Journal of Health, Population and Nutrition

REVIEW ARTICLE Open Access

Pooled estimate of vitamin D deficiency among pregnant women in India: a systematic review and meta-analysis

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Abstract

Background: Vitamin D deficiency among pregnant women is a public health concern globally. In India, individual studies report high prevalence. However, lack of national data masks the true burden. This work determined the pooled prevalence of vitamin D deficiency among pregnant women in India through a systematic review of literature and meta-analysis.

Methods: Three different search engines yielded 15 eligible articles. Study quality was assessed by 10 different criteria and summary of study quality was categorized as per Cochrane standards. Meta-analysis was performed to estimate pooled prevalence of vitamin D deficiency among healthy pregnant women and heterogeneity among selected studies. A sample of $n = 4088$ was used to study the pooled prevalence among pregnant women.

Results: The random effects combined estimate was 32.35% (95% CI, (12.58–117.48). High heterogeneity ($tau^2 = 0.39$, $I^2 = 100\%$) and high risk of bias was observed among the selected studies. The test for overall effect was observed to be $z = 2.54 (P = 0.01)$.

Conclusion: Pooled estimate > 30% emphasizes the need for screening through antenatal care services and initiate preventive measures to address the deficiency.

Keywords: Vitamin D deficiency, Pregnant women, Systematic review, Meta-analysis

Introduction

Vitamin D has emerged as a micronutrient of concern due to widespread prevalence of deficiency [1]. Among the different definitions, Endocrine Society defines deficiency of vitamin D as serum levels of 25-hydroxyvitamin D (25[OH]D) below 20 ng/ml and levels between 20 and 30 ng/ml as insufficient [2]. The global prevalence of deficiency or insufficiency ranges between 54–100% and 39–76%, respectively [3]. Mild to severe deficiencies have been reported both in developed as well as third world countries [4]. Among European countries, Belgium reports > 70% prevalence, while tropical countries in Asia with abundant sunshine report even higher prevalence (> 80%) [4–6]. Compared to Asia (80%), African countries show less prevalence (30%). Among Asian countries, in India, the prevalence of vitamin D deficiency among healthy pregnant women is reportedly high [4, 7]. Individual studies report 93% prevalence in Delhi, 97% in Bangalore, Karnataka, and 94% in Mumbai, Maharashtra [6, 8, 9]. High prevalence has been reported among women in reproductive age group both in rural and urban areas, as well as across economic classes [4].

The physiological role of vitamin D implicated beyond bone health evoked extensive research with this vitamin. From a maternal and child health perspective, its role in

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fertility and conception, pathogenesis in preterm birth, gene transcription in placenta, and immune function are widely researched [10–14]. Deficiency in pregnancy is known to increase risk of pre-eclampsia, gestational diabetes mellitus, preterm birth, and other tissue-specific conditions [1, 11]. Moreover, vitamin D status of neonates and infants is affected by vitamin D levels of mothers [15, 16]. Lactation further increases requirements and severe deficiency has been reported during this phase too [17–20]. As per the guidelines of Endocrine Society, poor vitamin D status in adolescence and increased requirements during pregnancy make the reproductive phase vulnerable [2, 21]. Unlike other vitamins that are obtained through foods, most of the foods commonly consumed are poor sources of vitamin D. The World Health Organization has emphasized the importance of investigating this vitamin as it affects pregnancy outcome [1]. The paucity of national data and high prevalence as per regional evidence identifies the need to estimate the burden among pregnant women in India. The present work is a systematic review and meta-analysis to determine the combined estimate of vitamin D deficiency among healthy pregnant women in India.

Methods

Standard protocols for systematic review writing by Khan and coworkers [22] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [23] were followed.

Preliminary research and idea validation

To ensure validity of the chosen topic and to avoid duplication of work, we performed a preliminary search in PubMed with search terms viz. vitamin D deficiency/insufficiency + pregnant women + India. As we did not come across systematic review and meta-analysis for vitamin D deficiency among pregnant women or national prevalence data in India, we chose to perform this systematic review and meta-analysis. We also found substantial responses to these search terms that enabled us to progress with this research.

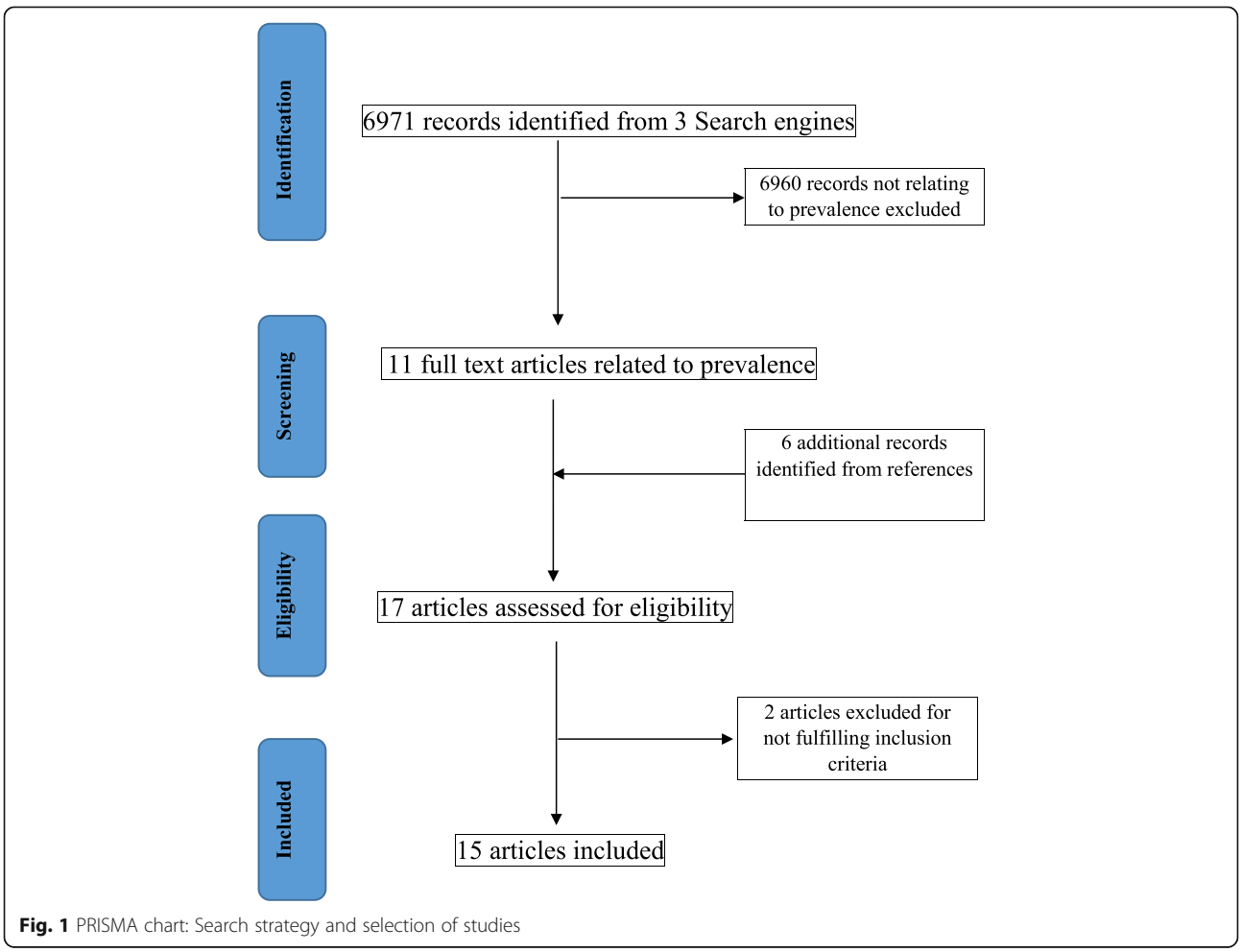

Fig. 1 PRISMA chart: Search strategy and selection of studies

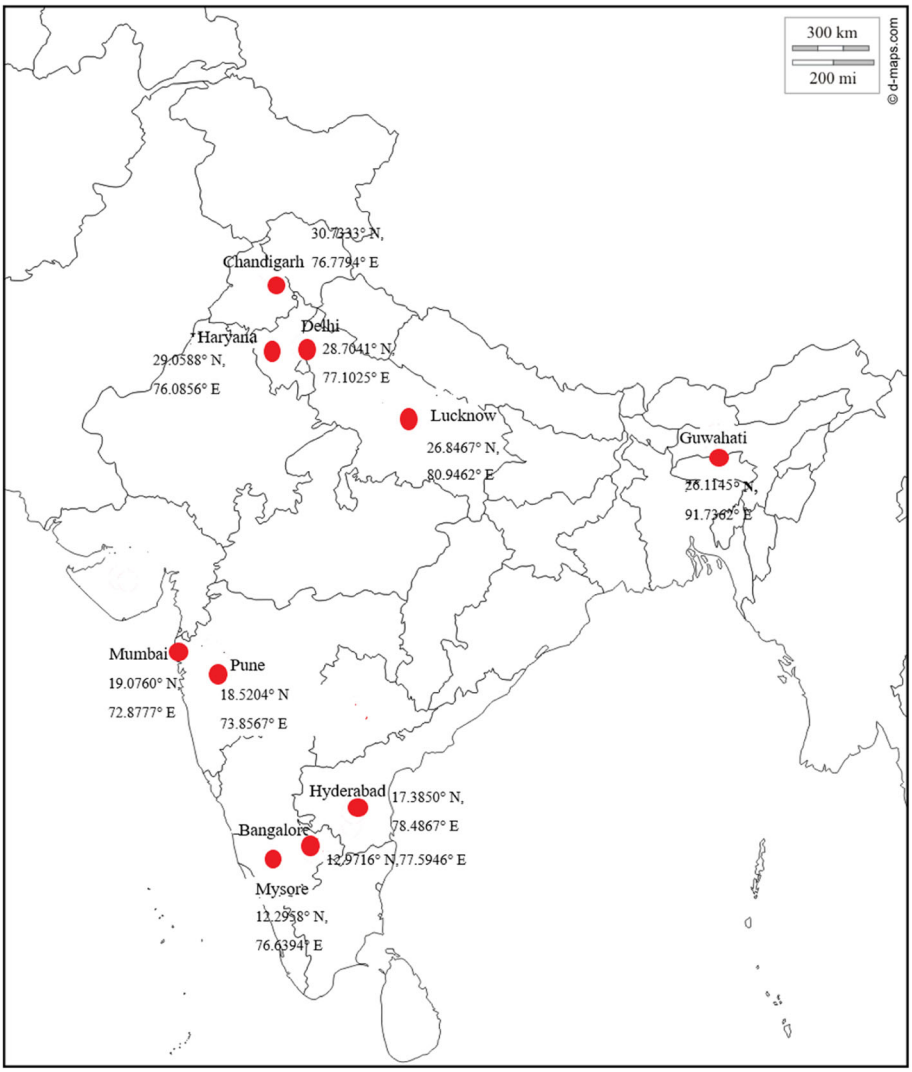

Fig. 2 Map showing studies selected from Indian states and their coordinates

Literature search

A systematic literature search was performed by two researchers independently in electronic databases that included PubMed, Google Scholar, and Web of Science in November 2018. The search terms used were ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "prevalence"[All Fields] OR "prevalence"[MeSH Terms]) AND ("vitamin D deficiency"[MeSH Terms] OR "25 OH Vitamin D levels"[All Fields]) AND ("pregnant women"[MeSH Terms] OR ("pregnant"[All Fields] AND "women"[All Fields]) OR "pregnant women"[All Fields]) AND ("india"[MeSH Terms] OR "india"[All Fields])) AND ("2007/12/03"[PDat] : "2018/11/29"[PDat]) (Fig. 1).

Study selection

Applying selection criteria (a) studies that were original articles, (b) published in English language, (c) study designs that were observational, intervention studies that provided baseline information on vitamin D levels of healthy pregnant women, (d) India as study location, (e) studies that determined the prevalence of vitamin D deficiency among pregnant women across gestational age, irrespective of parity were selected. (f) Time frame for literature selection was restricted to those published between 2005 and 2018. (g) As the objective of the present review is to study vitamin D deficiency among pregnant women, studies that recruited pregnant women from hospitals were included. Reference lists of the selected articles were used for manually identifying relevant literature. Full-text articles that were unavailable and data required for participants in specific age groups were obtained from authors on request. All papers were screened and verified by two researchers independently.

Table 1 Description of studies among pregnant women in India

References	Location	Sample size	Study design	Prevalence
Sachan et al. 2005 [31]	Lucknow (North)	207	Cross-sectional	66.6%
Farrant et al. 2009 [32]	Mysore (South)	559	Cross-sectional	66.0%
Sahu et al. 2009 [33]	Lucknow (North)	139	Cross-sectional	74.0%
Marwaha et al. 2011 [7]	Delhi (North)	541	Cross-sectional	96.30%
Jani et al. 2014 [9]	Mumbai (West)	150	Cross-sectional	94.0%
Singla et al. 2015 [34]	Chandigarh (North)	304	Prospective cohort	92.11%
Ajmani et al. 2016 [35]	Delhi (North)	200	Cross-sectional	37.50%
Sharma et al. 2016 [36]	Delhi (North)	418	Prospective cohort	34.54%
Krishnaveni et al. 2011 [37]	Mysore (South)	568	Prospective cohort	66.0%
Veena et al. 20162017 [38]	Mysore (South)	468	Prospective cohort	66.8%
Nandal et al. 2016 [39]	Haryana (North)	60	Prospective cohort	93.75%
Kumar et al. 2015 [40]	Bengaluru (South)	106	Prospective cohort	70.70%
Chary et al.2015 2014 [41]	Hyderabad (South)	153	Prospective cohort	52.2%
Dasgupta et al. 2012 [42]	Guwahati (North-East)	50	Cohort	42.00%
Sablok et al. 2015 [43]	Delhi (North)	165	RCT	77.50%

ELISA enzyme-linked immunosorbent assay, *CI* confidence interval, *RCT* randomized control trials

Exclusion criteria

(i) Earlier work had used > 30 sample as a selection criterion [24]. In our search, the least sample in the eligible studies was n = 20 and the next higher sample was n = 50. As smaller studies increase the risk of bias, studies with sample size less than 50 were excluded.

(i) Studies that reported vitamin D deficiency associated with specific disease conditions and (ii) eligible studies from which data if unavailable from authors after request were excluded.

Data extraction

Full texts of the selected articles were retrieved. To avoid publication bias, only peer-reviewed published studies were included. The outcome of interest was combined estimate of vitamin D deficiency among pregnant women in India. For this, the estimated prevalence of deficiency was recorded from every selected study. In addition, associated variables that describe the study characteristics such as study design, study setting, socio-demographic and economic status, and criteria used to categorize deficiency and sufficiency, season of study, maternal characteristics of pregnant women such as gestational age, and parity were recorded. Data was extracted and entered in Microsoft Excel in duplicate by RR and VS. Disagreement in selection of articles and data clarification if any was verified by third reviewer AJ.

Assessment of study quality

Criteria proposed by Hoy and coworkers [25] for prevalence studies were applied to assess the risk of bias in the selected articles. This model applies 10 criteria for assessment of risk of bias. Applying this, the papers were assessed for representation of population, sampling, random selection, non-response bias, data collected directly from subjects, case definition, reliability and validity of the method used, mode of data collection whether similar, length of shortest prevalence period, and numerator and denominator. The summary of study quality was categorized as per Cochrane standards [26] as low (all

Table 2 Description of associated variables in studies selected for estimating prevalence among pregnant women (n = 15)

Study	Age group/ mean age	Socio-economic status	Education	Rural/ urban	Parity	Trimester	Exposure to sunlight	Seasons of study
Ajmani et al. 2016 [35]	20–25	Lower, upper lower, lower middle, upper middle	Illiterate, primary level, graduate	Urban	Multi-gravida and Primigravida	All trimesters	NM	NM
Farrant et al. 2009] [32]	20–26	Upper, lower	NM	Urban	NM	< 32 weeks of pregnancy	NM	Summer, Winter
Jani et al. 2014 [9]	26.7 ± 4.1	NM	NM	Rural	NM	2nd trimester	Summer: 35.4 ± 15.9 h/day * %BSA	Summer, Winter
Marwaha et al. 2011 [7]	19–30	Lower middle	NM	Urban	1, 2, and > 2	All trimesters	1st trimester: 10–60 min 2nd trimester: 10–60 min 3rd trimester; 10–20 min	Summer, Winter
Sachan et al. 2005 [31]	24 ± − 4.1	Lower, middle	NM	Rural and urban	NM	3rd trimester	Urban: 4.1 ± 3.2 h/day*%BSA Rural: 9.7 ± 8.1 h/day*%BSA	Autumn
Sahu et al. 2009 [33]	20–25	Lower, upper	NM	Rural and urban	< 3	3rd trimester	Mean 14:00 ± 2 h	Spring summer
Sharma et al. 2016 [36]	22–23	Lower, upper lower, lower middle upper middle	Both educated and not educated	Urban	Primigravida	Full term	NM	Summer, Winter
Singla et al. 2015 [34]	18–35	Upper, upper middle, lower, lower middle	NM	Urban	Nulliparous, 1 and 2	2nd trimester	Summer: shorter ≤ 30 min Longer > 30 min Winter: Shorter ≤ 90 min Longer > 90 min	Summer, Winter
Krishnaveni et al. 2011 [37]	24 ± 4.3	Lower	NM	NM	NM	3rd trimester	NM	NM
Veena et al. 2017 [38]	23.9 ± 4.3	Lower	< 10(34.9% − 10(31.7%) > 10(33.4%	NM	1, 2, and > 2	3rd trimester	NM	NM
Nandal et al. 2016 [23, 39]	30.83 ± 4.0	upper	NM	urban	NM	2nd trimester	NM	NM
Kumar et al. 2015 [40]	NM	NM	NM	NM	NM	NM	NM	NM
Chary et al. 2015 [41]	24.5 ± 2.6	Upper, upper middle, lower, lower middle	Illiterate, primary level, High School Post high school	Rural and urban	NM	3rd trimester	< 60 min	NM
Dasgupta et al. 2012 [42]	20–40	NM	NM	NM	NM	1st trimester	33 ± 9.07%	Summer, rainy
Sablok et al. 2015 [43]	NM	Lower, middle	NM	NM	Primigravida	2nd trimester	< 1 h/day > 4 h/day	NM

NM not mentioned

10 criteria assessed to have low risk), moderate (at least two criteria showing high risk), and high risk (more than two criteria showing high risk).

Statistical analysis

Review manager [27] software version 5.3 was used to obtain a forest plot to demonstrate the degree of heterogeneity among the selected articles. The software uses Chi^2, I^2, and Tau^2 to study heterogeneity. Estimating pooled prevalence is a testing strategy where prevalence from a number of studies are aggregated into a single sample (or pool), which is then evaluated for the prevalence of interest [28]. In this review, reported prevalence in individual papers was extracted, log transformed, and standard error of proportion of prevalence was estimated. Considering the variation in the selected prevalence studies, and not assuming a uniform effect size in the selected studies, random effects model was used to perform meta-analysis. This model prevents one or few studies influencing the overall estimate and allows more balance in the relative weights of the studies [29]. The P value is the probability from chi-square statistic calculated using estimates of individual study weight, effect size, and overall effect size [30]. Publication bias was assessed using a funnel plot. Asymmetry in the distribution of studies in the funnel plot indicates the extent of bias.

Results

Literature search using specific search terms on prevalence of vitamin D deficiency among pregnant women in India identified 6971 articles. After screening titles and abstracts for relevance and excluding duplicates, 6960 articles were excluded as they did not match the

Table 3 Mean levels of serum 25 (OH) D among pregnant women

Study	Vitamin D estimation method	Mean serum 25(OH) D	25 (OH) D ranges in serum		
			Deficiency	Insufficiency	Sufficiency/adequacy
Ajmani et al. 2016 [35]	ELISA	23.25 ng/ml ± 18.49	< 20 ng/ml	20–30 ng/ml	> 30 ng/ml
Farrant et al. 2009 [32]	Radioimmunoassay	Median: 15.12 ng/ml	< 20 ng/ml	NM	NM
Jani et al. 2014 [9]	Chemiluminescent immunoassay	10.6 ng/mL	< 20 ng/ml	<20–30 ng/ml	30 ng/ml
Marwaha et al. 2011 [7]	ELISA	9.28 ng/ml	< 20 ng/ml	NM	NM
Sachan et al. 2005 [31]	Radioimmunoassay	14.93 ng/mL	< 20 ng/ml	NM	Normal: 20–80 ng/ml nmol/L
Sahu et al. 2009 [33]	Radioimmunoassay	15.12 ng/ml ± 7.92	< 20 ng/ml	NM	30 ng/ml
Sharma et al. 2016 [36]	ELISA	Deficiency: 7.10 ± 1.49 ng/ml	Severe < 10 ng/ml	Deficient < 20 ng/ml)	Normal 32–100 ng/ml
Singla et al. 2015 [34]	ELISA	Median: 7.9 ng/ml (IQR 5.7, 12	< 20 ng/ml	< 20–30 ng/ml	30 ng/ml
Krishnaveni et al. 2011 [37]	Radioimmunoassay	15.6 ng/ml	< 20 ng/ml	NM	NM
Veena et al. 2017 [38]	Radioimmunoassay	NM	< 20 ng/ml	NM	NM
Nandal et al. 2016 [39]	ELISA	11.98 ng/ml	< 12 ng/ml	12–20 ng/ml	20–30 ng/ml
Kumar et al. 2015 [40]	LC-MS/MS	16.3 ng/ml	< 20 ng/mL	NM	NM
Chary et al. 2015 [41]	HPLC	NM	< 19 ng/mL	20–29 ng/mL	> 30 ng/mL
Dasgupta et al. 2012 [42]	Radioimmunoassay	38.4 ± 18.37 ng/ml	< 20 ng/ml	NM	NM
Sablok et al. 2015 [43]	ELISA	18.44 ng/ml	< 20 ng/ml	< 20–30 ng/ml	30 ng/ml

NM not mentioned, *IQR* inter quartile range, *SD* standard deviation

selection criteria. This yielded 11 relevant articles. Six additional records were obtained from references cited within these articles. A total of 17 articles with sample size ranging from 50 to 568 were assessed for eligibility as per the selection criteria that further resulted in exclusion of two articles. Thus, 15 primary studies among pregnant women were included for the review.

Figure 2 shows the states where the studies were carried out and their coordinates on the Indian map. Nine out of 15 studies were conducted in Northern India. Five studies were conducted in south and one study each in west and north-east India. Table 1 describes the articles selected for the review. In all, the sample size in the studies ranged from 50 to 568. Of the 15 selected studies, 6 were cross sectional and the other 8 were prospective cohorts, and a randomized control trial. All studies were hospital based excluding Sahu's [33] work which was population based with calculated sample size. Table 2 describes the maternal characteristics of selected studies. The age of pregnant women ranged from 18 to 40 years in all the papers reviewed. Socioeconomic status of the study group ranged from upper, middle, and lower income groups. Six out of 15 studies provided information on the educational status of women. Work done by Ajmani and coworkers [35] described the distribution of women as per their level of education. Educational status of participants from other studies ranged from illiterate, primary education to graduates. Study setting was rural, urban, or combined representation of both rural and urban settings.

Parity was described in 7 out of 15 articles [31–44] accordingly pregnant women were primi or multi-gravida, nulliparous, or had parity less than three. Women across trimesters were recruited in two articles [35, 44]. Women in second trimester were enrolled in five studies [9, 32, 34, 39, 43] and four studies were conducted during the last trimester of pregnancy [33, 37–40, 42, 43]. Data pertaining to sunlight exposure was provided by 8 out of 15 papers. Of these, two papers [9, 42] provided a direct estimation of sunlight exposure by duration to percent body surface area and while two [9, 34] provided duration exposed specifically in summer and winter. Ajmani and coworkers [35] worked among burka-clad pregnant women and provided information about sunlight exposure indirectly by the number of hours of outdoor activity and use of sun screens and skin complexion. Eight studies mentioned the seasons of study [9, 32, 34, 36, 42, 44]; however, seven studies did not mention the season of study.

Table 3 describes the techniques used in determining the vitamin D levels and the estimated prevalence in the selected studies. Serum was used as the sample for vitamin D estimation in all the studies. Among the techniques used, ELISA [31, 32, 34, 35, 39, 44] and radioimmunoassay were used in six studies [32–34, 36–40, 42, 43] and chemiluminescent assay and HPLC [41]

Table 4 Risk of bias and summary of risk of selected studies

Risk of bias	Krishnaveni et al. 2011 [37]	Veena et al. 2017 [38]	Nandal et al. 2016 [39]	Dasgupta et al. 2012 [42]	Sachan et al. 2005 [31]	Sahu et al. 2009 [33]	Farrant et al. 2009 [32]	Sharma et al. 2016 [36]	Marwaha et al. 2011 [7]	Jani et al. 2014 [9]	Ajmani et al. 2016 [35]	Chary et al. 2015 [41]	Kumar et al. 2015 [40]	Singla et al. 2015 [34]	Sablok et al. 2015 [43]
Representation of data	High risk	High risk	High risk	High risk	High risk	Low risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk
Sampling	High risk	High risk	High risk	High risk	High risk	low risk	High risk	high risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk
Random selection	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Non-response bias	High risk	High risk	Low risk	Low risk	High risk	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk	High risk	High risk	Low risk
Data collected directly from subject	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Case definition	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Reliability and validity of method	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Same mode of data collected	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Length of the shortest period of the prevalence	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Numerator and denominator	High risk	High risk	High risk	High risk	High risk	Low risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	Low risk
Summary*	High risk of bias	High risk of bias	High risk of bias	High risk of bias	High risk of bias	Low risk of bias	High risk of bias	High risk of bias	High risk of bias	High risk of bias	High risk of bias	High risk of bias	High risk of bias	High risk of bias	Moderate risk of bias

Low risk of bias: all criteria met (i.e., low for each domain). *Moderate risk of bias: one to two criteria not met (i.e., high for each domain), High risk of bias: more than two criteria not met (i.e., high for each domain)

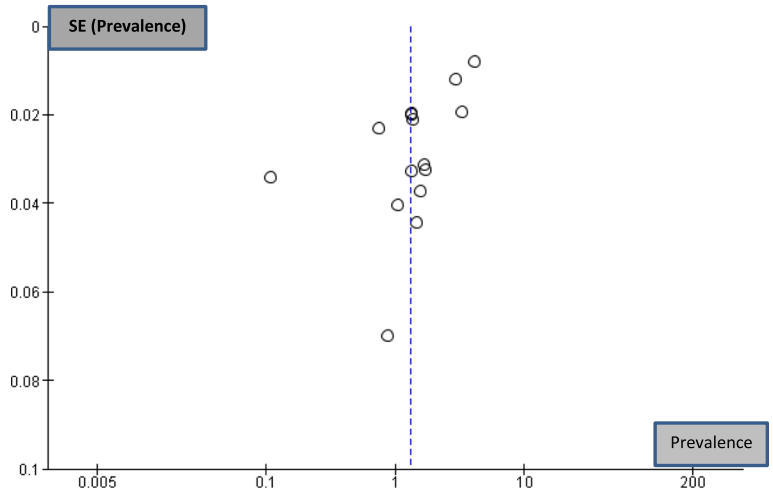

Fig. 3 Funnel plot of individual studies selected for meta-analysis

and LC-MS/MS [40] by one study each. Except Farrant's work [32] (2009), all studies were limited in detail pertaining to standardization and validation of methods. Majority of the studies (13 out of 15)) used 20 ng/ml as the cuff for defining deficiency, although some studies used [35, 39] 10 or 12 ng/ml defining severe deficiency. Table 4 summarizes risk of bias (RoB) of the selected papers among pregnant women. Sahu's work [33] was the only population-based study that estimated prevalence based on sample size calculation. Therefore, his work scored low risk in domains pertaining to (i) population representation and (ii) numerator and denominator. All other articles scored high risk in the above-mentioned domains. In all, 13 out of 15 selected studies were categorized as high risk as at least two domains were categorized as high risk, one study each were categorized as moderate and low risk, respectively.

The asymmetrical distribution of studies in the forest plot (Fig. 3) provides a visual representation of publication bias. Figure 4 shows the forest plot derived for the selected studies. The prevalence of vitamin D deficiency among pregnant women ranged from 34.45 to 96.30%. High heterogeneity was observed among the studies (Tau^2 = 0.39, chi^2 = 12509.42, df = 14, p = < 0.00001, I^2 = 100%). The test for overall effect was observed to be Z = 2.54(p = 0.01). As per categorization of heterogeneity by Higgins et al. 2003 [45], I^2 > 75% indicates considerable heterogeneity. This indicates large variation among included studies. The random effects combined estimate

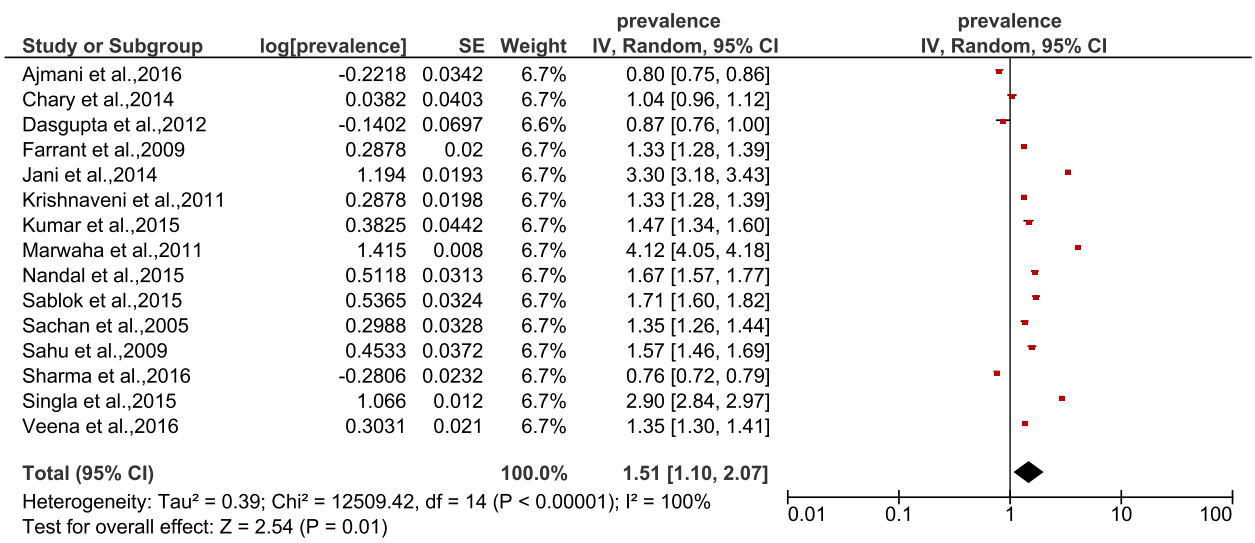

Fig. 4 Forest plot showing pooled estimate of vitamin D deficiency among pregnant women

for overall prevalence was 32.35%, 95% CI, 12.58–117.48).

Discussion

Vitamin D deficiency among women in reproductive age has gained public health attention in recent years. The estimated pooled prevalence as per this review was 32.35% among healthy pregnant women. As per current literature evidence, a population prevalence > 20% is considered a public health problem that calls for immediate intervention [46]. Data from individual studies in developing countries report high prevalence in Bangladesh (81%), Lahore, in Pakistan (73%), Beijing (40%), and Malaysia (90%) [46–49]. Another systematic review among Indian pregnant women by Tasset [50] reported 66–98% prevalence; however it was not a pooled estimate. These findings underscore the unmet requirements that increase vulnerability during the reproductive phase.

Besides high requirements in pregnancy, geographical location and climate affect vitamin D status. While lack of sunshine contributes to low vitamin D status in developed countries, poor living conditions, economic status, and cultural factors affect those in developing countries despite adequate sunshine. For instance, in Europe and Japan, low and high prevalence were reported in summer and winter, respectively [51, 52]. Whereas in developing countries, urbanization and transition increase risk for poor vitamin D status irrespective of season [53, 54] Although women in lower socioeconomic strata are highly susceptible, women from higher socioeconomic status who preferred indoors too were at equal risk [55]. Cultural practices such as women covering maximum body surface and veiling prevents maximum sun exposure [56]. Dark skin among south Asians further limits absorption of vitamin D. In resource poor settings houses are closely packed with no direct sunlight within their dwellings and high level of air pollution aggravates vulnerability [57]. High prevalence of deficiency has been reported among migrant women in developing countries [58]. The above factors associated with poor vitamin D status are commonly observed in developing countries as a consequence of urbanization [1, 59–64]. However, rural areas as place of residence did not decrease the risk of vitamin D deficiency. Poor access to nutrient dense foods increased risk in these settings as well [65]. Among maternal characteristics, multi-parity combined with low vitamin D intake is known to increase risk of deficiency [16, 66, 67]

A global summary of maternal and newborn vitamin D status reports 87% deficiency among pregnant women in Southeast Asia [68], while pooled estimates show lower prevalence. Varied estimates of prevalence arise due to variations in techniques and difference in defining deficiencies and geographical variations [69, 70].

Dearth of national level data in developing countries masks the true burden of this deficiency and limits comparison. National surveys have not focused on screening vitamin D levels of pregnant women for deficiency. In India, the national guidelines recommend 500 mg elemental calcium and 250 IU vitamin D3 twice a day to meet the increased requirements in pregnancy [71]. However, considering the low quality of available evidence between deficiency state and critical pregnancy outcome there exist no recommendation for vitamin D supplementation as part of routine antenatal care [72–74]. This meta-analysis has provided a pooled estimate in the absence of a national prevalence of vitamin D deficiency. However, it suffers from the following limitations: despite finding eligible studies some studies were excluded due to non-response from authors. Therefore, it is likely that the studies selected for this review are not a representation of the available literature. Although funnel plot was created using RevMan software, statistical test for publication bias could not be performed using this software. Sensitivity analysis could not be performed as prevalence from the excluded papers could not be derived. The high risk of bias due to low power of the selected studies and the time period applied for selecting studies further added to the study limitation.

Conclusion

The pooled estimate of vitamin D deficiency according to the selected Indian literature identifies a significant percentage of deficiency among pregnant women. Screening of women in reproductive age would identify the magnitude of deficiency to promote early intervention. Vitamin D deficiency is a potentially preventable micronutrient deficiency and high prevalence calls for public health strategies to address this serious issue.

Acknowledgements

The authors wish to thank Dr. Sumedha Dharmarajan and Dr. Swapnil Gadhave for their scientific support while we performed the meta-analysis.

Authors' contributions

AJ conceptualized the review. VS and RR extracted data and performed the meta-analysis under the guidance of AJ. Manuscript was written by AJ. All authors read and approved the final manuscript.

Funding

This project was funded by UGC-UPE–2018. The funding body did not play a role in the design of the study, analysis, interpretation of data, and in writing the manuscript.

Availability of data and materials

Please contact author for data requests.

Declarations

Ethics approval and consent to participate

Ethics approval of this study was obtained from the institutional ethics committee Ref: SPPU/IEC/2018/03. Consent was not applicable for this study.

Consent for publication

All authors have given their consent for this publication.

Competing interests

The authors declare that they have no competing interests.

Received: 15 September 2019 Accepted: 2 June 2021
Published online: 29 June 2021

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