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Growth patterns of urban Malaysian children under 24 months of age in Selangor, Malaysia

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ABSTRACT

Introduction: To identify the growth patterns of young children during the first two years of life according to gestational age, birth weight, and growth status at 24 months of age. **Methods:** This was a retrospective cohort study of 4,570 young children in Selangor. Data were extracted from children's health records in government health clinics. Growth data were analysed using the Anthro Plus software that utilises the World Health Organization growth standards. **Results:** Generally, wasting prevalence was the highest at birth and 24 months, but stunting was more predominant from 1 to 21 months. Weight-for-age z-scores (WAZ), length-for-age z-scores (LAZ), and weight-for-length z-scores (WLZ) from birth to 24 months were within -3.00 to 0.00 standard deviation (*SD*) for pre-term low birth weight children, –1.50 to 0.00 *SD* for pre-term normal birth weight children, and –2.50 to 0.50 *SD* for full-term low birth weight children. While WAZ, LAZ, and WLZ from birth to 24 months for underweight/stunted/wasted children were within –2.50 to 0.50 *SD*, the values for overweight/obese (OV/OB) children were within –1.00 to 2.00 *SD*. For normal children, WAZ, LAZ, and WLZ exhibited comparable trends, with values within –1.00 to 0.00 *SD* from birth to 24 months. **Conclusion:** While stunting and wasting persisted as the most common forms of malnutrition in this sample of young children, the prevalence of OV/OB increased by 24 months. Interventions to promote child growth should focus not only on the prevention of undernutrition, but also on OV/OB.

Keywords: Malaysia, malnutrition, obesity, overweight, retrospective studies

INTRODUCTION

Worldwide, the prevalences of stunting, wasting, and underweight among children under five years have been reported to be 21.3%, 14.0%, and 13.0%, respectively; with the highest prevalence in Asia and Africa (WHO, 2020). In Asia, the number of stunted children has decreased from 134 to 87 million, a 35% reduction in 16 years (WHO, 2020). Although the number of stunted children under five years in South Asia has also declined from 90.1 million to 56.1 million between 2000 and 2019, South Asia still has the highest prevalence of stunting in the world. In Malaysia, the prevalence

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of stunting (21.8%) remains the most prevalent form of undernutrition among children under five years in 2019, followed by underweight (14.1%) and wasting (9.4%) (IPH, 2020).

Approximately 45% of all deaths among children under five years of age are attributed, directly or indirectly, to undernutrition (WHO, 2020). These deaths often occur in the same countries where the rates of childhood obesity are rising. Worldwide, there are 38.3 million children under five years (5.9%) who are overweight; with Southeast Asia and Northern America being the only sub-regions that had a substantial rise in the number of overweight children from 2000 to 2019. In Malaysia, the prevalence of overweight and obesity (BAZ>+2 standard deviation, *SD*) in 2019 among children under five years was 5.6%, and it was more prevalent in the urban than rural areas (6.0% vs 4.4%), and among the bottom 40% (B40 – < RM 4,850) than middle 40% (M40 – RM 4,850 to RM 10,959) and top 20% of household income categories (T20 – > RM 10,959) (6.0% vs 5.6% vs 4.2%) (IPH, 2020).

The first two years of life are often referred to as a critical period, during which there is a higher energy and nutrient demand to support a child's growth and development needs (Arnold *et al.*, 2009). A poor diet together with frequent infections may contribute to infant growth retardation (Goulet, 2010). Evidence indicates that growth faltering often occurs among infants of low- and middle-income households at some point during the first two years of life, and it commonly starts between four and six months of age (Victora *et al.*, 2010). In developing countries, weight faltering in infants often occurs around four months of age, while faltering of height occurs around three months of age (Victora *et al.*, 2010).

Poor growth in early life is associated with many adverse health consequences, ranging from cognitive deficits to the risk of chronic diseases in later childhood and adulthood (Singhal, 2017). Child growth monitoring is therefore a crucial step to understand the patterns and timing of growth faltering in both weight and height of infants. In addition, children with different birth status (e.g., pre-term delivery, low birth weight) may have different patterns of growth due to substantial neonatal growth restriction and the need for intensive care in most pre-term and low birth weight infants. The insight on the growth patterns and timing of growth faltering in children under 24 months of age could be the starting point for developing strategies to prevent early childhood growth retardation. Thus, this study aimed to examine the growth patterns of young children during the first two years of life, specifically according to gestational age, birth weight, and growth status at 24 months of age.

MATERIALS AND METHODS

This retrospective cohort study was conducted in six randomly selected Maternal and Child Health (MCH) clinics in Hulu Langat, Petaling, and Sepang districts, Selangor. The study protocol was approved by the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia (NMRR-18-2604-43816). Informed consent was not required due to the retrospective study design, and all participants were anonymised.

Data sources

The source of data was health records of children born between January 2015 to December 2017. The health records contained the parent's background, birth information (e.g., gender, gestational age, length, head circumference, and birth weight), and growth assessment.

Data were extracted from the health records by trained enumerators.

Growth assessment

Growth data at birth, 1, 2, 3, 4, 5 6, 9, 12, 15, 18, 21, and 24 months were extracted. Weight (to the nearest 0.1 kg), and length (to the nearest 0.1 cm), were measured by the clinic nurses using a digital weighing scale with length meter, respectively, according to standard procedures (MOH Malaysia, 2015). Growth data were analysed using the Anthro Plus software that utilises the World Health Organization (WHO) growth standards (2006) (WHO, 2006). Three growth indicators [length-for-age *z*-scores (LAZ), weight-for-age *z*-scores (WAZ), and weight-for-length *z*-scores (WLZ)] were determined. Children were excluded when one of their anthropometric observations was biologically improbable according to the cut-offs defined by WHO (2006). Specifically, the cut-offs were LAZ < –6 *SD* or > +6 *SD*, WAZ < –6 *SD* or > +5 *SD* or WLZ < –5 *SD* or > +5 *SD*. The final data set consisted of 4,570 children. Underweight, stunting, wasting among children were defined as LAZ, WAZ, and WLZ of < –2 *SD*. Meanwhile, overweight (OV) and obesity (OB) were defined as +2 *SD* < WLZ < +3 *SD* and WLZ of > +3 *SD* (WHO, 2006).

Other variables

Mother's socio-demographic information on age, ethnicity, marital status, education level, obstetrical information (e.g., gravidity, parity), medical history [e.g., retroviral, hepatitis B, diabetes/gestational diabetes mellitus (GDM), hypertension/pregnancy-induced hypertension (PIH), thalassaemia], as well as anthropometric measurements (e.g., height, weight at 1 month postpartum, body mass index at one month postpartum) were extracted. Mode of birth (normal vaginal birth, assisted breech delivery, instrumental delivery or caesarean section), sex of infant, infant's birth weight, length, and head circumference were also obtained from the health records. The gestational age at birth was determined by last menstrual period (LMP) or by ultrasonography if the LMP was unsure. Pre-term birth was defined as birth occurring at less than 37 completed weeks of gestation or 259 days of gestation. Birth weight was categorised according to the recommendations of the United Nations Children's Fund (UNICEF) and WHO as < 2.5 kg for low birth weight, 2.5 – 4.0 kg for normal birth weight, and >4.0 kg for high birth weight (UNICEF, 2004).

Data analysis

Data were analysed using SPSS version 26, while Microsoft Excel 2010 was used to generate plots. Descriptive statistics (mean, standard deviation, frequency, and percentage) were used to describe the data. Z-score distribution of different anthropometric indicators was plotted. The z-score distribution for the high birth weight group was not presented, as only 15 children were observed in this group. *P* for linear trend (*P*-trend) of growth from birth to 24 months was analysed using repeated measures analysis of variance (ANOVA) for LAZ, WAZ, and WLZ. Independent *t*-test was used to compare the mean values for LAZ, WAZ, and WLZ between groups (birth status and growth status at 24 months of age). The statistical significance level was set at $p<0.05$.

RESULTS

Table 1 shows the characteristics of mothers and infants. The mean maternal age was 30.4±4.6 years, and most mothers were Malays (76.0%). Two-fifth of the mothers were either overweight (30.9%) or obese (17.1%), whereas 6.5% were underweight at one

Table 1. Characteristics of mothers and infants (*N*=4,570)

Characteristics	*n (%)*	*Mean±SD*
Maternal characteristics		
Maternal age (years)		30.43±4.64
Ethnicity		
Malay	3474 (76.0)	
Chinese	638 (14.0)	
Indian and others	458 (10.0)	
Marital status		
Single	10 (0.3)	
Married	4559 (99.6)	
Divorced	1 (0.1)	
Education level (*n*=4502)		
No formal education	4 (0.1)	
Primary to secondary	2846 (63.2)	
STPM/Matriculation/Diploma/Certificate	956 (21.2)	
Tertiary and above	696 (15.5)	
Gravidity		2.00±0.95
1	1576 (34.5)	
2	1883 (41.1)	
3	807 (17.7)	
≥4	304 (6.7)	
Parity		0.96±0.42
0	1631 (35.7)	
1	1874 (41.0)	
2	778 (17.0)	
≥ 3	287 (6.3)	
Height (cm)		155.45±5.69
Weight at 1 month postpartum (kg)		61.12±12.06
Body mass index (BMI) at 1 month postpartum (kg/m^2)		25.28±5.18
Underweight (<18.5)	301 (6.5)	
Normal (18.5 – 24.9)	2079 (45.5)	
Overweight (25.0 – 29.9)	1410 (30.9)	
Obese (≥30.0)	780 (17.1)	
Medical history of		
Retroviral	6 (0.1)	
Hepatitis B	5 (0.1)	
Diabetes / Gestational diabetes mellitus	902 (19.7)	
Hypertension / Pregnancy-induced hypertension	178 (3.9)	
Thalassaemia	7 (0.2)	
Birth information		
Mode of delivery		
Normal vaginal birth	4154 (90.9)	
Assisted breech delivery	10 (0.2)	
Instrumental delivery (forceps, vacuum)	35 (0.8)	
Caesarean section	371 (8.1)	
Complication during birth		
No	4545 (99.5)	
Foetal distress	25 (0.5)	

Table 1. Characteristics of mothers and infants (*N*=4,570) [Cont'd]

Characteristics	*n (%)*	*Mean±SD*
Infant characteristics		
Age (months)		
1 months		1.09±0.15
2 months		2.12±0.19
3 months		3.17±0.22
4 months		4.17±0.25
5 months		5.18±0.23
6 months		6.23±0.30
9 months		9.25±0.33
12 months		12.15±0.21
15 months		15.16±0.28
18 months		18.18±0.29
21 months		21.17±0.30
24 months		24.16±0.21
Gestational age at delivery (weeks)		38.33±2.01
< 37 weeks (pre-term)	679 (14.9)	
≥ 37 weeks	3891 (85.1)	
Infant's sex		
Male	2598 (56.8)	
Female	1972 (43.2)	
Infant's birth weight (kg)		3.02±0.41
< 2.5 (Low birth weight)	535 (11.7)	
2.5 – 4.0 (Normal birth weight)	4020 (88.0)	
> 4.0 (High birth weight)	15 (0.3)	
Infant's head circumference (cm)		32.81±1.49
Infant's length at birth (cm)		49.34±2.86

month postpartum. About 19.7% and 3.9% had a history of diabetes/GDM and hypertension/PIH, respectively. There were 2,598 male infants (56.8%) and 1,972 female infants (43.2%), with 85.1% born full-term. A total of 535 (11.7%) infants had low birth weights (<2.5 kg) and only 15 (0.3%) had high birth weights (>4.0 kg).

At birth and at 24 months, the prevalence of wasting (birth=13.6%; 24 months=8.1%) was higher than the prevalence of stunting (birth=11.3%; 24 months=7.7%), underweight (birth=6.5%; 24 months=5.6%) and OV/OB (birth=10.9%; 24 months=5.5%). However, the prevalence of stunting (11.1 – 16.3%) was the highest from 1 to 21 months of age. The prevalence of underweight remained within 6.8% to 10.8% from 1 to 21 months of age. The prevalence of OV/OB decreased gradually from 9.3% at 1 and 2 months to 2.3% at 12 months, then increased to 5.5% at 24 months. Based on the z-score distribution for LAZ, WAZ, and WLZ of children under 24 months compared with the WHO standards, the distribution of LAZ (median= –0.65) and WAZ (median= –0.52) appeared to be skewed to the left, but the curve of WLZ (median= –0.18) lay closely within the range to the right of the WHO standard (Table not shown).

Table 2 shows the nutritional status of children at birth, by birth status. About 41.6%, 86.5%, and 47.6% of the pre-term low birth weight children were stunted, underweight, and wasted at birth. For pre-term normal birth weight children, most of them were non-

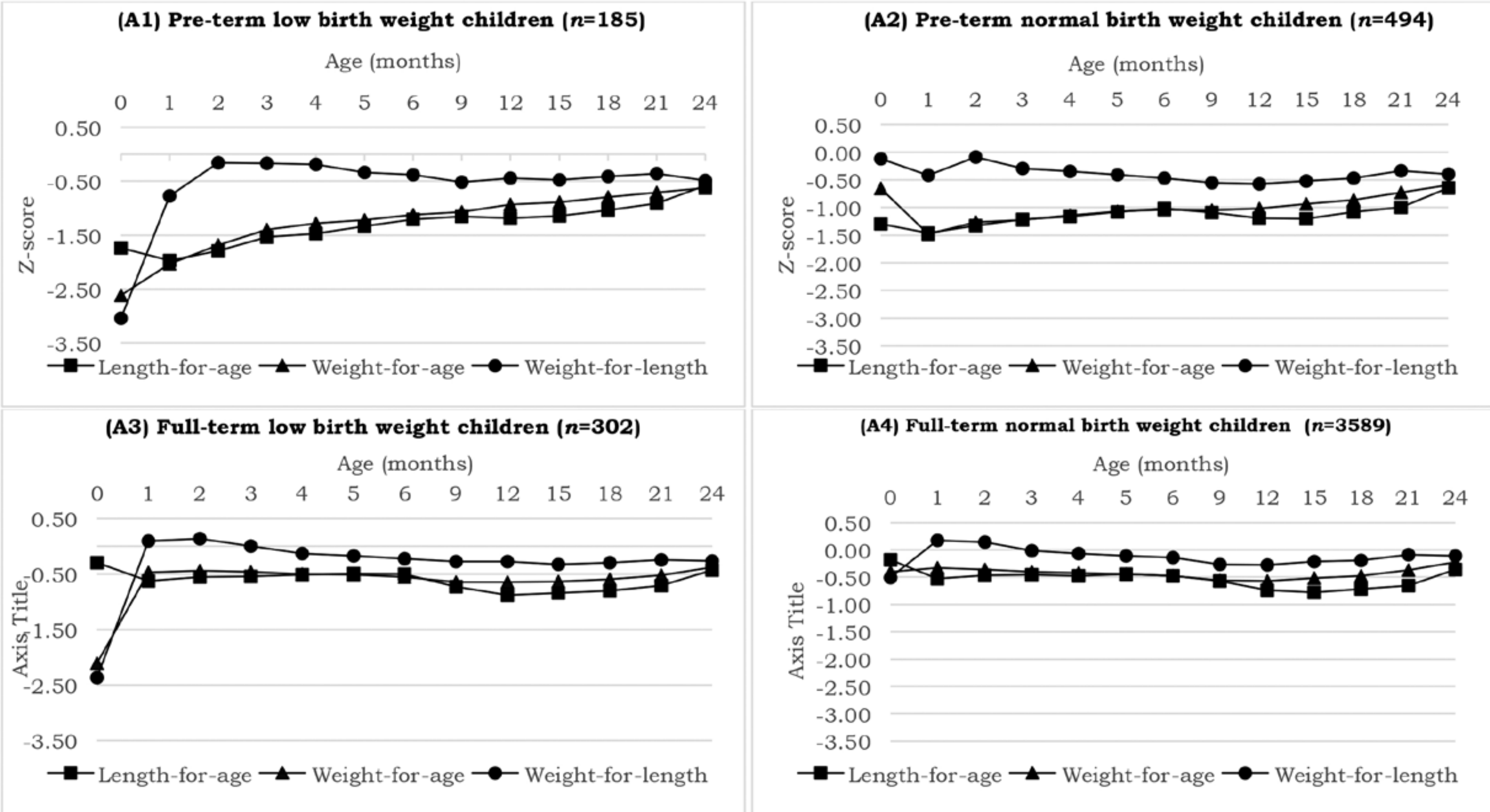
Table 2. Nutritional status of children at birth by birth status (N= 4,570)

	Total (n=4,570)	Birth status: Pre-term low birth weight (n=185)	Pre-term normal birth weight (n=494)	Full-term low birth weight (n=302)	Full-term normal birth weight (n=3589)	*p-value*
At birth						
Length-for-age z-score (LAZ), Mean±*SD*	-0.38±1.50	-1.74±1.92	-1.30±1.07	-0.30±1.44	-0.19±1.36	0.001***
Stunting, *n* (%)	516 (11.3)	77 (41.6)	145 (29.4)	32 (10.6)	262 (7.3)	0.001***
Non-stunting, *n* (%)	4054 (88.7)	108 (58.4)	349 (70.6)	270 (89.4)	3327 (92.7)	
Weight-for-age z-score (WAZ), Mean±*SD*	-0.63±0.91	-2.61±0.60	-0.66±0.78	-2.11±0.33	-0.40±0.71	0.001***
Underweight, *n* (%)	298 (6.5)	160 (86.5)	1 (0.2)	137 (45.4)	0 (0.0)	0.001***
Non-underweight, *n* (%)	4272 (93.5)	25 (13.5)	493 (99.8)	165 (54.6)	3589 (100.0)	
Weight-for-length z-score (WLZ), Mean±*SD*	-0.75±1.01	-2.76±1.56	-0.12±1.05	-2.37±1.06	-0.51±1.21	0.001***
Wasting, *n* (%)	713 (13.6)	88 (47.6)	1 (0.2)	223 (73.8)	401 (11.2)	0.001***
Normal, *n* (%)	3359 (73.5)	97 (52.4)	439 (88.9)	79 (26.2)	2744 (76.5)	
Overweight/obesity, *n* (%)	498 (10.9)	0 (0.0)	54 (10.9)	0 (0.0)	444 (12.4)	

Note: Stunting – LAZ <-2*SD*, Non-stunting – LAZ ≥ 2*SD*; Underweight – WAZ < -2*SD*, Non-underweight – WAZ ≥ -2*SD*; Wasting – WLZ < -2*SD*, Normal – WLZ ≥ ±2*SD*, Overweight/obesity – WLZ > + 2*SD*
***p<0.001

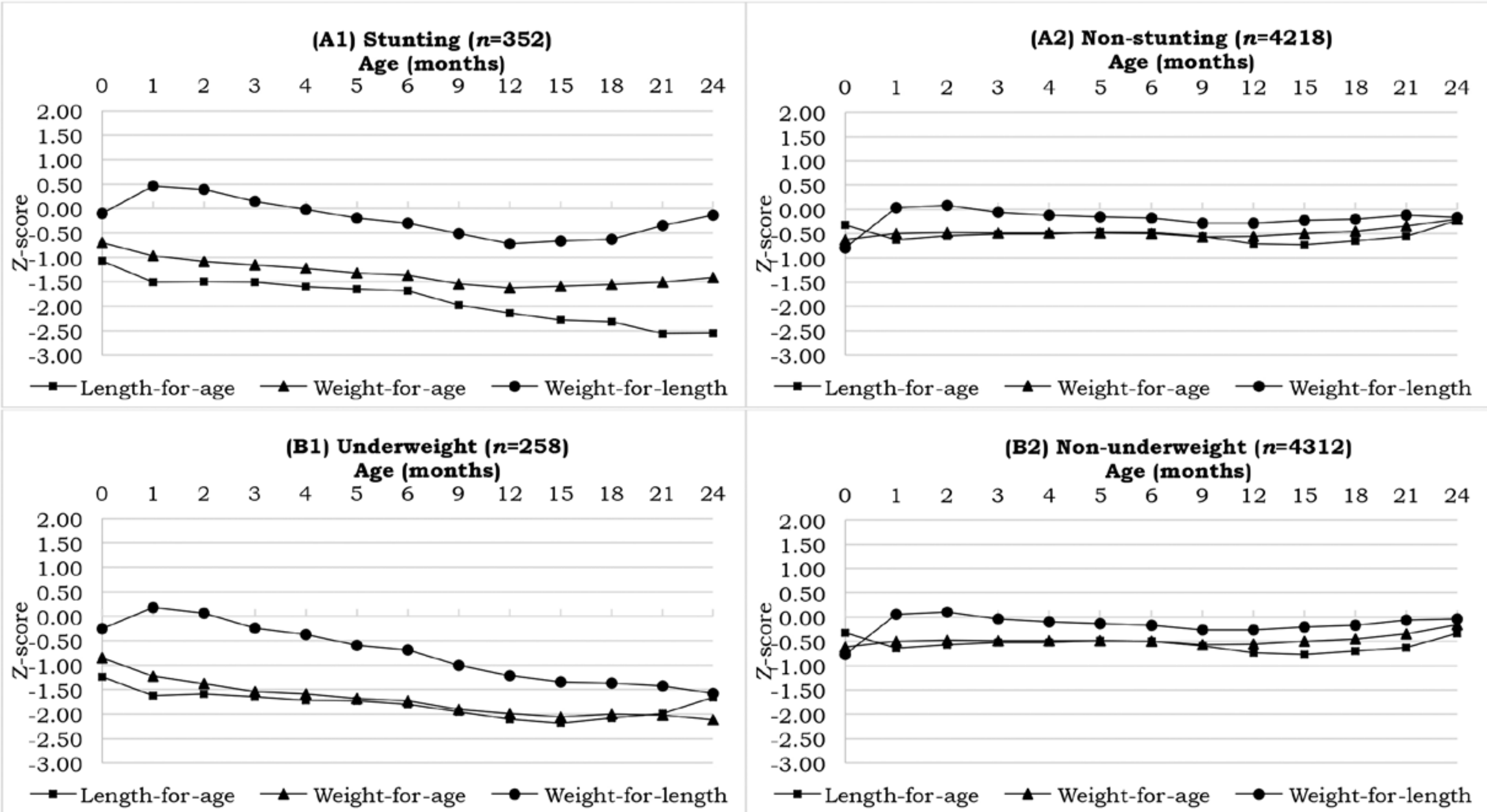
stunted (70.6%), non-underweight (99.8%), and non-OV/OB (88.9%) at birth. Meanwhile, for full-term low birth weight children, about 10.6% were stunted, 45.5% underweight, and 73.8% wasted.

Figure 1 shows the growth trend by birth status. There were significant differences in the means of LAZ, WAZ, and WLZ among children with different birth status (p<0.05). For pre-term low birth weight children, WLZ increased from birth to 2 months (–3.04 *SD* to –0.16 *SD*), decreased thereafter, and plateaued at –0.50 *SD* from 5 months onwards (*P*-trend <0.05). LAZ decreased to less than –1.50 *SD* at one month and increased thereafter to –0.58 *SD* at 24 months (*P*-trend <0.05). WAZ increased from birth to 24 months (–2.61 *SD* to –0.62 *SD*) (*P*-trend <0.05). For pre-term normal birth weight children, WLZ decreased from birth to one month (–0.12 *SD* to –0.41 *SD*), increased at two months (–0.09 *SD*), but decreased thereafter, and plateaued at –0.50 *SD* from five months onwards (*P*-trend <0.05). LAZ and WAZ decreased to less than –1.50 *SD* at one month and increased thereafter to –0.64 *SD* and –0.59 *SD* at 24 months, respectively (*P*-trend <0.05). WAZ for full-term low birth weight children increased from birth (< –2.11 *SD*) to 24 months (~ –0.50 *SD*), while LAZ showed a slight decline from birth to one month, but had a similar trajectory as WAZ thereafter (*P*-trend <0.05). WLZ for full-term and low birth weight children started below –2.00 *SD* at birth, but increased sharply by one month, reaching close to 0.00 *SD* at two months and maintained between –0.50



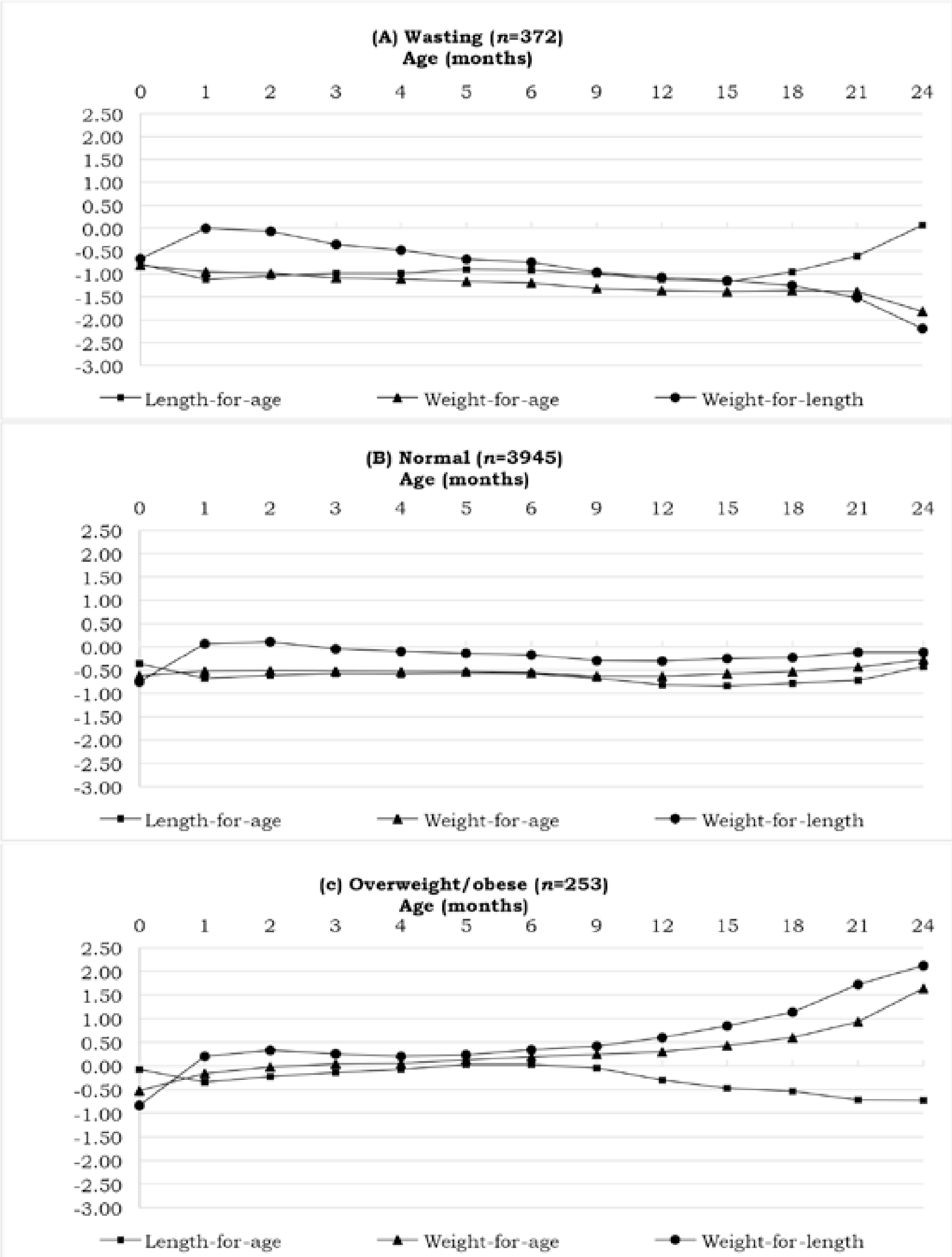
All p-trend <0.05.

Figure 1. Mean anthropometric z-scores (Length-for-age, weight-for-age, and weight-for-length) according to age relative to the World Health Organization (WHO) standards by birth status - (A1) Pre-term and low birth weight infants, (A2) Pre-term infants, (A3) Low birth weight infants, and (A4) Full-term and normal birth weight infants.



All p-trend <0.05.

Figure 2. Mean anthropometric z-scores (Length-for-age, weight-for-age, and weight-for-length) according to age relative to the World Health Organization (WHO) standards for (A1) stunting and (A2) non-stunting status at 24 months; (B1) underweight and (B2) non-underweight status at 24 months.



All *p*-trend <0.05

Figure 3. Mean anthropometric *z*-scores (Length-for-age, weight-for-age, and weight-for-length) according to age relative to the World Health Organization (WHO) standards for (A) wasting, (B) normal, and (C) overweight/obesity at 24 months.

SD to 0.00 *SD* thereafter (*P*-trend <0.05). For full-term normal birth weight children, both WAZ and WLZ increased from birth to one month, then gradually decreased to reach the lowest at 12 months (WAZ: –0.58 *SD*; WLZ: –0.28 *SD*), but increased thereafter (*P*-trend <0.05). LAZ decreased from birth to one month, remained stable (–0.45 *SD* to 0.48 *SD*) from two to six months, decreased thereafter to the lowest at 15 months, but showed an increasing trend to 24 months (P-trend <0.05).

Figures 2 and 3 show the means of LAZ, WAZ, and WLZ by growth status at 24 months. The means of LAZ, WAZ, and WLZ for stunted children were significantly lower than non-stunted children (Figure 2). For stunted children, there was an obvious decline in LAZ starting at nine months, which exceeded –2.00 *SD* at 12 months, and further exceeded –2.50 *SD* at 23 months and 24 months (*P*-trend <0.05). WAZ maintained between –1.63 *SD* to –1.42 *SD* from nine months until 24 months (*P*-trend <0.05). For underweight children, mean WAZ declined from birth (–0.85 *SD*) to 24 months (–2.12 *SD*) and exceeded –2.00 *SD* from 12 months onwards (P-trend <0.05). While LAZ decreased from birth (–1.63 *SD*) to 15 months (–2.19 *SD*) and increased thereafter to –1.66 *SD* at 24 months, WLZ gradually decreased from 1 to 24 months (0.18 *SD* to –1.58 *SD*) (*P*-trend <0.05). The mean WLZ for wasted children increased sharply from birth to 1 month (–0.66 *SD* to –0.01 *SD*), decreased thereafter, and exceeded –2.00 *SD* at 24 months (*P*-trend <0.05) (Figure 3). Conversely, for OV/OB children, WLZ increased sharply from birth to one month (–0.80 *SD* to 0.21 *SD*), gradually increased thereafter, and exceeded 2.00 SD at 24 months (2.12 SD) (P-trend < 0.05). While mean LAZ increased from 15 months onwards for wasted children, it decreased from 15 months onwards for OV/OB children (*P*-trend <0.05). WAZ for wasted children decreased from birth to 21 months (–0.81 *SD* to –1.39 *SD*) and further decreased to –1.82 *SD* at 24 months (*P*-trend <0.05). In contrast, WAZ for OV/OB children increased from birth to 21 months (–0.50 *SD* to 0.93 *SD*), and was above 1.00 *SD* at 24 months of age (1.64 *SD*) (*P*-trend <0.05). For normal children (non-stunted, non-underweight, non-wasted), WAZ, LAZ, and WLZ showed similar patterns as full-term children with values within –1.00 to 0.00 *SD* from birth to 24 months (*P*-trend <0.05). However, a slight decrease in LAZ was observed between 6 to 12 months in this group of normal children, after which LAZ showed a gradual increasing trend until 24 months (*P*-trend <0.05).

DISCUSSION

The present study found that the nutritional status of children was slightly better than children of a similar age group (24 months) in Thailand (The Thailand Multiple Indicator Cluster Survey (MICS) 2019 – 24 to 35 months, stunting: 11.9%; underweight: 7.5%; wasting: 7.7%) (National Statistical Office of Thailand, 2020), Cambodia (Cambodia Demographic and Health Survey 2014 – 24 to 35 months, stunting: 38.5%; underweight: 8.0%; wasting: 24.9%) (National Institute of Statistics, 2015), and Vietnam (Nutrition Surveillance Profiles 2013 – 24 to 29 months, stunting: 21.3%; underweight: 13.2%; wasting: 5.9%) (Vietnam National Institute of Nutrition, UNICEF, Alive & Thrive, 2014). The differences could be attributed to different socioeconomic status, cultural, and nutrition habits across the settings. The prevalences of stunting (7.7% vs 23.5% and 21.8%), underweight (5.6% vs 12.2% and 14.1%), and wasting (8.1% vs 10.5% and 9.4%) at 24 months for this sample was lower than the prevalences reported by the National Health and Morbidity Survey (NHMS) in

2016 (IPH, 2016) and 2019 (IPH, 2020), respectively. However, the prevalence of OV/OB at 5.5% was slightly higher than in NHMS (2019) (5.2%), but lower than that of NHMS (2016) (7.2%). This might be due to differences in demographic and socioeconomic backgrounds, such as the present data were collected in Selangor – a more developed state than other states in Malaysia, and NHMS 2019 that studied populations under five years old, with a wider age range compared to NHMS 2016 which focused on 24 to 35 months, as well as the inclusion of children from rural areas in NHMS 2019. Studies have shown that rural children have a higher prevalence of undernutrition, but lower prevalences of overweight and obesity compared to urban children, which could be attributed to lower socioeconomic status, poor hygiene and sanitation, as well as compromised living environment (Fagbamigbe, Kandala & Uthman, 2020).

The observed increasing growth trends among pre-term low birth weight, pre-term normal birth weight, and full-term low birth weight children could be attributed to the special postnatal care (e.g., more frequent follow-up to monitor their growth, post-discharge formula to top-up on feeding) provided by hospitals or MCH clinics within the first few years of life, until normal growth was achieved for these infants. This finding also reflects that the first 1,000 days of life is the most critical period of growth, and interventions during this period is likely to have the greatest impact in preventing child malnutrition (Martorell, 2017). It is also important to note that the while WAZ, LAZ, and WLZ for pre-term normal birth weight were within -1.50 to 0.00 *SD*, the WAZ, LAZ, and WLZ for full-term low birth weight children showed similar patterns as full-term children starting from 1 month and onwards, with values within -1.00 to 0.50 *SD* from birth to 24 months. These findings indicated that premature infants tend to grow more slowly compared with infants born at term regardless of birth weight.

Similar to previous studies that found stunting to be more predominant than underweight, wasting, and OV/OB among children at 24 months (Rojroongwasinkul *et al.*, 2016; Tariq *et al.*, 2018), children in the present study also experienced long-term nutritional deprivation. Stunting has been shown to be associated with biological (e.g., short maternal stature, intrauterine growth retardation, poor maternal nutrition before and during pregnancy) and environmental factors (e.g., poor socioeconomic conditions, frequent illness, inappropriate infant and young child feeding and care) (Fitriani, Achmad & Nurdiana, 2020). A meta-analysis showed that the attributed risk of prenatal growth failure (e.g., low birth weight, pre-term birth, small-gestational-age) for stunting at 12 – 60 months in low- and middle-income countries is about 20% (Christian *et al.*, 2013). The present study also found that a proportion of stunted children at 24 months were born pre-term (21.0%), with low birth weight (10.8%), and stunted at birth (20.2%). As this study did not assess maternal nutrition before and during pregnancy, it is unknown whether this contributed to poor intrauterine growth. Additionally, in contrast with previous studies (Karlsson *et al.*, 2021; Salimar, Irawati & Besral, 2019), the present study did not find any significant association between maternal height and stunting. It is speculated that environmental factors could be more important than biological factors for this cohort as only about one-fifth of children was linked to pre-term delivery, low birth weight, and stunted at birth. These children could be at a higher risk of concurrent stunting and OV/OB in the future if they remain in the same environment and have an unhealthy lifestyle, such as sedentary behaviour and unhealthy eating habits (e.g., consumption of high energy-dense, but low nutrient-dense foods) (Tzioumis *et al.*, 2016).

While stunting and wasting are indicators of chronic and acute malnutrition, respectively, being underweight is a composite indication that encompasses both acute and chronic conditions (De Onis & Blössner, 2003). For example, a child who is underweight may be stunted, wasted, or experiencing both conditions. The present study found that about 48.1% of underweight children were wasted, whereas 32.9% were stunted, and 10.9% were stunted and wasted. Additionally, about 26.7% and 13.2% of underweight children were born pre-term and with low birth weight. These observations indicated that most underweight children in the present study were prone to be acutely undernourished, partly due to restricted intrauterine growth (Christian *et al.*, 2013). Wasting may indicate a problem with current or recent starvation, inadequate or inappropriate supplementary foods, or it may be the result of an acute infectious illness (Caulfield *et al.*, 2006). As slightly less than half of the underweight children were wasted, it is plausible that these children might have experienced inappropriate infant and young child feeding practices (e.g., low frequency of breastfeeding, low quantity and quality of complementary foods) and/or infectious diseases (e.g., diarrhoea, respiratory infections), which caused them to lose weight or fail in weight loss recovery. An in-depth investigation of feeding practices and childhood diseases is needed to confirm such association.

Over the last decade, there has been a greater focus on the occurrence of stunting and wasting as evidence showed that children with concurrent wasting and stunting have the highest risk of mortality (McDonald *et al.*, 2013). South Asia had the greatest prevalence of concurrent stunting and wasting, with a prevalence of 8.0% for children at two years (Mertens *et al.*, 2020) and 4.4% for children under five years (McDonald *et al.*, 2013). Although the sample of children in the present study was from urban areas, about 0.6% (*n*=28) of them had concurrent stunting and wasting at 24 months of age. This result is consistent with a nationwide study in Thailand, which found that the prevalence of concurrent stunting and wasting was 0.7% and 0.6%, respectively, for children aged 12 to 23 months and for those in the wealthiest households (Okubo *et al.*, 2020). However, a prevalence of 0.2% was reported among children under seven years of age in China (Zhang *et al.*, 2021). Although the causes of wasting and stunting are often the same, the body responds to weight faltering by slowing linear growth, indicating that wasting raises the likelihood of future stunting (Schoenbuchner *et al.*, 2019). Subsequently, adequate weight is needed for linear growth recovery. Further research into the pathophysiology of these two types of malnutrition is required to design effective prevention and management programmes.

It is important to note that the prevalence of OV/OB increased from 2.4% at 15 months to 5.5% at 24 months. A rapid weight gain in OV/OB children was observed, whereby there was a sharp increase in the mean WLZ from six to 24 months. Further sub-sample analysis among OV/OB children showed that about 9.1% of them were born with low birth weight, while the remaining had normal birth weight and none were born with high birth weight (>4.0kg). Studies have documented the positive association between low birth weight and later obesity in children, whereby children with low birth weight might gain weight more rapidly in order to make up their lack of growth and this further contributes to the major components of metabolic syndrome (Chen *et al.*, 2019). As the prevalence of obesity in Malaysian adults has increased from 4.4% in 1996 to 19.7% in 2019 (IPH, 2020), the findings from the present study also suggest, therefore, that the primary prevention for cardiovascular diseases could begin as early as the first few months of life.

In developing countries, growth faltering in length often starts at 3 months and continues dramatically until 24 months of age (Victora *et al.*, 2010). The present study found that among normal children (non-stunted, non-underweight, non-wasted, or non-OV/OB), there was a slight decrease in LAZ between six to 12 months, but a gradual increase thereafter until 24 months. The WHO recommends that complementary feeding starts at six months of age in addition to breast milk (WHO, 2000). The NHMS (2016) showed that about 80.6% of children under 24 months in Selangor fulfilled the minimum meal frequency (children who received solid, semi-solid, and soft food for breastfed and non-breastfed children), but only 48.4% and 50.3% children met the minimum dietary diversity and minimum acceptable diet (IPH, 2016). Thus, it is plausible that the children in this cohort might have had poor feeding practices, such as inappropriate complementary feeding practices, which increased their risk for poor growth during early infancy. Promoting optimal breastfeeding and complementary feeding practices, through effective policies and interventions, could improve the initiation of breastfeeding, exclusive breast-feeding in the first six months of life, timing of introduction of solid foods, frequency of feeding, diversity of young children's diets, and subsequently child growth and development (Heidkamp *et al.,* 2021). While breastfeeding promotion has been much emphasised in the national plan of action for the nutrition of Malaysia, this study underscores the need for greater efforts in promoting optimal young child complementary feeding practices and preventing macro- and micronutrient deficiencies.

The limitation of this study was the use of anthropometric data from health records that could have introduced bias (e.g., measurement bias, data extraction bias). Nevertheless, all measurements were taken by trained nurses with a standard protocol to maintain the reliability of measurements. Despite this limitation, the present study has provided an insight into the nutritional status of urban children under 24 months of age.

CONCLUSION

Stunting was more common than underweight, wasting, and OV/OB from 1 to 21 months, although wasting prevalence was highest at birth and 24 months. While undernutrition prevailed, the prevalence of OV/OB increased, starting at 15 months up to 24 months. As both growth retardation and rapid growth in early life are predictive of later health outcomes, interventions should be aimed not only at achieving adequate growth for the prevention of growth faltering, but also for the prevention of rapid growth in the early years. With the tremendous progress over the years in maternal and child health care in Malaysia, as well as the global recognition that early life intervention is crucial for future health and disease prevention, strategies related to infant and young child feeding (i.e. breastfeeding, complementary feeding) could be further strengthened to improve the health and nutrition of children.

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Authors' contributions

Yong HY, led the data collection, data analysis and interpretation, prepared the draft of the manuscript, and reviewed the manuscript; Zalilah MS, principal investigator, conceptualised and designed the study with Yong HY, advised on data analysis and interpretation, and reviewed the manuscript; Wong CY, assisted in data analysis, and reviewed the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Arnold F, Parasuraman S, Arokiasamy P, & Kothari M (2009). *In: National Family Health Survey (NFHS-3) India 2005-06 Nutrition in India.* From http://www.mohfw.nic.in. [Retrieved March 1 2019].

Christian P, Lee SE, Donahue Angel M, Adair LS, Arifeen SE, Ashorn P, Barros FC, Fall CH, Fawzi WW, Hao W, Hu G, Humphrey JH, Huybregts L, Joglekar CV, Kariuki SK, Kolsteren P, Krishnaveni GV, Liu E, Martorell R, Osrin D, Persson LA, Ramakrishnan U, Richter L, Roberfroid D, Sania A, Ter Kuile FO, Tielsch J, Victora CG, Yajnik CS, Yan H, Zeng L & Black RE (2013). Risk of childhood undernutrition related to small-for-gestational age and pre-term birth in low- and middle-income countries. *Int J Epidemiol* 42(5):1340–1355.

De Onis M & Blössner M (2003). The World Health Organization Global Database on Child Growth and Malnutrition: Methodology and applications. *Int J Epidemiol* 32(4):518–526.

Fagbamigbe AF, Kandala NB & Uthman AO (2020). Demystifying the factors associated with rural–urban gaps in severe acute malnutrition among under-five children in low- and middle-income countries: a decomposition analysis. *Sci Rep* 10:11172.

Fitriani H, Achmad SR & Nurdiana P (2020). Risk Factors of Maternal Nutrition Status During Pregnancy to Stunting in Toddlers Aged 12-59 Months. *J Keperawatan Padjadjaran* 8(2):183.

Goulet O (2010). Growth faltering: setting the scene. *Eur J Clin Nutr* 64(Suppl):S2-4.

IPH (2016). *National Health & Morbidity Survey (NHMS) 2016*. Institute for Public Health, Ministry of Health Malaysia, Kuala Lumpur.

IPH (2020). *National Health and Morbidity Survey (NHMS) 2019: Vol. I: NCDs – Non-Communicable Diseases: Risk Factors and other Health Problems.* Institute for Public Health, Ministry of Health Malaysia, Kuala Lumpur.

Karlsson O, Kim R, Bogin B & Subramanian S (2021). Maternal height-standardised prevalence of stunting in 67 low- and- middle-income countries. *J Epidemiol* JE20200537:1-8.

Caulfield LE, Stephanice A, Richard JA, Rivera PM & Black RE (2006). Stunting, wasting, and micronutrient deficiency disorders. In Jamison DT, Breman JG & Measham AR (eds). *Disease Control Priorities in Developing Countries* (pp 237). Oxford University Press, New York.

Chen C, Jin Z, Yang Y, Jiang F, Huang H, Liu S & Jin X (2019). Association of low birth weight with thinness and severe obesity in children aged 3-12 years: a large-scale population-based cross-sectional study in Shanghai, China. *BMJ open* 9(5): e028738.

Martorell R (2017). Improved nutrition in the first 1000 days and adult human capital and health. *Am J Hum Biol* 29(2): 1–24.

McDonald CM, Olofin I, Flaxman S, Fawzi WW, Spiegelman D, Caulfield LE, Black RE, Ezzati M, Danaei G & Nutrition Impact Model Study (2013). The effect of multiple anthropometric deficits on child mortality: Meta-analysis of individual data in 10 prospective studies from developing countries. *Am J Clin Nutr* 97:896–901.

Mertens A, Benjamin-Chung J, Colford JM, Hubbard AE, van der Laan MJ, Coyle J, Oleg S, Cai W, Wendy J, Sonali D, Anna N, Nolan NP, Stephanie D, Anmol S, Esther OC, Ivana M, Nima H, Haodong L, Ryan H, Vishak S, Jonas H, Thea N, Parul C & Kenneth HB (2020). Child wasting and concurrent stunting in low- and middle-income countries. (pre-print). *medRxiv* 20126979. From http://medrxiv.org/content/early/2020/06/11/2020.06.09.20126979.abstract [Retrieved Jan 1 2021].

National Institute of Statistics (2015). *Cambodia Demographic and Health Survey 2014*. Phnom Penh, Cambodia, and Rockville, Maryland, USA. [Retrieved 12 February 2022].

Ministry of Health Malaysia (2015). *Garis Panduan Program Community Feeding*. Putrajaya, Malaysia. [Retrieved 21 January 2021].

National Statistical Office of Thailand (2020). *Thailand Multiple Indicator Cluster Survey 2019, Survey Findings Report.* Bangkok, Thailand. [Retrieved June 20 2020].

Okubo T, Janmohamed A, Topothai C & Blankenship JL (2020). Risk factors modifying the double burden of malnutrition of young children in Thailand. *Matern Child Nutr* 16(S2):1–9.

Rojroongwasinkul N, Bao Kle N, Sandjaja S, Poh BK, Boonpraderm A, Huu CN, Soekatri M, Wong JE, Deurenberg P & Manios Y (2016). Length and height percentiles for children in the South-East Asian Nutrition Surveys (SEANUTS). *Public Health Nutr* 19(10):1741–50.

Salimar S, Irawati A & Besral B (2019). Maternal height as determinant factors of children not to be stunting until age 59 months. *Indian J Public Heal Res Dev* 10(3):765–71.

Schoenbuchner SM, Dolan C, Mwangome M, Hall A, Richard SA, Wells JC, Khara T, Sonko B, Prentice AM & Moore SE (2019). The relationship between wasting and stunting: A retrospective cohort analysis of longitudinal data in Gambian children from 1976 to 2016. *Am J Clin Nutr* 110(2):498–507.

Singhal A (2017). Long-Term Adverse Effects of Early Growth Acceleration or Catch-Up Growth. *Ann Nutr Metab* 70(3): 236–40.

Tariq J, Sajjad A, Zakar R, Zakar MZ, Fischer F (2018). Factors associated with undernutrition in children under the age of two years: Secondary data analysis based on the Pakistan demographic and health survey 2012–2013. *Nutrients* 10(6):676-684.

Tzioumis E, Kay MC, Bentley ME & Adair LS (2016). Prevalence and trends in the childhood dual burden of malnutrition in low- and middle-income countries, 1990-2012. *Public Health Nutr* 19(8): 1375–88.

UNICEF (2004). *In: Low birthweight: country, regional and global estimates.* From https://apps.who.int/iris/handle/10665/43184. [Retrieved June 21 2018].

Victora CG, de Onis M, Hallal PC, Blossner M & Shrimpton R (2010). Worldwide timing of growth faltering: Revisiting implications for interventions. *Pediatrics* 25(3): e473–80.

Vietnam National Institute of Nutrition, UNICEF, Alive & Thrive (2014). *Nutrition Surveillance Profiles 2013*. Hanoi, Vietnam. https://www.unicef.org/vietnam/nutrition. [Retrieved June 20 2020].

WHO (2000). *Complementary feeding: Family foods for breastfed children.* WHO Press, World Health Organization, Geneva.

WHO (2006). *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-height and body mass index-for-age: methods and development.* WHO Press, World Health Organization, Geneva.

WHO (2020). *In: UNICEF/WHO/The World Bank Group joint child malnutrition estimates: levels and trends in child malnutrition: key findings of the 2020 edition.* World Health Organization. From: https://www.who.int/publications/i/item/jme-2020-edition [Retrieved Jan 21 2021].

Zhang YQ, Li H, Wu HH & Zong XN (2021). Stunting, wasting, overweight and their coexistence among children under 7 years in the context of the social rapidly developing: Findings from a population-based survey in nine cities of China in 2016. *PLoS One* 16(1):e0245455.