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Vitamin D Deficiency and Associated Risk Factors among Young Children in Malaysia

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ABSTRACT

Objectives: Vitamin D deficiency in children is a global medical problem. The current study aimed to assess vitamin D status among preschool children in Malaysia, as well as to identify the risk factors associated with vitamin D deficiency.

Methods: 120 healthy children were included. Blood samples were collected, and parents completed a questionnaire about family demographic characteristics, mother's pregnancy information, nutritional habits and sunlight exposure. The ELISA Kit was used to determine serum vitamin D levels. Descriptive statistics and bivariate analyses were performed. A p-value ≤ 0.05 was considered statistically significant.

Results: Vitamin D deficiency and insufficiency were reported in 35%, 20% of children respectively. Children deficient in vitamin D had significantly lower mean weight ($p=0.026$). Mothers who had health issues during pregnancy were significantly more likely to have children deficient in vitamin D ($p=0.039$). Only consumption of chicken ($p=0.048$) and fortified cereal ($p=0.037$) were associated with vitamin D status in children. Children exposed to sunlight in the last 2 weeks had sufficient levels of vitamin D ($p=0.026$).

Conclusion: High vitamin D deficiency was indicated among preschool Malaysian children. The lower body weight of children, mother's health issues during pregnancy, less consumption of chicken and fortified cereal, and less sunlight exposure were associated with vitamin D deficiency. Health education and promotion programs for parents would help to increase knowledge aspects of vitamin D and its related benefit.

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1. INTRODUCTION

Vitamin D is sunshine vitamin. It refers to both vitamin D_2 (ergocalciferol) and vitamin D_3 (cholecalciferol) (Calafiore et al., 2022). The human body cannot produce vitamin D_2 and is obtained only from plant sources and dietary supplements. Sunlight and food including oily fish, fortified foods and dietary supplements are the main sources of vitamin D (Calafiore et al., 2022). In humans, after skin is exposed to ultraviolet B solar radiation (UVB), the 7-dehydrocholesterol present in the skin is induced by UVB and converted to pre-vitamin D_3 that is rapidly turned into vitamin D_3 (Cui et al., 2022).

The serum 25(OH)D level is highly stable and considered the most reliable indicator of vitamin D status (Sempos et al., 2018). Vitamin D deficiency was defined as the level of 25-hydroxyvitamin D that is less than 50 nmol/L (20 ng/mL) (Holick et al., 2011). In fact, different criteria used to describe vitamin D deficiency, and no general agreement was indicated (Mogire et al., 2020). The serum levels that represent vitamin D deficiency and insufficiency are controversial and yet not well indicated by clinical trials, mainly in the paediatric population (Lee et al., 2013; Mansbach et al., 2009). There are some subtle differences in how vitamin D deficiency, insufficiency, and sufficiency are defined. Cut-offs vary depending on the organisation. The US Institute of Medicine (IOM) defines 25(OH)D levels < 30 nmol/L (< 12 ng/mL) to be deficient, 25(OH)D levels between 30–50 nmol/L (12-20 ng/mL) to be insufficient, and sufficient when serum 25(OH)D levels are ≥ 50 nmol/L (> 20 ng/mL) (Ross et al., 2011) while the US Endocrine Society defines vitamin D deficiency as 25(OH)D levels < 50 nmol/L (20 ng/mL), insufficiency as levels between 52.5 and 72.5 nmol/L (21–29 ng/mL), and sufficiency when levels exceed 75 nmol/L (> 30 ng/mL) (Holick et al., 2011).

Vitamin D deficiency may occur as a result of heritable, acquired metabolism disorders as well as lower skin production and lack of skin absorption of vitamin D (Holick, 2007). Generally, several factors influence vitamin D status including age and gender, obesity and body weight, skin colour, cultural behaviour, and low intake of foods containing vitamin D.

To our knowledge, no studies have specifically identified risk factors associated with vitamin D status among young children in Malaysia. Therefore, the objective of this study was to assess the determinants of vitamin D status in this population. Identifying these risk factors may facilitate early recognition of children at risk and support the development of prevention strategies, including culturally appropriate dietary interventions and parental education programs."

2. MATERIALS AND METHODS

2.1. Participants

This cross-sectional study was conducted as part of a study evaluating the level of vitamin D and its association with early childhood caries among preschool Malaysian children. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration. This study was approved by Human Ethics Committee of Universiti Teknologi MARA [600-RMI (5/1/6)] and Medical Research and Ethics Committee [MREC) NMRR-15-1857-25950 (IIR)]. Additionally, written informed consent was obtained from the parents. Data collection was undertaken from November 2016 to August 2019.

As this study focused on the possible risk factors associated with vitamin D deficiency in young children, information regarding the clinical examination and vitamin D measurement are summarized here. For further details on participant selection and vitamin D status data, please refer to Hussein et al. (2021).

A total of 120 healthy Malaysian children aged 30 to <72 months were recruited from the Faculty of Dentistry (UiTM) as well as the Paediatric Dental Clinics at Hospital Tengku Ampuan Rahimah Klang and

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Hospital Shah Alam, Selangor, Malaysia. Detailed information on the study design and sampling is available in Hussein et al. (2021).

2.2. Inclusion and exclusion criteria

Healthy children <72 months of age were included. Exclusion criteria were the presence of systemic disease or disabilities, inability to cooperate or follow instructions, and lack of parental consent.

2.3. Clinical examination and data collection

On the morning of data collection day, clinical examinations were performed by (MM) after recording child's information. Then, fasting blood samples (3 ml) were obtained from the children between 8.00 and 12.00 pm. It was drawn into a 4 ml vacutainer tube with no additives (BD, Franklin Lake, NJ, USA). Blood samples were transported in a cooler box within 1–4 hours after collection to the research laboratory for processing. They were centrifuged at 1500 rpm for 5 minutes at room temperature. The obtained serum was transferred into sterile cryovials and stored immediately at–80°C until further analysis. Parents completed a face-to-face modified questionnaire (Schroth et al., 2013). The questionnaire was administered in English by the researcher; however, for parents who were not proficient in English, interviews were conducted in Bahasa Melayu by a dental staff using a translated version. The translation followed a forward–backward method: the original English questionnaire was first translated into Bahasa Melayu by a certified translator, reviewed by two independent lecturers at UiTM, and minimally edited. This version was then back-translated into English by another certified translator, and the second English version was compared with the original to ensure semantic equivalence (Almoudi et al., 2016). The questionnaire was pre-tested among ten parents prior to the main study to assess clarity and comprehension, time required for completion, and potential difficulties during data collection

The questionnaire encompassed several sections including the demographic characteristics of the children and their parents, the pregnancy and delivery profile information, the nutrition profile and information regarding infant feeding practices, such as breastfeeding and bottle-feeding practices including duration of both breastfeeding and bottle feeding, the most often bottle contents during day and at night during bedtime, the first time solid foods were introduced to the child, and the frequency of sugary snacks. The questionnaire also collected information about the consumption of foods rich in vitamin D and milk consumption, and child's vitamin D supplement intake. In addition, information regarding sunlight exposure was obtained including questions on child's skin pigmentation, duration of indoor activities and watching television per day, time of sunlight exposure during the day, frequency of outside activity per week, and any sun protection behaviours.

2.4. Measurement of serum vitamin D levels

On the day of analysis, thawed serum and saliva samples were assessed for total vitamin D levels using a commercial 25(OH)D ELISA Kit (Enzo Life Sciences, Switzerland). This kit has been validated for the evaluation of 25(OH)D in blood and other body fluid (Sethu et al., 2016).

All samples were analysed according to the manufacturer's instructions. Briefly, 96-well ELISA plates were incubated for 5 minutes with the dissociation buffer, samples and standards. After adding vitamin D conjugate and antibody, the plates were incubated for one hour on a plate shaker. Following three successive washing, 200µL p-nitrophenyl phosphate was added and the plates were further incubated for 30 minutes with mixing on a plate shaker. After adding the stop solution, the plates were measured at optical density (OD) of 405 nm using a microplate reader (Infinite M200 Pro, Tecan). A standard curve was generated using Myassay.com software and all samples were measured in duplicate to obtain the final results. The cut-off of serum vitamin D status was based on the US Institute of Medicine (IOM) which defines 25(OH)D

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levels < 12 ng/mL (< 30 nmol/L) are considered deficient, 25(OH)D levels between 12-20 ng/mL (30-50 nmol/L) are deemed insufficient, and are sufficient when serum 25(OH)D levels > 20 ng/mL (> 50 nmol/L).

2.5. Data analysis

The data was coded and entered into the computer using Statistical Package for Social Science (SPSS) version 25.0 (SPSS Inc, IBM, New York, USA). Descriptive statistics were performed. Categorical data was presented using numbers and percentages. The normality of the data was checked using Histogram. Normally distributed data were presented using mean and standard deviation. Median and interquartile range were used to present non-normally distributed data. To compare the two groups, Chi-square and Fisher's exact tests were used for categorical variables whereas for continuous variables, the t-test for normally distributed data and Mann–Whitney U test for non-normally distributed data were used. Comparisons of normally distributed multiple groups were done using Analysis of Variance (ANOVA) with Tukey test and the Kruskal-Wallis test for non-normally distributed data. A p-value of ≤ 0.05 was considered statistically significant.

3. RESULTS

3.1. Demographic characteristics of participants

Sixty of children (50%) were females. Most children were Malay (88.3%), followed by Indian with 12 (10.0 %), and only two children were Chinese (1.7%). The mean age of children was 55.10 ± 11.04 months that ranged from 31 to 71 months, and almost half of children (59.2%) were less than 60 months of age. The mean weight and height of children were 14.93 ± 2.46 kilograms (kg) and 102.55 ± 7.00 centimeters (cm), respectively and mean BMI was 14.13 kg/m^2 (Table 1).

3.2. Descriptive analysis of serum vitamin D

The median value of serum vitamin D of children was 17.50 ng/mL. Distribution of serum vitamin D in young children based on the classifications from Institute of Medicine (IOM) is shown in Figure 1. Less than half of children (45.0%) had sufficient levels of serum vitamin D. Meanwhile 35% of children had deficient serum vitamin D levels.

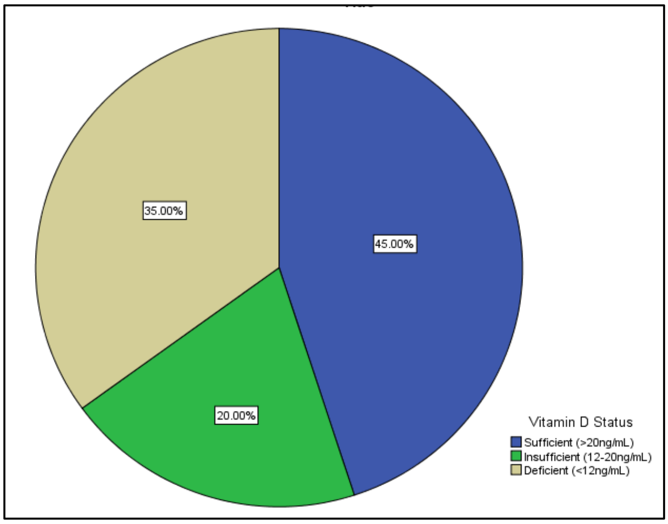

Fig. 1. Distribution of serum vitamin D status in children according to IOM Classification

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3.3. Vitamin D status among children by their demographic characteristics

In general, there was a significant difference between a status of vitamin D and children's race (p = 0.050), with Chinese children more likely to have sufficient vitamin D levels compared to other races.

In addition, the ANOVA analysis revealed that children with vitamin D deficiency had significantly lower mean weight compared to those with insufficient vitamin D levels (p = 0.026). Although, children with vitamin D deficiency also had lower mean height than those with insufficient in vitamin D levels, this difference did not reach the significance level (p = 0.054), as shown in Table 1.

Table 1. Vitamin D status of children by their demographic characteristics

Categorical variables	Total n (%)	Serum vitamin D status (ng/mL)			P-value
		Deficient (< 12) n (%)	Insufficient (12-20) n (%)	Sufficient (> 20) n (%)	
Age (n= 120)					
< 60 months	71 (59.2)	27 (38.0)	14 (19.7)	30 (42.3)	0.686[a]
≥ 60 months	49 (40.8)	15 (30.6)	10 (20.4)	24 (49.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Gender (n= 120)					
Male	60 (50)	23 (38.3)	11 (18.3)	26 (43.4)	0.733[a]
Female	60 (50)	19 (31.7)	13 (21.7)	28 (46.6)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Race (n= 120)					
Malay	106 (88.3)	41 (38.7)	19 (17.9)	46 (43.4)	**0.050[b]**
Chinese	2 (1.7)	0 (0.0)	0 (0.0)	2 (100.0)	
Indian	12 (10.0)	1 (8.3)	5 (41.7)	6 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Religion (n= 120)					
Islam	107 (89.2)	41 (38.3)	20 (18.7)	46 (43.0)	0.185[b]
Buddhist	3 (2.5)	0 (0.0)	1 (33.3)	2 (66.7)	
Hindu	10 (8.3)	1 (10.0)	3 (30.0)	6 (60.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Continues variables	n (Mean±SD)	Serum vitamin D status (ng/mL)			P-value
		Deficient (< 12) n (Mean±SD)	Insufficient (12-20) n (Mean±SD)	Sufficient (> 20) n (Mean±SD)	
Age(month)	120 (55.10±11.04)	42 (53.78±11.70)	24 (56.50±11.15)	54 (55.50±10.55)	0.595*
Height (cm)	120 (102.55±7.00)	42 (101±6.85)	24 (105.31±6.82)	54 (102.52±6.95)	0.054*
Weight (kg)	120 (14.93±2.46)	42 (14.30±2.05)	24 (15.99±2.13)	54 (14.95±2.74)	**0.026***
BMI (kg/m^2)	120 (14.13±1.27)	42 (13.98±1.23)	24 (14.41±1.32)	54 (14.11±1.29)	0.426*

[a]Chi-square test, [b]Fisher's exact test, *ANOVA, statistically significant at ≤ 0.05

3.4. Vitamin D status of children by their mother's pregnancy and delivery profile

There was no significant difference between vitamin D status among children and birthweight (p = 0.926) and premature birth (p = 0.539). However, mothers who had health issues during pregnancy were significantly more likely to have children deficient in vitamin D (p = 0.039) (Table 2).

Table 2. Vitamin D status of children by their mother's pregnancy and delivery profile

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Categorical variables	Total n (%)	Serum vitamin D status (ng/mL)			P-value
		Deficient (< 12) n (%)	Insufficient (12-20) n (%)	Sufficient (> 20) n (%)	
Premature birth (< 37 weeks) (n= 120)					
Yes	8 (6.7)	4 (50.0)	2 (25.0)	2 (25.0)	0.539[b]
No	99 (82.5)	32 (32.3)	21 (21.2)	46 (46.5)	
Don't know	13 (10.8)	6 (46.2)	1 (7.6)	6 (46.2)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Birth weight (n= 120)					
< 2.500kg	19 (15.8)	7 (36.8)	4 (21.1)	8 (42.1)	0.926[b]
≥ 2.500 kg	93 (77.5)	31 (33.4)	19 (20.4)	43 (46.2)	
Don't know	8 (6.7)	4 (50.0)	1 (12.5)	3 (37.5)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Mother's health issue during pregnancy (n= 120)					
Yes	4 (3.3)	4 (100.0)	0 (0.0)	0 (0.0)	**0.039[b]**
No	116 (96.7)	38 (32.8)	24 (20.6)	54 (46.6)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	

[b]Fisher's exact test, statistically significant at ≤ 0.05

3.5. Vitamin D status of children by their feeding practices

In this study, results of the chi-square analysis revealed that sufficient vitamin D levels were reported among 45.9% of exclusively breastfed children, which is defined as no other liquid or solid food given to the child compared to (42.9%) children who were not exclusively breastfed. However, this difference was nearly statistically significant ($p = 0.053$), as shown in Table 3. Similarly, vitamin D deficiency in children may be associated with prolonged exclusive breastfeeding. The ANOVA test showed that children deficient in vitamin D were exclusively breastfed for 6.32 ± 2.95 months compared to 4.68 ± 2.06 and 5.33 ± 2.20 months in children who had insufficient and sufficient vitamin D levels, respectively. However, this difference was also nearly statistically significant ($p = 0.054$), as shown in Table 3.

Table 3. Vitamin D status of the children by their feeding practices

Categorical variables	Total n (%)	Serum vitamin D status (ng/mL)			P-value
		Deficient (< 12) n (%)	Insufficient (12-20) n (%)	Sufficient (> 20) n (%)	
Child breastfeeding (n= 120)					
Yes	118 (98.3)	41 (34.7)	24 (20.4)	53 (44.9)	0.760[b]
No	2 (1.7)	1 (50.0)	0 (0.0)	1 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Child exclusive breastfed (No other liquid or solid is given to the child) (n= 120)					
Yes	85 (70.8)	25 (29.4)	21 (24.7)	39 (45.9)	**0.053[a]**
No	35 (29.2)	17 (48.6)	3 (8.5)	15 (42.9)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Bottle-feeding (n= 120)					
Yes	110 (91.7)	38 (34.5)	21 (19.1)	51 (46.4)	0.473[b]
No	10 (8.3)	4 (40.0)	3 (30.0)	3 (30.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Mixed feeding (n= 120)					
Yes	37 (30.8)	11 (29.7)	10 (27.1)	16 (43.2)	0.410[a]
No	83 (69.2)	31 (37.3)	14 (16.9)	38 (45.8)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Child's most often bottle content during day (n= 120)					
Milk	93 (77.5)	34 (36.5)	18 (19.4)	41 (44.1)	0.465[b]
Milo/syrup	16 (13.3)	3 (18.8)	3 (18.8)	10 (62.4)	

Water	1 (0.8)	1 (100.0)	0 (0.0)	0 (0.0)	
No bottle	10 (8.4)	4 (40.0)	3 (30.0)	3 (30.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Child's most often bottle/sippy cup content at night during bedtime (n= 120)					
Milk	73 (60.8)	28 (38.4)	12 (16.4)	33 (45.2)	0.347[b]
Milo/syrup	16 (13.4)	4 (25.0)	2 (12.5)	10 (62.5)	
Water	18 (15.0)	6 (33.3)	7 (38.9)	5 (27.8)	
No bottle	13 (10.8)	4 (30.7)	3 (23.1)	6 (46.2)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Child milk consumption (having 5 cups of milk or more a week) (n= 120)					
Regular	92 (76.7)	32 (34.8)	19 (20.6)	41 (44.6)	0.949[a]
Irregular	28 (23.3)	10 (35.7)	5 (17.9)	13 (46.4)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Solid foods were first fed to the child (n= 120)					
Rice	98 (81.6)	36 (36.7)	21 (21.4)	41 (41.9)	0.736[b]
Biscuit	2 (1.7)	0(0.0)	0(0.0)	2 (100.0)	
Fruit puree	2 (1.7)	0 (0.0)	1 (50.0)	1 (50.0)	
Mesh potato	1 (0.8)	0 (0.0)	0 (0.0)	1 (100.0)	
Nestum	9 (7.5)	2 (22.2)	1 (11.1)	6 (66.7)	
Vegetable puree	8 (6.7)	4 (50.0)	1 (12.5)	3 (37.5)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Frequency of sugary snacks between meals (n= 120)					
Often	37 (30.8)	13 (35.1)	8 (21.7)	16 (43.2)	0.312[a]
Sometimes	40 (33.4)	10 (25.0)	7 (17.5)	23 (57.5)	
Rarely	43 (35.8)	19 (44.2)	9 (20.9)	15 (34.9)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	

Continues variables	Total	Serum vitamin D status (ng/mL)			P-value
	n (Mean±SD) months	Deficient (< 12) n (Mean±SD) months	Insufficient (12-20) n (Mean±SD) months	Sufficient (> 20) n (Mean±SD) months	
Duration of breastfeeding	118(16.72±12.43)	41 (16.47±11.88)	24 (17.50±14.39)	53 (16.50±12.04)	0.946*
Duration of exclusive breastfeeding	85 (5.48±2.45)	25 (6.32±2.95)	21 (4.68±2.06)	39 (5.33±2.20)	**0.054***
Mixed feeding	37 (12.46±8.76)	11 (16.73±11.11)	10 (10.20±7.80)	16 (9.76±6.96)	0.115*
Age of starting bottle feeding	110 (9.97±9.72)	38 (10.38±9.59)	21 (12.42±12.28)	51 (8.50±8.36)	0.341*
Age of stop bottle feeding	110(42.62±12.92)	38 (41.54±11.17)	21 (46.00±18.07)	51 (42.30±12.84)	0.783*
Age of starting solid foods	120 (7.06±1.91)	42 (7.40±2.35)	24 (6.75±1.19)	54 (6.98±1.92)	0.380*

[a]Chi-Square test, [b]Fisher's exact test, *ANOVA, statistically significant at ≤ 0.05, Irregular milk drinker; having < 5 cups of milk a week, Often; once or more a day, Sometimes; once or more every week but less than every day, Rarely; less than once a week

3.6. Vitamin D status of children by their food and supplement Intake

Food items such as fish, meat, egg and dairy were not associated with vitamin D status among children in this study. However, only chicken and fortified cereal consumption were associated with vitamin D status in children. Children who never/rarely consumed chicken were more likely to have vitamin D deficiency (p = 0.048). Additionally, a higher proportion of children who often consumed fortified cereal were significantly having sufficient levels of vitamin D (p = 0.037). In addition, generally, there was no association between vitamin D status and the consumption of supplements (p = 0.525), as shown in Table 4.

Table 4. Vitamin D Status of children by their food and supplements intake

Categorical variables	Total n (%)	Serum vitamin D status (ng/mL)			P- value
		Deficient (< 12) n (%)	Insufficient (12-20) n (%)	Sufficient (> 20) n (%)	
Fish (n= 120)					
Often	21 (17.5)	6 (28.6)	4 (19.0)	11 (52.4)	
Sometimes	48 (40.0)	14 (29.2)	11 (22.9)	23 (47.9)	0.732[b]
Rarely	40 (33.3)	16 (40.0)	7 (17.5)	17 (42.5)	
Never	11 (9.2)	6 (54.5)	2 (18.2)	3 (27.3)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Sea food (n= 120)					
Often	5 (4.2)	3 (60.0)	1 (20.0)	1 (20.0)	0.531[b]
Sometimes	41 (34.2)	13 (31.7)	11 (26.8)	17 (41.5)	
Rarely	30 (25.0)	8 (26.7)	5 (16.6)	17 (56.7)	
Never	44 (36.6)	18 (40.9)	7 15.9)	19 (43.2)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Red meat (n= 120)					
Often	10 (8.3)	2 (20.0)	2 (20.0)	6 (60.0)	0.391[b]
Sometimes	57 (47.5)	19 (33.3)	14 (24.6)	24 (42.1)	
Rarely	35 (29.2)	14 (40.0)	3 (8.6)	18 (51.4)	
Never	18 (15.0)	7 (38.9)	5 (27.8)	6 (33.3)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Liver (n= 120)					
Often	4 (3.3)	0 (0.0)	1 (25.0)	3 (75.0)	0.495[b]
Sometimes	20 (16.7)	9 (45.0)	2 (10.0)	9 (45.0)	
Rarely	16 (13.3)	4 (25.0)	5 (31.2)	7 (43.8)	
Never	80 (66.7)	29 (36.2)	16 (20.0)	35 (43.8)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Chicken (n= 120)					
Often	89 (74.2)	34 (38.2)	16 (18.0)	39 (43.8)	**0.048[b]**
Sometimes	21 (17.5)	2 (9.5)	7 (33.4)	12 (57.1)	
Rarely	9 (7.5)	5 (55.6)	1 (11.1)	3 (33.3)	
Never	1 (0.8)	1 (100.0)	0 (0.0)	0 (0.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Mushroom (n= 120)					
Often	6 (5.0)	1 (16.7)	1 (16.7)	4 (66.6)	0.468[b]
Sometimes	54 (45.0)	19 (35.2)	8 (14.8)	27 (50.0)	
Never	60 (50.0)	22 (36.7)	15 (25.0)	23 (38.3)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Egg yolk (n= 120)					
Often	59 (49.2)	25 (42.4)	10 (16.9)	24 (40.7)	0.172[b]
Sometimes	32 (26.7)	5 (15.6)	10 (31.3)	17 (53.1)	
Rarely	16 (13.3)	6 (37.5)	2 (12.5)	8 (50.0)	
Never	13 (10.8)	6 (46.2)	2 (15.3)	5 (38.5)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Fortified butter (n= 120)					
Often	35 (29.2)	12 (34.3)	5 (14.3)	18 (51.4)	0.837[b]
Sometimes	36 (30.0)	12 (33.3)	8 (22.3)	16 (44.4)	
Rarely	43 (35.8)	17 (39.5)	9 (21.0)	17 (39.5)	
Never	6 (5.0)	1 (16.7)	2 (33.3)	3 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	

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Fortified margarine (n= 120)					
Often	29 (24.2)	9 (31.0)	4 (13.8)	16 (55.2)	0.795[b]
Sometimes	33 (27.5)	11 (33.3)	8 (24.3)	14 (42.4)	
Rarely	46 (38.3)	19 (41.3)	9 (19.6)	18 (39.1)	
Never	12 (10.0)	3 (25.0)	3 (25.0)	6 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Fortified cereals (n= 120)					
Often	19 (15.8)	1 (5.3)	7 (36.8)	11 (57.9)	0.037[b]
Sometimes	69 (57.5)	28 (40.6)	10 (14.5)	31 (44.9)	
Rarely	26 (21.7)	11 (42.3)	6 (23.1)	9 (34.6)	
Never	6 (5.0)	2 (33.3)	1 (16.7)	3 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Supplements (n= 120)					
Multivitamins	45 (37.5)	13 (28.9)	8 (17.8)	24 (53.3)	0.525[a]
Cod liver oil	32 (26.7)	13 (40.6)	5 (15.6)	14 (43.8)	
No supplements	43 (35.8)	16 (37.2)	11 (25.6)	16 (37.2)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	

[b]Fisher's exact test, statistically significant at ≤ 0.05, Often; once or more a day, Sometimes; once or more every week but less than every day, Rarely; less than once a week.

3.7. Vitamin D status of children by their sunlight exposure

This study found that children who were exposed to sunlight in the last two weeks had sufficient levels of vitamin D (p = 0.026). Detailed results on vitamin D status and sunlight exposure behaviours are presented in Table 5.

Table 5. Vitamin D status of children by their sunlight exposure behaviour

Categorical variables	Total n (%)	Serum vitamin D status (ng/mL)			P-value
		Deficient (< 12) n (%)	Insufficient (12-20) n (%)	Sufficient (> 20) n (%)	
Skin pigmentation (n= 120)					
Light colour	40 (33.3)	14 (35.0)	7 (17.5)	19 (47.5)	0.559[b]
Medium colour	77 (64.2)	28 (36.4)	17 (22.0)	32 (41.6)	
Dark colour	3 (2.5)	0 (0.0)	0 (0.0)	3 (100.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Fitzpatrick's classification of skin pigmentation (n= 120)					
Skin Type II	16 (13.3)	5 (31.2)	3 (18.8)	8 (50.0)	0.566[b]
Skin Type III	72 (60.0)	29 (40.3)	15 (20.8)	28 (38.9)	
Skin Type IV	30 (25.0)	8 (26.7)	5 (16.6)	17 (56.7)	
Skin Type V	2 (1.7)	0 (0.0)	1 (50.0)	1 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Indoor activities and watching television in the last 2 weeks (n= 120)					
< 4 hours per day	68 (56.7)	23 (33.8)	14 (20.6)	31 (45.6)	0.951[a]
≥ 4 hours per day	52 (43.3)	19 (36.6)	10 (19.2)	23 (44.2)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Sunlight exposure in the last 2 weeks (n= 120)					
Yes	94 (78.3)	34 (36.2)	14 (14.9)	46 (48.9)	**0.026**[a]
No	26 (21.7)	8 (30.8)	10 (38.4)	8 (30.8)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Child's body parts exposed to the sunlight (n= 120)					
Face	28 (23.4)	8 (28.6)	8 (28.6)	12 (42.8)	0.065[a]
Face and arm	25 (20.8)	4 (16.0)	7 (28.0)	14 (56.0)	
Face, arm and leg	67 (55.8)	30 (44.8)	9 (13.4)	28 (41.8)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	

Time of sun exposure (n= 120)					
Sunrise to 10a.m.	35 (29.2)	13 (37.1)	6 (17.1)	16 (45.8)	0.468[a]
10 am to 3 p.m.	46 (38.3)	19 (41.3)	7 (15.2)	20 (43.5)	
After 3p.m.	39 (32.5)	10 (25.6)	11 (28.2)	18 (46.2)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Children do, wear or use when they are outside in the sun (n= 120)					
Stay in shade.	2 (1.7)	1 (50.0)	0 (0.0)	1 (50.0)	0.743[b]
Long sleeves and long pants/skirts.	41 (34.2)	11 (26.8)	10 (24.4)	20 (48.8)	
Long sleeves, long pants/skirt and hat/veil.	43 (35.8)	15 (34.9)	7 (16.3)	21 (48.8)	
Long skirt/pants and	22 (18.3)	10 (45.5)	4 (18.2)	8 (36.3)	
stay in shade.	1 (0.8)	0 (0.0)	1 (100.0)	0 (0.0)	
Sunscreen	11 (9.2)	5 (45.5)	2 (18.2)	4 (36.3)	
None of this	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Total					
Time that children spent at nursery/ kindergarten (n= 93)					
Half day	43 (46.2)	15 (34.9)	9 (20.9)	19 (44.2)	0.991[a]
Full day	50 (53.8)	17 (34.0)	11 (22.0)	22 (44.0)	
Total	93 (100.0)	32 (34.4)	20 (21.5)	41 (44.1)	
Outdoor activities (n= 93)					
Yes	73 (78.5)	26 (35.6)	15 (20.6)	32 (43.8)	0.889[a]
No	20 (21.5)	6 (30.0)	5 (25.0)	9 (45.0)	
Total	93 (100.0)	32 (34.4)	20 (21.5)	41 (44.1)	
Frequency of outside activity per week (n= 73)					
Once a week	39 (53.4)	11 (28.2)	10 (25.6)	18(46.2)	0.295[b]
2- 4 times	28 (38.4)	14 (50.0)	4 (14.3)	10 (35.7)	
>4 times	6 (8.2)	1 (16.7)	1 (16.7)	4 (66.6)	
Total	73 (100.0)	26 (35.7)	15 (20.5)	32(43.8)	

[a]Chi-Square test, [b]Fisher's exact test, statistically significant at ≤ 0.05, Half day: children stay at nursery/ kindergarten until 12 p.m., Full day: children stay at nursery/ kindergarten until 6.30 p.m.

3.8. Vitamin D status of children by their parents' demographic characteristics

Table 6 shows vitamin D status of the children according to their parents' demographic characteristics. Father's race appears to be significantly associated with their children's vitamin D status. Chinese fathers were more likely to have children with sufficient vitamin D levels compared to Malay and Indian fathers (p = 0.050). No associations were found between vitamin D status of children and their parental age, education level, or area of residence.

Table 6. Vitamin D status of children by their family demographic characteristics

Categorical variables	Total n (%)	Serum vitamin D status (ng/mL)			P-value
		Deficient (< 12) n (%)	Insufficient (12-20) n (%)	Sufficient (> 20) n (%)	
Mother's age (years) (n= 120)					
≤ 40 years	111 (92.4)	39 (35.1)	23 (20.8)	49 (44.1)	0.729[b]
> 40 years	9 (7.6)	3 (33.3)	1 (11.1)	5 (55.6)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Father's age (years) (n= 120)					
≤ 40 years	107 (89.2)	36 (33.6)	22 (20.6)	49 (45.8)	0.739[b]
> 40 years	13 (10.8)	6 (46.2)	2 (15.3)	5 (38.5)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Mother' race (n= 120)					

Malay	106 (88.3)	41 (38.7)	19 (17.9)	46 (43.4)	0.103[b]
Chinese	3 (2.5)	0 (0.0)	1 (33.3)	2 (66.7)	
Indian	11 (9.2)	1 (9.1)	4 (36.4)	6 (54.5)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Father's race (n= 120)					
Malay	106 (88.3)	41 (38.7)	19 (17.9)	46 (43.4)	**0.050[b]**
Chinese	2 (1.7)	0 (0.0)	0 (0.0)	2 (100.0)	
Indian	12 (10.0)	1 (8.3)	5 (41.7)	6 (50.0)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Mother's education (n= 120)					
≤ Secondary	43 (35.8)	10 (23.3)	12 (27.9)	21 (48.8)	0.084[a]
College/University	77 (64.2)	32 (41.6)	12 (15.5)	33 (42.9)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Father's education (n= 120)					
≤ Secondary	48 (40.0)	14 (29.2)	13 (27.0)	21 (43.8)	0.245[a]
College/ University	72 (60.0)	28 (38.9)	11 (15.3)	33 (45.8)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	
Area of residence (n= 120)					
Rural	44 (36.7)	13 (29.5)	9 (20.5)	22 (50.0)	0.611[a]
Urban	76 (63.3)	29 (38.2)	15 (19.7)	32 (42.1)	
Total	120 (100.0)	42 (35.0)	24 (20.0)	54 (45.0)	

[a]Chi-Square test, [b]Fisher's exact test, statistically significant at ≤ 0.05

4. DISCUSSION

In this study, according to IOM classification, 35% of children were found to be vitamin D deficient, while 20% were insufficient. The high incidence of vitamin D insufficiency and deficiency among young children in the present study is troubling, especially with the limited previous data involving this age group.

Moreover, although different cut-offs were used, similar findings of high deficient and insufficient vitamin D levels were reported among older children in Malaysia. More than 70% of primary school children in Kuala Lumpur had vitamin D deficiency (≤ 37.5 nmol/L) and 37.1% had insufficient levels of serum vitamin D (> 37.5 – ≤ 50 nmol/L) (Khor et al., 2011). Additionally, almost half of the children (47.5 %) aged 4–12 years had vitamin D insufficiency (≤ 50 nmol/L) (Poh et al., 2013). In Malaysian adolescents aged 13 years old, the prevalence of vitamin D deficiency (≤ 37.5 nmol/L) was 78.9%, and vitamin D insufficiency (between 37.5 and 50 nmol/L) was 13.7%, and only 7.4% of them had sufficient vitamin D levels > 50 nmol/L (Al-Sadat et al., 2016). Furthermore, a previous case-control study that included children below 18 years old with and without atopic dermatitis found that 29.5% and 35.5% of children had vitamin D deficiency (< 20 ng/mL) and vitamin D insufficiency (20–30 ng/mL), respectively (Lee et al., 2019). In that study, a high median value of serum vitamin D of 32.6 ng/mL was found in children < 7 years old with atopic dermatitis and a median serum vitamin D of 33.3 ng/mL in the same age group without atopic dermatitis. Different measuring assays, such as electrochemiluminescence immunoassay (ECLIA), that is included in the study by Lee and colleagues may lead to higher serum vitamin D values (Lee et al., 2019). Our finding highlights the important public health issue of vitamin D deficiency among young children in Malaysia. However, the high vitamin D deficiency found among them was not expected. A previous study aimed to assess parental vitamin D knowledge among those attending the Paediatric Dental Clinic at the Faculty of Dentistry (UiTM), Malaysia. Regrettably, that study indicated a significant lack of knowledge about the sources of vitamin D, the role of sunlight in vitamin D synthesis, health-related benefits of vitamin D, and the risk factors that hindered vitamin D production (Hussein et al., 2018). This finding may reflect the considerably high vitamin D inadequacy among children in Malaysia since parents lacked basic knowledge about vitamin D.

Effective preventive strategies are needed to improve vitamin D status among children in Malaysia. Starting with developing effective education strategies to tackle the misunderstanding about vitamin D,

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improving vitamin D knowledge through suitable public health education and implementing prevention strategies that may help in increasing personal responsibility for preventing vitamin D deficiency (Hussein et al., 2018). Health policies including food fortification policies should be considered to ensure adequate vitamin D intake. Recently, the Ministry of Health, Malaysia has amended the recommended vitamin D daily intake from 200 IU/day in 2005 to 600 IU/day in 2017 for children aged 1–9 years old following the IOM recommended vitamin D daily intake (MOH, 2005, 2017). The recommendations with regards to diet and supplements need to be re-evaluated from time to time according to the current situation. Additionally, we must ensure that all those who deal with children including health care providers and parents are aware about the new daily vitamin D intake recommendations. For public health benefit, basic and essential food should be mandatorily fortified with vitamin D to prevent vitamin D deficiency (Holick, 2010).

Children's age, gender and religion were not associated with their vitamin D levels. Similar findings reported previously indicated that these variables were not predictors of vitamin D status (Mokhtar et al., 2018). Moreover, it was indicated that racial group is a significant predictor of serum vitamin D status (Cui et al., 2022). In this study, children's race appears to be significantly associated with their vitamin D status. Sufficient vitamin D levels were more apparent in Chinese children compared to Malay and Indian children. This finding was in accordance with a prior local study that indicated a significantly higher mean vitamin D levels among Chinese adolescents compared to Malay and Indian adolescents (Al-Sadat et al., 2016). It could be related to skin colour, where skin colour is considered a risk factor for vitamin D deficiency. Chinese have fairer skin compared to Malays and Indians (Al-Sadat et al., 2016). Skin pigmentation prevents the transformation of 7-dehydrocholesterol to vitamin D (Libon et al., 2013). Therefore, individuals with fair skin were found to have sufficient levels of serum vitamin D as compared to those with dark skin (Libon et al., 2013). However, this finding is not truly representative as the sample included only two Chinese and ten Indian children. A larger sample size encompassing different ethnic groups in Malaysia, while accounting for factors such as sun exposure and skin pigmentation, is needed before these results can be confirmed and applied as a predictive tool for vitamin D status.

Vitamin D deficiency and its relationship with the nutritional status of growing children is of particular concern. In the present study, our data showed that children deficient in vitamin D were significantly thinner than children with insufficient vitamin D levels. Additionally, although not significant ($p = 0.054$), children deficient in vitamin D were also a bit shorter than children with insufficient vitamin D levels. This finding is in accordance with a prior study which indicated that higher serum vitamin D levels were noticed among taller children (Marasinghe et al., 2015). It was also reported that lower serum vitamin D levels were noticed in underweight and stunted children compared to children with normal weight (Mokhtar et al., 2018). Adequate vitamin D influences linear growth of children (Mokhtar et al., 2018). Vitamin D enhances the sensitivity of the growth plate cells to the action of the growth hormone (Esposito et al., 2019). Thus, all these findings indicated the potential role of vitamin D as an important nutritional factor to prevent growth impairment and stunting in children.

In the present study, only four mothers had reported health issues during pregnancy. Three mothers reported gestational diabetes mellitus and only one mother reported hepatitis B infection during pregnancy. The prevalence of gestational diabetes mellitus in Selangor, Malaysia in 2014 is reported as 27.9% (Logakodie et al., 2017). Several international studies reported a relationship between gestational diabetes mellitus and vitamin D deficiency such as in Australia (Clifton Bligh et al., 2008) and Iran (Soheilykhah et al., 2010). These studies suggested higher rates of vitamin D deficiency among gestational diabetes mellitus women. Low maternal vitamin D is a risk factor for vitamin D deficiency in their infants (Anusha et al., 2019). In this study, we found that mother's health status during pregnancy were significantly associated with their children's vitamin D status later in life. Mothers who reported health issues during pregnancy were significantly more likely to have children deficient in vitamin D. However, we are not able to conclude or generalize this finding since only a few mothers reported health issues and gestational diabetes mellitus during their pregnancy.

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WHO recommended exclusive breastfeeding for the first 6 months of life and complementary breastfeeding up to 2 years of a child's life. Breastfeeding provides the essential nutrients required for young children's growth (WHO, 2018). However, breastfed infants may not maintain sufficient vitamin D levels from their mother's milk due to low maternal vitamin D levels (Tan et al., 2018). It is widely indicated that human milk is a poor source of vitamin D and exclusive and prolonged breastfeeding can cause vitamin D deficiency in children (Al-Qahtani et al., 2022). Previous studies have reported a wide variation of vitamin D deficiency and insufficiency in breastfed infants. The prevalence of vitamin D insufficiency (< 50 nmol/L) and deficiency (< 30 nmol/L) in 7-month-old Nepalese infants were 3.6% and 0.6%, respectively (Haugen et al., 2016). Additionally, the prevalence of vitamin D deficiency (50 mmol/L) in 1–6-month-old South Korean infants was 82.5% in the breastfed group and 17.5% in the formula fed group (Choi et al., 2013).

In the present study, vitamin D deficiency and insufficiency among exclusive breastfed children were 29.4% and 24.7%, respectively. In comparison, vitamin D deficiency and insufficiency among non-exclusive breastfed children were 48.6% and 8.6%, respectively. We found that children who are deficient in vitamin D were exclusively breastfed for a longer period compared to those children with insufficient and sufficient vitamin D levels; however, this finding was not statistically significant. These findings were in accordance with a prior study that included 6-year-old children. In that study, neither formula intake at the age of 13 months nor history of breastfeeding was associated with vitamin D status at the age of 6 years (Voortman et al., 2015). In fact, we are not able to determine the association between breastfeeding and vitamin D deficiency as vitamin D measurements were carried out while most of the children were no longer breastfed; only 4.2% of the children were still breastfeeding at the time of data collection. Additionally, other factors such as diet, children's skin colour and sun exposure might influence the vitamin D status in this group.

Limited consumption of certain foods has been related to low vitamin D levels. In the present study, among the items being studied, only chicken and fortified cereal consumption were related to vitamin D status in this group. Although chicken has a marginal amount of vitamin D compared to oily fish and fats, literature has indicated that the intake of the metabolized form of vitamin D (25(OH)D) that is present in foods such as meat, chicken, chicken skin, poultry, and eggs improved vitamin D status (Taylor et al., 2014). In fact, it was indicated that the amounts of 25(OH)D in different foods have not been investigated, and hence, have not been involved when reporting on foods that contain vitamin D (Taylor et al., 2014). 25(OH)D appears to be more effective in increasing serum vitamin D levels than the non-metabolized form of vitamin D (Taylor et al., 2014). In this study, the limited consumption of chicken was related to vitamin D deficiency amongst this group. Chicken consumption was the highest among all the other food items investigated in the present study, including fish, seafood, meat, eggs and liver. Almost two-thirds of children (74.2%) consumed chicken once or more a day and 17.5% of children consumed chicken once or more every week. This high consumption rate may partially explain the positive association between frequent chicken consumption and better vitamin D levels. Chicken consumption is very popular among Malaysians, it is considered the cheapest source of meat protein and it is free from religious restrictions (Dewan, 2017). However, logically, consuming only chicken may not contribute to adequate vitamin D levels. Thus, this finding is possibly confounded by other factors such as skin colour and sunlight exposure. Moreover, we found that children who often consumed fortified cereal were more likely to have sufficient levels of vitamin D, which is a similar finding reported previously (Powers et al., 2016)).

In the present study, none of the children consumed vitamin D supplementation, but the consumption of multivitamin and cod liver oil was reported. This finding may mirror the fact that Malaysian parents are not aware of the potential benefits of vitamin D and the current recommended vitamin D intake of 600 IU/day for children aged 1–9 years old (MOH, 2017). Parents may not be aware about vitamin D supplements due to a lack of information (Drury et al., 2015). A previous study surprisingly indicated that only 21.50% of Malaysian parents have cited vitamin D supplements as a good source of vitamin D, and the majority of them (91.5%) would like to have more information about the importance of vitamins for their children (Hussein et al., 2018). This finding emphasizes on the importance of increasing the knowledge and the awareness among parents about vitamin D and its health-related benefits, as well as emphasis on the importance of vitamin D supplementation for young children in Malaysia.

Sun is the main source of vitamin D. Sunlight exposure may provide our body with the required amount of vitamin D. However, safe sunlight exposure is encouraged to increase natural vitamin D synthesis and avoid the side effects of excessive sun exposure. The finding of the present study has indicated that children recently exposed to sunlight had sufficient vitamin D levels compared to those not exposed to sunlight. Similar findings were reported previously, whereby higher serum vitamin D levels were noted in children with frequent exposure to sunlight (Al-Qahtani et al., 2022). Encouraging outdoor activities among children should be advocated to promote an active lifestyle that may prevent vitamin D deficiency (Al-Qahtani et al., 2022). We recommend this finding of the beneficial effects of sunlight exposure to be used in health policymaking. All governmental and non-governmental organizations should collaborate to educate parents and children regarding the benefits of vitamin D, its sources and safe sunlight exposure. This will help to improve and boost overall health among the Malaysian population.

Sociodemographic status of parents did not produce any significant differences in their children's vitamin D status. This was in line with a previous study in Malaysia by Al Sadat et al. (2016) (Al-Sadat et al., 2016). In contrast, a significant association between low sociodemographic factors and vitamin D deficiency in school-age children was reported in the previous studies carried out in the United State of America (Carpenter et al., 2012) and Netherlands (Voortman et al., 2015). It was indicated that the difference in vitamin D levels between the lower and upper working classes could be related to the food quality and types that are consumed daily (Al-Sadat et al., 2016). Additionally, in this study, father's race is significantly associated with their children's vitamin D status. Chinese fathers were more likely to have children with sufficient vitamin D levels compared to Malay and Indian fathers. Ethnicity group is a significant predictor of vitamin D status (Cui et al., 2022). Differences in vitamin D levels between different racial groups might be attributed to the higher skin pigmentation, which hinders cutaneous vitamin D synthesis (Cui et al., 2022), or could be related to other genetic differences (Voortman et al., 2015). Cultural aspects, such as wearing cloth coverings and spending less time outside, could also explain these differences (Voortman et al., 2015).

4.1. Limitations of the Study

This study used a cross-sectional design; therefore, causality cannot be established. Parental knowledge was assessed via self-reported questionnaires, which may be subject to recall bias and desirability bias. Some parents may have responded in a way that presented their knowledge more favorably. The generalizability of the findings is limited due to the small sample size and underrepresentation of Chinese and Indian children. In addition, sun exposure was assessed using questions related to time and frequency of sun exposure, body parts exposed, and sunscreen used in the last two weeks. However, this approach may lack precision to determine the sun exposure. Future studies using more validated tools such as sun exposure scores to improve measurement accuracy are recommended.

5. CONCLUSION

High vitamin D deficiency and insufficiency was reported among preschool Malaysian children. Several factors were associated with vitamin D deficiency among young Malaysian children including lower body weight of children, mother's health issues during pregnancy, less consumption of chicken and fortified cereal and less sunlight exposure. Development and implementing wide-scale, long-term programs of health education and promotion for parents should be considered that would help to increase knowledge aspects of vitamin D and its related benefit. Furthermore, parents' motivation to adopt and promote oral health for their children should be emphasized.

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CONFLICT OF INTEREST

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

All authors made substantial contributions to the work including the conception and design of the study, data collection and analysis, and interpretation of the results. They were also actively involved in drafting, revising, and critically reviewing the manuscript. All authors approved the final version to be published, agreed on the choice of journal for submission, and accepted responsibility for all aspects of the work.

REFERENCES

Almoudi, M. M., Hussein, A. S., Doss, J. G., & Schroth, R. J. (2016). Expectant mothers' readiness to initiate preventive oral health care for their children. *Saudi Journal for Dental Research*, 7(2), 118–126. https://doi.org/10.1016/j.sjdr.2016.04.006.

Al-Qahtani, S. M., Shati, A. A., Alqahtani, Y. A., Dawood, S. A., Siddiqui, A. F., Zaki, M. S. A., & Khalil, S. N. (2022). Prevalence and correlates of vitamin D deficiency in children aged less than two years: a cross-sectional study from Aseer region, Southwestern Saudi Arabia. *Healthcare*, *10*(6), 1064. https://doi.org/ 10.3390/healthcare10061064.

Al-Sadat, N., Majid, H. A., Sim, P. Y., Su, T. T., Dahlui, M., Bakar, M. F. A., Dzaki, N., Norbaya, S., Murray, L., Cantwell, M. M., & Jalaludin, M. Y. (2016). Vitamin D deficiency in Malaysian adolescents aged 13 years: findings from the Malaysian Health and Adolescents Longitudinal Research Team study (MyHeARTs). *BMJ Open*, *6*(8), e010689. https://doi.org/ 10.1136/bmjopen-2015-010689.

Anusha, K., Hettiaratchi, U., Gunasekera, D., Prathapan, S., & Liyanage, G. (2019). Maternal vitamin D status and its effect on vitamin D levels in early infancy in a tertiary care centre in Sri Lanka. *International Journal of Endocrinology*, *9,* 2019. https://doi.org/10.1155/2019/9017951.

Calafiore, D., Fortunato, L., & Migliario, M. (2022). Vitamin D for clinical diseases in women: an indispensable factor in medicine and dentistry. *Journal of Clinical Medicine*, *11*(11), 3104. https://doi.org/10.3390/jcm11113104.

Carpenter, T. O., Herreros, F., Zhang, J. H., Ellis, B. K., Simpson, C., Torrealba-Fox, E., Kim, G. J., Savoye, M., Held, N. A., & Cole, D. E. C. (2012). Demographic, dietary, and biochemical determinants of vitamin D status in inner-city children. *The American Journal of Clinical Nutrition*, *95(1)*, 137–146. https://doi.org/ 10.3945/ajcn.111.018721.

Choi, Y. J., Kim, M. K., & Jeong, S. J. (2013). Vitamin D deficiency in infants aged 1 to 6 months. *Korean Journal of Pediatrics*, *56*(5), 205–210. https://doi.org/ 10.3345/kjp.2013.56.5.205.

Clifton Bligh, R. J., McElduff, P., & McElduff, A. (2008). Maternal vitamin D deficiency, ethnicity and gestational diabetes. *Diabetic Medicine, 25(6), 678–684.* https://doi.org/10.1111/j.1464-5491.2008.02422.x.

Cui, A., Xiao, P., Ma, Y., Fan, Z., Zhou, F., Zheng, J., & Zhang, L. (2022). Prevalence, trend, and predictor analyses of vitamin D deficiency in the US population, 2001–2018. *Frontiers in Nutrition, 9,* 965376. https://doi.org/10.3389/fnut.2022.965376.

Dewan, M. (2017). Malaysian chef's perception towards factory farmed poultry products: a qualitative enquiry. In Trends, issues and women in hospitality and tourism industry (First edit, pp. 21–35).

Drury, R., Rehm, A., Johal, S., & Nadler, R. (2015). Vitamin D supplementation: we must not fail our children! *Medicine*, *94*(18), e817. https://doi.org/10.1097/MD.0000000000000817.

Esposito, S., Leonardi, A., Lanciotti, L., Cofini, M., Muzi, G., & Penta, L. (2019). Vitamin D and growth hormone in children: a review of the current scientific knowledge. *Journal of Translational Medicine, 17*(1), 87. https://doi.org/10.1186/s12967-019-1840-4.

Haugen, J., Ulak, M., Chandyo, R. K., Henjum, S., Thorne Lyman, A. L., Ueland, P. M., Midtun, Ø., Shrestha, P. S., & Strand, T. A. (2016). Low prevalence of vitamin D insufficiency among Nepalese infants despite high prevalence of vitamin D insufficiency among their mothers. *Nutrients, 8*(12), 825. https://doi.org/10.3390/nu8120825.

Holick, M. F. (2007). Vitamin D deficiency. *New England Journal of Medicine, 357*(3), 266–281. https://doi.org/10.1056/NEJMra070553.

Holick, M. F. (2010). The vitamin D deficiency pandemic: a forgotten hormone important for health. *Public Health Reviews, 32*(1), 267–283. https://doi.org/10.1007/BF03391602.

Holick, M. F., Binkley, N. C., Bischoff-ferrari, H. A., Gordon, C. M., Hanley, D. A., Heaney, R. P., Murad, M. H., & Weaver, C. M. (2011). Evaluation, treatment, and prevention of vitamin D deficiency : an Endocrine Society Clinical Practice Guideline. *Journal of Clinical Endocrinology & Metabolism, 96*(7), 1911–1930. https://doi.org/10.1210/jc.2011-0385.

Hussein, A. S., Almoudi, M. M., Abu-Hassan, M. I., Schroth, R. J., Saripudin, B., & Shawal, M. F. (2021). Serum and saliva 25(OH)D levels in relation to dental caries in young children. *Journal of Clinical Pediatric Dentistry, 45*(6), 10–14. https://doi.org/10.17796/1053-4625-45.6.8.

Hussein, A. S., Almoudi, M. M., Zen, S. A. N. M., Azmi, N. H., Schroth, R. J., & Hassan, M. I. A. (2018). Parental awareness and knowledge of vitamin D and its health benefits for children. *Journal of International Dental and Medical Research, 11*(3), 916–924.

Khor, G. L., Chee, W. S., Shariff, Z. M., Poh, B. K., Arumugam, M., Rahman, J. A., & Theobald, H. E. (2011). High prevalence of vitamin D insufficiency and its association with BMI-for-age among primary school children in Kuala Lumpur, Malaysia. *BMC Public Health, 11*, 95, 1–8. https://doi.org/10.1186/1471-2458-11-95.

Lee, J. Y., So, T.-Y., & Thackray, J. (2013). A review on vitamin d deficiency treatment in pediatric patients. *Journal of Pediatric Pharmacology and Therapeutics, 18*(4), 277–291. 10.5863/1551-6776-https://doi.org/18.4.277.

Lee, Y. W., Choon, S. E., & Izham, S. (2019). Serum 25-hydroxyvitamin D deficiency in Malaysian children with severe atopic dermatitis. *Medical Journal of Malaysia, 74(4)*, 259–265.

Libon, F., Cavalier, E., & Nikkels, a. F. (2013). Skin color is relevant to vitamin D synthesis. *Dermatology, 227*(3), 250–254. https://doi.org/10.1159/000354750.

Logakodie, S., Azahadi, O., Fuziah, P., Norizzati, B. I. B., Tan, S. F., Zienna, Z. Z. R., Norliza, M., Noraini, J., Hazlin, M., Noraliza, M. Z., Sazidah, M. K., & Mimi, O. (2017). Gestational diabetes mellitus: The prevalence, associated factors and foeto-maternal outcome of women attending antenatal care. *Malaysian Family Physician, 12*(2), 9–17.

Mansbach, J. M., Ginde, A. A., & Camargo, C. A. (2009). Serum 25-hydroxyvitamin D levels among US children aged 1 to 11 years: do children need more vitamin D? *Pediatrics, 124*(5), 1404–1410. https://doi.org/ 10.1542/peds.2008-2041.

Marasinghe, E., Chackrewarthy, S., Abeysena, C., & Rajindrajith, S. (2015). Micronutrient status and its relationship with nutritional status in preschool children in urban Sri Lanka. *Asia Pacific journal of clinical nutrition, 24(1)*, 144–151. https://doi.org/10.6133/apjcn.2015.24.1.17

Mogire, R. M., Mutua, A., Kimita, W., Kamau, A., Bejon, P., Pettifor, J. M., Adeyemo, A., Williams, T. N., & Atkinson, S. H. (2020). Prevalence of vitamin D deficiency in Africa: a systematic review and meta-analysis. *The Lancet Global Health, 8(1)*, e134–e142. https://doi.org/10.1016/S2214-109X(19)30457-7.

MOH. (2005). Recommended nutrient intakes for Malaysia. A report of the technical working group on nutritional guidelines. National coordinating committee on food and nutrition, Ministry of health Malaysia, Putrajaya. https://www.moh.gov.my/moh/images/gallery/rni/insert.pdf.

MOH. (2017). Recommended nutrient intakes for Malaysia. A report of the technical working group on nutritional guidelines. National coordinating committee on food and nutrition, Ministry of health Malaysia, Putrajaya. https://hq.moh.gov.my/nutrition/wp-content/uploads/2023/12/FA-Buku-RNI.pdf

Mokhtar, R. R., Holick, M. F., Sempértegui, F., Griffiths, J. K., Estrella, B., Moore, L. L., Fox, M. P., & Hamer, D. H. (2018). Vitamin D status is associated with underweight and stunting in children aged 6–36 months residing in the Ecuadorian Andes. *Public Health Nutrition, 21*(11), 1974–1985. https://doi.org/10.1017/S1368980017002816.

Poh, B. K., Ng, B. K., Siti Haslinda, M. D., Nik Shanita, S., Wong, J. E., Budin, S. B., Ruzita, A. T., Ng, L. O., Khouw, I., & Norimah, a K. (2013). Nutritional status and dietary intakes of children aged 6 months to 12 years: findings of the Nutrition Survey of Malaysian Children (SEANUTS Malaysia). *British Journal of Nutrition, 110*(S3), S21–S35. https://doi.org/ 10.1017/S0007114513002092.

Powers, H. J., Stephens, M., Russell, J., & Hill, M. H. (2016). Fortified breakfast cereal consumed daily for 12 wk leads to a significant improvement in micronutrient intake and micronutrient status in adolescent girls: a randomised controlled trial. *Nutrition Journal, 15*(1), 69. https://doi.org/10.1186/s12937-016-

0185-6.

Ross, A. C., Taylor, C. L., Yaktine, A. L., & Del Valle, H. B. (2011). Dietary reference intakes for calcium and vitamin D. Washington, DC: National Academies Press. https://www.ncbi.nlm.nih.gov/books/NBK56070/ doi: 10.17226/13050.

Schroth, R. J., Levi, J. A., Sellers, E. A. C., Friel, J., Kliewer, E., & Moffatt, M. E. (2013). Vitamin D status of children with severe early childhood caries: a case-control study. *BMC Pediatrics, 13*(1), 174. https://doi.org/10.1186/1471-2431-13-174.

Sempos, C. T., Heijboer, A. C., Bikle, D. D., Bollerslev, J., Bouillon, R., Brannon, P. M., DeLuca, H. F., Jones, G., Munns, C. F., & Bilezikian, J. P., Andrea, G., & Binkley, N. (2018). Vitamin D assays and the definition of hypovitaminosis D: results from the First International Conference on Controversies in Vitamin D. *British Journal of Clinical Pharmacology, 84*(10), 2194–2207. https://doi.org/10.1111/bcp.13652.

Sethu, S., Shetty, R., Deshpande, K., Pahuja, N., Chinnappaiah, N., Agarwal, A., & Sharma, A., & Ghosh, A. (2016). Correlation between tear fluid and serum vitamin D levels. *Eye and Vision, 3*(1), 22. https://doi.org/10.1186/s40662-016-0053-7.

Soheilykhah, S., Mojibian, M., Rashidi, M., Rahimi Saghand, S., & Jafari, F. (2010). Maternal vitamin D status in gestational diabetes mellitus. *Nutrition in Clinical Practice, 25*(5), 524–527. https://doi.org/10.1177/0884533610379851.

Tan, M. L., Abrams, S. A., & Osborn, D. A. (2020). Vitamin D supplementation for term breastfed infants to prevent vitamin D deficiency and improve bone health. *Cochrane Database of Systematic Reviews, 12*(12), CD013046. https://doi.org/10.1002/14651858.CD013046.pub2.

Taylor, C. L., Patterson, K. Y., Roseland, J. M., Wise, S. A., Merkel, J. M., Pehrsson, P. R., & Yetley, E. A. (2014). Including food 25-hydroxyvitamin D in intake estimates may reduce the discrepancy between dietary and serum measures of vitamin D status. *The Journal of Nutrition, 144(5)*, 654–659. https://doi.org/10.3945/jn.113.189811.

Voortman, T., van den Hooven, E. H., Heijboer, A. C., Hofman, A., Jaddoe, V. W. V, & Franco, O. H. (2015). Vitamin D deficiency in school-age children is associated with sociodemographic and lifestyle factors. *The Journal of Nutrition, 145(4)*, 791–798. https://doi.org/10.3945/jn.114.208280.

WHO. (2018). Infant and young child feeding. https://www.who.int/data/nutrition/nlis/info/infant-and-young-child-feeding.

6. APPENDIX
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