−0.029	0.62	−44.384	2.85*	−4.980	1.43	−0.048	0.35
Morbidity																
RESP	0.522	0.82	1.448	1.29	0.515	0.62	0.161	1.65	0.000	0.00	36.310	1.82	2.399	0.54	−0.254	1.45
DIARR	−0.311	0.39	−0.633	0.45	0.009	0.00	−0.007	0.05	−0.062	0.83	5.038	0.20	−4.463	0.80	−0.060	0.28
Constant	100.033		87.209		95.832		14.059		5.387		1,216.36		350.932		11.563	
$\bar{R}^2$	0.094		0.168		0.098		0.030		0.415		0.306		0.308		0.092	

* $p < 0.01$.
† $p < 0.05$.
‡ $p < 0.001$. Two-tailed tests.

greater fatness (increased triceps, fat area, and weight for height) and with lower Hb values. More frequent consumption of foods, particularly beaten rice, roti, pigeon peas, and sugar, is associated with better growth.

Multiple regression equations are shown in **Table 4** for all of the anthropometric variables and for hemoglobin. All tests of significance given are two-tailed. The variable LAND is highly correlated with CRPVL ($r = 0.820$, $N = 461$, $p < 0.001$). Since both variables were thought to measure the same construct and since CPRVL was found to be related more consistently to the anthropometric variables (see Table 3), LAND has been deleted from the list of independent variables. The results in Table 4 indicate that age is a significant predictor of the anthropometric variables. The fact that age squared is positive and statistically significant in a number of the regressions suggests that the relationship between age and the anthropometric variables is not linear but U-shaped as was evident for height in Figure 1. DISTRICT is negatively associated with all of the anthropometric variables, suggesting that children from Bara are "better off" in ways not captured by the included background measures. The sex of the child is not an important predictor of any of the anthropometric variables: boys, however, are seen to have significantly greater Hb values than do girls. The associations observed previously in the table of simple correlations (Table 3) for caste (HICST and LWCST) and schooling (FASCH and MOSCH) are not statistically significant in the multiple regressions. A longer duration of breast feeding (MBF) is significantly associated with reduced stature (HA) and there is also a tendency for positive associations with fatness (weight for height, TRICEPS and FAREA). This pattern is consistent with negative associations between stature and fatness in the sample (HA and TRICEPS: $r = -0.18$, $p < 0.001$; HA and FAREA: $r = -0.07$, $p < 0.10$). Similarly, the longer the duration of exclusive breast-feeding (MEBF), the greater are the fat stores and the lower are the Hb values. Some of the dietary variables are significant predictors and children reporting respiratory illnesses the previous week have larger arm circumferences and arm muscle areas, but lower Hb levels.

CRPVL is one of the variables in Tables 3 and 4 that show consistent associations with the anthropometric variables and Hb. **Table 5** presents additional analyses and shows how the distribution of children classified as having "poor nutritional status" varied by terciles of CRPVL. Table 5 consists of five widely used indicators of nutritional status: stunting, wasting, the "color codes" of arm circumference, the Gómez classifications of weight for age, and anemia classifications. (See Table 5 for precise definitions of all of the indicators.) A very large percentage of the sample is stunted (331 of 510 cases or 64.9%); however, the prevalence of stunting significantly decreases as CRPVL increases. Wasting is seen to exist for 4.1% of the sample, but whereas it is 6.3% for those in the low tercile of CRPVL, it diminishes to only 0.6% in the upper tercile. While 20.6% of the children whose families had low CRPVL values fall into yellow and red categories of arm circumference, only 14.9% do so in the case of those whose families were in the high CRPVL group. The percentage of children classified as either moderately or severely malnourished according to the Gómez categories of weight for age is 66.4% for the bottom tercile, 64.2% for the middle tercile, and 54.6% for the top tercile of CRPVL. Finally, 36.1% of the children show some degree of anemia, but no relationship with CRPVL is evident.

Discussion

The extent of malnutrition found in this study is among the highest that has been reported outside of extraordinary deprivations occurring during events such as wars and famines. The results of the 1980 to 1981 survey were that 65% of the children were stunted, 4% were wasted, and 12% were Gómez 3 (less than 60% of weight for age). Results of earlier surveys in the same households also indicate that the rates of malnutrition were very high (8, 9). A national nutrition survey coordinated by the CDC (4) also reported high rates of malnutrition in a sample of Terai children 6 months to 6 yr of age; 45% of the CDC sample was found

TABLE 5
Distribution of categories of nutritional status by categories of total value of crops (CRPVL)

Value of crops	Stunting (%)		Wasting (%)		Arm circumference			Gomez categories				Anemia				Row total
	No	Yes	No	Yes	Green	Yellow	Red	Normal	Grade 1	Grade 2	Grade 3	None	Mild	Moderate	Severe	
Low	50	126	165	11	124	42	10	7	52	96	21	110	36	25	5	176
	(28.4)	(71.6)	(93.8)	(6.3)	(70.5)	(23.9)	(5.7)	(4.0)	(29.5)	(54.5)	(11.9)	(62.5)	(20.5)	(4.2)	(2.8)	
Middle	51	102	144	9	110	31	12	13	42	78	20	94	29	23	7	153
	(33.3)	(66.7)	(94.1)	(5.9)	(71.9)	(20.3)	(7.8)	(8.5)	(27.5)	(51.0)	(13.1)	(61.[illegible])	(19.0)	(15.0)	(4.6)	
High	78	103	180	1	154	20	7	20	62	79	20	122	30	25	4	181
	(43.1)	(56.9)	(99.4)	(0.6)	(85.1)	(11.0)	(3.9)	(11.0)	(34.3)	(43.6)	(11.0)	(67.4)	(16.6)	(13.8)	(2.2)	
Column total	179	331	489	21	388	93	29	40	156	253	61	326	95	73	16	510
χ^2	8.75*		9.06*		13.84†			9.66				2.92				

Note: row percentages are given in parentheses.

Definitions: Value of crops: low (CRPVL ≤ 5.6), Middle (5.6 < CRPVL ≤ 20.5), High (CRPVL > 20.5); Stunting: no (HA > 90 HA), yes (HA ≤ 90 HA); Wasting: no (WH > 80 WH), yes (WH ≤ 80); Arm circumference: green (AC > 13.4), yellow (12.5 < AC ≤ 13.4), red (AC ≤ 12.5); Gomez categories: normal (WA ≥ 90.0), grade 1 (75.0 ≤ WA ≤ 89.9), grade 2 (60.0 ≤ WA ≤ 74.9), grade 3 (WA ≤ 59.9); Anemia: none (HG ≥ 11.0), mild (10.0 ≤ HG ≤ 10.9), moderate (8.0 ≤ Hb ≤ 9.9), severe (Hb < 7.9)

* $p < 0.05$.

† $p < 0.01$.

to be stunted and 9% to be wasted. The difference in age between the two samples may account for the differences in the degree of stunting and wasting.

The CDC-coordinated survey also included a Nepal urban population for comparison. Twenty-nine percent of this sample was found to be stunted, and 2% was found to be wasted (4). Similarly, Farquharson (10) measured a rural "well-to-do" group chosen from among children attending private clinics or schools and from among the children of health workers. Visual inspection of the growth curves prepared by Farquharson (10) shows that relatively affluent rural children grow better than do their poor counterparts. Means for the well-to-do were plotted between the 10th and the 50th percentile of the British standards, while those for the poorer children fell far below the 10th percentile. Few details were provided by Brink et al (4) and Farquharson (10) on the characteristics of the well-to-do samples, and it is difficult to assess whether their results represent the genetic potential of the Nepalese. Studies from northern India, for example, show that elite Hindu children have the same anthropometric characteristics as British and American children (11–13).

The Hb values of the Bara/Rautahat sample were very low. Equally low values have been reported for Nepalese children by Brink et al (4), as well as for Indian children (14–17).

It is difficult to obtain accurate age information in Nepal (19). Inspection of the data shows that 83% of the children have reported ages that were multiples of 12 months. There is clearly an excessive tendency toward "heaping" around completed years since, if age were randomly distributed, only 8% of the children would be expected to have ages divisible by 12. Mothers are believed to have rounded upward when asked their children's ages. The consequence of this is that many of the analyses have compared younger Nepalese children to older children in the NCHS sample and thus overestimated the magnitude of retardation in age-dependent measures such as height and arm muscle area. As the average age of the study sample is underestimated by no more than 6 months, however, the bias introduced is small. Indeed, analyses of variance showed no difference in height, weight, or weight for height between "heapers" and "nonheapers." Also, the two groups were evenly distributed across sex and district lines and showed no socioeconomic differences (eg, CRPVL, LAND).

Unlike malnourished children from Latin America (18, 19), Nepalese children are not able to maintain normal weight to height relationships but are instead 1 to 1.5 kg lighter when compared with well-nourished children of the same height. Relative to height, arm muscle area in the Nepalese sample is smaller than in the NCHS sample, while muscle areas in Latin American children are normal once size is taken into account (19, 20). Nepalese and Guatemalan children show markedly lower arm fat areas when compared to NCHS children of the same size (20); however, Brazilian children show fat areas closer to US norms (19). We hypothesize that the growth patterns in Nepal, Guatemala, and Brazil reflect different degrees of severity of the same underlying response to protein-energy malnutrition. The severity of protein-energy malnutrition is greater in Nepal than in Guatemala and Brazil, and Latin American children may be able to cope with the stress of malnutrition by growing less in body size but without altering weight/height ratios. The situation in Nepal may reflect more severe conditions which demand more powerful adaptive mechanisms. In Nepal, growth in height is affected to an even greater degree, and weight for height ratios are diminished as well.

The data presented here are also informative of the correlates of nutritional status measures in Nepal. Caste and sex were two such variables investigated. High caste was associated with increased skinfolds and fat areas, and low caste was associated with reduced heights and weights (Table 3). Once other socioeconomic indicators were taken into account, however, all associations with caste lost their statistical significance (Table 4). Brink et al (4) found caste to be essentially unrelated to nutritional status in the Nepal national nutrition survey. Also, Brown et al (21) reported there were no marked differences in nutrient intakes associated with caste in poor rural families of Nepal. On the other hand, two Indian studies in the Punjab found caste to be a significant predictor of child nutritional status (22, 23). No differences were found between boys and girls in the degree of growth retardation relative to the NCHS norms. Differential treatment favoring boys over girls may not be as marked in Nepal as reported for India (23).

Nepalese babies are breast-fed for long periods of time. Farquharson (10) states that most are breast-fed for at least 2 yr and frequently longer. Brown et al (21) found that nearly all children were breast-fed for more than 18 months, and over half were breast-fed for more than 2 yr. The duration found in this study was 34 months, which does not seem unreasonable in view of previous findings. Solids tend to be introduced to the diets of Nepalese infants at later ages than in many areas of the world (10, 21). However, the finding in this study that the average duration of exclusive breast-feeding is 18 months is probably an exaggeration. Perhaps, the question was not properly understood and instead the results refer to the timing of the full establishment of the regular adult diet. The variable MEBF (months of exclusive breast-feeding) was found to be positively associated with greater fatness (ie, skinfold, fat area, and weight for height). MEBF was negatively associated, however, with the level of Hb, a finding that might suggest a difficulty in recovering good iron status in this population, even several years after the introduction of food solids. The total length of breast-feeding (MBF) was not found to be related to physical growth measures in bivariate fashion but, after controlling for all other independent factors, the duration of breast-feeding is associated with a greater degree of stunting and with larger skinfolds and fat areas. This is a population reporting universal and prolonged breast-feeding, and the association with stunting should be interpreted with caution.

The analysis of previous survey data pointed to a significant negative association between infectious disease and nutritional status, particularly between diarrhea and low weight for height (8). This same association was not found in the analysis of the 1980 to

1981 data. The fact that the children in the 1980 to 1981 survey were past the age of peak diarrheal illness, combined with the fact that the diarrhea data referred only to the previous week, probably explains the finding of no association between diarrhea and nutritional status. Findings with respect to upper respiratory illness were inconsistent.

The usual diet of the Nepalese Terai population consists primarily of rice, dhal (cracked legumes cooked to a soup-like consistency), a vegetable curry (made predominantly of potatoes and a variety of coarse spinaches), small amounts of milk, and occasional fruits and vegetables (10, 21). Many families follow the Hindu prohibition against meat. Dietary data in this study were limited to the frequency of consumption of particular food items.The 10 most variable dietary variables were considered in the analyses and it was found that a number of them were consistently related to nutritional status. However, most of these associations were considerably attenuated after controlling for other factors in multivariate analyses. Some variables were negatively related to growth in the multivariate analyses: roti (with height) and turnips (with arm circumference and muscle area). While never significant, associations involving sweet potatoes were often negative. Sweet potatoes and turnips are known to be foods that are consumed more frequently by poorer families. Also, the code of Manu forbids the higher castes from eating turnips (24).

Finally, socioeconomic variables (CRPVL and LAND) were found to be significant determinants of nutritional status. Studies in India (15, 22, 23) and Latin America (25) have found that income, for which CRPVL is a proxy in this study, is one of the most significant predictors of nutritional status. The amount of land available to the family is another important variable predictive of nutritional status, as has been shown in other studies as well (26–29). These findings reinforce the views that protein-energy malnutrition is a problem of poverty and suggest that substantial improvement is likely to come from raising the standard of living.

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