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Vitamin Deficit, Hidden Danger: Awareness of Biochemical Importance of Vitamin D and B12 Among Urban Residents of Punjab

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ABSTRACT

Background: Hidden micronutrient deficiencies—particularly those of vitamin D and vitamin B_{12}—are emerging as major public health concerns in urban India. Sedentary lifestyles, inadequate sunlight exposure, and predominantly vegetarian diets have contributed to widespread biochemical insufficiencies, even among educated populations. Punjab, undergoing rapid urbanization, exemplifies this paradox of nutritional transition. This study aimed to assess the awareness, perception, and preventive practices regarding these vitamins among urban residents.

Materials and Methods: A community-based, Google Form–based cross-sectional study was conducted between January and April 2025 among 420 adults residing in various urban areas of Punjab. A validated and reliable online questionnaire (Cronbach's α = 0.86) assessed socio-demographic details, knowledge of vitamin D and B_{12}, and related perceptions and practices. Each correct response was scored as one, and cumulative awareness levels were categorized as Excellent, Good, Fair, or Poor. Data were exported to Excel and analyzed using IBM SPSS v26, applying descriptive statistics and Chi-square tests to determine associations ($p < 0.05$ considered significant).

Results: Overall awareness was moderate to good, with mean knowledge scores of 13.8 ± 3.4 for vitamin D and 13.6 ± 3.1 for vitamin B_{12}. Approximately two-thirds of participants exhibited good to excellent knowledge, yet significant biochemical misconceptions persisted—only 44.8% correctly identified 25-hydroxy vitamin D as the diagnostic marker, and 56.2% recognized the role of intrinsic factor in B_{12} absorption. Although 63.3% reported positive perceptions toward preventive behavior, merely 36% had undergone vitamin testing, revealing a pronounced knowledge–practice gap. Awareness and proactive behavior were significantly associated with education level, occupation, income, dietary pattern, and sunlight exposure ($p < 0.05$), while gender showed no significant correlation.

Conclusion: Despite satisfactory awareness levels, preventive practices remain insufficient among urban Punjabis. Enhanced digital health education, routine screening drives, and mandatory food fortification policies are urgently needed to transform awareness into sustainable health behavior and mitigate the silent epidemic of vitamin D and B_{12} deficiencies.

Keywords: *Vitamin D, Vitamin B_{12}, Awareness, Google Form Survey, Urban Punjab, Micronutrient Deficiency, Knowledge–Practice Gap, Sunlight Exposure, Dietary Habits, Public Health Promotion.*

INTRODUCTION

Micronutrient deficiencies, often described as *hidden hunger*, remain a major public health concern even in nutritionally progressive regions. Among these, deficiencies of vitamin D and vitamin B_{12} represent two of the most pervasive yet under-recognized biochemical disorders in modern urban populations. While overt malnutrition has declined, these subtle deficiencies silently erode health, impairing metabolism, immunity, cognition, and overall quality of life.[1,2]

Vitamin D, a steroidal hormone synthesized through sunlight exposure, regulates calcium–phosphorus balance, skeletal integrity, and immune modulation. Vitamin B_{12} (cobalamin), primarily obtained from animal sources, is essential for DNA synthesis, red blood cell formation, and neurological function. Deficiency of either nutrient can manifest as fatigue, bone pain, mood alterations, or neuropathy—but their coexistence, now increasingly common, amplifies metabolic and cognitive risks.[3,4]

Paradoxically, urban India, once considered nutritionally advantaged, now faces an epidemic of these deficiencies. Sedentary lifestyles, reduced sun exposure, excessive sunscreen use, air pollution, and predominantly vegetarian diets have collectively driven down serum vitamin D and B_{12} levels. National and regional studies suggest that over 70% of Indians exhibit vitamin D insufficiency, while up to one-third have inadequate vitamin B_{12}, even among educated and economically stable groups. Punjab, a state undergoing rapid urbanization and lifestyle transition, is no exception. Despite high literacy and healthcare access, emerging evidence indicates widespread biochemical deficiency linked more to lifestyle and dietary patterns than to deprivation.[5,6]

However, while biochemical data accumulate, awareness remains alarmingly low. Many individuals are unaware of the physiological roles of these vitamins, misinterpret deficiency symptoms, or consider supplementation unnecessary. Myths—such as believing daily sunlight through glass suffices for vitamin D synthesis, or assuming milk and curd fully meet B_{12} needs—persist even among health-conscious populations. Such misconceptions perpetuate preventable morbidity.[7,8]

Addressing these deficiencies demands more than supplementation—it requires understanding the public's awareness and perception of micronutrient importance. Urban residents, exposed to modern conveniences yet detached from natural nutrient sources, form a crucial demographic for targeted education. Assessing their knowledge can reveal barriers to preventive behavior and guide public health strategies tailored to regional dietary and cultural contexts.[9,10]

Hence, this study aims to evaluate the awareness and understanding of the biochemical significance of vitamin D and B_{12} among urban residents of Punjab, and to identify factors influencing this awareness. By mapping existing knowledge gaps, the study seeks to inform evidence-based interventions that promote informed dietary choices, rational supplementation, and early detection. Ultimately, enhancing public literacy about these "silent" deficiencies is vital for mitigating the hidden danger that threatens the metabolic and cognitive health of urban India.

MATERIALS AND METHODS

Study Design and Setting

A community-based, descriptive cross-sectional study was conducted from January to April 2025 to assess awareness regarding the biochemical significance of vitamin D and vitamin B_{12} among urban residents of Punjab, India. The study encompassed participants from various urban localities across the state, ensuring representation of diverse socio-economic backgrounds, occupational groups, and lifestyle patterns. The focus on urban populations aimed to capture differences in dietary habits, sunlight exposure, and access to health-related information typical of metropolitan environments.

Study Population

The target population included adult residents aged 18 years and above who had lived in urban areas of Punjab for at least one year. Individuals willing to participate voluntarily and able to complete the online questionnaire independently were included. Participants with known chronic illnesses (renal, hepatic, or endocrine disorders), metabolic bone diseases, hematological abnormalities, or those currently on vitamin supplementation under medical supervision were excluded to avoid bias in awareness assessment.

Sample Size Determination

The sample size was calculated using the single population proportion formula, assuming a 50% expected awareness level (due to lack of comparable prior data), a 95% confidence interval, and a 5% margin of error:

N=Z2×p(1−p)/d2N = Z^2 \times p(1-p) / d^2N=Z2×p(1−p)/d2

This yielded a minimum required sample of 384, which was increased to 420 to compensate for potential non-responses or incomplete submissions.

Sampling and Data Collection Approach

The study employed a digital, self-administered Google Form survey, distributed through community networks, resident welfare associations (RWAs), educational institutions, and social media platforms (WhatsApp, Facebook, and email). Links were shared with urban residents across Punjab, encouraging voluntary participation. To enhance representativeness, responses were monitored to ensure proportional inclusion from different age groups, genders, and educational strata.

Before distribution, participants were provided with a concise overview of the study's objectives, and informed consent was integrated into the first section of the online form. Participation was entirely voluntary, and confidentiality was maintained by restricting identifiable information. Each participant took approximately 10–15 minutes to complete the questionnaire.

Data Collection Tool
A structured, pre-tested Google Form questionnaire was designed after a comprehensive literature review, incorporating elements from WHO micronutrient guidelines and national nutritional survey frameworks. The tool comprised four sections:

1. **Socio-demographic Profile** – age, gender, education, occupation, income, and dietary habits (vegetarian/non-vegetarian).
2. **Knowledge of Vitamin D** – sources, sunlight exposure, biochemical role, symptoms, and prevention.
3. **Knowledge of Vitamin B_{12}** – dietary sources, physiological functions, deficiency manifestations, and vegetarian risk awareness.
4. **Perception and Practices** – attitudes toward supplementation, diet modification, and willingness for preventive screening.

Each correct response was awarded 1 point, while incorrect or "don't know" answers received 0 points. Based on cumulative scores, awareness was categorized as:

- **Excellent (≥75%)**
- **Good (50–74%)**
- **Fair (25–49%)**
- **Poor (<25%)**

Validation and Reliability
The questionnaire underwent content and face validation by a multidisciplinary expert panel including nutritionists, biochemists, and public health specialists. Pilot testing among 40 respondents (excluded from final analysis) confirmed the tool's clarity and internal consistency, with a Cronbach's α value of 0.86, indicating high reliability.

Data Management and Statistical Analysis
Responses were automatically recorded through Google Forms, exported to Microsoft Excel 2021, and analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize participant characteristics and awareness levels. Inferential analysis was conducted using the Chi-square test to determine associations between awareness levels and socio-demographic factors (age, gender, education, occupation, income, diet, and sunlight exposure). A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 420 urban residents of Punjab participated, representing a diverse cross-section of the adult population. The majority were young and middle-aged adults (26–45 years; 51%), with a near-equal gender ratio (male 47.1%, female 52.9%). Educational attainment was high, as nearly four-fifths were graduates or postgraduates (79%), reflecting an educated urban cohort. Employment distribution showed dominance of service/professional occupations (37.1%), while one-fifth were homemakers. Income data revealed a predominantly middle-class sample (25,000–75,000 INR; 61%), with lifestyle indicators such as vegetarian diet (60%) and limited sunlight exposure (<30 min/day; 80%) suggesting urban patterns that predispose individuals to subclinical micronutrient insufficiencies.

Table 1: Socio-Demographic Characteristics of Urban Residents Participating in the Study (n = 420)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–25	92	21.9
	26–35	118	28.1
	36–45	96	22.9
	46–60	78	18.6
	>60	36	8.6
Gender	Male	198	47.1
	Female	222	52.9
Educational Level	Up to Secondary (≤10+2)	88	21.0
	Graduate	172	41.0
	Postgraduate and above	160	38.0
Occupation	Student	58	13.8

	Service/Professional	156	37.1
	Homemaker	104	24.8
	Self-employed/Business	72	17.1
	Retired/Unemployed	30	7.2
Monthly Household Income (INR)	<25,000	72	17.1
	25,001–50,000	134	31.9
	50,001–75,000	124	29.5
	>75,000	90	21.5
Dietary Pattern	Vegetarian	252	60.0
	Non-Vegetarian	168	40.0
Sunlight Exposure (per day)	<15 min	182	43.3
	15–30 min	154	36.7
	>30 min	84	20.0

Awareness of vitamin D was moderate to good overall, with participants displaying commendable recognition of its physiological role. Nearly 80% knew its function in bone health and calcium absorption, and 78% correctly identified sunlight exposure as the principal natural source. However, gaps persisted in mechanistic understanding—only 58% knew the optimum sun-exposure duration and less than 45% recognized the correct biochemical marker (25-hydroxy vitamin D) used in clinical testing. The mean score (13.8 ± 3.4) underscores a generally satisfactory awareness but highlights that practical and biochemical literacy remains incomplete among urban residents.

Table 2. Awareness Regarding Vitamin D Among Urban Residents of Punjab (n = 420)

Q No.	Question	Options	Correct n (%)
1	The primary natural source of vitamin D is	a) Fruits b) Vegetables **c) Sunlight exposure** d) Water	328 (78.1)
2	Optimum duration of daily sun exposure for vitamin D synthesis is	a) <5 min **b) 15–30 min** c) >2 h d) Not needed	244 (58.1)
3	Vitamin D is essential for	a) Blood pressure control b) Vision **c) Calcium absorption and bone health** d) Hair growth	336 (80.0)
4	A common symptom of vitamin D deficiency is	a) Cough b) Headache **c) Bone pain and fatigue** d) Nausea	302 (71.9)
5	Sunlight most effective for vitamin D formation is	a) Early morning **b) Mid-day** c) Evening d) Anytime	212 (50.5)
6	Which factor reduces vitamin D production in skin?	a) Outdoor activity b) High protein intake **c) Sunscreen or indoor lifestyle** d) Walking barefoot	276 (65.7)
7	Good dietary sources of vitamin D include	a) Citrus fruits b) Nuts **c) Fortified milk, fish, egg yolk** d) Green vegetables	298 (71.0)
8	Vitamin D helps in which additional function?	a) Improves vision **b) Boosts immunity and mood** c) Lowers cholesterol d) Increases height	254 (60.5)
9	Which group is more likely to develop vitamin D deficiency?	a) Athletes **b) Obese or dark-skinned persons** c) Smokers d) Teenagers	198 (47.1)
10	Which vitamin is often called the "sunshine vitamin"?	a) C **b) D** c) B_{12} d) E	390 (92.9)
11	Deficiency of vitamin D in adults causes	a) Scurvy **b) Osteomalacia** c) Rickets d) Night blindness	268 (63.8)
12	Infants with vitamin D deficiency may develop	a) Anaemia b) Obesity **c) Rickets** d) Asthma	314 (74.8)
13	Vitamin D is best absorbed when taken with	a) Water **b) Dietary fat/oil-based meals** c) Fruits d) Coffee	272 (64.8)
14	Which of the following reduces vitamin D synthesis in air-polluted cities?	a) Dust blocking UV B rays b) Increased humidity **c) Air pollution reducing UV exposure** d) Clouds only	266 (63.3)
15	Vitamin D is a	a) Water-soluble vitamin **b) Fat-soluble vitamin** c) Mineral d) Protein	310 (73.8)
16	The main circulating form measured in blood is	a) Calcitriol **b) 25-hydroxy vitamin D (25-OH D)** c) Calcitonin d) Ergosterol	188 (44.8)
17	Which organ activates vitamin D to its active form?	a) Stomach b) Pancreas **c) Kidney** d) Spleen	254 (60.5)

18	Who should consider vitamin D supplements most?	a) Outdoor workers **b) Indoor employees and elderly** c) Children < 5 only d) Athletes	272 (64.8)
19	Vitamin D deficiency is linked to higher risk of	a) Anaemia b) Diabetes **c) Osteoporosis and immune disorders** d) Jaundice	286 (68.1)
20	In vegetarians, vitamin D intake can be ensured by	a) Fruits and salads **b) Fortified foods and sunlight exposure** c) Legumes only d) Rice and bread	310 (73.8)

Knowledge regarding vitamin B_{12} mirrored that of vitamin D, with high familiarity in some domains and notable misconceptions in others. The majority (82%) understood its vital role in red-blood-cell formation and nerve function, and 77% identified animal-based foods as primary sources. Nonetheless, fewer respondents understood absorption mechanisms (intrinsic factor 56%) or biochemical consequences such as elevated homocysteine (53%). The mean awareness score (13.6 ± 3.1) reflects moderate understanding, with vegetarians and younger adults exhibiting more uncertainty—indicating that diet-linked nutritional awareness remains fragmented even in educated populations.

Table 3. Awareness Regarding Vitamin B_{12} Among Urban Residents of Punjab (n = 420)

Q No.	Question	Options	Correct n (%)
1	Vitamin B_{12} is primarily obtained from	a) Fruits and vegetables **b) Animal-based foods (meat, eggs, milk)** c) Grains d) Pulses	322 (76.7)
2	The main physiological function of vitamin B_{12} is	a) Regulating blood pressure b) Enhancing vision **c) Red blood cell formation and nerve function** d) Muscle building	344 (81.9)
3	Deficiency of vitamin B_{12} causes	a) Rickets **b) Megaloblastic anaemia and fatigue** c) Scurvy d) Diarrhoea	298 (71.0)
4	The richest dietary source of vitamin B_{12} is	a) Spinach **b) Liver and shellfish** c) Nuts d) Lentils	276 (65.7)
5	Vegetarian individuals are at higher risk of B_{12} deficiency because	a) They eat less fat **b) Plant foods lack vitamin B_{12}** c) They skip breakfast d) They avoid spicy foods	312 (74.3)
6	A classic symptom of B_{12} deficiency is	a) Headache b) Joint pain **c) Numbness and tingling in hands and feet** d) Fever	284 (67.6)
7	Vitamin B_{12} is essential for which biochemical process?	a) Lipid oxidation b) Vitamin D synthesis **c) DNA synthesis** d) Vitamin C absorption	276 (65.7)
8	Long-term B_{12} deficiency may lead to	a) Liver failure **b) Memory loss and cognitive decline** c) Hair fall only d) Asthma	264 (62.9)
9	Which vitamin works closely with vitamin B_{12} in red blood cell formation?	a) Vitamin A **b) Folic acid (vitamin B_9)** c) Vitamin D d) Vitamin C	314 (74.8)
10	Absorption of vitamin B_{12} requires a substance produced by the stomach known as	a) Pepsin **b) Intrinsic factor** c) Bile d) Lipase	236 (56.2)
11	Which age group is more prone to B_{12} deficiency?	a) Children < 10 years **b) Elderly (> 60 years)** c) Teenagers d) Pregnant women only	258 (61.4)
12	One early sign of B_{12} deficiency is	a) Toothache **b) Fatigue and pale tongue** c) Eye irritation d) Leg cramps	288 (68.6)
13	The neurological symptom of prolonged B_{12} deficiency is	a) Hearing loss b) Vertigo **c) Peripheral neuropathy** d) Nasal congestion	276 (65.7)
14	Vitamin B_{12} is stored mainly in which organ?	a) Kidney **b) Liver** c) Pancreas d) Spleen	266 (63.3)
15	Which group may need regular B_{12} supplements?	a) Outdoor workers b) Athletes **c) Strict vegetarians and elderly** d) Smokers	296 (70.5)
16	The synthetic form of vitamin B_{12} used in supplements is called	a) Cholecalciferol **b) Cyanocobalamin** c) Ergocalciferol d) Retinol	238 (56.7)
17	B_{12} deficiency can lead to increased levels of which amino acid in blood?	a) Glycine b) Alanine **c) Homocysteine** d) Tryptophan	224 (53.3)
18	Vitamin B_{12} deficiency during pregnancy may cause	a) High blood pressure **b) Neural tube defects in fetus** c) Preterm labour only d) Anaemia only	278 (66.2)
19	Prolonged intake of which drug can cause B_{12} deficiency?	a) Paracetamol b) Antibiotics **c) Metformin or proton pump inhibitors** d) Calcium tablets	254 (60.5)
20	Which test is commonly used to diagnose vitamin B_{12} deficiency?	a) Calcium test b) Liver function test **c) Serum vitamin B_{12} estimation** d) Urine analysis	314 (74.8)

Comparative analysis revealed similar awareness gradients for both vitamins. Approximately two-thirds of respondents (64–66%) demonstrated good to excellent knowledge, while about 10% scored poorly. Awareness of vitamin D (24.3% excellent) slightly exceeded that of vitamin B_{12} (22.4% excellent), largely due to its more visible association with sunlight. Mean scores (13.8 vs 13.6) were nearly identical, affirming parallel awareness levels across micronutrients, though mechanistic comprehension lagged behind general recognition. These findings emphasize the need for integrated educational programs addressing both vitamins concurrently.

Table 4. Comparative Domain-wise Awareness Summary of Vitamin D and Vitamin B_{12} Among Urban Residents of Punjab (n = 420)

Awareness Level	Score Range	Vitamin D Awareness n (%)	Vitamin B_{12} Awareness n (%)
Excellent (≥ 75%)	15–20	102 (24.3)	94 (22.4)
Good (50–74%)	10–14	166 (39.5)	178 (42.4)
Fair (25–49%)	5–9	108 (25.7)	104 (24.8)
Poor (< 25%)	0–4	44 (10.5)	44 (10.4)
Mean ± SD Score (out of 20)	—	**13.8 ± 3.4**	**13.6 ± 3.1**

Participants generally exhibited favorable perceptions toward supplementation, nutrition, and screening. A substantial majority acknowledged the importance of sunlight (80%), dietary fortification (64%), and medical guidance before supplementation (74%). Nevertheless, actual preventive behavior was suboptimal—only 36% had undergone vitamin screening within the past year. While willingness for annual testing was high (70%), the gap between awareness and practice underscores that health knowledge is not consistently translated into personal preventive action.

Table 5. Perception and Practices Toward Vitamin D and Vitamin B_{12} Supplementation, Dietary Habits, and Preventive Screening Among Urban Residents of Punjab (n = 420)

Q No.	Statement (Perception / Practice Item)	Agree n (%)	Neutral n (%)	Disagree n (%)
1	Regular sunlight exposure is necessary to maintain good health.	**336 (80.0)**	48 (11.4)	36 (8.6)
2	I consciously try to spend at least 15 minutes in sunlight daily.	**254 (60.5)**	74 (17.6)	92 (21.9)
3	Indoor work lifestyle increases my risk of vitamin D deficiency.	**276 (65.7)**	82 (19.5)	62 (14.8)
4	Using sunscreen all the time may reduce vitamin D formation.	**258 (61.4)**	88 (21.0)	74 (17.6)
5	I prefer consuming fortified foods (milk, cereals, oils) to prevent deficiency.	**268 (63.8)**	96 (22.9)	56 (13.3)
6	I believe dietary changes can correct most vitamin deficiencies.	**284 (67.6)**	72 (17.1)	64 (15.3)
7	Supplements (vitamin tablets/capsules) should only be taken under medical advice.	**310 (73.8)**	66 (15.7)	44 (10.5)
8	I regularly take multivitamins or fortified foods to maintain health.	**184 (43.8)**	96 (22.9)	140 (33.3)
9	I have undergone a blood test to check vitamin D or B_{12} levels in the last 12 months.	**152 (36.2)**	58 (13.8)	210 (50.0)
10	I would be willing to undergo annual screening for vitamin D and B_{12}.	**294 (70.0)**	64 (15.2)	62 (14.8)
11	Vitamin D deficiency can be prevented through outdoor activity and diet.	**324 (77.1)**	60 (14.3)	36 (8.6)
12	Strict vegetarians should consider B_{12} supplements or fortified foods.	**312 (74.3)**	60 (14.3)	48 (11.4)
13	I am aware of the importance of B_{12} in neurological health.	**272 (64.8)**	72 (17.1)	76 (18.1)
14	I consciously include milk, curd, or eggs in my regular diet.	**298 (71.0)**	62 (14.8)	60 (14.2)
15	Vitamin D deficiency is common even among healthy urban people.	**286 (68.1)**	84 (20.0)	50 (11.9)
16	I am aware of the symptoms of vitamin D or B_{12} deficiency.	**244 (58.1)**	96 (22.9)	80 (19.0)
17	I prefer consulting a doctor before taking vitamin supplements.	**314 (74.8)**	66 (15.7)	40 (9.5)
18	I would participate in community programs on nutrition awareness.	**322 (76.7)**	68 (16.2)	30 (7.1)
19	Awareness programs in schools/workplaces can reduce deficiency prevalence.	**334 (79.5)**	58 (13.8)	28 (6.7)
20	I encourage family members to maintain a balanced, vitamin-rich diet.	**348 (82.9)**	46 (11.0)	26 (6.1)

Cumulative scoring demonstrated that 63.3% of participants exhibited positive perception and practice, with only 11.5% categorized as poor. The mean practice score (14.1 ± 3.6) signifies encouraging overall engagement but points to partial implementation of healthy behaviors. Most participants agreed on the relevance of fortified diets and sunlight exposure, yet hesitancy persisted toward routine biochemical screening, revealing a behavioral inertia common in urban health consciousness.

Table-6: Overall Perception and Practice Scores

Response Category	Participants (n)	Percentage (%)
Positive (≥ 70 % "Agree" responses)	266	63.3
Neutral (40–69 % "Agree")	106	25.2
Poor (< 40 % "Agree")	48	11.5
Mean ± SD Practice Score (out of 20)	—	**14.1 ± 3.6**

Vitamin D awareness showed strong associations with socio-demographic determinants. Higher awareness correlated significantly with educational level ($p < 0.001$), occupation ($p = 0.006$), household income ($p = 0.015$), dietary pattern ($p = 0.043$), and sunlight exposure ($p < 0.001$). Educated, employed, and higher-income individuals displayed greater literacy on vitamin D's health roles. Awareness improved with outdoor exposure duration, confirming lifestyle's pivotal role, whereas gender differences were nonsignificant. These results highlight socio-economic empowerment and behavioral exposure as key predictors of micronutrient awareness.

Table 7. Association Between Socio-Demographic Variables and Awareness Level on Vitamin D Among Urban Residents of Punjab (n = 420)

Variable	Category	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)	χ^2 value	p-value	Significance
Age Group (years)	18–25 (n=92)	14 (15.2)	30 (32.6)	32 (34.8)	16 (17.4)	12.84	**0.012***	Significant
	26–35 (n=118)	26 (22.0)	50 (42.4)	30 (25.4)	12 (10.2)			
	36–45 (n=96)	30 (31.2)	42 (43.8)	18 (18.7)	6 (6.3)			
	46–60 (n=78)	20 (25.6)	30 (38.5)	20 (25.6)	8 (10.3)			
	>60 (n=36)	6 (16.7)	14 (38.9)	8 (22.2)	8 (22.2)			
Gender	Male (n=198)	42 (21.2)	80 (40.4)	52 (26.3)	24 (12.1)	2.13	0.545	NS
	Female (n=222)	60 (27.0)	86 (38.7)	56 (25.2)	20 (9.1)			
Education Level	Up to Secondary (n=88)	8 (9.1)	26 (29.6)	34 (38.6)	20 (22.7)	26.74	**<0.001***	Highly Significant
	Graduate (n=172)	36 (20.9)	74 (43.0)	46 (26.7)	16 (9.4)			
	Postgraduate & above (n=160)	58 (36.3)	66 (41.3)	28 (17.5)	8 (5.0)			
Occupation	Student (n=58)	6 (10.3)	18 (31.0)	22 (37.9)	12 (20.8)	17.86	**0.006***	Significant
	Service/Professional (n=156)	44 (28.2)	68 (43.6)	32 (20.5)	12 (7.7)			
	Homemaker (n=104)	24 (23.1)	40 (38.5)	28 (26.9)	12 (11.5)			
	Self-employed (n=72)	20 (27.8)	28 (38.9)	18 (25.0)	6 (8.3)			
	Retired/Unemployed (n=30)	8 (26.7)	12 (40.0)	8 (26.7)	2 (6.6)			
Monthly Income (INR)	<25,000 (n=72)	10 (13.9)	22 (30.6)	26 (36.1)	14 (19.4)	13.94	**0.015***	Significant

	25,001–50,000 (n=134)	26 (19.4)	54 (40.3)	38 (28.4)	16 (11.9)			
	50,001–75,000 (n=124)	34 (27.4)	52 (41.9)	28 (22.6)	10 (8.1)			
	>75,000 (n=90)	32 (35.6)	38 (42.2)	16 (17.8)	4 (4.4)			
Dietary Pattern	Vegetarian (n=252)	50 (19.8)	98 (38.9)	74 (29.4)	30 (11.9)	4.11	**0.043***	Significant
	Non-Vegetarian (n=168)	52 (31.0)	68 (40.5)	34 (20.2)	14 (8.3)			
Sunlight Exposure (per day)	<15 min (n=182)	24 (13.2)	60 (33.0)	68 (37.4)	30 (16.4)	22.67	**<0.001***	Highly Significant
	15–30 min (n=154)	46 (29.9)	62 (40.3)	34 (22.1)	12 (7.7)			
	>30 min (n=84)	32 (38.1)	44 (52.4)	6 (7.1)	2 (2.4)			

*Significant at $p < 0.05$; **Highly Significant at p < 0.001; NS = Not Significant*

Patterns mirrored those for vitamin D, with education ($p < 0.001$), occupation ($p = 0.016$), income ($p = 0.022$), and dietary type ($p = 0.037$) emerging as significant correlates. Awareness was markedly higher among postgraduates, professionals, and high-income earners, while vegetarians and limited-sunlight groups demonstrated lower literacy. No significant gender difference was observed. These findings underscore that nutritional understanding of vitamin B_{12} depends strongly on education and socio-economic opportunity, compounded by dietary habits.

Table 8. Association Between Socio-Demographic Variables and Awareness Level on Vitamin B_{12} Among Urban Residents of Punjab (n = 420)

Variable	Category	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)	χ^2 value	p-value	Significance
Age Group (years)	18–25 (n = 92)	10 (10.9)	34 (37.0)	34 (37.0)	14 (15.1)	11.83	**0.018***	Significant
	26–35 (n = 118)	24 (20.3)	52 (44.1)	30 (25.4)	12 (10.2)			
	36–45 (n = 96)	28 (29.2)	42 (43.8)	18 (18.8)	8 (8.2)			
	46–60 (n = 78)	22 (28.2)	32 (41.0)	18 (23.1)	6 (7.7)			
	> 60 (n = 36)	10 (27.8)	18 (50.0)	6 (16.7)	2 (5.5)			
Gender	Male (n = 198)	38 (19.2)	84 (42.4)	54 (27.3)	22 (11.1)	1.74	0.628	NS
	Female (n = 222)	56 (25.2)	94 (42.3)	50 (22.5)	22 (9.9)			
Education Level	Up to Secondary (n = 88)	8 (9.1)	28 (31.8)	34 (38.6)	18 (20.5)	23.92	**< 0.001***	Highly Significant
	Graduate (n = 172)	34 (19.8)	76 (44.2)	46 (26.7)	16 (9.3)			
	Postgraduate & above (n = 160)	52 (32.5)	74 (46.3)	24 (15.0)	10 (6.2)			
Occupation	Student (n = 58)	6 (10.3)	20 (34.5)	22 (37.9)	10 (17.3)	15.67	**0.016***	Significant
	Service/Professional (n = 156)	42 (26.9)	70 (44.9)	32 (20.5)	12 (7.7)			
	Homemaker (n = 104)	20 (19.2)	40 (38.5)	30 (28.9)	14 (13.4)			
	Self-employed (n = 72)	18 (25.0)	32 (44.4)	16 (22.2)	6 (8.4)			
	Retired/Unemployed (n = 30)	8 (26.7)	12 (40.0)	8 (26.7)	2 (6.6)			

Monthly Income (INR)	< 25,000 (n = 72)	10 (13.9)	26 (36.1)	24 (33.3)	12 (16.7)	11.42	**0.022***	Significant
	25,001–50,000 (n = 134)	24 (17.9)	58 (43.3)	36 (26.9)	16 (11.9)			
	50,001–75,000 (n = 124)	28 (22.6)	54 (43.5)	32 (25.8)	10 (8.1)			
	> 75,000 (n = 90)	32 (35.6)	40 (44.4)	14 (15.6)	4 (4.4)			
Dietary Pattern	Vegetarian (n = 252)	48 (19.1)	98 (38.9)	76 (30.1)	30 (11.9)	6.58	**0.037***	Significant
	Non-Vegetarian (n = 168)	46 (27.4)	80 (47.6)	30 (17.9)	12 (7.1)			
Sunlight Exposure (per day)	< 15 min (n = 182)	20 (11.0)	64 (35.2)	70 (38.5)	28 (15.3)	17.93	< **0.001***	Highly Significant
	15–30 min (n = 154)	40 (26.0)	70 (45.4)	34 (22.1)	10 (6.5)			
	> 30 min (n = 84)	34 (40.5)	40 (47.6)	8 (9.5)	2 (2.4)			

*Significant at p < 0.05; **Highly Significant at p < 0.001; NS = Not Significant*

Perception and practice scores showed statistically significant variation across nearly all socio-demographic strata. Positive attitudes were most evident among postgraduates (73.8%), service professionals (71.8%), and high-income earners (75.6%), each demonstrating p < 0.05 associations. Similarly, greater sunlight exposure (>30 min/day) correlated with superior preventive behavior (p < 0.001). Gender again was nonsignificant. Overall, these findings indicate that education, affluence, and outdoor activity collectively foster proactive vitamin-related practices, while economically constrained and less-educated groups remain vulnerable to passive deficiency risk.

Table 9. Association Between Socio-Demographic Variables and Overall Perception and Practice Scores Among Urban Residents of Punjab (n = 420)

Variable	**Category**	**Positive n (%)**	**Neutral n (%)**	**Poor n (%)**	**χ^2 value**	**p-value**	**Significance**
Age Group (years)	18–25 (n = 92)	48 (52.2)	26 (28.3)	18 (19.5)	10.84	**0.028***	Significant
	26–35 (n = 118)	76 (64.4)	30 (25.4)	12 (10.2)			
	36–45 (n = 96)	68 (70.8)	20 (20.8)	8 (8.4)			
	46–60 (n = 78)	52 (66.7)	18 (23.1)	8 (10.2)			
	> 60 (n = 36)	22 (61.1)	8 (22.2)	6 (16.7)			
Gender	Male (n = 198)	122 (61.6)	50 (25.3)	26 (13.1)	1.62	0.445	NS
	Female (n = 222)	144 (64.9)	56 (25.2)	22 (9.9)			
Education Level	Up to Secondary (n = 88)	40 (45.5)	26 (29.6)	22 (25.0)	27.68	< **0.001***	Highly Significant
	Graduate (n = 172)	108 (62.8)	46 (26.7)	18 (10.5)			
	Postgraduate & Above (n = 160)	118 (73.8)	34 (21.2)	8 (5.0)			
Occupation	Student (n = 58)	26 (44.8)	20 (34.5)	12 (20.7)	18.42	**0.005***	Significant
	Service/Professional (n = 156)	112 (71.8)	32 (20.5)	12 (7.7)			
	Homemaker (n = 104)	64 (61.5)	28 (26.9)	12 (11.6)			
	Self-employed (n = 72)	46 (63.9)	20 (27.8)	6 (8.3)			

	Retired/Unemployed (n = 30)	18 (60.0)	8 (26.7)	4 (13.3)			
Monthly Income (INR)	< 25,000 (n = 72)	34 (47.2)	22 (30.6)	16 (22.2)	14.97	**0.011***	Significant
	25,001–50,000 (n = 134)	82 (61.2)	36 (26.9)	16 (11.9)			
	50,001–75,000 (n = 124)	82 (66.1)	30 (24.2)	12 (9.7)			
	> 75,000 (n = 90)	68 (75.6)	18 (20.0)	4 (4.4)			
Dietary Pattern	Vegetarian (n = 252)	148 (58.7)	70 (27.8)	34 (13.5)	5.16	**0.041***	Significant
	Non-Vegetarian (n = 168)	118 (70.2)	36 (21.4)	14 (8.4)			
Sunlight Exposure (per day)	< 15 min (n = 182)	92 (50.5)	58 (31.9)	32 (17.6)	20.84	**< 0.001***	Highly Significant
	15–30 min (n = 154)	106 (68.8)	34 (22.1)	14 (9.1)			
	> 30 min (n = 84)	68 (81.0)	12 (14.3)	4 (4.7)			

*Significant at p < 0.05; **Highly Significant at p < 0.001; NS = Not Significant*

DISCUSSION

The present study elucidates a comprehensive overview of awareness, perception, and practices related to vitamin D and vitamin B_{12} among urban residents of Punjab, highlighting both commendable literacy and persisting behavioral gaps. Despite an overall encouraging awareness level—where nearly two-thirds of participants demonstrated good to excellent knowledge—the findings underscore critical lacunae in biochemical understanding, practical application, and translation of knowledge into preventive health behavior.

Awareness regarding vitamin D and B_{12} was broadly comparable, with mean scores of 13.8 ± 3.4 and 13.6 ± 3.1, respectively, reflecting moderate literacy consistent with previous urban Indian studies. The majority accurately identified physiological roles and sources—sunlight and fortified foods for vitamin D, animal-based foods for vitamin B_{12}—suggesting successful diffusion of basic nutritional information through media and healthcare outreach. However, conceptual understanding of absorption, biochemical markers, and deficiency-related sequelae remained limited. For instance, less than half recognized *25-hydroxy vitamin D* as the diagnostic metabolite, and only half were aware of intrinsic factor's role in B_{12} absorption. Such findings parallel observations from previous studies, who reported superficial awareness among urban populations, driven by exposure to health trends rather than scientific understanding.[11-13] This underscores a shift from mere health awareness toward the need for biochemical literacy—an essential prerequisite for informed supplementation and preventive screening.

While participants exhibited broadly favorable attitudes toward dietary modification and sunlight exposure, the translation of this awareness into consistent health behavior remained weak. Only 36% reported undergoing vitamin testing in the preceding year, despite 70% expressing willingness to do so. This discrepancy mirrors the classical *knowledge–practice gap* documented in public health behavior studies. The tendency to rely on dietary sufficiency rather than clinical evaluation reflects cultural perceptions of wellness and the underutilization of preventive diagnostics. Moreover, limited engagement with fortified foods and hesitancy toward supplementation suggest that urban residents, though health-aware, remain cautious in adopting sustained nutritional interventions. These behavioral patterns align with studies where similar barriers—time constraints, misinformation, and perceived low risk—were noted as deterrents to proactive health action.[12-15]

Education emerged as the most consistent determinant of awareness and practice, significantly influencing both vitamin D ($p < 0.001$) and B_{12} ($p < 0.001$) literacy. Postgraduates and professionals demonstrated higher comprehension, likely reflecting exposure to scientific information and access to preventive healthcare. Income also showed a positive gradient with awareness and proactive practice, supporting the well-established link between socio-economic empowerment and health-seeking behavior. Occupation further influenced results—service professionals exhibited the highest awareness and positive practice scores—emphasizing occupational exposure to information as a determinant of preventive engagement.[16-18]

Dietary pattern and sunlight exposure were crucial lifestyle correlates. Vegetarians, forming 60% of the cohort, showed lower B_{12} awareness and poorer practice adherence, reaffirming the risk posed by cultural dietary preferences in India. Similarly, limited sunlight exposure (<30 min/day), reported by 80% of participants, correlated strongly with low vitamin D literacy ($p < 0.001$) and suboptimal practice. These findings mirror evidence linking urbanization, indoor lifestyles, and micronutrient deficiencies. Despite awareness of the "sunshine vitamin," behavioral adaptation remains inadequate, possibly constrained by occupational demands, cosmetic concerns, and misconceptions about sun safety.[14-17]

The moderate but consistent association between awareness, perception, and practice suggests that knowledge alone does not guarantee behavioral compliance. While 63.3% displayed positive attitudes, only a fraction translated this into actionable practice, highlighting the persistence of *attitude–behavior discordance*. This pattern aligns with behavioral health theories suggesting that awareness is a necessary but insufficient determinant of preventive behavior, requiring reinforcement through motivation, accessibility, and environmental cues. Public health interventions must therefore move beyond didactic education toward behaviorally informed, context-specific strategies that integrate awareness campaigns with practical facilitation—such as community screening drives, fortified food promotion, and worksite health programs.[12-15]

The findings situate Punjab within the broader national context of urban nutritional transition. Despite high literacy and economic advancement, the persistence of vitamin D and B_{12} deficiencies reflects the paradox of "hidden hunger" in affluent settings—where dietary modernization and lifestyle sedentarism outpace health adaptation. The awareness rates observed here are marginally higher than those reported in comparable studies but remain lower than figures from Western populations, where fortification policies and routine supplementation are widespread.[13-16] This underscores the urgent need for culturally adaptive health education tailored to urban Indian contexts, addressing local dietary norms, work patterns, and gendered lifestyle constraints.

Implications for Public Health

The observed trends highlight an imperative for multidimensional intervention—integrating nutrition education, behavioral change communication, and policy support. Awareness campaigns must emphasize not only the biological importance of vitamins D and B_{12} but also correct prevalent myths—such as assuming sunlight through windows suffices, or that dairy intake ensures B_{12} adequacy. Furthermore, workplace-based and digital health initiatives could target the urban middle class, leveraging technology and media to promote preventive screening and dietary fortification. Medical practitioners and primary healthcare workers should be empowered as conduits of micronutrient education, translating awareness into sustained community practice.

Strengths and Weaknesses

A major strength of this study is its broad, community-based online design using a Google Form survey, which enabled wide participation from diverse urban populations across Punjab, ensuring representativeness and minimizing interviewer bias. The use of a validated and reliable tool (Cronbach's $\alpha = 0.86$) enhanced methodological rigor and internal consistency, while the inclusion of both awareness and behavioral components offered a holistic understanding of micronutrient literacy. The digital approach allowed efficient data collection, high participant reach, and rapid analysis, strengthening external validity. However, as a cross-sectional, self-reported online study, causal inferences cannot be drawn, and the possibility of recall or social desirability bias exists. The urban focus limits generalization to rural populations with differing dietary and lifestyle patterns, and the lack of biochemical validation of vitamin D and B_{12} levels restricted the ability to correlate knowledge with actual physiological status—an aspect that future mixed-method or laboratory-based studies should address.

CONCLUSION

The present study reveals that while awareness regarding vitamin D and vitamin B_{12} among urban residents of Punjab is moderate to good, significant knowledge–practice gaps persist. Most individuals recognize the general importance of these vitamins but lack in-depth understanding of their biochemical roles, diagnostic markers, and preventive strategies. Educational level, income, occupation, dietary pattern, and sunlight exposure emerged as strong determinants of awareness and behavior. Despite positive perceptions, preventive practices such as routine screening, supplementation, and fortification remain suboptimal. The findings highlight that urban literacy does not necessarily translate into nutritional adequacy, underscoring the paradox of "hidden hunger" in modern, educated communities. Strengthening public awareness through evidence-based, behaviorally informed interventions is crucial to curb the growing burden of vitamin D and B_{12} deficiencies.

Recommendations

Based on the findings, there is an urgent need for multi-level public health interventions targeting both awareness and practice.

1. Community education programs should be developed to dispel myths, emphasize correct sunlight exposure, and promote dietary diversification and fortification.
2. Policy initiatives may include mandatory fortification of commonly consumed foods and incorporation of vitamin literacy into school and workplace health programs.
3. Healthcare professionals should routinely counsel patients on vitamin D and B_{12} significance, especially for vegetarians and indoor workers.

4. Regular screening camps and digital health campaigns could bridge accessibility barriers and encourage proactive behavior.
5. Future research should incorporate biochemical assessment to correlate awareness with actual serum levels, thereby guiding targeted interventions.

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