**Determinants of Vitamin D Deficiency: A Comprehensive Analysis of Demographic and Health Characteristics**

**Abstract**

**Background:** Vitamin D deficiency is a prevalent global health concern with significant implications for various chronic conditions, including cardiovascular diseases, diabetes, and certain cancers. It also plays a crucial role in immune function. This study aims to investigate the determinants of vitamin D deficiency, focusing on demographic and health characteristics such as sex, BMI, socio-economic status, duration of asthma, occupation, and smoking history.

**Methods:** A cross-sectional study was conducted at Imran Idrees Teaching Hospital, Sialkot, from November 2023 to May 2024. The study included 250 adults aged 18-65 years with documented vitamin D levels. Participants were selected based on inclusion and exclusion criteria and provided informed consent. Data were collected using a structured questionnaire and analyzed using SPSS. Descriptive statistics summarized participant characteristics, and chi-square tests assessed associations between vitamin D status and various variables, with significance set at p<0.05.

**Results:** The study sample consisted of 250 participants (77.6% male, 22.4% female). Vitamin D deficiency was observed in 148 participants (59.2%). Significant associations were found between vitamin D deficiency and smoking history (p=0.023), but not with sex (p=0.963), BMI (p=0.486), socio-economic status (p=0.088), duration of asthma (p=0.908), or occupation (p=0.559). Among smokers, 66.1% were deficient in vitamin D compared to 52.0% of non-smokers.

**Conclusions:** This study identifies smoking as a significant determinant of vitamin D deficiency. Other factors such as sex, BMI, socio-economic status, duration of asthma, and occupation did not show significant associations. Targeted public health interventions are needed to address vitamin D deficiency, particularly among smokers, to improve overall health outcomes.

**MeSH Keywords**

Vitamin D Deficiency, Demography, Body Mass Index, Socioeconomic Factors

**Introduction**

Vitamin D deficiency is a global health concern that has garnered increasing attention due to its widespread prevalence and significant health implications1. This fat-soluble vitamin plays a crucial role in calcium homeostasis and bone metabolism, and its deficiency has been linked to various chronic conditions, including cardiovascular diseases, diabetes, and certain cancers2. Moreover, vitamin D is essential for immune function, and low levels have been associated with increased susceptibility to infections and autoimmune diseases3. Recent studies have highlighted the alarming rates of vitamin D deficiency across different populations, emphasizing the need for a deeper understanding of the factors contributing to this deficiency4. The prevalence of vitamin D deficiency varies widely across different demographic groups, influenced by factors such as age, sex, body mass index (BMI), socio-economic status, lifestyle, and geographic location5. For instance, studies have shown that women and individuals with higher BMI are more likely to suffer from vitamin D deficiency due to the sequestration of the vitamin in adipose tissue6. Additionally, socio-economic factors, including income and education levels, have been found to correlate with vitamin D status, with lower socio-economic groups exhibiting higher deficiency rates. These disparities underscore the importance of targeted public health interventions to address vitamin D deficiency in vulnerable populations7. Asthma, a chronic respiratory condition, has also been linked to vitamin D levels. Vitamin D is believed to have immunomodulatory effects that can influence asthma pathogenesis and control8. Observational studies suggest that vitamin D deficiency may be associated with increased asthma severity and frequency of exacerbations9. Furthermore, certain occupations that limit exposure to sunlight, such as indoor and shift work, have been identified as risk factors for vitamin D deficiency. This is particularly relevant in urban settings where occupational and lifestyle factors can significantly limit sun exposure, the primary source of vitamin D synthesis10. Smoking has emerged as another critical factor affecting vitamin D levels. The toxic effects of smoking can impair vitamin D metabolism and function, leading to lower serum levels in smokers compared to non-smokers11. This relationship highlights the multifaceted nature of vitamin D deficiency, where lifestyle choices compound the risk posed by environmental and demographic factors12.

Despite the extensive research on vitamin D deficiency, there remains a need for comprehensive studies that integrate multiple demographic and health-related variables to elucidate their collective impact on vitamin D status. This study aims to fill this gap by investigating the association between vitamin D deficiency and various demographic and health characteristics, including sex, BMI, socio-economic status, duration of asthma, occupation, and smoking history by identifying key determinants of vitamin D deficiency, this research seeks to inform targeted intervention strategies to improve vitamin D status and overall health outcomes in diverse.

### Methodology:

This cross-sectional study was conducted in Imran Idrees Teaching Hospital Sialkot setting over a period of six months November 2023 to May 2024. The study design involved the recruitment of 250 participants to assess the determinants of vitamin D deficiency.Informed consent was obtained from all study participants, highlighting the voluntary nature of their participation and the confidentiality of their responses. Sample size calculation The sample size of 250 participants9 was calculated to ensure statistical relevance, based on a 95% confidence level and a 5% margin of error. Inclusion criteria included adults aged 18-65 years, with documented vitamin D levels and available demographic and health data. Exclusion criteria were participants with chronic kidney disease, liver disease, or those on vitamin D supplementation. Data were collected using a structured questionnaire that captured demographic information, health status, and lifestyle factors. Data entry was performed using statistical software SPSS, ensuring accuracy and completeness. Data analysis involved descriptive statistics to summarize participant characteristics and chi-square tests to assess the association between vitamin D status and variables such as sex, BMI, socio-economic status, duration of asthma, occupation, and smoking history, with a significance level set at p<0.05 and a 95% confidence interval. Ethical considerations included obtaining informed consent from all participants and ensuring confidentiality of their data. Operational definitions were applied to categorize BMI, socio-economic status, and smoking history.

### Operational Definitions:

1. **Vitamin D Deficiency**: Defined as serum 25-hydroxyvitamin D levels below 20 ng/mL2.
2. **Body Mass Index (BMI)**: Categorized as <25 kg/m² (normal) and >25 kg/m² (overweight/obese)6.
3. **Socio-Economic Status**: Categorized into three groups based on income and education levels7.

**Results**

# **Table no.1 Participant Demographics and Health Characteristics**

|  |  |  |
| --- | --- | --- |
| Variable | Frequency | Percent |
| **Sex** | | |
| Male | 194 | 77.6% |
| Female | 56 | 22.4% |
| Total | 250 | 100.0% |
| **Low vit d** | | |
| |  |  |  | | --- | --- | --- | | No | 105 | 41.2% | | Yes | 95 | 37.3% | | | |
|  | | |
| **BMI** | | |
| <25kg/m² | 168 | 67.2% |
| >25kg/m² | 82 | 32.8% |
| Total | 250 | 100.0% |
| **Socio-Economic Status** | | |
| 1.00 | 113 | 45.2% |
| 2.00 | 103 | 41.2% |
| 3.00 | 34 | 13.6% |
| Total | 250 | 100.0% |
| **Duration of Asthma** | | |
| <5 years | 131 | 52.4% |
| >5 years | 119 | 47.6% |
| Total | 250 | 100.0% |
| **Occupation** | | |
| Factory Worker | 71 | 28.4% |
| Laborer | 50 | 20.0% |
| Businessman | 48 | 19.2% |
| Teacher | 33 | 13.2% |
| Hospital Janitorial Staff | 21 | 8.4% |
| Housewife | 15 | 6.0% |
| House Help | 12 | 4.8% |
| Total | 250 | 100.0% |
| **History of Smoking** | | |
| Yes | 127 | 50.8% |
| No | 123 | 49.2% |
| Total | 250 | 100.0% |

# Table 1 presents the demographics and health characteristics of the study participants. The sample consists of 250 individuals, predominantly male (77.6%), with the remaining 22.4% being female out of which 37.3% shows low vit d levels . In terms of BMI, 67.2% have a BMI of less than 25 kg/m², while 32.8% have a BMI greater than 25 kg/m². Socio-economically, 45.2% fall into the highest category (1.00), 41.2% into the middle category (2.00), and 13.6% into the lowest category (3.00). Regarding asthma duration, 52.4% have had asthma for less than 5 years, and 47.6% for more than 5 years. Occupationally, 28.4% are factory workers, 20.0% laborers, 19.2% businessmen, 13.2% teachers, 8.4% hospital janitorial staff, 6.0% housewives, and 4.8% house helps. Additionally, 50.8% of participants have a history of smoking, while 49.2% do not.

# **Table no.2 Vitamin Deficiency Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | No (n=102) | Yes (n=148) | Total (n=250) |
| **Sex** | | | |
| Male | 79 | 115 | 194 |
| Female | 23 | 33 | 56 |
| **BMI** | | | |
| <25kg/m² | 66 | 102 | 168 |
| >25kg/m² | 36 | 46 | 82 |
| **Socio-Economic Status** | | | |
| 1.00 | 49 | 64 | 113 |
| 2.00 | 45 | 58 | 103 |
| 3.00 | 8 | 26 | 34 |
| **Duration of Asthma** | | | |
| <5 years | 53 | 78 | 131 |
| >5 years | 49 | 70 | 119 |
| **Occupation** | | | |
| Factory Worker | 33 | 38 | 71 |
| Laborer | 20 | 30 | 50 |
| Businessman | 20 | 28 | 48 |
| Teacher | 11 | 22 | 33 |
| Hospital Janitorial Staff | 9 | 12 | 21 |
| Housewife | 7 | 8 | 15 |
| House Help | 2 | 10 | 12 |
| **History of Smoking** | | | |
| Yes | 43 | 84 | 127 |
| No | 59 | 64 | 123 |

# Table 2 outlines the distribution of vitamin D status among 250 participants, with 102 having no deficiency and 148 having a deficiency. Among males, 79 have no deficiency while 115 have a deficiency, and among females, 23 have no deficiency while 33 have a deficiency. For BMI, 66 participants with a BMI of less than 25 kg/m² have no deficiency compared to 102 with a deficiency, while for those with a BMI greater than 25 kg/m², 36 have no deficiency and 46 have a deficiency. Regarding socio-economic status, 49 participants in the highest category (1.00) have no deficiency compared to 64 with a deficiency, and in the lowest category (3.00), 8 have no deficiency compared to 26 with a deficiency. For asthma duration, 53 participants with less than 5 years of asthma have no deficiency compared to 78 with a deficiency, and for more than 5 years, 49 have no deficiency compared to 70 with a deficiency. Among smokers, 43 have no deficiency compared to 84 with a deficiency.

# **Table no.3 Cross Tabs for Low Vitamin D Status and Associated Variables**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Low Vitamin D | Chi-Square Value | P-Value |
| **Sex** | | | |
| Male | 115 | 0.002 | 0.963 |
| Female | 33 |  |  |
| **BMI** | | | |
| <25kg/m² | 102 | 0.486 | 0.486 |
| >25kg/m² | 46 |  |  |
| **Socio-Economic Status** | | | |
| 1.00 | 64 | 4.862 | 0.088 |
| 2.00 | 58 |  |  |
| 3.00 | 26 |  |  |
| **Duration of Asthma** | | | |
| <5 years | 78 | 0.013 | 0.908 |
| >5 years | 70 |  |  |
| **Occupation** | | | |
| Factory Worker | 38 | 4.882 | 0.559 |
| Laborer | 30 |  |  |
| Businessman | 28 |  |  |
| Teacher | 22 |  |  |
| Hospital Janitorial Staff | 12 |  |  |
| Housewife | 8 |  |  |
| House Help | 10 |  |  |
| **History of Smoking** | | | |
| Yes | 84 | 5.150 | 0.023 |
| No | 64 |  |  |

Table 3 shows the chi-square analysis of the relationship between low vitamin D levels and various participant characteristics revealed that sex (p = 0.963), BMI (p = 0.486), socio-economic status (p = 0.088), duration of asthma (p = 0.908), and occupation (p = 0.559) do not have significant associations with vitamin D status, indicating similar distributions of vitamin D levels across these variables. However, there was a significant association between history of smoking and vitamin D status (p = 0.023), suggesting that smokers are more likely to have sufficient vitamin D levels compared to non-smokers.

**Discussion:**

The current study displayed a notable disparity in gender distribution, with a larger percentage of male subjects (77.6%) in comparison to the female counterparts (22.4%). Regarding the occurrence of Vitamin D insufficiency, it was observed that 59.3% of male participants were deficient in Vitamin D, while 40.7% were not deficient. Similarly, among the female participants, the figures were relatively close, as 58.9% showed insufficiency while 41.1% did not manifest any deficiency. The study found a significant association between vitamin D deficiency and various demographic and health characteristics. The prevalence of vitamin D deficiency was higher among females (58.9%) compared to males (59.3%), although the difference was not statistically significant (p=0.963). Similar studies globally have shown mixed results regarding sex differences in vitamin D deficiency. Some studies indicate higher deficiency rates in women, potentially due to factors like higher body fat percentage or less exposure to sunlight due to cultural clothing practices as observed by a study conducted in Saudi Arabia, a similar trend has been observed, where a study revealed that a significant 81% of women tested had low levels of vitamin D13. In a systematic review and meta-analysis, it was found that overweight and obesity diminish the effectiveness of vitamin D supplementation, with individuals having a higher BMI experiencing less pronounced increases in vitamin D levels, suggesting an impaired response to supplementation (p < 0.05)14. This is particularly relevant to our current study where, despite a non-significant p-value (p = 0.486), the trend shows that participants with a BMI over 25 kg/m² have higher rates of vitamin D deficiency compared to those under 25 kg/m². The current study shows a socio-economic gradient in vitamin D deficiency. In the highest SES category, the participants are nearly equally divided between those with and without deficiency (49 not deficient, 64 deficient). In contrast, in the lowest SES category, more participants are deficient (26 deficient, 8 not deficient), suggesting that lower SES may lead to higher vitamin D deficiency rates due to poorer diet, less healthcare access, and fewer opportunities for sun exposure. An Indonesian study examined the risk factors related to socio-economic status, dietary intake, and lifestyle, with logistic regression showing significant associations. The p-value for these associations was less than 0.05, suggesting that differences in vitamin D status related to socio-economic factors are statistically significant​15. For asthma duration, the comparison of vitamin D deficiency among asthma patients shows 53 without deficiency and 78 with deficiency for those with less than 5 years of asthma, versus 49 without deficiency and 70 with deficiency for those with more than 5 years of asthma. The high p-value of 0.908 suggests there is no significant difference in vitamin D deficiency related to the duration of asthma. A similar study focused on adult asthma patients revealed that vitamin D levels were significantly related to asthma control and severity. Specifically, patients with severe or uncontrolled asthma had the lowest vitamin D levels compared to those with milder forms of the disease (p = 0.030 for asthma control and p = 0.046 for severity16. the analysis reveals a significant association between smoking history and vitamin D deficiency, with a chi-square value of 5.150 and a p-value of 0.023. This indicates that smoking is statistically significantly associated with lower levels of vitamin D. Specifically, among the participants, more smokers (84 out of 127) are deficient in vitamin D compared to non-smokers (64 out of 123). This pattern suggests that smoking may impair the body's ability to maintain adequate levels of vitamin D, possibly due to effects on calcium metabolism, decreased dietary intake, or less outdoor activity, all of which are crucial for vitamin D synthesis and regulation. This finding is consistent with a study that found 50.3% had vitamin D deficiency, 8.8% had sufficient levels. Smoking correlated with lower vitamin D levels (p < 0.001). Smokers had significantly lower vitamin D levels than non-smokers (p < 0.001). In the 40-50 age group, smokers had significantly lower vitamin D levels (p = 0.003). Young smokers (20-29 years) were more likely to have vitamin D deficiency compared to non-smokers in the same age group (p = 0.04117)17.

**Limitation of study**

The study relied on a single-center population, which may restrict the generalizability of the findings to other settings or populations. Moreover the gender imbalance, self-reported data for some variables, such as smoking history and socio-economic status, may be subject to recall bias or social desirability bias.

**Conclusion**

This study highlights smoking as a significant determinant of vitamin D deficiency among adults, while other factors such as sex, BMI, socio-economic status, asthma duration, and occupation did not show statistically significant associations. These findings emphasize the need for targeted public health interventions to address modifiable risk factors, particularly among smokers, to improve vitamin D status and associated health outcomes. Further research is needed to explore causal mechanisms and to identify additional factors influencing vitamin D deficiency in diverse populations.

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