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# The Determinants of Child Weight and Height in Sri Lanka

## A Quantile Regression Approach

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**Abstract**

Reducing child malnutrition is a key goal of most developing countries. To combat child malnutrition with the right set of interventions, policymakers need to have a better understanding of its economic, social and policy determinants. While there is a large literature that investigates the determinants of child malnutrition, it focuses almost exclusively on mean effects of these determinants. However, socioeconomic background variables and policy interventions may affect child nutrition differently at different points of the conditional nutritional distribution. Using quantile regressions, this paper explores the effects of variables such as a child's age, sex and birth order; household expenditure per capita; parental schooling; and infrastructure on child weight and height at different points of the conditional distributions of weight and height using

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Keywords: child health, child nutrition, malnutrition, child weight, child height, quantile regression, Sri Lanka

JEL classification: D12, D13, I12, O12



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data from Sri Lanka's Demographic and Health Survey. Results indicate that OLS estimates can be misleading in predicting the effects of determinants at the lower end of the distributions of weight and height. For example, even though on average Sri Lankan girls are not nutritionally-disadvantaged relative to boys, among children at the highest risk of malnutrition girls are disadvantaged relative to boys. Likewise, although expenditure per capita is associated with strong nutritional improvement on average, it is not a significant determinant of child height or weight at the lower end of the distribution. Similarly, parental education, electricity access, and the availability of piped water have larger effects on child weight and height at the upper quantiles than at the lower quantiles. The policy implication is that general interventions—parental schooling, infrastructure and income growth—are not as effective for children in the lower tail of the conditional weight and height distributions. These children, who are at the highest risk of malnutrition, are likely to need specialized nutritional interventions.

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## 1 Introduction

Reducing child malnutrition is a key goal of most developing countries. A number of studies have documented the wide range of adverse economic and social consequences of child malnutrition. For instance, malnutrition during infancy and childhood substantially raises vulnerability to infection and disease, and increases the risk of premature death. It is also believed to impair cognitive achievement, labour productivity during adulthood, and lifetime earnings.[1] Thus, combating child malnutrition is of central importance to the economic and social welfare of countries.

To combat child malnutrition with the right set of interventions, policymakers need to have a better understanding of its economic, social, and policy determinants. While there have been several studies that have analyzed the socioeconomic correlates of child nutrition,[2] they suffer from two major shortcomings. First, they do not focus enough on indirect policy interventions, such as improved infrastructure, that could have as large effects on child nutrition as direct nutritional interventions (such as food supplementation schemes). Second and more importantly, previous studies have almost exclusively concerned themselves with estimating the mean effect on child nutrition of variables such as a child's sex, the schooling of its mother, and household income. Such estimates miss a point that is crucial for policymakers, namely, that socioeconomic background variables and policy interventions may affect child nutrition differently at different points of the conditional nutritional distribution. For example, while some interventions may not matter for child nutrition 'on average', they may matter a great deal for children at the bottom of the conditional nutritional distribution (i.e., children at the highest risk of malnutrition).

This paper attempts to address these shortcomings of the existing literature. Using data from Sri Lanka, we estimate quantile regressions to analyze the socioeconomic and policy determinants of child nutrition at different points of the conditional distribution of child nutrition. This allows us to address not only the question, 'can policy influence child nutrition?' but, more importantly, the question, 'for whom do policy interventions matter the most?' To our knowledge, no previous study has addressed the latter question.

## 2 Child malnutrition in Sri Lanka

Child malnutrition in Sri Lanka is very high. Nearly one in three children aged 3-59 months is underweight, and about one in seven children in this age group suffers

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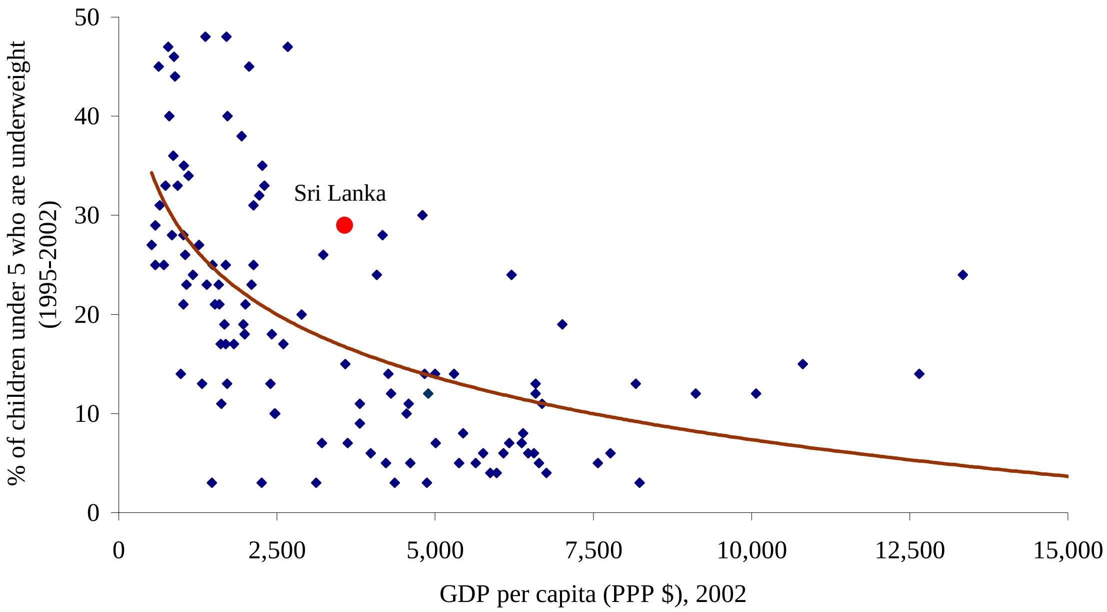
1 See Behrman (1992) for an exhaustive survey of this literature. Studies that suggest direct labour productivity and/or wage effects of anthropometric indicators of health and nutrition include Strauss (1986), Deolalikar (1988), Sahn and Alderman (1988), Behrman and Deolalikar (1989b), and Haddad and Bouis (1991). Behrman and Lavy (1994) also find effects on cognitive achievement.

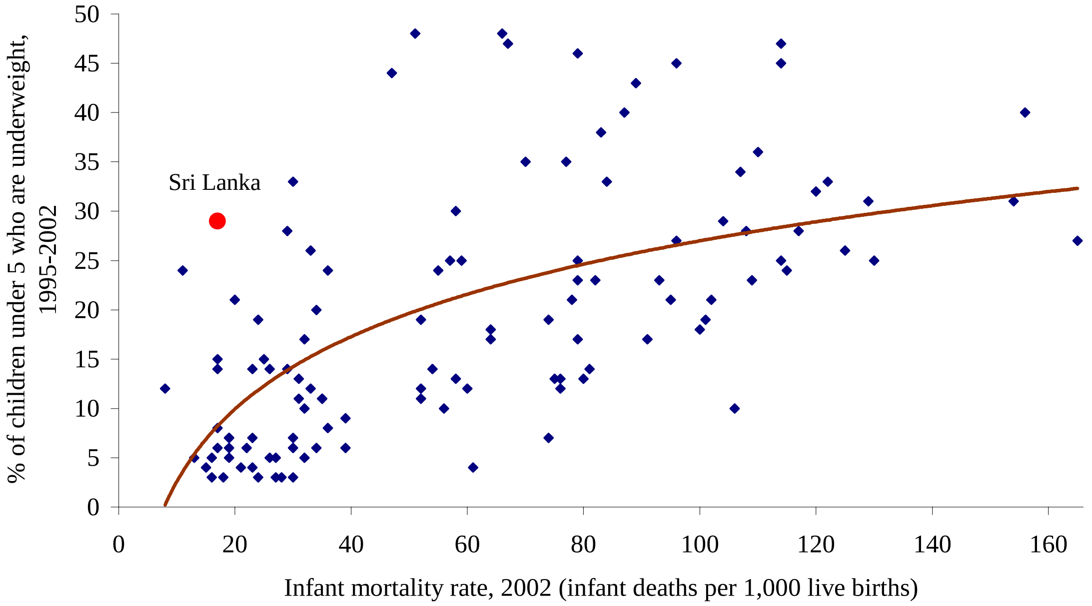
2 See Behrman and Deolalikar (1988) and Strauss and Thomas (1995) for recent surveys. Some of the individual studies include Akin, Guilkey and Popkin (1990), Barrera (1990a, 1990b), Behrman and Deolalikar (1989a), Behrman and Wolfe (1987), Cebu Study Team (1989), Haddad et al. (2003), Horton (1988), Sahn (1989), Stifel and Alderman (2003), Strauss (1990), Thomas, Strauss and Henriques (1990, 1991), Thomas, Lavy and Strauss (1996), and Wolfe and Behrman (1987).

Figure 1
Relationship between child underweight rates (1995-2002) and GDP per capita (2002) across a cross-section of low- and medium-human development countries




Source: Computed by authors using data from UNDP (2002).

Figure 2
Relationship between the per cent of children under 5 who were underweight in 1995-2002 and the infant mortality rate in 2002 across a cross-section of low- and medium-human development countries




Source: Computed by authors using data from UNDP (2002).

chronic or acute malnutrition.[3] An international comparison of child malnutrition rates relative to per capita income, based on cross-sectional data for 2002 on 113 low- and middle-income countries (UNDP 2000), shows that Sri Lanka has a significantly higher child underweight rate than would be expected on the basis of its per capita GDP (Figure 1). This is in sharp contrast to Sri Lanka's celebrated performance on other social indicators, such as primary education enrolment, adult literacy, infant mortality and life expectancy, where the country performs well above the levels that would normally be expected at its level of per capita income. Indeed, Figure 2 indicates that Sri Lanka has a child underweight rate that may be three times as high as what would be expected of a country with its level of infant mortality. There is thus a big disconnect between Sri Lanka's performance on child health and its performance on child malnutrition. This incongruence is difficult to understand as most factors that are associated with low rates of infant and child mortality (e.g., delivery and utilization of high-quality health services, high female literacy, and good hygiene and health practices) typically also influence child malnutrition rates.

## 3 Data

The data for this paper are drawn from the 2000 round of the demographic and health survey (DHS). The DHS 2000 is the sixth in a series of surveys conducted by Sri Lanka's Department of Census and Statistics since 1975 to collect data on fertility, family planning and other reproductive health information (DCS 2002). The survey is based on a multi-stage stratified sample of nearly 8,000 households (and 6,385 women in childbearing years), and provides anthropometric data for 2,576 children under 5 years of age, as well as information on the health of children and mothers, schooling and work (occupation) of both parents, and hygiene, feeding and contraception practices. In addition, the survey includes questions on housing conditions, access to safe drinking water, and sanitation. One shortcoming of all DHS surveys is that they do not contain information on household income or expenditure; however, detailed data are available on asset ownership and characteristics of dwellings, which are used to construct a measure of living standards in this paper.[4]

## 4 Child malnutrition patterns

The DHS data indicate that about 29 per cent of children 3-59 months are moderately or severely underweight (Table 1).[5] A smaller, but still unacceptably high, proportion (14 per cent) of children in this age group suffer from stunting and wasting. These findings imply that children suffer from short-term acute food deficits, reflected in low weight

3 As in the nutritional literature, a child is considered underweight when his or her weight-for-age is more than two standard deviations below the NCHS/WHO reference weight. A child is stunted when his or her height-for-age is more than two standard deviations below the NCHS/WHO reference. A child is said to be severely malnourished when the relevant nutritional indicator is more than three standard deviations below the NCHS/WHO reference.

4 See the Appendix.

5 Throughout this report, data on child malnutrition rates are reported only for children aged 3 months or older. As seen below in Table 2, child malnutrition in Sri Lanka, as in most other countries, only sets in after the age of 6 months, when children are weaned from exclusive breast-feeding.

for age, as well as longer-term chronic under-nutrition, manifested in high rates of stunting.

Malnutrition for a large proportion (about a fifth) of children begins after the six month of life (Table 2). Reasons for this include low-birth weights, inadequate breast-feeding, poor weaning practices and insufficient consumption of nutritious food. The risk of malnutrition increases sharply in the second year of life (beginning at age 12 months), when most children stop breastfeeding and begin relying almost exclusively on solid foods. The insufficiency and inadequacy of weaning diets in Sri Lanka increases the risk of malnutrition among infants.

Rates of moderate child malnutrition are fairly similar across boys and girls (Table 2). However, severe malnutrition shows significant gender differences, with girls having a 40 per cent and 70 per cent greater likelihood of being severely stunted and underweight, respectively, than boys (Table 2). Of course, rates of severe malnutrition are significantly lower than that of moderate malnutrition among both boys and girls.

Table 1
Malnutrition rates (%) of children aged 3-59 months, 2000

| Indicator | Underweight (weight for age) | | Stunting (height for age) | |
|---|---|---|---|---|
| Moderate or severe | 29 | (1.03) | 14 | (0.76) |
| Severe | 5 | (0.46) | 3 | (0.37) |

Note: The malnutrition rates reported here cover seven of the eight provinces, excluding the conflict affected North-Eastern Province, where the DHS could not be conducted in 2000. Standard errors in parentheses.

Source: Calculations from DCS-DHS (2000).

Table 2
Child malnutrition rates by age and sex, 2000

| Age in months | Moderate or severe malnutrition | | | | Severe malnutrition | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight for age | | Height for age | | Weight for age | | Height for age | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| 3-5 | 0.90 | 0.00 | 6.12 | 1.83 | 0.90 | 0.00 | 3.23 | 1.83 |
| | (0.90) | (0.00) | (2.98) | (1.81) | (0.90) | (0.00) | (2.27) | (1.81) |
| 6-11 | 23.50 | 14.54 | 6.17 | 5.02 | 1.71 | 4.30 | 1.64 | 1.76 |
| | (3.59) | (3.93) | (2.04) | (2.39) | (0.99) | (2.49) | (1.10) | (1.74) |
| 12-23 | 30.57 | 26.87 | 11.74 | 21.53 | 5.04 | 4.27 | 2.89 | 3.76 |
| | (3.21) | (3.09) | (2.19) | (2.85) | (1.58) | (1.30) | (1.14) | (1.28) |
| 24-35 | 31.95 | 36.26 | 10.54 | 14.47 | 4.5 | 7.09 | 1.74 | 4.41 |
| | (3.23) | (3.75) | (2.02) | (2.41) | (1.34) | (1.71) | (0.90) | (1.41) |
| 36-47 | 26.69 | 35.23 | 12.02 | 14.76 | 1.72 | 7.59 | 1.03 | 2.84 |
| | (3.08) | (3.49) | (2.18) | (2.48) | (0.80) | (1.89) | (0.58) | (1.01) |
| 48-59 | 38.20 | 37.47 | 18.95 | 19.28 | 3.99 | 6.93 | 4.43 | 3.49 |
| | (3.51) | (3.64) | (2.81) | (2.98) | (1.31) | (1.93) | (1.37) | (1.46) |
| All | 29.04 | 29.81 | 11.90 | 15.34 | 3.37 | 5.80 | 2.41 | 3.35 |
| | (1.43) | (1.51) | (0.99) | (1.17) | (0.54) | (0.75) | (0.46) | (0.58) |

Note: Standard errors in parentheses.

Source: Calculations from DCS-DHS (2000).

Table 3
Child malnutrition rates by birth order and sex, 2000

| Child's birth other | Moderate or severe malnutrition | | | | Severe malnutrition | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight for age | | Height for age | | Weight for age | | Height for age | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Firstborn | 23.50<br>(2.00) | 25.46<br>(2.16) | 8.55<br>(1.27) | 10.42<br>(1.46) | 3.27<br>(0.84) | 4.96<br>(1.62) | 1.32<br>(0.51) | 2.25<br>(0.70) |
| Second | 31.97<br>(2.62) | 30.87<br>(2.73) | 11.41<br>(1.71) | 16.03<br>(2.20) | 2.14<br>(1.01) | 5.30<br>(0.71) | 2.10<br>(0.75) | 3.56<br>(1.09) |
| 3-5 | 35.21<br>(3.22) | 36.28<br>(3.38) | 18.85<br>(2.67) | 23.53<br>(2.90) | 4.37<br>(1.26) | 8.02<br>(1.27) | 4.12<br>(1.28) | 4.81<br>(1.45) |
| 6th and over | 48.16<br>(11.74) | 47.79<br>(13.07) | 25.07<br>(10.03) | 33.88<br>(12.76) | 15.88<br>(8.61) | 10.00<br>(9.32) | 15.88<br>(8.62) | 11.77<br>(9.34) |
| All | 29.04<br>(1.43) | 29.81<br>(1.51) | 11.90<br>(0.99) | 15.34<br>(1.17) | 3.37<br>(0.54) | 5.80<br>(0.75) | 2.41<br>(0.46) | 3.35<br>(0.58) |

Note: Standard errors in parentheses.
Source: Calculations from DCS-DHS (2002).

There is a very clear pattern of child malnutrition rates increasing with the birth order of children (Table 3). For sixth- and higher-order children, the risk of malnutrition is nearly two times as large as that for first-born children. In the case of stunting, gender appears to interact with birth order, such that higher order girls have a significantly greater likelihood of being stunted than higher order boys.

## 5 Model

The focus of this paper is on the reduced-form demand relations for child weight and height as dependent on income and other child, household and community characteristics. Such relations are consistent with constrained maximization of an unified preference function or with the bargaining framework emphasized by Folbre (1984a, 1984b, 1986), Manser and Brown (1980), and McElroy and Horney (1981). In either case, household preferences are defined over levels of and changes in various child anthropometric indicators, and the constraints typically include a budget or income constraint and biological child growth production functions that characterize the 'production' of weight or height in anthropometric indicators from food consumption, unobserved endowments of a child, the state of health technology (embodied in, say, the education of the health-care provider at home—typically, the mother), and on various environmental influences (such as the availability of clean drinking water).

The household maximization process results in a system of reduced-form demand equations for weight and height as well as derived demand equations for food consumption. These reduced-form equations have as arguments food and other prices, household income, child characteristics, and relevant family- and location-specific environmental variables.

The previous literature has typically estimated these reduced-form equations for the average child (i.e., at the conditional mean levels of child weight or height). However, since the objective of policy is to improve the nutritional status of malnourished children, it may be more meaningful to investigate the effect of income and other interventions on child anthropometry at the lowest quantiles of the child weight or height distribution. In this paper, we estimate the reduced-form child anthropometry equations at different points of the dependent variable's conditional distribution, using the quantile regression technique. The quantile regression technique was initially developed as a 'robust' regression technique that would allow for estimation where the typical assumption of normality of the error term might not be strictly satisfied (Koenker and Bassett 1978). More recently, it has been used to understand the relationship between the dependent and independent variables over the entire distribution of the dependent variable, not just at the conditional mean (Buchinsky 1994, 1995; Eide and Showalter 1998).

Our dependent variables are the z-scores of height and weight—that is, the number of standard deviations that a child is below (or above) the NCHS/WHO reference weight for his/her age and sex. A child is typically considered moderately malnourished (underweight or stunted) when his/her weight or height is more than two standard deviations below the NCHS/WHO reference. Severe malnutrition is said to occur when the relevant nutritional indicator is more than three standard deviations below the NCHS/WHO reference.

The independent variables include a number of child-level characteristics, such as a child's birth order, age (represented by dummy variables for six discrete age categories: 0-5, 6-11, 12-23, 24-35, 36-47 and 48-59 months), and sex.[6] In addition, the model includes several household-level variables, including log household expenditure per capita,[7] mother's and father's schooling (represented by four discrete schooling categories), ethnicity (whether Sinhalese; Sri Lankan Tamil; Indian Tamil; or Moor, Malay, Burgher, and other), access to piped water, and availability of a flush toilet. Another infrastructure variable—access to electricity—is captured at the provincial-level by the number of electricity connections per capita in a province.

The model is estimated using the least-absolute value minimization technique described by Koenker and Bassett (1978). Because of the potential non-independence of the error term, the errors in the deciles may be heteroscedastic, and the quantile regression variances may be biased. Therefore, bootstrap estimates of the asymptotic variances of the quantile coefficients are calculated with 100 repetitions (see, e.g., Efron 1979; Chamberlain 1994) and are used in the reported asymptotic t-ratios.

## 6 Results

The quantile regression estimates of child weight are reported in Table 4, while those for child height are reported in Table 5. For comparison purposes, we also report OLS estimates in both tables.

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6 Interactions between the age dummies and sex were included but were generally not significant, suggesting that the age-profile of z-scores does not differ significantly across boys and girls.

7 The DHS data do not collect expenditure or income data. We have made use of the availability of identical variables to those found in the DHS (household size and composition, housing characteristics, ownership of assets, and location) as well as expenditure data in the Sri Lanka Integrated Survey (SLIS) 1999-2000 to predict log expenditure per capita for the DHS sample using the estimated coefficients from a log per capita expenditure function estimated using the SLIS data. Details are given in the Appendix.

First, consider the weight results. The OLS estimates indicate strong age effects, with z-scores declining with age. While sex does not appear to significantly influence child weight, birth order does. Even after controlling for age, higher birth-order children have lower weights than lower birth-order children. Among the household-level variables, log expenditure per capita has a significant effect on weight, with a 1 per cent increase in per capita expenditure being associated with an increase of about 0.1 in the z-score. Both father's and mother's schooling have significant effects, but only at higher levels of schooling (typically completion of GCE O- or A-levels or equivalent). Access to piped water and electricity has strong positive effects. Indian Tamils are at significantly higher risk of being undernourished relative to other groups.

The quantile regression results suggest important differences at different points in the conditional distribution of weight. At the lower end of the distribution, the coefficients on the sex variable are large, significant and negative; however, they are insignificant at the 0.75 and 0.95 quantiles. Insofar as the dependent variable is already standardized for sex- and age-differences, the result is indicative of intra-household gender discrimination (in the allocation of food) at the bottom of the conditional distribution of weight but not at the top.

Another interesting finding is the significance of birth order in the middle of the conditional distribution (the 0.25, 0.50 and 0.75 quantiles), but not at the very bottom (0.10) and the very top (0.90), of weight. It is unclear why this would be the case.

Yet another notable result is the complete absence of significant income (expenditure) effects on weight at all but the 0.90 quantile and above. The estimated coefficient on per capita expenditure is not only significant but also quite large at this point of the conditional weight distribution (0.19 standard deviation for a 1 per cent increase in household expenditure per capita). This result, while rather surprising and counter-intuitive, has an important policy implication, viz., that policy interventions that aim to increase household incomes (e.g., stronger economic growth and the income support component of the *Samurdhi* programme)[8] are unlikely to be effective in improving the weights of children at the lower end of the conditional weight distribution.

The results with respect to parental schooling also suggest a similar story. Of the eight dummy variables included for father's and mother's schooling, only one has a significant coefficient at the 0.10 quantile. In contrast, four of the dummy variables have significant coefficients at the 0.90 quantile. Having a mother who has completed GCE A-level or equivalent level of schooling is associated with no significant increase in the weight of a child at the 10th quantile and with increases of 0.27, 0.35, 0.39 and 1.12 standard deviations at the 0.25, 0.50, 0.75 and 0.90 quantiles, respectively. Thus, the 'beneficial' effect of maternal schooling on weight accrues disproportionately to children in the upper tail of the conditional weight distribution.

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8 Under the *Samurdhi* programme, the government provides an income supplement of between Rs 500-1,000, depending upon family size and household poverty level, which can be used to purchase food items, such as grains, cereals and legumes. In addition, the program has officers trained in maternal and child nutrition and infant care who wok with target groups, such as pregnant women, lactating mothers and undernourished children, to help improve nutrition levels.

Table 4
OLS and quantile regressions for child weight (z-score), 2000

| | | | Quantile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OLS | | 0.10 | | 0.25 | | 0.50 | | 0.75 | | 0.90 | |
| Independent variable | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| Whether child is aged:[a] | | | | | | | | | | | | |
| 6-11 months?* | **-0.535** | -4.81 | **-0.793** | -6.54 | **-0.638** | -4.50 | **-0.622** | -4.44 | **-0.490** | -3.34 | -0.264 | -0.92 |
| 12-23 months?* | **-1.032** | -10.18 | **-0.968** | -8.09 | **-1.003** | -6.71 | **-1.040** | -8.35 | **-1.036** | -7.29 | **-1.127** | -6.05 |
| 24-35 months?* | **-1.085** | -10.83 | **-1.265** | -10.01 | **-1.046** | -6.84 | **-1.089** | -8.76 | **-0.977** | -6.46 | **-1.049** | -5.64 |
| 35-47 months?* | **-1.035** | -10.29 | **-0.935** | -8.57 | **-0.887** | -6.10 | **-1.038** | -8.77 | **-0.994** | -6.93 | **-1.192** | -6.80 |
| 48-59 months?* | **-1.085** | -10.67 | **-1.053** | -9.27 | **-0.999** | -6.86 | **-1.115** | -9.34 | **-0.954** | -5.81 | **-1.097** | -5.60 |
| Whether child is female?* | -0.054 | -1.24 | **-0.124** | -2.02 | **-0.118** | -2.15 | **-0.087** | -1.69 | -0.054 | -1.03 | 0.079 | 0.97 |
| Birth order of child | **-0.044** | -2.27 | -0.034 | -1.00 | **-0.056** | -2.79 | **-0.049** | -2.20 | **-0.082** | -2.68 | -0.040 | -0.94 |
| Predicted log household expenditure per capita** | **0.093** | 2.21 | 0.007 | 0.15 | 0.073 | 1.44 | 0.092 | 1.43 | 0.066 | 1.08 | **0.190** | 2.17 |
| Whether child's father has:[b] | | | | | | | | | | | | |
| Primary schooling?* | 0.032 | 0.28 | 0.187 | 1.10 | 0.196 | 1.44 | -0.056 | -0.35 | -0.023 | -0.11 | -0.190 | -0.82 |
| Secondary schooling?* | 0.028 | 0.24 | 0.207 | 1.08 | **0.257** | 1.69 | -0.015 | -0.10 | -0.056 | -0.28 | -0.359 | -1.53 |
| GCE O/L or equivalent?* | 0.015 | 0.11 | 0.270 | 1.37 | 0.253 | 1.64 | -0.035 | -0.22 | 0.003 | 0.02 | **-0.558** | -2.55 |
| GCE A/L or equivalent?* | **0.245** | 1.77 | **0.433** | 1.90 | **0.448** | 2.65 | 0.193 | 1.10 | 0.184 | 0.81 | -0.189 | -0.68 |
| Whether child's mother has:[b] | | | | | | | | | | | | |
| Primary schooling?* | -0.045 | -0.41 | -0.146 | -1.46 | 0.055 | 0.37 | -0.008 | -0.07 | -0.146 | -0.88 | 0.105 | 0.54 |
| Secondary schooling?* | 0.161 | 1.49 | -0.052 | -0.51 | 0.169 | 1.26 | 0.156 | 1.39 | 0.059 | 0.38 | **0.375** | 1.97 |
| GCE O/L or equivalent?* | **0.238** | 1.94 | -0.018 | -0.14 | 0.221 | 1.41 | **0.311** | 2.40 | 0.119 | 0.64 | **0.516** | 2.22 |
| GCE A/L or equivalent?* | **0.400** | 3.00 | 0.084 | 0.62 | **0.274** | 1.66 | **0.349** | 2.46 | **0.389** | 2.12 | **1.124** | 4.57 |
| No of electrical connections per capita in province of residence | **1.309** | 3.17 | **0.843** | 1.91 | 0.713 | 1.39 | **1.123** | 2.30 | **1.816** | 3.16 | **2.393** | 3.06 |
| Whether household has flush toilet in home? | 0.083 | 1.49 | 0.083 | 1.20 | 0.038 | 0.60 | **0.121** | 2.01 | 0.070 | 1.02 | 0.061 | 0.59 |
| Whether household has piped water? | **0.208** | 3.53 | **0.202** | 2.78 | **0.249** | 3.73 | **0.149** | 2.09 | **0.215** | 2.21 | **0.322** | 2.68 |
| Whether household belongs to following ethnic group:[c] | | | | | | | | | | | | |
| Sri Lankan Tamil | -0.073 | -0.73 | -0.167 | -1.12 | -0.051 | -0.35 | -0.019 | -0.16 | -0.069 | -0.49 | -0.355 | -1.45 |
| Indian Tamil | **-0.228** | -2.73 | **-0.318** | -2.74 | **-0.272** | -2.26 | **-0.262** | -2.60 | -0.175 | -1.54 | **-0.351** | -2.93 |
| Moor, Malay, Burgher and other | 0.059 | 0.71 | **0.176** | 1.96 | 0.139 | 1.35 | 0.023 | 0.25 | 0.113 | 0.84 | -0.047 | -0.30 |
| Intercept | **-2.076** | -5.19 | **-2.350** | -4.84 | **-2.459** | -4.73 | **-1.965** | -3.34 | **-1.402** | -2.28 | **-1.998** | -2.40 |
| Number of observations | 2,423 | | 2,423 | | | | | | | | | |
| R-squared | 0.15 | | 0.08 | | 0.08 | | 0.09 | | 0.09 | | 0.12 | |

Note: Asymptotic t-ratios are shown above (heteroskedasticity robust for OLS; bootstrapped for quantiles). Figures in bold indicate statistically significance of the estimated coefficient at the 10% or lower level. * Dichotomous variable. ** See Appendix for a discussion of how the predicted per capita expenditure variable was generated; [a] Excluded category is 3-5 months; [b] Excluded category is no schooling; [c] Excluded category is Sinhalese.

Table 5
OLS and Quantile Regressions for Child Height (z-score), 2000

| | | | Quantile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OLS | | 0.10 | | 0.25 | | 0.50 | | 0.75 | | 0.90 | |
| Independent variable | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| Whether child is aged:(a | | | | | | | | | | | | |
| 6-11 months?* | -0.205 | -1.58 | -0.331 | -1.33 | -0.089 | -0.45 | **-0.342** | -2.38 | **-0.294** | -1.82 | 0.021 | 0.08 |
| 12-23 months?* | **-0.772** | -6.47 | **-0.745** | -3.57 | **-0.701** | -3.62 | **-0.736** | -5.12 | **-0.854** | -5.77 | **-0.600** | -2.43 |
| 24-35 months?* | **-0.498** | -4.21 | **-0.519** | -2.26 | **-0.426** | -2.28 | **-0.530** | -3.95 | **-0.578** | -3.71 | -0.333 | -1.40 |
| 35-47 months?* | **-0.662** | -5.61 | **-0.463** | -1.97 | **-0.428** | -2.37 | **-0.639** | -4.87 | **-0.807** | -5.72 | **-0.583** | -2.43 |
| 48-59 months?* | **-0.735** | -6.19 | **-0.656** | -3.00 | **-0.625** | -3.42 | **-0.761** | -5.91 | **-0.817** | -5.07 | **-0.541** | -2.16 |
| Whether child is female?* | -0.078 | -1.53 | **-0.169** | -1.90 | **-0.145** | -2.16 | -0.083 | -1.65 | -0.025 | -0.39 | 0.060 | 0.65 |
| Birth order of child | **-0.077** | -3.36 | **-0.173** | -4.46 | **-0.099** | -3.31 | **-0.079** | -2.86 | **-0.060** | -1.83 | **-0.071** | -1.98 |
| Predicted log household expenditure per capita** | **0.106** | 2.11 | 0.065 | 0.74 | **0.103** | 1.68 | 0.090 | 1.54 | **0.174** | 2.67 | 0.052 | 0.60 |
| Whether child's father has:(b | | | | | | | | | | | | |
| Primary schooling?* | 0.137 | 1.02 | 0.416 | 1.55 | 0.269 | 1.49 | 0.090 | 0.60 | -0.166 | -0.62 | -0.143 | -0.43 |
| Secondary schooling?* | 0.178 | 1.32 | **0.462** | 1.69 | 0.266 | 1.29 | 0.192 | 1.30 | -0.037 | -0.14 | -0.196 | -0.58 |
| GCE O/L or equivalent?* | 0.178 | 1.17 | 0.498 | 1.62 | 0.200 | 0.92 | 0.229 | 1.29 | -0.038 | -0.13 | -0.011 | -0.03 |
| GCE A/L or equivalent?* | **0.418** | 2.57 | **0.568** | 1.89 | **0.417** | 1.76 | **0.351** | 1.80 | 0.091 | 0.28 | 0.280 | 0.76 |
| Whether child's mother has:(b | | | | | | | | | | | | |
| Primary schooling?* | -0.034 | -0.27 | -0.068 | -0.34 | -0.093 | -0.69 | -0.059 | -0.40 | 0.052 | 0.40 | 0.154 | 0.59 |
| Secondary schooling?* | 0.045 | 0.35 | -0.061 | -0.29 | -0.006 | -0.05 | -0.009 | -0.06 | 0.163 | 1.37 | 0.189 | 0.74 |
| GCE O/L or equivalent?* | 0.131 | 0.91 | -0.009 | -0.04 | 0.152 | 0.89 | 0.214 | 1.24 | **0.257** | 1.78 | 0.164 | 0.58 |
| GCE A/L or equivalent?* | 0.239 | 1.52 | 0.061 | 0.26 | 0.149 | 0.84 | 0.210 | 0.99 | **0.462** | 2.36 | 0.448 | 1.48 |
| No of electrical connections per capita in province of residence | 0.421 | 0.86 | -0.131 | -0.16 | 0.006 | 0.01 | 0.483 | 0.91 | 0.924 | 1.50 | 0.961 | 1.08 |
| Whether household has flush toilet in home? | **0.156** | 2.35 | 0.150 | 1.33 | **0.171** | 1.93 | **0.128** | 2.04 | **0.123** | 1.81 | 0.046 | 0.38 |
| Whether household has piped water? | **0.180** | 2.58 | 0.177 | 1.50 | **0.181** | 2.51 | **0.177** | 2.04 | **0.227** | 2.61 | **0.356** | 2.51 |
| Whether household belongs to following ethnic group:(c | | | | | | | | | | | | |
| Sri Lankan Tamil | -0.125 | -1.06 | -0.196 | -1.10 | -0.120 | -0.77 | -0.099 | -0.56 | **-0.247** | -1.87 | -0.316 | -1.40 |
| Indian Tamil | **-0.656** | -6.66 | **-0.731** | -5.09 | **-0.696** | -5.97 | **-0.746** | -5.36 | **-0.555** | -4.23 | **-0.736** | -4.35 |
| Moor, Malay, Burgher and other | **0.178** | 1.82 | **0.299** | 2.17 | 0.107 | 1.04 | 0.116 | 0.97 | 0.088 | 0.85 | -0.013 | -0.07 |
| Intercept | **-1.497** | -3.15 | **-2.120** | -2.41 | **-1.988** | -3.34 | **-1.366** | -2.42 | **-1.439** | -2.43 | -0.080 | -0.09 |
| Number of observations | 2,314 | | 2,314 | | | | | | | | | |
| | 14.73 | | | | | | | | | | | |

Note: See notes to Table 4.

The empirical results show access to electricity having significant effects on weight throughout the conditional weight distribution. However, as with expenditure per capita and parental schooling, electricity access has disproportionately larger nutritional effects in the upper than in the lower end of the conditional weight distribution. For instance, a one unit increase in the number of electricity connections per capita in a province is associated with an increase of 0.8 standard deviations in weight at the 0.10 quantile, 1.1 standard deviations at the 0.50 quantile, and 2.4 standard deviations at the 0.90 quantile. Thus, the effect of electricity access on child weight is three times as large at the 0.90 as at the 0.10 quantile.

The results with respect to child height are broadly similar, with the major difference being that electricity access appears to have no significant effect on child height at any quantile. On the other hand, access to a flush toilet has significant effects on height, but not on weight. The effects of household expenditure per capita and parental schooling are generally less pronounced for height than for weight. The results also suggest that being Indian Tamil is more strongly negatively related with child height than with child weight at all points of the conditional weight distribution.

## 7 Concluding remarks and policy implications

Using quantile regressions, this paper has explored the effects of variables such as a child's age, sex and birth order; household expenditure per capita; parental schooling; and infrastructure on child weight and height at different points of the conditional distributions of weight and height. We find that OLS estimates of the determinants of child weight and height, which effectively estimate the effects of intervention variables at the mean, can be misleading. For instance, the OLS estimates do not indicate the presence of intra-household gender discrimination in the allocation of nutritional inputs; however, the quantile regressions show evidence of discrimination against girls at the lower end of the weight and height distribution. In other words, even though on average Sri Lankan girls are not nutritionally-disadvantaged relative to boys, among children at the highest risk of malnutrition, girls are disadvantaged relative to boys. Policy interventions to address child malnutrition need to be sensitive to this reality, and need to especially target girls at high risk of undernutrition.

Likewise, OLS estimates of the income effect on child weights and heights can also be misleading. While such estimates would lead one to believe that increases in income are associated with strong nutritional improvements, the quantile regressions indicate that this is generally true only at the upper end of the conditional weight and height distributions (0.75 and 0.90 quantiles). Over much of the lower end of the distributions, household expenditure per capita is not a significant determinant of child weight or height. What this means is that income-generating interventions, while very important for a number of other social outcomes, are unlikely to be effective in raising the nutritional levels of those at the greatest risk of malnutrition.

Indeed, the quantile regressions show that most of the explanatory variables considered in this paper tend to have larger and more significant effects on child weight and height at the higher quantiles than at the lower quantiles. Thus, for example, parental education, electricity access, and even availability of piped water have larger effects on child weight and height at the upper quantiles than at the lower quantiles. The implication for policy is that since these general interventions—parental schooling, infrastructure and income growth—are not as effective in raising the nutritional status of children in the lower tail of the conditional weight and height distributions, it may be important to target direct nutritional interventions, such as food supplementation programmes (which we have not considered in this paper owing to lack of data), to at-risk children.[9]

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9 One such intervention in Sri Lanka is the Thriposha (triple nutrient) programme. Thriposha is a pre-cooked cereal-based food designed to supplement energy, protein and micronutrients among nutritionally-vulnerable women and children. It is provided to pregnant and lactating women during the first six months and infants between 6-11 months of age. In addition, it is given to children between 12-60 months who are at risk, as shown by growth faltering or other measures and as certified by the medical officer of health. Another intervention is a school-feeding program under which poor children are given a hot meal in school. The twin objectives of the school meal are to attract poor children to attend school and to provide these children with adequate nutrition to stay in school and do well in school work.

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**Appendix: Derivation of log household expenditure per capita**

The Demographic and Health Survey does not collect expenditure or income data. This problem was addressed by predicting log per capita expenditure for each household in the DHS sample based on the coefficients from a regression using household demographics, location variables, and housing and asset variables as explanatory variables on the sample of households from the Sri Lanka Integrated Survey (SLIS) 1999/2000 where the explanatory variables were identical to variables available in the DHS data (Table A1).

The SLIS was carried out across all provinces of the country between October 1999 and the third quarter of 2000. It surveyed a total of 7,500 households in 500 urban, rural and estate communities using household, community and price questionnaires. The DHS covered all provinces except the Northern and Eastern provinces and was in the field from May to August of 2000 (DCS 2002). Thus, the assumption underlying the exercise—that the relationship between household consumption and other household variables is the same in both samples—is not unreasonable given that the survey periods—and geographical coverage—overlap.

Total household expenditure in SLIS was calculated by adding all monthly expenditure on food and non-food consumption items from sections 6 (expenditure and durable goods), 3 (housing) and 4 (education) of the questionnaire for each household in the sample and adjusting by a spatial cost-of-living index. Per capita expenditure was defined as total household expenditure divided by the number of household members.

A set of variables common to both questionnaires was first identified, and based on these variables, several others were constructed, totalling 76. These included household age-sex composition; age, gender and marital status (namely, whether widow or widower) of household head; education of household head and the head's spouse; drinking water source; availability and type of toilet; quality of housing (namely, material of floor, roof and wall); type of cooking fuel; and the presence of household 'assets' (such as refrigerator, bicycle and motorcycle), and location of the household (whether rural and the district in which the household is located). An additional 70 variables were generated using two-way interactions of the basic variables with age and gender of head and location (rural or otherwise). The complete list of common and constructed variables is shown in Table A1, which also reports the regression results.

The regression model performed well with an adjusted $R^2$ of 0.53. The sample mean of log per capita expenditure was 7.4257 (indicating per capita expenditure of Rs 1,678.71), while the predicted value of the same from regression estimates was 7.4258 (per capita expenditure of Rs 1,678.53).

Table A1
Regression of log annual consumption expenditure per capita, SLIS data

| Independent variable | Coeff. | T-statistic |
|---|---|---|
| Intercept | 7.834 | 49.72 |
| Household size | -0.086 | -12.6 |
| No of females aged 0-4 as % of HH size | 0.001 | 0.72 |
| No of males aged 5-14 as % of HH size | 0.002 | 1.84 |
| No of females aged 5-14 as % of HH size | 0.002 | 2.41 |
| No of males aged 15-24 as % of HH size | 0.002 | 2.49 |
| No of females aged 15-244 as % of HH size | 0.004 | 4.11 |
| No of males aged 25-44 as % of HH size | 0.005 | 5.49 |
| No of females aged 25-44 as % of HH size | 0.003 | 2.79 |
| No of males aged 45-59 as % of HH size | 0.005 | 4.58 |
| No of females aged 45-59 as % of HH size | 0.003 | 2.85 |
| No of males aged 60 and over as % of HH size | 0.003 | 3.12 |
| No of females aged 60 and over as % of HH size | 0.003 | 2.61 |
| No of females aged 0-4 as % of HH size*head of HH is female | -0.003 | -0.90 |
| No of males aged 5-14 as % of HH size*head of HH is female | 0.001 | 0.29 |
| No of females aged 5-14 as % of HH size*head of HH is female | 0.003 | 1.15 |
| No of males aged 15-24 as % of HH size*head of HH is female | 0.003 | 1.33 |
| No of females aged 15-244 as % of HH size*head of HH is female | 0.001 | 0.42 |
| No of males aged 25-44 as % of HH size*head of HH is female | 0.002 | 0.83 |
| No of females aged 25-44 as % of HH size*head of HH is female | 0.004 | 1.73 |
| No of males aged 45-59 as % of HH size*head of HH is female | 0.005 | 1.83 |
| No of females aged 45-59 as % of HH size*head of HH is female | 0.003 | 1.27 |
| No of males aged 60 and over as % of HH size*head of HH is female | 0.003 | 1.06 |
| No of females aged 60 and over as % of HH size*head of HH is female | 0.004 | 1.60 |
| Head of HH is female | -0.212 | -0.96 |
| Household size*head of HH is female | -0.006 | -0.60 |
| Age of HH head | 0.003 | 0.83 |
| Age of HH head squared | 0.000 | -2.10 |
| HH head is a widow | 0.032 | 0.73 |
| Head of household's highest level of schooling is: | | |
| Middle school (grade 7-10) | -0.093 | -1.58 |
| O/L or equivalent | -0.087 | -1.06 |
| A/L or equivalent | 0.009 | 0.08 |
| Degree or above | -0.036 | -0.15 |
| Head of household's highest level of schooling is: | | |
| Primary school (grade 1-6)*age of head | 0.003 | 3.48 |
| Middle school (grade 7-10)*age of head | 0.006 | 5.21 |
| O/L or equivalent*age of head | 0.008 | 5.29 |
| A/L or equivalent*age of head | 0.009 | 4.30 |
| Degree or above*age of head | 0.013 | 2.87 |
| Head of household's highest level of schooling is: | | |
| Primary school (grade 1-6)*HH is located in rural area | -0.110 | -2.20 |
| Middle school (grade 7-10)*HH is located in rural area | -0.116 | -2.14 |
| O/L or equivalent*HH is located in rural area | -0.140 | -2.32 |
| A/L or equivalent*HH is located in rural area | -0.201 | -2.92 |
| Degree or above*HH is located in rural area | -0.291 | -2.78 |

Note: HH = household

Table 1A continues

Table A1 (con't)
Regression of log annual consumption expenditure per capita, SLIS data

| Independent variable | Coeff. | T-statistic |
|---|---|---|
| HH size*HH is located in rural area | 0.011 | 1.51 |
| Head is female*HH is located in rural area | 0.012 | 0.26 |
| Age of HH head*HH is located in rural area | 0.000 | 0.21 |
| HH head is a widow*HH is located in rural area | -0.040 | -0.82 |
| Highest educational level of spouse of head is: | | |
| Primary (grade 1-6) | -0.020 | -1.05 |
| Middle school (grade 7-10) | 0.040 | 2.03 |
| O/L or equivalent | 0.095 | 4.05 |
| A/L or equivalent | 0.173 | 5.61 |
| Degree or above | 0.311 | 4.65 |
| Drinking water source: | | |
| Unprotected well | -0.159 | -2.15 |
| Tube well | 0.174 | 1.99 |
| Street tap | -0.048 | -1.27 |
| Tap in house | 0.104 | 2.70 |
| River/stream | -0.159 | -0.77 |
| Other | -0.076 | -0.75 |
| Toilet: | | |
| Pour flush | 0.219 | 3.56 |
| Waterseal | 0.032 | 0.59 |
| Pit | -0.043 | -0.50 |
| Bucket | -0.062 | -0.36 |
| Other | 1.419 | 3.48 |
| Shared with other households | -0.080 | -3.60 |
| Fuel for cooking: | | |
| Sawdust | -0.139 | -1.12 |
| Kerosene | -0.057 | -1.15 |
| Gas | 0.355 | 12.67 |
| Electricity | 0.350 | 0.87 |
| Other | -1.359 | -7.46 |
| Roof type: | | |
| Asbestos | -0.080 | -2.81 |
| Tin | -0.135 | -3.07 |
| Cadjan/palmyrah/straw | -0.128 | -1.33 |
| Other | -0.240 | -4.07 |
| Floor type: | | |
| Cement | -0.357 | -5.76 |
| Wood | 0.777 | 1.90 |
| Prepared clay | -0.602 | -7.06 |
| Unprepared earth | -0.486 | -4.11 |
| Other | -0.247 | -1.17 |
| Wall type | | |
| Mud | -0.079 | -1.01 |
| Wood | -0.157 | -2.60 |
| Cadjan/palmyrah | -0.081 | -0.41 |
| Other | 0.289 | 2.41 |

Table 1A continues

Table A1 (con't)
Regression of log annual consumption expenditure per capita, SLIS data

| Independent variable | Coeff. | T-statistic |
|---|---|---|
| Drinking water source: | | |
| unprotected well*HH location is rural | 0.088 | 1.15 |
| Tube well*HH location is rural | -0.206 | -2.25 |
| Street tap*HH location is rural | 0.056 | 1.31 |
| Tap in house*HH location is rural | 0.060 | 1.30 |
| River/stream*HH location is rural | 0.063 | 0.30 |
| Other*HH location is rural | -0.049 | -0.44 |
| Toilet: | | |
| Pour flush*HH location is rural | -0.042 | -0.62 |
| Waterseal*HH location is rural | 0.001 | 0.01 |
| Pit*HH location is rural | -0.035 | -0.40 |
| Bucket*HH location is rural | -0.081 | -0.39 |
| Other*HH location is rural | -1.340 | -3.23 |
| Fuel for cooking: | | |
| Sawdust*HH location is rural | 0.096 | 0.59 |
| Kerosene*HH location is rural | 0.227 | 2.41 |
| Gas*HH location is rural | -0.010 | -0.26 |
| Electricity*HH location is rural | 0.165 | 4.60 |
| Other*HH location is rural | 0.085 | 1.75 |
| Roof type: | | |
| Asbestos*HH location is rural | 0.073 | 0.73 |
| Tin*HH location is rural | 0.247 | 3.24 |
| Cadjan/palmyrah/straw*HH location is rural | -0.012 | -0.14 |
| Other*HH location is rural | -1.402 | -2.96 |
| Floor type | | |
| Cement*HH location is rural | 0.096 | 0.91 |
| Wood*HH location is rural | -0.034 | -0.25 |
| Prepared clay*HH location is rural | -0.078 | -0.29 |
| Unprepared earth*HH location is rural | 0.048 | 0.59 |
| Other*HH location is rural | 0.046 | 0.56 |
| Wall material: | | |
| Mud*HH location is rural | 0.028 | 0.13 |
| Wood*HH location is rural | -0.155 | -1.20 |
| Cadjan/palmyrah*HH location is rural | 0.323 | 1.62 |
| Other*HH location is rural | -0.276 | -0.44 |
| HH has a fridge | 0.673 | 0.55 |
| HH has a bicycle | -0.541 | -0.78 |
| HH has a motorbike | -0.383 | -0.53 |
| HH location is rural | -0.184 | -1.27 |
| Whether HH resident of the following district: | | |
| Gampaha | -0.144 | -2.51 |
| Kalutara | -0.098 | -2.01 |
| Kandy | -0.235 | -5.08 |
| Matale | -0.192 | -3.36 |
| Nuwara Eliya | 0.192 | 3.37 |
| Galle | -0.302 | -5.75 |
| Matara | -0.332 | -5.95 |

Table A1 continues

Table A1 (con't)
Regression of log annual consumption expenditure per capita, SLIS data

| Independent variable | Coeff. | T-statistic |
|---|---|---|
| Hambantota | -0.125 | -1.80 |
| Kurunegala | 0.017 | 0.27 |
| Puttalam | -0.113 | -1.76 |
| Anuradapura | 0.187 | 3.17 |
| Polonnaruwa | 0.101 | 0.93 |
| Badulla | 0.041 | 0.79 |
| Monaragala | 0.082 | 1.95 |
| Ratnapura | -0.034 | -0.51 |
| Kegalle | -0.220 | -3.10 |
| Gampaha*HH location is rural | 0.218 | 3.23 |
| Kalutara*HH location is rural | 0.000 | 0 |
| Kandy*HH location is rural | -0.035 | -0.58 |
| Matale*HH location is rural | -0.004 | -0.05 |
| Nuwara Eliya*HH location is rural | -0.200 | -2.81 |
| Galle*HH location is rural | 0.180 | 2.76 |
| Matara*HH location is rural | 0.202 | 2.93 |
| Hambantota*HH location is rural | 0.295 | 3.61 |
| Kurunegala*HH location is rural | -0.009 | -0.12 |
| Puttalam*HH location is rural | 0.246 | 3.21 |
| Anuradapura*HH location is rural | 0.008 | 0.11 |
| Polonnaruwa*HH location is rural | 0.122 | 1.04 |
| Badulla*HH location is rural | 0.006 | 0.09 |
| Ratnapura*HH location is rural | 0.099 | 1.28 |
| Kegalle*HH location is rural | 0.006 | 0.07 |
| Adjusted $R^2$ | 0.527 | |
| F (145, 5465) | 44.07 | |
| Sample size | 5,611 | |