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**Original Research Article**

# Hospital Based Cross Sectional Study to Assess the Serum Vitamin D Deficiency in NICU Hospitalized Neonates and Its Association with Neonatal Outcomes

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**Abstract**

**Aim:** Serum Vitamin D Deficiency in NICU Hospitalized Neonates and Its Association With Neonatal Outcomes.

**Methods:** Hospital based cross sectional study conducted in the Department of Pediatrics, Madhubani Medical Colleges and Hospital, Madhubani, Bihar, India,for 1 year. All the neonates with medical and surgical diseases hospitalized in NICU were enrolled in this study. The subjects were breast fed before admission. Immediately on admission, serum sample for vitamin D measurement was obtained along with routine blood sampling, thus the impact of the affecting factors was minimized. Serum vitamin D and calcium levels were measured by Electrochemiluminescence immunoassay and Calcium Assay kit (colorimetric) methods, respectively.

**Results:** From the studied neonates, 10 had normal vitamin D level, 50 had insufficient vitamin D level and 40 had vitamin D deficiency. So, vitamin D deficiency and insufficiency were present in 90% of our patients. The mean±SD serum level of vitamin D was 14.93±17.96 ng/ml (Min=2, Max=151 ng/ml) in our patients. The mean±SD values between hospitalized neonates due to medical and surgical causes were 15.11±18.95 and 14.36±14.61 ng/ml respectively. The mean serum value of vitamin D was similar among both gender (p=0.31). There were no significant differences in the neonatal vitamin D status regarding medical or surgical causes of admission (p=0.77). Moreover, longer length of hospital stay was not associated with lower levels of vitamin D (p=0.87). A significant association was observed between vitamin D status and season of birth. Most of the neonates with vitamin D deficiency were born in winter (p=0.015). More than half of the neonates (55%) with vitamin D deficiency were also hypo calcemic (p=0.026). There was no significant difference between the term and preterm neonates regarding the prevalence of vitamin D deficiency, insufficiency and sufficiency (p=0.19), but the mean value of vitamin D in term neonates was significantly lower than preterm neonates (11.74 ng/ml vs. 21.63 ng/ml; p=0.032).

**Conclusion:** The vitamin D deficiency and insufficiency were common among neonates admitted to NICU. Low levels of vitamin D were not associated with neonatal outcomes including longer hospital stay or increased mortality rate during hospital admission.

**Keywords:** Vitamin D, NICU, Neonates



## Introduction:

Vitamin D as a fat-soluble vitamin plays important roles in calcium and phosphorus homeostasis, bone metabolism, modulating innate and acquired immune responses, inhibition of cancer cell proliferation, regulating organ and hormones functions. Vitamin D receptors (VDR) are expressed in many cells and tissues throughout the body.[1,2] Vitamin D is transferred from the mother to the fetus to provide crucial supports in implantation process, placental formation, and fetal developmental stages by its metabolic, immunomodulatory and anti-inflammatory effects.[2,3] Several studies have demonstrated a high frequency of vitamin D deficiency among critically ill adults who hospitalized in the intensive care units (ICU).[4-6] An investigation showed that of all critically ill cases, survivors had significantly higher vitamin D concentrations and lower pre-ICU hospital stay compared to non-survivors, however, no association was observed between vitamin D level and mortality.[4] Another investigation showed that there was a significant association between vitamin D deficiency and mortality rate in ICU hospitalized adult subjects.[5] A high prevalence of vitamin D deficiency was observed among ICU hospitalized severely ill patients; the mean vitamin D concentration in 130 ICU admitted patients was reported 14.04 ± 6.9 ng/ml. Moreover among the deceased patients, the survival time in the vitamin D deficient cases was shorter than the vitamin D sufficient group.[6] Previous studies have also indicated a high prevalence of vitamin D deficiency among hospitalized critically ill children at intensive care units.[7] Significant associations were reported between vitamin D deficiency with the severity of illness, multiple organ dysfunctions, higher admission days and mortality rate in patients admitted to pediatric ICU.[8,9]

The high prevalence rate of vitamin D deficiency was also demonstrated among pregnant women as a high-risk population by 60–80%.[10,11] Moreover, a positive correlation has been demonstrated between mother and neonate's vitamin D levels.[12] So it seems that neonates could be strongly affected by vitamin D deficiency-related adverse effects. To the best of our knowledge, there are very few studies assessing the prevalence of vitamin D deficiency among NICU hospitalized neonates and its correlation with mortality/morbidity rate.[13-16]

## Material and methods

This prospective hospital based cross-sectional descriptive study conducted in the Department of Pediatrics, Madhubani Medical Colleges and Hospital, Madhubani, Bihar, India, for 1 year, after taking the approval of the protocol review committee and institutional ethics committee.

## Methodology

All the neonates with medical and surgical diseases hospitalized in NICU were enrolled in this study. Neonates without written parental consent, those who received large doses of vitamin D or had no acceptable plasma specimen for vitamin D measurement were excluded. The subjects were breast fed before admission. Immediately on admission, serum sample for vitamin D measurement was obtained along with routine blood sampling, thus the impact of the affecting factors was minimized. Serum vitamin D and calcium levels were measured by Electrochemiluminescence immunoassay and Calcium Assay kit (colorimetric) methods, respectively. Vitamin D deficiency, insufficiency and sufficiency were defined as serum 25 (OH) vitamin D<20 ng/ml, 20-30 ng/ml and >30 ng/ml, respectively.[17,18] Serum Calcium less than 8 mg/dL was also considered as hypocalcemia.[19] Confounding factors that could have an impact on calcium status such as serum levels of albumin, phosphate and magnesium or acid-base disorders have been considered and ruled out in the subjects. Regarding financial issues, we were not able to measure serum vitamin D level in their mothers at the same time. Demographic and clinical data of neonates including sex, gestational age, and the season of birth, serum levels of vitamin D and calcium, causes of hospitalization, age at hospital admission were recorded. Association between vitamin D levels and neonatal clinical outcomes including length of hospital stay and mortality rate during hospitalization were assessed.

## Statistically Analysis

Analyses were statistically performed by using the software package SPSS Version 25.0. Quantitative and qualitative variables were reported by mean±SD and percent, respectively. Independent Student t, Chi-square, and Bivariate Correlation tests were used for determining associations between vitamin D serum concentration and different variables. The Kaplan-Meier analysis was also performed to analyze the correlations between variables and the neonatal mortality rate. The level of significance was considered as $P < 0.05$

## Results

Of the 100 neonates admitted to the NICU during the study period, 58% were female and 42% were male. Among them 57% were term and 43% were preterm. The mean±SD birth weight was 2258 ±726.46 grams. The causes of hospitalization in 75% were medical and 25% were surgical diseases. The mean±SD age at hospital admission were 63.60±31.59 days in the sufficient group, 10.09±12.04 days in the insufficient group and 6.92±8.54 days in the deficient group. The length of hospital stay was 10±8.82, 11.80±6.99 and 12.81±11.70 days in sufficient, insufficient and deficient groups respectively. 43 (43%) cases were born in spring and summer and 57(57%) were born in fall and winter.

From the studied neonates, 10 had normal vitamin D level, 50 had insufficient vitamin D level and 40 had vitamin D deficiency. So, vitamin D deficiency and insufficiency were present in 90% of our patients. The mean±SD serum level of vitamin D was 14.93±17.96 ng/ml (Min=2, Max=151 ng/ml) in our patients. The mean±SD values between hospitalized neonates due to medical and surgical causes were 15.11±18.95 and 14.36±14.61 ng/ml respectively.

About 37% of the neonates had hypocalcemia. The mean±SD serum calcium level was 8.54±1.35 mg/dL (Min=2, Max=10.9). The mean±SD values among neonates with medical and surgical disorders were 8.37±1.44 and 8.75±0.92 mg/dL respectively.

**Associations between neonatal vitamin D status and demographic and clinical characteristics:** The baseline demographic and clinical characteristics of the neonates according to vitamin D status were shown in Table 1. We did not find any association between serum vitamin D level and neonatal sex. The mean serum value of vitamin D was similar among both gender (p=0.31). There were no significant differences in the neonatal vitamin D status regarding medical or surgical causes of admission (p=0.77). Different etiologies for NICU admission are demonstrated in Table 2. Moreover, longer length of hospital stay was not associated with lower levels of vitamin D (p=0.87).

A significant association was observed between vitamin D status and season of birth. Most of the neonates with vitamin D deficiency were born in winter (p=0.015). More than half of the neonates (55%) with vitamin D deficiency were also hypo calcemic (p=0.026). Neonates with sufficient levels of vitamin D had a higher mean age at the time of admission compared to deficient and insufficient groups. This difference between the mean age of admission and vitamin D status in newborn infants was significant (p<0.001). However, there was no significant difference between the term and preterm neonates regarding the prevalence of vitamin D deficiency, insufficiency and sufficiency (p=0.19), but the mean value of vitamin D in term neonates was significantly lower than preterm neonates (11.74 ng/ml vs. 21.63 ng/ml; p=0.032).

**Associations between neonatal mortality, demographic characteristics and Vitamin D status:** Of all neonates, 7 patients (3 females and 4 males) died. Causes of death were clinical sepsis in three, necrotizing enterocolitis in one and congenital heart disease (single ventricle) in the other patient. Two were preterm. All of them had deficient or insufficient levels of vitamin D and two had hypocalcemia as well. Kaplan-Meier analysis indicated no correlation between neonatal mortality with vitamin D status (p=0.88) or serum calcium level (p=0.88). There was no significant correlation between neonatal mortality with sex and gestational age (p>0.05). All of the neonates with surgical underlying diseases survived during the study period.

**Table 1: Correlations between vitamin D status and neonatal characteristics in NICU hospitalized neonates**

| Variables | Vitamin D Sufficient (n=10) | Vitamin D Insufficient (n=50) | Vitamin D Deficient (n=40) | P value |
|---|---|---|---|---|
| Sex [n (%)] | | | | 0.27 |
| Female | 5 | 30 | 23 | |
| Male | 5 | 20 | 17 | |
| Gestational age [n (%)] | | | | 0.19 |
| Gestational age<37 weeks | 7 | 47 | 37 | |
| Gestational age≥37 weeks | 3 | 3 | 3 | |
| Causes of hospitalization [n (%)] | | | | 0.77 |
| Medical | 9 | 37 | 29 | |
| Surgical | 1 | 13 | 11 | |
| Season of birth [n (%)] | | | | 0.015 |

| | | | | |
|---|---|---|---|---|
| Spring | 4 | 8 | 6 | |
| Summer | 0 | 20 | 5 | |
| Fall57 | 4 | 12 | 10 | |
| Winter | 2 | 10 | 19 | |
| Age at admission (days)* | 63.60±31.59 | 10.09±12.04 | 6.92±8.54 | <0.001 |
| Length of hospital stay* (days) | 10.00±8.82 | 11.80±6.99 | 12.81±11.70 | 0.87 |
| Calcium status [n (%)] | | | | 0.026 |
| Normal | 6 | 27 | 20 | |
| Low | 4 | 13 | 20 | |

Vitamin D sufficiency: 25(OH) D>30ng/ml, Vitamin D insufficiency: 25(OH) D: 20-30ng/ml, Vitamin D deficiency: 25(OH) D<20ng/ml.
*mean±SD

**Table 2: The causes of admission according to vitamin D status in NICU hospitalized neonates**

| Variables | Sufficient (n=10) | Insufficient (n=50) | Deficient (n=40) |
|---|---|---|---|
| Medical causes (n=75) | | | |
| Hyperbilirubinemia | - | 4 | 3 |
| Respiratory distress syndrome | 4 | 8 | 7 |
| Metabolic disorders | - | 2 | 2 |
| Seizure disorders | - | 8 | 6 |
| Sepsis | - | 3 | 1 |
| Electrolyte imbalance | - | 4 | 1 |
| Hypoglycemia | - | 1 | 4 |
| Necrotizing enterocolitis | - | 4 | 1 |
| Congenital heart diseases | - | 5 | 2 |
| Neonatal diabetes | 2 | - | - |
| Others | - | 2 | 2 |
| Surgical causes (n=25) | | | |
| Intestinal atresia | 2 | 7 | 8 |
| Myelomeningocele | - | 2 | 3 |
| Urologic disorders | 2 | - | - |

## Discussion

The result of the present study showed that the prevalence of vitamin D deficiency and insufficiency were 40% and 50% in the neonates hospitalized in the NICU. The majority of neonates (90%) had abnormal levels of vitamin D at the time of admission. In the study held by Bhimji et al. among neonates admitted to the neonatal ward of a tertiary care hospital, about 80% of the neonates had vitamin D deficiency.[20] A prevalence of 94% vitamin D deficiency was also reported in Jordanian newborns. This low level of vitamin D was not associated with NICU admission.[21] Chacham et al. conducted an observational study at a tertiary care center on infants aged equal or less than one-year-old to evaluate the prevalence of vitamin D deficiency. 80% of the studied population was neonates and the prevalence

of vitamin D deficiency was 79% among them.[22] Based on the results of a study from Iran, of 522 enrolled newborns, 93.3% had mild to severe vitamin D deficiency at birth.[23] Another research from Saudi Arabia reported vitamin D deficiency in 86% of the studied newborns.[24] Tanbakuchi et al. observed a low level of vitamin D in 76.6% of term and 90% of preterm Iranian newborn infants at the birth time.[25] Previous Investigations from Albany and Australia found vitamin D deficiency or insufficiency in 80% of preterm infants with a birth weight of less than 1500 gr.[26] and in 35.7% of preterm neonates who were admitted at NICU[27] , respectively. The high prevalence of the low levels of vitamin D in our patients similar to others could be attributed to maternal vitamin D status. Various factors like mother's clothing style, nutritional diet and prenatal vitamin D supplements, geographic region, sunshine exposure, ethnicity, genetic factors, underlying illnesses and different laboratory cut-offs are possible reasons for the high prevalence of vitamin D deficiency in mothers.[28,29] In our patients, a significant association was present between serum vitamin D levels and the age of admission at NICU. Lower levels of vitamin D were observed in younger neonates and sufficient levels in older newborn infants. This finding may indicate a preexisting vitamin D deficiency in pregnant mothers. By advancing feeding and supplementing vitamins including vitamin D, a sufficient level might be achieved in older infants. Panda et al revealed an increasing trend in vitamin D levels in preterm infants admitted to NICU by vitamin D supplementation.

Our findings showed that neonatal vitamin D status was significantly correlated with the season of birth. Of all the vitamin D deficient neonates, the majority of them were born in winter. This association between vitamin D status and season of birth was reported by Madden et al. They showed that neonates who were admitted during summer had higher levels of vitamin D compared to those admitted in other seasons. The least levels of vitamin pertained to subjects who were admitted during fall or winter.[30] The correlation between vitamin D levels and season of birth was also reported by Korj-Bulos et al. They showed low levels of vitamin D in neonates who were born during winter months.[21] Other studies demonstrated higher prevalence of vitamin D deficiency in colder seasons.[21] However, some other researchers did not find any significant differences between season of birth and the vitamin D level.[31,32] It seems seasonal variation and changes in sunlight exposure are some environmental factors that may affect serum vitamin D level.

According to our data, a significant correlation between neonatal serum vitamin D and total calcium level was present. The majority of our patients with low levels of vitamin D were hypo calcemic as well. This significant correlation between neonatal vitamin D status and serum calcium level was also stated by another study from Iran.[23] Consistent with our findings, McNally et al. have demonstrated a lower level of vitamin D was associated with hypocalcemia.[33] Other studies reported the lowest concentration of ionized calcium with lower levels of vitamin D in PICU patients.[34] Vitamin D is essential for calcium and phosphorus hemostasis. Low levels of this vitamin in pregnant mothers may affect placental calcium transfer and influences neonatal calcium level.[23] Moreover, low levels of vitamin D may result in poor intestinal calcium absorption.

In our study, the mean value of vitamin D in term neonates was significantly lower than preterm neonates. In line with our study, Fallahi et al. from Iran reported a lower level of vitamin D in term neonates compared to the preterm infants (13.39 vs. 13.91 ng/ml),

however, the difference was not significant (p= 0.850).[35] This finding was supported by Thomas et al who found no difference between the vitamin D levels in term and preterm infants.[36] Other studies also observed no significant difference in vitamin D status among term and preterm newborn infants. Therefore, regardless of gestational age vitamin D deficiency can affect both term and preterm neonates.[37] However, there are several studies in contrary to our results that indicated a lower level of vitamin D among preterm infants compared to their term counterparts.[38,39]

We find no significant difference regarding neonatal vitamin D levels between medical and surgical patients. Compatible with our results, Arson et al. did not find any correlation between vitamin D levels and the causes of hospitalization.[40] In Rippel et al. study, low levels of vitamin D were more common in cardiac patients than non cardiac cases (40% vs 22%). Vitamin D deficiency was observed in 40.5% of postoperative cardiac patients.[34] Cardiac bypass can lower the vitamin D level. Madden et al did not find lower levels of vitamin D in children with confirmed or suspected sepsis in comparison with other critically ill children admitted to PICU except for severe septic shock.[30] Respiratory morbidities including respiratory distress syndrome and bronchopulmonary dysplasia were more common in preterm infants with severe vitamin D deficiency described by Kim et al.[37] Another study demonstrated a high prevalence of vitamin D deficiency in critically ill asthmatic children.[17] Various responses to acute stress and severe illnesses besides geographic and ethnic differences could explain different findings between studies.

The absence of a significant association between duration of NICU hospitalization and serum vitamin D status was compatible with multiple studies. Rey et al.[31] (30) and Rippel et al.[34] (18) found no association between vitamin D deficiency and ICU or hospital length of stay. Somewhat different results were demonstrated by McNally et al.[41] and Sankar et al[42] which longer length of stay was associated with vitamin D deficiency. Kim et al. reported the average duration of NICU hospitalization in vitamin D deficient group was significantly longer than vitamin D insufficient or sufficient groups.[37] Another study demonstrated a significant correlation between neonatal vitamin D levels with the duration of NICU hospitalization[42] Various causes and severity of diseases upon admission in ICUs may describe these variations between different studied patients.

## Conclusion

The present study demonstrated that vitamin D deficiency and insufficiency were common among neonates admitted to NICU. Low levels of vitamin D were not associated with neonatal outcomes including longer hospital stay or increased mortality rate during hospital admission. In order to prevent or reduce the high prevalence of low levels of vitamin D in neonates, it is reasonable to reconsider the recommendation of vitamin D supplementation for mothers during pregnancy. Moreover, there may be a role for routine evaluation of the vitamin D status in all neonates for prompt diagnosis and appropriate treatment of any suboptimal levels of vitamin D.

## References

1. Shreya A, Oormila K, Devendra KA. Vitamin D and its impact on maternal-fetal outcomes in pregnancy: A critical review. Journal Critical Reviews in Food Science Nutrition. 2018;58(5):755–69.
2. Ian K, Sung Sh, Jee IS, Seock H, Ga YP, Yong-Wha L. Association between vitamin D level at birth and respiratory morbidities in very-low-birth-weight

infants. Korean J Pediatr. 2019;62(5):166–72.
3. Eremkina AK, Mokrysheva NG, Pigarova EA, Mirnaya SS. Ter Arkh.Vitamin D: effects on pregnancy, maternal, fetal and postnatal outcomes. 2018;90(10):115–127.
4. Azim A, Ahmed A, Yadav S, Baronia A, Gurjar M, Godbole M, et al. Prevalence of vitamin D deficiency in critically ill patients and its influence on outcome: experience from a tertiary care centre in North India (an observational study). Journal of Intensive Care. 2013;1:14.
5. Sindhaghatta V, Sridhar C, Muhammad A, Abayomi S, Madanmohan P. Gilda D. Vitamin D deficiency is associated with mortality in the medical intensive care unit. Crit Care. 2011;15:292.
6. Arson Y, Grinzauz I, Itzhaky D, Amital H. Vitamin D deficiency is associated with poor outcomes and increased mortality in severely ill patients. Q J Med. 2012;105:633–9.
7. Corsino R, Sánchez-Arangob D, López-Hercec J, Martínez-Camblord P, García-Hernándeze I, Prietof B, Pallavicini Z. Vitamin D deficiency at pediatric intensive care admission. J Pediatr (Rio J). 2014;90(2);135 – 42..
8. McNally J, Nama N, O'Hearn K. Margaret Sampson,KarinAmrein, KlevisIliriani,et al. Vitamin D deficiency in critically ill children: a systematic review and meta-analysis. Crit Care. 2017;21:287.
9. Madden K, Feldman H. RandolphAG.Vitamin D Deficiency in Critically Ill Children. Pediatrics. 2012;130(3):421–8.
10. Sasan B, Zandvakili F, Soufizadeh N. Effects of Vitamin D Supplement on Prevention of Recurrence of Preeclampsia in Pregnant Women with a History of Preeclampsia. ObstetGynecol Int. 2017;249264.
11. Rostami M, Ramezani Tehrani F, Simbar M. Rationale and Design of Khuzestan Vitamin D Deficiency Screening Program in Pregnancy: A Stratified Randomized Vitamin D Supplementation Controlled Trial. JMIR Res Protoc. 2017;6(4):54.
12. Mirzaei F, Amiri Moghadam T, Arasteh P. Comparison of serum 25-hydroxy vitamin D levels between mothers with small for gestational age and appropriate for gestational age newborns in Kerman. Iran J Reprod Med. 2015;13(4):203–8.
13. Pirdehghan A, Vakili M, Dehghan R, Zare F. High Prevalence of Vitamin D Deficiency and Adverse Pregnancy Outcomes in Yazd, a Central Province of Iran. J ReprodInfertil. 2016;17(1):34–8.
14. Paulraj S, Sajeethakumari R, Ramasamy P, Doraisami B, Muthulakshmi M. Correlation between maternal and neonatal blood vitamin D levels and its effect on the newborn anthropometry. Int J Reprod Contracept Obstet Gynecol. 2016;5(9):2983–8
15. Khuri-Bulos N, Lang RD, Blevins M, Kudyba K, Lawrence L, Davidson M, Faouri S. Halasa NB. Vitamin D Deficiency among Newborns in Amman, Jordan. Global Journal of Health Science. 2014;6(1):162– 71.
16. Mohaghegh Z, Abedi P, Dilgouni T. The relation of preeclampsia and serum level of 25- Hydroxyvitaminamin D in mothers and their neonates: a case control study in Iran. HormMetab Res. 2015;47:284–8.
17. Hebbar KB, Wittkamp M, Alvarez JA, McCracken CE, Tangpricha V. Vitamin D Deficiency in Pediatric Critical Illness. J Clin Transl Endocrinol 2014; 1:170–5.
18. Ringe JD, Kipshoven C. Vitamin D-insufficiency. An estimate of the situation in Germany. Dermatoendocrinol 2012; 4: 72-80.
19. Chiruvolu A, Engle WD, Sendelbach D, Manning MD, Jackson GL. Serum calcium values in term and late- preterm

neonates receiving gentamicin. Pediatr Nephrol 2008; 23: 569-74.
20. Bhimji KM, Naburi H, Aboud S, Manji K. Vitamin D status and associated factors in neonates in a resource constrained setting. Int J pediatr 2018: 9614975.
21. Khuri-Bulos N, Lang RD, Blevins M, Kudyba K, Lawrence L, Davidson M, et al. Vitamin D Deficiency among Newborns in Amman, Jordan. Glob J Health Sci 2013; 6:162-71.
22. Chacham S, Rajput S, Gumurkar S, Mirza A, Saxena V, Daksinamurthy S, et al. Prevalence of Vitamin D Deficiency Among Infants in Northern India: A Hospital Based Prospective Study. Cureus 2020; 12: e11353.
23. Maghbooli Z, Hossein-Nezhad A, Shafaei AR, Karimi F, Madani FS, Larijani B. Vitamin D status in mothers and their newborns in Iran. BMC Pregnancy Childbirth 2007; 7: 1.
24. Al-Wassia H, Abo-Ouf N. Prevalence of vitamin D deficiency in mother–infant pairs in a tertiary hospitalin the west coast of Saudi Arabia. Journal of Clinical Neonatology 2016; 5: 243-6.
25. Tanbakuchi B, Taheri F, Zardast M, Ramazani A. Effect of Vitamin D Supplementation on Vitamin D Levels of Term and Preterm Neonates and their Mothers: A Clinical Trial Study. International Journal of Pediatrics 2019; 7: 10311-22.
26. Munshi UK, Graziano PD, Meunier K, Ludke J, Rios Serum 25 Hydroxy Vitamin D Levels in Very Low Birth Weight Infants Receiving Oral Vitamin D Supplementation. J Pediatr Gastroenterol Nutr 2018; 66: 676-9.
27. Panda M, McIntosh J, Chaudhari T, Kent AL. Do Maternal Vitamin D Levels Influence Vitamin D Levels in Preterm Neonates? International Journal of Pediatrics 2019; 5: 1-7.
28. Spiro A, Buttriss JL. Vitamin D: An overview of vitamin D status and intake in Europe A. Nutr Bull 2014; 39: 322–50.
29. Aly H, Abdel Hady H. Vitamin D and the Neonate: An Update. Journal of Clinical Neonatology 2015; 4:1-7.
30. Madden K, Feldman HA, Smith EM, Gordon CM, Keisling SM, Sullivan RM, et al. Vitamin D Deficiency in Critically Ill Children. Pediatrics 2012; 130: 421-8.
31. Rey C, Sánchez-Arango D, López-Herce J, Martínez- Camblor P, García-Hernándeze I, Prietof B, et al. Vitamin D deficiency at pediatric intensive care admission. J Pediatr (Rio J) 2014; 90; 135-42.
32. Hosseinzadeh Z, Kazemian M, Mashak B, Torkmandi H, Badfar GH. Vitamin D status in pregnant women and their newborn in karaj. Int J Pediatr 2018; 6: 7117-27.
33. McNally JD, Menon K, Chakraborty P, Fisher L, Williams KA, Al-Dirbashi OY, et al. The Association of Vitamin D Status with Pediatric Critical Illness. Pediatrics 2012; 130: 429-36.
34. Rippel C, South M, Butt ww, Shekerdermian LS. Vitamin D status in critically ill children. Intensive Care Med 2012; 38: 2055-62
35. Fallahi M, Afjeh A, Saneifard H, Namazi N, Kazemian M, Tabatabaee Sh. Comparison of Vitamin D Level in Preterm and Term Infant–Mother Pairs: A Brief Study. Iranian Journal of Neonatology 2016; 7:31-6.
36. Thomas DJ, Khan HU, Paul S, Jaidev MD, Hegde P. A study on vitamin D levels in preterm and term neonates and their mothers. International Journal of Contemporary Pediatrics 2020; 7: 387-92
37. Kim I, Kim SS, Song JI, Yoon SH, Park GY, Lee YW. Association between vitamin D level at birth and respiratory morbidities in very-low-birth-weight infants. Korean J Pediatr 2019; 62: 166-72.

38. Burris HH, Van Marter LJ, McElrath TF, Tabatabai P, Litonjua AA, Weiss ST, et al. Vitamin D status among preterm and full term infants at birth. Pediatr Res 2014; 75: 75 80.
39. Monangi N, Slaughter JL, Dawodu A, Smith C, Akinbi HT. Vitamin D status of early preterm infants and the effects of vitamin D intake during hospital stay. Arch Dis Child Fetal Neonatal Ed 2014; 99: F166-8.
40. Arnson Y, Grinzauz I, Itzhaky D, Amital H. Vitamin D deficiency is associated with poor outcomes and increased mortality in severely ill patients. QJM 2012; 105: 633-9.
41. McNally JD, Nama N, O'Hearn K, Sampson M, Amrein K, Iliriani K, et al. Vitamin D deficiency in critically ill children: a systematic review and meta-analysis. Crit Care 2017; 21: 287.
42. Sankar J, Lotha W, Ismail J, Anubhuti C, Meena RS, Sankar MJ. Vitamin D deficiency and length of pediatric intensive care unit stay: a prospective observational study. Ann Intensive Care 2016; 6: 3