Original Article

Inequality in malnutrition by maternal education levels in early childhood: the Prospective Cohort of Thai Children (PCTC)

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Background and Objectives: As tackling socioeconomic inequality in child malnutrition still remains one of the greatest challenges in developing countries, we examined maternal educational differences in malnutrition and the magnitude of its inequality among 4,198 children from the Prospective Cohort study of Thai Children (PCTC). **Methods and Study Design:** Prevalence of stunting, underweight, and wasting from birth to 24 months was calculated using the new WHO growth chart. The Relative Index of Inequality (RII) was used to examine the magnitude and trend of inequality in malnutrition between maternal educational levels. **Results:** The low education group had lower weight and height in most ages than the high education group. Faltering in height was observed in all education levels, but was most remarkable in the low education group. On the other hand, while upward trends for weight-for-age and weight-for-height across ages were observed in the high education group, a marked decline between 6 to 12 months was observed in the low education group. An increasing trend in inequality in The RII revealed an increasing trend in inequality in stunting, underweight, and wasting by maternal education levels was observed during infancy with an almost monotonic increase until 24 months, although the inequality in wasting decreased after 18 months of age. **Conclusion:** Inequality in malnutrition remarkably increased during infancy, and for stunting and underweight it remained until 24 months. These findings shed light on the extent of malnutrition inequality during the first 2 years of life and they suggest sustainable efforts must be established at the national level to tackle the malnutrition inequality in infancy.

Key Words: early childhood, inequality, malnutrition, children under 2 years, maternal education

INTRODUCTION

Thailand has experienced enormous economic and social improvements since the 1980s,[1] which led to financial support for widespread community-based programs including nutrition.[2-4] These efforts produced a steady decline in the under-5 mortality rate from 37 per 1,000 live births in 1990[5] to 12.4 in 2010.[1] On the other hand, the economic improvement contributed to persistent income inequality.[6] This discrepancy would make the economically and socially disadvantaged population, particularly women and children more vulnerable.[7] Indeed, a study using Thai population census data showed that socioeconomic inequality in child mortality still existed,[8] despite great reduction in the disparity from 1990 to 2000. It shows that tackling socioeconomic inequality in child health still remains one of the greatest challenges in developing as well as developed countries.[9]

Malnutrition has great impacts on child health, including mortality,[10] morbidity, cognitive development[11-13] and reduced work efficiency and poor reproductive outcomes in adult life.[14] Despite an impressive decline in stunting and underweight since 1987 in Thailand, their prevalence remained at 10-15% during the past two decades[15] and was particularly concentrated among the low socioeconomic population.[16-19] Therefore, understanding the impact of socioeconomic status (SES) in malnutrition in the first 2 years of life is important for effective nutrition intervention strategies, given the importance of early child growth and development, particularly within that period[20] because of its long term health and functional consequences. However, to our knowledge, there is no study to evaluate the extent to which SES affects child growth faltering across ages during the first 2 years of life. To evaluate trends in socioeconomic inequalities in malnutrition, this study used the relative inequality index (RII), which provides a meaningful summary measure of socioeconomic health inequalities over time.[21] Its use thus greatly facilitates monitoring changes of inequality over time. This study, therefore, evaluated the magnitude of

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inequality in malnutrition by maternal education level, indicated by RII, in Thai children from birth to 24 months of age using a prospective birth cohort study.

MATERIALS AND METHODS

Study dataset and subjects

The analysis was done by using data from the Prospective Cohort study of Thai Children (PCTC), an observational community-based study, conducted in 5 regions (Panomtuan District in Kanchanaburi, Thepa District in Songkla, Kranuan District in Konkaen, Muang District in Nan, and Bangkok) from October 2000 to September 2002. The study methods have been described in detail elsewhere.[16] The study was approved by the National Ethical Committee, Ministry of Public Health in Thailand. All families were informed about study procedures and possible risks before signing the consent form. Of 4,245 children, infants having no information on weight, height, education or income were excluded. A total of 4,198 children were included in the analysis.

Socioeconomic status measure

Maternal education was measured as a SES indicator in the study. It is used as a strong indicator reflecting SES in many epidemiological studies.[18,22-23] Furthermore, education attainment is positively associated with the health status of a population and also to some extent, it reduces the impact of poverty on health, irrespective of the availability of health services by shaping maternal attitude and behaviors.[24] Maternal education was classified as the highest level of individual education completed and was categorized into three groups: primary school or less (≤6 y of schooling), high school (7-12 y of schooling), and college or higher (≥13 y of schooling).

Measurements of nutrition status in children

Height and weight of children were measured by physicians and specially trained research assistants at birth and then six-monthly until 24 months of age. Recumbent length was measured using a graduated board with a fixed headboard and movable footboard (1 m/0.1 cm), and recorded to the nearest 0.1 cm. Body weight was assessed in light clothing, without shoes, and recorded to the nearest 0.1 kg using a calibrated electronic scale. The WHO's 2006 reference growth charts[25] were used to estimate age- and sex-specific z-scores and prevalence of child malnutrition(stunting, wasting and underweight). Two standard deviations (SD) below the median z-scores were used as cutoffs for assessing stunting (length-for-age), wasting (weight-for-length), and underweight (weight-for-age).

Statistical analysis

Prevalence of malnutrition was calculated for each maternal education level after adjustment for study sites and infant's sex. The trend tests for linearity were conducted by treating the median value for each education group as a continuous variable in the analyses. The RII is a summary measure of relative inequality and was estimated using an indicator of relative educational position (a value from 0 to 1).[26] This was determined by computing the relative position in the cumulative population distribution of the central subject in each group of educational hierarchy. The relative rank variable was then entered as an independent variable into log-binomial regression analyses using PROC GENMOD.[27] Thus, this RII is the relative risk of malnourishment at the lowest end (relative rank=1) of the educational hierarchy compared with the risk at the top (relative rank=0) of the educational hierarchy, weighted by the population distribution of individuals across educational groups.[26] The trend for the RII was estimated by examining the p-value for an interaction term for the relative education indicator and time (year) variable in the model. All analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

RESULTS

General characteristics of the study population are shown in Table 1. The mean of maternal age at delivery was 27 years old. Approximately 53% of mothers had primary school education or lower and 24% and 40% of mothers had BMI below 18.5 kg/m^2 and gestational age 38 weeks or less, respectively. Proportions of male infants were half and 10.5% of infants were low birth weight.

The low education group had lower weight and height in most ages than the high education group (Table 2). The discrepancy in weight and height between education levels became wider with age. A similar pattern was found in terms of mean z-score of height-for-age, weight-for-age, and weight-for-height using the new WHO growth charts (Figure 1). The faltering in height during the first two years was observed in all education levels, but was most remarkable in the low education group. The differential of growth faltering patterns by education levels increased after 6 months. On the other hand, while upward trends for weight-for-age and weight-for-height across ages were observed in the high education group, downward trends in both of these indicators were observed in the low education group, with a marked decline between age 6 to 12 months, and while weight-for-age remained at about the same z-score until 24 months, weight-for-height shifted upward from 12 months onwards. While the slope of trend in weight-for-height (from 12-24 months) of the low educational group was similar to the other two higher education levels, attained weight-for-height at 24 months was at z-score -0.2, compared with above 0 for the other two groups.

For prevalence of stunting and underweight, the low education group had about double the proportion after 6 or 12 months (Table 3). At 24 months, the low education group showed 25.7% for stunting and 12.0% for underweight compared with 13.4% and 6.4% in the high education group. For wasting, the proportion was higher in the low SES group at all ages except at birth. The difference between maternal education levels remained wide from 12 to 18 months and then reduced at 24 months. The inequalities between education levels in malnutrition, indicated by the RII, were apparent at most ages (Figure 2). For stunting, the RII value was around 1.37 during the first 6 months and then dramatically rose at 12 months (RII=3.04, 95% CI=1.97-4.67), and slightly increased until 24 months (RII=3.20, 95% CI=2.29-4.47). For underweight and wasting, a trend of increasing RII was observed until 18 months (RII=2.71, 95% CI=1.74-4.21 for underweight and RII=2.48, 95% CI=1.31-4.68 for

Table 1. General characteristics of study population

	Total(n=4,198)	
	N	%
Mother's characteristics		
Maternal age at delivery		27.0±6.3
<20 years	499/4198	11.9
20-34 years	3139/4198	74.8
≥35 years	560/4198	13.3
Household income		
Low	1397/4189	33.4
Middle	1407/4189	33.6
High	1385/4189	33.1
Maternal Education		
Primary -	2212/4178	52.9
High school	1189/4178	28.5
College+	777/4178	18.6
Maternal pre-pregnancy BMI		
<18.5 kg/m^2	995/4192	23.7
18.5-22.9 Kg/m^2	2293/4192	54.7
≥23 kg/m^2	904/4192	21.6
Study site		
Central	787/4192	18.8
South	1068/4192	25.4
Northeast	863/4192	20.6
North (City)	661/4192	15.8
North (Hill)	119/4192	2.8
Bangkok	700/4192	16.7
Infant's characteristics		
Gender (boys, %)	2092/4198	49.8
Gestational age at birth	3875	38.7±1.9
≤38 weeks	1555/3875	40.1
>38 weeks	2320/3875	59.9
Birth weight (kg)	4043	3.0±0.5
Low birth weight (< 2500 g, %)	510/4198	12.2
Sibling (number)	3591	2.2±1.4
1	1274/3591	35.5
2	1244/3591	34.6
≥3	1073/3591	29.9

Table 2. Adjusted mean and 95% CI of height and weight according to infant's age and maternal educational level

	Maternal educational level			*p*-trend
	College +	High school	Primary school -	
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	
Weight (kg)				
Birth	3.1 (3.0, 3.1)	3.0 (3.0, 3.1)	3.1 (3.0, 3.1)	0.325
6 months	7.3 (7.3-7.4)	7.3 (7.2, 7.3)	7.2 (7.1, 7.2)	<0.0001
12 months	9.1 (9.0-9.2)	8.9 (8.8, 8.9)	8.6 (8.6, 8.7)	<0.0001
18 months	10.4 (10.3, 10.6)	10.2 (10.1, 10.2)	9.8 (9.7, 9.8)	<0.0001
24 months	11.8 (11.7, 11.9)	11.4 (11.3, 11.6)	11.0 (10.9, 11.0)	<0.0001
Height (cm)				
Birth	49.4 (49.2, 49.6)	49.3 (49.1, 49.5)	49.2 (49.0, 49.3)	0.029
6 months	66.0 (65.8, 66.2)	65.6 (65.5, 65.8)	65.4 (65.3, 65.5)	<0.0001
12 months	73.9 (73.7, 74.2)	73.5 (73.3, 73.7)	72.9 (72.8, 73.1)	<0.0001
18 months	79.8 (79.6, 80.1)	79.0 (78.8, 79.2)	78.2 (78.0, 78.3)	<0.0001
24 months	84.5 (84.2, 84.7)	83.7 (83.4, 83.9)	82.6 (82.4, 82.8)	<0.0001

All values were adjusted for study site and infant's sex.

wasting) and then remained for underweight (RII=2.65, 95% CI=1.68-4.17) or decreased for wasting (RII=1.45, 95% CI=0.70-3.01).

DISCUSSION

This study focused on the relationship of inequality in malnutrition to maternal education levels across infant ages from birth to 24 months using a prospective birth cohort study. Different patterns between maternal education levels were found in terms of mean z-score of height-for-age, weight-for-age, and weight-for-height. The faltering in height was observed in all education levels, but was most remarkable in the low education group. On the other hand, while upward trends for weight-for-age and weight-for-height across ages were observed in the high education group, a marked decline between age 6 to 12

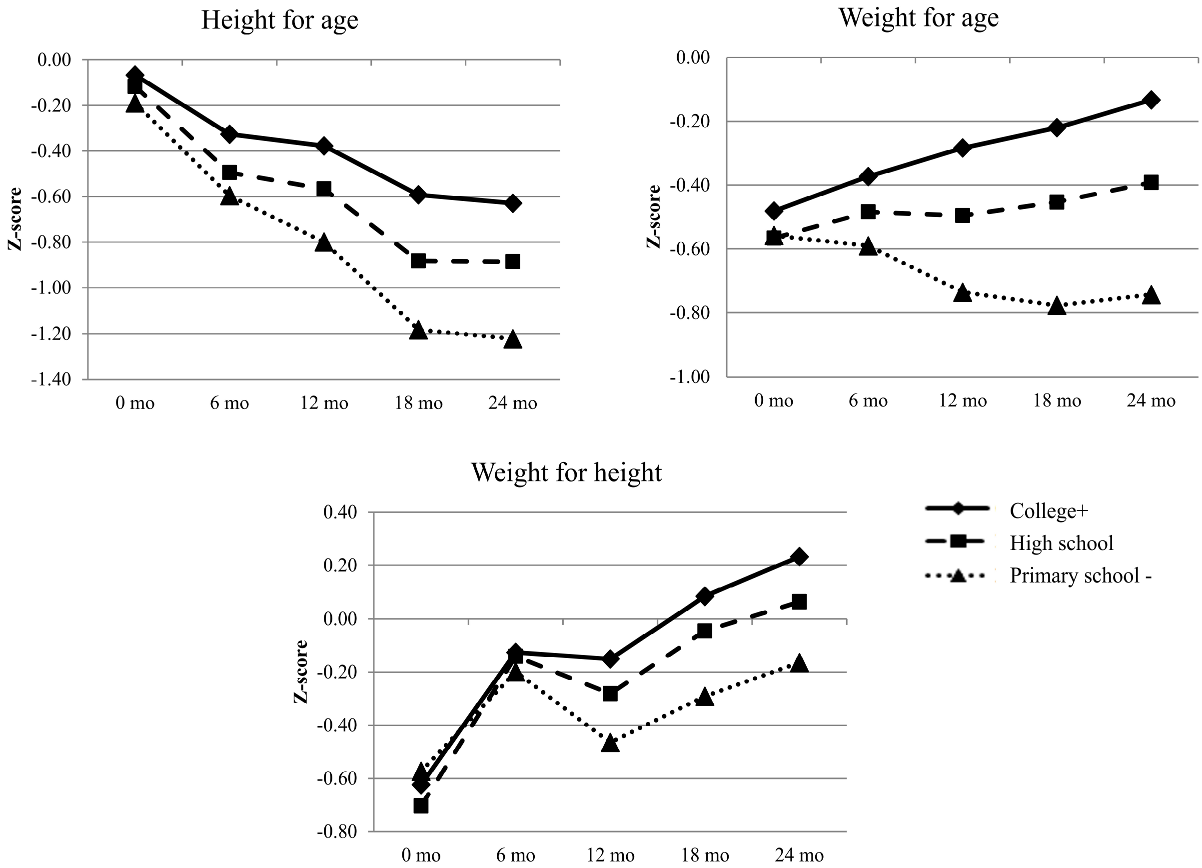

Figure 1. Mean z-scores of height-for-age, weight-for-age and weight for height among Thai children from birth to 24 months of age by maternal educational level across ages. *z-scores were estimated using the WHO growth standards (2006) and the means were adjusted for study sites and infant's sex.

months was observed in the low education group. The inequalities in malnutrition, indicated by the RII, were apparent from birth through 24 months of age. Trends of increasing RII for all malnutrition indicators by education levels were observed until around 18 months of age, when RII of both stunting and underweight remained the same at 24 months, while that for wasting dropped substantially.

As inequality in malnutrition seemed obvious in early childhood among Thai children, consistent with the other studies in low- and middle-income countries,[18-19,28] our finding supports that socioeconomic inequality is not associated with overall malnutrition rate.[28] This is supported by a recent Thai study showing that underweight and stunting (-0.219 and -0.177 measured by Concentration index) were least equitably distributed among the lowest income groups, while wasting seemed a bit better (-0.066).[17] However, a Brazilian study showed a decreasing trend of stunting inequality as well as overall malnutrition rate.[29] The dramatic decline of stunting inequality in the last 10 years of the period was explained by improvement of access to education, health care and water and sanitation services and reproductive health indicators.[29] Similarly, Thailand provides equitable health systems and a high coverage of health care was achieved in 2002,[17] which led to child immunization and family planning intervention being fairly equitably distributed.[17] Although the health care system in Thailand has improved the overall health of the population, there remain challenges in malnutrition. Inequality in malnutrition as reflected by differential prevalence in stunting, wasting and underweight across the first two years of life is critical and has both short and long terms consequences in health/disease and functions.

The inequality in chronic malnutrition, such as stunting and underweight, increased with age in early childhood in the study. Due to lack of studies on socioeconomic inequality in child malnutrition across ages, it is difficult to compare the results from other studies. In a China study among children under 10 years of age, educational inequality in stunting might be narrowed with age after early childhood.[19] Recently, Prentice et al suggested that regain of height after 2 years was observed even in the absence of external nutritional interventions in Brazil, Guatemala, Philippines, and South Africa but not India, probably due to food availability and the prevailing burden of infectious diseases.[30] However, as the complex interrelations of low birth weight, poor access to safe water and health care and inadequate child care and feeding practices, which are key factors in high childhood malnutrition in Asia,[29,31] are profound in low SES and more deprived areas, the accumulated risk factors in low SES and more deprived areas are likely to make the malnutrition inequality worse. In contrast with inequality in stunting and underweight, wasting inequality was apparently decreased substantially after 18 months of age. This may lead to overlook the fact that children in the low education group were more stunted and growth in weight actu-

Table 3. Prevalence of stunting, underweight and wasting according to infant's age and maternal educational level

	Maternal educational level			
	College +	High school	Primary school -	*p*-trend
	% (95% CI)	% (95% CI)	% (95% CI)	
Stunting				
Birth	6.3 (4.2, 8.4)	6.2 (4.6, 7.8)	7.4 (6.2, 8.7)	0.191
6 months	9.4 (7.1, 11.7)	10.4 (8.7, 12.1)	11.0 (9.7, 12.3)	0.241
12 months	9.2 (6.8, 11.6)	11.8 (9.9, 13.7)	15.9 (14.5, 17.4)	<0.0001
18 months	12.7 (9.9, 15.6)	17.8 (15.6, 20)	23.6 (21.9, 25.3)	<0.0001
24 months	13.4 (10.2, 16.5)	18.6 (16.2, 21)	25.7 (23.9, 27.6)	<0.0001
Underweight				
Birth	5.6 (3.5, 7.8)	6.4 (4.8, 8.1)	7 (5.8, 8.3)	0.253
6 months	4.4 (2.3, 6.6)	5.7 (4.1, 7.3)	7.1 (5.8, 8.3)	0.027
12 months	6.5 (4.2, 8.8)	8.6 (6.8, 10.4)	11.4 (10, 12.8)	<0.0001
18 months	6.9 (4.5, 9.2)	9.3 (7.4, 11.1)	12.9 (11.5, 14.4)	<0.0001
24 months	6.4 (3.9, 9)	8.2 (6.2, 10.1)	12 (10.5, 13.5)	<0.0001
Wasting				
Birth	13 (10.1, 15.9)	14.2 (12, 16.5)	10.6 (8.8, 12.3)	0.021
6 months	4.1 (2, 6.1)	3.9 (2.4, 5.4)	5.1 (4, 6.3)	0.190
12 months	2.8 (0.9, 4.8)	5.4 (3.9, 6.9)	6.6 (5.5, 7.8)	0.002
18 months	2.6 (0.9, 4.4)	3.4 (2.1, 4.9)	5.2 (4.1, 6.2)	0.004
24 months	2.1 (0.6, 3.7)	3 (1.8, 4.2)	3.2 (2.3, 4.2)	0.303

All values were adjusted for study site and infant's sex.

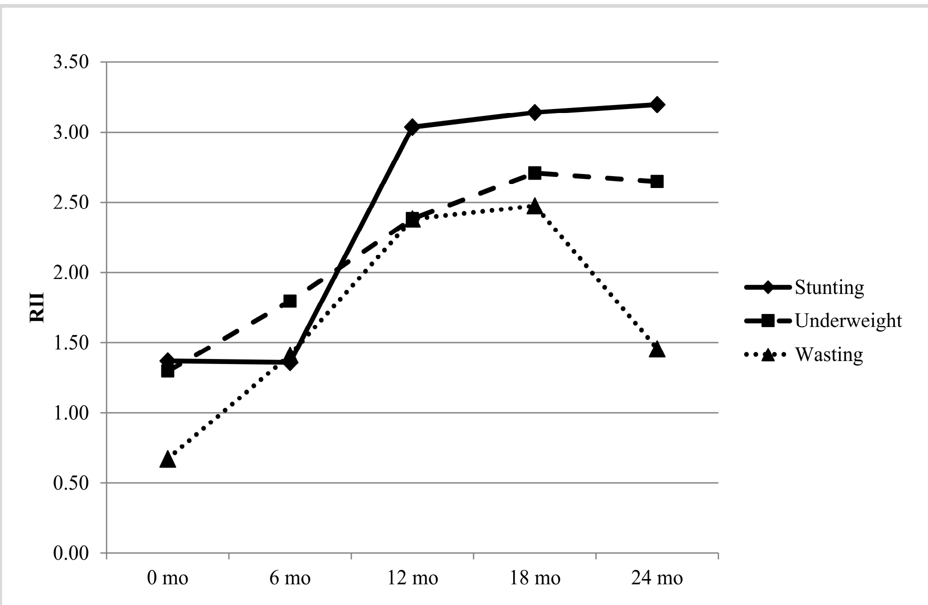

Figure 2. Trends in inequality in stunting, underweight and wasting by maternal educational level using Relative Index of Inequality (RII) according to infant's age. All values were adjusted for study site and infant's sex. The RII values (95% CI) for stunting are 1.37 (0.84-2.24) at birth, 1.36(0.82-2.24) at 6 months, 3.04 (1.97-4.67) at 12 months, 3.14 (2.23-4.42) at 18 months, and 3.20 (2.29-4.47) at 24 months. For underweight, they are 1.30 (0.82-2.05), 1.79(1.02-3.16), 2.38 (1.52-3.74), 2.71(1.74-4.21), 2.65(1.68-4.17), and for wasting, 0.67(0.49-0.92), 1.41(0.79-2.54), 2.38 (1.37-4.14), 2.48(1.31-4.68), 1.45(0.70-3.01), respectively.

ally adjusted to the compromised height. Therefore, wasting among children in the low education group still needs attention. Depending on the eating/feeding patterns after the first 3 y, gaining weight with low height may result in under- or over-nutrition in older childhood and adulthood.[32] Children of less educated mothers are shorter and lighter than their counterparts. It should be kept in mind that multiple insults with limited recovery time lead to persistent height deficits[33] particularly among children in low SES.

Our study showed divergent growth faltering patterns between maternal education levels and greater magnitude of inequality measured by RII for all of malnutrition indicators from 6 to 12 months of age. Infant feeding practice is one of the key contributors to malnutrition in early childhood. Among factors related with infant feeding practice, early introduction of poor quality/low quantity of semi-solid foods or prolonged breastfeeding with inappropriate complementary foods could be important contributors to malnutrition inequality associated with maternal education. Children of uneducated mothers are more likely to be breastfed for over 12 months,[34] to be introduced to nutritious complementary food later, and to be malnourished (unpublished data). Some studies suggested that the duration of breastfeeding and the timing of complementary feeding can be confounded by recent illness, such as diarrhea[35] and feeding meals are given depending on the children's growth.[35-36] For example, when children have diarrhea or poor growth, mothers are likely to continue to breastfeed longer.[35] On the other hand, as the incidence of diarrhea diseases can be especially high after weaning is initiated,[37] contaminated complementary feeding with poor hygiene practice can result in diarrhea as well. Therefore, a higher proportion of child pneumonia and diarrhea in the low SES group is likely to contribute to malnutrition inequality.[17,29] These factors may moderate the association between prolonged breastfeeding and malnutrition. In addition, complementary foods with a relatively high energy and nutrient density must be given at about six months of age. Inadequate and inappropriate complementary food consumption, lower availability and quality of alternative energy-dense foods accompany poor household conditions in more deprived areas. Prolonged breastfeeding after 6 months without appropriate complementary foods (energy and micronutrient dense), coupled with proneness to infection due to poor hygiene, were important risks for malnutrition among children in the second half of infancy (6-12 months) and continued into the second year. Our study supports this by showing that when analyzing the RII in the other areas after excluding Bangkok, the inequalities of malnutrition were much larger in most ages, particularly during infancy (data not shown). The dietary and environmental determinants of the malnutrition in the low SES group and by regions remain to be elucidated.

In Thailand, the Poverty Alleviation Plan with multi-sectoral community based strategies based on Primary Health Care and Food and Nutrition Plan since 1981 has succeeded in reducing mortality and malnutrition.[2,4] Despite the successful story, growth faltering was obvious in infancy particularly among children in the low maternal education group. Thus, existing inequality in child mortality[8] and malnutrition leads to the need for nutrition education on adequate and appropriate feeding practices as well as special supplementary intervention programs to improve maternal and child nutrition. These programs, such as the pregnant Women, Infants, and Children (WIC) program in the USA to target low SES groups, including less educated mothers, have been shown to be effective.[38] Special efforts should be made to improve the situation of women as primary child care givers, with particular attention to complementary feeding and to the protection and promotion of breastfeeding.

Some limitations of the present study need to be acknowledged. First, the participants may not be representative of the Thai general population to analyze the socioeconomic differences, as the high socioeconomic population mostly resided in urban areas, such as Bangkok and Nan city. To compensate for these limitations, all values were presented after adjustment for study sites. Second, although education is considered as a significant indicator among SES indicators, other indicators, such as income were not used in the study. However, education and income are highly correlated and the results by household income levels were similar with those by education levels (data not shown). Furthermore, in light of high commitment of mothers to childcare and its strong association with child health, education can be a strong predictor of SES. Regardless of these limitations, it is noteworthy that this study, to our knowledge, is the first study to investigate the magnitude of inequality in malnutrition by RII in the first two years with a prospective cohort study, which led to minimization of the recall bias by collecting weight and height at the follow-up period. Further research is needed to identify the underlying, intermediate and proximate determinants to tackle the malnutrition inequality in childhood.

In conclusion, the magnitude of inequality in malnutrition across ages during the first 2 years of life, indicated by Relative Index of Inequality (RII), was evaluated with a prospective birth cohort study. Socioeconomic inequality in malnutrition remarkably increased during infancy and the extent of stunting and underweight was maintained until 24 months. More special, sustainable efforts are needed at the national level to target nutrition interventions to attack malnutrition inequality.

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AUTHOR DISCLOSURES

There is no conflict of interest to declare.

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