Original Article

Decomposition of childhood malnutrition in Cambodia

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Abstract

Childhood malnutrition is a major problem in developing countries, and in Cambodia, it is estimated that approximately 42% of the children are stunted, which is considered to be very high. In the present study, we examined the effects of proximate and socio-economic determinants on childhood malnutrition in Cambodia. In addition, we examined the effects of the changes in these proximate determinants on childhood malnutrition between 2000 and 2005. Our analytical approach included descriptive, logistic regression and decomposition analyses. Separate analyses are estimated for 2000 and 2005 survey. The primary component of the difference in stunting is attributable to the rates component, indicating that the decrease of stunting is due mainly to the decrease in stunting rates between 2000 and 2005. While majority of the differences in childhood malnutrition between 2000 and 2005 can be attributed to differences in the distribution of malnutrition determinants between 2000 and 2005, differences in their effects also showed some significance.

Keywords: child growth, child nutrition, international child health nutrition, low income countries, nutrition, socio-economic factors.

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Introduction

Studies have long established the impact of malnutrition on the life and health of children (Pollit 1984; Horton 1986; Lichter 1997; UNICEF 1998). For example, children who are malnourished have a greater risk of stunting and impaired brain development, which in turn affects their ability to accrue skills critical to their life chances (UNICEF 2010). There is evidence that nutritional status is correlated with intelligence quotient level (Horton 1986) and that children who are malnourished at an early age are more likely to have reduced educational attainment (Pollit 1984). Children who suffer from malnutrition are vulnerable to limited cognitive development,

physical incapacity, emotional disturbances and, in some cases, mental defects (Lichter 1997). Further, adults who survive malnutrition as children are more vulnerable to the development of physical and intellectual impairments and they are more likely to suffer from higher levels of chronic illness and disability (Smith & Haddad 2000; UNICEF 2010).

Perhaps one of the major accomplishments in the last decade is the tremendous progress in reducing child malnutrition and mortality in developing countries. The prevalence of stunting showed a 28% decline from 40% in 1990 to 29% in 2008 in developing countries. During the same period, mortality rate of children under age 5 has decreased from 89 deaths per 1000 live births in 1990 to 60 in 2009, a decline

of one-third (UNICEF 2010). Despite these developments, the severity of malnutrition and its consequences continue to hamper the social and economic development of the society and impede the potential to reduce poverty, primarily in countries in Asia and Africa where over 90% of developing world's chronically malnourished live (UNICEF 2010).

Cambodia is one such country in Southeast Asia where childhood malnutrition remains a major public health problem with almost half of the children under the age of 5 are malnourished as measured by the height-for-age or weight-for-age (Fujii 2005). Recent estimates show that one-third of the population live below the poverty line and the gap between rural poor and a minority urban rich is widening rapidly (UNDP 2007). While nutritional status of children has improved in the recent years, stunting or chronic malnutrition remains a major public health threat in Cambodia and one of the leading causes of morbidity and mortality among children (Hong & Mishra 2006). Current statistics available indicate that approximately 37% of children are stunted which ranges from 45% of children born in Pursat province to 22% of children born in Phnom Penh (National Institute of Public Health, National Institute of Statistics [Cambodia] and ORC Macro 2006).

Studies on the determinants of childhood malnutrition in Cambodia are few and far between. The few studies available on malnutrition in Cambodia often focused on the effects of proximate (or proximal) and socio-economic determinants on malnutrition (Yanagisawa 2004; Smith *et al.* 2005; Hong & Mishra 2006; Hong & Hong 2007). However, a number of studies from other countries from Asia and Africa have shown the significance of socio-economic conditions on explaining childhood malnutrition (Fotso &

Kuate-Defo 2005; Sunil 2009) in addition to demographic characteristics. The proximate determinants of childhood malnutrition are related to biological functions (of mothers and children) or to specific maternal practices related to health and caregiving (Smith *et al.* 2005) and include mother's weight, whether or not received adequate levels of prenatal care, delivery care, initiation and duration of breastfeeding and childhood immunisations (Caulfield *et al.* 1996; Brennan *et al.* 2004; Caulfield *et al.* 2004; Semba *et al.* 2007;). For example, studies have reported that children born to women who had prenatal visits during pregnancy and children who had received immunisations tend to have better nutritional status as compared with their counterparts (Brennan *et al.* 2004; Semba *et al.* 2007). On the other hand, prolonged breastfeeding was associated with malnutrition in children (Caulfield *et al.* 1996; Jakobsen *et al.* 1996). However, a study from Cambodia found that feeding practices and health-seeking behaviours were significantly associated with explaining acute malnutrition in children (Jacobs & Roberts 2004). These and similar studies assumed that proximate determinants related to maternal and child characteristics were directly linked to the nutritional status of the children.

A number of studies have emphasised the significance of social and economic conditions in childhood malnutrition in developing countries (Monteiro *et al.* 1992; Frongillo *et al.* 1997; Delpeuch *et al.* 2000; Menon *et al.* 2000; Wagstaff 2002; Fotso & Kuate-Defo 2005; Hong 2006; Hong & Mishra 2006; Sunil 2009; Subramanyam *et al.* 2010; Headey 2012). These determinants represent the resources necessary for achieving care and a healthy environment (Smith *et al.* 2005). These studies have shown that variables

Key messages

- Childhood malnutrition is a major problem in developing countries, and in Cambodia, it is estimated that approximately 42% of the children are stunted, which is considered to be very high.
- While nutritional status of children has improved in the recent years, stunting or chronic malnutrition remains a major public health threat in Cambodia and one of the leading causes of morbidity and mortality among children
- Results demonstrated that the difference in stunting between 2000 and 2005 is mainly due to an overall trend improvement in proximate and socio-economic characteristics of the most disadvantaged children

such as parent's education, parent's occupation and household economic conditions were significantly and negatively associated with childhood nutrition. For example, parents with better education and occupation were directly linked to health-seeking behaviours promoting or generating resources for better health and nutrition within the household (Fotso & Kuate-Defo 2005). Thus, nutritional levels tend to be better for children born to parents with higher education and better occupations as compared with the nutritional status of children born to parents with no or some years of schooling and with low paying jobs (Bicego & Boerma 1993; Fotso 2007). In addition to proximate and social and economic conditions, demographic characteristics such as child's age, mother's age and gender of the child have also commonly been used to explain childhood malnutrition (Hong & Mishra 2006; Sunil 2009).

In the present study, we included both proximate and socio-economic determinants in examining their effects on childhood malnutrition in Cambodia using the data from two cross-sectional national surveys in Cambodia. In addition, we also examined the effects of the changes in these proximate determinants on childhood malnutrition between two time periods. By comparing the nutritional status of children between two time periods, we will be able to establish if these differences can be explained by differing compositional characteristics with respect to proximate determinants or social and economic conditions between these two time periods.

Data and methods

Data for this analysis come from the 2000 and the 2005 Cambodia Demographic and Health Survey (CDHS), which are designed to be nationally representative sample of women of reproductive age (i.e. between the ages of 15 and 49 years). The DHS is the primary source of information on fertility, reproductive health, nutrition, mortality and HIV/AIDS health behaviours in developing countries. The data are generally collected using three different questionnaires: an individual women's, an individual men's and a household questionnaire.

The 2000 CDHS and 2005 CDHS collected information on child nutritional status. In both surveys, anthropometric data (height and weight) was collected for only 50% of the total sample of children between the ages of 0 and 59 months. Children's height and weight measurements were collected in the survey using standardised equipment and following rigorous procedures, hence minimising risks of bias in the measurements (National Institute of Public Health, National Institute of Statistics [Cambodia] and ORC Macro 2006).

Different steps were taken to construct the study samples. Information on height and weight were merged to household recode then household members recoded the information, then merged it to women recode and to children recode. Observations with missing values for any of the variables were excluded from the analysis. Observations with implausible height-for-age z-scores (less than -6 and greater than 6) are considered illogical and therefore were dropped from the analysis. Our study final sample is restricted to 1717 children for 2000 and 3521 children for 2005 under the age of 5 for whom complete information is available with regard to nutritional status, maternal characteristics and household characteristics.

Dependent variable

Because the dependent variable in this study is whether or not a child is stunted, height-for-age is used to construct a dichotomous measure of stunting. Height-for-age refers to cumulative linear growth achieved before birth and during childhood. It is indicative of past or chronic malnutrition and/or chronic or frequent illness, thus it cannot measure short-term changes in malnutrition. In the survey, height-for-age compares a child's height (in centimetres) against an international standard distribution of the height for children of the same gender and age (in months) (National Institute of Public Health, National Institute of Statistics [Cambodia] and ORC Macro 2006).

Anthropometric indices are commonly expressed in the form of z-scores. The height-for-age is expressed in standard deviation (SD) units (z-scores)

from the median of the reference population. Children whose height-for-age *z*-score is below minus two (-2) SD from the mean of the reference population are considered chronically malnourished or stunted. The measure of stunting in this paper is a dummy variable with a value of 1 if the child is stunted (i.e. *z*-score below 2 SD).

Independent variable

Control variables

The child's age refers to the age of the child at the time of survey. A set of four dummy variables is used to measure the variable including, less than 1, 1, 2, 3 and 4 years. We also considered the age of the mother as a control variable. In the survey, the age of the mother was captured age by 5-year age groups. Based on this consideration, we used a set of seven dummy variables to measure the age of the mother.

Proximate determinants

Woman's nutritional status is assessed using body mass index (BMI). The variable measures whether or not a woman is underweight. A BMI less than 18.5 kg m^{-2} is an indication of under nutrition (WHO 1995). Mother's health-seeking behaviours during pregnancy and for childbirth are included in the study. Antenatal care use is assessed by two dichotomous variables. The first dummy variable indicates whether or not the mother received any prenatal care, while the second dummy variable indicates whether or not the mother received at least four prenatal visits as recommended by the World Health Organization (WHO). Alternatively, delivery care status is used to reflect whether or not the mother delivered in a medical facility.

Using child feeding practices information, we first created a dummy variable to assess whether or not a child was breastfed within 1 day of birth. Then we constructed a set of dummy variables, which captures duration of breastfeeding including 1, 2 and 3 years or more of duration. Given the importance of immunisation to child health, we included a measure reflecting whether a child has ever been vaccinated.

Socio-economic determinants

Mother's education was reported in the survey in terms of highest level of education completed. We used three dummy variables to measure maternal education: no formal education, primary education and secondary education or more. Mother's occupation was analysed in terms of the following binary variables: no occupation, agriculture and modern sector. Father's education is measured by three binary variables including no formal education, primary education and secondary education or more and father's occupation was grouped into three dummy variables including no occupation, agriculture and modern sector.

Furthermore, various measures of the household health environment and economic status are included in the study. Children from households that lack access to safe water and adequate sanitary facilities are at higher risk of infectious diseases such as diarrhoea, cholera and malaria (World Bank 2000).

Household economic status is measured in this study using a proxy of socio-economic status in terms of wealth or assets. However, in the 2000 CDHS and the 2005 CDHS household wealth index was not calculated, therefore we constructed a wealth index based on information collected on the ownership of household assets including: consumer items, such as a refrigerator, television, telephone, agricultural land, farm animals and means of transportation and dwelling characteristics, such as floor material, type of drinking water source and toilet facilities (Rustein & Johnson 2004). These responses were then converted into an asset index with a mean of 0 and an SD of 1 that approximates the wealth of a household based on a principal component analysis. Households are ranked from the poorest to the wealthiest based on the household score including: poorest, poor, middle, rich and richest. Five dummy variables were created based on these categories.

Methods

Our analytical approach included descriptive, logistic regression and decomposition analyses. Separate analyses are estimated for 2000 and 2005 survey. Due

to the complex sample design of the DHS, descriptive statistics are calculated using the survey commands in STATA 9.0, which allows adjusting for sample design by using appropriate weights (StataCorp 2005). Logistic regression models were estimated to approximate the relationship between stunting and the selected predictors. The logistic regression model for the log odds of stunting is modelled as follows:

$$\text{Logit}(\pi) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k,$$

where π is the probability of being stunted based on a non-linear function. β_0 represents the constant and β_1 to β_k represent the estimated regression coefficients related to each variable included in the model.

We then performed a decomposition analysis to account for changes in childhood malnutrition between 2000 and 2005. A decomposition analysis refers to the act of dividing a time series (or other system) into its constituent parts namely: long-term trend, variations and amplitude about this trend, seasonal component and irregular component. This method allows an examination of measured differences in a specified outcome over time in non-panel longitudinal data. Using regression standardisation, the measured differences in a specified outcome between two points in time can be divided up into four components (i.e. intercept, composition, regression coefficient and interaction) that can be attributed to the existing independent variables. Drawing from Iams & Thornton (1975), the equation of the decomposition analysis is expressed as follows:

$$\begin{aligned} \text{Logit}(5) - \text{logit}(0) &= \beta_0(5) - \beta_0(0) + \sum \text{Pij}(0)(\beta_{ij}(5) - \beta_{ij}(0)) \\ &+ \sum \beta_{ij}(0)(\text{Pij}(5) - \text{Pij}(0)) \\ &+ \sum \text{Pij}(5) - \text{Pij}(0) - (\beta_{ij}(5) - \beta_{ij}(0)) \end{aligned}$$

Where $\text{Logit}(5) - \text{logit}(0)$ is equal to the measured difference in stunting between 2005 and 2000. This measured difference is decomposed into four components: (1) $\beta_0(5) - \beta_0(0)$ is the intercept component which represents the difference in stunting due to the difference in intercepts; (2) $\sum \text{Pij}(0)(\beta_{ij}(5) - \beta_{ij}(0))$

is the composition component, the portion of the overall difference produced by the independent variables. This reflects the amount of change that is attributable to variations in independent variables; (3) $\sum \beta_{ij}(0)(\text{Pij}(5) - \text{Pij}(0))$ represents the coefficient component, the amount of difference in stunting attributable to differences in the sizes of the slopes or regression coefficients that measure the rates of change between the zero (unfavourable characteristics) and the one (favourable characteristics) categories for each independent variable in the analysis; (4) $\sum \text{Pij}(5) - \text{Pij}(0) - (\beta_{ij}(5) - \beta_{ij}(0))$ is the interaction component, corresponding to the combined effects of variations in composition (component 2) and regression coefficients (component 3).

Results

Descriptive analysis

Table 1 presents the distribution of the 2000 and 2005 sample across all variables used in this analysis. The 2000 and 2005 samples reveal that malnutrition is a persistent problem in Cambodia affecting a considerable proportion of children, around 50% and 42% respectively.

In both samples, a higher proportion of children was under age 1 and of age 1. The proportion of children is evenly distributed by gender in both the 2000 and the 2005 samples. Most children have mothers between the age groups of 20–24, 25–29, 30–34 and 35–39. Among the proximal determinants, about 20% of children have mothers who are underweight. While only 43.89% of children have mothers who had at least one prenatal visit in 2000, a considerable proportion, about 71% of children have mothers who attended at least one prenatal visit in 2005. Very few children have mothers who received the adequate number of prenatal visits. Similarly, most children have mothers who did not utilise health care services for delivery care purposes. Many children tend to be breastfed within 1 day of birth, and a considerable proportion of children are breastfed for 2 years. Immunisation affects most children with a proportion of 70.05% in 2000 and 90.48% in 2005. Among the socio-economic determinants, more than

Table 1. Weighted percentages of stunting and selected characteristics, 2000 and 2005 Cambodia Demographic and Health Survey (CDHS)

Variables	2000 CDHS- <i>n</i> = 1717		2005 CDHS- <i>n</i> = 3521	
	Number	Percentage	Number	Percentage
Stunting				
Yes	870	50.10	1574	42.26
No	847	49.90	1947	57.74
Control variables				
Child's age				
<1	609	35.08	1052	28.55
1	423	24.54	1021	29.25
2	308	18.59	663	19.27
3	226	13.30	464	13.53
4	151	8.49	321	9.40
Sex of child				
Boy	855	50.07	1742	48.95
Girl	862	49.93	1779	51.05
Mother's age				
15–19	52	2.79	97	2.55
20–24	255	15.64	831	24.18
25–29	449	24.04	874	24.52
30–34	446	26.68	730	20.88
35–39	301	18.24	586	16.50
40–44	166	10.17	331	9.46
45–49	48	2.46	72	1.91
Proximal determinants				
Underweight mother				
Yes	344	19.87	642	19.25
No	1373	80.13	2879	80.75
Prenatal care				
Yes	724	43.89	2427	70.92
No	993	56.11	1094	29.08
Adequate prenatal care				
Yes	129	8.92	848	25.93
No	1588	91.08	2673	74.07
Delivery care				
Yes	147	10.59	651	21.55
No	1570	89.41	2870	78.55
Breastfeeding within 1 day of birth				
Yes	822	48.27	2748	79.69
No	895	51.73	773	20.31
Duration of breastfeeding				
1 year	793	46.54	1524	41.71
2 years	714	42.72	1605	47.93
3 years or more	210	10.74	392	10.36
Vaccination				
Yes	1128	70.05	3111	90.48
No	589	29.95	410	9.52
Socio-economic determinants				
Mother's education				
No education	623	31.78	1028	24.12
Primary	879	54.16	1967	58.40
Secondary or higher	215	14.06	526	17.48
Mother's occupation				
None	360	20.87	33	1.07
Agriculture	822	46.66	1984	53.58
Modern sector	280	17.88	1504	45.35

Table 1. Continued

Variables	2000 CDHS- <i>n</i> = 1717		2005 CDHS- <i>n</i> = 3521	
	Number	Percentage	Number	Percentage
Father's education				
No education	340	16.72	623	14.12
Primary	881	51.49	1830	51.33
Secondary or higher	496	31.79	1065	34.48
Father's occupation				
Agriculture	1333	75.16	1219	61.90
Modern sector	384	24.84	2302	38.10
Household wealth index				
Poorest	353	20.76	812	20.66
Poor	460	25.90	883	24.03
Middle	297	17.09	527	16.07
Rich	286	16.48	681	19.29
Richest	321	19.77	618	19.95
Safe drinking water				
Yes	470	31.93	1633	51.23
No	1247	68.07	1888	48.77
Toilet facility				
No Facilities	1475	85.07	2775	77.76
Not improved	170	9.19	131	2.84
Improved	72	5.73	724	19.50
Type of residence				
Rural	1473	85.93	2797	86.13
Urban	244	14.07	724	13.87

half of children have mothers with a primary education, followed by children whose mothers have no education then with those who have mothers with a secondary or higher education. Both samples show that the majority of children have mothers who work in the agricultural sector. In terms of father's educational attainment, most children have fathers who have a primary education while very few have fathers who have no education. Similar to mother's occupation, most children have fathers who work in the agricultural sector. The distribution of the sample by wealth index shows that most children live in poor households. A considerable portion of children come from households that have no access to safe drinking water as well as no access to toilet facilities. No less than 85% of children live in rural areas.

Bivariate and multivariate analysis of children's stunting status

Table 2 displays chi square statistics and *P*-value of the associations between children's stunting status

and independent variables included in this study. Looking at the 2000 CDHS sample, statistically significant associations are noted for all variables except sex of the child, mother's age, adequate prenatal care, undertaking of breastfeeding within 1 day of birth, safe drinking water and type of residence. However, the findings of the bivariate analysis using the 2005 CDHS sample reveal statistically significant associations between stunting and all control variables, proximal and socio-economic factors.

Table 3 shows the results of the logistic regression analysis of children's status in 2000 and 2005 in Cambodia by reporting the odds and confidence intervals.

Multivariate analysis of the 2000 CDHS reveals that the risk of stunting increases significantly with children's age. Stunting is significantly higher for 2-year-old [odds ratio (OR) = 1.676], 3-year-old (OR = 1.795) and 4-year-old children (OR = 1.713) compared with children under the age of 1. Mother's age have a statistically significant impact on stunting. Children whose mothers aged 40 to 44 are less likely to suffer from stunting (OR = 0.497) than children

Table 2. Bivariate associations between children's stunting status and covariates, 2000 and 2005 Cambodia Demographic and Health Survey (CDHS)

Variables	2000 CDHS- <i>n</i> = 1717		2005 CDHS- <i>n</i> = 3521	
	Chi-square [degrees of freedom (d.f.)]	<i>P</i> -value	Chi-square (d.f.)	<i>P</i> -value
Control variables				
Child's age	45.915 (4)	0.000	85.531 (4)	0.000
Sex of child	0.212 (1)	0.645	4.786 (1)	0.029
Mother's age	6.130 (6)	0.409	22.872 (6)	0.001
Proximal determinants				
Underweight mother	1.664 (1)	0.197	5.620 (1)	0.018
Prenatal care	25.686 (1)	0.000	27.769 (10)	0.000
Adequate prenatal care	2.940 (1)	0.086	21.936 (1)	0.000
Delivery care	17.843 (1)	0.000	57.727 (1)	0.000
Breastfeeding within 1 day of birth	0.189 (1)	0.663	6.630 (1)	0.010
Duration of breastfeeding	62.008 (2)	0.000	82.253 (2)	0.000
Vaccination	5.260 (1)	0.022	5.763 (1)	0.016
Socio-economic determinants				
Mother's education	23.008 (2)	0.000	100.185 (2)	0.000
Mother's occupation	13.410 (2)	0.001	20.720 (2)	0.000
Father's education	11.819 (2)	0.001	81.751 (2)	0.000
Father's occupation	19.966 (1)	0.000	11.452 (1)	0.001
Household wealth index	33.243 (4)	0.000	122.587 (4)	0.000
Safe drinking water	0.598 (1)	0.439	14.490 (1)	0.000
Toilet facility	51.637 (2)	0.000	85.470 (2)	0.000
Type of residence	1.428 (1)	0.233	11.058 (1)	0.001

whose mothers aged 15 to 19. The receipt of at least one prenatal visit decreases significantly the risk of stunting among children. Children whose mothers had at least one prenatal visit have 20% lower odds of being stunted than children whose mothers did not receive any prenatal care. Duration of breastfeeding has a significant impact on children's risk of stunting. The risk of stunting is significantly lower for children who were breastfed for 1 year ($OR = 0.492$), for 2 years ($OR = 0.634$) than children who were breastfed for 3 years or more.

Mother's education is protective against the risk of stunting among children. Children whose mothers have a primary education have 24% lower odds of being stunted than children whose mothers have no education. Household wealth matters in children's stunting status, with children from households in the richest quintile being less likely to suffer from stunting ($OR = 0.648$) than children from households in the poorest quintile.

The risk of child stunting increases noticeably with the existence/type of toilet facilities in the household. Children living in households with no toilet facility

have higher odds of stunting ($OR = 3.157$) than children living in household with improved toilet facility. The likelihood of stunting among children is associated with place of residence with children who live in urban residence having higher odds of being stunted ($OR = 1.477$) than children who live in rural areas.

Compared with the findings of the 2000 CDHS sample, results of the 2005 CDHS sample show no statistical significant impact for mother's age, prenatal care, toilet facility and place of residence.

Furthermore, sex of the child has been found to influence the risk of stunting, with the odds of being stunted being significantly lower among girls ($OR = 0.867$) compared with boys. Children whose mothers are underweight appear less likely to be stunted ($OR = 0.308$) compared with children whose mothers are not underweight.

Decomposition analysis

Table 4 presents detailed results of the decomposition analysis in stunting among children under the age of 5 years between 2000 and 2005. As shown in Table 4,

Table 3. Logistic regression results of child stunting, 2000 and 2005 Cambodia Demographic and Health Survey (CDHS)

Variables	2000 CDHS- <i>n</i> = 1717		2005 CDHS- <i>n</i> = 3521	
	Odds Ratio	95% [confidence interval (CI)]	Odds Ratio	95% CI
Control variables				
Child's age				
<1 (reference)				
1	1.332	0.904; 1.962	1.913***	1.483; 2.465
2	1.676*	1.107; 2.536	2.170***	1.648; 2.857
3	1.795*	1.144; 2.815	2.356***	1.739; 3.192
4	1.713*	1.055; 2.781	2.249***	1.625; 3.110
Sex of child				
Boy (reference)				
Girl	0.913	0.746; 1.115	0.867*	0.753; 0.997
Mother's age				
15–19 (reference)				
20–24	0.592	0.313; 1.119	1.442	0.906; 2.294
25–29	0.675	0.366; 1.243	1.428	0.898; 2.271
30–34	0.560	0.302; 1.034	1.560	0.975; 2.492
35–39	0.644	0.342; 1.211	1.442	0.894; 2.323
40–44	0.497*	0.253; 0.972	1.599	0.969; 2.635
45–49	0.487	0.210; 1.129	1.557	0.799; 3.034
Proximal determinants				
Underweight mother				
Yes	1.174	0.910; 1.512	0.308***	0.185; 0.511
No (reference)				
Prenatal care				
Yes	0.796*	0.634; 0.997	0.922	0.779; 1.091
No (Reference)				
Adequate prenatal care				
Yes	1.428	0.931; 2.189	1.046	0.866; 1.263
No (Reference)				
Delivery care				
Yes	0.811	0.527; 1.247	0.822	0.663; 1.017
No (reference)				
Breastfeeding within one day of birth				
Yes	1.002	0.817; 1.229	0.956	0.804; 1.137
No (reference)				
Duration of breastfeeding				
1 year	0.492**	0.311; 0.776	0.734*	0.543; 0.991
2 years	0.634*	0.438; 0.916	0.680**	0.528; 0.874
3 years or more (reference)				
Vaccination				
Yes	0.861	0.685; 1.080	0.859	0.685; 1.076
No (reference)				
Socio-economic determinants				
Mother's education				
No Education (reference)				
Primary	0.759*	0.600; 0.961	0.802*	0.675; 0.952
Secondary or higher	0.940	0.628; 1.409	0.603***	0.458; 0.792
Mother's occupation				
None (reference)				
Agriculture	0.887	0.705; 1.113	0.914	0.435; 1.919
Modern sector	0.767	0.552; 1.065	0.915	0.436; 1.918

Table 3. Continued

Variables	2000 CDHS- <i>n</i> = 1717		2005 CDHS- <i>n</i> = 3521	
	Odds Ratio	95% [confidence interval (CI)]	Odds Ratio	95% CI
Father's education				
No Education (reference)				
Primary	1.241	0.936; 1.643	0.774*	0.631; 0.947
Secondary or higher	0.823	0.579; 1.168	0.704**	0.549; 0.901
Father's occupation				
Agriculture (reference)				
Modern sector	1.040	0.771; 1.400	0.953	0.799; 1.135
Household wealth index				
Poorest (reference)				
Poor	0.810	0.602; 1.088	1.185	0.970; 1.447
Middle	0.875	0.629; 1.217	0.931	0.735; 1.179
Rich	0.718	0.511; 1.008	0.825	0.659; 1.031
Richest	0.648*	0.442; 0.949	0.560***	0.417; 0.750
Safe drinking water				
Yes	1.086	0.858; 1.374	0.908	0.786; 1.048
No (reference)				
Toilet facility				
No facilities	3.157**	1.604; 6.209	1.150	0.898; 1.472
Not improved	1.609	0.797; 3.247	1.022	0.673; 1.552
Improved (reference)				
Type of residence				
Rural (reference)				
Urban	1.477*	1.068; 2.042	1.020	0.841; 1.235

****P* < 0.001 ***P* < 0.01 **P* < 0.05.

composition rates, regression coefficients and interaction term were computed separately for each independent variable. Then, estimates of each variable were summed up for each of the component to obtain the decomposition of differences in stunting between 2000 and 2005 (as presented in the last row of Table 4). Focusing only on the last row of the table, results show that the measured difference in stunting is mostly attributable to the changes in the intercept component and changes in size of the regression coefficients. Estimates of the intercept component (47.73%) clearly make the most significant contribution to the measured difference in stunting compared to the regression coefficient component (27.56%), the composition component (12.96%) and the interaction component (11.75%). Changes in intercepts measure the amount of change among children considered the most vulnerable based on all the proximate and socioeconomic variables included in the present study. Differences in intercepts indicate that the rates of change

among the most vulnerable children are larger than the rates of change among all children together. Further, even though changes in the size of regression coefficients are far less important than that of the intercepts, they warrant some attention.

Discussion

Childhood malnutrition is a major problem in developing countries, and in Cambodia, it is estimated that approximately 42% of the children is stunted, which is considered to be very high (WHO 1995). In the present study, we looked at the effects of both proximate and social and economic determinants on childhood malnutrition in Cambodia using the data from two cross-sectional national surveys. In addition, we also examined the effects of the changes in these determinants on childhood malnutrition between the two time periods.

Table 4. Decomposition of differences in stunting between 2000 and 2005 among children under the age of 5 years

	Proportion of changes due to			
	Intercept	Composition rate	Rate or regression Coefficient	Interaction
Control variables				
Child's age		0.0171	0.3078	0.0333
Sex of child		-0.0001	-0.0781	-0.0018
Mother's age		0.0057	1.0935	-0.0244
Proximate determinants				
Underweight mother		0.0659	0.0039	0.0121
Prenatal care		-0.0644	0.1018	0.0627
Adequate prenatal care		0.0341	-0.0164	-0.0313
Delivery care		-0.0130	0.0056	0.0058
Breastfeeding within 1 day of birth		-0.0015	0.0054	0.0035
Duration of breastfeeding		0.0138	0.2860	-0.0168
Vaccination		-0.0334	-0.2071	-0.0604
Socio-economic determinants				
Mother's education		-0.0094	-0.0176	-0.0122
Mother's occupation		-0.0987	0.1883	0.1493
Father's education		-0.0022	-0.3663	-0.0088
Household wealth index		-0.0081	0.0839	-0.0014
Safe drinking water		0.0300	-0.0718	-0.0434
Toilet facility		-0.1273	-0.8605	0.1076
Type of residence		-0.0007	-0.0493	0.0007
Total percent of absolute change	47.73	12.96	27.56	11.75

Cambodia has made tremendous progress towards improving nutritional status of the children in addition to several proximate and social and economic conditions during the two time periods considered in the study. In particular, proximate determinants such as prenatal care coverage, adequate use of prenatal care and vaccination have significantly improved during 2000 and 2005. Bivariate analysis clearly established the significant association between the selected proximate and social and economic variables and childhood stunting in Cambodia. Results from the multivariate logistic regression analyses are similar to previous studies on childhood malnutrition in developing countries (for example see, Smith *et al.* 2005; Hong & Mishra 2006; Sunil 2009; Van de Poel & Speybroeck 2009). Among all the proximate variables considered in the model, variables such as mother's nutritional status (BMI), prenatal care use, breastfeeding duration have found to be statistically significant. Contrary to our expectation, women who

had BMI less than 18.5 kg m^{-2} likely to have lower odds of having childhood stunting compared with children born to women who were not underweight in 2005. Similar discrepancy was also reported in Hong & Mishra (2006) using 2000 data. Prenatal care use is another determinant found to be significant. Prenatal care services provide an opportunity for preventative measures including early detection of pregnancy complications and monitoring fetal development (Smith *et al.* 2005). Thus, similar to previous findings, the study results showed that increase in prenatal care had lower odds of stunting compared to women who had no prenatal care visits during pregnancy. However, it is important to note that while about 71% of women received prenatal care services during pregnancy, only a quarter of the women received adequate levels of prenatal care. Thus, efforts should be in place to cover all pregnant women with adequate levels of prenatal care visits. The association between breastfeeding and stunting seems to provide the protective effects of breastfeeding on stunting which is reported in other studies from developing countries (Smith *et al.* 2005; Hong & Mishra 2006; Sunil 2009; Van de Poel & Speybroeck 2009). These studies have showed that early and sustained breastfeeding influence infant's metabolism and provide natural immunities protecting the child from any infection (Brennan *et al.* 2004). This is also reflected in the age differentials in stunting. It was observed that odds for stunting do not seem to be different between 2, 3 and 4-year-olds, but only between each of those age groups and the younger children. Thus, as discussed in Victora *et al.* (2010) there is an urging need for emphasising the significance of interventions early during pregnancy and the first 2 years of life.

Among the social and economic determinants, parent's education, household wealth index, toilet facility at the house and type of residence were found to be significantly associated with stunting. The parental education (both mothers and fathers) tends to have a significant impact on childhood stunting which was shown in previous studies as well (see Pena *et al.* 2000; Hong & Mishra 2006; Hong & Hong 2007; Grover *et al.* 2008; Sunil 2009; Mazumdar 2010). In previous papers, household social and

economic conditions are identified as a key component for promoting childhood nutrition and directly linked to health seeking behaviours promoting or generating resources for better health and nutrition within the household (Fotso & Kuate-Defo 2005). This finding concurs with previous assertions that higher levels of parental education would provide higher levels of household food availability and quality diets to children, and better health care practices (Grover *et al.* 2008; Ojiako *et al.* 2009).

Another major contribution of this paper lies in the use of the decomposition analysis to examine how variations in proximate and socio-economic determinants between 2000 and 2005 accounted for the measured difference in stunting between the two periods of time. Decomposing the effects of determinants of childhood malnutrition between two time periods provided valuable insights into the changing social and behavioural dynamics of the society. Between 2000 and 2005, nutritional status of children in Cambodia has improved; stunting among children under the age of 5 has decreased by 8% from 50% to 42%. The decrease in malnutrition is a multifaceted function of changes in public health programmes, economic environment and feeding practices. Results demonstrated that the difference in stunting between 2000 and 2005 is mainly due to an overall trend improvement in proximate and socio-economic characteristics of the most disadvantaged children. In some ways, the most vulnerable children are the ones who to a greater extent benefited from progress in public health interventions, health behaviours and economic development. Of the proximate determinants, prenatal care, breastfeeding and childhood vaccination were found to be more influential in the overall decrease in malnutrition rates between 2000 and 2005 in Cambodia. It is important to note that in recent years, Cambodia has received significant support to improve antenatal services, breastfeeding duration and childhood vaccination from the international community. These include, for example, the Health Behavior Change Communication (BCC) programme jointly funded by UNICEF and the European Commission to strengthen the capacity of MoH staff and health

workers at national, provincial, district and village levels to practise effective antenatal visits within the first month after missing the menstrual period (UNICEF 2009). In addition, recently, a joint programme supported by the Royal Government of Cambodia in association with UNICEF, United States Agency for International Development and the WHO launched a nationwide campaign to improve complementary feeding practices for children aged 6 to 24 months (UNICEF 2012). Given the ongoing support from the international donor agencies and the commitment of the local government, one could expect significant improvements in levels of childhood malnutrition in Cambodia in the coming years.

It can be also noted that socio-economic determinants such as mother's education and occupation, father's education, toilet facility and type of residence had an impact in the measured difference in child stunting between 2000 and 2005. The significance of education, mother's education in particular, on childhood malnutrition has been widely discussed in the literature (Monteiro *et al.* 1992; Subramanyam *et al.* 2010). Studies have showed that improving mother's education provides a protective environment to reduce childhood malnutrition in developing countries (Headey 2012). While the percentage of women with no education has declined to 24.12% in 2005 from 31.78% in 2000 in Cambodia (see Table 1), wide gender differentials in education still persists within Cambodia. For example, approximately 62% of the women from Mondol Kiri/Rattanak Kiri province have no education as compared with 44% of males (National Institute of Public Health, National Institute of Statistics [Cambodia] and ORC Macro 2006). Thus, to further reduce malnutrition among children, the government must take steps towards improving educational opportunities to its citizens. The ongoing educational programmes funded by World Bank such as Education Sector Support Scale Up Action Program Project and other programmes supported by international agencies have shown improvements in access and in reducing dropouts at the primary level. However, the sustainability of such programmes after the funding period is not clear.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

TSS initiated the paper, provided statistical guidance in data analysis and wrote the initial draft of the manuscript. MS analysed and interpreted the data. All authors participated in manuscript preparation and critically reviewed all sections of the text for important intellectual content.

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