ISSN: 2692-5370
DOI: 10.33552/ASOAJ.2024.05.000614
Anaesthesia & Surgery
Open Access Journal
Iris Publishers

Research Article

The Alarming of Zinc Deficiency and Vitamin D Insufficiency and The Associated Factors Among Vietnamese Adolescents 10-14 Years Old

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Received Date: September 03, 2024

Published Date: September 09, 2024

Abstract

Zinc deficiency (ZnD) and vitamin D insufficiency (VDI) are common health issues among adolescents. There is a gap in knowledge on the prevalence of ZnD and VDI among adolescents aged 10-14 years in Viet Nam. The study aimed to determine the prevalence of ZnD and VDI among 10-14-year-old adolescents and identify the risk factors.

This cross-sectional study was conducted on six public secondary school students 10-14 years old in Thai Nguyen City in November 2022. The sample size was 324 secondary school students aged 10-14. Participants were randomly chosen from the list of 5,030 students. They were obtained blood tests, anthropometric measurements, and socio-demographic characteristics. The AU400 Series Clinical Chemistry Analyzer analyzed zinc serum. Vitamin D concentration was performed by the UniCel Dxl 800 Access Immunoassay System. The cut-off point for ZnD was 55 mcg/gl, and VDI's was 30 ng/ml. Written consent was sent to parents before collecting data and to the students on data collection day. The ZnD proportion in Vietnamese adolescents was 37.7%. The proportion of VDI was 69.8%. The factor associated with ZnD was the underweight adolescents. The participants who were female, studied in suburban schools, and had siblings were more likely to be VDI than their counterparts. The main reason for the high prevalence of ZnD and VDI may be inadequate essential micronutrients in the diet of the Vietnamese.

The high prevalence of ZnD and VDI in Vietnamese adolescents 10-14 years old is a common health problem in the community. The factor positively associated with ZnD was underweight secondary school students. Factors such as female students, the place of school in a suburban part of the city, and the number of siblings ≥2 increased the risk of VDI situation.

Keywords: Zinc deficiency; Vitamin D insufficiency; Adolescents; Secondary school; Student; aged 10-14; Vietnam

Abbreviations: ZnD: Zinc deficiency; VDI: Vitamin D insufficiency; The US: The United States; IZiNCG: International Zinc Nutrition Consultative Group; BMI: Body Mass Index; WHO: World Health Organization; OR: Odds Ratios; AOR: Adjusted Odds Ratios; CI 95: 95% confidence intervals

Introduction

Micronutrient deficiency, such as zinc and vitamin D, is common in developing countries [1,2]. Zinc or vitamin D deficiency occurs when the zinc and vitamin D concentration in the serum is less than the recommended cut-off point. The cut-off point for zinc or vitamin D deficiency varies depending on the study objectives, study population, and testing methods [3-6]. However, obvious criteria and evidence are required in specific situations to decide on the optimal cutoff points for each study.

Zinc and vitamin D are crucial micronutrients for human growth, particularly during adolescence. Zinc is involved in over 300 enzymes and coenzymes, significantly affecting biological processes such as DNA synthesis, cell growth, metabolism, and immunization [7,8]. Meanwhile, vitamin D plays a key role in maintaining optimal bone health and co-functions in several important metabolic pathways [9]. Additionally, zinc serum and vitamin D were proven to synergistically affect a child's development and body mass index (BMI) [10,11]. The combination of zinc and vitamin D supplements might improve depression among obese persons as well as enhance the immune system [12,13]. Therefore, both zinc and vitamin D are vital for promoting height and weight and protecting children from infectious diseases during their development [14,15]. The inadequacy of either of these two nutrients can result in various disorders affecting almost all body systems. Lack of zinc serum could raise serious health problems in children, for example, the increase in the risk of mortality and morbidity among children and the retardation in children's growth [16,17]. Similarly, vitamin D insufficiency (VDI) in the body negatively affects children's development and body composition [18].

The prevalence of zinc deficiency (ZnD) worldwide was estimated at about 17.3%, and vitamin D deficiency was 15.7% in all populations [1,2]. In low- and middle-income countries, adolescents who underwent ZnD were approximately 20% to 80%, while this proportion in European countries was less than 10% [19,20]. Likewise, more than 308 studies estimated about 50% of the population has a vitamin D concentration level of less than 30ng/ml [2]. The school-aged children in India, Pakistan, and Afghanistan had lower vitamin D concentration levels (more than 20% of children) than developed countries (6-13%), such as The United States (US), Canada, and Europe [21]. The inadequate diet has been the main and direct reason for micronutrient deficiency, including ZnD and VDI. However, the risks of ZnD and VDI are diversified according to different factors [1,9]. Zinc deficiency may be higher among eating disorder adolescents and stunting children [1,5]. Those groups of people who are middle-aged, malnourished, and alcohol-used could be at a higher risk of ZnD [22,23]. Meanwhile, vitamin D concentration in the blood may decrease among dark-skinned people, females, low-income countries or during the winter and less sunlight exposure [2,4,6]. Additionally, zinc serum may have a positive correlation with vitamin D concentration [10,11].

The data on micronutrient deficiency in secondary-school age, such as zinc and vitamin D, has yet to be uncovered in Viet Nam. Despite some local reports predicting the estimated zinc deficiency among children under five years old was about 70%, no research on this health problem among adolescents has been published. Given the similar situation of vitamin D insufficiency. Therefore, this research aims to define the prevalence of zinc deficiency and vitamin D insufficiency among secondary school students and explore some risk factors for these health issues among those adolescents.

Methods

Study design and sample

This study was a cross-sectional study. The data were collected on secondary school students in Thai Nguyen City, Viet Nam, in November 2022. The sample size was calculated using the formula to estimate the proportion of binary outcomes for a descriptive study [24]. Due to the lack of previous data on ZnD and VDI among adolescents in Viet Nam, we estimated a p=0.7 and a confidence interval of 95% [25]. Considering a 10% increase in non-participation, the anticipated sample size was 317 students.

The sampling method was the cluster, stratified sample approach. Based on the city's geographic administration, the list of 38 public secondary schools in Thai Nguyen City was divided into the central and suburban parts. We arbitrarily selected three secondary schools from each part of the city. Given a reference population of 5,030 secondary school students, 6% were randomly selected in each school. The final sample size obtained was 324 students.

Participants

The participants were secondary school students aged 10 to 14 in 6 selected schools. Excluded students were individuals with any acute or chronic diseases or on any medication or special diet or physical deformities that affect the height or refusal of participation. Students obtained the blood test, anthropometric measurements, and questionnaire on socio-demographic characteristics.

Laboratory blood testing

Blood testing was taken on the morning of the data collection day. Students were requested to skip breakfast and were collected 3.0 ml fasting blood at the vein. After that, the blood samples were left in the tube without anticoagulant at a low temperature (0-100C) and sent to the laboratory within eight hours. At the laboratory, a blood sample was centrifuged to separate serum or plasma and then entered the analyzing system. UniCel Dxl 800 Access Immunoassay System automatically analyzed samples for vitamin D [26]. Meanwhile, the AU400 Series Clinical Chemistry Analyzer (Beckman Coulter, USA) was employed to explore serum zinc levels. These systems were regularly and periodically maintained.

The zinc serum was measured using a colorimetric method. Since the cut-off point suggested by the International Zinc Nutrition Consultative Group (IZiNCG) was significantly high for Vietnamese adolescents, we used the cut-off point for ZnD at 55 mcg/dl, which was suggested for adolescents by the University of California, San Francisco (UCSF) clinical laboratory and make-up criteria for healthy Indian children 1-19 years old [5,27]. The vitamin D serum concentration was assessed to estimate the vitamin D level. We used the US Endocrine Society classification to define VDI ≤ 30 ng/ml because school-aged children's health should be approached as a public health issue [28].

Other variables

The anthropometric data consisted of the weight and height of the participants. Weight assessment was used by the InBody Dial, H20N scale with a capacity of 150 kg and a precision of 0.1 kg. The height was used by a portable wooden height measuring board with a sliding headpiece, performed in 250 millimeters [29]. The Body Mass Index (BMI) was calculated and classified by Z-Score for age and sex, using the World Health Organization (WHO) International Child Growth Standards for children from 5 to 19 years old [30]. BMI was defined as underweight, normal, and overweight. In this study, overweight students included students who were overweight or obese. All data collectors were trained following the WHO guidelines [31].

Socio-demographics were collected using a self-recorded questionnaire. The students obtained their ages, sex, ethnicity, place of school, and the number of siblings. Age was categorized into five groups: 10, 11, 12, 13, and 14 years old. Ethnicity was classified as Kinh and others, which were minority groups including Tay, Nung, Thai, Muong, and San Chi ethnics. The place of school was grouped into the central and the suburban parts of the city. The number of children in the household was categorized as a single child and ≥ two children.

Statistical Analysis

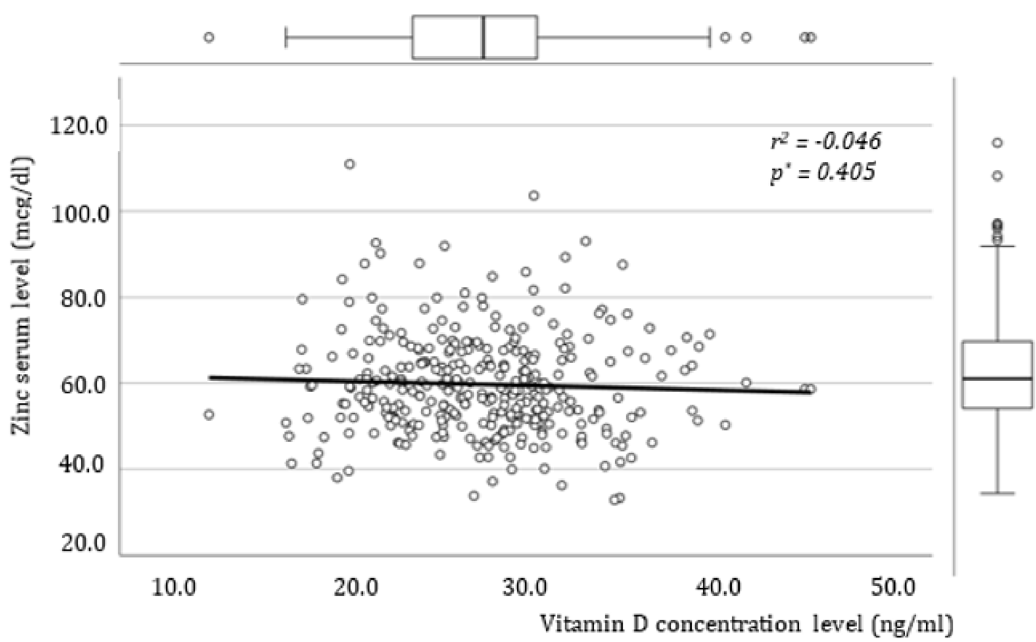
The data was entered by Epi data 3.1 and analyzed by SPSS 22. The Chi-square test was applied to determine whether there were significant differences between the study groups. Univariate and multivariate logistic regression was applied to find the relationship between zinc deficiency and vitamin D insufficiency and the association factors. We performed odds ratios (OR), adjusted odds ratios (AOR), and 95% confidence intervals (CI 95%). A p-value less than 0.05 was taken as a level of statistical significance.

Ethical approval

This study was conducted with the permission of the Thai Nguyen General Hospital's ethical committee. The committee's license code was IRD-VN01048. Parents were informed about the students' blood test via the homeroom teacher and the principal. A written consent form was given to parents and collected via the homeroom teachers. All students signed a written consent form on the data collection day before taking blood. Students had a right to participate voluntarily, to refuse to answer some questions and to stop at any time during the research.

Results

The characteristics of secondary students in Vietnam



Zinc serum: Mean 59.71±11.75 mcg/dl
Vitamin D concentration: Mean 27.60± 5.21 ng/ml
**Pearson Correlation*

Figure 1: The correlation of zinc serum and vitamin D concentration in secondary school students' blood (N=324).

The prevalence of ZnD among Vietnamese secondary school students was 37.7%, and the proportion of vitamin D insufficient students was 69.8% (Table 1). The mean of zinc serum was 59.71±11.75 mcg/dl, and the mean of vitamin D concentration was 27.60±5.21 ng/ml. There was an adverse correlation between the participants' zinc serum and vitamin D concentration; however, this relationship was insignificant (r2 = -0.046, p = 0.405) (Figure 1).

The students' age ranged from 10 to 14 years, and the mean age was 12.7±1.13. The percentage of male students was 52.8%, higher than that of females with 48.2%. Kinh ethnicity made up the biggest ethnic groups (75.3%). Most of the secondary students lived in the central part of the city (56.8%). Almost all participants had siblings (85.5%), and only 6.8% were the single child. The overweight students accounted for 32.4%, while the rate of underweight students was a mere 6.2% (Table 1).

Table 1: The socio-demographic characteristics of students with calcium and vitamin D deficiency

Variables		Total N (%)	Zinc deficiency n (%)	No Zinc deficiency n (%)	p*	VTM D Insufficiency n (%)	No VTM D Insufficiency n (%)	p*
Ages	10	14 (4.3)	5 (35.7)	9 (64.3)	0.665	8 (57.1)	6 (42.9)	0.373
	11	86 (26.5)	34 (39.5)	52 (60.5)		61 (70.9)	25 (29.1)	
	12	79 (24.4)	28 (35.4)	51 (64.6)		59 (74.7)	20 (25.3)	
	13	84 (25.9)	36 (42.9)	48 (57.1)		53 (63.1)	31 (36.9)	
	14	61 (18.8)	19 (31.1)	42 (68.9)		45 (73.8)	16 (26.2)	
Sex	Boys	171 (52.8)	61 (35.7)	110 (64.3)	0.436	103 (60.2)	68 (39.8)	<0.001
	Girls	153 (47.2)	61 (39.9)	92 (60.1)		123 (80.4)	30 (19.6)	
Ethnicity	Kinh	244 (75.3)	97 (39.8)	147 (60.2)	0.173	166 (68.0)	78 (32.0)	0.239
	Other[a]	80 (24.7)	25 (31.3)	55 (68.8)		60 (75.0)	30 (25.0)	
Place of school	Central part	184 (56.8)	71 (38.6)	113 (61.4)	0.691	118 (64.1)	66 (35.9)	0.012
	Suburban part	140 (43.2)	51 (36.4)	89 (63.6)		108 (77.1)	32 (22.9)	
Number of children in the households	Single child	22 (6.8)	11 (50.0)	11 (50.0)	0.298	10 (45.5)	12 (54.5)	0.008
	≥ 2 children	277 (85.5)	104 (37.5)	173 (62.5)		202 (72.9)	75 (27.1)	
	No anwer	25 (7.7)	7 (28.0)	18 (72.0)		14 (56.0)	11 (44.0)	
BMI	Underweight	20 (6.2)	12 (60.0)	8 (40.0)	0.101	13 (65.0)	7 (35.0)	0.711
	Normal	199 (61.4)	73 (36.7)	126 (63.3)		142 (71.4)	57 (28.6)	
	Overweight	105 (32.4)	37 (35.2)	68 (64.8)		71 (67.6)	34 (32.4)	
Total		324 (100.0)	122 (37.7)	202 (62.3)		226 (69.8)	98 (30.2)	

** Chi-square test*

[a] Others included minor ethnicities such as Tay, Nung, Thai, Muong, San Chi

Abbreviations: VTM D: Vitamin D. BMI: body mass index.

The factors associated with Zinc deficiency and vitamin D insufficiency among secondary students in Vietnam

The logistic regression was performed to identify the factors associated with Zinc deficiency and vitamin D insufficiency among adolescents 10-14 years old in Viet Nam.

Regarding sexes, female participants tended to be more likely to suffer from both ZnD and VDI. Girl adolescents tended to be at 2.62 higher risk of VDI than boys. [Adjusted odds ratio (AOR) = 2.62; 95% Confidence interval (95%CI) 1.53-4.48]. However, among groups of zinc deficiency, the association with gender was not a significant statistic (AOR = 1.24; 95% CI 0.77-2.00) (Tables 2 and 3).

The underweight participants were more likely to have ZnD than normal and overweight secondary school students (AOR = 2.73; 95%CI 1.04-7.17). Other socio-demographic factors, such as age groups, ethnicity, place of school, and number of children in the household, were not significant statistics with ZnD (Table 2).

Table 2: Univariate and multivariate analyses of Zinc deficiency.

Variables		Zinc deficiency n=122 (100.0%)	OR (CI95%)	AOR (CI95%)
Ages	10	9 (4.1)	1 (reference)	1 (reference)
	11	34 (27.9)	1.77 (0.36-3.81)	1.06 (0.32-3.55)
	12	28 (23.0)	0.99 (0.30-3.24)	0.93 (0.28-3.14)
	13	36 (29.5)	1.35 (0.42-4.37)	1.26 (0.38-4.19)
	14	19 (15.6)	0.81 (0.24-2.76)	0.71 (0.20-2.46)

Sex	Boys	61 (50.0)	1 (reference)	1 (reference)
	Girls	61 (50.0)	1.20 (0.76-1.88)	1.24 (0.77-2.00)
Ethnicity	Kinh	97 (79.5)	1 (reference)	1 (reference)
	Othera	25 (20.5)	0.69 (0.40-1.18)	0.64 (0.37-1.12)
Place of school	Central part	71 (58.2)	1 (reference)	1 (reference)
	Suburban part	51 (41.8)	0.91 (0.57-1.44)	0.92 (0.57-1.48)
Number of children in the house-holds	Single child	11 (9.0)	1 (reference)	1 (reference)
	≥ 2 children	104 (85.2)	0.60 (0.25-1.44)	0.56 (0.23-1.36)
	No anwer	7 (5.7)	0.39 (0.12-1.30)	0.33 (0.10-1.15)
BMI	Underweight	12 (9.8)	2.59 (1.01-6.63)*	2.73 (1.04-7.17)*
	Normal	73 (59.8)	1 (reference)	1 (reference)
	Overweight	37 (30.3)	0.94 (0.57-1.54)	0.96 (0.57-1.63)

**p<0.05, **p≤0.01, ***p≤0.001*

[a] Others included minor ethnicities such as Tay, Nung, Thai, Muong, San Chi

Abbreviations: OR: Odds ratios; AOR: adjusted odds ratios; CI95%: 95% confidence intervals. BMI: body mass index.

Secondary students studying in the suburban part school of Thai Nguyen City were more likely to have vitamin D insufficiency than their counterparts (AOR = 1.74; 95% CI 1.03-2.95). Additionally, secondary school students who had siblings seemed to suffer from vitamin D insufficiency than the single child (AOR = 3.91; 95% CI 1.53-9.98) (Table 3).

Table 3: Univariate and multivariate analyses of Vitamin D insufficiency.

Variables		VTM D Insufficiency n=226 (100.0%)	OR (CI95%)	AOR (CI95%)
Ages	10	8 (3.5)	1 (reference)	1 (reference)
	11	61 (27.0)	1.83 (0.58-5.82)	2.05 (0.60-7.04)
	12	59 (26.1)	2.21 (0.68-7.16)	2.55 (0.73-8.85)
	13	53 (23.5)	1.28 (0.41-4.04)	1.51 (0.45-5.11)
	14	45 (19.9)	2.11 (0.63-7.02)	2.55 (0.72-9.10)
Sex	Boys	103 (45.6)	1 (reference)	1 (reference)
	Girls	123 (54.4)	2.71 (1.64-4.48)***	2.62 (1.53-4.48)***
Ethnicity	Kinh	166 (73.5)	1 (reference)	1 (reference)
	Othera	60 (26.5)	1.41 (0.79-2.50)	1.20 (0.65-2.21)
Place of school	Central part	118 (52.2)	1 (reference)	1 (reference)
	Suburban part	108 (47.8)	1.89 (1.149-3.10)*	1.74 (1.03-2.95)*
Number of children in the households	Single child	10 (4.4)	1 (reference)	1 (reference)
	≥ 2 children	202 (89.4)	3.23 (1.34-7.79)**	3.91 (1.53-9.98)**
	No anwer	14 (6.2)	1.53 (0.48-4.84)	2.39 (0.70-8.16)
BMI	Underweight	13 (5.8)	0.75 (0.28-1.96)	0.76 (0.27-2.16)
	Normal	142 (62.8)	1 (reference)	1 (reference)
	Overweight	71 (31.4)	0.84 (0.50-1.40)	0.90 (0.51-1.57)

**p<0.05, **p≤0.01, ***p≤0.001*

[a] Others included minor ethnicities such as Tay, Nung, Thai, Muong, San Chi

Abbreviations: VTM D: Vitamin D; OR: Odds ratios; AOR: adjusted odds ratios; CI95%: 95% confidence intervals. BMI: body mass index.

Discussion

The prevalence of zinc deficiency and vitamin D insufficiency among secondary students in Viet Nam was significantly higher (37.7% and 69.8%, respectively). The factor associated with ZnD in Vietnamese secondary school students was the underweight. Meanwhile, factors such as female students, the place of school in a suburban part of the city, and the number of children in the households ≥2 enhanced this population's VDI prevalence in children 10-14 years old.

Zinc deficiency prevalence in Vietnamese secondary school students was 37.7%, higher than the situation in some low- and middle-income countries, namely Mexico, India, and Filipino adolescents [19]. Nevertheless, those studies applied the cut-off point for ZnD of IZiNCG, which was <70 mcg/dL in female students and <74 mcg/dL in male students by fasting status in the morning, were much higher than our study's cut-off point. Therefore, if similar cut-off point was applied, more than 80% of Vietnamese children aged 10-14 might be suspected of ZnD. The reasons for ZnD were various; in this study, the zinc deficit may be mainly caused by inadequate essential micronutrients in the diet of the Vietnamese population, particularly in children [32,33]. This is because the traditional Vietnamese diet mainly consists of grains, sweets, vegetables, and fruits. Vietnamese diet patterns usually lack red meat and dairy, which provide abundant zinc nutrients [34]. The 10–14-year-old children who were underweight were 2.73 times more likely to suffer from ZnD. We could not find a significant correlation between ZnD and other factors such as age groups, gender, ethnicity, school place, and the number of children in the household in this study. This finding was consistent with previous research on ZnD in children [35,36].

At the cut-off point of 30 ng/ml, the proportion of participants with VDI was 69.8%, almost double the global prevalence at the same cut-off point and equivalence with the percentage of the African region. Besides the lack of micronutrients in the diet, the duration of sunlight exposure affected the vitamin D concentration [6,32]. This study was conducted in November, the winter season in northern Viet Nam, with less sunlight and low temperatures. Students wearing thick coats and avoiding going out might cause a high percentage of VDI due to reduced sunlight exposure duration. In addition, girls were 2.62 times at higher risk of VDI compared with boys. A similar association was revealed in previous studies [2]. Otherwise, secondary school students in the suburban part of the city were 1.74 times more likely to undergo VDI than those who studied in schools located in the central part of the city. Adolescents aged 10-14 in this study who had siblings may be more likely to have VDI than those who were single children 3.91 times. There was no specific explanation in this case. In fact, low- and middle-income countries faced a higher vitamin D deficiency proportion than developed countries [2,4,21]. Indeed, the financial burden of each family could be an obvious risk for vitamin D insufficiency; therefore, students 10-14 years old who lived in the surrounding areas of the city may be highly included in the low-income family. Similarly, a family with more than one child usually faces a bigger expenditure for living and sharing time for caring for each child. Those mentioned issues may indirectly increase the risk of VDI among secondary school students.

Conclusion

In this study, the proportion of zinc deficiency among secondary school students aged 10-14 years in Viet Nam was 37.7%. Among them, the percentage of vitamin D insufficiency was 69.8%, significantly higher than the global estimation's prevalence. The factor associated with ZnD in Vietnamese secondary school students was the underweight children. Meanwhile, female students, the place of school in a suburban part of the city, and the number of children in the households ≥2 children increased the risk of vitamin D insufficiency.

Acknowledgment

None.

Conflict of Interest

The authors declare no conflict of interest.

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Citation: Tran Thi Hong Van, Le Thi Huong Lan, Pham Thanh Hai and Nguyen Thi Thanh Tam*. The Alarming of Zinc Deficiency and Vitamin D Insufficiency and The Associated Factors Among Vietnamese Adolescents 10-14 Years Old. Anaest & Sur Open Access J. 5(3): 2024. ASOAJ.MS.ID.000614. **DOI:** 10.33552/ASOAJ.2024.05.000614.