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Abstract

Purpose: This study aimed to examine the association between minimum dietary diversity (MDD) and the concurrence of stunting and overweight (CSO) among children aged 6-23 months.

Design/methodology/approach: A cross-sectional study was conducted in Sedayu Subdistrict, Bantul District, Daerah Istimewa Yogyakarta. We assessed the concurrence of stunting (height-for-age Z-score below -2 SD) and overweight/obesity (BMI-for-age Z-score above +2 SD) among a total of 189 children aged 6-23 months as the primary outcome. We defined MDD as consuming at least four out of seven food groups using a single 24-hour recall. We also included other covariates, including sociodemographic characteristics, exclusive breastfeeding history, and complementary feeding practices. To identify factors associated with CSO, we conducted multiple logistic regression across the study variables using STATA 16.1. **Findings:** In the adjusted model, children who met the MDD criterion were associated with a reduced risk of CSO (adjusted OR: 0.14; 95% CI: 0.03-2.43). Compared to boys, girls were more likely to experience CSO (adjusted OR: 5.23; 95% CI: 1.02-26.9). Middle economic status was a protective factor for CSO (adjusted OR: 0.10; 95% CI: 0.01-0.98). We did not find a significant relationship between CSO and the child's age, low birth weight, exclusive breastfeeding, energy intake, protein intake, parental education, and parental occupation.

Practical implications: This study suggests future programs and policies promote dietary diversity to reduce the risk of concurrence stunting and overweight.

Originality/value: The present study reveals the association between minimum dietary diversity and the coexistence of stunting and overweight.

Keywords: children, double burden; minimum dietary diversity; overweight; stunting

Introduction

The double burden of malnutrition (DBM) has become a public health concern in the developing world. It is characterized by the concurrence of undernutrition, alongside overweight, obesity or diet-related non-communicable diseases, which could occur in the individual, household, community, and across the life cycle. At the individual level, the dual burden of malnutrition presents simultaneously through the development of two or multiple types of malnutrition (WHO, 2017). In children, under and overnutrition may put them at a higher risk of undernutrition-related diseases, obesity-related diseases, and non-communicable diseases (Zhang *et al.*, 2016).

Globally, it is estimated that stunting has threatened the lives of 149.2 million children under five, while overweight has affected 38.9 million children under five. In addition, some have suffered from more than one malnutrition form, such as the concurrence of stunting and overweight (World Health Organization *et al.*, 2021). At the country level, DBM is concentrated in East Asia and Pacific, South Asia, and Sub-Saharan Africa (Popkin *et al.*, 2020). In Indonesia, the most current nationwide survey has shown that the prevalence of stunting was 30.8%, whereas the prevalence of overweight and obesity was 8% in children (NIHRD, 2019).

While economic change and physical activity can contribute to nutritional status, diet plays a critical role in the DBM (Popkin *et al.*, 2020; WHO, 2017). The nutrition transition or a change in how people eat and drink impacts the distribution of body composition (Popkin *et al.*, 2020). Thus, the link between stunting and overweight may reflect the transformation from traditional diets (i.e., low in fat, high in fibre) to Western diets (i.e., high in energy, low in fibre) as the rapid socioeconomic development and urbanization occur (Zhang *et al.*, 2016). In addition, stunting has been related to impaired fat oxidation, which may explain the increases in body fatness and, thus, obesity among stunted adolescents and adults (De Lucia Rolfe *et al.*, 2018; Muhammad, 2018). However, little is known about DBM issues among children.

The association between child nutritional status and feeding has been established. Adequate dietary practices in children may lead to optimal growth (UNICEF, 2021). Minimum dietary diversity (MDD) is one of the complementary feeding indicators that reflects diet quality and quantity in infants and young children (Arsenault *et al.*, 2013; WHO/UNICEF, 2021; Zongrone *et al.*, 2012). Previous research has shown that possible mechanisms between dietary diversity and stunting are because eating a varied diet is correlated with sufficient energy, protein, and micronutrient statuses (Aboagye *et al.*, 2021; Masuke *et al.*, 2021). Meanwhile, the association between dietary diversity and obesity has been inconsistent, depending on which food groups dominated the diet. For example, a diet variety in non-recommended foods (e.g., energy-dense starchy food) may increase the risk of obesity compared to a diet variety in recommended foods (e.g., fruits and vegetables) (Khamis *et al.*, 2019; Otto *et al.*, 2018).

Previous studies of the determinants of the concurrence of stunting and overweight (CSO) have shown unconcluded results and were conducted among children in different age groups (Benedict *et al.*, 2021; Ciptanurani and Chen, 2021; Farah *et al.*, 2021; Zhang *et al.*, 2021).

Besides, there is limited evidence on how diet influences CSO among younger children (Benedict *et al.*, 2021). While findings from earlier research have shown a significant association with stunting (Khamis *et al.*, 2019; Paramashanti *et al.*, 2017; Wang *et al.*, 2017), the link between MDD and CSO has not been well-established (Benedict *et al.*, 2021). Thus, our study aims to examine the relationship between MDD and CSO in Bantul District, Yogyakarta, Indonesia.

Methods

Design and study participants

A cross-sectional study was conducted between February and March 2016 in Sedayu Subdistrict, Bantul District, Yogyakarta Special Region, Indonesia. Study participants were mothers of infants and young children aged 6-23 months. They were eligible for participation in this study if they lived in Bantul District and signed written consent. Those with any missing data on child nutritional status and food group consumption were excluded. We selected mothers using probability proportional to size where *posyandu* were used as clusters. *Posyandu* is a village-level integrated health post to improve maternal and child health, including nutrition, in Indonesia (Ministry of Health of Indonesia, 2012). The sample size was calculated based on the prevalence of stunting in the Yogyakarta Special Region in 2015 (14.36%) (Daniel, 1999; Syahputri and Anggraini, 2019), with type 1 error at 5%, and a precision of 0.05, resulting in a minimum of 179 samples. However, we included all eligible samples in the Sedayu Subdistrict which was 189 mothers of children aged 6-23 months. This study was ethically approved by the Institutional Review Board of Universitas Alma Ata, Indonesia (reference number: KE/AA/I/05/EC/2016).

Study variables

Our dependent variable was the concurrence of stunting and overweight (CSO). Stunting was a length-for-age Z-score below -2 SD, while overweight was a BMI-for-age Z-score above +2 SD based on the population reference (World Health, 2006). A child was considered as having CSO if he/she experienced combined stunting and was overweight during the data collection (Rachmi *et al.*, 2016).

The independent variable included dietary practices and factors at the child, parental, and household levels. We defined MDD as consuming at least four out of seven food groups using a single 24-hour recall. These foods included 1) grains, roots and tubers, 2) legumes and nuts, 3) dairy products, 4) eggs, 5) flesh foods, 6) vitamin A-rich fruits and vegetables, and 7) other fruits and vegetables (WHO, 2008). Following the guidance (WHO, 2008), we collected information about the child's diet, including liquids and foods, preceding the interview using a 24-hour food recall. The interviewer wrote the name of the food in the form as the mother recalled the food. When the mother responded with mixed dishes, the interviewer asked about all the ingredients of the dish. We included all foods in the forms of solid, semi-solid, or soft foods into the corresponding food groups. We included some liquids into specific food groups: 1) liquid or thin yoghurt, but not yoghurt drink, into dairy products and 2) thin porridge into food made from grains. We also considered vitamin-A fruit juices into vitamin-A-rich fruits and vegetables if they contained a minimum of 120 retinol equivalents per 100 grams (WHO, 2008). The interviewer used a separate form to determine which food groups the food was classified into. We excluded food used as condiments since it was used in a small quantity; thus, did not belong to any food group. Finally, we scored the response as either "1" for every food group consumed or "0" for not consuming. The sum of food group consumption resulted in a dietary diversity score.

Exclusive breastfeeding was defined as feeding a baby with only breast milk without any additional food or liquid for the first six months of life (WHO/UNICEF, 2003). Energy and protein intakes were collected using 24-hour dietary recall. By referring to the recommended dietary allowances (RDA), we categorised energy and protein as adequate if the intakes meet ≥80% of RDA and inadequate if <80% of RDA (Kementrian Kesehatan Republik Indonesia, 2019).

Child level factors were sex (male, female), age (6-11 months, 12-17 months, 18-23 months), and birth weight (≥2500 g, <2500 g). We categorized the maternal age into <30 years and ≥30 years since the mean maternal age in the present study was 30 years. The use of the mean of maternal age as a cut-off was also used by previous research with similar topics (Modjadji *et al.*, 2022). Other parental factors were parental education (junior high school or below, senior high school, higher degree), maternal working status (not working, working), and paternal occupation type (not working or informal work, formal work). Working in formal sectors meant that fathers worked as private or government employees, whereas working in informal sectors meant that fathers worked as entrepreneurs, farmers, fishermen, or labourers (Siswati *et al.*, 2022). The household level factor was household economic status based on monthly income (poor, middle, rich).

Statistical analysis

The initial analysis involved descriptive statistics when presenting participants' characteristics. Then, we performed univariate logistic regression to test the association between each variable and stunting independently. Unadjusted odds ratios (OR) were reported. Variables with $p<0.25$ were entered into the multivariable analysis. Finally, we conducted multiple logistic regression to identify factors associated with combined stunting and overweight and reported adjusted odds ratios (AOR). We selected the model using the backward elimination technique at the significance level of 0.05. We only retained significant variables in the final model. We set the child's age, exclusive breastfeeding, and maternal education as fixed variables and presented them regardless of their significance. All analyses were done using STATA 16.1.

Results

Table I shows the characteristics of the study participants. More than half of the children were males (59%) and were born with normal weight (76%). Mothers of children mostly aged above 30 years (51%), completed senior high school (46%) and were unemployed (56%), whereas the majority of fathers completed senior high school (52%) and worked in informal sectors (68%).

Table I. Characteristics of study participants (n= 189)

Characteristics	**n**	**%**
Child level		
Sex		
Male	111	58.7
Female	78	41.3
Age		
6-11 months	59	31.2
12-17 months	63	33.3
18-23 months	67	35.5
Birth weight		
>=2500 g	143	75.7
<2500 g	46	24.3
Parental level		
Mother's age		
<30 years	93	49.2
>=30 years	96	50.8
Mother's education		
Junior high school or below	65	34.4
Senior high school	86	45.5
Higher educational degree	38	20.1
Mother's occupation		
Not working	105	55.6
Working	84	44.4
Father's education		
Junior high school or below	55	29.1
Senior high school	99	52.4

Higher educational degree	35	18.5
Father's occupation		
Not working or informal	60	31.8
Formal	129	68.3
Household level		
Household economic status		
Poor	65	34.4
Middle	61	32.3
Rich	63	33.3

Thirty-one per cent of the children experienced stunting, while 11% of the children were overweight. Six per cent had CSO. Around 36% of the children were exclusively breastfed. Half children had adequate energy intake, and nearly all had sufficient protein intake in the last 24 hours. Eating a diversified diet was found among 61% of the children (see Table II).

Table II. Frequency distribution of child nutritional status and feeding practices (n= 189)

Variables	**n**	**%**
Nutritional status		
Stunted		
No	131	69.3
Yes	58	30.7
Overweight		
No	169	89.4
Yes	20	10.6
Both stunted and overweight		
No	178	94.2
Yes	11	5.8
Feeding practices		
Exclusive breastfeeding		
No	122	64.6
Yes	67	35.5
Energy intake		
Inadequate	82	43.4
Adequate	107	56.6
Protein intake		
Inadequate	14	7.4
Adequate	175	92.6
Dietary diversity		
<4	74	39.2
>=4	115	60.9

In Table III, the unadjusted analysis showed that MDD (OR= 0.12; 95% CI: 0.02-0.57) and low birth weight (OR= 6.24; 95% CI: 1.74-22.3) were the only factors significantly associated with CSO. We included exclusive breastfeeding, dietary protein intake, sex, maternal occupation, paternal education, and household economic status in the multivariable analysis since their p<0.25. Despite their significance, we also kept the child's age and maternal education as fixed variables. Results from the multiple logistic regression revealed that MDD and the middle-income household were protective factors against CSO (AOR= 0.08; 95% CI: 0.01-0.47 and AOR= 0.10; 95% CI: 0.01-0.98), respectively. Being female was associated with a higher risk of CSO (AOR= 4.83; 95% CI: 1.09-21.4).

Table III. Unadjusted and adjusted odds ratios of factors associated with the coexistence of stunting and overweight/obese (n= 189)

Variables	OR	95% CI	*p*	AOR	95% CI	*p*
Feeding practices						
Exclusive breastfeeding						
No	1			1		
Yes	0.39	0.08-1.84	0.233	0.53	0.10-2.79	0.453
Energy intake						
Inadequate	1					
Adequate	0.62	0.18-2.11	0.445			
Protein intake						
Inadequate	1					
Adequate	0.33	0.06-1.68	0.180			
Minimum dietary diversity						
<4	1			1		
>=4	0.12	0.02-0.57	0.008*	0.08	0.01-0.47	0.005*
Child level						
Sex						
Male	1			1		
Female	2.64	0.75-9.34	0.133	4.83	1.09-21.4	0.038*
Age						
6-11 months	1			1		
12-17 months	1.27	0.27-5.91	0.765	1.07	0.18-6.47	0.942
18-23 months	1.19	0.35-5.53	0.829	0.50	0.09-2.89	0.442
Birth weight						
>=2500 g	1					
<2500 g	6.24	1.74-22.3	0.005*			
Parental level						
Mother's age						
<30 years	1					
>=30 years	0.80	0.25-2.71	0.716			
Mother's education						
Junior high school or below	1			1		
Senior high school	0.59	0.15-2.27	0.439	0.75	0.15-3.80	0.723
Higher educational degree	0.67	0.12-3.62	0.638	1.70	0.17-17.2	0.655
Mother's occupation						
Not working	1					
Working	0.45	0.12-1.75	0.248			
Father's education						
Junior high school or below	1					

Senior high school	0.42	0.11-1.64	0.212			
Higher educational degree	0.61	0.11-3.31	0.456			
Father's occupation						
Not working or informal	1					
Formal	0.54	0.16-1.83	0.321			
Household level						
Household economic status						
Poor	1			1		
Middle	0.14	0.01-1.16	0.068	0.10	0.01-0.98	0.048*
Rich	0.41	0.10-1.68	0.217	0.45	0.07-3.04	0.413

Discussion

The present study revealed factors associated with CSO among children aged 6-23 months in Bantul District, Yogyakarta, Indonesia. The prevalence of CSO, stunting and overweight was 6%, 31% and 11%, respectively. Similar to our finding, a previous study conducted among children aged 24-59 months in Indonesia has shown that the prevalence of CSO was around 6% between 1993 and 2007 (Rachmi *et al.*, 2016). Being male, eating a diverse diet and coming from middle-income families were associated with reduced risks of CSO in young children.

MDD was protective against the combination of stunting and overweight in children. Previous studies showed a significant association between MDD and stunting (Aboagye *et al.*, 2021). Since MDD ensures the consumption of various food groups, it is linked the micronutrient adequacy which is important for child growth (Molani-Gol *et al.*, 2023; Zongrone *et al.*, 2012). At the same time, a study in China suggested that eating a diversified diet could minimise high-fat and high-calorie food consumption, thus reducing the risk of overweight and obesity in children (Tao *et al.*, 2020). While MDD may help shape a balanced diet, further study is required to elaborate on the influence of MDD on child nutritional status, particularly under and overnutrition that go in reverse directions.

Girls were more likely to be both stunted and obese. Two other studies also found that girls tend to experience CSO simultaneously compared to boys (Atsu *et al.*, 2017; Okubo *et al.*, 2020).

Gender differences in susceptibility to malnutrition can be explained by biological and social mechanisms or a combination of both (Thurstans *et al.*, 2020). Females are more at risk for stunting and overweight because of the inherent biological differences. Even in fetal life, male and female offspring have different strategies for allocating energy to somatic tissue. The allocation of energy stores is associated more strongly with fat mass in females and lean mass in males (Rogers *et al.*, 2006). Moreover, gender disparities in food allocation for children in a household are influenced by societal cultural norms (Kuntla *et al.*, 2014). For example, an anthropological study in Ecuador reported that boys received better breastfeeding and weaning practices, and regardless of the breastfeeding status, boys had better dietary diversity than girls, mainly because of the traditional belief that boys needed to be stronger (Evers *et al.*, 2022). Similarly, a study in India found that girls had shorter breastfeeding duration and low consumption of fresh milk compared to boys (Fledderjohann *et al.*, 2014). In addition, previous research in Indonesia revealed that girls had poorer quality of complementary feeding than boys (Ng *et al.*, 2012). Overall, the relationship between gender and CSO is likely to be influenced by the biological nature of energy storage and allocation, and the quality of infant and young child feeding. However, further research is also needed to clarify the association between these variables.

This study found that middle economic status was a protective factor for CSO compared to poor economic status. The results were in line with previous studies showing that lower household income was a risk factor for CSO (Atsu *et al.*, 2017; Keino *et al.*, 2014). Household economic status is a basic cause of malnutrition and a key predictor affecting child malnutrition distribution (Zhang *et al.*, 2016). Lower economic status is associated with inappropriate feeding practices (e.g., not meeting minimum dietary diversity) (Paramashanti *et al.*, 2022; Sebayang *et al.*, 2020) and poor diet quality (e.g., high in energy-dense food, low in nutrient-dense food)

(Popkin *et al.*, 2012). It is suggested that low consumption of animal protein inhibits linear growth, whereas a high carbohydrate diet may increase fat deposition (Modjadji *et al.*, 2022). In fact, the food cost can be a barrier to implementing a lower energy and nutrient-dense diet for poorer households (Darmon and Drewnowski, 2008). Moreover, the risk of being overweight and obese does not only increase in the highest economic status but also poorest families, increasing the likelihood of a double burden of malnutrition among these groups (Popkin *et al.*, 2020).

Our study has several limitations. Firstly, recall bias may occur when using the 24-hour dietary recall. Secondly, the nature of the cross-sectional design may limit the ability to draw a causality effect between the independent and dependent variables. Thirdly, since this study was conducted before the new indicator of MDD was developed (WHO/UNICEF, 2021), we did not collect any data related to current breastfeeding status. Breastfeeding has been set as one of the additional food groups in the updated MDD indicator. Thus, we still adopted the old MDD indicator of a minimum of four of seven food groups in our analysis (WHO, 2008), excluding the breast milk component. However, the old MDD indicator is still useful to inform health providers, policymakers, and future researchers regarding dietary diversity in children, to help assist in monitoring and evaluation of different food group consumption over time, and to make a comparison between previous research that used the same indicator.

Conclusion

Minimum dietary diversity is a protective factor against concurrent stunting and overweight among infants and young children. Our findings suggest the need for healthcare providers to continue to provide nutrition education targeting the improvement of child dietary quality and, thus child nutritional status. Promoting a variety of locally-based food consumption may enhance diet diversity across different community socioeconomic backgrounds. Policymakers and public health actors should ensure the implementation of the updated minimum dietary diversity indicators to assess and monitor complementary feeding practices. Finally, future research should seek to expand the knowledge of the various dietary diversity determinants across populations with more advanced designs (e.g., cohort studies, community trials).

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Tables

Table I. Characteristics of study participants (n= 189)

Characteristics	**n**	**%**
Child level		
Sex		
Male	111	58.7
Female	78	41.3
Age		
6-11 months	59	31.2
12-17 months	63	33.3
18-23 months	67	35.5
Birth weight		
>=2500 g	143	75.7
<2500 g	46	24.3
Parental level		
Mother's age		
<30 years	93	49.2
>=30 years	96	50.8
Mother's education		
Junior high school or below	65	34.4
Senior high school	86	45.5
Higher educational degree	38	20.1
Mother's occupation		
Not working	105	55.6
Working	84	44.4
Father's education		
Junior high school or below	55	29.1
Senior high school	99	52.4
Higher educational degree	35	18.5
Father's occupation		
Not working or informal	60	31.8
Formal	129	68.3
Household level		
Household economic status		
Poor	65	34.4
Middle	61	32.3
Rich	63	33.3

Table II. Frequency distribution of child nutritional status and feeding practices (n= 189)

Variables	**n**	**%**
Nutritional status		
Stunted		
No	131	69.3
Yes	58	30.7
Overweight		
No	169	89.4
Yes	20	10.6
Both stunted and overweight		
No	178	94.2
Yes	11	5.8
Feeding practices		
Exclusive breastfeeding		
No	122	64.6
Yes	67	35.5
Energy intake		
Inadequate	82	43.4
Adequate	107	56.6
Protein intake		
Inadequate	14	7.4
Adequate	175	92.6
Dietary diversity		
<4	74	39.2
>=4	115	60.9

Table III. Unadjusted and adjusted odds ratios of factors associated with the coexistence of stunting and overweight/obese (n= 189)

Variables	**OR**	**95% CI**	***p***	**AOR**	**95% CI**	***p***
Feeding practices						
Exclusive breastfeeding						
No	1			1		
Yes	0.39	0.08-1.84	0.233	0.53	0.10-2.79	0.453
Energy intake						
Inadequate	1					
Adequate	0.62	0.18-2.11	0.445			
Protein intake						
Inadequate	1					
Adequate	0.33	0.06-1.68	0.180			
Minimum dietary diversity						
<4	1			1		
>=4	0.12	0.02-0.57	0.008*	0.08	0.01-0.47	0.005*
Child level						
Sex						
Male	1			1		
Female	2.64	0.75-9.34	0.133	4.83	1.09-21.4	0.038*
Age						
6-11 months	1			1		
12-17 months	1.27	0.27-5.91	0.765	1.07	0.18-6.47	0.942
18-23 months	1.19	0.35-5.53	0.829	0.50	0.09-2.89	0.442
Birth weight						
>=2500 g	1					
<2500 g	6.24	1.74-22.3	0.005*			
Parental level						
Mother's age						
<30 years	1					
>=30 years	0.80	0.25-2.71	0.716			
Mother's education						
Junior high school or below	1			1		
Senior high school	0.59	0.15-2.27	0.439	0.75	0.15-3.80	0.723
Higher educational degree	0.67	0.12-3.62	0.638	1.70	0.17-17.2	0.655
Mother's occupation						
Not working	1					
Working	0.45	0.12-1.75	0.248			
Father's education						
Junior high school or below	1					
Senior high school	0.42	0.11-1.64	0.212			
Higher educational degree	0.61	0.11-3.31	0.456			
Father's occupation						
Not working or informal	1					
Formal	0.54	0.16-1.83	0.321			
Household level						
Household economic status						
Poor	1			1		
Middle	0.14	0.01-1.16	0.068	0.10	0.01-0.98	0.048*
Rich	0.41	0.10-1.68	0.217	0.45	0.07-3.04	0.413