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Dietary diversity, vitamin D intake and childhood stunting: a case-control study in Bantul, Indonesia

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ABSTRACT

Introduction: Stunting is known to be a major public health problem among Indonesian children. We aimed to examine the association between dietary diversity and vitamin D intake with stunting in children aged 6-23 months. **Methods:** This case-control study was conducted in Bantul District, Yogyakarta Special Region, Indonesia. A total of 79 subjects aged 6-23 months were selected for each case and control group based on their stunting status. We assessed potential explanatory variables at the child, parental, household, and community levels. **Results:** Factors which were significantly associated with stunting included young children aged 18-23 months (adjusted *OR* = 3.84; 95% CI: 1.17-12.26), birth length ≥48 cm (adjusted *OR* = 0.36; 95% CI: 0.16-0.83), inadequate intake of vitamin D (adjusted *OR* = 5.18; 95% CI: 1.03-26.02), and diversified diet (adjusted *OR* = 0.17; 95% CI: 0.03-0.92). Other variables such as household economic status, living residency, history of exclusive breastfeeding, and infectious diseases, as well as intakes of energy and protein were not significantly related to stunting. **Conclusion:** Minimum dietary diversity, vitamin D intake from complementary foods, and birth length were associated with stunting status among children. Therefore, it is crucial to focus on stunting prevention programmes in the first two years of life, or even since the preconception period.

Keywords: Stunting, dietary diversity, vitamin D, determinants, Indonesia

INTRODUCTION

Stunting is a public health problem in Indonesian children. According to the Indonesian National Basic Health Survey in 2018, the prevalences of stunting and severe stunting in children under two years old were 17.1% and 12.8%, respectively (NIHRD, 2019), which meant that one in three Indonesian children under 2-year-old experienced chronic undernutrition. Stunting has been associated with increased adverse effects including failure of reaching growth potential, decreased neurocognitive functions, and greater risk of obesity and non-communicable diseases in later life (de Onis & Branca, 2016). In addition, it is responsible for 14.5% of deaths and 12.6% of disability-adjusted life-years (DALY) in children under the age of 5 years (Black *et al.*, 2008).

Stunting is an interlinked process of growth which may begin *in utero*, then continue to neonatal, infant and childhood, pubertal, and adulthood, where each stage is influenced by different mechanisms (Prendergast & Humphrey, 2014). Nonetheless, it is important to

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realise that for a nutritional challenge such as stunting, its causes are deeply embedded in situational structures. A previous review on stunting determinants among Indonesian children highlighted that birth outcomes, infant and young child feeding practices, hygiene and sanitation, and sociodemographic factors may influence childhood stunting (Beal *et al.*, 2018).

A large-scale study in Indonesia found that the odds of stunting was greater in children who were living in a household with three or more toddlers, had five to seven household members, mothers who attended <4 times of antenatal care during pregnancy, boys, and children who were born <2500 g in weight (Titaley *et al.*, 2019). However, another similar study concluded that feeding factors such as exclusive breastfeeding were not related to childhood stunting (Paramashanti, Hadi & Gunawan, 2015). Specifically, an earlier study conducted in Yogyakarta Special Region reported that one of key determinants of childhood stunting included poor dietary diversity (Paramashanti, Paratmanitya & Marsiswati, 2017).

Vitamin D intake may have a potential effect on stunting prevention and treatment (Yu *et al.*, 2017). However, none of the previous studies in Indonesia showed this significant association (Ramadhani, Bahar & Dachlan, 2019; Chairunnisa, Kusumastuti & Panunggal, 2018). Due to the inconsistent results and limited variables used, as well as the cross-sectional designs used by most of these studies, we could not draw any conclusion.

Bantul is one of the five districts/ municipalities in Yogyakarta Special Region recruited by the Indonesian government as an intervention area to resolve stunting, even though the prevalence of stunting in this area is not so high. In the national programme of tackling stunting, our local government initiated a nutrition-improved village model in several regions in Yogyakarta Special Region. The public health office of Yogyakarta Special Region made an additional nutrition programme for pregnant women and children by giving fortified biscuits especially in areas with high malnutrition cases. The prevalence of stunting among children under 5 years old for Bantul District in 2017 was 10.41%, the lowest prevalence amongst other districts in Yogyakarta Province (MOH Indonesia, 2017). A previous study showed that the odds of stunting increased significantly in children aged 12-24 months (Titaley *et al.*, 2019), but there are no public data available yet about the prevalence of stunting for children under 2 years old for Bantul District.

Reducing stunting from a not-so-high prevalence sounds challenging, therefore it is necessary to identify the proper risk factors in order to achieve this target. The intervention to reduce stunting will address some of the risk factors mentioned above, but also some other important risk factors that have not been investigated yet. Previous studies that have investigated the risk factors of stunting among Indonesian children had limitations such as unavailability of children's nutrient intake data, infectious diseases being limited only to diarrhoea in the past two weeks before data collection, and child's length at birth was not analysed (Beal *et al.*, 2018; NIHRD, 2013). Therefore, this study aimed to examine whether dietary diversity and vitamin D intake were associated with stunting in children under the age of 2 years in Bantul District, Yogyakarta Special Region, Indonesia.

MATERIALS AND METHODS

A case-control study was conducted in Bantul District, Yogyakarta Special Region, Indonesia. The Yogyakarta

Special Region is located 565 km from Jakarta, the capital city of Indonesia. The region consists of five municipalities/ districts: Bantul, Sleman, Kulonprogo, Gunungkidul, and Yogyakarta City. Specifically, the Bantul District was selected as the study location as it mirrored urban and rural areas. This study was done between July and September 2019.

The population in this study were young children aged 6-23 months residing in Bantul District, with samples recruited under the areas of Sewon, Pandak, and Bambanglipuro sub-districts. We defined case as a child whose height-for-age Z-score was <-2 SD, whereas control was a child with a height-for-age Z-score ≥-2 SD, based on the World Health Organization (WHO) growth chart (WHO, 2006). For both cases and controls, we excluded children who did not own a maternal and child health book, were not *de jure* residents and diagnosed with congenital diseases that limited them for height measurement.

Sample size was calculated using OpenEpi version 3 with proportions of non-exclusive breastfeeding based on a previous study (Paramashanti *et al.*, 2015). We set 95% level of confidence (CI), 80% power, and 1:1 ratio between case and control groups within the Kelsey formula. Thus, we obtained 80 subjects for each case and control group. Samples were selected by using multistage cluster sampling, where we divided our samples based on sub-districts as clusters. Firstly, three of 17 sub-districts were chosen randomly, namely Sewon, Pandak, and Bambanglipuro sub-districts. Secondly, two villages were selected randomly by lottery in every sub-district to represent each the rural and urban areas. Lastly, we obtained the village-level nutritional status data listed in the February 2019 report from each village's primary health centre.

To minimise potential bias in this study, we reassessed the lengths of children to determine stunting status. In this study, 37 *Posyandu* (integrated health posts at the village level) were identified to be included. As *Posyandu* was held routinely to monitor children's body weight, to provide supplementary foods for wasted children, and to deliver counselling for mothers, thus it was feasible to interview mothers and to measure their child's height during data collection. Then, we differed children based on their stunting status. A computerised simple random sampling was used to select cases in each *Posyandu*, whereas controls were chosen within the same *Posyandu*.

Screenings from public health centres of both case and control groups showed that we obtained 122 stunted and 718 normal children. We randomly selected 80 subjects for each group. Unfortunately, one subject from the case group was excluded due to incorrect measurement result, thus resulting in only 79 children for each group (a total of 158 children) being analysed (Figure 1).

The primary outcome of this study was childhood stunting. A child was considered as stunted if the height-for-age Z-score was <-2 SD below the growth reference curve (WHO, 2006). At the time of the interview, the length of the child was measured by using an infantometer. Meanwhile, our predictors were dietary diversity and intake of vitamin D among the children. Dietary diversity is defined as the consumption of at least four food groups of a total of seven food groups: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products; 4) flesh foods; 5) eggs; 6) vitamin-A rich fruits and vegetables; and 7) other fruits and vegetables (WHO, 2008). Dietary diversity was estimated by a semi-quantitative food frequency

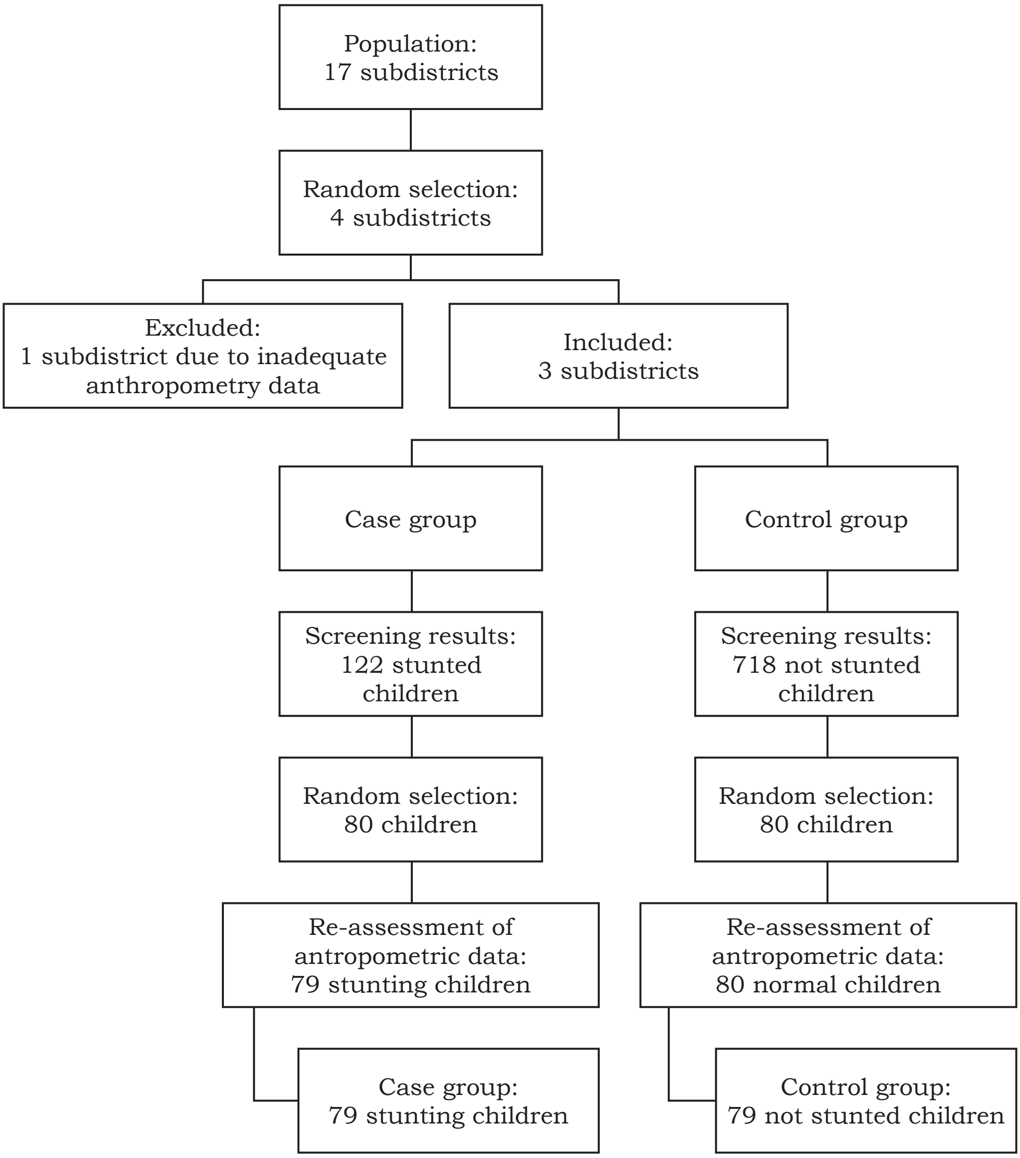

Figure 1. Diagram of case-control study subjects

questionnaire (semi-FFQ) with a three-month timeframe. A minimum of ten grams per day was considered as consumption of each food item. Using the same semi-FFQ, intake of vitamin D was assessed using the Nutrisurvey Indonesia software and compared to the Recommended Dietary Allowance (RDA) of Indonesian population (MOH Indonesia, 2013). We set a cut-off of 80% to categorise vitamin D intake.

Other variables collected in this study included child, parental, household, and community factors. Child factors were sex, age, feeding practices, infections, and history of birth outcomes. Infectious diseases were the occurrence of fever, cough, flu, and diarrhoea for the last one month. Feeding practices included history of exclusive breastfeeding, timing of introduction to complementary foods, and intakes of energy, protein, calcium, iron, phosphorus, and animal source foods. Animal source foods intake was the consumption of at least three of a total of six food groups: 1) breast milk and any other milk from animals; 2) other dairy products; 3) flesh foods; 4) organs; 5) fish or shellfish; and 6) eggs (Sebayang *et al.*, 2019). Birth outcomes which included birth length, birth weight, and gestational age at birth were collected by enumerator's observation on the maternal and child health book. Parental factors were education levels of mothers and fathers. Educational attainment was considered as high if mothers or fathers completed at least senior high school education. Household and community factors included the number of children under 5 years, household economic status, and rural-urban living residency. Household economic status was calculated based on the household expenditure, then divided into three tertiles, which were poor, middle, and rich.

We described child, parental, household and community factors by using descriptive statistics. To analyse the relationship between each variable and stunting, we used the univariate logistic regression. All variables with a *p*-value <0.25 were included in the multiple logistic regression that controlled for the undesirable effects of potential confounding factors. A significance level was set at 5% to determine significant predictors. All analyses were performed by using STATA 14.2 (Stata Corporation, College Station, TX).

Ethical statements

This study was conducted according to the guidelines laid out in the Declaration of Helsinki and all procedures involving research study participants were approved by Alma Ata University Research Ethics Committee (No: KE/AA/VII/986/EC/2019). All mothers in this study gave their written informed consent and subject anonymity data form prior to data collection.

RESULTS

Population characteristics

A total of 158 children (79 cases and 79 controls) were included in this study. More than half of the cases were males (54.4%), whereas controls were females (53.2%). Majority of children, 71 (89.9%) cases and 62 (74.5%) controls, were aged between 12-23 months. Mothers of 70 (88.6%) cases and controls, and fathers of 61 (77.2%) cases and 65 (82.3%) controls completed senior high school education. Majority of cases (84.8%) and controls (88.5%) had one child under the age of 5 years within their household (Table 1).

The differentiation of covariate variables in stunted and non-stunted children

More than half of the stunted children had a birth length <48 cm, whereas 67.1% non-stunted children had a birth length ≥48 cm. Approximately 90% of both cases and controls were born with normal birth weights (≥2500 g) and term gestational age (≥37 weeks). Seventy-six (96.2%) cases and controls ever received breastmilk. Exclusive breastfeeding proportion was 64.6% among cases and 70.9% among controls. Majority of young children had adequate intakes of energy (70.9% and 79.8%, respectively in cases and in controls) and protein (81.0% and 84.8%, respectively in cases and in controls) from complementary foods (Table 2).

Factors associated with stunting among young children

Univariate logistic regression between

Table 1. Socio-demographic characteristics of young children in Bantul District

Characteristics	*Stunted (n=79)* *n (%)*	*Not stunted (n=79)* *n (%)*	*p*
Child factors			
Sex			0.340
Male	43 (54.4)	37 (46.8)	
Female	36 (45.6)	42 (53.2)	
Child's age			0.000
6-11 months	8 (10.1)	17 (21.6)	
12-17 months	15 (19.0)	31 (39.2)	
18-23 months	56 (70.9)	31 (39.2)	
Parental factors			
Mother's education level			1.000
Not completed elementary school	0 (0.0)	1 (1.3)	
Completed elementary school	5 (6.3)	2 (2.5)	
Completed junior high school	4 (5.1)	6 (7.6)	
Completed senior high school	50 (63.3)	46 (58.2)	
Completed tertiary education	20 (25.3)	24 (30.4)	
Father's education level			0.428
Not completed elementary school	1 (1.3)	0 (0.0)	
Completed elementary school	2 (2.5)	2 (2.5)	
Completed junior high school	15 (19.0)	12 (15.2)	
Completed senior high school	51 (64.5)	52 (65.8)	
Completed tertiary education	10 (12.7)	13 (16.5)	
Household and community factors			
Number of children under 5 within household			0.502
1	67 (84.8)	69 (88.5)	
≥2	12 (15.2)	9 (11.5)	
Household economic status			0.505
Poor	31 (40.2)	21 (28.0)	
Middle	24 (31.2)	26 (34.7)	
Rich	22 (28.6)	28 (37.3)	
Living residency			0.203
Rural	44 (55.7)	36 (45.6)	
Urban	35 (44.3)	43 (54.4)	

potential associated determinants and status of stunting in children are shown in Table 3. This study showed that children 18-23 months old (*COR*: 3.84, *p*=0.005) and with birth length ≥48 cm (*COR*:0.47, *p*=0.022) were associated with stunting. However, after using adjusted odds ratio, children 18-23 months old (*AOR*: 3.80,

Table 2. Distribution of covariates across stunted and non-stunted young children in Bantul District

Variables	*N*	*Stunted* *n (%)*	*Not stunted* *n (%)*
Birth outcomes			
Birth length	76		
<48 cm		39 (51.3)	25 (32.9)
≥48 cm		37 (48.7)	51 (67.1)
Birth weight	76		
<2500 g		7 (9.2)	5 (6.3)
≥2500 g		69 (90.8)	74 (93.7)
Gestational age	76		
<37 weeks		6 (10.0)	6 (7.9)
≥37 weeks		70 (90.0)	70 (92.1)
Feeding practices			
Prelacteal	79		
Yes		6 (7.6)	7 (8.9)
No		73 (92.4)	72 (91.1)
Ever breastfed	79		
Yes		76 (96.2)	76 (96.2)
No		3 (3.8)	3 (3.8)
Exclusive breastfeeding	79		
Yes		51 (64.6)	56 (70.9)
No		28 (35.4)	23 (29.1)
Introduction of complementary food	79		
<6 months		20 (25.3)	16 (20.2)
≥6 months		59 (74.7)	63 (79.8)
Energy intake from complementary food	79		
<80% RDA		23 (29.1)	16 (20.2)
≥80% RDA		56 (70.9)	63 (79.8)
Protein intake from complementary food	79		
<80% RDA		15 (19.0)	12 (15.2)
≥80% RDA		64 (81.0)	67 (84.8)
Calcium intake from complementary food	79		
<80% RDA		50 (63.3)	45 (57.0)
≥80% RDA		29 (36.7)	34 (43.0)
Iron intake from complementary food	79		
<80% RDA		42 (53.2)	45 (57.0)
≥80% RDA		37 (46.8)	34 (43.0)

Table 2. Distribution of covariates across stunted and non-stunted young children in Bantul District [Cont'd]

Variables	*N*	*Stunted* *n (%)*	*Not stunted* *n (%)*
Phosphorus intake from complementary food	79		
<80% RDA		25 (31.6)	23 (29.1)
≥80% RDA		54 (68.4)	56 (70.9)
Vitamin D intake from complementary food	79		
<80% RDA		75 (94.9)	68 (86.1)
≥80% RDA		4 (5.1)	11 (13.9)
Dietary diversity	79		
<4 food groups		7 (8.9)	4 (5.1)
≥4 food groups		72 (91.1)	75 (94.9)
Animal source food	79		
<3 food groups		47 (59.5)	39 (49.4)
≥3 food groups		32 (40.5)	40 (50.6)
Infectious diseases			
Fever	79		
Yes		15 (19.0)	10 (12.7)
No		64 (81.0)	69 (87.3)
Cough	79		
Yes		10 (12.7)	9 (11.4)
No		69 (87.3)	70 (88.6)
Flu	79		
Yes		12 (15.2)	10 (12.7)
No		67 (84.8)	69 (87.3)
Diarrhoea	79		
Yes		4 (5.1)	5 (6.3)
No		75 (94.9)	74 (93.7)

RDA: recommended dietary allowance

p=0.026), vitamin D intake <80% of RDA from complementary foods (*AOR*: 5.18, p=0.046), dietary diversity status ≥4 food groups (*AOR*: 0.17, p=0.040), and birth length ≥48 cm (*AOR*: 0.36, p=0.016) were associated with stunting. Older children had a four-fold increased risk to be stunted than 6-11 months old children. Longer birth lengths had a protective effect against stunting in children, with a two-fold increased chance of being non-stunted compared to children who had shorter birth lengths. Similar result was found in the association between birth length and stunting in children even after adjusting for confounding variables. Children who had lower vitamin D intakes from complementary feeding had about five times higher risks of developing stunting than children who had ≥80% RDA of vitamin D intake. Moreover, a protective effect was found

Table 3. Bivariate and multivariate results of factors associated with stunting

Variables	*COR*	*p*	*AOR*	*p*
Child factors				
Sex				
Male (ref)				
Female	0.74 (0.40-1.38)	0.340		
Child's age				
6-11 months (ref)				
12-17 months	1.03 (0.36-2.92)	0.958	0.80 (0.22-2.89)	0.733
18-23 months	3.84 (1.49-9.91)	0.005*	3.80 (1.17-12.26)	0.026*
Parental and household factors				
Mother's education level				
Low (ref)				
High	1.00 (0.38-2.67)	1.000		
Father's education level				
Low (ref)				
High	0.73 (0.33-1.59)	0.429		
Household and community factors				
Number of children under 5 within household				
1 (ref)				
≥2	1.37 (0.54-3.47)	0.503		
Household economic status				
Poor (ref)				
Middle	0.63 (0.29-1.37)	0.240	0.66 (0.25-1.80)	0.419
Rich	0.53 (0.24-1.17)	0.116	0.69 (0.26-1.85)	0.463
Living residency				
Rural (ref)				
Urban	0.67 (0.36-1.25)	0.204	0.90 (0.43-1.91)	0.790
Birth outcomes				
Birth length				
<48 cm (ref)				
≥48 cm	0.47 (0.24-0.90)	0.022*	0.36 (0.16-0.83)	0.016*
Birth weight				
<2500 g (ref)				
≥2500 g	0.67 (0.20-2.20)	0.505		
Gestational age				
<37 wk (ref)				
≥37 wk	0.86 (0.27-2.68)	0.791		
Feeding practices				
Exclusive breastfeeding				
Yes (ref)				
No			1.48 (0.66-3.32)	0.338
Introduction of complementary food				
<6 months (ref)				
≥6 months	0.75 (0.35-1.58)	0.449		

Table 3. Bivariate and multivariate results of factors associated with stunting [Cont'd]

Variables	*COR*	*p*	*AOR*	*p*
Energy intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.62 (0.78-3.36)	0.198	1.03 (0.33-3.21)	0.956
Protein intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.31 (0.57-3.01)	0.527	1.58 (0.40-6.26)	0.510
Calcium intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.30 (0.69-2.47)	0.417	0.96 (0.33-2.75)	0.933
Iron intake from complementary food				
≥80% RDA (ref)				
<80% RDA	0.86 (0.46-1.61)	0.631	0.97 (0.31-3.04)	0.954
Phosphorus intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.13 (0.57-2.22)	0.729	0.80 (0.25-2.55)	0.707
Vitamin D intake from complementary food				
≥80% RDA (ref)				
<80% RDA	3.03 (0.92-9.98)	0.068	5.18 (1.03-26.02)	0.046*
Dietary diversity				
<4 food groups (ref)				
≥4 food groups	0.55 (0.15-1.95)	0.354	0.17 (0.03-0.92)	0.040*
Infectious diseases				
Fever				
No (ref)				
Yes	1.62 (0.68-3.86)	0.279		
Cough				
No (ref)				
Yes	1.13 (0.43-2.94)	0.807		
Flu				
No (ref)				
Yes	1.24 (0.50-3.05)	0.646		
Diarrhoea				
No (ref)				
Yes	0.79 (0.20-3.06)	0.732		

*$p<0.005$
COR: crude odds ratio; AOR: adjusted odds ratio; RDA: recommended dietary allowance

in the group of children who consumed ≥4 food groups compared to those who had <4 food groups of dietary diversity.

DISCUSSION

Our results showed that low dietary diversity was associated with stunting. A significant association between dietary diversity and childhood stunting was documented previously in an earlier studies (Paramashanti *et al.*, 2017). Dietary diversity is a good indicator of micronutrient density in the diet, thus reflecting diet quality (%) (Moursi *et al.*, 2008). Nonetheless, apart from micronutrient sufficiency, dietary diversity has a positive effect on stunting as we found vitamin D was the only micronutrient linked with stunting. Dietary diversity may also capture energy and macronutrient intakes as one eats different sources of foods (Muslimatun & Wiradnyani, 2016), but there was no relationship between energy and protein intakes with stunting in our study. It becomes important to consider other factors such as gut microbiome, which could mediate the pathway between a diversified diet and a child's linear growth. Some studies suggested that greater dietary diversity promotes a more diverse gut microbial community in the human body, thus affecting linear growth (Reese & Dunn, 2018; Robertson *et al.*, 2019).

In this study, we found that children whose intakes of vitamin D were below the recommended guideline were more likely to become stunted. This result confirmed a previous study conducted in low- and middle-income setting (Mokhtar *et al.*, 2018). Meanwhile, some trials have reported different results (Ganmaa *et al.*, 2017; Hyppönen *et al.*, 2011). The prevalence of inadequate vitamin D intake (<80% Indonesian RDA or <480 IU) were present in both case (94.94%) and control groups (86.08%) of our study. Throughout childhood, the risk of deficiency among both males and females may increase significantly due to dietary intake insufficiency and poor access to sunshine (Koo & Walyat, 2013; Viljakainen & Hyppönen, 2013). Vitamin D is an essential micronutrient for bone mineralisation, growth, and development (Koo & Walyat, 2013). However, hypovitaminosis D, if not addressed while growing, could give negative impacts on growth and development (Viljakainen & Hyppönen, 2013).

Human growth is a multifaceted process beginning in the foetal period and ending in adolescence. In children, linear growth is regulated by growth hormone (GH) and insulin-like growth factor (IGF-1) (Esposito *et al.*, 2019). Vitamin D may have a direct influence on GH/IGF-1 axis but the interplay between both remains incompletely understood (Ciresi & Giordano, 2017). Indirectly, vitamin D plays some roles in calcium metabolism, which is also important in stature growth. However, there was no significant relationship between calcium intake and stunting in this study.

Birth length and stunting were linked in this research. Short-statured neonates may grow as stunted children if they are not provided with adequate breastfeeding and complementary foods, proper stimulation and nurturing, and prevention practices of infectious illnesses (Prendergast & Humphrey, 2014). Consequently, infants born with a short length may not have the opportunity for catch-up growth during the window of opportunity period. As many previous studies have concluded (Aryastami *et al.*, 2017), this could be explained by the intergenerational process of linear growth. A study in Myanmar showed that not only low birth weight, but also short birth length, increased the risk of stunting (Khaing *et al.*, 2019). The Bogor Longitudinal Study on Child Growth and Development which was conducted in Bogor City, Indonesia to study the dominant risks of stunting among 650 children aged 0-23 months found that birth weight, length at birth and maternal short stature were the most dominant risks of developing stunting (Utami *et al.*, 2018). However, in this current study, we found no relationship between birth weight and stunting status. Having a short birth length might indicate poor nutritional status during pregnancy, where mothers had inadequate energy and micronutrient requirements (Paramashanti *et al.*, 2017; Utami *et al.*, 2018). This can be worsened if they had low-quality antenatal care during pregnancy (Eka *et al.*, 2018). Prenatal nutrition is an important period as stunting often begins *in utero*. Therefore, optimum nutrition is strongly suggested even before conception as it has a vital role to promote optimum growth *in utero* that will be represented in the outcomes of a newborn's birth size and should be continued for at least the first two years of post-natal life (Aryastami *et al.*, 2017; Titaley *et al.*, 2019).

Older children (18-23 months) were more likely to become stunted compared with younger children. A study in Afghanistan showed a higher chance of being stunted among children aged 25-59 months compared with younger age groups (Akseer *et al.*, 2018). This indicated that height-for-age Z-score may become lower as the child gets older, confirming that stunting is a chronic undernutrition problem. Growth faltering may occur as soon as an infant is born, but it mostly takes place between 3 and 18-24 months (Victora *et al.*, 2010). While 20% of stunting rates that occur at birth indicate prenatal malnutrition, the prevalence increases to 58% between 18 to 23 months (de Onis & Branca, 2016), and this later stunted growth could be explained by poor breastfeeding and complementary feeding practices. In our study, besides dietary diversity and intake of vitamin D that may affect stunted growth, there could be a possible explanation of early weaning practices among older children. In India, weaning children after six months of age increased the risk of stunted growth (Padmadas, Hutter & Willekens, 2002). This finding highlighted the importance of the continuation of breastfeeding up to 2 years old as the primary nutritional source alongside complementary feeding, especially when complementary foods do not meet the nutritional values and safety criteria. Nevertheless, we did not collect data on breastfeeding continuation in this study.

There was no significant difference in exclusive breastfeeding between stunted and non-stunted children. This could be due to the influence of complementary feeding quality (Rusmil *et al.*, 2019). Based on Black *et al.* (2008) in the Lancet series, the risk of becoming stunted still exists even among exclusively breastfed children if they do not receive an adequate complementary feeding both in quality and in quantity, whereas among 6-8 months and 9-10 months old infants, breastmilk can only fulfil 70% and 50%, respectively, of energy requirement, which should be complemented by foods. For this issue, if an infant fails to meet the energy requirement provided from complementary foods, she/he may have a state of growth faltering (PAHO/WHO, 2004).

Household economic status was not related to stunting. Low economic status is generally linked with consuming cheaper foods and low diversity diet. However, high economic status does not always guarantee a good nutritional status (Ibrahim & Faramita, 2015). Results from the Indonesia Basic Health Research showed that 20%

of young children from middle- and higher economic status were stunted. The underlying factors included low quality of dietary intake, which was higher in carbohydrate, sugar, and fat intakes. These inappropriate practices of complementary feeding may start since the beginning of the introduction to complementary foods (NIHRD, 2019).

Living residence of young children was not associated with stunting. This may be caused by the homogeneity of geographical areas in our study locations, so there was not much difference between urban and rural areas. Busy schedules that are much more associated with urban parents is arguably proposed as a factor that could predispose children to malnutrition (Adenuga *et al.*, 2017). On the other hand, limited access to health facilities such as primary health centres or hospitals and nutrition knowledge in rural areas may contribute to stunting problems. Although this cannot be fully explained from the data collected in this case-control study, it does suggest that the risks of stunting vary widely across communities. This needs further investigation, particularly along urban-rural divides (Samuel, 2013).

Despite the insignificant results from macronutrient and micronutrient intakes, except for vitamin D, we could not neglect the importance of these nutrients on growth. However, our data might have been influenced by recall bias from the food frequency questionnaire which we used. Both feeding practices and history of infections were self-reported by mothers, thus adding to the possibility of recall bias in this study. Moreover, we did not take into account the duration and frequency of infections, which might have limited our understanding of the association between infectious diseases and childhood stunting in this study. However, this study succeeded to cover variables at the individual level including dietary intakes, household level, and community level, which have been adjusted during the analysis, in order to provide the best data possible in relation to stunting.

CONCLUSION

In conclusion, minimum dietary diversity, vitamin D intake from complementary foods, and birth length were associated with stunting among young children in Bantul District, Yogyakarta Special Region, Indonesia. Therefore, promoting adequate and varied dietary intakes with a focus in the first thousand days of life since preconception is highly recommended to improve child nutritional status.

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Authors' contributions

EN, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; BAP, led the data collection in Bantul, data analysis and interpretation, and reviewed the manuscript; DA, led the data collection in Bantul and reviewed the manuscript; ASA, assisted in drafting of the manuscript and reviewed the manuscript.

Conflict of interest

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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