Determinants of Vitamin D Deficiency Among Under-five Children in Urban Slums of Mumbai, India

A community-based study was undertaken in an urban slum in Mumbai, between October, 2015 and September, 2017 among 426 healthy children (aged 1–5 years) to assess prevalence of vitamin D deficiency (VDD) and its determinants. VDD was classified as 25(OH)D <20 ng/mL. The prevalence of VDD was 76.8% (*n*=327), and sun-exposure, male sex, and calcium and vitamin D supplementations during infancy were important determinants. Routine supplementation with vitamin D in infancy is likely to reduce the occurrence of VDD in children.

Keywords: *Infant, Rickets, Sun-exposure, Supplementation.*

Published online: May 28, 2021; ***PII:*** S097475591600338

Maintaining optimum vitamin D levels among under-five children is a growing concern given its important role in bone mineralization, remodelling, and immunological functions [1]. Nearly 90% of vitamin D requirement is met through exposure of bare arms, and face to midday sun (between 10 AM and 3 PM) for 10-30 minutes, and 10% through diet [2]. Vitamin D deficiency (VDD) therefore is more likely to be prevalent in overcrowded slums compromising adequate sunlight exposure. Studies have reported VDD prevalence ranging from 34 - 80% among children [3,4]. Very few investigated the determinants of VDD such as sun-exposure among under five children [3]. Hence, a community based study was undertaken to assess prevalence and determinants of VDD among children in the age group of 1-5 years.

A total of 426 apparently healthy children aged 1-5 years were enrolled from a selected urban slum of Mumbai after ethics approval and parental consent over a period of 2 years (1 October, 2015 to 30 September, 2017). There were approximately 20000 households in the study area. Initially the list of 759 children (aged 1-5 years) was obtained from anganwadi workers. A trained social worker visited these households to screen the eligible children. Apparently healthy children aged 1-5 years were included and children with chronic illness, skeletal diseases, and those receiving vitamin D supplementation were excluded. In case the house was locked, it was revisited in next three consecutive days. In case of more than one child in the household, krish grid method of sampling was used to select eligible children. Out of 759 children, 195 children were not eligible, parents of 21 children refused, 8 households were locked, 12 children were in households with more than one child, and parents of 97 children did not consent for phlebotomy.

Details about sociodemographic status, diet (24-hour dietary recall) [5], physical activity and clinical profile were recorded, followed by biochemical investigations. The nutrient composition including calcium and phytate was interpreted as per dietary guidelines for Indian children [5]. Direct sun-exposure was calculated considering average duration and percentage of the exposed body surface area between 10 AM to 3 PM over last 6 months [6]

Serum calcium, phosphorus, alkaline phosphatase, 25-Di-hydroxy vitamin D (25(OH)D) and parathyroid hormone (PTH) were estimated in fasting state using automated blood analyzer and commercially available ELISA based diagnostic kits. VDD was classified as 25(OH)D <20 ng/mL [7].

Association of VDD was assessed with variables such as age, sex, socioeconomic status, physical activity; nutrition intake; growth and clinical parameters and biochemical markers. Chi-square test, Pearson correlation and logistic regression were conducted using SPSS Version 19 (IBM Corp) and $P<0.05$ was considered as statistically significant.

The mean (SD) age of the children was 34.8 (13) months with 53.8% boys; 76% children belonged to middle socioeconomic group; 84% were in preschools and 7.5% were involved in outdoor activities at school.

The prevalence of VDD among children was 76.8% (95% CI 73.1-80.5). There was no association of VDD status with age and socioeconomic status; though, it was significantly associated with duration of sun-exposure of less than 10 minutes between 10 AM to 3 PM ($P=0.01$). Despite sun exposure of 10 to 45 minutes in a day, 68.8% children had VDD.

The levels of PTH, alkaline phosphatase and calcium were within normal limits among 83.9%, 92.2% and 87.5% of children, respectively in spite of 25(OH)D <20 ng/mL, with a significant negative correlation (r=-0.12; $P=0.02$) between PTH and 25(OH)D. Clinical signs of VDD i.e., either genu varum, genu valgum, metaphyseal widening or frontal bossing were evident among 42.7% of children with significant association with frontal bossing ($P<0.001$), genu varum ($P<0.001$) and metaphyseal widening ($P=0.02$). It was more common among children having recurrent upper respiratory tract infections (URTI) ($P<0.001$).

VDD had no significant association with consumption of adequate calcium intake (≥600 mg/day) or with consumption of vitamin D rich food. However, it was significantly less among children with adequate dietary calcium intake and supplemented with calcium and vitamin D during infancy ($P=0.02$).

Logistic regression analysis was carried out to look for predictors of VDD (**Table I**). It was found that male children were 43% less likely to have VDD. Children having frontal bossing or ≥6 episodes of URTI in the last one year were approximately 3-times more likely to have VDD than their counterparts. Children who had spent less than 10 minutes in outdoor activities between 10 AM to 3 PM were 75% more likely to have VDD than those who spent more than 10 minutes.

The study specifically elucidates the community-based

Table I Vitamin D Deficiency Among Children by Selected Background Characteristics and Odds of Vitamin D Deficiency (VDD) Among Children (*N*=426)

Characteristics	*VDD, n=327*	*Adjusted OR(95% CI)*
Male sex, *n*=229	168 (73.4)	0.57 (0.35,0.95)
Time spent outdoor[a]		
5-10 min, *n*=211	174 (82.5)	1.75 (1.06, 2.88)
>10 min, *n*=215	153 (71.2)	1.00
Dentition initiation <1 y, *n*=315	239 (75.9)	0.95 (0.53,1.70)
Supplementation during infancy,[b] *n*=160	113 (70.6)	0.56 (0.34,0.92)
Frontal bossing, *n*=192	168 (87.5)	3.07 (1.78,5.30)
Recurrent URTI,[c] *n*=249	209 (83.9)	3.19 (1.93,5.27)

Values in no. (%). Vitamin D deficiency (VDD) was classified as 25(OH)D <20 ng/mL as per Institute of Medicine (IOM) classification. [a]*between 10 AM and 3 PM;* [b]*calcium and vitamin D supplementation; ≥6 upper respiratory tract infections in the last one year.*

prevalence of 76.8% and determinants of VDD among a large cohort of under-five children. VDD was significantly associated with duration of sun-exposure reemphasizing the importance sun-exposure for optimal vitamin D status [3,4]. However, prevalence of VDD despite adequate sun exposure among more than 50% children necessitates need of exploring other determining factors among under-fives. Intriguingly, majority had normal PTH despite low 25(OH)D indicating PTH response variation among children [8]. This highlights that physiological difference in PTH response can be a confounder in interpretation of VDD among under-five children.

Our study highlighted significant association of URTI with VDD, unlike with lower respiratory tract infections reported earlier [9]. Significantly lower proportion of VDD with calcium and vitamin D supplementation during infancy endorses the importance of routine supplementation during first year [10]. Certain limitations of the study were inability to correlate seasonal variations, and evaluate bone mineral density among deficient children.

To summarize, sun-exposure, male sex, and calcium and vitamin D supplementations during infancy can be considered as protective against VDD among under-five children.

Acknowledgments: The authors acknowledge the encouragement and guidance received from Dr. Smita Mahale, Director, ICMR-NIRRH, including reviewing the article and scientific inputs. Mrs. Varsha Tryambake, Mrs. Bhagyashree Kanje, Ms. Sharmila Kamat, Mr. Iranna Mashal, Mrs. Shobha Vange, Mrs. Rachana Dalvi and Mrs. Vaishali Chalke for data collection and data entry.

Ethics clearance: NIRRH ethics committee for clinical studies; No. D/ICEC/Sci117/127/2017, No. 275/2015 dated 8 May, 2015.

Contributors: SS,SB,SC,MIK,BJ: conceptualized and designed the study; SS,BJ: conducted clinical examination, data Collection; MIK,SS: interpreted the biochemical parameters; SB: conducted statistical analysis and interpretation; SS,BJ: drafted the initial manuscript; SB,MIK,SC: reviewed the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work *Funding*: None; *Competing interests*: None stated.

SUCHITRA SURVE,[1] SHAHINA BEGUM,[2] SANJAY CHAUHAN,[3] MI KHATKHATAY,[4] BEENA JOSHI[5]*

Departments of [1]Clinical Research, [2] Biostatistics, [3] Clinical and Operational Research, [4]Molecular Immunodiagnostics, and [5]Operational Research, Indian Council of Medical Research-National Institute of Research in Reproductive Health, Parel, Mumbai, Maharashtra.

[*]bjoshithane@gmail.com

REFERENCES

1. Holick MF. Biological effects of sunlight, ultraviolet radiation, visible light, infrared radiation and vitamin D for health. Anticancer Res. 2016;36:1345-56.
2. Report of the Joint FAO/WHO Expert Consultation on Vitamin and mineral requirement in human nutrition: Bangkok 1998. Second Edition. FAO. 2004.
3. Ekbote VH, Khadilkar AV, Mughal MZ, et al. Sunlight exposure and development of rickets in Indian toddlers. Indian J Pediatr. 2010;77:61-5.
4. Tiwari L, Puliyel JM. Vitamin D level in slum children of Delhi. Indian Pediatr. 2004; 41:1076-7.
5. Longvah T, Ananthan R, Bhaskarachary K, et al. Food composition tables. *In*: Nutritive Value of Indian Foods. National Institute of Nutrition, Indian Council of Medical Research. 2017.
6. Bailey H, Love RJM, Russell RCG, et al. Bailey and Love's Short Practice of Surgery. 27th Edition : The Collector's edition. CRC Press, 2018.
7. Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: National Academies Press; 2011.
8. Atapattu N, Shaw N, Hogler W. Relationship between serum 25-hydroxyvitamin D and parathyroid hormone in the search for a biochemical definition of vitamin D deficiency in children. Pediatr Res. 2013;74:552-6.
9. Velarde López AA, Gerber JS, Leonard MB, et al. Children with lower respiratory tract infections and serum 25-hydroxyvitamin D3 levels: A case-control study. Pediatr Pulmonol. 2016; 51:1080-87.
10. Khadilkar A, Khadilkar V, Chinnappa J, et al. Prevention and Treatment of Vitamin D and Calcium Deficiency in Children and Adolescents: Indian Academy of Pediatrics (IAP) Guidelines. Indian Pediatr. 2017;54:567-73.