Prevalence and Risk Factors for Vitamin D Deficiency among Mothers in Labor and Their Newborns

Fadheela T Al-Mahroos, MD, MHPE* Huda S Al-Sahlawi, MD**
Eshraq Al-Amer, MBBS, Arab Board*** Naeema A Mahmood, MBBS, ABOG****
Amarjit K Sandhu, FRCOG, FICOG***** Huda Sharida, FRCOG******
Das S Nagalla, MD******* Ahmed A Jaradat, PhD (Biostatistics)********
Salam O Jibrel, MD********* Shatha AS Bin Jamal, MBBS, ABOG**********
Fatima A Al-Haddad, MSc, RD LD***********

Background and Objectives: Vitamin D deficiency is recognized as a global public health problem. Studies of vitamin D levels in mothers in labor and their newborns in Bahrain are lacking. The aim of this study is to identify the prevalence of vitamin D (25(OH)D) deficiency among mothers in labor and their newborns in Bahrain.

Design: A cross-sectional multicenter study.

Setting: Four Public and Four Private Maternity Hospitals in Bahrain.

Method: The study was conducted in April 2012. It included mothers in labor and their newborns. Differences between the subgroups were analyzed using Chi-Square or Student's *t*-test as appropriate. Linear regression analysis was used to evaluate independent predictors of 25(OH)D level.

Result: The study included 403 mothers and 403 newborns. Overall prevalence of 25(OH)D deficiency (<50 nmol) was 358 (88.8%) of the mothers and 364 (90.3%) of the newborns. The mean maternal alkaline phosphatase level was significantly higher than the neonatal level and the maternal mean calcium was significantly lower than the neonatal level.

Significant association with vitamin D deficiency was found among Bahraini and non-Bahraini Arab mothers, delivering in public rather than private hospital, living in flats, low education, the use of veil, gravida ≥4, not using multivitamins, vitamin D or calcium supplements.

Conclusion: Vitamin D deficiency among mothers and their newborns is high. This mandates increasing awareness, vitamin D supplementation among mothers in labor and their infants; in addition to the introduction of vitamin D fortification of dairy products and flour at the national level.

Bahrain Med Bull 2013; 35(2):

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*	Consultant & Associate Professor, AGU Department of Pediatrics, SMC
**	Resident, Radiology Department, SMC
***	Chief Resident Pediatric Department, SMC
****	Consultant and Assistant Professor, AGU Department of Obstetrics & Gynecology, SMC

***** Consultant and Assistant Professor, AGU
Department of Obstetrics & Gynecology, SMC
****** Consultant and Assistant Professor, AGU
Department of Obstetrics & Gynecology, Bahrain Defense Force Hospital
******* Consultant Pathologist, SMC
******** Associate Professor, Biostatistics, AGU
********* Consultant Obstetrician & Gynecologist, Bahrain Specialist Hospital
********** Consultant Obstetrician & Gynecologist, Bahrain International Hospital
*********** Clinical Dietician, Salmaniya Medical Complex
Kingdom of Bahrain
Email: fadheela@batelco.com.bh

Vitamin D is a prohormone synthesized from 7-dehydrocholesterol in the skin upon exposure to ultraviolet B rays (UVB) in the range of 280-320 nm. The sun is the source of 90% of body stores of vitamin D and about 10% comes from dietary sources. Food, in general, is a poor source of vitamin D except in some oily fish, eggs and fortified foods[1].

Vitamin D is essential for the health of the musclo-skeletal system. The deficiency leads to rickets, osteomalacia, osteopenia, osteoporosis, impaired muscles tone and body balance. Vitamin D deficiency is associated with other serious health disorders, such as diabetes mellitus, hypertension, autoimmune disorders and cancer[2,3]. Vitamin D deficiency is a public health problem worldwide and it is reported in Western and Eastern countries[4-16]. However, the problem is more prevalent and more severe among mothers and children from Middle Eastern and Asian societies[17].

The cut-off point for 25(OH)D deficiency has been controversial. Some experts considered 25(OH)D level of <75 nmol/L as deficient while others suggested 90-100 nmol/L as the desirable level for optimal musculoskeletal health[18-21]. The latter was supported by finding the mean 25(OH)D level of 115 nmol/L among traditionally living population in Africa who have skin type VI and have a moderate degree of clothing[22].

In 2011, the US Institute of Medicine (IOM) revised the recommended intake of vitamin D for adults to 600 IU in order to achieve a serum 25(OH)D level of at least 50 nmol/L[23]. Similar level was recommended by the American Academy of Pediatrics (AAP)[24]. However, these recommendations have not been uniformly accepted[18,25]. It is considered inadequate to meet the body needs for the multiple functions of vitamin D. Keeping in mind these different viewpoints, the available scientific evidence and for the purpose of this study, we considered vitamin D as deficient when 25(OH)D is <50 nmol/L.

To our knowledge, there is no published research about vitamin D status among pregnant women in Bahrain. The aim of this study is to identify the prevalence of 25(OH)D deficiency and risk factors among mothers in labor and their newborns.

METHOD

A cross-sectional multi-center study was conducted in the second and third weeks of April 2012. The study subjects included the mothers who presented to the participating hospitals during active labor and their newborns (full term, premature or stillborn babies). The patients were recruited from four public and four private maternity hospitals in Bahrain. These eight hospitals represent 95% of all annual deliveries in Bahrain[26].

Mothers suffering from any disease, which might interfere with vitamin D absorption or metabolism or calcium homeostasis or taking any drugs that are known to interfere with vitamin D absorption or metabolism were excluded.

Data collection methods were based on a questionnaire and laboratory measurements. In addition, personal data, lifestyle issues and medical history were documented. Outcome measures included maternal and neonatal serum 25(OH) D, calcium, phosphorus and alkaline phosphatase.

Pilot study: Ten mothers in labor and their newborns were randomly selected from the participating maternity hospitals over two days at the end of March 2012. Based on the feedback received, some adjustments of the processes and procedures were made and the questionnaire was amended accordingly. Informed consent was obtained from all participants.

Blood samples were collected from the mothers on arrival to the maternity hospital and from the cord blood in the third stage of labor. The measurements included serum 25(OH)D, calcium, phosphorus, magnesium and alkaline phosphatase.

Vitamin D was assayed as 25(OH)D using chemiluminescence method on Architect (Abbott). This method (in our laboratory) has correlation coefficient with high performance liquid chromatography (HPLC) assay of 0.92. Therefore, Chemiluminescence method was chosen because it is economical. PTH was not obtained because of its low reliability during pregnancy[27].

SPSS statistical package versions-19 was used for data entry and analysis. Differences between subgroups were analyzed using Chi-Square or Student's *t*-test as appropriate. Linear regression analysis was used to evaluate independent predictors of 25(OH)D level. P-value <0.05 was considered significant.

RESULT

The total number of mothers was 403 and the newborns were 415 including 10 sets of twins and one triplet. One newborn from each set was randomly selected. Therefore, 403 mothers in labor and their 403 newborns were included in the study.

The mothers' mean age ± standard deviation (SD) was 29 ± 5.7 years, ranging from 16-52 years. There was one mother under the age of 18 years. Three hundred fifty-eight (88.8%) of the participants were from public hospitals and 45 (11.2%) were from private hospitals. Mothers' nationalities were as follow: 258 (64%) were Bahrainis, 67 (16.6 %) were non-Bahraini Arabs, 75 (18.6%) were Asians, 2 (0.5%) were Africans and one (0.2%) was European.

Three hundred fifty-eight (88.8%) mothers and 364 (90.3%) newborns had 25(OH)D level of <50 nmol/L, see table 1. In addition, 133 (33%) mothers and 213 (52.9%) newborns had 25(OH)D level of <25 nmol/L. If we take the cut-off point of deficiency as <80 nmol/L, only three mothers and three newborns (0.7%) had 25(OH)D level of ≥80 nmol/L.

Table 1: Maternal and Neonatal 25(OH)D Levels

Vitamin D (nmol/L)	Mothers		Newborns	
	Number (Percentage)			
<25	133 (33)	358 (88.8)*	213 (52.9)	364 (90.3)**
25 - 49.99	225 (55.8)		151 (37.5)	
≥50	45 (11.2)	45 (11.2)	39 (9.7)	39 (9.7)
Total	**403 (100)**	**403 (100)**	**403 (100)**	**403 (100)**

*133 (33) + 225 (55.8) = 358 (88.8), **213 (52.9) + 151 (37.5) = 364 (90.3)

The mean maternal 25(OH)D level was significantly higher than neonatal level (P<0.001), see table 2. The mean maternal alkaline phosphatase was significantly higher than neonatal level (P<0.001). In contrast, the mean calcium level was significantly lower in the maternal than in the neonatal blood (2.09 ± 0.10 vs. 2.42 ± 0.15 mmol/L, P<0.001). Phosphorous level was significantly lower in maternal than neonatal blood (P<0.001). Pearson correlation coefficient between maternal and neonatal levels was high (0.81) for 25(OH)D, moderate (0.49) for phosphorous, low (0.23) for calcium and almost none (0.04) for alkaline phosphatase. Calcium level was below 2.1 mmol/L in 47.8% of the mothers but only 2% of the newborns, see table 3.

Table 2: Correlation of Maternal and Neonatal Biochemical Profiles

	Number	Mean (SD)	P*	Range	Pearson CC**	P***
25(OH)D						
Mothers'	403	33.3 (13.8)	0.000	10 - 88	0.81	0.01
Cord blood	403	27.4 (15.0)		1.6 - 85		
Calcium (mmol/L)						
Mothers'	402****	2.09 (0.10)	0.000	1.58 - 2.70	0.23	0.01
Cord Blood	402****	2.41 (0.15)		1.63 - 2.80		
Alkaline Phosphatase (IU)						
Mothers'	402****	220.0 (78.2)	0.000	28.0 - 719.0	0.04	0.39
Cord Blood	402****	201.0 (71.1)		91.0 - 598.0		
Phosphorus (mmol/L)						
Mothers'	402****	1.26 (0.28)	0.000	0.50 - 3.30	0.49	0.01
Cord Blood	402****	1.93 (0.40)		0.76 - 3.60		

SD: Standard deviation *Independent samples test **Correlation coefficient ***Chi-square ****Missing data

Table 3: Association of Maternal and Neonatal Calcium with 25(OH)D Level

Calcium (mmol/L)	Vitamin D (nmol/L)			P-value
	Total	<50	≥50	
	Number (Percentage)			
Maternal				
<2.1	192 (47.8)	178 (92.7)	14 (7.3)	0.018
≥2.1	210 (52.2)	179 (85.2)	31 (14.8)	
Total	402 (100)*	357 (88.8)	45 (11.2)	
Neonatal				
<2.1	8 (2)	7 (87.5)	1 (12.5)	0.56
≥2.1	395 (98)	357(90.4)	38 (9.6)	
Total	403 (100)	364 (90.3)	39 (9.7)	

*Missing data

25(OH)D deficiency was significantly common among Bahrainis and non-Bahraini Arab (P=0.01), those delivering in public rather than private hospitals (P<0.001), those with lower education (P=0.040) and those living in flats (P=0.025), see table 4. Linear regression analysis showed that same factors were significantly and independently associated with 25(OH)D level. Both mothers' age and income showed no significant association with 25(OH)D levels.

Table 4: Association of Personal Characteristics with 25(OH)D Level

	Total	Vitamin D (nmol/L)		P-value	Linear Regression
		<50	≥50		
Mothers' Age (years)	Number (Percentage)				
16-29	223	197 (88.3)	26 (11.7)		
30-39	162	147 (90.7)	15 (9.3)	0.239	-
40-52	18	14 (77.8)	4 (22.2)		
Total	403	358 (88.8)	45 (11.2)		
Nationality					
Bahraini	258	233 (90.3)	25 (9.7)		
Non-Bahraini Arab	67	63 (94.0)	4 (6)	0.010	0.000
Other Nationalities	78	62 (79.5)	16 (20.5)		
Total	403	358 (88.8)	45 (11.2)		
Hospital					
Public	358	330 (92.2)	28 (7.8)		
Private	45	28 (62.2)	17 (37.8)	0.000	0.000
Total	403	358 (88.8)	45 (11.2)		
Education					
None-Primary	60	58 (96.7)	2 (3.3)		
Secondary-Diploma	169	152 (89.9)	17 (10.1)	0.040	0.002
University	174	148 (85.1)	26 (14.9)		
Total	403	358 (88.8)	45 (11.2)		
Income (BD)					
<300	24	24 (100)	0 (0)		
301-500	41	39 (95.1)	2 (4.9)	0.092	-
501-1000	58	52 (89.7)	6 (10.3)		
1001-2000	8	6 (75)	2 (25)		
Total	131*	121 (92.4)	10 (7.6)		
Residence					
House with garden	115	96 (83.5)	19 (16.5)		
House without garden	58	49 (84.5)	9 (15.5)		
Flat	226	209 (92.5)	17 (7.5)	0.025	.028
Total	399**	354 (88.7)	45 (11.3)		

*Remaining 272 are house-wives or students **Missing data

Table 5 shows the association of lifestyle factors with 25(OH)D. Mothers gravida ≥4 and the use of veil were significantly associated with 25(OH)D deficiency (P=0.048 and 0.002 respectively). Linear regression analysis proved that both are significant. Furthermore, as the degree of veil coverage increased, the prevalence of low 25(OH)D had increased (P=0.008). Smoking and physical exercise showed no significant association with 25(OH)D.

Table 5: Association of Life Style Factors with 25(OH)D Level

	Total	Vitamin D (nmol/L)		P-value	Linear Regression
		<50	≥50		
Smoking					
Yes	8	8 (100)	0 (0)	0.397	-
No	390	347 (89)	43 (11)		
Total	398**	355 (89.2)	43 (10.8)		

Exercise					
Yes	106	94 (88.7)	12 (11.3)	0.460	-
No	279	250 (89.6)	29 (10.4)		
Total	385**	344 (89.4)	41 (10.6)		
Use of Veil					
Yes	351	319 (90.9)	32 (9.1)	0.002	0.044
No	52	39 (75)	13 (25)		
Total	403	358 (88.8)	45 (11.2)		
Extent of Veil Coverage					
Head Only	258	230 (89.1)	28 (10.9)		
Head & face without eyes	75	70 (93.3)	5 (6.7)	0.008	
Head, face & eyes	17	17 (100)	0 (0)		0.525
None	50	38 (76)	12 (24)		
Total	400**	355 (88.8)	45 (11.2)		
Gravida					
1-3	286	247 (86.4)	39 (13.6)		
4-6	97	92 (94.8)	5 (5.2)	0.048	0.043
7-9	20	19 (95.0)	1 (5.0)		
Total	403	358 (88.8)	45 (11.2)		

**missing data

The use of veil was significantly more prevalent among Bahraini (95.7%) and non-Bahraini Arab (98.5%) mothers than Asian (49%) and African (50%) mothers (P=0.000). One European woman in the study did not use a veil and her vitamin D level was 74.1 nmol/L. Linear regression analysis showed that nationality was insignificant (P=0.567), while the use of veil was significant and independently associated with 25(OH)D deficiency (P=0.000).

25(OH)D deficiency was significantly less common in patients supplemented with multivitamins, vitamin D or calcium (P=0.001, 0.017, and 0.007 respectively), see table 6. Linear regression analysis revealed that all supplements remained significantly and independently associated with higher 25(OH)D.

Table 6: Association of 25(OH)D Level with the Use of Supplements

	Total	Vitamin D (nmol/L)		P-value	Regression Analysis
		<50	≥50		
Multivitamins					
Yes	223	186 (83.4)	37 (16.6)		
No	180	172 (95.6)	8 (4.4)	0.000	0.000
Total	403	358 (88.8)	45 (11.2)		
Vitamin D					
Yes	64	51 (79.7)	13 (20.3)		
No	339	307 (90.6)	32 (9.4)	0.017	0.003
Total	403	358 (88.8)	45 (11.2)		
Calcium					
Yes	168	141 (83.9)	27 (16.1)		0.022
No	235	217 (92.3)	18 (7.7)	0.007	
Total	403	358 (88.8)	45 (11.2)		

DISCUSSION

In this study, 88.8% of mothers and 90.3% of their newborns had 25(OH)D level of <50 nmol/L. In addition, 30% of the mothers and 50% of the newborns had 25(OH)D level of <25 nmol/L, the level at which the risk of rickets increases significantly[28]. Pregnancy is well-known to put extra demands on mothers' vitamin D and calcium stores[29]. However, the high prevalence of vitamin D deficiency in Bahrain, which is a sunny country almost year round, is unexpected. Vitamin D deficiency during pregnancy was reported across continents and racial groups. However, it is more prevalent and more severe among Asian and Middle Eastern countries[7-17,30-34].

In this study, the newborns maintained normal calcium level despite significant maternal hypocalcaemia (P=0.000). Furthermore, the mean maternal alkaline phosphatase level was significantly higher than the neonatal level (P=0.000) despite that maternal mean of 25(OH)D was significantly higher than the neonatal level (P=0.000). Similar findings were reported in Canadian and Saudi mothers[35,36]. This indicates an active calcium transport against concentration gradient regardless of maternal calcium level. This might be attributed to the placental activation of 25(OH)D[37,38]. Furthermore, the higher alkaline phosphatase in mothers is compatible with the documented evidence of negative correlation between 25(OH)D level and bone resorption markers among mothers in labor[39,40].

Numerous factors are known to negatively influence cutaneous synthesis of vitamin D including higher latitude, winter season, darker skin, older age, high body mass index, the use of UVB block creams, extensive skin covering with cloths, veil and working indoor[41,42].

The use of veil showed a significant association with lower 25(OH)D level (P=0.002). Furthermore, as the degree of veil coverage increased, the prevalence of hypovitaminosis increased. However, with linear regression analysis the association with the degree of coverage disappeared which was most likely caused by the small number of mothers in this subgroup. Other studies found that the use of veil and concealing cloths are major contributing factors to 25(OH)D deficiency among women[43-46].

Maternal 25(OH)D deficiency was significantly more prevalent among Bahraini and non-Bahraini Arab mothers than other nationalities (P=0.01). Linear regression analysis showed that nationality became insignificant (P=0.567) but the use of veil became highly significant and independently associated with 25(OH)D deficiency (P=<0.001). Therefore, it can be inferred that it is the use of veil rather than the nationality which contributed to the higher prevalence of 25(OH)D deficiency.

There was a clear trend of higher prevalence of vitamin D deficiency among mothers as the income decreased; however, this difference did not reach a statistical significance in both bivariate and linear regression analyses. This could be explained by the presence of very low cell values including a zero. Many other studies linked 25(OH)D deficiency with low socioeconomic status[46,47].

Nonetheless, vitamin D deficiency showed a significant association with other factors related to lower socio-economic status, such as, mothers living in flats rather than houses (P=0.02), those with low level of education (P=0.04), those delivering in public rather than in private hospitals (P=0.000) and those not supplemented with multivitamins, vitamin D or calcium (P=0.001, 0.017 and 0.007 respectively). Other studies showed similar impact of the type of dwelling which is probably due to poor sun exposure and lower intake of vitamin D[46,48,49]. Mothers gravida ≥4 showed a significantly higher 25(OH)D deficiency (P=0.048), which was expected due to the depletion of maternal stores of vitamin D. Similarly, another study showed that multiple and twin pregnancies put more demand on maternal vitamin D stores[50].

Despite the fact that mothers supplemented with vitamins were less likely to be 25(OH)D deficient, still 83% of those receiving multivitamins and 79.7% of those receiving vitamin D were 25(OH)D deficient. This might indicate that the prescribed conventional dose of vitamin D was either inadequate or there was a problem with compliance. Similar findings were reported by Bodnar et al[51].

Although smoking did not show a significant association, all the eight smokers had vitamin D level <50 nmol/L. Lack of association was most likely to be caused by the small number of smokers rather than genuine lack of association. Other studies found that smoking significantly reduced 25(OH)D level[52].

In addition, vitamin D deficiency is aggravated by the population lifestyle, which leads to limited sun exposure. To avoid the hot climate of Bahrain, most people work, shop, exercise and conduct social activities indoor. Furthermore, because of the concern about skin health, more people limit their sun exposure and the use of sun block to avoid the risk of skin cancer[53]. Furthermore, supplementing pregnant women with vitamin D up 4000 IU/d has been shown to be safe and effective, very few professionals have been prescribing it to mothers[54,55].

The findings of this study highlight the need for improving professionals and public awareness about vitamin D deficiency and its risk factors. In addition, there is a need for the fortification of common food such as flour, milk, and dairy products with vitamin D.

This study was done among pregnant women and cannot be generalized to other women in Bahrain. It highlights the need for further studies among randomly selected sample from the general population to study the consequences of vitamin D deficiency on maternal health and neonatal outcome.

CONCLUSION

The prevalence of vitamin D deficiency among mothers in labor and their newborns in Bahrain is high. Because of the impact of vitamin D deficiency on the health of mothers and their newborns, it is essential to raise awareness among professionals and the general population. Furthermore, we recommend vitamin D supplementation of 1000 IU during pregnancy and 600 IU during infancy and to introduce vitamin D fortification of milk and dairy products, and flour.

Author contribution: All authors share equal effort contribution towards (1) substantial contributions to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of the manuscript version to be published. Yes

Potential conflicts of interest: None **Competing interest**: None

Sponsorship: 75% of the fund was provided by Gulf Petrochemical Industries Company and 25% of the fund by Dr. Ali Al-Khailfa Medical Research Fund

Submission date: 4 February 2013 **Acceptance date**: 16 March 2013

Ethical approval: Approved by the research and ethics committees at the participating medical institutions, Bahrain.

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