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Original Research Article

Prevalence and Risk Factors of Vitamin D Deficiency in Rural Population

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Abstract: ***Introduction*:** Vitamin D is crucial for bone growth, mineralization, and various metabolic processes in the body. Consequently, a deficiency or insufficiency of this vitamin can lead to long-term consequences, especially in children. ***Aim of the Study*:** The aim of this study was to identify the prevalence and risk factors associated with vitamin D deficiency in rural children. ***Methods*:** This was an observational study and was conducted in the Department of Pediatric in Santhia Upazila Health Complex, Pabna, Bangladesh during the period from January 2022 to July 2022. In total 100 children presenting with symptoms of vitamin D deficiency who visited the pediatrics department at our institution. Statistical analysis was done by using SPSS (Statistical Package for Social Science) Version 23 for windows 10. ***Result*:** Participants were categorized into four age groups: infants (up to 1 year), children (2–5 years), prepubertal (6–11 years), and adolescents (12–16 years), with a mean age of 12.84 ± 3.98 years. Most children (60%) were female, and 70% had less than 30 minutes of daily sun exposure. Vitamin D deficiency (<10 ng/ml) was most prevalent in children aged 12-16 years (61.76%), followed by 2-5 years (60%) and 6-11 years (47.62%). Deficiency was also observed in 50% of infants up to 1 year old. Children with insufficient vitamin D (10-29 ng/ml) had intermediate height (124.81 cm) and weight (26.12 kg), while those with deficiency had the lowest height (104.62 cm) and weight (22.57 kg). ***Conclusion*:** This study shows that vitamin D deficiency is high among our study children. A comprehensive action plan, including supplementation and food fortification, is crucial to prevent this deficiency in Bangladesh.

Keywords: Prevalence, Risk factors, Vitamin D, Deficiency, Children.

INTRODUCTION

Vitamin D deficiency (VDD) is among the most widespread micronutrient deficiencies affecting both children and adults globally [1]. It has resurfaced as a significant public health concern in both developing and developed regions, including North America, Europe, and the UK—areas where it was previously believed to be under control [2-4]. The global prevalence of VDD in children is estimated to be between 30% and 50%, while in tropical countries like India, it affects 70% to nearly 100% of individuals across all age groups [5, 6]. Vitamin D deficiency has reached epidemic proportions, yet it remains one of the most underdiagnosed and undertreated nutritional deficiencies worldwide. It affects people across all age groups, genders, races, and geographical locations. Surprisingly, even in sun-rich tropical countries like Bangladesh, where sunlight is abundant, vitamin D deficiency is widespread. Today, it is recognized as a silent and often overlooked global public health concern, with nearly one billion individuals worldwide suffering from vitamin D deficiency or insufficiency [7]. Often referred to as "the sunshine vitamin," vitamin D is primarily obtained through sun exposure. When the skin is exposed to ultraviolet (UV) radiation, it synthesizes vitamin D3 through the photoisomerization of 7-dehydrocholesterol (7DHC), leading to the formation of pre-vitamin D3 [8]. A common misconception is that vitamin D deficiency is limited to Western countries with less sunlight. However, this belief is inaccurate. While it is generally assumed that people in tropical regions are less prone to hypovitaminosis D due to higher sun exposure, studies show otherwise. In South Asia, approximately 80% of the seemingly healthy population has vitamin D levels below 20 ng/mL, and up to 40% are severely deficient with levels below 10 ng/mL [9].

Vitamin D deficiency is a leading cause of rickets in children. This condition is particularly prevalent in certain regions, such as Northern China, where studies have shown that 42% of infants suffer

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from rickets, primarily due to vitamin D deficiency during the winter and spring months [10]. Despite being a major public health issue, vitamin D deficiency often goes unnoticed and untreated, affecting nearly one billion people globally [7].

In Northern Pakistan, rickets remains a common condition among infants and children, even though sunlight is plentiful. Factors such as malnutrition, lack of public awareness, and inadequate maternal care during pregnancy contribute significantly to this problem [11]. In South Asia, the high prevalence of vitamin D deficiency can also be attributed to darker skin pigmentation, which reduces the skin's ability to synthesize vitamin D, and to traditional clothing styles that limit sun exposure [12]. The vitamin D receptor (VDR) is widely distributed throughout the body, including in osteoblasts, the small intestine, colon, activated T and B lymphocytes, islet cells, mononuclear cells, and various other organs such as the brain, heart, skin, gonads, prostate, and breast [13]. In recent years, extensive research has explored the role of vitamin D beyond bone health, highlighting its impact on extra-skeletal systems [14-20]. Hypovitaminosis D has been linked to a range of conditions, including diabetes mellitus [15], various cancers [16], autoimmune disorders [17], infectious diseases [18], multiple sclerosis [19], and cardiovascular diseases [20]. Despite extensive research, there is no universally established threshold for the optimal blood levels of 25-hydroxyvitamin D. However, most experts consider a serum 25-hydroxyvitamin D level below 50 nmol/L (or 20 ng/ml) to indicate vitamin D deficiency [21]. The ideal level for maintaining overall health in children remains uncertain due to limited outcome data. A relative deficiency in children is generally defined as a 25-hydroxyvitamin D level between 50 and 75 nmol/L [22]. In this study, aimed to determine the prevalence and identify the risk factors associated with vitamin D deficiency among rural children in Bangladesh aged 1 to 16 years.

OBJECTIVES

The main objective was to identify the prevalence and risk factors associated with vitamin D deficiency in rural children.

METHODOLOGY & MATERIALS

This was an observational study and was conducted in the Department of Pediatric in Santhia Upazila Health Complex, Pabna, Bangladesh during the period from January 2022 to July 2022. In our study, we included 100 children presenting with symptoms of vitamin D deficiency who visited the pediatrics department at our institution.

Inclusion Criteria:

a) Children ages ranged from 1 to 16 years
b) Children with leg pain
c) Children with growth retardation
d) Children with muscle and bone pain.

Exclusion Criteria:

a) Participants who were suffering from chronic disease
b) Already on vitamin D supplementation.
c) Children having any endocrine disorder
d) Parents who were unwilling to participate were excluded from our study.

The privacy and anonymity of all participants were strictly preserved throughout the study. Participants were categorized into four age groups: infants (up to 1 year), children (2–5 years), prepubertal (6–11 years), and adolescents (12–16 years). Participant weights were measured using digital scales, while heights were recorded using a wall-mounted stadiometer. The most reliable marker for assessing overall vitamin D status is the measurement of circulating 25-hydroxyvitamin D [25(OH)D] levels. Several established methods are available for measuring serum 25(OH)D, with the direct enzyme-linked immunosorbent assay (ELISA) technique being the most commonly used in Bangladesh. This was the method we used in our study. We categorized vitamin D status as follows: sufficient (30–100 ng/ml), insufficient (10–29 ng/ml), and deficient (less than 10 ng/ml). A standardized semi-structured data collection sheet was used to collect necessary information and face to face interview. The data collected on a standardized sheet for each patient included: age, sex, mother's education, and presenting symptoms, sunlight, skin color. A semi structured questionnaire was developed in English. The questionnaire was developed using the selected variables according to the specific objectives. A checklist was also developed to record desired variables from admission record, history sheet and related medical records. Data were checked immediately after completing interview and review of necessary investigation reports. All relevant data were collected from each respondent by use of an interview schedule, measured parameters, and investigations in a predesigned format. Patients who were fulfilled the inclusion criteria and willing to enroll in the study were included in the study after receiving the informed written consent.

Statistical Analysis:

All data were recorded systematically in preformed data collection form and quantitative data was expressed as mean and standard deviation and qualitative data was expressed as frequency distribution and percentage. Statistical analysis was carried out by using Statistical analysis was done by using SPSS (Statistical Package for Social Science) Version 23 for windows 10. P value <0.05 was considered as statistically significant. Confidentially was strictly maintained.

RESULT

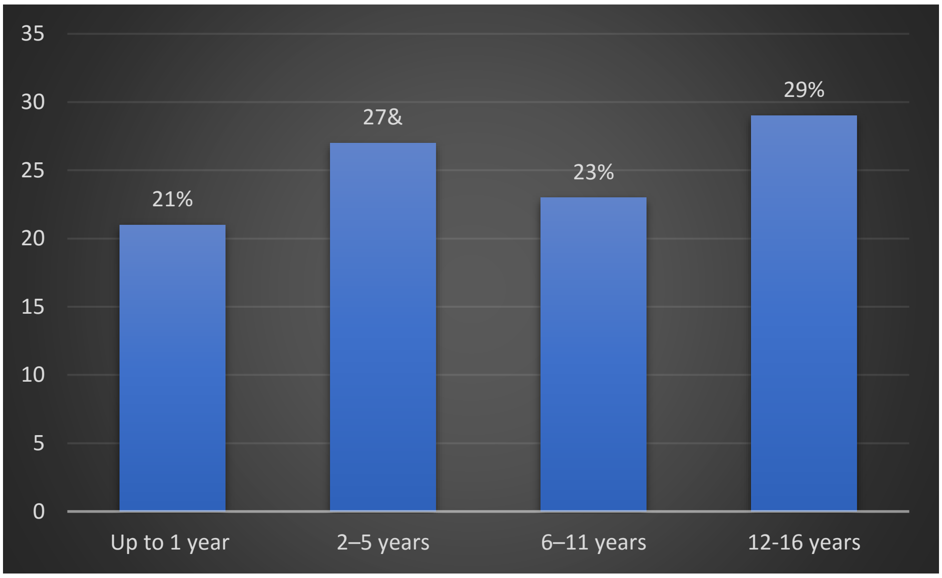

Figure 1: Age distribution of our study subjects (N=100)

Figure 1 showed that majority (29%) of our patients were aged 12-16 years old, followed by 27% aged 2-5 years old, 23% aged 6-11 years old and 21% up to 1 year old respectively. The mean age was 12.84 ± 3.98 years.

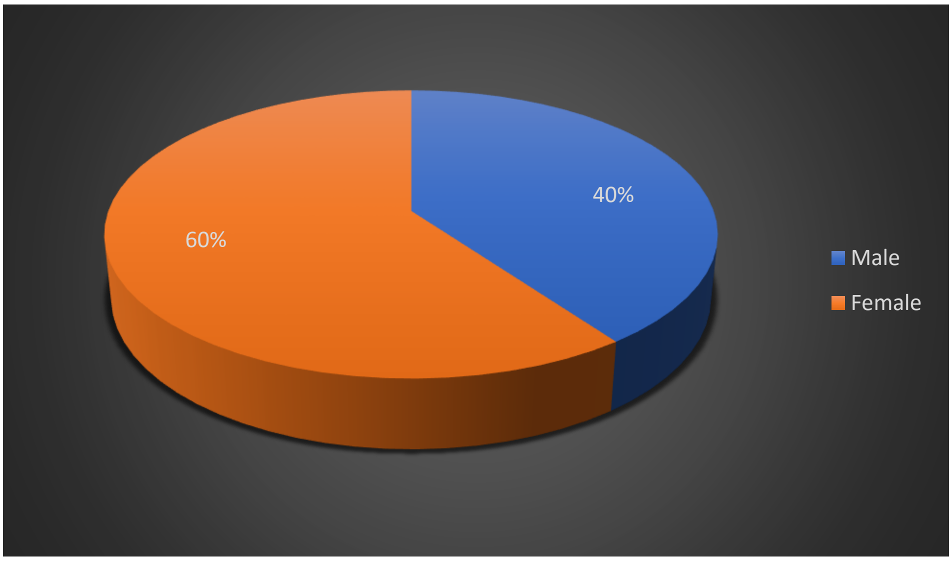

Figure 2: Gender distribution of our study subjects (N=100)

Figure 2 showed that majority (60%) of our patients were female and 40% of patients were male.

Table 1: Baseline characteristics of the study population

Characteristics	Frequency	Percentage (%)
Mean age (years)	12.84 ± 3.98	
Height (cm)	110.85 ± 52.86	
Weight (kg)	28.14 ± 19.31	
BMI	21.9 ± 7.27	
Maternal education status		
Illiterate	22	22
SSC	26	26
HSC	34	34
Graduation or above	18	18

Characteristics	**Frequency**	**Percentage (%)**
Exposure to sunlight (n-150)		
<30 min/day	70	70
>30 min/day	30	30
Skin color		
Dark	65	65
Fair	35	35
Symptoms		
Muscle pain/bone pain	42	42
Leg pain	10	10
Tingly sensation in hands or feet	60	60
Growth retardation	48	48

In table 1 we showed the baseline characteristics of the respondents. The study population had a mean age of 12.84 years, with an average BMI of 21.9. Most children (70%) had less than 30 minutes of daily sun exposure, and 65% had dark skin. Common symptoms included tingling sensations (60%), growth retardation (48%), and muscle or bone pain (42%). Maternal education varied, with 22% illiterate and only 18% having a graduate degree.

Table 2: Risk Factors of subjects according to age and serum 25-hydroxyvitamin D levels

Variables		**<10 ng/ml**		**10 - 29 ng/ml**		**30 - 100 ng/ml**	
		Frequency	**Percentage (%)**	**Frequency**	**Percentage (%)**	**Frequency**	**Percentage (%)**
Age	Up to 1 year (n=20)	10	50	6	30	4	20
	2–5 years (n=25)	15	60	8	32	2	8
	6–11 years (n=21)	10	47.62	8	38.10	3	14.29
	12–16 years (n=34)	21	61.76	8	23.53	5	14.71
Sun exposure	<30 min/day (n=62)	32	51.61	20	32.26	10	16.13
	>30 min/day 9n=38)	18	47.37	12	31.58	8	21.05

Table 2 highlights the distribution of serum 25-hydroxyvitamin D levels across different age groups and sun exposure durations. Vitamin D deficiency (<10 ng/ml) was most prevalent in the 12–16 years age group (61.76%), followed closely by the 2–5 years group (60%), and the 6–11 years group (47.62%). Even infants up to 1 year old showed a 50% deficiency rate. In terms of sun exposure, 51.61% of children with less than 30 minutes of daily exposure had vitamin D levels below 10 ng/ml, compared to 47.37% among those with over 30 minutes of exposure. Insufficient levels (10–29 ng/ml) were also commonly observed in all age groups, particularly among those aged 6–11 years (38.10%) and 2–5 years (32%). Sufficient vitamin D levels (30–100 ng/ml) were relatively rare across all groups, found in only 14.29–21.05% of subjects depending on age and sun exposure.

Table 3: Anthropometric Measurements of Study Participants Categorized by Serum 25-Hydroxyvitamin D Levels

Variables	**<10 ng/ml**	**10 - 29 ng/ml**	**30 - 100 ng/ml**
Height (cm)	104.62 ± 50.28	124.81 ± 54.62	123.85 ± 53.84
Weight (kg)	22.57 ± 17.34	26.12 ± 16.25	29.74 ± 20.36

Table 3 shows anthropometric measurements by vitamin D levels in children with serum 25-hydroxyvitamin D levels <10 ng/ml had the lowest average height (104.62 cm) and weight (22.57 kg), while those with sufficient vitamin D levels (30–100 ng/ml) had higher average height (123.85 cm) and weight (29.74 kg). Participants with insufficient levels (10–29 ng/ml) also showed intermediate values for both height (124.81 cm) and weight (26.12 kg).

DISCUSSION

In this study, we found that approximately 56% of the evaluated children had vitamin D deficiency, defined by serum 25-hydroxyvitamin D levels below 10 ng/ml. These findings highlight a significant inadequacy in vitamin D status among Bangladeshi children, potentially exposing them to the adverse health effects associated with vitamin D deficiency. Our results indicate that serum 25-hydroxyvitamin D levels in the pediatric population decrease with age, leading to a higher prevalence of vitamin D deficiency as children grow older. Similar findings have been observed in other studies, where it is documented that Bangladeshi infants begin life with low vitamin D levels due to insufficient maternal antenatal 25(OH)D among both urban and rural Bangladeshi women of reproductive age [23]. In India, a study found that 51% of three-month-old breastfed infants had 25(OH)D levels below 37.5 nmol/L, with a mean of 49 nmol/L [24]. In Pakistan, 38 breastfed infants aged six months had a mean 25(OH)D level of 25 nmol/L, and 71% of infants under three months had levels below 40 nmol/L [25]. A Middle Eastern study reported that 82% of 1–4-month-old breastfed infants, born to women with low milk intake and a habit of full-body covering when outdoors, had 25(OH)D levels below 25 nmol/L, with a median level of 11.5 nmol/L [26]. In studies conducted in countries such as Saudi Arabia, the United Arab Emirates, Australia, Turkey, India, and Lebanon, 30 to 50% of both children and adults were found to have 25-hydroxyvitamin D levels below 20 ng per milliliter [27, 28-30].

In the United States, the prevalence of vitamin D insufficiency was found to be higher among children aged 6–11 years (73%) compared to those aged 1–5 years (63%), and higher in girls (71%) compared to boys (67%), with non-Hispanic black (92%) and Hispanic (80%) children having higher insufficiency rates than non-Hispanic white children (59%) [31]. A study in Boston [32] showed that 52% of Hispanic and black adolescents and a study in Maine [33] found that 48% of white preadolescent girls had 25-hydroxyvitamin D levels below 20 ng per milliliter. Comparatively, our study reveals a much higher prevalence of vitamin D deficiency in Bangladeshi rural children than in American children and adolescents. In light of these findings, the American Academy of Pediatrics' recommendation in November 2008 for all children to receive 400 IU/day of vitamin D from birth through adolescence should be implemented in Bangladesh as well [34]. Given the severe deficiency observed in Bangladeshi children compared to American children and other ethnic groups, we strongly advocate for the inclusion of vitamin D supplementation in the national health policy.

The high and alarming prevalence of vitamin D deficiency and insufficiency among Bangladeshi children calls for further research, particularly using nationally representative samples. Since vitamin D is crucial for children's growth and development, the country should develop a comprehensive action plan to prevent deficiency. We recommend that vitamin D supplementation be introduced for all Bangladeshi children, from birth to adolescence, and be implemented promptly at the government level. In addition, awareness campaigns on the importance of vitamin D should be expanded. Food fortification programs—such as fortifying milk, oil, yogurt, and cereals—should be developed, along with strict quality control to ensure effective fortification and prevent deficiency.

Undiagnosed vitamin D deficiency remains common, and 25-hydroxyvitamin D is the best indicator of vitamin D status [35]. Beyond its role in bone health, serum 25-hydroxyvitamin D is also an independent predictor of cancer and other chronic diseases. There is growing evidence that current recommended intake levels are insufficient and should be increased. Since dietary sources alone, particularly oily fish, may not provide adequate vitamin D3, sensible sun exposure and supplementation are essential to meet the body's requirements while minimizing the risks of skin cancer from excessive sunlight exposure

Limitations of the study

This study was conducted at a single center, which may limit the generalizability of the findings to the broader pediatric population of Bangladesh. Additionally, the relatively small sample size may impact the external validity of the results. Furthermore, the study did not account for other important factors influencing vitamin D status, such as the intake of supplements, lifestyle habits, and dietary factors. These variables could provide a more comprehensive understanding of the factors contributing to vitamin D deficiency in the population.

CONCLUSION

The prevalence of vitamin D deficiency among children in Bangladesh, with a decline in serum 25-hydroxyvitamin D levels as children grow older. The findings emphasize the urgent need for vitamin D supplementation and public health interventions to address this deficiency, particularly since vitamin D plays a crucial role in bone health and overall growth and development. Given the high prevalence of deficiency in Bangladeshi children compared to international data, we recommend the implementation of a nationwide vitamin D supplementation program from birth through adolescence. Additionally, expanding public awareness campaigns and fortifying commonly consumed foods such as milk, oil, and cereals could contribute to improving the vitamin D status in this population. Further research using nationally representative samples is required to better understand the full extent of vitamin D deficiency and its potential long-term health consequences in Bangladesh.

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