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RESEARCH ARTICLE

Community-based social and demographic assessment of knowledge, attitudes, practices and medical conditions related to vitamin D deficiency in Gilgit Baltistan, Pakistan

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Abstract

Vitamin D is an important nutrient for bone health, and vitamin D deficiency increases the risk of various diseases. Gilgit Baltistan, the northern-most area of Pakistan, has a high prevalence of vitamin D deficiency, despite many nutritional and food safety programmes. The present study aimed to find how knowledge, attitudes and practices associated with vitamin D related to the prevalence of vitamin D deficiency among people residing in different areas of Gilgit Baltistan. The cross-sectional study was descriptive and used data from a survey carried out between February 2019 and December 2020 on individuals of both sexes aged 10 years or over in Gilgit Baltistan. Of the 575 survey participants, 306 (53.2%) had experienced signs and symptoms of vitamin D deficiency, i.e. tiredness, fatigue and bone weakness. Approximately 64.8% had some general knowledge of vitamin D and its relation to health. Participants aged 19–25 years had the highest scores on knowledge of vitamin D. Only 22.7% of interviewees had ever taken any supplements and only 25.6% often exposed themselves to sunlight. Females' mean knowledge score (28.7; SD 7.02) was higher than that of males (24; SD 9.01). A lack of consistency was observed between attitude towards daylight exposure and knowledge of vitamin D. There was a large correlation between knowledge and attitude (p=0.001), while a non-significant association was demonstrated between knowledge and practices (p=0.1). Better knowledge, attitude and practices by people living in cities or more-developed regions indicates that education can be an effective way to provide awareness regarding micronutrient deficiencies. More emphasis is needed on enhancing knowledge, awareness and practices associated with vitamin D deficiency in rural areas of Pakistan. It is strongly recommended that an awareness campaign on micronutrients is launched in both rural and urban areas of Pakistan, concentrating on poor socioeconomic settings.

Keywords: Vitamin D; Knowledge; Pakistan

Introduction

Approximately 1 billion individuals of all ethnicities and ages which are nearly 15% of the world population, are vitamin D-deficient (<20 ng/ml or 20–30 ng/ml) (Iqbal & Khan, 2010). Vitamin D is crucial for bone health and a deficiency increases the likelihood of many diseases, including chronic diabetes, respiratory diseases and adverse pregnancy outcomes (Wacker & Holick, 2013). Vitamin D deficiency has also been linked to the progression of osteoporosis and bone fractures. Sufficient level of vitamin D helps prevent rheumatoid arthritis, diabetes, heart disorders, metabolic ailments, depression, nervous disorders, respiratory diseases and it also lowers all-cause mortality (Shiekh *et al*., 2012; Riaz *et al*., 2016). The main drivers of vitamin D deficiency are inadequate exposure to natural ultraviolet B (UVB) radiation from sunlight,

dietary insufficiency, age and less physical activity. This is often complicated by factors like body mass index (BMI), skin pigmentation and environmental conditions, i.e. latitude, altitude and meteorological conditions, which affect circulating vitamin D levels. Lack of exposure to sunlight is probably the predominant risk factor for vitamin D deficiency (Roth *et al*., 2018).

Vitamin D deficiency is an under-diagnosed and under-treated dietary inadequacy in many countries, including Pakistan, yet the published data on vitamin D deficiency does not address differences by age, sex, income and place of residence (Riaz *et al*., 2016). According to Pakistan's National Nutrition Survey (NNS) conducted by UNICEF in 2018, the prevalence of vitamin D deficiency in the country was 69% in pregnant women, 67% in non-pregnant women and 63% in children under the age of 5, with severe deficiency in a significant proportion of all children (13.2%). The prevalence is slightly higher in girls (63%) than in boys (62%) and more common in urban (84%) than in rural areas (77%). The prevalence increased from 2011 to 2018 (UNICEF, 2018). A study on immigrant Pakistanis in Norway in 2005 found that vitamin D deficiency was more prevalent in Pakistani men and women than in the indigenous Norwegian population (Holvik, 2015). This study found that about 10% of women and 8% of men of Pakistani origin had vitamin D serum levels (25(OH)D) of 50 nmol/l or more, whereas a higher percentage of people of Norwegian background (86%) achieved this level. A survey in Pakistan showed that 12.6% of healthy women and 33% of pregnant women had many biochemical abnormalities in their serum, with deficiencies in calcium, phosphorus and alkaline phosphatase, which were corrected by vitamin D administration (Rab, 1976).

Community Knowledge, Attitude and Practices (KAP) influence the risk of diseases such as those affected by vitamin D deficiency (Bolek-Berquist, *et al*., 2009; Vu *et al*., 2010; Christie & Mason, 2011; Al Bathi *et al*., 2012; Zhou *et al*., 2016; Aljefree *et al*., 2017; O'Connor *et al*., 2018; AlBishi *et al*., 2018). A study based on the Vietnamese population showed a significant inverse relationship between vitamin D level in the blood and age (Ho-Pham *et al*., 2011). An immigrant groups health study in Norway identified that there was widespread vitamin D deficiency in people born in Pakistan, Turkey, Sri Lanka, Iran and Vietnam residing in Oslo (Holvik *et al*., 2005). The prevalence was higher in women than in men, and higher in Pakistani individuals and lower in those born in Vietnam compared with other ethnic groups (Holvik *et al*., 2005). Lower concentrations of vitamin D were seen in Asians compared with Chinese individuals and in women compared with men. These findings also demonstrated the importance of sex and race in identifying those most at risk (Hawkins, 2017).

There are other risk factors for vitamin D deficiency, i.e. latitude, age and urbanization (Mays *et al*., 2018). A study on vitamin D deficiency has been conducted in Swat, Pakistan, by Haq *et al*. (2017), but the present study is the first to examine this issue in Gilgit Baltistan – the northern-most territory administered by Pakistan. According to the 2018 NNS survey, the prevalence of Vitamin D deficiency among non-pregnant women was 81.9% and 76.0% in pregnant women in Gilgit Baltistan. The NNS 2018 was the first large survey in Pakistan to assess vitamin D deficiency using biochemical data (UNICEF, 2018). The purpose of the present study was to assess this population's general knowledge, nutritional knowledge, general habits, dietary habits, attitudes and general practices regarding vitamin D and their correlation with selected factors.

Methods

Study population and area

The study was performed in the self-governing territory of Gilgit Baltistan, Pakistan. This has seven districts with a total population of 1.24–1.8 million (2013–2015). It borders Azad Kashmir to the south, the province of Khyber Pakhtunkhwa (KPK) to the west, Afghanistan to the north, the Xinjiang region of China to the east and the Indian-administered state of Jammu and Kashmir to the south-east (Wikipedia, 2011). Gilgit Baltistan has many poor regions and districts. The targeted regions of this study were Skardu, Chitral, Hunza, Kailash and Shigar. The red dots on Figure 1 show the study population and regions (Benz, 2016). Most of the population of these areas are ignorant of the effects of a healthy diet and disease prevention due to poverty, illiteracy and lack of facilities.

Study design and data collection

The study was conducted between February 2019 and December 2020. A self-administered questionnaire was used with 75 questions divided into different sections: 21 questions were related to general knowledge and awareness of vitamin D; 8 related to nutrition knowledge and medical conditions; 18 were regarding attitudes (social and cultural factors); and 20 were about the practices of people in relation to vitamin D. The structured questionnaire was designed to gather data on knowledge, attitudes, general behaviors and perceptions of the public towards vitamin D within the underprivileged areas of Gilgit Baltistan. It was designed based on prior research on vitamin D (Christie & Mason, 2011; Haq *et al*., 2017).

Academic nutritionists and experts validated the questionnaire before use. Pilot testing was carried out by the research advisor, with help from experts. Sections 1 and 2 gathered data on knowledge and attitudes regarding vitamin D

and the factors affecting these, including sun exposure habits and use of sun protection. Section 3 was designed to determine participants' behavior and practices with reference to vitamin D. Questions related to knowledge, perceptions and behaviour were adapted from various approved questionnaires and guidelines (Bolek-Berquist *et al*., 2009). Each section contained questions and multiple-choice answers. A survey link was generated using Google Forms for participants who found it more convenient to do the survey online. For that purpose, an invitation was sent through social media (Twitter®, Facebook® and WhatsApp®) and emails were sent to people if they were willing to participate in the study. Each potential participant was assessed to ensure they met the selection criteria.

The questionnaire was developed from literature associated with knowledge and practices towards vitamin D deficiency. It was translated into Urdu (the national language of Pakistan) for the convenience of participants. It was distributed among students, housewives and workers. Illiterate participants were interviewed separately as they were unable read or write and respond to the questionnaire. Data on socio-demographic factors, i.e. age, sex, education level, place of residence, employment and profession, were collected. Information on behavioural risk factors like smoking and other health conditions was also collected.

Participants (N=594) were made aware of the objective of the study and were also informed that their answers would remain anonymous and confidential. They were able to withdraw from the study at any time as participation was voluntary for adults. Verbal consent was taken before data collection. Participants signed a written consent form while illiterate participants gave verbal consent. For children, informed consent was provided by their parents or guardians.

Statistical analysis

Data were entered into a Microsoft Excel spreadsheet. Responses to each question were assessed by calculating the frequency distribution and percentages. Queries regarding knowledge and practice were scored and a total 'knowledge and practice' score was enumerated for each participant. KAP scores were obtained by combining scores for their respective columns. Individual variables were scored based upon what percentage of symptoms or sources participants knew. A prospective study was conducted to check the applicability and viability of the tools. Analysis was done using R statistical package and SPSS. Data were presented quantitatively using descriptive statistics and frequencies and percentages. Means and standard deviations were calculated for different intervals and ratio variables. Correlations or associations among different variables were tested using Pearson's correlation coefficient r with a significance level of $p<0.05$. This measures the association or relationship between two variables. Generally, an r value greater than 0.7 is considered a strong correlation, while an r of less than 0.4 suggests a weak or no correlation. Any value between 0.5 and 0.7 is a moderate correlation. A one-way analysis of variance (ANOVA) was used to determine whether there were any statistically significant differences between the means of three or more independent (unrelated) groups.

Results

Socio-demographic characteristics of participants

A total of 575 individuals (54.0% female, 46.0% male) were included in the study. Of these, 40.0% were aged 19–25 years and approximately 30.3% were illiterate. The majority of participants (52.0%) were students (10^{th} grade (Matric) or university graduates (Master's degree). Most of the uneducated (no formal education) participants were farmers or shopkeepers. Regarding medical conditions, 23.1% participants have bone problems on permanent basis, 46.7% have pain in their bones, 33.2% have always face tiredness and weakness while 19.8% have muscle weakness. The participants' demographic characteristics and medical conditions are summarized in Tables 1 and 2.

Knowledge about vitamin D

Table 3 shows the participants' knowledge of vitamin D. Most (64.8%) had heard of vitamin D; 30.6% agreed that the most common sources of information about vitamin D were social media, newspapers and television, while 58.3% disagreed. Over half of participants knew that vitamin D has an impact on bone health and knew the sources of the vitamin; 53.2% thought that older people were at higher risk of vitamin D deficiency, 48.2% thought that it varied with age. That the main source of vitamin D is sun exposure was agreed with by 57.4% of participants, while 16.3% disagreed and 26.3% had no knowledge about it. Among deficiency risk factors 26.6% agreed that smoking and vitamin D are related. That there are various symptoms of vitamin D deficiency, such as bone fracture and fatigue, was agreed with by 48.3% of participants, and 13.0% disagreed and 38.6% had no idea. Deficiency risk being equal in both sexes was agreed with by 48.3% of participants, while 15.5% disagreed and 36.2% had no knowledge about this (Table 3).

Table 4 shows the vitamin D knowledge of educated participants. Their overall knowledge regarding sources of vitamin D was as follows: food 5.8%, sunshine 11.9%, food and sun 61.8% and other 11.4%. The majority (as compared with other mentioned options) of people thought that a deficiency can result in carcinoma.

Attitudes to vitamin D

Table 5 shows participants' attitudes towards vitamin D. A total of 26.1% were unsure whether urbanization prevented sun exposure and the production of required vitamin D, but 17.7% strongly agreed, 34.9% agreed and 10.8% disagreed. A high proportion (40.9%) strongly disagreed that Islam doesn't allow women to travel outside, and very few (17.0%) agreed. In addition, 21.9% strongly disagreed that wearing Hijab (veiling in Islam) could be a reason for vitamin D deficiency and only (17.2%) agreed. An important cultural factor is 'permission', with 25.4% agreeing that 'People (men) don't allow females to go outside the house' but 31.5% strongly disagreed with this statement.

Almost half the participants (40.3%) agreed that 'It becomes difficult to go outside and work during the winter', and 15.3% strongly agreed with the statement, although 16.7% disagreed and 9.0% were unsure. There was general agreement that a shortage of public places for outdoor activities prevents people receiving the sun exposure required for adequate absorption of vitamin D, with 34.1% agreeing that this was the case and only 13.9% disagreeing.

A large proportion of people (30.6%) had no concept of the requirement for enough vitamin D. Only 23.7% thought that they had enough vitamin D, and 21.2% thought they hadn't. On the question 'Lack of education makes people unaware of the production of vitamin D', the majority of people (33.5%) agreed or strongly agreed (30.3%) while only 7.8% disagreed. As for the statement 'Indoor life prevents the required amount of Vitamin D due to less exposure to the sun', 36.1% agreed and 19.7% strongly agreed, and 25.2% were unaware with even fewer (9.4%) showing disagreement. Additionally, 31.3% of the respondents stated that permanent usage of sunscreen products on the face, neck and hands prevents the sun exposure required for vitamin D production (Table 5).

As for use of vitamin D supplements, around 44.5% did not know whether this was more effective than other means, 15.7% strongly agreed, 25.6% agreed and 9.7% disagreed. Nearly 27.1% thought that an unwillingness to take vitamin D supplements results in deficiency and is a barrier to having sufficient vitamin D; and 34.1% responded positively to the statement that 'the high cost of Vitamin D dietary source is actually a barrier to providing the nutrient' (Table 5).

Practices related to vitamin D

Table 6 represents participants' practices related to vitamin D deficiency. Almost 25.6% indicated that they regularly engaged in outdoor activities to get exposed to sunlight. Almost 33.6% responded they 'often' exposed themselves to daylight– 23.1% 'always' and 21.6% 'sometimes'.

Only 15.1% of women agreed that it sometimes becomes difficult for them to go outside due to Hijab issues, and 17.2% preferred to expose themselves to the sun only during the afternoon. Nearly 13.7% preferred to stay inside as they didn't like sunlight. Moreover, 30.4% claimed that they sometimes used vehicles to avoid walking. Regarding indirect exposure to sunlight (through room windows), 11.8% indicated they 'always' did while 11.3% 'never' did so.

When questioned on whether they ate dairy products and other foods, 22.9% said they often consumed fortified milk, cheese and egg yolks in order to be vitamin D sufficient: 18.8% 'always', and 8.9% 'never'. Only 10.3% said they always took multivitamins and/or vitamin D supplements, 24.5% used these sometimes while 34.1% never took them. Medication can also affect the level of absorption of vitamin D and its level in the body, so participants were asked if they were taking any other supplementation or medicine for any health condition: 23.8% reported sometimes doing so, 13.4% did so rarely 29.7% never did so and 15.5% always have done so. Eating fish increases vitamin D levels: 28.3% of participants said they consumed fish twice a week, 26.6% said they never ate fish for this purpose, 14.6% did often, 14.9% said they rarely ate fish, while 15.5% consumed it sometimes (Table 6).

Relationship between knowledge, attitudes and practices

Table 7 presents the results of the statistical analysis showing the associations between participants' education and their knowledge, attitude and practices related to vitamin D using the Pearson correlation.

Medical problems and knowledge had r=–0.059, showing no correlation. Furthermore, the correlation between knowledge and attitude gave r=0.280 (p< 0.001), while its association with practice gave r=0.068 (p=0.104). Attitude had a significant but weak association with practice (r=–0.202, p=0.001). The correlation between medical issues and attitude was also negative (–0.170, p=0.001). A lower attitude score was correlated with increased medical issues. Moreover, medical conditions were weakly correlated with practices (r=0.245, p=0.001) (Figure 2).

The differences between the groups (residence, age group, gender, education and profession) showed great variation (Table 8).

Residence comparison

The region with the highest mean knowledge score was Hunza (30) and that with the lowest was Kailash (18). The mean (SD) attitude score in the Hunza region was highest at 62 (11), and the lowest was in Kailash at 58. The highest practice score was in Gilgit (65) and the lowest was in Kailash (57).

Age comparison

The 19–25 age group had the best mean knowledge score (28) and the lowest mean score was in the 50+ age group (21). Similarly, the mean attitude score was highest in the 19–25 age group (60) and lowest in the 50+ group (59). The practice score was highest in the 19–25 group (64) and lowest in the 31–50 group (60).

Education comparison

The scores among uneducated and educated groups are shown in Table 8, and suggest that education level is directly linked to knowledge and awareness of vitamin D. The practice score was highest in higher secondary school students (65) and lowest in secondary school students (62).

Sex comparison

The knowledge score among females (29) was higher than that among males (24) with a standard deviation. Moreover, the attitude and practice scores of females (60, 63) were also higher than those of males (59, 62).

Discussion

This study in Gilgit Baltistan quantitatively examined the population's knowledge, attitudes and perceptions of vitamin D. The general population had a good level of knowledge about vitamin D, and a moderately good attitude towards the importance of vitamin D. The main socio-demographic factors assessed in the study, i.e. age, sex, rural/urban residence, education level and profession, were found to have both direct and indirect effects KAP. Of the 575 participants, most were female and aged 19–25 years. Most participants resided in Skardu (22.0%) followed by Gilgit (17.0%) and then Hunza (16.0%). The people living in these specific areas are generally better educated than those living in other areas of Gilgit Baltistan, and show great differences in awareness of vitamin D deficiency and resources. This might be because of the better development of these areas, along with the presence of good educational facilities (Benz, 2013).

Of the 575 respondents, 64.8% knew about vitamin D and its role in health; 57.4% correctly identified the sun as a source of vitamin D, 55.1% knew its effects on health and 5.8% knew about food sources of vitamin D; nevertheless, their specific knowledge of dietary food sources was poor. A lack of consistency was observed between attitude towards sunlight exposure and knowledge of vitamin D. Haq *et al*. (2017), in their study among medical college students in Swat, Pakistan, found that student's knowledge about vitamin D was good but their attitude towards sun exposure and dietary practices did not correspond to their knowledge.

Recent studies have been conducted to access the knowledge, attitude and practices regarding vitamin D in Ethiopia (Mekonnen *et al*., 2020), Denmark (Özel *et al*., 2020), Malaysia (Shahudin *et al*., 2020), UK (O'Connor *et al*., 2018; Burchell *et al*., 2020), Saudi Arabia (AlBishi *et al*., 2018; Geddawy *et al*., 2020), Pakistan (Tariq *et al*., 2020), United Arab Emirates (Anwar *et al*., 2019) and Poland (Zadka *et al*., 2018).

Attitudes toward vitamin D in the present study were found to be were mixed. Only 59.5% of the population were willing to use supplements, but most individuals (51.5%) were willing to test their vitamin D levels. Furthermore, the consumption of fortified foods was acknowledged by two-thirds of the population as important, but vitamin D supplement use was low (22.7%). Aljefree *et al*. (2017), in their study conducted in Saudi Arabia, showed that women were willing to improve their vitamin level.

Many of the individuals who worked mainly indoors responded that they did not like to be exposed to the sun, despite their recognition that vitamin D was good for health. This finding was consistent with the reality that many Asians, despite living in tropical regions, have vitamin D insufficiency or deficiency (Nimitphong & Holick, 2013). A similar study conducted in Ho Chi Minh City, Vietnam, showed that there was a negative attitude towards sunlight exposure and lack of knowledge of vitamin D, which could adversely affect bones and general health of the community (Ho-Pham *et al*., 2012).

The present study examined various factors, including sun exposure, religion, culture and weather. About a third of participants believed that urbanization prevented sun exposure as studied by (Mays *et al*., 2018) and 17.0% believed that religion might be a factor preventing women from going outside and being exposed to sunlight. In addition, 25.4% agreed that cultural reasons could hinder sun exposure. Similar studies have been conducted in Islamic countries, including Iran and Saudi Arabia (Faghih *et al*., 2014; Christie & Mason, 2017). Weather might be one of the reasons people are not exposed to enough sun, especially during the winter (Kashi *et al*., 2011), and in the present study 40.3% agreed that it becomes difficult to go outside due to cold weather. Poverty is one of the reasons for lacking knowledge on nutrition (Haque *et al*., 2010), as is education, with around a third of this study's participants recognizing the importance of education for understanding vitamin D. Over 31.3% of the respondents knew that the use of sunscreen on the face, neck and hands prevented vitamin D production. A similar study on workers in urban offices in Brisbane, Australia, suggested that there was a lack of sun-protective behavior due to some confusion about vitamin D and sun exposure (Vu *et al*., 2010).

A quarter of participants regularly engaged in outdoor activities and exposed themselves to sunlight, while slightly fewer often consumed food to increase their vitamin D levels. Only 22.7% had ever taken supplements. A study in the UK

suggested that supplementation and fortification, alongside education strategies, may be an effective way to improve vitamin D health among the UK populations (O'Connor *et al*., 2018).

The main sources of participants' knowledge about vitamin D were social media, newspapers and TV. A study in China showed that social media and health professionals were mostly responsible for students' knowledge of vitamin D (Zhou *et al*., 2016). Knowledge of issues like vitamin D should be disseminated by medical professionals rather than social media in Pakistan.

A weak correlation was found between vitamin D knowledge, attitudes and practices. The study results suggest overall people's behaviour ('practice') is disappointing despite good knowledge and attitudes. A study conducted in the Saudi population (AlBishi *et al*., 2018) showed that the population had some knowledge and understanding of vitamin D and its effects on the cardiovascular system, yet they had poor practices related to sun exposure. The public need continuing education to increase awareness and knowledge about the importance of vitamin D. In Riyadh City, Saudi Arabia, a study identified differences between knowledge and practice among primary health care physicians. The confusion could be partly attributed to different sources of information and guidelines. AlBisihi *et al*. (2018) showed that online sources and medical education were the most common sources of information about vitamin D among the physicians studied.

The ANOVA (Kruskal–Wallis) results indicated significant differences in knowledge, attitudes, practices and medical conditions for almost all demographic factors (Table 8). The findings suggest that most of the target population had knowledge regarding vitamin D sources, dietary intake and its role in the body, but most had poor attitudes and practices related to reducing the risk of deficiency. Other studies in Kuwait have found that most participants had limited knowledge, poor practices and negative attitudes toward vitamin D (Al-Bathi *et al*., 2012). Palkowska *et al*. (2018), in their study in Poland, found that only a few respondents took vitamin D supplements, or gave them to their children. While most mothers knew very little about the role of vitamin D in the body, they did know at least one of its functions but had a low level of knowledge about its dietary sources

There are factors that may limit the production of vitamin D in the body, including high latitude, being indoors, living in a highly polluted area, using a large quantity of sunscreen, having darker skin, diet, being overweight, age, gut health, kidney health, liver health and pregnancy or breastfeeding (Tsiras & Weinstock, 2011; Mazahery & von Hurst, 2015; Harvard Health, 2017). These factors should be considered and awareness of them increased in the general public. The participants from the study area had experienced tiredness, fatigue, hair loss and other symptoms. Moreover, better knowledge, attitude and practices were shown by people residing in better environmental conditions (districts) compared with small towns (more underprivileged/fewer educational facilities).

The study had its limitations. In particular, the questionnaire did not include questions on working hours, so although questions on exposure to sunlight were asked, potential barriers to exposure were possibly overlooked. Secondly, the questionnaire lacked detailed enquiry into dietary habits. These factors should be investigated in more detail. Future studies should include more groups, such as pregnant or breastfeeding women, menopausal women and individuals aged over 65 years. This study enrolled few of these groups and so the results may be unrepresentative. Participants were from Gilgit Baltistan and their lifestyle and cultural background may be different from those of other populations, so the present findings might not be generalizable to other parts of the world.

Despite the limitations, the study provides important indications on the prevention of vitamin D deficiency in the general population in Gilgit Baltistan, Pakistan, and could be helpful in designing more appropriate and better public health initiatives around vitamin D deficiency. The findings suggest that younger women, especially those who with a negative perception of sunlight exposure, should be targeted with education. Mass media campaigns with national coverage may be preferable to educational materials or talks in community organizations, since the main sources of information for this group are mainly radio, newspapers and television. Future research should include a nationwide study taking into consideration the restrictions discussed here and authenticating this questionnaire. In particular, correlating knowledge, attitudes and perceptions with serum 25(OH)D may be useful.

In conclusion, this study showed that 64.8% of participants had heard of vitamin D and its importance for health. Younger people had higher knowledge scores. Vitamin D supplementation was positively viewed by most of the study participants, suggesting that fortification and supplementation may be a useful means to improve vitamin D health. There is a need to improve the education system for providing basic awareness regarding micronutrients. Seminars, awareness activities and different forms of media can play a vital role in this, especially in small towns and rural areas of Gilgit Baltistan.

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Conflicts of Interest. The authors have no conflicts of interest to declare.

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Author Contributions. SM collected the data and wrote the manuscript following discussions with HA. SM and SS contributed equally to this study. NAS helped design the study. WH did the statistical analysis. SM, MSA, NB and RZA revised the paper. ADB revised critically and improved the technical quality of the manuscript. All authors approved the final version of the paper.

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Figure 1. Map of Pakistan showing the regions of Gilgit Baltistan targeted in the study. The red dots represent the sampling sites.
Figure 2. Correlations of knowledge with other parameter of attitude and practice.

Table 1. Frequency distribution of the socio-demographic characteristics of study participants, *N*=575

Characteristic	*n*	%
Age (years)		
10–18	173	30.1
19–25	227	39.5
26–30	69	12.0
31–50	58	10.1
50+	48	8.3
Sex		
Female	312	54.3
Male	263	45.7
Occupation (uneducated)		
Shopkeeper	50	8.7
Farmer	50	8.7
Housewife	40	6.9
Housekeeper	20	3.5
Chef	5	0.9
Driver	8	1.4
Delivery boy	5	0.9
Security guard	2	0.3
Occupation (educated)		
Business	5	0.9
Housewife	3	0.5
Office	77	13.4
Worker (No specific office work)	9	1.6
Student	299	52.0
No profession	2	0.3
Region		
Gilgit	95	16.5
Hunza	90	15.6
Skardu	127	22.0
Shigar	50	8.7
Chitral	20	3.5
Other	193	33.7
Health		
Bone weakness and pain	263	45.7
Healthy	124	21.6
Fatigue and tiredness	43	7.5
Obesity	25	4.3
Stomach problem	19	3.3
High blood pressure	52	9.0
Anxiety and depression	49	8.5
Education		
Master’s degree	124	21.5
Undergraduate degree	100	17.4

Intermediate	65	11.3
Matric	106	18.26

Table 2. Medical conditions reported by participants, *N*=575

Medical condition	*n*	%
Bone problems		
Always	133	23.1
Never	136	23.7
Sometimes	89	15.5
Rarely	62	10.8
Never	155	26.9
Bones hurt		
Always	269	46.7
Never	128	22.3
Sometimes	85	15.0
Rarely	64	11.0
Never	29	5.0
Muscles weakness		
Always	114	19.8
Often	130	22.6
Sometimes	86	14.9
Rarely	75	13.0
Never	170	29.6
Tiredness and weakness		
Always	191	33.2
Often	79	13.7
Sometimes	119	20.7
Rarely	58	10.0
Never	128	22.3
Hair loss		
Always	166	28.8
Never	78	13.5
Sometimes	125	22.0
Rarely	59	10.3
Often	147	25.4
Feel sick		
Always	160	27.8
Never	80	13.9
Sometimes	92	16.0
Rarely	68	11.8
Often	175	30.4
Back pain		
Always	58	10.1
Never	125	21.7
Sometimes	97	16.9
Rarely	89	15.5
Often	206	35.8
Depressed or anxious		

Always	105	18.3
Never	97	16.8
Sometimes	80	13.9
Rarely	73	12.7
Often	220	38.3

Table 3. Participants' knowledge about vitamin D, *N*=575

Question	Response	*n*	%
Heard of vitamin D	Yes	373	64.8
	No	158	27.5
	Don't know	44	7.6
Know about effect on health	Yes	317	55.1
	No	139	24.2
	Don't know	119	20.7
Know about effect on bone health	Yes	347	60.3
	No	121	21.0
	Don't know	107	18.6
Know sources of vitamin D	Yes	330	57.4
	No	160	27.8
	Don't know	85	14.8
Know sunlight is source of vitamin D	Yes	330	57.4
	No	94	16.3
	Don't know	151	26.3
Would undergo a test willingness	Yes	296	51.5
	No	196	34.1
	Don't know	83	14.4
Would take supplements willingness	Yes	342	59.5
	No	139	24.2
	Don't know	94	16.3
Ever taken vitamin D supplements	Yes	131	22.7
	No	234	40.7
	Don't know	210	36.5
Know cigarette smoke and vitamin D are related	Yes	153	26.6
	No	150	26.1
	Don't know	272	47.3
Source of knowledge through social media, newspapers and TV	Yes	176	30.6
	No	335	58.3
	Don't know	64	11.1
Know both sexes are at equal risk of deficiency	Yes	278	48.3
	No	89	15.5
	Don't know	208	36.2
Know about complications of vitamin D deficiency	Yes	230	40.0
	No	154	26.8
	Don't know	191	33.2
Know about effectiveness of programmes in schools/colleges the awareness	Yes	150	26.1
	No	210	36.5
	Don't know	215	37.4
Know about effect of inappropriate dietary intake on vitamin D deficiency	Yes	211	36.7
	No	88	15.3
	Don't know	276	48.0
Know deficiency varies with age	Yes	277	48.2
	No	60	10.4
	Don't Know	238	41.4
Know risk of deficiency for pregnant and lactating women	Yes	241	42.0
	No	53	9.2

	Don’t know	281	48.8
Know main source is sun exposure	Yes	280	48.7
	No	51	8.9
	Don’t know	244	42.4
Know most important health issues in country	Yes	230	40.0
	No	154	26.8
	Don’t know	191	33.0
Know deficiency risk increases with age	Yes	306	53.2
	No	77	13.4
	Don’t know	192	33.4
Know about different supplement intake requirements for the seasons of the year	Yes	229	39.8
	No	109	18.9
	Don’t know	237	41.2
Know the deficiency symptoms bone pain and fatigue	Yes	278	48.3
	No	75	13.0
	Don’t know	222	38.6

Table 4. Knowledge about source of vitamin D among educated population (*N*=395)

Question	Answers and sub-categories	Have knowledge *n* (%)
Sources of vitamin D	Food	23 (5.8)
	Sunshine	47 (11.9)
	Food and sun	244 (61.8)
	Other	45 (11.4)
	Don't know	36 (9.1)
Sources of information about vitamin D	Newspapers	18 (4.5)
	TV/radio	70 (17.7)
	People	61 (15.4)
	Internet	174 (44.1)
	People & internet	12 (3.1)
	People & TV/radio	34 (8.6)
	Other	26 (6.6)
Food sources of vitamin D	Dairy products	80 (20.2)
	Meat and poultry	84 (21.3)
	Supplements	231 (58.5)
Roles of vitamin D in the body	Bone development/mineralization	255 (64.6)
	Blood clotting	70 (17.7)
	Immune system function	45 (11.4)
	Antioxidant	25 (6.3)
Diseases associated with low levels of vitamin D	Breast cancer	19 (4.8)
	Depression	14 (3.5)
	Skin cancer	58 (14.7)
	Rheumatoid arthritis, rickets and osteoporosis	11 (2.8)
	Arthritis, depression, rickets and osteoporosis	14 (3.5)
	None	37 (9.4)
	Rickets	30 (7.6)
	Osteoporosis	39 (9.9)
	Rickets and osteoporosis	19 (4.8)
	Other	154 (38.9)
How can vitamin D amount in body be determined?	Eye test	30 (7.6)
	Blood test	267 (67.6)
	Muscle inflammation	3 (0.8)
	All of the above	29 (7.3)
	Eye test, blood test and muscle inflammation	40 (10.1)

	Other	26 (6.6)

Table 5. Attitudes of participants to vitamin D, *N*=575

Question	*n*	%
Urbanization prevents sun exposure and production of required vitamin D		
Agree	201	34.9
Disagree	62	10.8
No idea	150	26.1
Strongly agree	102	17.7
Strongly disagree	60	10.4
Hijab may be the reason for vitamin D deficiency		
Agree	99	17.2
Disagree	128	22.3
No idea	155	26.9
Strongly agree	67	11.7
Strongly disagree	126	21.9
Islam doesn't allow women to go outside and do things		
Agree	98	17.0
Disagree	111	19.3
No idea	75	13.0
Strongly agree	56	9.7
Strongly disagree	235	40.9
People [men] don't allow females to go outside the house (due to the culture)		
Agree	146	25.4
Disagree	102	17.7
No idea	79	13.7
Strongly agree	67	11.6
Strongly disagree	181	31.5
You mostly like staying at home rather than going outside		
Agree	171	29.7
Disagree	114	19.8
No idea	93	16.2
Strongly agree	92	16.0
Strongly disagree	105	18.3
A shortage of public places for outdoor activities prevents the sun exposure required for production of vitamin D		
Agree	196	34.1
Disagree	80	13.9
No idea	156	27.1
Strongly agree	100	17.4
Strongly disagree	43	7.5
It becomes difficult to go out and work during the winter		
Agree	232	40.3
Disagree	96	16.7
No idea	52	9.0
Strongly agree	88	15.3
Strongly disagree	107	18.6
Lack of education makes people unaware of the production of vitamin D		
Agree	193	33.5
Disagree	45	7.8
No idea	112	19.5
Strongly agree	174	30.3
Strongly disagree	51	8.9
You have enough amount of vitamin D in your body and don't need anymore		
Agree	136	23.7

Disagree	122	21.2
No idea	176	30.6
Strongly agree	68	11.8
Strongly disagree	73	12.7
Taking vitamin D supplement unless recommended by a physician is wrong		
Agree	140	24.3
Disagree	94	16.3
No idea	148	25.7
Strongly agree	149	25.9
Strongly disagree	44	7.7
Indoor life most of the time prevents sun exposure required for vitamin D		
Agree	208	36.1
Disagree	54	9.4
No idea	145	25.2
Strongly agree	113	19.7
Strongly disagree	55	9.6
Taking supplements is necessary for treatment of vitamin D deficiency but not for its prevention		
Agree	210	36.5
Disagree	73	12.7
No idea	152	26.4
Strongly agree	80	13.9
Strongly disagree	60	10.4
In vitamin D deficiency, supplement intake is more effective than dietary intake and sun exposure		
Agree	147	25.6
Disagree	56	9.7
No idea	256	44.5
Strongly agree	90	15.7
Strongly disagree	26	4.5
Taking supplements is only necessary in the case of lack of exposure to sunlight		
Agree	173	30.1
Disagree	72	12.5
No idea	156	27.1
Strongly agree	92	16
Strongly disagree	82	14.3
Unwillingness of individuals to take vitamin D supplement is one of the barriers to providing this nutrient		
Agree	156	27.1
Disagree	68	11.8
No idea	207	36.0
Strongly agree	94	16.3
Strongly disagree	50	8.7
I am willing to get exposed to sunlight more for vitamin D		
Agree	180	31.3
Disagree	69	12.0
No idea	126	21.9
Strongly agree	132	22.9
Strongly disagree	68	11.8
Permanent use of sunscreens on face, neck and hands prevents the sun exposure required for production of vitamin D		
Agree	180	31.3
Disagree	53	9.2

No idea	165	28.7
Strongly agree	111	19.3
Strongly disagree	66	11.5
High cost of dietary sources of vitamin D is a barrier to providing this nutrient		
Agree	196	34.1
Disagree	62	10.8
No idea	191	33.2
Strongly agree	89	15.5
Strongly disagree	37	6.4

Table 6. Practices among participants regarding vitamin D, *N*=575

Question	*n*	%
I regularly engage in outdoor activities to get exposed to sunlight		
Always	147	25.6
Never	50	8.7
Often	119	20.7
Rarely	88	15.3
Sometimes	171	29.7
I can't go outside more often due to hijab issues (females only)		
Always	105	18.3
Never	234	40.7
Often	84	14.6
Rarely	65	11.3
Sometimes	87	15.1
I often expose myself to sunlight by indirect ways (room/vehicle window)		
Always	133	23.1
Never	57	9.9
Often	193	33.6
Rarely	68	11.8
Sometimes	124	21.6
Would you prefer to expose yourself to sunlight only in afternoon?		
Always	99	17.2
Never	111	19.3
Often	122	21.2
Rarely	90	15.7
Sometimes	153	26.6
Would you like to expose yourself to sunlight while not preferring to go outside and expose to sunlight (via indirect means)		
Always	58	10.1
Never	152	26.5
Often	81	14.1
Rarely	122	21.2
Sometimes	162	28.2
I don't like to go outside to get exposed to sunlight		
Always	79	13.7
Never	152	26.4
Often	142	24.7
Rarely	74	12.9
Sometimes	128	22.3
I preferred to use vehicle to go outside instead of walking		
Always	84	14.6
Never	104	18.1
Often	117	20.3
Rarely	95	16.5
Sometimes	175	30.4
I only expose face and hands (Hijab reasons)		
Always	157	27.3
Never	178	30.9
Often	99	17.2
Rarely	66	11.5
Sometimes	75	13.0
I drink carbonated beverages		
Always	72	12.5
Never	132	22.9
Often	117	20.3
Rarely	89	15.5

Sometimes	165	28.7
To be vitamin D sufficient, I take vitamin D supplements or multivitamins		
Always	59	10.3
Never	196	34.1
Often	104	18.1
Rarely	75	13.0
Sometimes	141	24.5
Are you taking any medicine for other medical conditions?		
Always	89	15.5
Never	171	29.7
Often	101	17.6
Rarely	77	13.4
Sometimes	137	23.8
To be vitamin D sufficient, I consume fortified milk, cheese, egg yolks etc.		
Always	108	18.8
Never	51	8.9
Often	132	22.9
Rarely	95	16.5
Sometimes	189	32.9
In order to be vitamin D sufficient, I consume fish at least twice a week		
Always	163	28.3
Never	153	26.6
Often	84	14.6
Rarely	86	14.9
Sometimes	89	15.5
For sufficient exposure to sunlight, I walk outdoors daily		
Always	122	21.2
Never	60	10.4
Often	124	21.6
Rarely	85	14.8
Sometimes	184	32.0
I use caps/hats to avoid severe sun exposure		
Always	66	11.5
Never	136	23.7
Often	106	18.4
Rarely	73	12.7
Sometimes	194	33.7
During the day I am directly exposed to sunlight (outdoors)		
Always	110	19.1
Never	39	6.8
Often	133	23.1
Rarely	103	17.9
Sometimes	190	33.0
I use sunscreen on my hands and face		
Always	74	12.9
Never	149	25.9
Often	132	22.9
Rarely	83	14.4
Sometimes	137	23.8
I smoke		
Always	49	8.5
Never	314	54.6
Often	61	10.6
Rarely	43	7.5
Sometimes	108	18.8

During the day I am indirectly exposed to sunlight (through the glass of windows)		
Always	68	11.8
Never	65	11.3
Often	161	28.0
Rarely	76	13.2
Sometimes	205	35.7
I do not go outside in winter due to the cold temperatures		
Always	70	12.2
Never	98	17.1
Often	158	27.5
Rarely	71	12.3
Sometimes	178	30.9

Table 7. Associations between knowledge, education, attitudes and practices

Variable	Statistical test	Knowledge	Medical problem	Attitude	Practice
Medical problem	Pearson correlation	–0.059			
	Sig. (2-tailed)	0.155			
Attitude	Pearson correlation	0.280	–0.170		
	Sig. (2-tailed)	< 0.001	< 0.001		
Practice	Pearson correlation	0.068	0.245	–0.202	
	Sig. (2-tailed)	0.104	<0 .001	<0 .001	
Knowledge	Pearson correlation	0.655	–0.075	0.262	–0.036
	Sig. (2-tailed)	<0 .001	0.071	<0 .001	0.389

Table 8. ANOVA comparison between groups and within groups

Variable	χ^2	df	p
Residence			
General knowledge	68.5	8	< 0.001
Nutrition knowledge	40.7	8	<0 .001
Medical condition	14.3	8	0.075
Attitude	12.7	8	0.122
Practice	20.5	8	0.008
Age group			
General knowledge	48.64	4	< 0.001
Nutrition knowledge	40.39	4	<0.001
Medical condition	16.91	4	0.002
Attitude	2.57	4	0.633
Practice	21.07	4	<0 .001
Sex			
General knowledge	40.0845	1	< 0.001
Nutrition knowledge	22.0215	1	<0 .001
Medical condition	0.0123	1	0.912
Attitude	2.1555	1	0.142
Practice	2.0171	1	0.156
Education			
General knowledge	143.98	4	< 0.001
Nutrition knowledge	126.41	4	< 0.001
Medical condition	13.05	4	0.011
Attitude	3.20	4	0.525
Practice	17.78	4	0.001
Profession			
General knowledge	131.6	12	<0 .001
Nutrition knowledge	116.1	12	<0 .001
Medical condition	34.7	12	<0 .001
Attitude	23.8	12	0.021
Practice	30.2	12	0.003