DOI: http://doi.org/10.4038/sljm.v31i2.339 *Sri Lanka Journal of Medicine Vol. 31 No.2,2022*

Sri Lanka Journal of Medicine SLJM

Original Research

Citation: *Madusanka MAIS[1], Dissanayake M[2]& Akalanka HMK[2]* et al,2022. A cross-sectional study on the Vitamin D status in a group of indoor and outdoor workers in Galle, Sri Lanka. Sri Lanka Journal of Medicine, pp 35-42
DOI: http://doi.org/10.4038/sljm.v31i2.339

A cross-sectional study on the Vitamin D status in a group of indoor and outdoor workers in Galle, Sri Lanka

Madusanka MAIS[1], Dissanayake M[2], Akalanka HMK[2], Bandara T[1]

[1] Faculty of Allied Health Sciences, University of Ruhuna, Galle, Sri Lanka.
[2] Teaching Hospital Karapitiya, Galle, Sri Lanka.
[3] Faculty of Allied Health Sciences, University of Sri Jayewardenepura, Nugegoda, Sri Lanka.

Correspondence:
Madusanka MAIS[1]
Department of Medical Laboratory Sciences, Faculty of Allied Health Sciences, University of Ruhuna, Galle, Sri Lanka.
E mail: isurusrim@gmail.com
https://orcid.org/0000000316723046

Abstract

Background: Vitamin D deficiency influences various disease conditions; thus, it is important to evaluate the social groups for vitamin D deficiency to reduce the risk. Occupation-related factors are believed to be contributing to vitamin D deficiency.

Objectives: To assess the vitamin D status of indoor and outdoor workers, the effect of sunlight exposure, and other work-related factors on vitamin D status.

Method: This cross-sectional study measured the 25 hydroxy Vitamin D (25(OH) Vit D) levels using chemiluminescence immunoassay in male workers (n=96) working indoors and outdoors in Galle, Sri Lanka. Data on sunlight exposure and other factors were collected by using an interviewer-administered questionnaire and statistically analyzed using SPSS software version 20.0.

Results: The mean±SD 25(OH) Vit D level of outdoor and indoor workers were 17.94±3.85 ng/mL and 16.79±4.52 ng/mL, respectively (p=0.185). The prevalence of vitamin D deficiency (< 20ng/mL) of the sample was 73%, and 27% of the participants were vitamin D insufficient (21 -30ng/mL). There was a positive correlation of 25(OH) Vit D level with the duration of sun exposure (r=0.153, p=0.136). Significantly different 25(OH) Vit D levels were found with educational level, monthly income, and clothing pattern ($p < 0.05$).

Conclusions: There was no significant difference between the vitamin D levels of indoor and outdoor workers. The results of this study revealed that vitamin D deficiency was highly prevalent among workers in Sri Lanka. As the reference ranges of vitamin D status for the Sri Lankan population is not well stated, further studies are needed to confirm the same.

Keywords: Vitamin D level, 25- OH vitamin D level, vitamin D deficiency, workers, Sri Lanka

Received: 2021-11-19 **Accepted revised version: 2022-01-05** **Published: 2023-01-08**

INTRODUCTION

Vitamin D is one of the essential vitamins to the human body. About 90% of the body's circulating vitamin D arises from the cutaneous synthesis of vitamin D due to sunlight exposure[1]. UV B of solar radiation is required for the production of vitamin D in the skin, the amount of UV B radiation that reaches the skin depends on many factors such as the solar zenith angle which depend on the time of day, the month of the year, and other factors like duration of sunlight exposure, the ozone layer, clouds, aerosols, latitude and altitude[2]. Melanin pigment of the skin act as a barrier for the UV B radiation reaching the 7-dehydrocholesterol in the epidermal cells of the skin and dark-skinned individuals shall spend more time in sunlight than light skin individuals to obtain the dose required to produce the same amount of vitamin D[3]. 7-dehydrocholesterol level drops with aging reducing the ability to synthesize vitamin D in the skin[4]. Other than that, an individual's dietary pattern, social, religious, and lifestyle habits also affect an individual's vitamin D status. 1,25-dihydroxy vitamin D is the active form of vitamin D and it interacts with vitamin D receptors to affect the functioning of many body tissues. Inadequacy of 1,25-dihydroxy vitamin D leads to manifest the signs and symptoms of vitamin D deficiency[7]. Vitamin D deficiency directly affects bone health and causes rickets in children and osteomalacia in adults[8]. Further, it may lead to non-skeletal diseases such as metabolic syndrome, hypertension, impaired glucose metabolism, and type 2 diabetes[9].

Even though South Asian countries receive plenty of sunlight throughout the year, the attitudes and behavior of an individual toward sun exposure are considered determinants of vitamin D status[3]. Data on Sri Lankan population have shown that the prevalence of vitamin D deficiency was 58.8% and vitamin D insufficiency was 31.4% [10]. According to a systematic review that depicts the vitamin D status among South Asian adults, Sri Lanka has placed 5th in the vitamin D deficiency rankings and was 48%[11]. Hence, a high prevalence of vitamin D deficiency and insufficiency was reported among Sri Lankan populations. Vitamin D status of female, pregnant women, infants, and children have been assessed in Sri Lanka and no specific study was found targeting the adult male population in Sri Lanka[12,13].

Studies have shown that there was a significant effect of the individuals' occupation on the vitamin D status[14,15] and the delay in the rise of vitamin D level to its peak concentration depends on working conditions[16]. Low vitamin D levels were observed in workers who worked in indoor locations when compared with the workers who worked in outdoor places [16,17,18]. Although few studies have been carried out around the world, there was no evidence of such a specific study to assess the vitamin D status of the Sri Lankan working population. Thus, we designed this study to assess the vitamin D status and its relation with sunlight exposure of indoor and outdoor workers working in Karapitiya (6.06 °N, 80.23 °E), Galle, Sri Lanka.

METERIALS AND METHODS

Ethical approval for the study was sought from the Ethics Review Committee, Faculty of Allied Health Sciences, University of Ruhuna, Sri Lanka (Reference number:01.07.2020;3.13). This cross-sectional study was conducted between January 2021 and February 2021. The sample size calculation used the formula ($n = (\sigma^2_1 + \sigma^2_2/K)(z_{1-\alpha/2} + z_{1-\beta})^2/\Delta^2$ where $\alpha = 0.05$, $\beta = 0.1$ and power $= 0.9$)[19]. According to the previous study population, mean and standard deviation were taken as (20.26 ± 9.18) ng/ml and a 30% increase was expected from the second group thus sample size was 48 for each group[10]. 48 indoor workers were selected from the workers who were working in the indoor places during day time such as wards and laboratories of Teaching Hospital Karapitiya, Galle, and 48 outdoor workers who were working in open outdoor locations like construction sites around the Karapitiya area were selected. Male workers only participated in the study as there were few female workers who worked in outside locations around the study settings. Individuals with chronic illnesses, lost limbs, burn scars or any other skin disorders were excluded.

After obtaining informed written consent, data were collected from participants using a pre-tested interviewer-administered questionnaire. The questionnaire was developed based on the literature review. The questionnaire was composed of four sections which collected data on socio-demographic facts, work-related facts, sunlight exposure, lifestyle, and physical activities. Socio-demographic variables such as age, race, marital status, place of residence, and work-related factors such as occupation, shift work, stability of employment, work tenure, and the number of working hours per day were collected from the questionnaire. The day's sunlight exposure and the duration of direct sunlight exposure during time intervals of a day were assessed by interviewing the subjects with respect to their outdoor behavior. Here the daily sunlight exposure was collected as less than 15 minutes, 15-30 minutes, 30-60 minutes, 60-120 minutes, and more than 120 minutes, and the duration of sun exposure between 7 am-9 am, 9 am-11 am, 11 am-1 pm, 1 pm-3 pm and 3 pm-5 pm was collected. The physical activities of workers were assessed in the work-related factors and lifestyle and physical activities.

One milliliter of random venous blood sample was collected from a participant. Then serum was separated and tested with SNIBE Maglumi 800 immunodiagnostic analyzer to determine serum 25(OH) Vit D assay which is a two incubation chemiluminescence immunoassay. Vitamin D status was classified in a way such that < 20 ng/mL as vitamin D deficient, 21 -29 ng/ml as vitamin D insufficient, 30-150 ng/mL as vitamin D sufficient, and > 151 ng/mL as vitamin D toxicity[20].

STATISTICAL ANALYSIS

The mean, standard deviations, percentages, and frequencies of the group were analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 20.0. Serum 25(OH) Vit D levels of indoor and outdoor workers were compared using the independent t-test. Pearson correlation statistics were used to assess the correlation of 25(OH) Vit D level with the duration of sunlight exposure and anthropometric parameters. Individuals were grouped into two based on their total sunlight exposure and compared using the independent t-test. To find the difference among a group of means ANOVA was used. A *p*-value of less than 0.05 was considered statistically significant.

RESULTS

The age range of the participants was 18 to 59 years and the majority represented the age category of 26-35 years (n=36). Most of the workers (n=67) were married and more than half (n=51) of the sample had an education level below A/L. A major part of the workers have resided in rural areas and n=86,07, and 03 Sinhala, Tamil, and Muslim workers respectively participated in the present study. Table 1 indicates the relationship between vitamin D levels and demographic characteristics.

Table 1. Relationship of vitamin D level and demographic characteristics.

Characteristic		**n**	**25 - OH Vitamin D level (ng/mL) Mean (SD)**	***p-value***
Age	18 – 25 years	16	17.14 (4.56)	0.718
	26 – 35 years	36	16.61 (4.24)	
	36 – 45 years	26	18.27 (4.62)	
	46 – 55 years	16	18.02 (3.31)	
	55 + years	02	16.56 (0.31)	

Education	Above A/L	45	16.24 (4.29)	0.013
	Below A/L	51	18.36 (3.92)	
Monthly income	More than Rs.50,000	43	16.10 (3.54)	0.006
	Less than Rs. 50,000	53	18.44 (4.46)	
Marital status	Married	67	17.94 (3.77)	0.041
	Unmarried	29	16.03 (4.90)	
Place of residence	Urban	19	16.49 (5.15)	
	Suburban	21	17.25 (4.19)	0.553
	Rural	56	17.71 (3.90)	
Race	Sinhala	86	17.03 (4.23)	
	Tamil	07	20.69 (2.83)	0.06
	Muslim	03	19.36 (2.71)	

The mean (±SD) 25(OH) Vit D level of the sample is 17.37 (4.21) ng/mL. The median 25(OH) Vit D level and IQR were 17.13 ng/mL and IQR 14.16-20.17. The range of 25(OH) Vit D level of the sample was 8.12 ng/mL-27.82 ng/mL. The prevalence of vitamin D deficiency and insufficiency in the population was 72.9% and 27.1%, respectively. Figure 1 indicates the distribution of 25(OH) Vit D levels of the sample.

The mean ± SD 25(OH) Vit D level of outdoor and indoor workers were 17.94 ± 3.85 ng/mL and 16.79 ± 4.52 ng/mL, respectively (p=0.185). The percentage of vitamin D deficient and insufficient indoor workers was 77.1% and 22.9% ($p<0.05$). The percentage of vitamin D deficient and insufficient outdoor workers was 68.8% and 31.2%, ($p<0.05$).

There was no significant difference between 25(OH) Vit D levels among different occupations. The distribution of 25(OH) Vit D levels among different occupations are listed in table 2.

The mean±SD 25(OH) Vit D level of workers with and without shift work was 17.81±4.27 ng/mL and (17.12±4.19) ng/mL respectively ($p>0.05$).

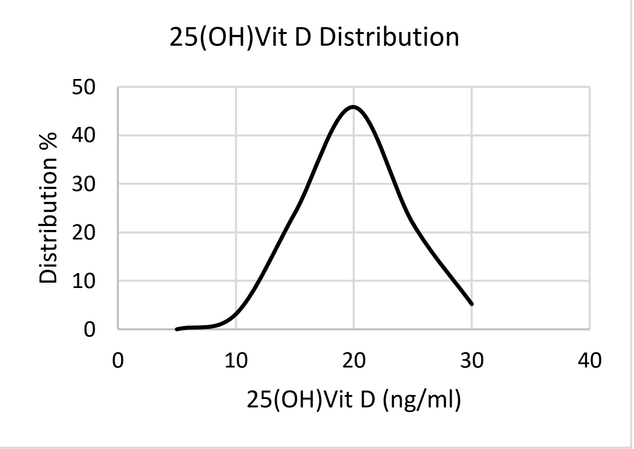

Figure 1. Distribution of 25(OH) Vit D levels.

Permanent workers reported lower 25(OH) Vit D level (16.89±4.29) ng/mL than temporary workers (18.16±4.01) ng/mL ($p>0.05$). Workers who were working less than 8 hours per day had a 25(OH) Vit D level of (18.53±2.52) ng/mL while workers who were working more than 8 hours per day had a 25(OH) Vit D level of (17.48±4.23) ng/mL ($p>0.05$).

Table 2: The distribution of 25 - OH Vitamin D levels among different occupations.

		25 - OH Vitamin D level (ng/mL)		
Occupation	**n**	**Mean**	**SD**	**Range**
Mason	6	19.01	3.63	13.96 - 23.77
Laborer	37	18.24	3.84	10.32 - 26.46
Site Supervisor	5	14.38	2.45	11.88 - 17.54
Healthcare Assistant	20	17.86	5.43	8.12 - 27.82
Medical Laboratory Technologist	13	14.73	3.47	10.46 - 20.85
Doctor	8	15.97	3.99	9.39 - 20.90
Nurse	7	18.52	2.53	16.27 - 22.96

p = 0.06

Serum 25(OH) Vit D level and mean duration of sunlight exposure were not significant (p=0.136) with a Pearson correlations coefficient of 0.153. However, men who were exposed to sunlight for less than 15 minutes (13.90 ± 2.81) ng/mL (n=8) had significantly low 25-(OH) Vit D levels when compared to men who were exposed to sunlight more for than 15 minutes (17.68 ± 4.19) ng/mL (n = 88) (p = 0.014). The 25(OH) Vit D levels with respect to the duration of sunlight exposure are shown in table 3.

Table 3. The 25(OH) Vit D levels with respect to the duration of sunlight exposure

Parameter	Daily sunlight exposure groups					Total
	Less than 15 minutes	15 – 30 minutes	30 – 60 minutes	60 -120 minutes	More than 120 minutes	
N	8	22	13	5	48	96
25(OH) Vit D level (ng/mL)	13.90±2.81	17.61±5.26	18±3.77	14.58±2.50	17.94±3.85	17.37±4.21

Table 4: Association of 25-OH Vitamin D level with areas of the body exposed to sunlight during daytime.

The body areas exposed to sunlight	**n**	**25 - OH Vitamin D level (ng/mL) (Mean ± SD)**	***p-value***
Face	18	14.45 ± 3.03	0.003
Hands and face	68	17.89 ± 4.09	
Hands, face, and legs	10	19.02 ± 4.84	

Workers who worked with long sleeve shirts had a low 25 - OH Vitamin D level (14.45 ± 3.03) ng/mL than men who did not wear long sleeve shirts (18.04 ± 4.17) ng/mL (*p*=0.001). 25(OH) Vitamin D levels showed a significant association with the area of the body exposed to sunlight. The results are shown in table 4.

DISCUSSION

The majority of the participants in the study were vitamin D deficient (72.9%) and the remaining (27.1%) had an insufficient level of 25(OH) Vit D. There was no worker reported with a sufficient level of 25(OH) Vit D (30 -150 ng/mL). Vitamin D deficiency and insufficiency were reported to be 90.2% in the Colombo district of Sri Lanka [10]. The prevalence of vitamin D deficiency was much higher in the present study than the reported vitamin D deficiency in the previously published Sri Lankan data[10,21,22]. The prevalence of vitamin D deficiency was 70 % or higher in the South Asian population with similar cut-off values for vitamin D levels[3]. As cut-off values of vitamin D deficiency of the Sri Lankan population are not well defined, further studies are required to define the vitamin D status of the Sri Lankan population.

The mean 25(OH) Vit D level of indoor workers was lower than that of outdoor workers but it was not significant. It has also been found that there were no significant differences in 25(OH) Vit D levels among people who work indoors, outdoors, and in both[23]. However, the expected significantly high 25(OH) Vit D level of outdoor workers was not observed here. The majority of both indoor and outdoor workers were vitamin D deficient whereas indoor workers had a significantly high prevalence of vitamin D deficiency when compared with outdoor workers. A significantly low 25(OH) Vit D level was reported among indoor workers than outdoor workers as they were exposed to sunlight during morning and evening where the solar UV B exposure is low[18]. There was no significant difference in mean 25(OH) Vit D levels observed among different occupations. Working conditions such as shift work and permanent work have affected individuals' 25(OH) Vit D levels significantly[15]. This study revealed that there is no significant difference between mean 25(OH) Vit D levels of workers with and without shift work, permanent and temporary workers. The number of working hours per day did not show any significant effect on the vitamin D level of individuals. When considering the results of this study, working location and other work-related factors deem to be factors that are not affecting the vitamin D status of an individual in this part of the world.

People who lived in urban places showed significantly low 25(OH) Vit D levels than rural residents[24]. A high level of industrialization has deteriorated the air quality in urban areas resulting in cutting the UV B radiation reaching the earth's surface. In this study, higher 25(OH) Vit D levels were observed in rural residents than in urban residents but the difference was not significant. Literature showed that there were no differences in 25(OH) Vit D levels based on the level of education[14]. But here workers with an education level below A/L had significantly high 25(OH) Vit D levels than workers with an education level above A/L which could be due to the less sunlight exposure of workers with higher education. Several studies have studied the relationship between monthly income and 25(OH) Vit D levels. Some have found that there is no relation between monthly income and 25(OH) Vit D level[25]. Another study showed that high-income workers had a high prevalence of vitamin D deficiency than low-income workers[14]. Similarly, the present study has observed a significantly high 25(OH) Vit D level of workers with monthly income below 50,000 LKR than workers with income above 50,000 LKR. Though there is no biological interpretation, the vitamin D levels were significantly different with respect to marital status.

In literature, many studies have suggested durations of sun exposure to maintain a sufficient level of serum 25(OH) Vit D level[24] have concluded that 1-2 hours of sun exposure was adequate to maintain a normal vitamin D status in the body. This study revealed an insignificant positive correlation between 25(OH) Vit D levels and the duration of sun exposure. It was found that the 25(OH) Vit D level of workers who had sun exposure for less than 15 minutes was significantly lower than that of workers with sun exposure above 15 minutes in a day. With increasing duration of daily sunlight exposure 25(OH) Vit D levels increase up to 30 -60 minutes duration and then had fluctuations. This may cause due to the varying sample size for each sub-category. Literature has shown that an estimate of 30-35 minutes of sun exposure is adequate to instigate a production of 1000 IU of vitamin D in the body and this time duration may vary with the regional and seasonal variations[26]. According to the Department of Meteorology, Sri Lanka, the average sunrise and sunset time in January were 6.26 a.m. and 6.13 p.m., respectively. The average sunshine hours in the same month were 4.1 hours. The average sunrise and sunset time in February were 6.27 a.m. and 6.21 p.m., respectively. The average sunshine hours in the same month were 7.4 hours. According to this data even though the sun is out for around 12 hours a day, the direct sunshine falls on the island for a much lesser period. The amount of UVB reaching the earth's surface should be even low due to atmospheric disturbances. Hence a solar radiation-based study is necessary to determine the UV B exposure required to maintain a healthy level of vitamin D status in the Sri Lankan population.

When considering the clothing of workers, men who wore long sleeve shirts showed significantly low 25(OH) Vit D levels than those who didn't wear long sleeve shirts which again represents the association of vitamin D status with sunlight exposure. Similarly, men with face, hands, and legs exposure to sunlight had significantly high 25(OH) Vit D levels than the others with only face, face, and hands exposure. This finding was in line with the literature which has depicted the clothing pattern and the sun-exposed body area effects serum 25(OH) Vit D levels[6].

CONCLUSION

There was no significant difference between the vitamin D levels of indoor and outdoor workers. In conclusion, no work-related factors deem to be affected the vitamin D deficiency of individuals in Sri Lanka. The results of this study revealed that vitamin D deficiency was highly prevalent among workers in Sri Lanka. As the reference ranges of vitamin D status for the Sri Lankan population is not well stated, further studies are needed to confirm the same.

LIMITATIONS

Our sample comprised participants from seven different occupational categories. The number of participants in each occupational category was not equal and this could affect the sub-group analyses.

Author declaration

Acknowledgements:

Authors are grateful to all individuals who participated and supported the study. Elixir Healthcare is gratefully acknowledged for providing Vitamin D assay kit for this study.

Funding sources:

There is no source of funding.

Conflict of interest:

Author declares no conflicts of interest.

Statement on ethical clearance:

Ethical approval for the study was sought from Ethics Review Committee, Faculty of Allied Health Sciences, University of Ruhuna, Sri Lanka (Reference number:01.07.2020;3.13). Informed written consent was obtained from all participants.

Data availability: The data that support the findings of this study are available**.**

REFERENCE

1. Holick, M.F. Environmental factors that influence the cutaneous production of vitamin D. Am J Clin Nutr. 1995 Mar;61(3 Suppl):638S-645S. DOI: http://doi.org/10.1093/ajcn/61.3.638S
2. Harinarayan, C.V., Holick, M.F., Prasad, U.V., Vani, P.S., and Himabindu, G. Vitamin D status and sun exposure in India. Dermatoendocrinol. 2013 Jan 1;5(1):130-141. DOI: http://doi.org/10.4161/derm.23873
3. Nimitphong, H., and Holick, M.F. Vitamin D status and sun exposure in southeast Asia. Dermatoendocrinol. 2013 Jan 1;5(1):34-7. DOI: http://doi.org/10.4161/derm.24054
4. MacLaughlin, J., and Holick, M.F. Aging decreases the capacity of human skin to produce vitamin D3. J Clin Invest. 1985 Oct;76(4):1536-8. DOI: http://doi.org/10.1172/JCI112134
5. Wacker, M., and Holick, M.F. Vitamin D - effects on skeletal and extra skeletal health and the need for supplementation. Nutrients. 2013 Jan 10;5(1):111-48. DOI: http://doi.org/10.3390/nu5010111
6. Parisi, A.V. and Wilson, C.A. Pre-vitamin D_3 effective ultraviolet transmission through clothing during simulated wear. Photodermatology,

Photoimmunology & Photomedicine. 2005; 21:303-310. DOI: http://doi.org/10.1111/j.1600-0781.2005.00180.x

7. Wimalawansa, S.J. Vitamin D: What clinicians need to know. Sri Lanka Journal of Diabetes Endocrinology and Metabolism. 2012;2(2):73-88. DOI: http://doi.org/10.4038/sjdem.v2i2.4776

8. Harinarayan, C.V., Ramalakshmi, T., and Venkataprasad, U. High prevalence of low dietary calcium and low vitamin D status in healthy south Indians. Asia Pac J Clin Nutr. 2004;13(4):359-364.

9. Makariou, S., Liberopoulos, E.N., Elisaf, M., and Challa, A. Novel roles of vitamin D in disease: what is new in 2011? Eur J Intern Med. 2011 Aug;22(4):355-362. DOI: http://doi.org/10.1016/j.ejim.2011.04.012

10. Subasinghe, C.J., Gunawardena, K., Ediriweera, D., and Somasundaram, N.P. 'Prevalence of vitamin D deficiency / Insufficiency and its metabolic associations in an urban setting in Sri Lanka : Data from Colombo Urban study, Sri Lanka Journal of Diabetes Endocrinology and Metabolism, 2013; 9(2), pp. 16 – 24 DOI: http://doi.org/10.4038/sjdem.v9i2.7394

11. Siddiqee, M.H., Bhattacharjee, B., Siddiqi, U.R., and Rahman, M.M. High prevalence of vitamin D deficiency among the South Asian adults: a systematic review and meta-analysis. BMC Public Health 21, 1823 (2021). DOI: https://doi.org/10.1186/s12889-021-11888-1

12. Kaneshapillai, A., Hettiarachchi, U., Gunasekara, D., Prathapan, S., and Liyanage, G., Maternal Vitamin D Status and Its Effect on Vitamin D Levels in Early Infancy in a Tertiary Care Centre in Sri Lanka. International Journal of Endocrinology, 2019; 2019. DOI: http://org/10.1155/2019/9017951

13. Jayathissa, R., Lekamwasam, S., Ranbanda, J.M., Ranasinghe, S., Perera, A.G., and De Silva, K.H., Vitamin D deficiency among children aged 10-18 years in Sri Lanka. Ceylon Medical Journal, 64(4), pp. 146-154 DOI: http://doi.org/10.4038/cmj.v64i4.8991

14. Divakar, U., Sathish, T., Soljak, M., Bajpai, R., Dunleavy, G., Visvalingam, N., et al. Prevalence of Vitamin D Deficiency and Its Associated Work-Related Factors among Indoor Workers in a Multi-Ethnic Southeast Asian Country. *International Journal of Environmental Research and Public Health*. 2020;17(1):164. DOI: http://doi.org/10.3390/ijerph17010164

15. Jeong, H., Hong, S., Heo, Y., Chun, H., Kim, D., Park, J., et al. Vitamin D status and associated occupational factors in Korean wage workers: data from the 5th Korea national health and nutrition examination survey (KNHANES 2010-2012). Ann Occup Environ Med. 2014 Sep 16; 26:28. DOI: http://doi.org/10.1186/s40557-014-0028-x

16. Devgun, M.S., Paterson, C.R., Johnson, B.E., and Cohen, C. Vitamin D nutrition in relation to season and occupation. *The American Journal of Clinical Nutrition.* 1981 Aug; 34(8):1501–1504. DOI: http://doi.org/10.1093/ajcn/34.8.1501

17. Devgun, M.S., Paterson, C.R., and Martin, B.T. Seasonal changes in the activity of serum alkaline phosphatase. Enzyme. 1981;26(6):301-305. DOI: http://doi.org/10.1159/000459198

18. Sowah, D., Fan, X., Dennett, L., Hagtvedt, R., and Straube, S. Vitamin D levels and deficiency with different occupations: a systematic review. BMC Public Health. 2017 Jun 22;17(1):519. DOI: http://doi.org/10.1186/s12889-017-4436-z

19. ClinCalc, Sample size calculator, viewed 23 April 2021, < https://clincalc.com/stats/samplesize.aspx>

20. Holick, M.F. Vitamin D status: measurement, interpretation, and clinical application. Ann Epidemiol. 2009 Feb;19(2):73-8. DOI: http://doi.org/10.1016/j.annepidem.2007.12.001

21. Meyer, H.E., Holvik, K., Lofthus, C.M., and Tennakoon, S.U. Vitamin D status in Sri Lankans living in Sri Lanka and Norway. Br J Nutr. 2008 May;99(5):941-944. DOI: http://doi.org/10.1017/S0007114507844138

22. Rodrigo, M., Hettiarachchi, M., Liyanage, C., and Lekamwasam, S. Low serum vitamin D among community-dwelling healthy women in Sri Lanka. Health.2013; 05. 1997-2003. DOI: http://dx.doi.org/10.4236/health.2013.512270

23. Al Attia HM. Understanding the Relation between Outdoor and Indoor Life Style and the Hypovitaminosis in a Year-Round Sunny Area. Ann Arthritis Clin Rheumatol. 2018; 1(1): 1003

24. Acherjya, G.K., Ali, M., Tarafder, K., Akhter, N., Chowdhury, M.K., Islam, D.U., et al. Study of Vitamin D Deficiency among the Apparently Healthy Population in Jashore, Bangladesh. Mymensingh Med J. 2019 Jan;28(1):214-221

25. Tangoh, D.A., Apinjoh, T.O., Mahmood, Y., Nyingchu, R.V., Tangunyi, B.A., Nji, E.N., et al. (2018) 'Vitamin D Status and Its Associated Risk Factors among Adults in the Southwest Region of Cameroon', Journal of Nutrition and Metabolism, 2018.

26. Augustine, L., Nair, K., and Kulkarni, B. Optimal duration of sun exposure for adequate cutaneous synthesis of vitamin d IN Indian cities: An estimate using satellite-based ultraviolet index data', Biomed J Sci & Tech Res, 2018; 6(2).