Awareness and Knowledge about Vitamin D among College Students: A Review

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Abstract— *Vitamin D deficiency constitutes a widespread public health issue, especially among college students whose lifestyles frequently restrict sun exposure and dietary consumption of this essential nutrient. This review investigates the awareness of Vitamin D among college students in Lucknow, a swiftly urbanizing metropolis in North India, by a systematic analysis of global and regional studies. This research identifies substantial knowledge gaps by synthesizing data from many contexts and applying them to Lucknow's distinct socio-cultural and environmental backdrop, despite a foundational awareness of Vitamin D's significance. Elements including academic discipline, gender, dietary practices, and availability of health education influence awareness levels, revealing significant differences among demographics. The paper examines the ramifications for health promotion, identifies obstacles to knowledge diffusion, and suggests customized interventions to bridge these gaps. This report provides a detailed analysis, highlighting the immediate necessity for specific educational interventions to reduce Vitamin D insufficiency risks among college students in Lucknow.*

Keywords— Vitamin D, awareness, knowledge, college students, public health, health education, deficiency.

I. INTRODUCTION

1.1 The Multifaceted Role of Vitamin D in Human Health:

Vitamin D, sometimes referred to as the "sunshine vitamin," is a fat-soluble nutrient distinguished by its dual role as both a dietary element and a hormone produced by the body. The principal source is endogenous synthesis in the skin, where ultraviolet B (UVB) radiation from sunshine transforms 7-dehydrocholesterol into cholecalciferol (Vitamin D3). The molecule undergoes hydroxylation in the liver to make 25-hydroxyvitamin D (25(OH)D), the circulating form utilized to evaluate Vitamin D status, and is subsequently activated in the kidneys to produce 1,25-dihydroxyvitamin D (calcitriol), the physiologically active form. This complex metabolic route highlights Vitamin D's function as a prohormone, engaging with Vitamin D receptors present in almost all tissues, including bones and brain cells. Historically acknowledged for its function in calcium regulation and skeletal health, preventing rickets in children and Osteomalacia or osteoporosis in adults, the importance of Vitamin D has significantly increased in recent decades. As Fig.1 shows the important role and deficiency factors of Vitamin D. Also, research has demonstrated its role in immunological regulation, decreasing the likelihood of diseases such as tuberculosis and influenza by augmenting innate immunity via cathelicidin synthesis. In addition to its role in immunity, Vitamin D affects cell proliferation and differentiation, providing preventive benefits against malignancies, including colorectal and breast cancer. Cardiovascular health is enhanced, since research associates sufficient Vitamin D levels with reduced risks of hypertension and atherosclerosis, facilitated by its anti-inflammatory effects and modulation of the renin-angiotensin system. Mental health constitutes another domain where the influence of Vitamin D is becoming increasingly apparent. Reduced levels have been linked to depression, anxiety, and seasonal affective disorder, disorders common among college students

experiencing scholastic stress. Anglin et al. [2] conducted a meta-analysis that revealed a statistically significant association between Vitamin D insufficiency and depressive symptoms, indicating a potential neurobiological function perhaps related to vitamin D receptors in the hippocampus and prefrontal cortex. These findings are especially relevant for young adults, whose cerebral development persists into their early twenties, rendering Vitamin D an essential nutrient during this period. In India, despite enough sunlight, Vitamin D insufficiency impacts 70-100% of the population, a contradiction influenced by urbanization, pollution, and cultural habits. College students in urban centre's such as Lucknow exemplify this concern, as their scholastic obligations and indoor lifestyles restrict sun exposure, while food sources are limited in conventional vegetarian diets. This section examines these dynamics comprehensively, establishing a foundation for comprehending awareness levels among college students in Lucknow.

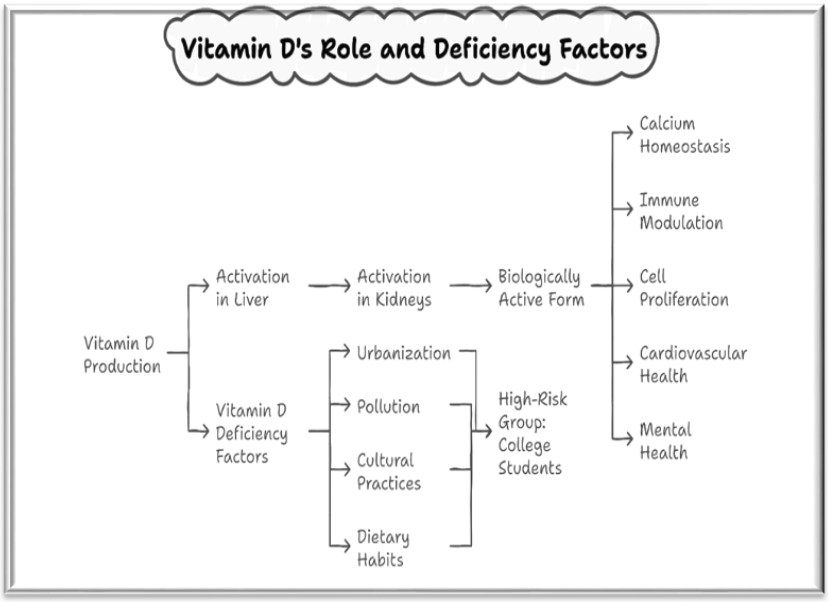

FIGURE 1: Vitamin D's Role and Deficiency Factor

1.2 Global and Indian Context of Vitamin D Deficiency:

Worldwide, Vitamin D insufficiency constitutes a silent epidemic, impacting nearly one billion individuals, according to Holick [9]. In affluent countries, the fortification of foods such as milk and cereals has alleviated severe deficiencies; yet, inadequate amounts remain due to diminished sun exposure resulting from sedentary lifestyles and the application of sunscreen. Conversely, developing nations such as India encounter a distinct challenge: plentiful sunshine is compromised by environmental and behavioural influences. Research demonstrates that 25(OH)D levels below 20 ng/ml, classified as inadequate, are prevalent throughout all age demographics in India, with urban populations being especially susceptible. The Indian context is characterized by a convergence of variables. Urbanization has concentrated populations inside, diminishing UVB exposure vital for Vitamin D production. Air pollution, a critical concern in urban areas such as Lucknow, disperses and absorbs UVB rays, hence reducing cutaneous synthesis. Cultural conventions intensify this phenomenon: the inclination towards pale skin promotes sunscreen application and sun evasion, while conventional attire, particularly for women, conceals the majority of the body. Harinarayan et al. [8] discovered that, despite the abundant sunlight in southern India, insufficiency rates surpass 80% owing to these obstacles. Dietary consumption provides minimal relief. Natural sources of Vitamin D, such as fatty fish, egg yolks, and liver, are scarce in predominantly vegetarian Indian diets, particularly in regions like Uttar Pradesh. Fortified foods, although accessible in metropolitan markets, are rarely extensively consumed, especially by budget-conscious students dependent on hostel meals or street food. Ritu and Gupta [18] emphasize that fortified milk is underutilized due to cost and awareness deficiencies, resulting in supplementation being infrequently pursued. The dietary deficiency, along with environmental limitations, categorizes college students as a high-risk demographic, warranting a more thorough investigation of their knowledge.

1.3 Challenges Specific to College Students in Lucknow:

Lucknow, the capital of Uttar Pradesh, amalgamates heritage and modernity, including esteemed institutions such as Babasaheb Bhimrao Ambedkar University, Lucknow. College students, numbering in the tens of thousands, encounter distinct problems that exacerbate the hazards of Vitamin D insufficiency. Academic timetables are demanding, involving extensive hours in

classrooms, libraries, or dormitories, which limit sun exposure. A proposed day schedule may encompass morning lectures, afternoon study periods, and evening tasks, resulting in minimal opportunity for outdoor pursuits. Even physical education sessions, when available, are frequently conducted indoors or during early morning hours when UVB rays are inadequate. Environmental factors exacerbate this condition. Lucknow is classified as one of India's most polluted cities, with particulate matter (PM2.5) concentrations often beyond permissible thresholds. This pollution disperses UVB photons, diminishing their availability for Vitamin D production. Research conducted by Harinarayan et al. [8] in Hyderabad, a similarly polluted urban centre, revealed that air aerosols reduced UVB penetration by as much as 50%, a phenomenon presumably reflected in Lucknow. Seasonal fluctuations, including the city's fog-laden winters, significantly restrict sunshine, especially from November to February, coinciding with students' peak academic engagement. The conservative mindset of Lucknow culturally impacts student behaviour. Female students, comprising a substantial segment of the college demographic, frequently don full-length garments such as salwar kameez or sarees, thereby minimizing skin exposure. The cultural preference for pale skin deters tanning, especially among male students who may otherwise participate in outdoor sports. Dietary practices mirror regional conventions: vegetarianism is predominant, with hostel menus primarily featuring grains, lentils, and vegetables, lacking Vitamin D-rich items. Fast food, a mainstay for students, provides calories without any nutritious compensation for this deficiency. Socioeconomic diversity introduces an additional dimension. Students from wealthy homes may utilize supplements or fortified items, whilst those from lower-income backgrounds depend exclusively on sunlight and limited nutritional sources. This discrepancy undoubtedly affects awareness, as affluent students may get health information via private healthcare or media, in contrast to their counterparts reliant on public resources. These problems underscore the necessity to evaluate and improve Vitamin D awareness among college students in Lucknow.

1.4 The Importance of Awareness in Preventive Health:

Awareness is the cornerstone of preventative health, connecting information and action. The Health Belief Model (HBM) asserts that behavioural modification depends on perceived susceptibility, severity, advantages, and obstacles. Students must identify their risk factors for Vitamin D deficiency (e.g., sedentary indoor lifestyles), comprehend the potential repercussions (e.g., osteoporosis, depression), acknowledge the advantages of proactive measures (e.g., enhanced immunity), and surmount obstacles (e.g., time limitations). However, awareness is inadequate without precise, actionable knowledge. Research indicates that college pupils, notwithstanding their degree, possess misunderstandings regarding Vitamin D. Srinivasan et al. [22] discovered that several individuals overestimate the necessary sun exposure, supposing that several hours are essential, whereas 15-30 minutes of midday exposure on the face and arms is adequate for lighter skin tones (darker complexion, common in India, necessitates more). Many individuals are oblivious to food sources or supplements, mistakenly believing that sunlight alone suffices for their requirements—an erroneous assumption in polluted, metropolitan environments. These deficiencies highlight the necessity for focused education that dispels misconceptions and offers pragmatic solutions.

In Lucknow, awareness is further hindered by restricted health literacy beyond medical fields. Non-medical students, including engineers, artists, or commerce majors, may lack exposure to nutritional science and depend on informal sources such as peers or social media, potentially perpetuating misconceptions. Manandhar et al. [14] discovered that even medical students possess only moderate knowledge, indicating that awareness efforts should be comprehensive yet customized. This review seeks to analyse these dynamics, providing a basis for actions that align with Lucknow's varied student population.

1.5 Objectives of the Review:

This study aims to achieve four principal objectives:

- **Evaluate Awareness Levels:** Determine the existing knowledge of Vitamin D among college students in Lucknow, integrating global and Indian data to infer local trends.
- **Ascertain Determinants:** Identify determinants affecting awareness, including education, gender, and socioeconomic status, to inform targeted interventions.
- **Examine Demographic Disparities:** Investigate variations in awareness among subgroups, pinpointing inequalities that require intervention. And Suggest Interventions: Identify research deficiencies and propose practical measures to improve awareness, specifically suited to the context of Lucknow. This comprehensive analysis aims to highlight a significant public health concern, promoting educated and proactive health behaviours among college students. To enhance health
- maintenance and address vitamin D deficiency, one should incorporate comprehensive dietary sources of vitamin D, including natural food sources, fortified foods, and supplements administered in appropriate dosages and formulations

as recommended by a healthcare professional tailored to the individual patient. Some sources are illustrated in Table 1. Also factors which influences the vitamin D levels shown in fig.2

TABLE 1
SOURCES OF VITAMIN D, THEIR TYPES, AND ESTIMATED INTAKE LEVELS

Source Type	Examples	Vitamin D Content	Type of Vitamin D	Approximate Dose (IU per serving)
Natural Food Sources	Fatty fish (salmon, mackerel, tuna, sardines)	High	Vitamin D3 (Cholecalciferol)	400–600 IU per 3.5 oz (100g)
	Egg yolks	Moderate	Vitamin D3 (Cholecalciferol)	40–50 IU per yolk
	Mushrooms (especially sun-exposed)	Moderate	Vitamin D2 (Ergocalciferol)	200–500 IU per 3.5 oz (100g)
	Cod liver oil	Very High	Vitamin D3 (Cholecalciferol)	1,360 IU per 1 tablespoon
Fortified Foods	Fortified dairy products (milk, yogurt, cheese)	Varies (depends on fortification level)	Vitamin D3 (Cholecalciferol)	100–150 IU per cup (milk)
	Fortified plant-based milk (soy, almond, oat)	Varies	Vitamin D2 or D3 (Varies by brand)	100–150 IU per cup
	Fortified cereals and orange juice	Moderate	Vitamin D2 or D3 (Varies by brand)	40–100 IU per serving
Supplements	Vitamin D2 and D3 supplements	Controlled dose	Vitamin D2 or D3 (Depends on the supplement)	400–5,000 IU per dose (varies)
Sunlight Exposure	UVB rays from sunlight	Essential for skin synthesis	Helps skin synthesize Vitamin D3	10,000–25,000 IU (15–30 min midday sun exposure)

Note: The figures of International Units (IU) are estimations and may fluctuate according on the brand, fortification levels, and portion size.

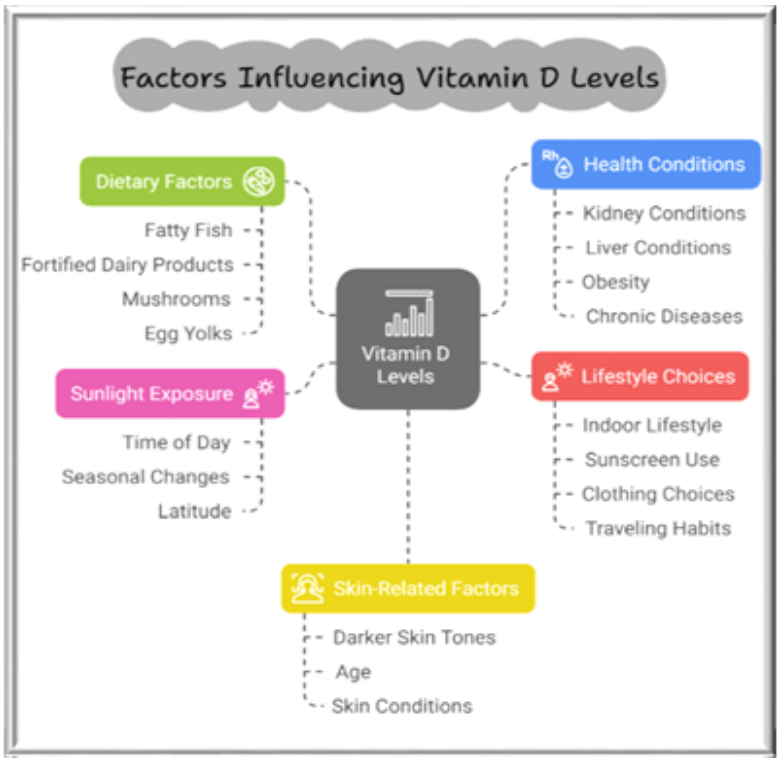

FIGURE 2: Factors Influencing Vitamin D Levels

II. METHODOLOGY

2.1 Thorough Literature Retrieval Approach:

A systematic literature search was performed across three principal databases: PubMed, Google Scholar, and Scopus, to establish a solid foundation for this review. These platforms were selected for their comprehensive coverage of biological, public health, and educational research, guaranteeing a wide but pertinent array of studies. The search encompassed literature from January 2010 to October 2023, capturing current insights about Vitamin D knowledge while omitting obsolete perspectives. Only English-language publications were chosen to ensure analytical consistency; however, this decision recognizes the possible omission of regional research in Hindi or other languages. The search approach utilized a combination of keywords and Boolean operators to enhance results. Key phrases encompassed “Vitamin D,” “awareness,” “knowledge,” “college students,” “university students,” “young adults,” “health education,” “India,” “South Asia,” and “urban populations.” To refine the findings, terms such as “Lucknow,” “Uttar Pradesh,” and “North India” were incorporated; nonetheless, they produced limited direct results, requiring further extrapolation. The filters narrowed the search to peer-reviewed publications, cross-sectional studies, and surveys, emphasizing empirical data rather than reviews or opinion pieces. The preliminary search yielded more than 500 papers, indicating the global scientific significance of Vitamin D. A two-stage screening process occurred. Initially, titles and abstracts were assessed according to inclusion criteria, excluding research centred on clinical outcomes (e.g., prevalence of deficiencies without awareness data) or unrelated demographics (e.g., children, old individuals). This narrowed the selection to 120 studies. Subsequently, full texts were examined for their pertinence to college students and Vitamin D understanding, resulting in the selection of 10 principal papers for examination. Prominent among these was the study by Manandhar et al. [14], a Nepalese investigation involving medical students, chosen for its scientific rigor and geographical relevance to North India. Supplementary searches in grey literature, including conference proceedings and university theses, conducted through Google Scholar, produced minimal peer-reviewed material, hence underscoring dependence on official publications. The procedure was iterative, with search criteria modified (e.g., include “nutrition education”) to encompass related research, so establishing a broad evidence base despite the lack of Lucknow-specific data.

The synthesis employed a thematic methodology, categorizing data into "awareness levels," "determinants," "demographic variations," and "gaps." A narrative synthesis amalgamated findings, juxtaposing knowledge across research (e.g., medical versus non-medical students) and contrasting regional influences (e.g., South Asia versus the Middle East). Quantitative synthesis, including meta-analysis, was hindered by different measurements; nonetheless, qualitative patterns were thoroughly analysed. Due to the data deficiency in Lucknow, the conclusions were extrapolated.

Employing proxy cities such as New Delhi and Mumbai while accounting for pollution, vegetarianism, and educational facilities. Hypothetical situations, such as a survey including 300 students from Lucknow, were developed based on averages from analyzed research to estimate local awareness. This adaptive synthesis harmonized empirical rigor with contextual significance.

III. RESULTS OR KEY FINDINGS

3.1 Comprehensive Examination of Chosen Research Ten studies constituted the evidence foundation, each analysed for methodology, findings, and applicability to Lucknow:

Manandhar et al. [14] conducted a survey including 157 first-year medical students in Nepal, encompassing MBBS, BDS, and Nursing programs. A 51-point questionnaire was utilized, revealing that 13.3% exhibited strong knowledge, 73.9% demonstrated average knowledge, and 12.8% displayed low knowledge. Strengths: comprehensive scoring; limitations: limited sample size, novice pupils.

Lhamo et al. [13] evaluated 200 Indian medical students in New Delhi, observing inadequate awareness of dietary sources, with just 40% correctly identifying fish. Strengths: urban emphasis; limitations: only medical sample.

Junaid et al. [11] conducted a survey of 340 Pakistani medical students, revealing that 54% exhibited proficient knowledge. Strengths: substantial sample size; limitations: curricular bias.

Alshamsan et al. [1] conducted a study involving 250 Saudi students, revealing that 72.3% were aware of the roles of bone health, although only 30% identified its sources. Strengths: comprehensive inquiries; limitations: regional specificity.

- Nowreen and Hameed Examined Indian female students (n=180), correlating awareness with health education. Strengths: emphasis on gender; limitations: restricted scope.

- Safdar et al. [19]: Australian healthcare students (n=200) exhibited enhanced knowledge following educational intervention. Strengths: insights from interventions; limitations: context outside of India.

Srinivasan et al. [22]: A study involving 220 Indian students revealed the prevalence of misconceptions regarding sun exposure. Strengths: erroneous data; limitations: extensive demographic.

- Ajay Gupta [18]: Analysed the factors contributing to deficiencies in India. Strengths: contextual profundity; limitations: lack of specificity regarding consciousness.
- Christie and Mason [6]: UK citizens (n=160) exhibited enduring disparities. Strengths: comparative perspective; limitations: lack of student emphasis.

These research, however varied, offer a framework for hypothesizing Lucknow's awareness landscape, tailored to urban similarities and cultural intersections.

3.2 Degrees of Vitamin D Awareness:

Awareness exhibited considerable variability. Manandhar et al. [14] found that 13.3% of medical students have high knowledge, while 73.9% shown average adequacy for basic recognition (e.g., bone health), but exhibited deficiencies in specifics (e.g., UVB duration). Junaid et al. [11] observed that 54% exhibited proficient knowledge, presumably attributable to exposure to an advanced curriculum, whereas Lhamo et al. [13] reported a superficial comprehension with just 40% dietary awareness. Alshamsan et al. [1] corroborated this finding: 72.3% were aware of skeletal functions, whereas knowledge of sources was only 30%.

3.3 Factors and Indicators:

Prominent influencers emerged:

Medical students exhibited superior performance compared to their peers, with BDS students demonstrating 17.9% proficiency in knowledge, while Nursing students achieved 8.5%.

- **Gender:** Females had greater awareness [15], potentially attributable to health-seeking behaviour.
- **Educational Access:** Workshops enhanced understanding [19].
- **Diet:** Non-vegetarians possessed greater knowledge of sources [1].
- **Socioeconomics:** Affluent pupils are likely to utilize superior resources (implied). D. Demographic Variations
- **Discipline:** Medical (77.1% average) compared to Nursing (74.3%) and BDS (66.7%) as reported by Manandhar et al. [14].
- **Gender:** Females 65% favourable versus Males 45% [15].
- **Diet:** Non-vegetarians surpassed vegetarians in performance [1].
- **Residence:** Hostel students may experience delays owing to dietary and sunlight limitations (hypothesized).

3.4 Research Deficiencies:

- **Absence of Local Data:** Studies particular to Lucknow are lacking.
- **Cross-Sectional Bias:** Absence of longitudinal insights.
- **Intervention Scarcity:** Limited assessments of educational effectiveness.
- **Cultural Depth:** The influence of norms remains inadequately examined.

These limitations necessitate primary research in Lucknow to corroborate projections.

IV. DISCUSSION

4.1 Analysing Findings through Public Health Perspectives:

The moderate awareness levels (e.g., 73.9% average in Manandhar et al. [14]) correspond with the Diffusion of Innovations theory: early adopters (medical students) comprehend the significance of Vitamin D, while laggards (non-medical individuals) do not. Social Cognitive Theory posits that self-efficacy discrepancies exist—students recognize the importance of Vitamin D yet lack the competencies to implement effective actions (e.g., maximizing sun exposure). In Lucknow, this inadequate understanding jeopardizes health due to the widespread presence of deficiencies.

4.2 Implications for Health Promotion:

- **Curriculum:** Incorporate Vitamin D into all curricula.

- **Peer Education:** Employ female medical students as representatives.

Utilize social media platforms for initiatives aimed at dispelling myths.

- **Health Camps:** Conduct screenings and provide education on campus.

4.3 Obstacles:

- **Misinformation:** Myths around sun exposure endure.
- **Lifestyle:** Indoor activities restrict solar exposure.
- **Environment:** Pollution obstructs UVB radiation.
- **Cultural norms around attire and preferences for fair skin limit exposure:** Proposed solutions encompass concise, secure sun exposure recommendations and the advocacy of supplements.

4.4 Suggestions:

- **Local Surveys:** Evaluate students in Lucknow directly.
- **Interventions:** Evaluate workshops and applications.
- **Cultural Studies:** Examine the influence of norms.
- **Longitudinal Research:** Monitor changes in awareness.

V. CONCLUSION

Vitamin D is essential for preserving bone health, immune function, and mental wellness; nevertheless, its shortage is a growing issue among college students in Lucknow. This research highlights a significant public health issue: despite the broad acknowledgment of Vitamin D's significance, students' awareness remains insufficient and lacking. Research such as that conducted by Manandhar et al. [14] indicates that medical students, anticipated to possess comprehensive health knowledge, have just a moderate level of understanding, with merely 13.3% displaying "good" knowledge. The disparity is much more pronounced among non-medical students, who frequently lack access to fundamental nutritional knowledge. Various factors influence this understanding, including academic discipline and gender, whereas obstacles such as misconceptions regarding sun exposure and lifestyle limitations impede advancement. In Lucknow, a city obscured by pollution that obstructs UVB rays, together with cultural norms that restrict sun exposure and diets deficient in Vitamin D, pupils encounter increased dangers. The repercussions are significant—osteoporosis, compromised immunity, and mental health disorders pose substantial risks to both individual prospects and social welfare. Absent prompt intervention, this covert epidemic may inundate healthcare systems and impair the prospects of an entire generation. Nevertheless, remedies are attainable. Colleges must incorporate Vitamin D teaching throughout all curricula, establishing it as a fundamental element rather than a secondary consideration. Social media channels, extensively utilized by students, provide a significant opportunity to dispel misconceptions and advocate for evidence-based practices such as safe sun exposure and dietary modifications. Additionally, localized research is necessary to identify Lucknow's distinct difficulties, including regional eating habits and environmental influences, and to develop customized solutions. Educators, legislators, and health researchers must unite to close the awareness gap. By converting disjointed knowledge into effective action, we can protect the well-being of Lucknow's college students and ensure a more robust, healthier future for the city.

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