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Review Article

Sunlight Exposure and Risk of Vitamin D Deficiency: A Review of Rural Settings with Reference to Ziro, Arunachal Pradesh

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Abstract: Vitamin D, often referred to as the "sunshine vitamin''. Vitamin D is essential for various health conditions, such as bone health and immune function. It can be synthesized by the body through exposure to ultraviolet B (UVB) radiation, which comes from sunlight. Unfortunately, despite India's abundance of sunshine, vitamin D deficiency is still prevalent in the country. This review explores the multifaceted factors contributing to vitamin D deficiency in rural regions, with a special focus on Ziro in Arunachal Pradesh. Despite its high-altitude location, environmental conditions such as cold weather and overcast skies, coupled with cultural habits like traditional clothing and limited dietary diversity, may restrict adequate ultraviolet B (UVB) exposure. By synthesizing data from rural India and contextualizing it for Ziro, this paper highlights the biochemical implications of deficiency, proposes public health interventions like supplementation and fortification, and underscores the need for region-specific research to address tribal health disparities.

Keywords: Vitamin D, Sunlight, Ziro, Arunachal Pradesh, Rural Health, UVB, Deficiency, Biochemistry.

1. INTRODUCTION

Vitamin D is a fat-soluble prohormone camping member of the secosteroid hormone family that is necessary for musculoskeletal health, immune function and metabolic homeostasis (Holick 2007). About 80 to 90% of the human body's vitamin D is produced endogenously from the dermal synthesis of vitamin D_3. That is, in the skin through exposure to UVB radiation or ultraviolet light (290–315 nm) (Jones, 2008). Despite being a tropical country, there are reports of a wide variation in the proportion of Vitamin D deficiency, between 50% and 90% among urban and rural populations from India (Ritu & Gupta, 2014). This paradox is particularly noteworthy among people living in rural areas, who are often believed to get enough Vitamin D from sunlight. Ziro, a town situated at a high altitude in Arunachal Pradesh (between 1,500 and 1,750 meters), primarily inhabited by the Apatani community, presents a unique example. Its subtropical highland climate, traditional way of life, and dietary habits might contribute to an understated prevalence of Vitamin D deficiency.

This review intends to examine how Vitamin D is produced in the body, evaluate the risk factors for deficiency in rural India, and relate these insights to Ziro, highlighting potential public health measures to address this concern.

2. Biochemistry of Vitamin D Synthesis:

Vitamin D has two forms:

Vitamin D_2 (ergocalciferol) derived from plant foods and D_3 (cholecalciferol) produced in humans' skin. The synthesis process involves:

Photochemical Conversion:

UVB radiation (290-315 nm) converts 7-dehydrocholesterol in the skin to previtamin D_3, which then isomerizes to Vitamin D_3 (Holick, 2007).

Metabolic Activation:

Vitamin D_3 is hydroxylated in the liver through 25-hydroxylase to form 25-hydroxyvitamin D [25(OH) D], the major circulatory form and the best indicator of Vitamin D status. Subsequent hydroxylation in the kidney by 1α-hydroxylase results in 1,25-dihydroxyvitamin D [$1,25(OH)_2D$], the biologically active form that promotes calcium and phosphate homeostasis (Jones, 2008).

Table 1: Factors Affecting Vitamin D Synthesis

Factor	Impact on Synthesis
Latitude	UVB availability is decreased at higher latitudes (>35°), particularly during the winter
Season	Winter reduces UVB intensity, which restricts synthesis
Time of Day	10 AM to 3 PM is when UVB exposure is at its highest.
Pigmentation of skin	For equal synthesis, a darker complexion (higher melanin) needs three to five times as much exposure.
Clothing	Cover the entered body significantly reduces the UVB exposure
Sunscreen	About 97% of UVB rays are blocked by sunscreen with an SPF of 30 or higher, which prevents synthesis.
Altitude	UVB intensity increases at higher elevations, exposure may be limited by cold weather.

3. Global and Indian Context of Vitamin D Deficiency

Globally, Vitamin D deficiency affects over 1 billion people, with serum 25(OH)D levels <20 ng/mL considered deficient (Holick & Chen, 2008). In India, despite abundant sunlight, deficiency is widespread:

Urban Areas: Studies report 60–90% prevalence due to indoor lifestyles, pollution, and sunscreen use (Ritu & Gupta, 2014).

Rural Areas: Contrary to assumptions, rural populations also show high deficiency rates:

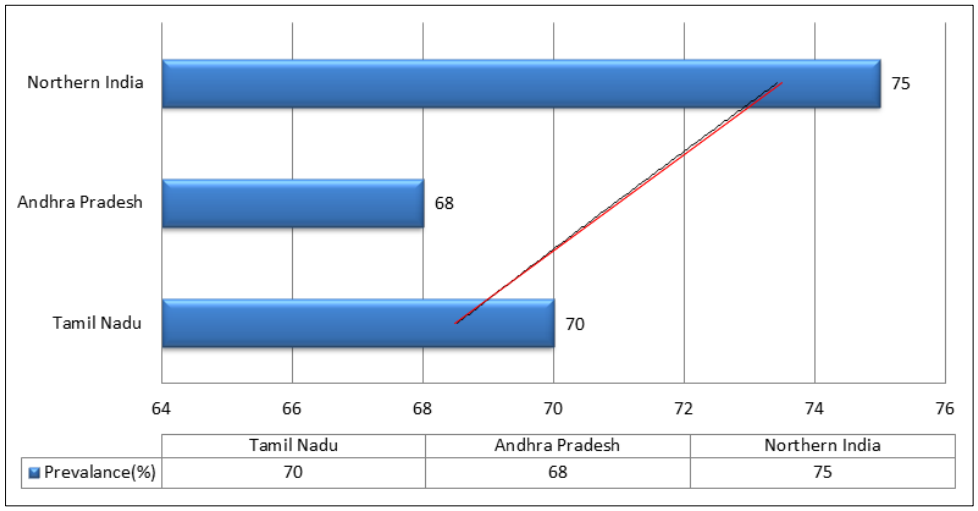

Fig. 1.0: Prevalence of Vitamin D Deficiency in Rural India (Selected Studies)

Fig.1.0. Shows the Prevalence of Vitamin D deficiency across rural Indian regions (Tamil Nadu, Andhra Pradesh, Northern India).

4. Rural Settings: Misconceptions and Reality

The assumption that rural populations receive adequate sunlight overlooks several barriers**:**

1. **Climatic Factors**: Cold or overcast seasons reduce effective UVB exposure.
2. **Cultural Practices**: Traditional clothing covering most of the body limits skin exposure.
3. **Lifestyle Patterns**: Women, in particular, may spend significant time indoors due to household responsibilities.
4. **Dietary Constraints**: Rural diets often lack Vitamin D-rich foods (e.g., fatty fish, fortified dairy), exacerbating deficiency risks.

Table 2: Comparison of Vitamin D Sources in Rural vs. Urban Settings

Source	Rural Availability	Urban Availability
Exposure to sunlight	Limited by clothing, cold seasons	Limited by indoor lifestyle, pollution
Dietary Vitamin D	Minimal (rice, vegetables dominate)	Higher (fortified foods, supplements)
Fortified Foods	Rare due to supply chain issues	Common in processed dairy, cereals
Supplements	Limited access, low awareness	Widely available, higher awareness

5. The Case of Ziro, Arunachal Pradesh

5.1. Geographic and Climatic Overview

Ziro, located at 27.63°N latitude and 1,500–1,750 meters altitude, experiences a subtropical highland climate with cold winters (5–15°C) and overcast skies from November to February. While higher altitudes increase UVB intensity, cold weather and cloud cover may reduce effective exposure time.

5.2. Cultural and Lifestyle Practices

Apatani Tribe:

The Apatani people engage in wet rice cultivation, requiring outdoor work but often in fully covered clothing to protect against cold or sun.

Diet:

Predominantly rice, vegetables, and fermented foods, with occasional meat or fish. Vitamin D-rich foods are scarce, and fortified products are unavailable.

Gender Dynamics:

Women, who manage both agricultural and domestic tasks, may have less sun exposure due to indoor activities during colder months.

5.3. Health Infrastructure

Ziro's healthcare system Includes Primary Health Centers (PHCs) and a General Hospital, but routine Vitamin D screening is absent. Limited awareness among healthcare providers and the community further complicates early detection.

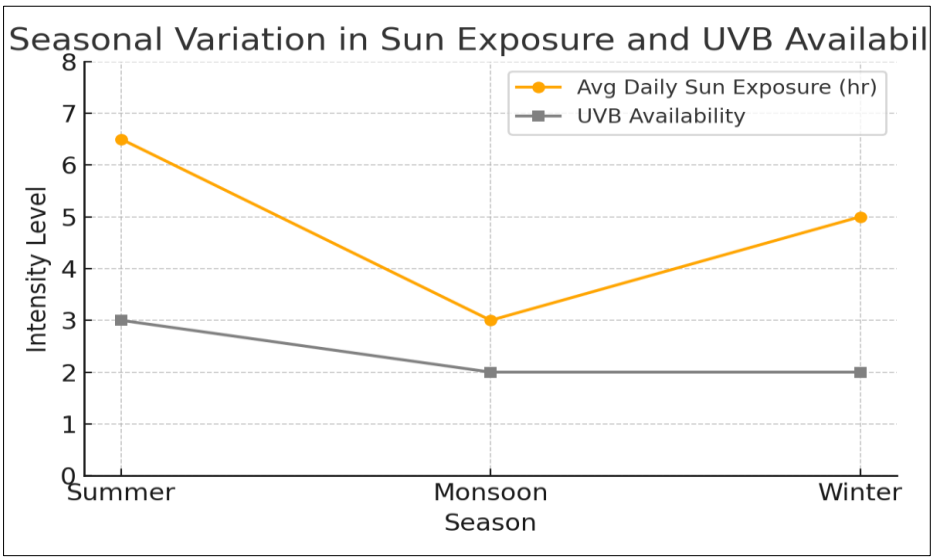

Fig. 2: Estimated Sun Exposure in Ziro by Season

Fig.2. shows the estimated daily sun exposure in Ziro by season, highlighting monsoon & winter limitations.

Note: The Data estimated based on regional climate patterns and cultural practices.

6. Biochemical Implications of Vitamin D Deficiency:
Vitamin D deficiency disrupts calcium and phosphate homeostasis, leading to:

Skeletal Effects:

- **Rickets in children**: Soft, deformed bones.
- **Osteomalacia in adults**: Bone pain, muscle weakness.
- **Osteoporosis in the elderly**: Increased fracture risk.

Non-Skeletal Effects:

- ❖ Impaired immune function, increasing infection susceptibility (Bikle, 2014).
- ❖ Higher risk of autoimmune diseases, cardiovascular conditions, and type 2 diabetes (Pludowski *et al*., 2013).
- ❖ Neuropsychiatric symptoms, including depression and fatigue.

Table 3: Clinical Implications of Vitamin D Deficiency

Condition	Population Affected	Symptoms
Rickets	Children	Bowed legs, delayed growth
Osteomalacia	Adults	Bone pain, muscle weakness
Osteoporosis	Elderly	Fractures, reduced bone density
Immune Dysfunction	All	Frequent infections
Depression/Fatigue	All	Mood disturbances, low energy

7. Recommendations and Public Health Strategies:

7.1. Screening and Surveillance

- ❖ Conduct community-based surveys to measure 25(OH) D levels in Ziro's population.
- ❖ Integrate Vitamin D testing into mobile health units and district hospitals.
- ❖ Train ASHA workers to identify deficiency symptoms during routine visits.

7.2. Nutrition and Supplementation

- ➢ Provide Vitamin D supplements (e.g., 600–800 IU/day) to high-risk groups: children, pregnant women, and the elderly.
- ➢ Develop locally acceptable fortified foods, such as Vitamin D-enriched rice or edible oils.
- ➢ Partner with NGOs to improve supply chains for fortified products in remote areas.

7.3. Awareness Programs

- ➢ Launch culturally sensitive campaigns emphasizing safe sun exposure (e.g., 15–30 minutes daily on exposed arms and legs).
- ➢ Use school health programs to educate children and parents.
- ➢ Leverage local festivals and community gatherings for outreach.

Table 4: Proposed Public Health Interventions for Ziro

Intervention	Target Group	Implementation Strategy
Screening Surveys	General Population	Mobile health units, PHCs
Supplementation	Children, Pregnant Women	Free distribution via ASHA workers
Food Fortification	All	Partner with local food suppliers`
Awareness Campaigns	Community, Schools	Radio, posters, community events

8. Limitations and Future Directions

This review is constrained by the lack of primary data on Vitamin D status in Ziro. However, evidence from similar rural and tribal settings suggests a high deficiency risk. Future research should focus on:

- Cross-sectional studies to establish baseline 25(OH)D levels in Ziro.
- Longitudinal studies correlating sun exposure, diet, and clinical outcomes.
- Randomized controlled trials to evaluate supplementation or fortification efficacy.
- Qualitative research to understand cultural barriers to sun exposure and dietary change.

CONCLUSION

Vitamin D deficiency is a silent problem in the rural sun-drenched Ziro valley of Arunachal Pradesh. It is due to climatic oppressions, cultural trend and other dietary restrictions that probably leads to the problem in the Apatani tribe. Combating this hidden burden will require targeted interventions (screening, supplementation, fortification, and awareness campaigns) that are regionally specific. Policymakers can be instrumental in reducing the skeletal and non-skeletal burden of Vitamin D deficiency through prioritised tribal health care and region specific data, which will enhance the general well being of communities.

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REFERENCES

- Bansal, B., Bansal, S., Mithal, A., & Kaur, P. (2012). High prevalence of vitamin D deficiency in women of reproductive age in Northern India. *Indian Journal of Endocrinology and Metabolism*, 16(3), 388.
- Bener, A., Al-Ali, M., & Hoffmann, G. F. (2009). High prevalence of vitamin D deficiency in young children in a highly sunny country: a global health problem. *Minerva Pediatrica*, 61(1), 15–22.
- Bhatia, V., Mishra, S. K., & Agarwal, A. (2013). Vitamin D status of healthy school children in northern India. Indian Pediatrics, 50(11), 1036–1039.
- Bikle, D. D. (2014). Vitamin D metabolism, mechanism of action, and clinical applications. Chemistry & Biology, 21(3), 319–329.
- Chacko, S. A., & Song, Y. (2008). Vitamin D status and cardiovascular disease risk factors in adults. *The American Journal of Clinical Nutrition*, 87(4), 1109S–1117S.
- Goswami, R., Gupta, N., Goswami, D., Marwaha, R. K., Tandon, N., & Kochupillai, N. (2000). Prevalence and significance of low 25-hydroxyvitamin D concentrations in healthy subjects in Delhi. *The American Journal of Clinical Nutrition*, 72(2), 472–475.
- Harinarayan, C. V., Ramalakshmi, T., & Prasad, U. V. (2011). Vitamin D status in Andhra Pradesh: A

population-based study. Indian Journal of Medical Research, 127(3), 211–218.

- Holick, M. F. (2007). Vitamin D deficiency. New England Journal of Medicine, 357(3), 266–281.
- Holick, M. F., & Chen, T. C. (2008). Vitamin D deficiency: A worldwide problem with health consequences. The American Journal of Clinical Nutrition, 87(4), 1080S–1086S.
- Jones, G. (2008). Pharmacokinetics of vitamin D toxicity. The American Journal of Clinical Nutrition, 88(2), 582S–586S.
- Kumar, V., Yadav, S., & Goel, A. (2021). Prevalence of Vitamin D deficiency and associated risk factors among children and adolescents in India: A narrative review. *Cureus*, 13(3), e13815.
- Mithal, A., Wahl, D. A., Bonjour, J. P., Burckhardt, P., Dawson-Hughes, B., Eisman, J. A., ... & IOF Committee of Scientific Advisors Working Group on Nutrition. (2009). Global vitamin D status and determinants of hypovitaminosis D. *Osteoporosis International*, 20(11), 1807–1820.
- Palacios, C., & Gonzalez, L. (2014). Is vitamin D deficiency a major global public health problem? *The Journal of Steroid Biochemistry and Molecular Biology*, 144, 138–145.
- Pludowski, P., Holick, M. F., Pilz, S., Wagner, C. L., & Misra, M. (2013). Vitamin D effects on musculoskeletal health, immunity, autoimmunity, cardiovascular disease, cancer, fertility, pregnancy, and mortality. Frontiers in Endocrinology, 4, 161.
- Prentice, A. (2008). Vitamin D deficiency: a global perspective. *Nutrition Reviews*, 66(suppl_2), S153–S164.
- Ritu, G., & Gupta, A. (2014). Vitamin D deficiency in India: Prevalence, causalities and interventions. Nutrients, 6(2), 729–775.
- Sachan, A., Gupta, R., Das, V., Agarwal, A., Awasthi, P. K., & Bhatia, V. (2005). High prevalence of vitamin D deficiency among pregnant women and their newborns in northern India. *The American Journal of Clinical Nutrition*, 81(5), 1060–1064.
- Tsiaras, W. G., & Weinstock, M. A. (2011). Factors influencing vitamin D status. *Acta Dermato-Venereologica*, 91(2), 115–124.
- van Schoor, N. M., & Lips, P. (2011). Worldwide vitamin D status. *Best Practice & Research Clinical Endocrinology & Metabolism*, 25(4), 671–680.
- Wacker, M., & Holick, M. F. (2013). Sunlight and Vitamin D: A global perspective for health. *Dermato-Endocrinology*, 5(1), 51–108.