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Vitamin-D status among adolescent attending in the Out Patient Department of Selected Tertiary Hospitals in Bangladesh

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ABSTRACT

Background:

Lack of vitamin D is a global issue that has been linked to a number of health problems. In Bangladesh, it is quite prevalent in all age categories, but it is particularly prevalent in children and adolescents of both sexes. Since vitamin D is produced by cutaneous synthesis when exposed to plenty of sunlight, the incidence of vitamin D insufficiency in Bangladesh is often disregarded. The objective of the current study was to assess the vitamin D status of adolescents attending in the outpatient department (OPD) of selected tertiary hospitals in Bangladesh, as well as the relationship between vitamin D status and dietary habits and sociodemographic traits.

Key words: Adolescents, Vitamin D, Serum 25(OH) D, Socio-demographics, Dietary habits, Bangladesh.

I. INTRODUCTION

"The Sunshine Vitamin" is the moniker given to vitamin D. For most humans, exposure to solar radiation is the primary source of vitamin D. When exposed to ultraviolet (UV) radiation, the process of photo isomerization of 7-dehydrocholesterol (7DHC) in human skin produces pre-vitamin D3 [1]. Consuming 20,000 IU of vitamin D is equivalent to getting the amount of sunlight exposure necessary it cause a mild pinkish tint on the skin after 24 hours (1MED) [2]. One of the most common micronutrient deficits in children and adults globally is vitamin D insufficiency (VDD) [3].

Seldom found foods that naturally contain vitamin D include milk, cereal, orange juice, yoghurt, margarine, shitake mushrooms, tuna, salmon, sardines, tuna, and hardboiled eggs. However, those don't meet adults' and children's needs for vitamin D [3]. In children, vitamin D deficiency can lead to rickets, but this is just the tip of the vitamin D deficiency iceberg. In addition to osteoblasts, the small intestine, colon, activated T and B lymphocytes, B islet cells, mononuclear cells, and the majority of human organs, including the brain, heart, skin, gonads, prostate, and breast, vitamin D receptors are present in these tissues [4].

Bangladesh, a small nation in South Asia with a total size of 147,570 km2, is home to 163 million people, making it the eighth most densely populated nation worldwide. It is situated in an area with a tropical to subtropical climate that has enough UV radiation (290–315 nm) and spans latitudes 200°43´ to 260°36´N and longitudes 880°3´ to 920°40´E. It was therefore long believed that Bangladeshis have sufficient amounts of vitamin D. Nevertheless, despite Bangladesh's abundance of sunshine, a few previous studies consistently shown that vitamin D insufficiency are a quiet epidemic [5].

Just twenty years ago, there was a dearth of research on vitamin D insufficiency in various population groups in Bangladesh. The last several years have seen a rise in interest in vitamin D deficiency and insufficiency as a possible public health concern and a significant field of study. Numerous factors, including as age, the amount of time spent in the sun, the area of skin exposed, the time of day, latitude, atmospheric pollution, season, clothing, melanin pigmentation, use of sunscreen, use of supplements, food, and heredity, are associated with low levels of vitamin D [6].

A global issue, vitamin D insufficiency is linked to a number of negative health effects. All age groups in Bangladesh are affected by vitamin D deficiency, although adolescents and children of both sexes are more likely to be susceptible from it. One billion individuals worldwide are estimated to be vitamin D deficient [7].

A hidden and often ignored global public health concern these days is vitamin D insufficiency. Worldwide, over one billion individuals experience insufficiency or deficit in vitamin D [6]. It's a common misconception that vitamin D deficiency only affects people in western countries, but the reality is far different. Previous hypotheses proposed that hypovitaminosis D is less common in tropical countries because sun exposure increases the synthesis of vitamin D on the skin. Surprisingly, nevertheless, 80% of the population who appears healthy is deficient in vitamin D (<20 ng/mL), whereas up to 40% of people in South Asia suffer from severe deficiency (<10 ng/mL) [8].

Many variables have been linked to vitamin D insufficiency, including an indoor lifestyle, inadequate solar exposure, air pollution, skin tone, the mother's educational background, and the mother and child's clothing choices. Lack of vitamin D is another effect of exclusively breastfeeding an infant [9] [10] [11].

II. LETERATURE REVIEW

SOURCES OF VITAMIN D

The skin's endogenous production of vitamin D3, which accounts for around 90% of blood 25 (OH) D concentrations, is a major source of vitamin D [12]. Two more substantial means of getting vitamin D are supplements and foods that have been fortified. There are quite a number of naturally occurring foods that contain vitamin D. fatty fish, such as salmon, sardines, and tuna [12], as well as fresh or sun-dried shiitake mushrooms, are examples of natural sources [6]. Foods such as milk, orange juice, yoghurts, cheeses, butter, margarine, infant formulae, and breakfast cereals are examples of fortified foods [6].

VARIABLES THAT AFFECT THE STATUS OF VITAMIN D

A lack of vitamin D is connected to various factors, including age, length of sun exposure, exposed skin area, time of day, latitude, geographic location, air pollution, season, gender, race, clothing, melanin pigmentation, use of sunscreen, use of supplements, dietary habits, genetic factors, outdoor activities lifestyle, and obesity, and so forth [6]. The following section discusses some causes of a lack of vitamin D: people who spend long periods of time indoors or who wear clothes that covers a lot of skin are more probable to be vitamin D deficient due to a lack of sun exposure, vegetarians are more vulnerable to vitamin D deficiency shortage since animal products including fish, egg yolks, and fish oil are key sources of Vitamin D, those with darker skin tones and higher melanin levels have a decreased capacity to produce previtamin D3. Melanin inhibits the photolysis of provitamin D3 to generate previtamin D3, competing with it, much as sunlight exposure does, given that fat cells may easily absorb vitamin D from the bloodstream since it is fat- soluble, obesity is another important factor contributing to vitamin D insufficiency and etc. many more [13].

DIETARY PATTERNS

Fat-soluble vitamin D is created in the skin by ultraviolet B (UVB) light exposure and is present in diet. Technically speaking, vitamin D is a class of secosteroids with paracrine and endocrine properties rather than a true vitamin. Whenever exposed to ultraviolet B (UVB) radiation from solar (wavelength: 280 to 315 nm), pre-vitamin D3, which is produced by photo converting 7-dehydrocholesterol to vitamin D3, isomerizes to become vitamin D3. The main environmental elements that affect the body's ability to synthesise vitamin D are latitude, season, time of day, ozone and clouds, surface reflectivity, and personal factors like skin type, age, clothes, and use of sunscreen creams. The FAO/WHO expert panel reports that there is an abundance of sunshine in most places in the world that are located between latitudes 420N and 420S. This is the process by which the skin naturally produces vitamin D from 7-dehydrocholesterol found in subcutaneous fat.

There are several ways in which vitamin D is not like other vitamins. The biggest difference is that vitamin D in circulation does not originate primarily from food consumption. The truth is that vitamin D is found in very few foods, including egg yolks, sun-dried mushrooms, and oily salmon. Fortified foods and beverages, such as cereals, milk, fruit drinks, and breads contain trace amounts of vitamin D. Because of this, most individuals only get very little natural vitamin D from their diet and need to spend time in the sun in order to maintain adequate blood levels.

Dietary pattern analysis is an alternate strategy that gets around these drawbacks and is gaining popularity. This method looks at how food and nutrients are combined, based on eating habits, to uncover dietary patterns [14]. As dietary patterns are not directly measurable,

A multivariate statistical technique called factor or principal component analysis uses data gathered from food frequency questionnaires (FFQs) or dietary notebooks. It finds commonalities (or patterns) in food intake and offers scores that let people rank each other according to how closely they match the overall pattern [14].

METHODS FOR DETERMINATION OF VITAMIN D STATUS

Numerous researches have revealed that it's possible that vitamin D deficiency is more prevalent than it was and has grown to be an issue for public health globally. The increasing prevalence of vitamin D deficiency thus creates a growing requirement towards 25(OH)D detection. The growing need for the 25(OH)D test has compelled clinical laboratories to extend precise techniques that are suitable for everyday readings.

25(OH)D is the sole metabolite of vitamin D that may be used to measure a patient's vitamin D status. 25(OH)D, which has a half-life of about two to three weeks, is the main form of vitamin D in circulation.

Currently, an assortment of techniques based on distinct measurement principles are used for the primary 25(OH) D detection methods.

Radioimmunoassay (RIA), enzyme-linked immunosorbent assay, high-performance liquid chromatography (HPLC), liquid chromatography coupled with mass spectrometry (LC-MS), and automated assay employing chemiluminescence immunoassay (CLIA) are a few of the frequently used alternative assays [15].

RECOMMENDATIONS AND THE STATUS OF VITAMIN D

The optimal level of vitamin D status is not yet widely defined [16]. In the past, the Institute of Medicine (IOM) and the American Academy of Paediatrics both declared that newborns and young children with a blood 25(OH)D concentration of less than 11 ng/mL (≤27.5 nmol/L) indicated vitamin D deficiency [17]. The consensus states that the thresholds for vitamin D deficiency and insufficiency are ≤20 ng/mL (≤50 nmol/L), vitamin D sufficiency is >30 ng/mL (>75 nmol/L), and insufficiency is ≤30 ng/mL (≤75 nmol/L) [6] [18] [19] [20]. Based to the IOM's most recent definition, vitamin D deficiency was defined as ≤12 ng/mL (≤30 nmol/L) and sufficiency as >20 ng/mL (>50 nmol/L) [16]. For children and adolescents, the Recommended Daily Allowance (RDA) and Estimated Average Requirement (EAR) for vitamin D are 400 IU/d and 600 IU/d, respectively [16]. The committee of IOM further declared when values above 50 ng/mL (125 nmol/L) may be reason for worry and because there isn't any reliable proof to link higher advantage when blood 25(OH) D levels are more than 30 ng/mL (>75 nmol/L) [16]. Then, in July 2011, the Endocrine Society published guidelines stating that in order to elevate blood 25(OH) D levels over 30 ng/mL; infants under the age of one should get at least 600 IU and maybe up to 1000 IU/d of vitamin D [21].

III. RATIONALE OF THE STUDY

Numerous investigations have assessed how often it is to be inadequate in or lacking in vitamin D adolescents, revealing a significant worldwide frequency of vitamin D insufficiency [22] [23]. As this was true even in nations where sunlight is plentiful, which is essential for the creation of endogenous vitamin D. For instance, studies on vitamin D deficiency's frequency in adolescents indicated that it had been 85%–98% in India [24] [25] and approximately 96% in Saudi Arabia [26]. Data on vitamin D levels in paediatric and adolescent populations are scarce in Arab states in the Gulf or the larger Middle East. Significant methodological flaws plagued the few research that reported a high occurrence of vitamin D insufficiency in teenagers [26] [27] [28].

It's anticipated that Bangladesh is susceptible to rickets and other health effects connected to a deficit of vitamin D according to all these reports from other Asian countries.

Other research indicates that between 30% and 50% of children in Australia, Turkey, India, and Lebanon may be vitamin D insufficient [29] [30] [31].

The availability of vitamin D deficiency in Bangladesh was often disregarded because as it was thought to pose little danger because of the capacity of the skin to produce vitamin D when exposed as to plenty that of sunlight. A recent study discovered that, similar to other places, children in Bangladesh possessed a significant frequency of inadequate vitamin D (80.0%) [32].

Published evidence, however, pertaining to the evaluation of vitamin D levels among adolescents within Bangladesh is still scarce. The current investigation aimed as to evaluate the vitamin D status among adolescent attending into the outpatient department (OPD) of selected tertiary hospitals in Bangladesh as well as evaluate its association with socio- demographic characteristics and dietary habits.

IV. STUDY OBJECTIVES

General Objective

To ascertain the vitamin-D status level among adolescent attending into the outpatient department of selected tertiary hospitals in Bangladesh.

Specific Objectives

a. To identify the sociodemographic traits of adolescents

b. To assess the levels of serum vitamin D among adolescents who attended an OPD of selected tertiary hospitals

c. To know the dietary history of the adolescents using FFQ (Food Frequency Questionnaire)

d. To investigate the frequency of vitamin D deficiency in among adolescents who attended an OPD of selected tertiary hospitals

V. METHODOLOGY

Design, Settings and Population of study

An investigation that was cross-sectional conducted for this research. The study has been carried out at two selected tertiary hospitals, and data were collected from the outpatient department of two selected Hospitals. The selected study population was adolescents (10–19 years of age) who attended hospitals with minor symptoms in the outpatient department.

Sample size

The sample's composition was established using following n=z2pq/d2 is the formula.

Where,

n=the preferred sample size.

z=Standard normal distribution value as specified by the significance (confidence) level; typically, 1.96 at the 95% Confidence Interval

p= Prevalence value (50%) [Using Cochran's method (Equation 1), the necessary sample size was determined to be 305, taking into account Bangladesh's 28% point prevalence of stunting among children under five.]

q = 1-p = 1-0.5 = 0.5

d = Study's acceptable error of 5% (0.05)

Hence desired sample size,

n is equal to {(1.96)2 x (0.5) x (0.5)} / (0.05)2 = 384.6.

So desired sample size was 384.

Sampling technique

A convenience sampling technique was employed to select participants from adolescents who came to attend the hospital in the study area.

Criteria for Inclusion and Exclusion

In this study, the adolescent (10–19 years) who came to the outpatient department of two selected hospitals with minor symptoms and those whose levels of vitamin D in their blood were examined were included where as those who were critically ill, having a long-term illness or who were taken Vitamin D supplementation and as well as those participants, parents, careers, or attendees who failed to respond to or finish the FFQ were not included in this study.

Development of study questionnaire

1 Development of socio-demographic questionnaire

Participants responded to a validated vitamin D questionnaire, which included socio-demographic questionnaire and Food Frequency Questionnaires (FFQ). Demographic questions included (15 items) age, sex, height, weight, living area, religion, mother and father's educational backgrounds, their occupations, and the total earnings of the family, etc. Many more questions were also structured as closed-ended questions. For example, selection options were given for reason behind attending hospitals, educational status, occupation status, etc.

2 Development of Food Frequency Questionnaire (FFQ)

The frequencies of consuming foods that were naturally or enriched with vitamin D were taken into account within the FFQ to assess the dietary patterns of adolescent. A questionnaire has been developed, examined, and approved. The food frequency questionnaire included a total of 71 food items, which contained both general food items and vitamin D-rich food items. Foods were grouped similarly to those used in previous studies and classified based on the vitamin D nutritional content or culinary application. Further 39 food items were focused on as they were rich sources of vitamin D. The food items were separated under 10 different food groups like was the cereal group, pulses group, meat group, fish group, egg group, milk and milk products group, oil group, nuts group, fruits and vegetables group, and miscellaneous group, following accordingly the Food Composition Table for Bangladesh. But in **Table 1** only vitamin D rich 8 food group are shown.

Participants were questioned about how often they ingested meals, and they responded per day, week, month, or never. The response for consumption pattern was as follows: never, once a month, twice a month, once a week, 2-4 times a week, 5–6 times a week, once a day, 2-3 times a day, 4-5 times a day, and 6+ times a day. Further, it was categorized as four labels for consumption frequency (**Table 2**). Major dietary patterns were identified based on how frequently each participant consumed each of these 10 food groups.

Table 1. List of Vitamin D rich food item

Food Group	**Food item**	
Meat	Beef	
Fatty Fish	Hilsa Pangash Catla Puti Mola Mrigal Rohu Salmon	Tuna Nile tilapia Prawn Rupchada Koi mach Gura mach (Sagor Ponna)
Egg	Chicken egg with yolk Duck egg with yolk Koel egg with yolk	
Dairy	Milk (cows) Yoghurt Cheese Butter Pasteurized/UHT milk Dairy desert (custard, pudding, Firni/Payesh)	

	Ice cream Milk shake	
Fortified oil	Teer Fortified (Vit D) Soyabean Oil Bashundhara Fortified (Vit D) Soyabean Oil Cod liver oil	
Nuts	Almonds Cashews	
Fruits and vegetables	Dates Raisins Fortified Orange Juice Ripe Banana	Spinach Brocoli Mushroom
Miscellaneous	Horlicks	

Table 2. Consumption frequency

Frequent consumption	Daily (at least one time)/ 5-6 times per week
Occasionally	2-4 times a week or once every week
Rarely	Once a month or up to three times per month
Never	Never eaten

Data collection tools

Well-structured paper versions of the questionnaire were used for data collection and were filled out by the self, participants, mother, career, or attendee who was attending with adolescent. The questionnaire covered both socio-demographic characteristics and dietary habits (including vitamin D sources) by FFQ. Participants were interviewed in the out-patient departments (OPDs) of two selected tertiary hospital to gather information on the socio-demographic characteristics and dietary patterns of adolescent. Data collection consisted of direct interviews and collecting vitamin D blood sample reports from the selected hospitals for later vitamin D level measurements. Strict protocols were put in place to protect participant anonymity and data confidentiality during the research process, and written agreement was also acquired from all participants, parents, careers, or attendees.

Assessment of vitamin D status: The most dependable and trustworthy method is measuring circulation levels of 25-hydroxyvitamin D [25(OH) D]. There are numerous techniques used to measure it in Bangladesh, including high-performance liquid chromatography (HPLC), chemiluminescent immunological assay, enzyme-linked immunosorbent assay (ELFA), and others.

From the lab records, a serum 25(OH) D report was obtained. Participants in the sample collection rooms of the hospitals were venipunctured in accordance with normal techniques to obtain blood samples. Here, the sample report was taken from two different laboratories in different hospitals and analysed using the automated chemiluminescence microparticle immuneassay (CMIA) method.

So, there are several ways to define or classify either sufficient or insufficient for circulation 25 (OH) D. Vitamin D sufficiency was classified by the IOM as >20 ng/mL (>50 nmol/L) and vitamin D deficiency as ≤12 ng/mL (≤30 nmol/L) **(Table 3)** [16]. In this investigation, it served as the cutoff value for circulating 25(OH) D. The recommended daily allowance and estimated average requirement for vitamin D in children and adolescents, respectively, are 600 IU/d and 400 IU/d, according to these guidelines [16].

Table 3.

Segmenting Vitamin D Status Based on Blood 25-Hydroxyvitamin D		
ng/mL	**nmol/L**	**Classification**
Less than 12 ng/mL	Less than 30 nmol/L	Deficient
More than 20 ng/mL	More than 50 nmol/L	Sufficient

Statistical Analysis

The IBM SPSS (version 25) was primarily used for data analysis. Different descriptive and inferential statistics were used based on data distribution. Chi-square statistics were reported for categorical variables. This non-parametric test was chosen to find out the association of different socio-demographic characteristics and dietary pattern with vitamin D status. Multinomial logistic regression model was fitted to explore the association of various socio demographic factors and dietary habits with vitamin D status. Level of vitamin D was dependent variable categorized as: deficient, insufficient, and normal status. Socio-demographic factors and dietary habits were independent variables.

VI. RESULTS

The following is an analysis of the study's findings:

Table 4 shows that among 384 respondents, there were 58.3% of those in the 10–14 year age group and 41.7% of those in the 15–19 year age group, as well as females at 64.1% and males at 35.9%. 89.6% were Muslims, 9.1% were Hindus, and 1.3% was Christians by religion. According to the living area, 77.6% belongs to the non-slum area, and 22.4% belongs to the slum area. By mother education level, 51.3% (n = 197) were graduated or post-graduated, 21.9% (n = 84) were HSC passed, 17.7% (n = 68) were primary pass/below, and 9.1% (n = 35) were SSC passed/below. According to father educational level, 74.6% (n = 286) were graduated or post-graduated, 12.0% (n = 46) were SSC passed or below, 9.4% (n = 36) were primary pass/below, and 4.2% (n = 16) were HSC passed. By occupation of mother, 34.6% (n = 133) were housewives, 33.6% (n = 129) were service holders, 16.9% (n = 65) were self-employed, and 14.8% (n = 57) had a low-paid job like;

Garments worker, Tailoring, Maid servant, etc. According to father's occupation, 46.9% (n = 180) were service holders, 28.4% (n = 109) were businessmen, 7.0% (n = 27) were drivers, 6.5% (n = 25) were cleaners, 6.5% (n = 25) were day labourers, 2.9% (n = 11) were gatekeepers, and 1.8% (n = 7) were rickshaw pullers. By family income, 49.7% (n = 191) earned more than 500001 BDT, 35.2% (n = 135) earned between 250001 and 50,000 BDT, and 15.1% (n = 58) BDT earned less than 25,000 BDT taka.

Table 4 General characteristics of the study subjects (n = 384)

Variable	**n (%)**
Age category	
10-14	224 (58.3)
15-19	160 (41.7)
Sex	
Male	138 (35.9)
Female	246 (64.1)
Religion	
Muslim	344 (89.6)
Hindu	35 (9.1)
Christian	5 (1.3)
Living area	
Slum	86 (22.4)
Non-slum	298 (77.6)
Education level of mother	
Primary pass/below	68 (17.7)
SSC pass/below	35 (9.1)
HSC pass	84 (21.9)
Graduation/post-graduation	197 (51.3)
Education level of father	
Primary pass/below	36 (9.4)
SSC pass/below	46 (12.0)
HSC pass	16 (4.2)
Graduation/post-graduation	286 (74.6)
Occupation of mother	
Housewife	133 (34.6)
Service holder	129 (33.6)
Low paid job	57 (14.8)
Self-employed	65 (16.9)
Occupation of father	
Service Holder	180 (46.9)
Business	109 (28.4)
Driver	27 (7.0)
Cleaner	25 (6.5)
Day Labour	25 (6.5)
Gate keeper	11 (2.9)
Rickshaw puller	7 (1.8)
Family size	
≤3	37 (9.6)
4	194 (50.5)

≥5	153 (39.8)
Family income category (BDT)	
≤25,000	58 (15.1)
25001-50,000	135 (35.2)
≥50001	191 (49.7)

Figure 1 shows that among 384 respondents, 36.7% were insufficient, 32% were deficient, and 31.3% were sufficient in terms of vitamin D level.

Figure 1 Distribution of respondents by level of Vitamin D status (n=384)

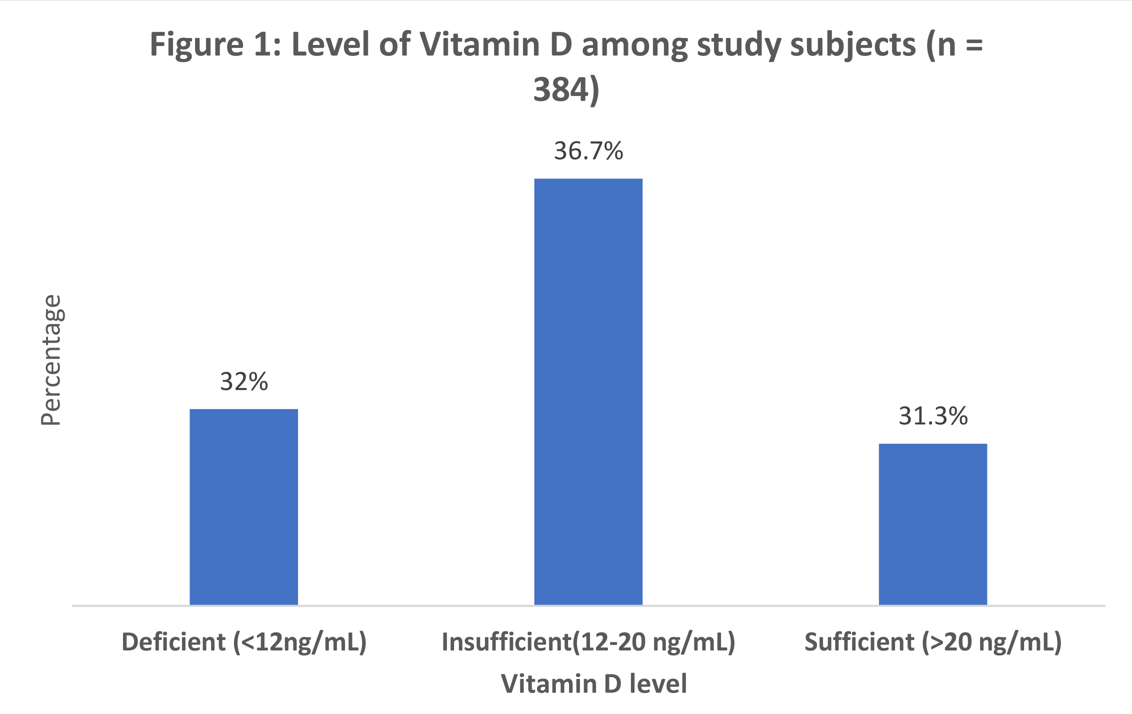

Table 5 shows the fact, among 15-19 age groups were vitamin D deficient by 35.6%, and 10-14 age groups, they were deficient by 29.5%, as the same 10-14 age groups had vitamin D sufficient by 33.0%, and 15-19 age groups were sufficient by 28.7%. Females were more deficient by 36.2% than males by 24.6%, and males had more vitamin D sufficiency by 39.9% than females by 26.4%. According to religion, Muslims were more vitamin D deficient by 33.7% than Hindus by 20.0%. In Hinduism, 34.3% had sufficient vitamin D, compared to Muslims by 31.1%. Among living areas, slum residences were more vitamin D deficient by 87.2% than non-slum residences by 16.1%, and non-slum residents had more vitamin D sufficient by 39.9% than slum residences by 1.2%.

According to educational level, primary passed/below or no institutional education mothers had higher levels of vitamin D deficiency by 92.6%, 62.9% deficient in SSC passed/below mothers, 17.9% deficient in HSC passed mothers, and 11.7% deficient in graduated/post-graduated mothers, and by 50.8% had vitamin D sufficient in graduated/post-graduated mothers, 20.2% had sufficient in HSC passed mothers, and 8.6% had sufficient in SSC passed/below mothers. Among fathers who were primary passed/below no institutional education were discovered to be more vitamin D-deficient by 94.4%, 91.3% were deficient in SSC passed or below father, 31.3% were deficient in HSC passed father, 14.7% were deficient in graduated or post-graduated father, 41.6% had sufficient vitamin D in graduated or post-graduated father, and 6.3% in HSC passed father.

Among low-paid job mothers, 89.5% were deficient in vitamin D by occupation status; 34.6% were deficient in housewife mother; 26.2% were deficient in self-employed mother; 7.0% were deficient in service holder mother; 48.8% had sufficient vitamin D in service holder mother; 40.0% had sufficient in self-employed; 22.6% had sufficient in housewife; and 1.8%. Among low-paid job fathers, 85.3% were deficient in vitamin D, 18.3% were deficient in service-holder fathers, 8.3% were deficient in business fathers, 52.3% had sufficient vitamin D in business fathers, 33.9% had sufficient in service-holders, and 2.1% had sufficient in low-paid job fathers.

According to family income, 91.4% were vitamin D deficient and earned less than 25,000 taka per month; 34.8% were deficient and earned between 25,001 and 50,000 taka; 12% were deficient and earned more than 50,001 taka per month; 53.4% had sufficient vitamin D and earned more than 50,001 taka; and 13.3% had sufficient vitamin D and earned between 25001 and 50,000 taka per month.

Table 5: Relationship between vitamin D level and social and economic categories

Characteristics	Circulating 25OH vitamin D status			P value
	Deficient Below 12 ng/mL)	Insufficient (Between 12-20 ng/mL)	Sufficient (Above 20 ng/mL)	
Age category				
10-14	66 (29.5)	84 (37.5)	74 (33.0)	0.41
15-19	57 (35.6)	57 (35.6)	46 (28.7)	
Sex				
Male	34 (24.6)	49 (35.5)	55 (39.9)	0.012
Female	89 (36.2)	92 (37.4)	65 (26.4)	
Religion				
Muslim	116 (33.7)	121 (35.2)	107 (31.1)	0.12
Hindu	7 (20.0)	16 (45.7)	12 (34.3)	
Christian	0	4 (80.0)	1 (20.0)	
Living area				
Slum	75 (87.2)	10 (11.6)	1 (1.2)	<0.001
Non-slum	48 (16.1)	131 (44.0)	119 (39.9)	
Education level of mother				
Primary pass/below	63 (92.6)	5 (7.4)	0	<0.001
SSC pass/below	22 (62.9)	10 (28.6)	3 (8.6)	
HSC pass	15 (17.9)	52 (61.9)	17(20.2)	
Graduation/post-graduation	23 (11.7)	74 (37.6)	100 (50.8)	
Education level of father				
Primary pass/below	34 (94.4)	2 (5.6)	0	<0.001
SSC pass/below	42 (91.3)	4 (8.7)	0	
HSC pass	5 (31.3)	10 (62.5)	1 (6.3)	
Graduation/post-graduation	42 (14.7)	125 (43.7)	119 (41.6)	
Occupation of mother				
Housewife	46 (34.6)	57 (42.9)	30 (22.6)	<0.001
Service holder	9 (7.0)	57 (44.2)	63 (48.8)	
Low paid job	51 (89.5)	5 (8.8)	1 (1.8)	

Self-employed	17 (26.2)	22 (33.8)	26 (40.0)	
Occupation of father				
Service Holder	33 (18.3)	86 (47.8)	61 (33.9)	<0.001
Business	9 (8.3)	43 (39.4)	57 (52.3)	
Low paid job	81 (85.3)	12 (12.6)	2 (2.1)	
Family size				
≤3	5 (13.5)	10 (27.0)	22 (59.5)	<0.001
4	45 (23.2)	83 (42.8)	66 (34.0)	
≥5	73 (47.7)	48 (31.4)	32 (20.9)	
Family income category				
≤25,000	53 (91.4)	5 (8.6)	0	<0.001
25001-50,000	47 (34.8)	70 (51.9)	18 (13.3)	
≥50001	23 (12.0)	66 (34.6)	102 (53.4)	

* The Chi-square test's p value

Figure 2 Out of 384 respondents, reveals that 77.6% had eaten beef occasionally and 22.4% had never eaten it. Regarding fatty fish, 54.7% of respondents said they ate it rarely, 45% said they did it occasionally, and only 0.3% said they never did. Of those who ate eggs, 64.1% did so occasionally, 33.9% did so frequently, and only 2.1% did rarely. A little over 55.2% reported consuming dairy products occasionally, 34.1% reported doing it rarely, and 10.7% reported doing so frequently. Consumers of fortified soy oil reported using it frequently (29.4%) and occasionally (70.6%). Of the people who ate nuts, 67.4% consumed very rarely, 27.9% never did so, and only 4.7% had done so occasionally. With respect to fruits and vegetables, 67.4% of respondents said they ate them occasionally, 27.9% said they ate them rarely, and 4.7% said they ate them frequently. Of the Horlicks customers, 44.5% never ate Horlicks, 28.4% occasionally consumed Horlicks, 22.1% rarely consumed Horlicks, and 4.9% frequently consumed Horlicks.

Figure 2: Frequency of Vitamin D rich food item consumption

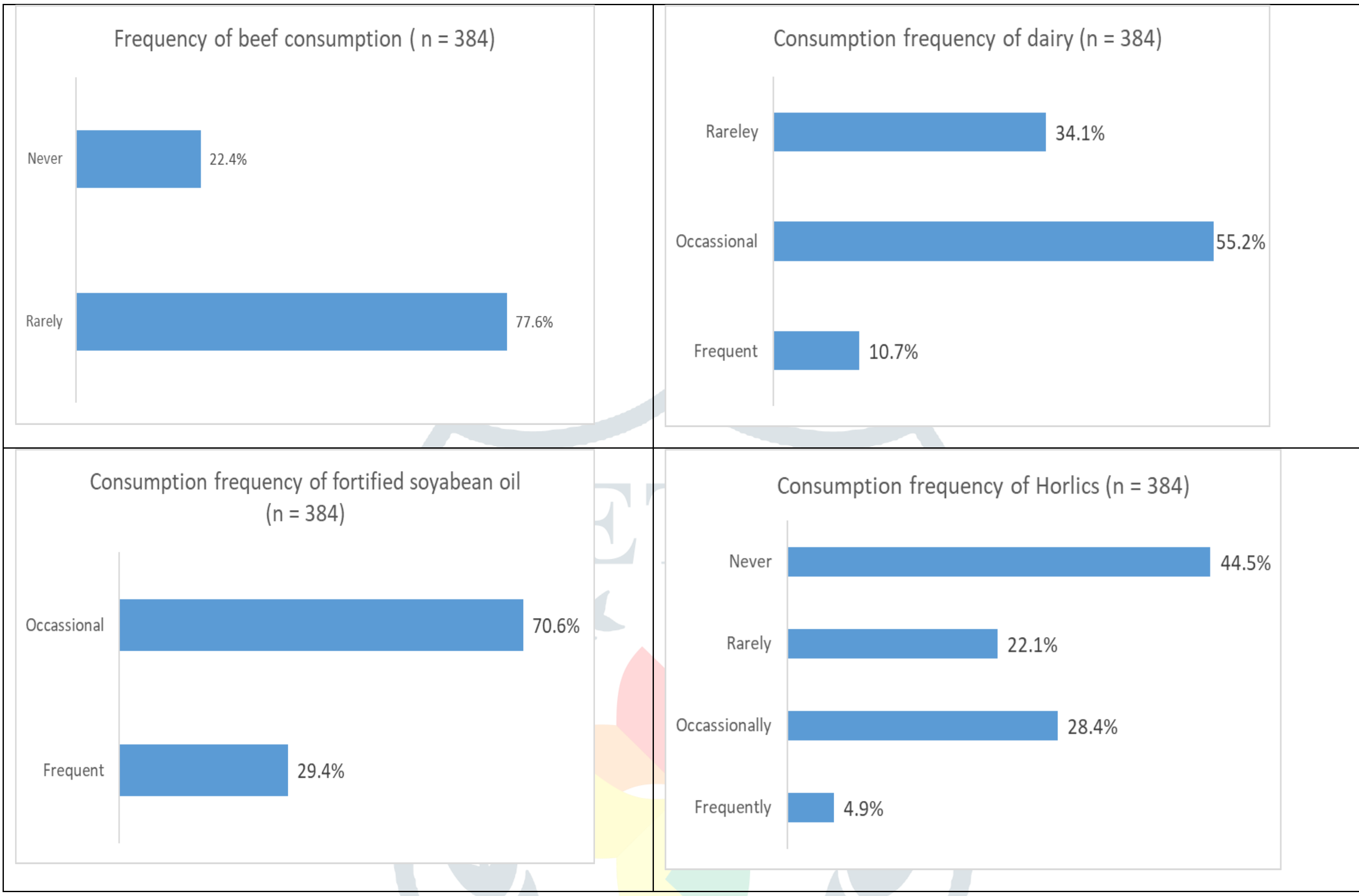

Table 6 demonstrates the facts 37.9% of respondents who rarely consumed beef had sufficient vitamin D, compared to 19.9% of respondents who rarely consumed beef; 8.1% of respondents who never consumed beef had sufficient vitamin D compared to 74.4% of respondents who had never consumed beef. A vitamin D deficiency of 100% was reported by those who never ate fatty fish, compared to 30.1% of those who did so rarely and 23.7% of those who did so occasionally as well as 46.2% of those who did occasionally, and 19.0% of those who did rarely had sufficient amounts of vitamin D.

Regarding how often people ate eggs, 100.0% had low vitamin D levels and rarely ate eggs, 40.7% had insufficient vitamin D levels and occasionally ate eggs also 11.5% had insufficient vitamin D levels and who frequently ate eggs, 60.0% had adequate vitamin D levels and frequently ate eggs, and also 17.1% had a sufficient level of vitamin D and who occasionally ate eggs.

A total of 85.4% of respondents had sufficient vitamin D when they frequently consumed dairy, 36.5% had sufficient vitamin D when they occasionally consumed dairy, and also 6.1% had sufficient vitamin D when they rarely consumed dairy. Of the respondents, 55.7% were deficient when they rarely consumed dairy, 21.7% were deficient when they occasionally consumed dairy, and also 9.8% were deficient when they frequently consumed dairy.

Based on how often oil was consumed, 39.6% of people had insufficient vitamin D and occasionally consumed oil, also 14.2% had insufficient vitamin D and regularly consumed oil, 60.2% had sufficient vitamin D and frequently consumed oil, and also19.2% had sufficient vitamin D and occasionally consumed oil.

Among the individuals who ate nuts, 68.2% had never eaten any, 19.3% had eaten some rarely and were vitamin D deficient, 94.4% had sufficient amounts of vitamin D and occasionally ate nuts, 36.7% had sufficient vitamin D and rarely ate nuts, and also 7.5% had sufficient vitamin D and never ate nuts.

Of those surveyed, 86.9% said they were deficient in vitamin D when they rarely ate fruits and vegetables; 24.9% said they were deficient when they occasionally ate; 13.8% said they were deficient when they frequently ate fruits and vegetables; and 64.9% said they had sufficient amounts of vitamin D when they frequently ate fruits and vegetables; 25.3% said they had sufficient when they occasionally ate; and 1.6% said they had sufficient vitamin D when they rarely ate fruits and vegetables.

Of the respondents who consumed Horlicks; 53.2% of never consumed Horlicks; 23.5% consumed it rarely; 11% had consumed it occasionally and was vitamin D deficient; 100.0% of consumers had sufficient amounts of vitamin D when they frequently consumed Horlicks; 40.4% had sufficient vitamin D when they took it rarely; 40.0% had sufficient vitamin D when they consume it rarely; and also 13.5% had sufficient vitamin D when they did not consume it.

Table 6: Relationship between food habits and vitamin D levels

Food item	Consumption frequency	Deficient (Less than 12 ng/mL)	Insufficient (Between 12-20 ng/mL)	Sufficient (More than 20 ng/mL)	p-value
Beef	Rarely Never	59 (19.9) 64 (74.4)	126 (42.3) 15 (17.4)	113 (37.9) 7 (8.1)	<0.001
Fatty fish	Occasionally Rarely Never	41 (23.7) 81 (30.1) 1 (100.0)	52 (30.1) 89 (42.4) 0	80 (46.2) 40 (19.0) 0	<0.001
Egg	Frequent Occasionally Rarely	15 (11.5) 100 (40.7) 8 (100.0)	37 (28.5) 104 (42.3) 0	78 (60.0) 42 (17.1) 0	<0.001
Dairy	Frequent Occasionally Rarely	4 (9.8) 46 (21.7) 73 (55.7)	2 (4.9) 89 (42.0) 50 (38.2)	35 (85.4) 77 (36.5) 8 (6.1)	<0.001
Oils	Frequent Occasionally	16 (14.2) 107 (39.6)	29 (25.6) 112 (41.3)	68 (60.2) 51 (19.2)	<0.001

Nuts	Occasionally Rarely Never	0 50 (19.3) 73 (68.2)	1 (5.6) 114 (44.0) 26 (24.3)	17 (94.4) 95 (36.7) 8 (7.5)	<0.001
Fruits and vegetables	Frequent Occasionally Rarely	13 (13.8) 57 (24.9) 53 (86.9)	20 (21.3) 114 (49.8) 7 (11.5)	61 (64.9) 58 (25.3) 1 (1.6)	<0.001
Horlicks	Frequent Occasionally Rarely Never	0 12 (11.0) 20 (23.5) 91 (53.2)	0 53 (48.3) 31 (36.5) 57 (33.3)	19 (100.0) 44 (40.4) 34 (40.0) 23 (13.5	<0.001

* The Chi-square test's p value

Supplementary in Table 7: Predictors of Lack of vitamin D (Multinomial logistic regression: The level of vitamin D was classified as deficient, insufficient and sufficient)

The factors associated with vitamin D level among the study subjects. Multinomial logistic regression model was fitted where a set of demographic factors were included as covariates along with consumption frequency of various food items rich with vitamin D. Significant predictors for vitamin D deficiency were occupation level of mother (service holder), consumption of beef, dairy, fortified oil and Horlicks. It has been found that odds of deficiency were lower among service holder mother than those with self-employment (AoR: 0.17, p = 0.012). This study also found a positive impact of consumption of certain vitamin D rich food items (beef, dairy, fortified oil and Horlicks) on vitamin D level. The likelihood of vitamin D deficiency was lower in adolescents who regularly consumed these types of food than those who did so infrequently or never at all.

VII. DISCUSSION

The prevalence of vitamin D deficiency among adolescents is not well-documented, despite the fact that numerous papers have mentioned it in relation to children, adults, or any other group in Bangladesh.

In this research, the age range of 10–14 years old comprised 58.3% of the 384 respondents. 77.6% of the living space is in non-slum areas. Of mothers, 17.7% had completed primary school or less or had never attended an institution, 9.1% had completed SSC, 21.9% had completed HSC, and 51.3% had graduated or pursued post-graduation their education. Regarding the father, 9.4% had only completed primary school or less, or had never attended an institution, 12.0% had completed their SSC or less, 4.2% had completed their HSC, and 74.6% had completed their undergraduate degree or above. By profession, 34.6% of the mothers were housewives, 33.6% worked in service holders, 16.9% were self-employed or in other professions, and 14.8% were in the garment sector. 46.9% of the fathers employed in service, 28.4% engaged with businesses, 7.0% were drivers, 6.5% were cleaners, 6.5% engaged in daily labour, and 4.7% were found to be in other occupations. ≤3 members made up 9.6% of the family, 4 members made up 50.5%, and ≥5 members made up 39.8%.

A survey comprising 274 children revealed that 26.3% of them were between the ages of 10 and 14. 51.8 percent of those surveyed was urban dwellers. 16.4% of the mothers had no schooling at all, 44.9% had completed primary school, 31.4% had completed high school (up to SSC), 4.7% had completed the HSC, and 2.6% had graduated. 14.2% of fathers had no schooling at all, 38.0% had completed primary school, 37.6% had completed high school (up to SSC), 5.5% had completed the HSC, and 4.7% had graduated. 76.3% of the mothers of their subjects were housewives, 8.8% had job holders, and 5.1% worked in the garment industry. The remaining 9.9% of mothers were employed in various occupations. Out of the fathers, 26.3% worked as service holders, 16.8% had engaged in businesses, 13.1% were drivers, 10.2% were cleaners, and 8.4% performed daily labour. Of them, 25.3% engaged across different professions. In terms of family size, 54.0% of them had up to four members, 41.6% had five to six members, and 4.4% had more than six members [33].

According to this study analysis, the vitamin D levels of 36.7% were insufficient, 32% were deficient and 31.3% were adequate. Age groups 10 to 14 had a 29.5% higher likelihood of vitamin D deficiency. Compared to men, women were more deficient by 36.2% against 24.6%.

40 percent of those surveyed had 25-OHD levels below 20 ng/mL overall, of which 110 of those surveyed (25%) had deficiencies and 66 of those surveyed (15%) had insufficiencies. Among the 10–16 age groups, they discovered an especially high frequency of low vitamin D status. When vitamin D levels were compared between age groups, older children showed a lower mean level of 25 (OH) D in the 10–16 age groups (18.7±11.5 ng/mL). Conversely, the blood vitamin D levels of 64.8% of teenage girls were less than 20 ng/mL. Girls had a greater probability of vitamin D deficiency [34].

In the adolescent age group, it was discovered that girls had a higher prevalence of vitamin D deficiency than boys. Noticeably, with growing age, vitamin D deficiency may occur more frequently.

According to the Oren et al.; 2010 [35] study, females are more likely than boys to be vitamin D insufficient. 64.8% of adolescent girls between the ages of 10 and 16 had vitamin D levels < 20 ng/mL [35]. Depending on the season and socioeconomic status, the frequency of vitamin D deficiency in a group of Turkish girls aged 14–18 years was shown to range from 15.6% to 59.4% [36].

Taking into account the age groups in this sample study also discovered that the prevalence of vitamin D deficiency was higher in females.

In Dhaka, the prevalence of hypovitaminosis D in children aged 0 to 16 was investigated by Zaman et al, 2017 [32]. They demonstrated a rising trend of vitamin D insufficiency and deficiency with age, as well as a very high prevalence of hypovitaminosis D. The prevalence of vitamin D deficiency and insufficiency (S-25OHD <75 nmoL/L) was found to be 41.02% and 52.56%, respectively, in the 6–11 year old group and 46.75% and 51.95%, respectively, in the 12–16 year old group. According to their research, as children grow older, the prevalence of vitamin D deficiency rises because serum 25-hydroxyvitamin D levels in the paediatric population gradually decline as children age [32].

According to the National Micronutrients Survey (NMS 2011–2012); [37], the prevalence of vitamin D deficiency in preschool- and school-aged children was 45.5% and 39.6%, respectively. It was discovered that children residing in slum areas were particularly susceptible to vitamin D deficiency [37]. According to the NMS conducted in 2019–2020; [38], 21.9% of children had an overall vitamin D insufficiency. The likelihood of deficiency was slightly higher in girls (23.0%) than in boys (21.0%). In contrast to rural areas, 8.3% of urban areas had higher deficiencies. Comparing the NMS 2011–12 and NMS 2019–20 vitamin D deficiency, NMS 2019–20 has an 18% lower level, at 39.6% and 21.9%, respectively [38].

Significant risk factors for vitamin D deficiency included the mother's job status as a service holder, as well as consumption of dairy, beef, fortified oil, and Horlicks. It was discovered that mothers who worked as service holders had lower odds of deficit than mothers who self-employed (AoR: 0.17, $p = 0.012$). This study concluded that eating foods high in vitamin D, such as dairy, meat, fortified oil, and Horlicks, had a beneficial effect on vitamin D levels. Adolescent who consumed these foods on a regular basis had a lower risk of vitamin D deficiency than those who did not or just occasionally did.

Few prior research have examined the connection between DP and serum vitamin D levels as well as food intake [39] [40] [42]. A cross-sectional study revealed a favorable correlation between vitamin D intake and "dairy and fish DP," which is high in dairy products and fish [39].

In terms of eating fatty fish of this research, 54.7% of respondents stated they ate very rarely, 45% said they ate so occasionally, and only 0.3% said they ate it never. A little over 55.2% said they occasionally consumed dairy products, 34.1% said they did rarely, and 10.7% said they did so frequently. Adolescent who consumed dairy products on a regular basis had found a correlation between lower risks of vitamin D deficiency and food intake.

In sample 742 Greek, Grigoriou et al.; 2020 [40], identified three categories of healthier DPs: "healthy DP," "vegetables fruit DP," and "traditional DP"; three categories of unhealthier DPs: "sweets DP," "fast food DP," and "western DP." Serum 25(OH) D was shown to positively correlate with "healthy DP," which included a lot of non-refined breads, low-fat dairy products, low-fat cheese, and low-fat yoghurt. However, "traditional DP," which was defined by a high positive loading factor of full-fat yoghurt and milk, and "vegetables fruit DP," which was rich in fruits, vegetables, refined rice, and fish, were not linked to 25(OH) D levels. Despite the fact that dairy products constituted the majority of the vitamin D dietary intake, "traditional DP," with its high loading factor of full-fat milk and full fat yogurt, did not correlate with 25(OH) D levels [40].

According to Sharifan P et al.; 2021 [41], there is a positive correlation between healthy DP and 25(OH) D over the winter months. This suggests that, in addition to other factors, food may play a significant influence on serum vitamin D levels in humans during this time of year, when sun exposure is less effective. The study population's "Western DP" and "fast food DP" were also identified. The term "Western DP" refers to a group of people who consume a lot of processed and red meat, pasta, potatoes, chicken, full-fat cheese, full-fat milk, full-fat yoghurt, and fish, while the term "fast food DP" refers to people who consume a lot of low-fat cheese, low-fat milk, and low-fat yoghurt, and a low amount of low- and full-fat milk, yoghurt, and fish. Despite the fact that dairy products are a rich source of dietary vitamin D, adherence to these two unhealthful dietary patterns did not correlate with serum vitamin D levels. Subsequently, a large intake of unhealthy foods may negate the beneficial effects of healthy foods on serum vitamin D levels [41].

The study conducted by Ganji et al.; 2018 [42] revealed a favorable correlation between the serum 25(OH)D level of participants aged 2-19 years old and "prudent DP," which is rich in vegetables, fruits, tomatoes, sea foods, and meat. There aren't many researches that demonstrate a negative or nonexistent relationship between serum 25(OH) D and unhealthy DPs.

According to Ganji et al.; 2018 [42], there is a negative correlation between serum 25(OH) D levels and "high-fat low-vegetable DP" (HFLVD). Fast food, energy drinks, condiments, snacks, sweets, and seafood showed high loading factors in HFLVD, but low-fat dairy products had a negative loading factor. Furthermore, those following an HFLVD diet typically had higher rates of obesity and overweight; hence, these individuals had decreased vitamin D bioavailability [42].

Based on the results of this study, 67.4% of participants reported eating fruits and vegetables occasionally, 27.9% said they ate them rarely, and 4.7% said they ate them frequently. Of them, 86.9% found to be vitamin D deficient despite the fact that vegetables are a poor source of the vitamin D.

Since devout vegetarians (those who abstain from animal-based foods like eggs and dairy products) frequently suffer from vitamin D deficiency, vegetables have a low vitamin D concentration [43].

According to a Mullie et al.; 2010 [44] study, male Mediterranean diet scores, healthy DP, and higher Healthy Eating Index (HEI) were positively correlated with higher education levels [44]. In another study involving a large Iranian population, participants with a lesser degree of education consumed a higher quality of a "western DP" [45]. High educational attainment was taken into account as a predictor of a healthy DP in a systematic review [46]. This conclusion may indicate that educated people are more concerned about their health, depending on their knowledge of nutritional needs and general health [47].

In this study, mothers' educational levels also revealed that 50.8% of graduated or post-graduated mothers had adequate vitamin D, compared to 92.6% of mothers with primary passed, below, or no institutional education. Among fathers, 41.6% had adequate vitamin D in those who had graduated or were post-graduated, compared to 94.4% of fathers who had only completed their primary schooling or had no schooling at all.

VIII. LIMITATION OF STUDY

Because the study was cross-sectional in nature, causal relationship couldn't be established between vitamin D status and other variables. Since the study covered only two selected hospitals in Dhaka city, study findings couldn't be generaliazed to all the adolescent patients. Furthermore, we were unable to completely rule out recall bias while evaluating dietary habits. We also couldn't include other important factors that can contribute to vitamin D level e.g., sunlight exposure, latitude of subject's home, use of sunscreen lotions, and clothing habits, etc.

IX. CONCLUSIONS AND RECOMMENDATION

It can be concluded that dietary and lifestyle choices made by Bangladeshi adolescents may pose a risk for vitamin D deficiency. This study highlights the severity and breadth of vitamin D insufficiency and deficiency among adolescent populations. Concerningly, adolescents in Bangladesh have a very high frequency of vitamin D deficiency and insufficiency It is difficult for public health campaigns aimed at addressing this issue to reach adolescents and communities, including tribal members who reside in hilly regions. To investigate among the national representative samples, more research is necessary. Moreover, the nation must create a thorough action plan to prevent such deficiencies because it is critical to the growth and development of teenagers.

The present study found a positive association between frequent consumption of vitamin D-rich food (either fortified or naturally rich in vitamin D). Hence, further research can be conducted to find the possibility and feasibility of fortification of other food items with vitamin D. The study found low consumption frequency of certain vitamin D rich food items. Therefore, (awareness program reheated narrative).

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