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Determinants of Nutritional Status among Pre-School Children in Sri Lanka

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ABSTRACT. *Despite various efforts made by the successive governments to improve the nutritional status of women and children, malnutrition among pre-school children continues to be a major health problem in Sri Lanka. The objectives of this study are to measure incidence, depth and severity of malnutrition by province, sector and gender and to find out the factors affecting nutritional status of pre-school children in Sri Lanka. Data from a sample of 1,764 pre-school children, obtained from the Sri Lanka Integrated Survey conducted by the World Bank and the Department of Census and Statistics in Sri Lanka, in 1999/2000, were used for the analysis. Nutritional status of the pre-school children was measured using the weight-for-age anthropometric indicator (underweight) which reflects both long term and short term nutritional status. Multiple linear regression and multinomial logit models were used to evaluate the determinants of underweight. The results revealed that relatively higher incidence, depth and severity of underweight children are recorded in Sabaragamuwa, Uva and North Western provinces. The results of the estimations indicate that the area of residence, household size, age of the child, mother's education, birth-weight of child and household income have significant effects on the status of malnutrition. The effect of household income on reducing malnutrition appears to be small compared to other determinants. Narrowing of regional disparities through investment in infrastructure and development of human capital through education and health are recommended as possible strategies to reduce child malnutrition in Sri Lanka.*

INTRODUCTION

Despite the great efforts on reducing poverty and malnutrition, 155 million children in the developing world are recorded to be malnourished. In 2003, 27% of the children in the world were underweight, 31% were stunted and 8% were wasted[2]. The prevalence of malnourished children in South Asia is far beyond the world averages and worse compared to the situation in Sub-Saharan Africa. Sri Lanka however has relatively low levels malnutrition compared to other South Asian countries. The prevalence of severe and moderate underweight, stunted and wasted children under five years of age in Sri Lanka in 2000 were 29%, 14% and 14% respectively (UNICEF, 2005). Recognizing the importanc of

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[2] Underweight (weight for age), stunting (height for age) and wasting (weight for height) are the commonly used anthropometric indicators in measuring the degree of malnutrition. Underweight captures the retarded weight for age, which is a consequence of concurrent short-term (acute) and long-term (chronic) malnutrition, whereas stunting measures only the long-term malnutrition and wasting measures only the short-term malnutrition.

having a healthy and productive future generation for a country for its economic and social development, the successive governments in Sri Lanka have strived towards alleviation of poverty and improvement of the nutritional status of children and mothers through provision of direct food supplements and infrastructures such as health and education. Halving the prevalence of malnourished children between 1990 and 2015 is one of the Millennium Development Goals. Even though child malnutrition is still a major health problem in Sri Lanka, an improvement in the nutritional status is apparent over the years possibly as a result of these government interventions. According to the dietary and health survey (DHS), conducted by the Department of Census and Statistics (DCS) in 2000, the percentage of underweight pre-school children in Sri Lanka was reduced by eight percentage points from their 1993 value (DCS, 2005).

Child-malnutrition can be a result of deficiencies in calories, proteins and/or micronutrients. The intake of these nutrients is influenced not only by the availability of food but also care for children and health environment at the household level. Some argue income levels (Alderman *et al.*, 2005; Pal, 1999; Haddad *et al.*, 2003), women's education (Smith and Haddad, 2000 and 2001; Behrman and Wolfe, 1984; Pal, 1999; Christiaensen and Alderman, 2004; Thomas *et al.*, 1990), health environment (Smith and Haddad, 2000; 2001), nutritional interventions (Alderman *et al.*, 2005), government transfers (Yamano *et al.*, 2005) and infrastructure (Fay *et al.*, 2005) determine the status of child malnutrition in a country. The effects of the above factors however are contextual - their influences in different countries found to be of different magnitudes and at times in different directions.

According to the DCS (2003), age of child, sector of residence, work status of mother, access to media by mother, mother's education and sanitation affect status of child malnutrition in Sri Lanka. According to the World Bank (2005), main determinants of child malnutrition, measured as percentage of underweight and stunted children, are infrastructure and female adult schooling. Both these studies have investigated the association between the indices of malnutrition and their possible determinants using national level data collected by DHS, which excludes information on the conflict affected North East province in 2000. The objectives of the present study are to measure the status of underweight among pre-school children in by province, sector and gender, and to assess the determinants of the underweight in Sri Lanka. National survey data collected by the Sri Lanka integrated survey (SLIS), which includes information on North East province, was used for the analysis (World Bank, 2000). The incidence, depth and severity of underweight were computed to show the status of malnutrition and determinants were obtained using multiple linear regression models and multinomial logit models.

METHODOLOGY

This study uses the underweight, which is prescribed by the World Health Organization (WHO) as the best measure of malnutrition, to measure malnutrition (Haddad *et al.*, 2003; Smith *et al.*, 2000; and Pal, 1999). The Z scores of underweight were calculated using actual weight (kg) and age (month) data and parameters of reference population using the equation (1).

$$Z = (W - W_r)/SD_{wr} \qquad (1)$$

where, W is the weight a child of a specified age group, W_r is the median weight of a healthy child from a reference population of the same age group, and SD_{wr} is the standard deviation of weight for the reference population of that age group. Median weights and standard deviations of weights of the reference population were obtained from the tables on reference data for the weight and height of children of the WHO, 1978.

Measurement of malnutrition

In order to calculate incidence, depth and severity of malnutrition, Foster, Greer and Thorbecke (FGT) type of measures were applied to Z scores obtained using equation (2), as follows.

$$P_\alpha = \frac{1}{n}\sum_i \left[\frac{z - Z_i}{z}\right]^\alpha \qquad (2)$$

Where Z_i is the Z score value, z is malnutrition poverty line, n is the size of the population. The Z score of -1.00 was considered as the malnutrition poverty line[3]. P is the status of malnutrition measures where, when α is zero it gives the prevalence of underweight (incidences of underweight), when α is one it provides the malnutrition gap index (depth of underweight) and when α is two it measures the squared malnutrition gap index (severity of underweight). Prevalence of underweight is the percentage of underweight children in a given population. Malnutrition gap index is the mean distance between an individual Z score value and the malnutrition poverty line. The squared malnutrition gap index is the squared mean distance between an individual Z score value and the malnutrition poverty line, which provides higher weights for those Z scores falls far below the malnutrition poverty line.

Determinants of malnutrition

In order to find out the determinants of malnutrition, the malnutrition status were econometrically estimated treating the status of malnutrition as the dependent variable and possible determinants as explanatory variables. In estimating such functions, the dependent variable can be specified as a continuous variable such as nutrient intake (Behrman and Wolfe, 1984) and Z scores of underweight (Haddad *et al.*, 2003) or stunting (Christiaensen and Alderman, 2004), as a rank variable (Pal, 1999) or as a categorical variables.

The analysis was performed using multiple linear regression models with Z scores of underweight and multinomial logit models with categorical dependent variable (Greene, 1999). Three categories of children were identified for the multinomial logit model: under-nourished, well-nourished and over-nourished. If the Z score is less than -1, the child is considered as under-nourished. If the Z score is more than +1, the child is considered as over-nourished. If the Z score is between -1 and +1, the child was considered as well-nourished. While the multiple linear regression models estimate the change in the Z score

[3] Most of the previous studies (Haddad *et al.*, 2003 and Christiaensen and Alderman, 2004) and the United Nations consider children below -2.00 Z scores as the underweight. DCS (2003), which used DHS data, considered children in the range -1.00 to -1.99 as mildly underweight, -2.00 to -2.99 as moderately underweight and children below -3.00 as severely underweight in Sri Lanka. For the data set used in the present study, underweight incidences at the national level, which were obtained from DHS, are consistent with Z scores below -1.00 and hence Z score of -1.00 was chosen as the poverty line.

due to a unit change in explanatory variables, the multinomial logit models estimate the direction and intensity of the explanatory variables on the categorical dependent variable by predicting a probability outcome associated with each category of dependent variable.

Four sets of explanatory variables were included in the above models showing characteristics of the child, the mother, the household and the region. Child characteristics included gender, age and birth-weight. Maternal characteristics included age, education and the income earned by the mother. Household characteristics included household size and household income. Regional characteristics were captured by dummy variables showing the province of residence and the sector. Birth-weight of a child is a proxy for health and nutritional status of the mother during the pregnancy. While household income captures the ability of a household access to food, mother's income indicates the bargaining power of the mother in accessing food and intra household distribution of food. The ability of a mother to obtain and use of information on nutrition and proper caring practices is proxied by the education level of the mother. The dummy variables showing provinces and sectors capture the location specific characteristics, mainly the access to infrastructure. Three separate equations were estimated for each model: female children, male children and pooled sample (see Pal (1999) for a similar specification).

Data

The study used data obtained from the Sri Lanka Integrated Survey (SLIS) conducted between October 1999 and the third quarter of 2000 by the World Bank. The survey covered 23 districts excluding Kilinochchi and Mullaitivu districts in all the nine provinces. The survey includes 7,500 households in 500 urban, rural and estate communities in Sri Lanka. The estimation was performed on those households with pre- school aged children (3-59 months of age) and the sample contains 1,764 pre-school children, of which 923 were male children[4].

RESULTS AND DISCUSSION

Descriptive statistics

Table 1 provides descriptive statistics for the pooled sample, under-nourished, well-nourished and over-nourished children. The results show that the under-nourished children are on average older and have lower birth-weights. The mothers of under-nourished children are not well educated and the total household income is lower. They come from relatively larger families. The differences in household income and the birth-weight between under-weight and average children are clearly visible. The average household income of the families with underweight children is Rs. 7,630 per month, whereas it is Rs. 8,462 per month for an average family in the sample. The average birth-weight of a presently underweight child is 2,730g whereas it is 2,859g for an average child. The variations in all the variables are quite high as shown by higher values for standard deviations. The correlation coefficients among variables showing characteristics of child, mother and household are found to be less than 25%.

[4] The original data set contained information on 2,203 pre-school children, however, observations with missing values and the outliers (Z scores less than –4 and greater than +4) were discarded.

Table 1. Socio-economic characteristics of the households with pre-school children

Variable	Unit	Pooled (-4 < Z < +4)		Under-nourished (-4 < Z < -1)		Well-nourished (-1 < Z < +1)		Over-nourished (+1 < Z < +4)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Average Z score		-0.07	1.54	-1.84	0.63	-0.01	0.58	2.01	0.79
Child's age	Months	27.56	15.98	32.88	15.24	28.42	14.63	19.30	16.17
Birth-weight	g	2859.16	480.81	2730.44	525.80	2879.61	449.29	2978.44	445.09
Mother's age	Years	30.20	6.17	30.24	6.13	30.38	6.14	29.80	6 27
Mother's income	Rs./ month	510.21	1681.62	470.63	1659.63	511.15	1691.09	557.37	1692.74
Mother's education	Rank	8 68	3.55	8.23	3.71	8.92	3.38	8.79	3.62
Total household income	Rs./ month	8461.87	9665.49	7630.78	8103 80	8711.54	9914.87	9001.02	10834.12
Household size	No.	5.51	1.99	5.63	2.10	5.45	1.95	5.50	1.92
Sample size.		1764		520		824		420	

Status of malnutrition

As stated earlier, the poverty line was treated as a Z score of -1.00. The data was adjusted for sample weights (number of children represented by each child) in calculating FGT indices, which was performed using "Distributive Analysis/Analyse Distributive" (DAD)[5]. Table 2 provides the incidence, depth and severity of underweight pre-school children by province, sector and gender in Sri Lanka. According to the results, the incidence of underweight children in Sri Lanka is 28%. Among the provinces the highest incidence, depth and severity of underweight children are recorded in Sabaragamuwa province. The second highest incidence is recorded in Uva province, however, second highest depth and severity figures are recorded for the North West province, which shows the third highest incidence. North Eastern province shows the third highest depth and severity. Among the sectors, rural sector shows the highest incidence, depth and severity of underweight. The estimates for estate sector and male children are below the national average incidences of malnutrition, which indicate that among the sectors, estate sector shows highest incidences (44% in estate sector compared to 31% in rural sector) and female children are more malnourished than male children (29% of male children and 29.8% of female children according to DCS, 2005)[6].

Determinants of underweight

The multiple linear regression models were estimated using ordinary least square (OLS) and the multinomial logit models were estimated using maximum likelihood (ML) estimation procedure in Time Series Package (TSP international, 2001). The multiple linear regression models were estimated using the 1,588 observations covering the children having

5 DAD is designed to facilitate the analysis and the comparisons of social welfare, inequality. poverty and equity across distributions of living standards. Its features include the estimation of a large number of indices and curves that are useful for distributive comparisons as well as the provision of asymptotic standard errors to enable statistical inference. The features also include basic descriptive statistics and provide simple non-parametric estimations of density functions and regressions (Araar and Duclos, 2004).

6 The lower values for the estate sector may be due to smaller sample size.

Z scores up to 2 in the pooled sample (830 male children and 758 female children). As stated earlier, the multinomial logit model included three categories of children: under-nourished, well-nourished and over-nourished. In all specifications of the multinomial logit model, under-nourished children category is used as the reference category and the estimation was performed for all 1,764 children in the pooled sample and 923 male children and 841 female children. The coefficients of the multiple linear models show the change in Z score as a result of a unit change in a respective explanatory variable (Table 3). The estimated coefficients of the multinomial logit model reflect the effect of the respective explanatory variable on the likelihood of moving to well-nourished or over-nourished category relative to under-nourished group (Table 4). The effects of explanatory variables on the change in probabilities obtained from the multinomial logit model are presented in Table 5.

Table 2. Province, sector and gender among pre-school children

Classification	Groups	Sample size	Average Z score	Incidence	Depth	Severity
Sri Lanka		1764	0.032	0.28	0.23	0.29
Provinces	Western	284	0.329	0.23	0.16	0.21
	Central	198	-0.150	0.26	0.25	0.32
	Southern	223	-0.111	0.31	0.21	0.22
	North East	561	0.136	0.26	0.26	0.38
	North Western	136	-0.176	0.34	0.30	0.38
	North Central	124	-0.208	0.29	0.20	0.20
	Uva	107	-0.423	0.35	0.22	0.23
	Sabaragamuwa	131	-0.480	0.46	0.33	0.43
	Urban	245	0.156	0.24	0.19	0.23
Sectors	Rural	1404	-0.011	0.29	0.24	0.31
	Estate	65	0.384	0.14	0.12	0.25
	Male children	923	-0.017	0.29	0.26	0.35
Gender	Female children	841	0.084	0.27	0.19	0.23

Although the model fits, as reflected by the R^2 measures, are quite low, most of the coefficients are statistically significant. The regression findings indicate that in most of the specifications, age and birth-weight of the child, education of the mother, total household income, and dummy variables which represent the provinces of residence and the sector have significant effects on the nutritional status of pre-school children. The following sections show the effects of different explanatory variables on nutritional outcome.

Gender

Gender is a dummy variable with a value of 1 for female children. According to the OLS estimates, there is no significant difference between the Z scores of male and female children. Same results hold true in multinomial logit model results. There is no significant difference between the probability of a female child being malnourished and a male child being malnourished. This finding contradicts the findings in many developing countries including Sri Lanka, which state that female children are prone to be malnourished than male children (World Bank, 2005). However, according to Haddad et al. (2003), no evidence of bias against females is observed for the 12 developing countries examined including Nepal and Pakistan.

Age of the child

Two variables, age of the child and squared age of the child were included in the multiple linear regression models to identify whether there is a quadratic relationship between age and the Z score. It was revealed that the relationship between age and the Z score is U shaped for all children, suggesting that newborn children and older children, within 3-59 month of age, are better nourished than the others.

Multinomial logit models show how the age of the child influences the probability of being well-nourished or over-weight as compared to the probability of being under-weight. The coefficients of the pooled sample, female children and male children show that, the older the child is, the lesser the probability of being well-nourished or over-weight, suggesting that older children are prone to be under-nourished. An increase in child's age by one month increases the probabilities of belonging to under-nourished group by 0.61%, 0.65% and 0.55% for the pooled sample, male children and female children, respectively (Table 5).

The reason for this phenomenon is that infants are breast-fed and older children eat a variety of foods. Soon after they start supplementary feeding until they become old enough to consume a variety of food, children may not obtain adequate levels of nutrients. Similar patterns were identified by the World Bank (2005) for Sri Lanka, which state that the risk of malnutrition sharply increases in the second year of life.

Birth-weight

In all the specifications the coefficient for birth-weight is positive and significant at the one percent level indicating that birth-weight is one of the crucial factors determining child malnutrition. The higher the birth-weight, the higher the *Z* scores and the higher the probability of being well-nourished or over-nourished and the lower the probability of being under-nourished. The probabilities of belonging to the under-nourished group decreases by 0.01%, 0.01% and 0.02% for the pooled sample, male children and female children respectively, when birth-weight is higher by one gram (Table 5).

Age and income of the mother

Neither the age nor the income of the mother show significant relationships with the *Z* scores or with the probability of being well-nourished or over-nourished in all of the specifications, except for the logit equation for male children, which shows that the higher the mother's age, the higher the probability of being well-nourished or over- nourished. The probability of belonging to the under-nourished group decreases by 0.61% when mother's age increases by one year, for male children. However, the World Bank (2005) identified a U-shaped relationship between mother's age and malnutrition.

The insignificant coefficient for mother's income may be due to lesser time availability for childcare, when mothers are at work. Ratnayake and Weerahewa (2005) however found a positive relationship between the income of the mother and calorie adequacy in the low-income households in Sri Lanka.

Table 3. The Results of the Multiple Linear Regression Model (Dependent variable: Z scores for underweight pre-school children

Levels	Variable	Coefficients		
		Pooled sample	Male Children	Female children
	Constant	-1.11***	0.96**	-0.36***
		(0.27)	(0.39)	(0.39)
Child	Gender (Male=0, female=1)	-0.06	n.a.	n.a.
		(0.06)		
	Age	-0.02***	-0.03***	-0.09***
		(0.78E2)	(0.01)	(0.01)
	Age squared	0.21E3	0.14E3	0.29E3**
		(0.12E3)	(0.18E3)	(0.18E3)
	Birth-weight	0.52E3***	0.46E3***	0.62E3***
		(0.63E4)	(0.86E4)	(0.95E4)
Mother	Age	0.21E2	0.01	-0.01
		(0.51E2)	(0.73E2)	(0.73E2)
	Income	0.40E5	-0.14E6	0.99E5
		(0.19E4)	(0.30E4)	(0.24E4)
	Education level	0.01*	-0.14E2	0.03***
		(0.91E2)	(0.01)	(0.01)
Household	Total household income	0.10E4	0.18E4	0.64E5
		(0.85E5)	(0.12E4)	(0.12E4)
	Squared total Household income	-0.11E9	-0.24E9	-0.44E10
		(0.13E9)	(0.20E9)	(0.17E9)
	Size	-0.02	-0.02	-0.01
		(0.01)	(0.02)	(0.02)
Provinces	Southern	-0.10	-0.31	-0.06
		(0.12)	(0.17)	(0.17)
	Central	-0.06	-0.08	-0.10
		(0.11)	(0.16)	(0.16)
	North East	-0.06	-0.20	-0.11
		(0.10)	(0.14)	(0.14)
	North Western	-0.24*	-0.17	-0.27
		(0.13)	(0.20)	(0.18)
	North Central	-0.06	-0.19	0.06
		(0.14)	(0.20)	(0.19)
	Uva	-0.22	-0.33*	-0.04
		(0.14)	(0.20)	(0.21)
	Sabaragamuwa	-0.41***	-0.40**	-0.37**
		(0.13)	(0.19)	(0.18)
Sector	Rural	-0.61**	-0.12	-0.23**
		(0.08)	(0.12)	(0.12)
	Estate	-0.11	-0.02	-0.27
		(0.18)	(0.24)	(0.26)
Statistical Criteria	R^2 value	0.10	0.11	0.12
	Number of observations	1588	830	758

* Significant at 0.1 level ** Significant at 0.05 level *** Significant at 0.01 level
Standard errors are in parenthesis; n.a.: Not included in the analysis

Table 4. Coefficient estimates of the multinomial logit model (dependent variable: under-nourished, well-nourished and over-nourished children)

Variables		Pooled		Male children		Female children	
		Well-nourished	Over-nourished	Well-nourished	Over-nourished	Well-nourished	Over-nourished
Constant		-0.9148*	-1.3847**	-0.9403	-1.063	-0.8354	-2.0809**
		(0.5220)	(0.6441)	(0.7218)	(0.8625)	(0.7569)	(0.9836)
Child	Gender	0.1027	-0.2689*	n.a.	n.a.	n.a.	n.a.
	(Male=0)	(0.1155)	(0.1443)				
	Age	-0.0207***	-0.0639***	-0.0200***	-0.0684***	-0.0216***	-0.0588***
		(00038)	(0.0050)	(0.0054)	(0.0069)	(0.0055)	(0.0075)
	Birth-	0.6894E3***	0.1237E2***	0.5316E3***	0.0011***	0.9211E3***	0.1494***
	weight	(0.1269E3)	(0.0161E2)	(0.1705E3)	(0.0002)	(0.1946E3)	(0.0262)
Mother	Age	0.0099	0.7233E2	0.0346**	0.0279*	-0.0191	-0.0208
		(0.0098)	(0.0122)	(0.0137)	(0.0165)	(0.0145)	(0.0190)
	Income	0.8684E5	0.5598E4	-0.7046E4	0.6316E4	0.7457E4	0.6081E4
		(0.3856E4)	(0.4678E4)	(0.5929E4)	(0.6562E4)	(0.5506E4)	(0.7309E4)
	Education	0.0338**	0.8033E2	0.7041E02	0.0297	0.0614***	0.0465
	level	(0.0168)	(0.0211)	(0.024)	(0.0296)	(0.0236).	(0.0310)
Household	household	0.1016E4	0.1373E4*	0.1118E4	0.1534E4	0.1288E4	0.1557E4
	income	(0.7343E5)	(0.0585E5)	(0.1159E4)	(0.1337E4)	(0.0998E4)	(0.1170E4)
	household	-0.0481*	-0.0467	-0.0505	-0.0660	-0.0431	-0.0188
	size	(0.0299)	(0.0370)	(0.0427)	(0.0514)	(0.0427)	(0.0547)
Provinces	Southern	0.0100	-0.3618	-0.0956	-0.5806	0.1129	-0.1080
(western=0)		(0.2435)	(0.2937)	(0.3319)	(0.3991)	(0.3624)	(0.4393)
	Central	-0.0983	-0.5139*	-0.1680	-0.4423	-0.1059	-0.7472*
		(0.2258)	(0.2733)	(0.3136)	(0.3627)	(0.3291)	(0.4286)
	North East	-0.1658	-0.1959	-0.3861	-0.4395	0.0630	0.0698
		(0.1981)	(0.2285)	(0.2742)	(0.3108)	(0.2905)	(0.3413)
	North	-0.4007	-0.6901**	-0.3724	-0.4084	-0.4255	-1.0141**
	Western	(0.2569)	(0.3167)	(0.3850)	(0.4418)	(0.3540)	(0.4757)
	North	0.1038	-0.5307	-0.0764	-0.7277	0.2150	-0.3817
	Central	(0.2714)	(0.3468)	(0.3720)	(0.4711)	(0.4045)	(0.5202)
	Uva	-0.0714	0.7656**	-0.1335	-1.028**	0.0479	-0.3768
		(0.2782)	(0.3658)	(0.3743)	(0.5051)	(0.4228)	(0.5372)
	Sabaraga	-0.5610**	-1.6168***	-0.4666	-1.2477***	-0.6438*	-2.2233***
	muwa	(0.2542)	(0.3506)	(0.3623)	(0.4485)	(0.3645)	(0.6246)
Sectors	Rural	-0.2848*	-0.4555**	-0.2063	-0.4140	-0.4200*	-0.6043**
(urban=0)		(0.1684)	(0.2039)	(0.2292)	(0.2705)	(0.2525)	(0.3166)
	Estate	-0.3421	0.2734	-0.2901	0.3204	-0.5282	0.0508
		(0.3555)	(0.4042)	(0.4725)	(0.5383)	(0.5406)	(0.6199)
Scaled R^2		0.17		0.18		0.19	
Log likelihood		-1700.56		-898.81		-786.61	
Number of observations		1764		923		841	

* Significant at 0.1 level ** Significant at 0.05 level *** Significant at 0.01 level. n.a.: Not included in the analysis

Table 5. **The effect of explanatory variables on probabilities of the multinomial logitmodel (dependent variable: Under-nourished, Well-nourished and Over-nourished children)**

Levels	Variable	Pooled			Male children			Female children		
		Under-nourished	Well-nourished	Over-nourished	Under-nourished	Well-nourished	Over-nourished	Under-nourished	Well-nourished	Over-nourished
Constant		0.1957	-0.0752	-0.1205	0.1846	-0.1105	-0.0740	0.0206	0.0119	-0.2180
Child	Gender (Male=0)	-0.0002	0.0533	-0.0530	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Age	0.0061	0.0071	-0.0078	0.0065	0.0025	-0.0091	0.0055	0.0008	-0.0063
	Birth-weight	-0.0001	0.0000	0.0001	-0.0001	0.0000	0.0001	-0.0002	0.0000	0.0001
Mother	Age	-0.0017	0.0016	0.0000	-0.0061	0.0052	0.0008	0.0035	-0.0025	-0.0011
	Income	0.40D5	0.38D5	0.78D5	0.56D5	-0.02D3	0.02D3	-0.01D3	0.01D3	0.12D5
	Education level	-0.0050	0.0073	-0.0023	0.0007	0.0048	-0.0056	-0.0105	0.0100	0.0004
Household	Household income	-0.21D5	0.10D5	0.11D6	-0.23D5	0.10D5	0.13D5	0.24D5	0.15D5	0.95D6
	Household size	0.0089	-0.0067	-0.0022	0.0104	-0.0049	-0.0054	0.0067	-0.0084	0.0017
Provinces (western=0)	Southern	0.0171	0.0406	-0.0578	0.0458	0.0394	-0.0852	-0.0109	0.0383	-0.0273
	Central	0.0397	0.0305	-0.0702	0.0474	0.0073	-0.0547	0.0471	0.0511	-0.0982
	North East	0.0326	-0.0194	-0.0132	0.0759	-0.0451	-0.0308	-0.0117	0.0080	0.0037
	North Western	0.0900	-0.0241	-0.0659	0.0723	-0.0451	-0.0272	0.1029	0.0014	-0.1043
	North Central	0.0129	0.0813	-0.0942	0.0516	0.0599	-0.1115	-0.0132	0.0910	-0.0777
	Uva	0.0489	0.0636	-0.1126	0.0763	0.0785	-0.1549	0.0097	0.0502	-0.0599
	Sabaragamuwa	0.1593	0.0350	-0.1944	0.1327	0.0224	-0.1552	0.1857	0.0727	-0.2585
Sectors (urban=0)	Rural	0.0622	-0.0208	-0.0413	0.0508	-0.0048	-0.0459	0.0844	-0.0393	-0.0451
	Estate	0.0327	-0.1118	0.0791	0.0198	-0.1038	0.0839	0.0710	-0.1326	0.0616

Education level of mothers

Mother's educational level shows a significant positive relationship with Z scores, for the pooled and female children samples. Similar results were obtained from the multinomial logit models. Increases in mother's educational level increases the probability of being well-nourished and over-nourished as compared to the probability of being under-nourished for all children and female children. An increase in mother's educational level by one unit decreases the probabilities of belonging to under-nourished group by 0.5% and 1.05% for the pooled and female children samples, respectively (Table 5). However, this relationship is statistically insignificant for male children. These results imply that children, especially female children, with highly educated mothers have a lesser probability of being under-nourished (Table 5).

A similar pattern is identified by the World Bank (2005) and DCS (2005) for Sri Lanka, Smith and Haddad (2000 and 2001) for developing countries, and Behrman and Wolfe (1984) for Nicaragua. Thomas et al. (1990) found that mother's as well as father's education is positively associated with their child's height in Brazil. Pal (1999) found that higher female literacy help to increase nutritional status of male children in India.

Household income

Household income and the squared household income were included to capture whether there is a quadratic relationship between the household income and underweight in the multiple linear regression model. Results indicate that the relationship between household income and Z score is statistically significant for male children and has an inverted U shape. It indicates that increase in household income decreases malnutrition when the income is low, whereas further increase in incomes increases malnutrition when income is high, for male children. According to the results from the multinomial logit models, household income does not have any effect on the probability of being under-nourished for female and male children models. However, it shows a small positive effect on being over-nourished (Table 5).

These results are somewhat consistent with Ratnayake and Weerahewa (2005), which show a positive relationship between income and calorie adequacy among low-income households in Sri Lanka. According to Smith and Haddad (2001), national food availability has a declining marginal effect on malnutrition, suggesting the importance of improving food availability for lower income countries/groups of households. Behrman and Wolfe (1984) revealed that income elasticities of nutrition demand are small and they are inversely associated with income levels in Nicaragua. Pal (1999) found that higher per capita income help to increase nutritional status of male and female children in India.

Family size

The relationship between family size and the Z score is not statistically significant in the multiple linear regression models, though the relationship has negative signs in all 3 specifications (Table 3). The results from the multinomial logit model for all children show that the probability of being under-weight is higher in larger families. An increase in family size by one unit increases the probability of belonging to the under-nourished group by 0.89% for the pooled sample (Table 5). However, according to the results from the multinomial logit models for male and female children, family size does not have a significant effect on the probability of being under-weight or well-nourished. Previous studies however show that the relationship between family size and malnutrition as positive, indicating some economies of size (Behrman and Wolfe, 1984).

Regional characteristics

The dummy variables that represents the provinces of residence, which treats Western as the base province, indicates that on average, children in the North-Western and Sabaragamuwa, male children in Uva and Sabaragamuwa, and female children in Sabaragamuwa have significantly lower Z scores as compared to those in the Western province. In all specifications, rural sector have significantly lower Z scores than in the urban and estate sectors except for male children.

In terms of the probability of malnutrition, the children in Sabaragamuwa province have lower probabilities of being well-nourished and children in Central, North West and Sabaragamuwa have lower probabilities of being over-weight compare to those who live in the Western province. The probabilities of children belonging to under-nourished group, compared to those who reside in Western province, are 15.93%, 9.00%, 4.89% and 3.97% for Sabaragamuwa, North-West, Uva and Central provinces respectively for the pooled sample. The probability of child in the rural sector belonging to under-nourished group, compared to that of urban sector, is 6.22% for the pooled sample (Table 5).

Male children in Uva and Sabaragamuwa provinces have lower probabilities of being over-nourished as compared to those who live in the Western province. Female children in almost all the provinces have lower probabilities of being over-nourished as compared to those who live in the Western province. All children, especially female children in rural sector, have lower probabilities of being well-nourished or over-nourished.

Prevalence of malnutrition in Sabaragamuwa, North Western, Uva, and Central provinces are probably due to poor infrastructure such as roads, electricity, access to drinking water etc. as compared to those in the Western province.

CONCLUSIONS AND POLICY IMPLICATIONS

In summary, the results reveal that higher incidence, depth and severity of underweight children are recorded in the Sabaragamuwa province and in the rural sector in Sri Lanka. The results from the multiple linear regression models and multinomial logit models show that major determinants of the status of malnutrition among pre-school children are area of residence, household size, age of the child, mother's education, birth-weight of child and household income.

These results lead to important conclusions and policy implications. First, the results show that the regional characteristics are important determinants of child malnutrition in Sri Lanka highlighting the necessity for provision of infrastructure to the needy areas such as Sabaragamuwa, North West and Uva provinces, especially for the rural areas. Second, the results show that child malnutrition is prevalent in larger families and among older children in the pre-school age. These results indicate that, such households and children should be especially targeted in providing government transfers. Third, the results show that when mothers are educated, the children are less prone to be malnourished, suggesting the importance of providing education to females. Fourth, a positive relationship between birth-weight of children and the degree of malnutrition is observed indicating the importance of a proper nutritional status of the pregnant mothers at the stage of pregnancy as it determines the health status of the newborn. Fifth, the results show a positive, though small, contribution from household income in alleviating malnutrition, indicating the need to implement policies to raise household income. Finally, over-nutrition might be an emerging problem in Sri Lanka, particularly among high-income families in Western province. Further studies will be necessary to address other aspects of malnutrition as measured by stunting and wasting and contribution of government transfers, specific infrastructure needs and parental characteristics etc. and their interaction effects, in alleviating malnutrition.

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