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Prevalence of Vitamin D Deficiency in Iran: A Systematic Review and Meta-Analysis

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ABSTRACT

Introduction: Vitamin D deficiency (VDD) affects more than one billion individuals globally. We aimed to review all the published papers on vitamin D deficiency in in the country.

Method: PubMed, Google Scholar, Web of Science, Scopus, Science direct and scientific information databases were searched for papers related to the prevalence of vitamin D insufficiency for all age groups in Iran from 2000 to 2018. The Joanna Briggs Institute prevalence critical appraisal tool was applied for the assessment of the methodological quality of these studies. The Meta-analysis is based on the random effect model using Comprehensive Meta-analysis data analysis.

Results: Eighty-seven original articles reported on participants with vitamin D insufficiency in Iran. According to the meta-analysis of the prevalence of moderately deficient of vitamin D in men and women as well as younger and older individuals (>18 years) using a cut-off point of 25(OH) D3<20 ng/mL was 39% and 51%, respectively. Vitamin D concentrations <30 ng/mL among Iranian populations in the cities of Tehran, Shiraz, Mashhad, and Zahedan were reported to be higher than 90%. The prevalence of vitamin D insufficiency in Iranian women was higher than in men in various age groups. The highest prevalence of vitamin D insufficiency in neonates, children, adults and pregnant women was observed in the Middle East. Most countries had a high prevalence of VDD in elderly people.

Conclusion: Vitamin D insufficiency is common in the Iranian population and is an important public health problem that should be considered seriously.

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Introduction

1. Rationale

Vitamin D is a lipid soluble vitamin with major functions in bone health via its effects on calcium and phosphorus metabolism (1). Recent studies report a direct relationship of dietary vitamin D in cancer prevention. It has been estimated that ovarian and colonic cancer rates can be reduced by about 30% and 50%, respectively, by a daily intake of 25mg vitamin D. Moreover, Higher levels of circulating vitamin D has been estimated that risk of colorectal and bladder malignancies can be reduced (2, 3).

Vitamin D is naturally found in two forms, vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol), which are produced from ergosterol and 7-dehydrocholesterol, respectively (4). The difference between vitamin D2 ($C_{28}H_{44}O$) and vitamin D3 ($C_{27}H_{44}O$) is a methyl group on carbon atom 24 and a double bond between carbon atom 22 and 23. Vitamin D is an essential micronutrient is that, in its physiologically active form 1,25-dihydroxyvitamin D3, plays an important role in the development and maintenance of bone structure and muscle function. It also regulates the absorption of calcium, phosphorus, magnesium and zinc from the gut and kidney (5, 6). Several factors effect serum vitamin D levels; these include: genetic factors (genetic polymorphisms), environmental factors (lifestyle) and other factors (age, sex, sunlight exposure, the use of sunscreen, skin pigmentation, latitude, dietary habits, supplement intake, and responsiveness (7), low skin synthesis, and impaired metabolism of vitamin D) (8).

Cut-off levels used to define vitamin D status are generally set as follows: severely deficient at a serum 25-hydroxyvitamin D concentration <25 nmol/L (12 ng/mL), moderately deficient <50 nmol/L (<20 ng/mL) and vitamin D insufficiency (VDI) <75 nmol/L (<30 ng/ml). In the literature, a circulating level of 25-(OH)-D of 75 nmol/l is suggested to maximize vitamin D's beneficial effects on health (9, 10). The global prevalence of VDI is increasing, and it has important implications for human health because it is related to several non-communicable diseases such as cancer, metabolic syndrome, high blood pressure, hyperlipidemia, obesity, insulin resistance, diabetes, multiple sclerosis, osteoporosis, cardiovascular disease, dental disease and other chronic diseases (9-16).

Studies have demonstrated a high prevalence of VDD with more than one billion subjects worldwide (15). A recent systematic review indicates that the prevalence of VDD is increasing, particularly in Middle-Eastern countries, including Iran (17). The prevalence of VDD in different provinces in Iran differs with gender and age group; varying between 30-90%, of adults with different degrees of VDD in the Iranian population (18-20). An important source of vitamin D is from dermal synthesis, and to some extent via vitamin D fortification in dietary products (21, 22). However, several studies have shown that there is no significant relationship between adequate sunlight and vitamin D fortification and the prevalence of VDD (11), and that it may be affected by other factors including the dietary intake of vitamin D, skin color, and clothing worn (21, 23, 24). There is also evidence showing that air pollution has a significant effect with VDD (25). The prevalence of VDD varies among different parts of Iran. Several studies have reported a high prevalence of VDI in some provinces including Tehran. Recent studies suggest that there is a high prevalence of VDD among different age groups such as infants, children, adults, elderly and pregnant women (22).

2. Objective

Gender-specific analysis was carried out in Iran because of the differences in serum vitamin D levels and status between men and women (22, 26). About 50% of the changes in serum 25(OH)-vitamin D levels may be related to genetic background (27). While, the role of the genetic risk factors for serum levels of this vitamin has been supported by several studies also in the Middle East (27, 28), there is a need to confirm this hypothesis using more genome wide association studies with large populations of Middle-East countries. However, interpretation of these findings is difficult because the existing data varies considerably regarding methodology, sample size, populations and how the results are presented and analyzed. Therefore, the aim of this study was to review all the regional published data on the frequency of VDD among different sex, age groups in various climates of Iran.

The template of this review was based on the MOOSE (Meta-analysis of Observational Studies in Epidemiology) guidelines (29).

Method

1. Research strategy, study selection and Information source

PubMed, Google Scholar, Scopus, Web of Science, Science direct, scientific information databases (SID) were searched for papers relating to the prevalence of VDI from 2000 to 2022 in apparently healthy Iranians (Figure 1). The search was restricted to original papers presented in English and Persian from medical subject headings, titles, or abstracts with the help of Boolean operators (AND, OR) by using the following keywords: Vitamin D; Deficiency; Prevalence and Iran. Two researchers independently screened the title and abstracts, and then the full text of articles. Any disagreements were solved by consensus.

2. Eligibility criteria

Articles were excluded if VDI was reported in subjects with non- communicable diseases. Inclusion criteria were all English and Persian cross-sectional studies. Total related original and review papers were considered as additional potential data sources. In the present review, the sample size and prevalence of VDI in male and female individuals of all age groups among different social subgroups such as infant, children, adolescent, adult, elder and pregnant women is investigated. Published articles were identified by the first search, then surveyed, relevant papers included in this review and non-relevant search results were excluded.

3. Risk of bias in individual studies and across studies

Data extraction

Two researchers independently extracted data. International guidelines for extracting data are included first author name, year of publication, year of participants' inclusion, city (or province),country, study design, setting, sample size, age distribution, proportion of males, and diagnostic criteria for VDD and event rate (prevalence).

Quality assessment of the included studies

We used the Joanna Briggs Institute prevalence critical appraisal tool for the assessment of the methodological quality of included studies (30). Based on our results, the studies with a score lower than 5 were considered to be low quality articles.

Data analysis

Heterogeneity was evaluated by I2 value (by Chi-square test). I2 of more than 50% were assumed as heterogeneous. In these cases, we used random effect model. Data were analyzed by CMA (Comprehensive Meta-Analysis).

Results

1. Study selection

According to figure 1, the studies with a score higher than 5 were considered to be high quality articles and finally 87 relevant papers included in this review (Figure 1).

2. Study characteristics

Study characteristics were summarized in tables 1-6.

3. Synthesis of results of individual studies

Prevalence of vitamin D insufficiency in different studies, geographical regions of Iran and age groups

In all of the studied papers, the prevalence of VDI was examined to assess differences between genders, age groups and regions of the Iran. The prevalence of VDI in 20 studies (for pregnant women) is presented in Table 1. All of the studies are presented; 7 studies in Tehran, one study each in Rasht, Sanandaj, Yazd, Kerman, Masjed Soleiman, Esfahan, Zanjan, Kashan, Bushehr, Shahroud, Mashhad, and 2 studies in Tabriz (Table 1). A high prevalence of VDD (41.9%, 68.6%) was reported for pregnant women in Iran using cut-off values of 10 and20 ng/ml, respectively. A status of ≥30 ng/ml was reached by 15.6% of the participants (Figures 2).

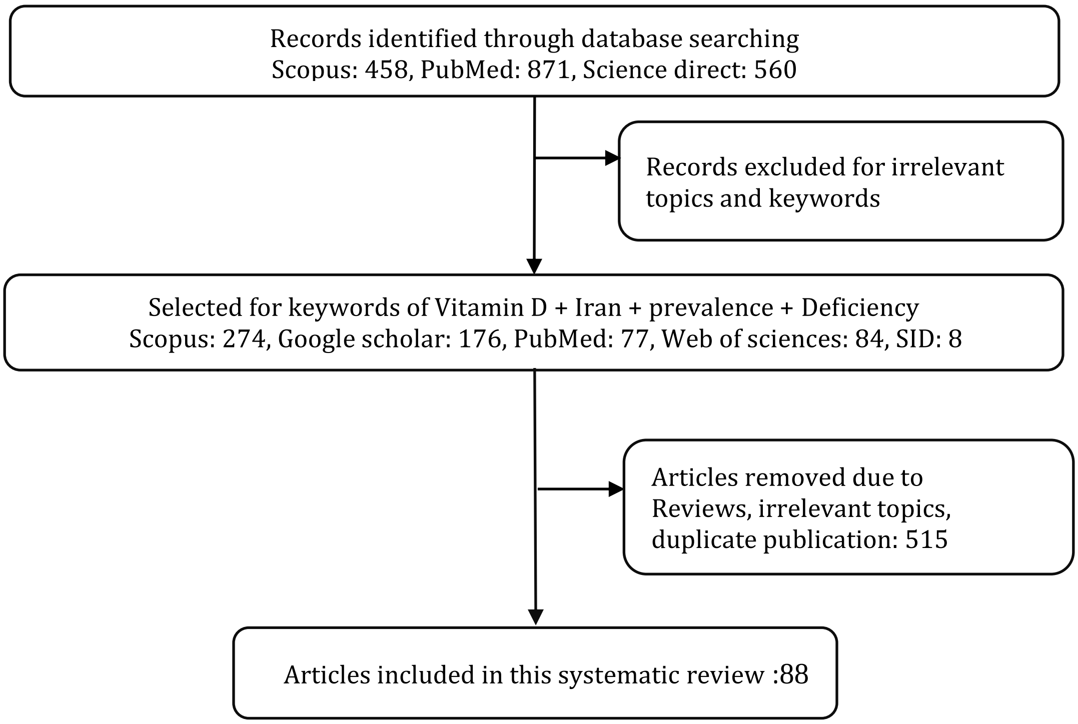

Figure 1. Flow chart for current systematic review.

Using the cut-off value <20 ng/mL, several studies (2001-2020) reported that 60-80% of pregnant women in Tehran were deficient (31). Kazemi and coworkers in a study on 67 pregnant women in Zanjan showed a prevalence of 86% and 46% of severely VDD in winter and summer, respectively (32). Asemi et al. reported the prevalence of severely VDD in Kashan as 95.8% using a cut-off value of ≤10 ng/ml (33). In turn, in the central region as well as the east and southern parts of Iran, vitamin D concentration <30 ng/ml was found in 42.9% and 90% of the population, respectively [30]. The same cut-off was reached by 15% of pregnant women (30). In turn, in a sample of 741 Iranian pregnant women, 71% were below this threshold (34). Prevalence rates of VDD in infants reported from different parts (Rasht, Shahroud, Tehran, Kerman, Mashhad and Booshehr) of Iran using a cut-off value <20 ng/ml ranged from 2.5-85.5% (Table 2). Azami and colleagues reported the prevalence of VDD in Iran as 42.42% and55.84% using cut-off values of 10 and 20, respectively, while the prevalence of vitamin D levels below 30 ng/ml was 80.82% (35). Other studies have reported very high rates of VDI in parts of Iran including Golestan (in the north), northeastern parts, Boushehr, Hormozgan and Khouzestan (36).

The prevalence of VDI among Iranian infants in 6 studies using different cutoff values, is reported in Table 2. All of the studies are presented; 2 studies in Tehran, one study each in Sanandaj, Kerman, Zanjan, and Shahroud (Table 2). A high prevalence of VDD (50% and 48.9%) was reported for infants in Iran using cut-off values of 20 and 12, respectively (Figures 3). The percentage of infants in Tehran presenting with 25-(OH)-D concentrations <30 ng/ml was 93.3%, higher than in other parts of country (37).

Table 3 shows the prevalence of VDI in 25 studies among Iranian children and adolescents. All of the studies are presented; 6 studies in Tehran, 2 studies in Esfahan, and Ilam, one study each in Yazd, Kerman, Khuzestan, Zanjan, Shahroud, Shiraz, Qazvin, Orumieh, Gorgan, Bojnourd, Arak, and 4 studies in other provinces. The highest prevalence of VDD was reported in Tehran followed by Arak, Qazvin Shahroud, Orumie and Shiraz using cutoff values of <20 ng/mL. Qazvin, Tehran, Arak, Shahroud, Esfahan had the highest rate of VDD prevalence among girls with a cut-off point of <20 ng/mL (Figure 4).

The prevalence of VDI in 42 studies among adults and older people varied from 1.6% to 95% as is shown in Table 4.

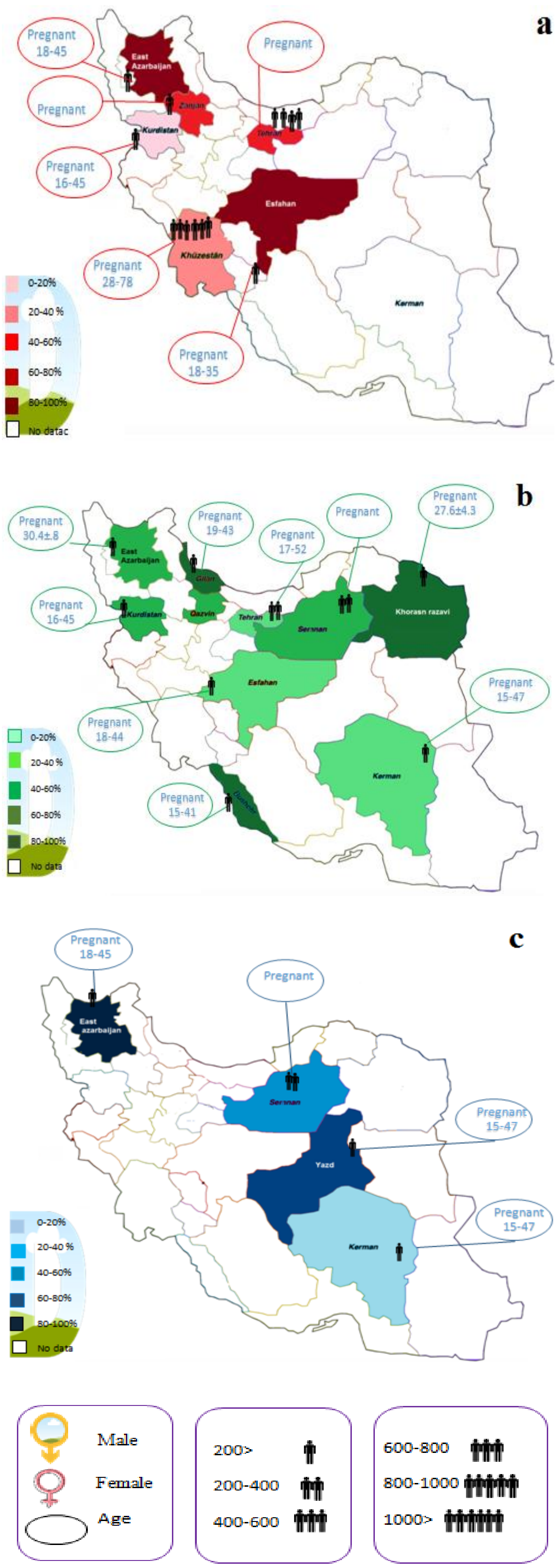

Figure 2. The prevalence of vitamin D deficiency in Iranian pregnant women using cut-off values of 12 and 20 as well as prevalence of 25-(OH)-D levels <30 ng/ml (a, b, c, respectively)

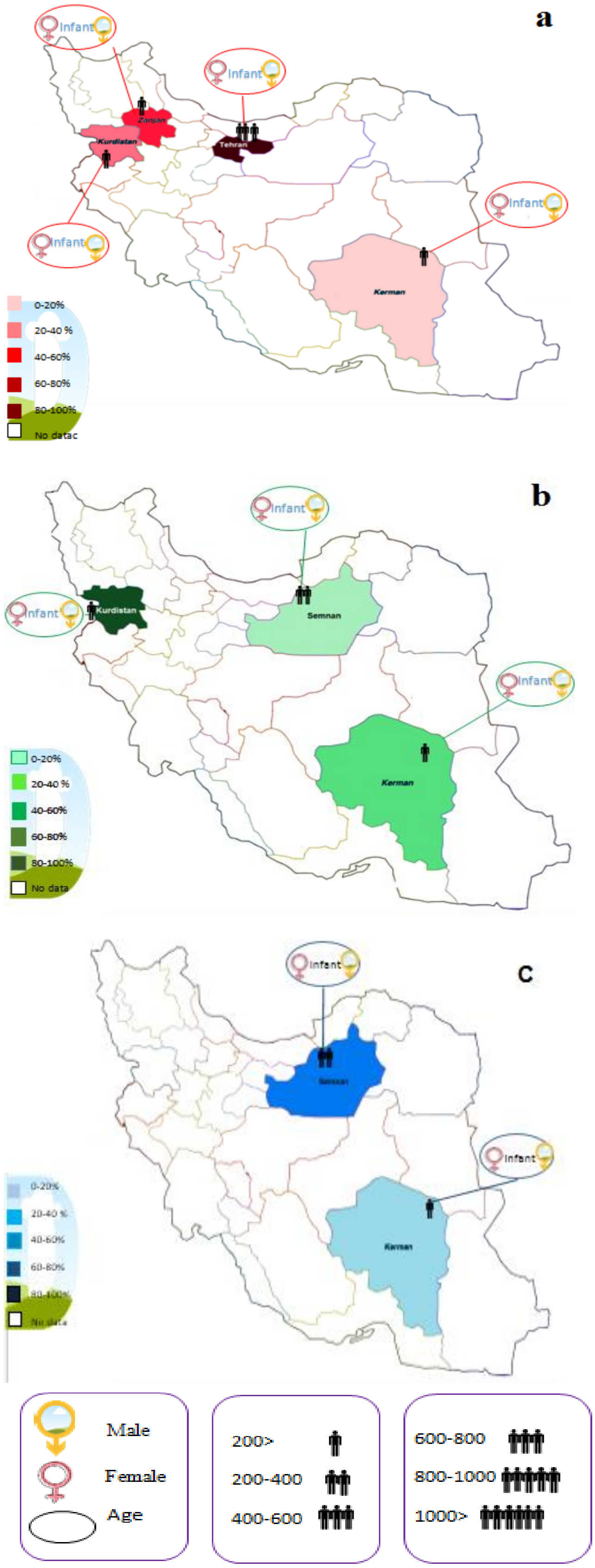

Figure 3. The prevalence of vitamin D deficiency in Iranian Infants using cut-off values of 12 and 20 ng/ml, as well as prevalence of 25-(OH)-D levels <30 ng/ml (a, b, c, respectively).

All of the studies are presented; 13 studies in Tehran, 4 studies in Mashhad, 3 studies each in Tabriz and Shiraz, 2 studies each in Arak, and Babol, one study each in Yazd, Ilam, Esfahan, Khuzestan, Golestan, Orumieh, Gulan, Boushehr, Sari, Sanandaj and 3 studies in other provinces. Two studies in 2009 and 2015 showed a VDD prevalence among Iranian older people (in subjects >60 years) of 41.9% (Amirkola in Babol) with a cut-off point of 12 ng/mL and of 75% (Tabriz) with a cut-off point of <20 ng/mL, respectively. A high prevalence of VDD (89% and 85%) was reported for Iranian adults using cut-off values of 10 and 20, respectively. Up to more than 90% of the participants in these studies had 25-(OH)-D levels <30 ng/ml. The prevalence of vitamin D levels <30 ng/ml is higher among adults in Tehran (93.3%) than in other parts of the country (Figure 5). The prevalence of vitamin D deficiency in girls across all studies was significantly higher than in boys as well as in girls from other countries of the Middle-East (8, 11, 38, 39).

Figure 6 presents the prevalence of VDD in both sexes in Iran. By considering 20 ng/mL as a cut-off point of VDD, we found that VDD is more prevalent in people aged less than 18 years and it is more common in females. The meta-analysis showed that the mean prevalence of VDD in females younger and older than 18 years, is 67% and 51%, respectively.

Gender and Age groups in Urban and Rural Iranian:

The Iran National Integrated Micronutrient Survey, NIMS, 2012 has evaluated the levels of iron, zinc, vitamins A and D as well as lifestyle, anemia prevalence and dietary intake. This study included 32,270 subjects in 11 geographical areas and three population groups (adolescents, elderly and pregnant women) of both sexes and also in urban and rural Iran (Figures 1 and 2 supplementary). The level of serum 25-hydroxyvitamin D used to define severely VDD status was <30 nmol/L (12 ng/mL). The rate of VDI among pregnant women was higher in the present version of the National Integrated Micronutrient Survey (NIMS) of Iran conducted in 2012 compared to the previous version of this study from 2002 (increase from 56.5% in 2002 to 85.3% in 2012; p-value <0.0001). In the whole country, the status of the vitamin D in adolescents (especially in geographical regions 4, 1 and 2, respectively in figure 1 supplementary), pregnant women and elderly people is a matter of concern (36).

The results of this national survey are comparable to regional studies and confirm that prevalence of VDI in different age groups is high.

The global epidemiology of vitamin D status (a comparison study)

The status of vitamin D deficiency among people worldwide is presented in table 6. The studies included in this overview used cut-off points for severely VDD of <30 nmol/L (12 ng/mL) and VDD <50 nmol/L (<20 ng/mL). The studies showed the highest prevalence of VDD in neonates, children, pregnant women and adults (especially among girls) from the Middle East while most countries had a high prevalence of VDD in elderly people (11). Most studies in this area were carried out in European countries. However, vitamin D levels were lower in Asian countries compared to the European countries and the USA (40).

Comparison of different studies

The current review presents the status of VDI in Iran. According to the presented studies the prevalence of VDD is very high in different age groups and different provinces of Iran.

Discussion

1. Prevalence of vitamin D insufficiency among pregnant women

A high VDD has been reported among pregnant women in the Middle East including Iran, Kuwait, Saudi Arabia and the United Arab Emirates (11, 28, 41, 42). The prevalence of VDD in pregnant women has been reported to be 19.5%, 31% and 96.8% in Greece, South of India and China, respectively (35).

VDD can be a cause of adverse maternal obstetrical outcomes, as well as for the offspring (28, 41, 43). VDI is related to a high risk of preeclampsia in pregnant women (44), a higher rate of Caesarian sections (45) and neonates that are small for gestational age (46).

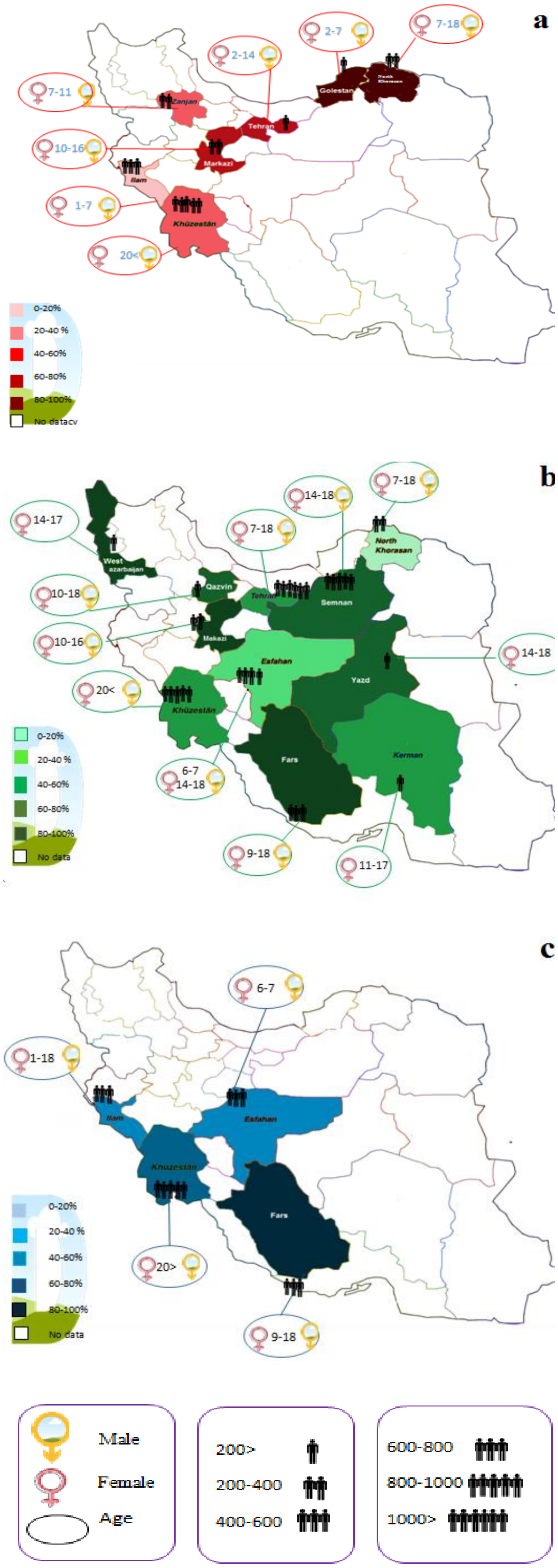

Figure 4. The prevalence of vitamin D deficiency in Iranian children and adolescents using cut-off values of 12 and 20 ng/ml, as well as prevalence of 25-(OH)-D levels <30 ng/ml (a, b, c, respectively)

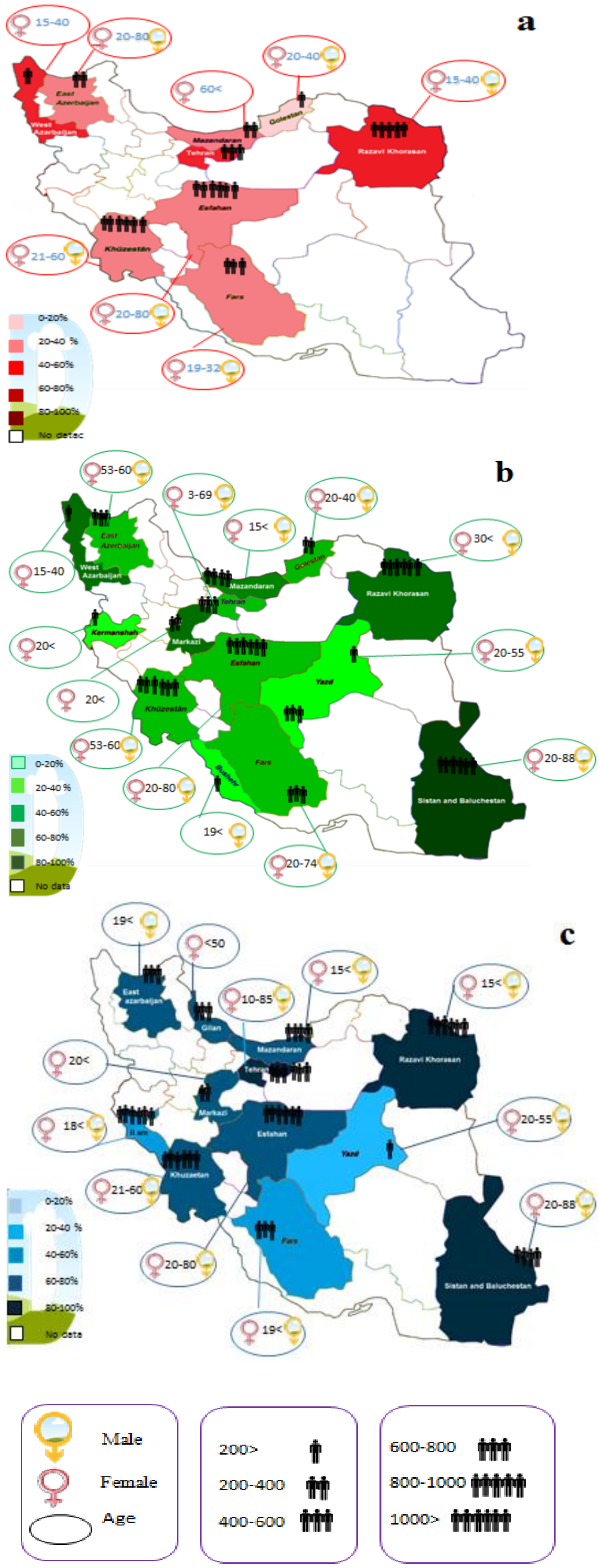

Figure 5. The prevalence of vitamin D deficiency in Iranian adults using cut-off values of 12 and 20 ng/ml, and prevalence of 25-(OH)-D levels <30 ng/ml (a, b, c, respectively)

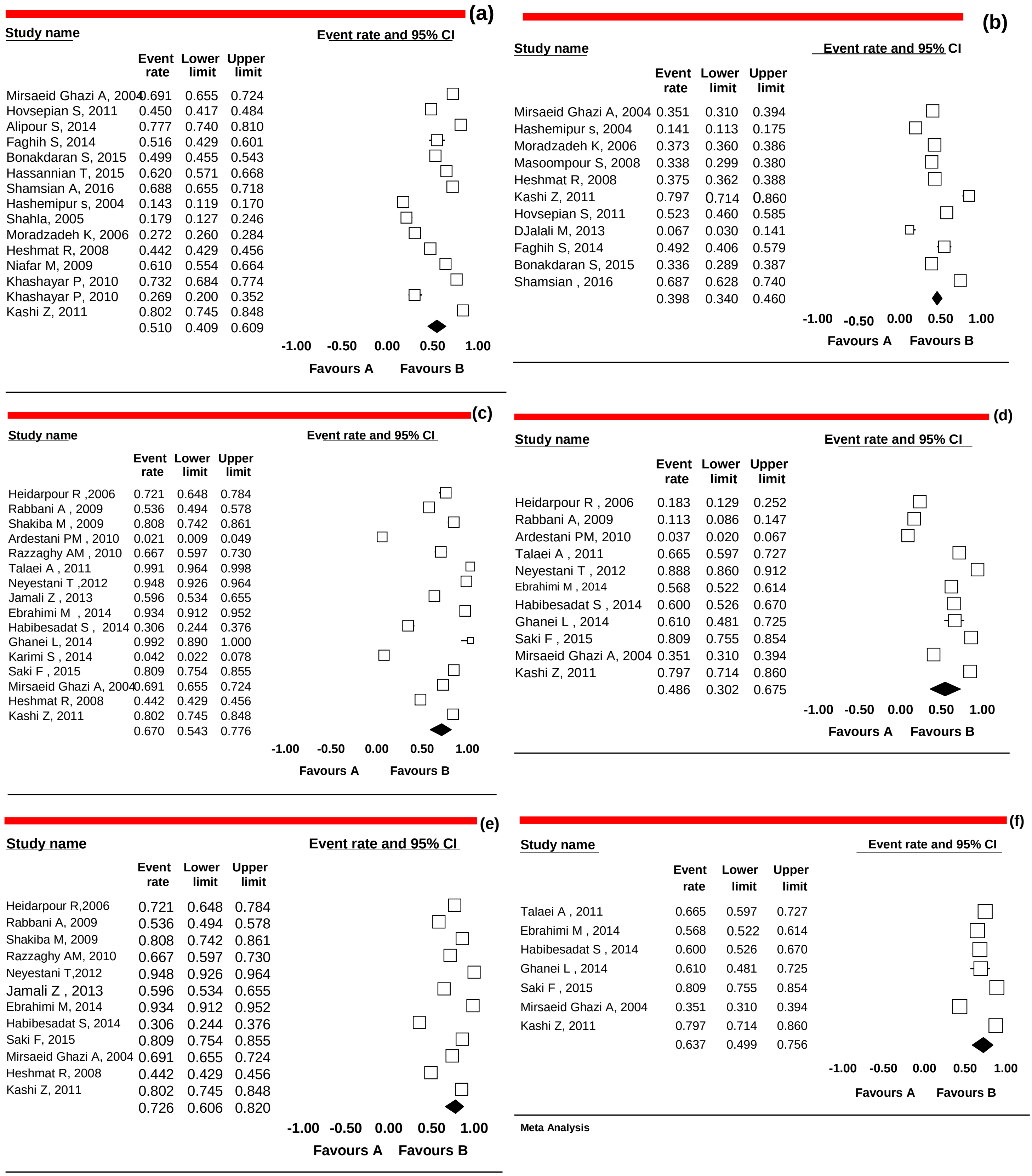

Figure 6. Meta-analysis of the prevalence of vitamin D deficiency (cut-off point: <20 ng/mL) (a) Females, more than 18 years old, (b) Males, more than 18 years old, (c) Females, less than 18 years old, (d) Males, less than 18 years old, (e) Females, less than 18 years old, after removing four extreme data (Ardestani, Karimi, Talaei, Ghanaei), and (f) Males, less than 18 years old, after removing four extreme data (Ardestani, Rabbani, Heidarpour, Neyestani)

A longitudinal cohort study has reported a positive association between maternal serum 25(OH) vitamin D during the third trimester and offspring bone mass in 9-year old children (47).

The observed results for 449 mother-offspring pairs in Tehran showed an association between sufficient calcium and vitamin D consumption, and neonatal length and Apgar score at birth [48]. The prevalence of Iranian pregnant women having 25-(OH)-D concentrations <30 ng/ml has increased between 2001 and 2015. The highest prevalence of VDD based on the cut-off of 10 ng/ml was observed in the second trimester of pregnancy, while for a cut-off of 20 ng/ml, it was in the first trimester. Women in the third trimester showed the highest prevalence of 25-(OH)-D levels <30 ng/ml (35). It has been reported that the maximum deposition of calcium in the skeleton might be affected as a consequence of calcium, vitamin D deficiency in utero and childhood (8, 49). However, vitamin D has important effects on the health of the mothers and neonates, so that vitamin D deficiency should be considered as a main priority by health authorities. This vitamin deficiency might bring about several diseases including hypertension, obesity, colon and breast cancers (50, 51).

2. Prevalence Vitamin D deficiency and insufficiency among infants

In 2009, a study in Zanjan showed that over half of the infants were diagnosed with severely VDD using a cut-off value of 12 ng/mL (32). Sanandaj also had a very high prevalence of VDD (50.3%) as compared to other cities with a cutoff point <50 nmol/L (<20 ng/mL) (52). Recently, Olang et al., in a cross-sectional study have reported that almost one third (32.9%) of infants have VDD in all regions (53). Mirzaei et al. demonstrated that approximately 17.5% of the newborn had evidence of VDD based on a cut-off value of 12 ng/mL (54) while, in 2016, Abbasian et al. In Shahrood indicated it as 48.9% (55). VDD among infants particularly in the Middle East has a high prevalence (11, 28, 56).

Therefore, improving vitamin D status could be effective in promoting the health of infants and children (57, 58). Bottle feeding leads to decreased serum levels of vitamin D (59). In turn, it was shown that a combined supplement of vitamin A and D is effective in reducing the rate of VDD among infants (58). The National Integrated Micronutrient Survey (NIMS-2) in Iran reported that, as reported previously for pregnant women, the prevalence of VDD and insufficiency has increased among Iranian infants, from 3.7% in 2002 to 23.3% in 2012 (36).

Other studies have demonstrated that the mean level of serum vitamin D has increased in Tehran and Mashhad since 1997 (9, 10).

3. Prevalence of vitamin D insufficiency among children and adolescents

The prevalence of VDD in girls in all studies was significantly higher than in boys as well as in girls from other countries of the Middle-East (8, 11, 38, 39, 42). Recently, the NIMS-2 in Iran has demonstrated that 61.8% of 6-year-old children have serum 25(OH)-vitamin D values <50 nmol/L (<20 ng/mL) (36). It was unexpected that the sunniest provinces of Iran (in the south of the country) such as Boushehr, Hormozgan and Khouzestan have higher VDD prevalence rates than other cities (75%) (36).

The prevalence of VDD among adolescents was reported equal to 43.3% by Larijani et al., in Tehran using a cut-off value 20 ng /ml (60). In 2014, Mohammadian and coworkers indicated that 85.6 % of Gorgan adolescents suffered from severely VDD (61) while one-year later in Zanjan a prevalence of 31.1% was reported using a cut-off value of 12 ng /ml (62). Two recent studies revealed that less than 10% of adolescents living in Ilam had evidence of severely VDD using a cut-off value of 10 ng/ml (63). Similar findings came from West Azarbaijan , Semnan, Lorestan, South Khorasan , Khoozestan and Fars by Nikooyeh and et al. in 2017 (64). The NIMS-2 study also showed that 76% of adolescents 14-20 years old are faced with vitamin D deficiency.

4. Prevalence of vitamin D insufficiency among adults and older people

In the studies published in 2001, 2004, 2008, 2014, the severely VDD prevalence was reported equal to 36% in postmenopausal women, 2.1%, 71.5% and 58.6% in women aged 20-80 years in Tehran (with a 25-(OH)-

D cut-off value of 12 ng/ml), respectively (65-67) while Zabihiyeganeh, Salehi et al., have reported the severely VDD prevalence as 71.5% and 28.5% in Tehranian women and men, respectively, and 57.31% in women in Neishabour in 2014 (68, 69). On the other hand, according to a study in Tehran, Masoudi Alavi et al. showed a prevalence of severely VDD of 89% in Tehranian women in 2016 (70) using a cut-off point of 10 ng/mL. The results of this study were in good agreement with the results of the studies by Rajebi and Shala (71, 72). Researchers reported that 94.7% in Zahedan (in subjects 20-88 years) and >90% in Tehran (in subjects 10-30 years) showed 25-(OH)-D concentrations of <75 nmol/L (<30 ng/mL) (73,69). However, using the cut-off point of 20 ng/ mL, the VDD prevalence was reported as 23.2% in Yazd, 60.9% in Tabriz, 73.3% in Arak, 26% in Sannadaj, 80% in Sary, 47% in Esfahan, 85% in Zahedan, 79.3% in Mashhad, 50% in Shiraz, 75% in Tabriz, 60% in Khyzestan and 50% in Golestan. Based on a study in Birjand, Hoseinzadeh et al. showed an association between VDD and some risk factors of metabolic syndrome in elderly people in 2022 (74).

According to a report on vitamin D status in countries of Asia and Africa, VDD prevalence varied between different age groups (22). On the other hand, latest literature has reported high rates of VDD in adults (especially in the Middle East)(2). In general, the prevalence of VDD among US and Australian adults were 41.6% and 31%, (75, 76) with the cut-off point of ≤20 ng/mL (50 nmol/L), respectively. According to the reports of the recent validated National Integrated Micronutrient Survey of Iran, the vitamin D level is low among Iranian adults (59.1% of Iranian adults suffer from vitamin D deficiency or insufficiency) (36, 37). The levels of vitamin D among subjects of various regions were low, including Semnan, the center of Khorasan in the east, in the north-east, the west and the east of Azarbayjan and Ardebil in the north-west area (>72%) (36).

Nevertheless, in countries with long winters, a low prevalence of VDD is reported compared to sunny countries (11). In the absence of vitamin D, only 10-15% of dietary calcium and 60% of phosphorus are absorbed. Indeed, the main role of this vitamin in muscular function and bone health and in preventing falls and fractures was reported previously (8, 77-79). The prevalence of osteoporosis in Iranian women was 18.9 % (80). The results of a previous investigation with regard to supplement intake showed that 50000 IU vitamin D in 150 adult nurses could be effective in decreasing musculoskeletal pain in neck, shoulders, upper back, lower back, hips/tights, knees, and ankles/feet (81).

Developing countries like Iran were involved in a very fast nutrition transition (82-84). Various risk factors contributed to the low levels of this vitamin. Although Iran is a sunny country, its population generally has an unhealthy diet and sedentary behaviors (82), low consumption of fish (85), low physical activity levels (82, 86) and a dress style that impairs cutaneous vitamin D synthesis (8). Thus, it is strongly suggested to fortify foods and beverages with vitamin D to prevent VDD in order to decrease muscle and bone related diseases.

The prevalence mappings of vitamin D status in Iranian pregnant women, infants, children and adolescents, and adults are shown in Figures 2, 3, 4 and 5, respectively. Studies show that the prevalence of VDI among various age groups and in different geographical regions of Iran varies substantially. As is obvious from the figures, the highest prevalence of severely VDD was reported among Iranian infants in Tehran (93%) followed by pregnant women in Kashan (90%), children and adolescents (56%) in Tehran, and adults and elderly people in Tehran, Shiraz, Tabriz, and Mashhad (50%) with the cut-off value of ≤12ng /mL while the lowest prevalence of severely VDD using the threshold of 12 ng/mL was shown in Tabriz (10% in pregnant women), Tehran (2.1% in adult and elderly people), Ilam (6% in children and adolescents), and Sanandaj (25.9% in infants), respectively.

The prevalence of VDD among Iranian people using a cut-off value of ≤20 ng/mL varied from 2.5% to 85.2%. The highest prevalence of VDD, was calculated as 85.2% among adults and elderly in Zahedan, 84% among children and adolescents in Arak, 76% among pregnant women in Boushehr and 48.9% among infants in Shahroud.

The lowest prevalence of VDD among Iranian people with a cut-off value of ≤20ng /ml was reported as 20% of pregnant women in Kerman, 13% in adults and elderly in Tehran, 2.9% in children and adolescents in Esfahan and 2.5% in infants in Shahroud.

Among adults and elderly in Tehran, Mashhad, and Zahedan, the prevalence of vitamin D status ≤30ng /ml was higher (>90%) than in other regions, while the lowest prevalence under these premises was reported from Tehran (33.3%). Among Iranian children and adolescents and infants, the highest and lowest VDD were present in Orumie (96%) and Shiraz (4%), Shahroud (48.9%) and Kerman (12.5%), respectively (Table 4). In the NIMS-2 prevalence of vitamin D deficiency in adults (45-60 years old) was reported 59% .

As the cut-off point of VDD varied between different studies, we pooled all valid data from the whole country by using <20 ng/mL as a cut-off level. By removing duplicate (and suspicious to duplicate) populations, we found that the prevalence of VDD in males and females older than 18-years is 39% and 51%, respectively.

The prevalence increased obviously in younger population groups (Figures 6e, 6f). Although there are many different reports from all regions of the country, most of them indicate a high prevalence of VDD. So, even after removing the extreme data, the prevalence rate is still high.

Conclusion

The current review shows that the prevalence of VDI in Iran in different studies and within different geographical regions and age groups varies substantially. Briefly, the highest prevalence of VDI (>90%) was shown with a cut-off point of 30 ng/mL in Tehran, Shiraz, Mashhad, and Zahedan (Table 5). The prevalence of VDI in Iranian women was higher than in men in various age groups, which can depend on the dress style of women in Iran. However, several risk factors affect the prevalence of VDD or VDI in Iran that need a comprehensive and precise consideration. These risk factors include air pollution, dietary intake, and amount of skin pigmentation, genetic factors, cultural and social aspects, and insufficient exposure to sunlight. However, the VDD is very worrisome and it is an important public health problem in Iran and must be considered seriously. In this regard, regular food enrichment and supplementation programs can be helpful.

Abbreviations:

Vitamin D deficiency: **VDD**, Vitamin D insufficiency: **VDI**, Scientific information databases: **SID**, Comprehensive Meta-Analysis: **CMA**, The National Integrated Micronutrient Survey: **NIMS.**

Limitations

The limitations of this study may be a guide for future studies to overcome them. In this regard, only studies written in English were included. The sample sizes of the studies were quite small which could have a dramatic impact on the power of the study. In this study, vitamin D was smeseaured by using the different laboratory methods and also season of vitamin D measurement is not known in many articles to report the prevalence of seasonal VDD.

Declarations

Ethics approval and consent to participate

Informed consent was obtained from all subjects using protocols approved by the Ethics Committee of the Mashhad University of Medical Sciences. All participants were able to read and understand and were willing to provide written, informed consent.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgment

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Table 1. Characteristics and results from studies on the prevalence of vitamin D deficiency or insufficiency for pregnant women in Iran.

City	Age (year)	Total Sample Size	Sampling type	Sampling Time	Measurement Method	Cut off (ng/mL)	Prevalence of Deficiency (%)	References
Tehran	16-40	7000	prospective study	First trimester	Radioligand assay	<10	80	(3) Mondul et al. 2017
Sanandaj	16-45	193	Cross-sectional	At the end of pregnancy	NM*	<12	5.14	(87) Mosaed et al. 2005
						< 20	57	
Tehran	26	48	cohort	First trimester	EIA**	<10	20	(88)Ainy et al. 2006
						<20	40	
Tehran	-----	567	Cross-sectional	At the end of pregnancy	RIA***	<12	66.8	(37) Maghboooli et al. 2007
						< 20		
Esfahan	18-44	88	Cross-sectional	Second trimester	RIA			
Zanjan	28.5±5	67	Cross-sectional	At the end of pregnancy	ELISA	<12	Winter: 86 Summer: 46	(32) Kazemi et al. 2009
						< 20		
Kashan	18-35	147	Cross-sectional	Third trimester	EIA	<10	95.8	(33) Asemi et al. 2010
Masjed soleiman	28-78	1581	Cross-sectional	First trimester	ELISA	<12	37.4	(89) Rostami et al. 2015
						< 20		
						< 30	47	
Tehran	------	102	Cross-sectional	At the end of pregnancy	EIA	<12	48	(91, 92) Khalesi et al. 2012& 2015
						< 20	27.5	
Bushehr	15-41	F: 100	Cross-sectional	NM*	Global Autoanalyser	<	76	(93) hatami et al. 2014
Mashhad	27.6± 4.3	190	Cross-sectional	NM*	ELISA	<	85.3	(29) Akhlaghi 2014
Kerman	15-47	80	Cross-sectional	At the end of pregnancy	ELISA	<12		(54) Mirzaei et al. 2015
						< 20	20	
						< 30	17.5	
Tehran	17-52	186	Cross-sectional	NM*	ELISA	<20		
						20-29.9	20(23.3)	
Tabriz	18-45	40	Cross-sectional	Third trimester	competitive chemiluminescent Immunoassay	<12	10	(94) Sadin et al. 2015
						< 20		
						< 30	90	
Shahroud	-----	284	Cross-sectional	At the end of pregnancy	ELISA	<12		(55) abbasian et al. 2016
						< 20	48.9	
						< 30	60.2	
Tabriz	30.41±5.82	68	Cross-sectional	Second trimester	chemiluminescent immunoassay	Deficient	52(76.5)	(95)Vosughi et al. 2017
						Insufficient	11(16.2)	
						Sufficient	5(7.4)	
Yazd	15-47	200	Cross-sectional	At the end of pregnancy	ELISA	<12		(96) Pirdehghan et al. 2016
						< 20		
						< 30	78	
Rasht	19-43	179	Cross-sectional	3 months before pregnancy	NM	< 20	69.27	(97) Mirbolouk et al. 2016
Tehran		149	cohort			vitamin D deficiency	27	(98) Naseh et al. 2017
						insufficient vitamin D	73	

* Not mentioned
** Enzyme Immunoassay
***Radioimmunoassay

Table 2. Characteristics and main results on the prevalence of vitamin D deficiency or insufficiency in infants in Iran.

City	Age (year)	Sex	Total Sample Size	Sampling type	Measurement Method	Cut off (ng/mL)	Prevalence Deficiency (%)	Reference
Sanandaj	newborn	M+F*	193	cross-sectional	NM**	<12	25.9%	(53) Mosaed et al. 2006
						< 20	50.3%	
Tehran	newborn	M+F	567	cross-sectional	RIA**	<12	93.3%	(37) Maghbooli et al. 2007
						< 20		
Zanjan	newborn	M+F	67	cross-sectional	ELISA	<12	winter:75% summer:35%	(32) Kazemi et al. 2009
						< 20		
						< 20	32.9%	
						< 30	44%	
Tehran	newborn	M+F	100	cross-sectional	NM	<12	85%	(91) Khalesi et al. 2012
Kerman	newborn	M+F	80	cross-sectional	ELISA	<12		(54) Mirzaei et al. 2015
						< 20	17.5%	
						< 30	12.5%	
Shahroud	newborn	M+F	284	cross-sectional	ELISA	<12		(55) Abbasian et al. 2016
						< 20	2.5%	
						< 30	48.9%	

* M: males, F: females, M+F: combined data for males and females
** Not mentioned
**Radioimmunoassay

Table 3. Characteristic and main results for the prevalence of vitamin D deficiency or insufficiency in children and adolescents in Iran

City	Age (year)	Sex	Total Sample Size	Sampling type	Measurement Method	Cut off (ng/mL)	Prevalence Deficiency (%)	Reference
Esfahan	14-18	F:165 M:153	318	Cross-sectional	RIA	<20	F:72.1 M:18.3	(99) Heidarpour et al. 2006
----		F:242 M:271		Cross-sectional			F:12.26 M:13.74 (26.0)	(100) Salek et al. 2007
Tehran	7-18	M: 424 F: 539	963	Cross-sectional	RIA	<12		(101) Rabbani et al. 2009
						< 20	F: 53.6 M: 11.3	
						< 30		
Yazd	14-18	F	167	Cross-sectional	RIA	<12		(102) Shakiba et al. 2009
						< 20	81	
						< 30		
Esfahan	6- 7	M: 271 F: 242	530	Cross-sectional	RIA	<12		(23) Ardestani et al. 2010
						< 20	F: 2.1 M: 3.7	
						< 30	F: 26.5 M: 25	
Tehran	8-18	M: 121 F: 192	313	Cross-sectional	RIA	<12		(103) Razzaghy et al. 2010
						< 20	F: 66.6 M: 33.3	
						< 30		
Arak	10-16	F:220 M:200	420	Cross-sectional	RIA	<20	F:99.1 M:66.5 (84.0)	(104) Talaei et al. 2011
Tehran	9-12	M: 573 F: 538	1111	Cross-sectional	ELISA	<12		(105) Neyyestani et al. 2012
						< 20	F: 94.8 M: 88.8	
						< 30		
Rafsanjan	11-17	F	250	Cross-sectional	NM	<12		(106) Jamali et al. 2013
						< 20	59.6	
						< 30		
Shahroud	14-18	M: 438 F: 610	1047	Cross-sectional	EIA	<12		(107) Ebrahimi et al. 2014
						< 20	F: 93.4 M: 56.9	
						< 30		
Bojnurd	7-18	M: 175 F:186	361	Cross-sectional	EIA	<12		(108) Habibesadat et al. 2014
						< 20	F:30.6 M: 0.6	
						< 30	F: 69.3 M: 11.4	

Continue Table 3. Characteristic and main results for the prevalence of vitamin D deficiency or insufficiency in children and adolescents in Iran .

City	Age (year)	Sex	Total Sample Size	Sampling type	Measurement Method	Cut off (ng/mL)	Prevalence Deficiency (%)	Reference
Gorgan	2-7	M: 125 F: 90	215	Cross-sectional	ELISA	<12	85.6	(61) Mohammadian et al. 2014
						< 20		
						< 30		
Qazvin	10-18	F:65 M:59	124	Cross-sectional	ELISA	<20	F:100 M:61 (81)	(109) Ghaeni et al. 2010
Bukan (Orumie)	14-17	F	216	Cross-sectional	ELISA	<20	96	(110) Karimi et al. 2014
						<30	4.0	
						≥ 30		
Zanjan	7-11	M+F*	297	Cross-sectional	ELISA	<12	31.0	(62) Mellati et al. 2015
						< 20		
						< 30		
Shiraz	9-18	M: 241 F: 236	477	Cross-sectional	HPLC	<12		(111) saki et al. 2015
						< 20	81	
						< 30	F: 97 M: 95	
Tehran	2-14	M+F	90	Cross-sectional	RIA	<12	66.7	(112) Motlaghzadeh et al. 2016
						< 20		
						< 30		
Tehran	14.34	F:217 M:227	444		Enzyme Immunoassay	<20	F:71.23 M:17.74 (43.3)	(60) Larijani et al. 2016
Tehran		F:30 M:32 (51.6%)	62	Cross-sectional	NM	< 10	56.5	(113) Fallahi et al. 2016
27 provincs of Iran	10-18	F:526 M:569	1095		direct competitive immunoassay	<30	F:39.3 M:40.7 (40)	(114) (115) Jari et al. 2015 & Kelishadi et al. 2016
Ilam	1-7	M+F	156	Cross-sectional	ELISA	≤10	3.8	(63) Rahmati et al. 2016
						10–30	41	
						30-100	55.1	
Ilam	7-18	M+F	349	Cross-sectional	ELISA	≤10	8.0	(63) Rahmati et al. 2016
						10–30	50. 7	
						30-100	41. 3	
Khozestan	≤20	M+F	962	Cross-sectional	Chemiluminesent	≤10	30.8	(116) Mohammadi et al. 2016
						10–20	30.8	
						20–30	17.2	
						≥30	21.5	
6 province**	5-17	M+F	667	Cross-sectional	ELISA	<20	56	(64) Nikooyeh et al. 2016

* M: males, F: females, M+F: combined data for males and females
** West Azarbaijan , Semnan , Lorestan, South Khorasan , Khoozestan and Fars

Table 4. Characteristic and main results for the prevalence of vitamin D deficiency or insufficiency in Iranian children, adolescents, adults and elderly.

City	Age (year)	sex	Total Sample Size	Sampling type	Measurement Method	Cut off	Prevalence of Deficiency (%)	Reference
Tehran	early postmenopausal	F	73	cross-sectional	HPLC	<12	36	(66) Rassouli et al. 2001
Tehran	3-69	F;682 (59%) M;490(41%)	1210	cross-sectional	RIA	≤ 20	52 F:69 M:35	(117) Ghazi et al. 2004
Tehran	20-62	F;715 (59%) M;495(41%)	1210	cross-sectional	RIA	<12.5	9.5	(20) Hashemipour et al. 2004
						12.5-25	57.6	
						< 25	14.2	
-----		F	252	cross-sectional			64.2	(118) Rahimi et al. 2005
Tehran	29.7	M+F*	90	cross-sectional	HPLC CPBA RIA	< 30	33.3	(119) Zahedi rad et al. 2013
Orumieh	15-40	F	162	cross-sectional	#	<10	57.4	(70) Alavi et al. 2016 (71) Shahla et al. 2005
						10-20	24.7	
						20>	17.9	
Zone1**	20 -75	M+F	5329	cross-sectional	RIA	<12	F: 42.8 M: 34.8	(120) Moradzadeh et al. 2005
						< 20	F: 27.2 M: 37.3	
Shiraz	20-74	M	520	cross-sectional	IA	< 25	33.9	(121)Masoompour et al. 2008
Yazd	20-55	M+F	82	cross-sectional	ELISA	<12	_	(122) Shakiba et al. 2008
						< 20	23.2	
						< 30	37.8	
Zone2***	50>	F	5232	Yes (cross-sectional	RIA	<12.5	47.2	(5) Heshmat et al. 2008
	50-60					12.5-25	45.7	
	60<					< 25	44.2	
	50>	M				<12.5	54.2	
	50-60					12.5-25	41.2	
	60<					< 25	37.5	
Guilan	50>	F(427 in urban areas and 219 women in rural areas)	646	cross-sectional	RIA	<12		(123) Maddah et al. 2009
						< 20	_	
						< 30	84.7(urban) 79.5 (rural)	
Tabriz	53-80	F	300	cross-sectional	Chemiluminescence's immunoassay	<12	38.3	(124) Niafar et al. 2009
						< 20	60.9	
Tehran	19<	M	380	cross-sectional	ELISA	≤35	85.7	(125) Rahnavard et al. 2010
Bushehr	19<	M	111		ELISA	≤35	40.3	
Tabriz	19<	M	516		ELISA	≤35	71.14	
Shiraz	19<	M	239		ELISA	≤35	62.1	
Mashhad	19<	M	276		ELISA	≤35	73.59	
Tehran	10-85	M+F	107	cross-sectional	LIAISON 25 -OH Vitamin D Total Assay	Deficient	25.2	(126) Alizadeh et al. 2015
						Insufficient	_	
						Sufficient	50.5	
Arak	>20	F	369	cross-sectional	NM	≤20	294(73.3)	(19) Khashayar et al. 2017
						20–30	47(79.7)	
						>30	28(71.8)	
Sannadaj	>20	F	130	cross-sectional	NM	≤20	107(26.7)	(19) Khashayar et al. 2017
						20–30	12(20.3)	
						>30	11(28.2)	

* M: males, F: females, M+F combined data for males and females
** Zone1: Tehran, Tabriz, Mashhad, Shiraz, and Booshehr.
***Zone2: Tehran-Shiraz -Tabriz- Mashhad.
\# Full-text is not available

Continue Table 4. Characteristic and main results for the prevalence of vitamin D deficiency or insufficiency in Iranian children, adolescents, adults and elderly.

City	Age (year)	sex	Total Sample Size	Sampling type	Measurement Method	Cut off	Prevalence of Deficiency (%)	Reference
Tehran	20-55	F	100	cross-sectional	EIA	≤ 10	36	(127) Hosseinzadeh et al. 2010
Sari	10-70	F;232 M;118	351	cross-sectional	ELISA	< 20	80	(128) Kashi et al. 2011
Zone1**	20-69	M+F	3763	cross-sectional	NM	<12		(129) Khashayar et al. 2011
						< 20	57.5	
						< 30		
Esfahan	20-80	F;848 M;243	1,111	cross-sectional	RIA	<12	F: 16 M: 30	(130) Hovsepian et al. 2011
						< 20	F: 45 M: 52.4	
						< 30	F: 67.7 M: 71.1	
Zahedan	20-88	M+F	993	cross-sectional	chemiluminescent immunoassay	<12		(73) Kaykhaei et al. 2011
						< 20	85.2	
						< 30	94.7	
Tehran	51/55	M+F	85	cross-sectional	chemilumi-nescence	<12		(131) Taheri et al. 2011
						< 20	57	
						< 30	75.6	
Babol	>15	M+F	576 females and 120 males	prospectively - cross-sectional	ELISA	<20		(132) Heidari et al. 2012
						20-29.9	F: 70.8 M: 67.5	
Mashhad	>30	M+F	902	cross-sectional	RIA	<12		(133) Bonakdaran et al. 2015
						< 20	79.3	
						< 30	90.3	
Tehran	20-80	M+F	90	cross-sectional	chemilumi-nescence immunoassay	<12	F: 2.1	(67)Djalali et al. 2013
						< 20	F: 18.3 M: 7	
						< 30	F: 47.5 M: 23.3	
Tehran	20-80	F	538	cross-sectional	electrochemiluminiscence	<12	58.6	(65) Alipour et al. 2014
						< 20	77.7	
						< 30	85.7	
Shiraz	19-32	M(128) F(126)	254	cross-sectional	RIA		F: 44 M: 1.6	(134) Faghih et al. 2014
							F: 51.2 M: 49.6	
							F: 3.2 M: 48	
Neishabour	15-40		841	cross-sectional	chemiluminescence	<12	57.3	(68) Salehi et al. 2015
						< 30	87.8	
Tehran	20-30	M+F	100	cross-sectional	RIA	<12	F: 71.5 M: 28.5	(69) Zabihiyeganeh et al. 2014
						< 20	77	
						< 30	99	
Tabriz	>60	M+F	280	cross-sectional	Electrochemiluminescence immunoassay	< 20	75	(135) Agha Mohammadzadeh et al. 2014
						< 30		
Amirkola (Babol)	>60	M:599 F:258	858	cross-sectional	ELISA	<12	41.9	(136) Alipour et al. 2015

* M: males, F: females, M+F combined data for males and females
** Zone1: Tehran, Tabriz, Mashhad, Shiraz, and Booshehr.
***Zone2: Tehran-Shiraz -Tabriz- Mashhad.

Continue Table 4. Characteristic and main results for the prevalence of vitamin D deficiency or insufficiency in Iranian children, adolescents, adults and elderly

City	Age (year)	sex	Total Sample Size	Sampling type	Measurement Method	Cut off	Prevalence of Deficiency (%)	Reference
Mashhad	46±7	F:489 M:357	841	cross-sectional	competitive electroluminescence	<20	F: 45.89 M:33.5	(137) Bonakdaran et al. 2016
Arak	>20	F	382	cross-sectional	RIA	<12	_	(138) Hassannia et al. 2015
						< 20	62	
						< 30	74.94	
Tehran	32±5.22	F	200		ELISA	<10	89	(70) Alavi et al. 2016
Tehran	>20	F	114	cross-sectional	EIA	<10	69.3	(73) Rajebi et al. 2016
Ilam	18-60	M+F	2189	Cross-sectional	ELISA	≤10	254(11.6)	(63) Rahmati et al. 2016
						10–30	1147(52.4)	
						30-100	788(36)	
Ilam	>60	M+F	225	Cross-sectional	ELISA	≤10	17(7.5)	(63) Rahmati et al. 2016
						10–30	225(50.6)	
						30-100	94(41.8)	
Ilam	36.25±17.1	F;2053(70.3) M;836(29.7%)		Cross-sectional	ELISA	30-100	62 (61.1:F and 58.2:M)	(63) Rahmati et al. 2016
Khozestan	21-40	M+F	1562	Cross-sectional	Chemiluminesent	≤10	40	(116) Mohammadi et al. 2016
						10–20	30.5	
						20–30	12.9	
						≥30	16.5	
Khozestan	41-60	M+F	1550	Cross-sectional	Chemiluminesent	≤10	30.6	
						10–20	30.6	
						20–30	15.5	
						≥30	23.4	
Khozestan	60≥	M+F	500	Cross-sectional	Chemiluminesent	≤10	14.6	
						10–20	23.2	
						20–30	24	
						≥30	38.2	
Golestan	20-40	F:129 M:71	200	Cross-sectional	ELFA	≤10	12	(128) Kasi et al. 2011
						10–20	37.55	
						20–30	22	
						30-100	28.5	

* M: males, F: females, M+F combined data for males and females
** Zone1: Tehran, Tabriz, Mashhad, Shiraz, and Booshehr.
***Zone2: Tehran-Shiraz -Tabriz- Mashhad.
\# Full-text is not available

Table 5. The provinces with the highest and lowest rate of prevalence of Vitamin D deficiency and Vitamin D insufficiency in Iran.

City	Group (age)	Sex	Sample size	Cut off (ng/ml)	Prevalence Deficiency (%)	Reference
Pregnant						
Sananda	16-45	193	No	<12	5.12	(87) Mosaed et al. 2005
Zanjan	-------	67	No	<12	86(Winter)	(32) Kazemi et al. 2009
Adult/elderly						
Zone1*	50>	F/M	5232	<12	F: 47.2 M: 54.2	(5) Heshmat et al. 2008
Tehran	20-80	M+F	90	<12	F: 2.1	(67) Djalali et al. 2013
Tehran	32±5.22	F	200	<10	89	(70) Alavi et al. 2016
Ilam	60<	M+F	225	<10	7.5	(63) Rahmati et al. 2016
Zahedan	20-88	M+F	993	<20	85.2	(73) Kaykhaei et al. 2011
Tehran	20-80	M+F	90	<20	13	(67) Djalali et al. 2013
Tehran	10-30	M+F	100	<30	>90	(69) Zabihiyeganeh et al. 2014
Mashhad	>30	M+F	1000	<30	>90	(133) Bonakdaran et al. 2015
Zahedan	20-88	M+F	1000	<30	>90	(73) Kaykhaei et al. 2011
Tehran	29.7	M+F	90	<30	33.3	(119)Zahedi rad et al. 2013
Children						
Tehran	-	F:30 M:32	62	<10	56.5	(113) Fallahi et al. 2016
Ilam	7-18	M+F	349	<10	6	(63) Rahmati et al.2016
Tehran	9-12	F:538 M:573	1111	<20	91.7	(105) Neyestani et al. 2012
Arak	10-16	F:220 M:200	420		84	(104) Talai et al. 2011
Esfahan	6- 7	M: 271 F: 242	530	<20	2.9	(23) Ardestani et al.2010.
Shiraz	9-18	M: 241 F: 236	477	<30	96	(111)
Bukan (Orumie)	14-17	F	216	<30	4	(110) Karimi et al. 2014
Infants						
Tehran	newborn	M+F	567	<12	93.3	(37) Maghbooli et al. 2007
Sanandaj	newborn	M+F	193	<12	25.9	(52) Mosaed et al. 2006
				<20	53	
Shahroud	newborn	M+F	284	<20	2.5	(55) Abbasian et al. 2016
Shahroud	newborn	M+F	284	<30	48.9	(55) Abbasian et al. 2016
Kerman	newborn	M+F	80	<30	12.5	(54) Mirzaei et al. 2015
Iran	15-23month	M+F	7112	<12	-	(53) Olang et al. 2011
				< 20	32.9%	
				< 30	44%	

* Zone1: Tehran-Shiraz -Tabriz- Mashhad

Table 6. Prevalence of moderate vitamin D deficiency worldwide.

Country	Group	Cut off	Prevalence Deficiency (%)	reference
Iran	Infants	<20 ng/ml	93	(29)
Pakistan	Infants	<20 ng/ml	71	(140)
Germany	Infants	<20 ng/ml	69	(141)
Alaska	Infants	<20 ng/ml	11	(142)
China	Infants	<20 ng/ml	5	(143)
United States	Black Infants	<20 ng/ml	46	(44)
	white Infants	<20 ng/ml	10	
Turkey	Infants	<20 ng/ml	90	(144)
Kuwait	Infants	<20 ng/ml	96	(21)
India	Infants	<20 ng/ml	99	(145)
Argentina	Infants	<20 ng/ml	24	(146)
Tanzania	Infants	<20 ng/ml	9	(147)
Australia	Infants	<20 ng/ml	40	(148)
Iran	Children	<20 ng/ml	36	(149)
Afghanistan	Children	<20 ng/ml	95	(150)
Great Britain	Children	<20 ng/ml	35	(151)
canada	Children	<20 ng/ml	39	(152)
Belgium	Children	<20 ng/ml	58	(153)
China	Children(6-11)	<20 ng/ml	40	(143)
Qatar	Children	<20 ng/ml	38	(154)
Jordan	Children	<20 ng/ml	28	(155)
Israel	Children	<20 ng/ml	38(M), 53(F)	(156)
Malaysia	Children	<20 ng/ml	72	(157)
South Africa	Children	<20 ng/ml	7	(158)
Iran	Adolescents	<20 ng/ml	35	(159)
9 European countries*	Adolescents	<20 ng/ml	42	(160)
Canada	Adolescents	<20 ng/ml	26	(161)
United States	Adolescents(16-19)	<20 ng/ml	33	(162)
Saudi Arabia	Adolescents	<12 ng/ml	81	
Qatar	Adolescents	<20 ng/ml	62	(159)
Korea	Adolescents	<20 ng/ml	57(M), 68(F)	(163)
India (Female)	Adolescents	<20 ng/ml	91	(164)
Brazile(Female)	Adolescents	<20 ng/ml	36	(165)
China	Adolescents	<20 ng/ml	46	(143)
Iran	Adults	<20 ng/ml	51	(166)
Pakistan	Adults	<20 ng/ml	58	(167)
Canada	Adults	<20 ng/ml	20	(168)
United States	Adults	<20 ng/ml	34-37	(162)
Denmark	Adults	<20 ng/ml	52	(169)
Norway	Adults	<20 ng/ml	40	(170)
Finland	Adults	<20 ng/ml	65	(171)
Germany	Adults	<20 ng/ml	57(M),58(F)	(172)
Korea	Adults	<20 ng/ml	62	(173)
Thailand	Adults	<20 ng/ml	6	(174)
Australia	Adults	<20 ng/ml	31	(76)
Malasia	Adults	<20 ng/ml	70	(175)
China	Elders	<20 ng/ml	36	(176)
Australia	Elders	<12 ng/ml	22-45	(177)
New Zealand	Elders	<20 ng/ml	41(M),58(F)	(178)
Jordan	Elders	<20 ng/ml	4(M),12(F)	(179)
India	Elders	<20 ng/ml	91	(180)
Israel	Elders	<20 ng/ml	43-49 (M),47-54(F)	(156)
Korea	Elders	<20 ng/ml	69(M),87(F)	(181)
Japan	Elders	<20 ng/ml	5(M),18(F)	(182)
Canada	Elders	<20 ng/ml	19	(161)

*Italy, Greece, Austria, Spain, Sweden, Hungary, France, Belgium, Germany .

Continue Table 6. Prevalence of moderate vitamin D deficiency worldwide.

Country	Group	Cut off	Prevalence Deficiency (%)	reference
United States	Elders	<20 ng/ml	34	(162)
Guatemala	Elders	<20 ng/ml	46	(183)
Chile	Elders	<20 ng/ml	48	(184)
Finland	Elders	<20 ng/ml	66	(185)
Sweden	Elders	<20 ng/ml	4	(186)
England	Elders	<20 ng/ml	52	(187)
Spain	Elders	<20 ng/ml	86	(188)
Italy	Elders	<20 ng/ml	51(M),75(F)	(189)
Brazil	Elders	<20 ng/ml	57%	(190)
Argentina	Elders	<20 ng/ml	52(north),64(central),87 (south)	(191)
Poland	elders	<20 ng/ml	83(F)	(192)
Turkey	Elders	<20 ng/ml	33	(193)
Germany	Elders	<20 ng/ml	89	(194)
Iran	elders	<20 ng/ml	80-85	(195)
Australia	Pregnant	<20 ng/ml	48	(148)
India	Pregnant	<20 ng/ml	96	(145)
Vietnam	Pregnant	<20 ng/ml	7	(196)
China	Pregnant	<20 ng/ml	69	(197)
Pakistan	Pregnant	<20 ng/ml	72	(140)
Iran	Pregnant	<20 ng/ml	67	(198)
Turkey	Pregnant	<20 ng/ml	90	(144)
Canada	Pregnant	<20 ng/ml	24	(199)
United States	Pregnant	<20 ng/ml	33	(200)
Netherlands	Pregnant	<20 ng/ml	44	(201)
England	Pregnant	<20 ng/ml	31	(202)
Spain	Pregnant	<20 ng/ml	20	(203)
Tanzania	Pregnant	<20 ng/ml	1	(147)
Germany	Pregnant	<20 ng/ml	77	(141)

*Italy, Greece, Austria, Spain, Sweden, Hungary, France, Belgium, Germany.

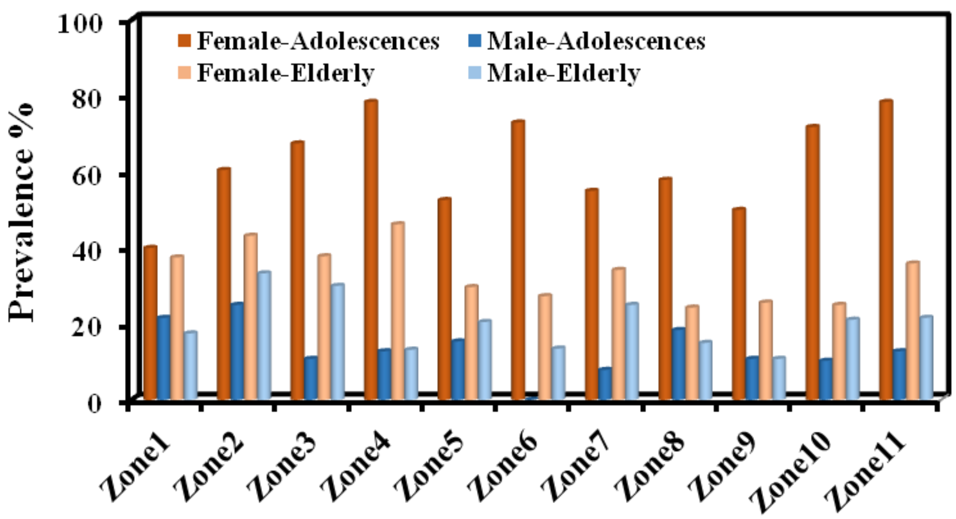

Figure 1 supplementary. The status of vitamin D deficiency according to geographical regions, specific age groups and sex; Study Poura, Spring 2012.

Zone1: Guilan, Mazandaran ; **Zone2**: west and yeast Azerbaijan, Ardabil ; **Zone3**: North khorasan, Golestan; **Zone4**: Semnan,razavi khorasan ; **Zone 5**: south khorasan, sistan and baluchestan ; **Zone 6**: yazd, kerman,esfahan and chahar mahal bakhtiari; **Zone 7**: bushehr,hormozgan and khuzestan; **Zone 8**: Tehran and alborz; **Zone 9**: ghom, zanjan, markazi and qazvin; **Zone 10**: ilam, kordestan,lorestan,Khuzestan,hamedan and kermanshah; **Zone 11**: fars, kerman and kohkelue and buyerahmad.

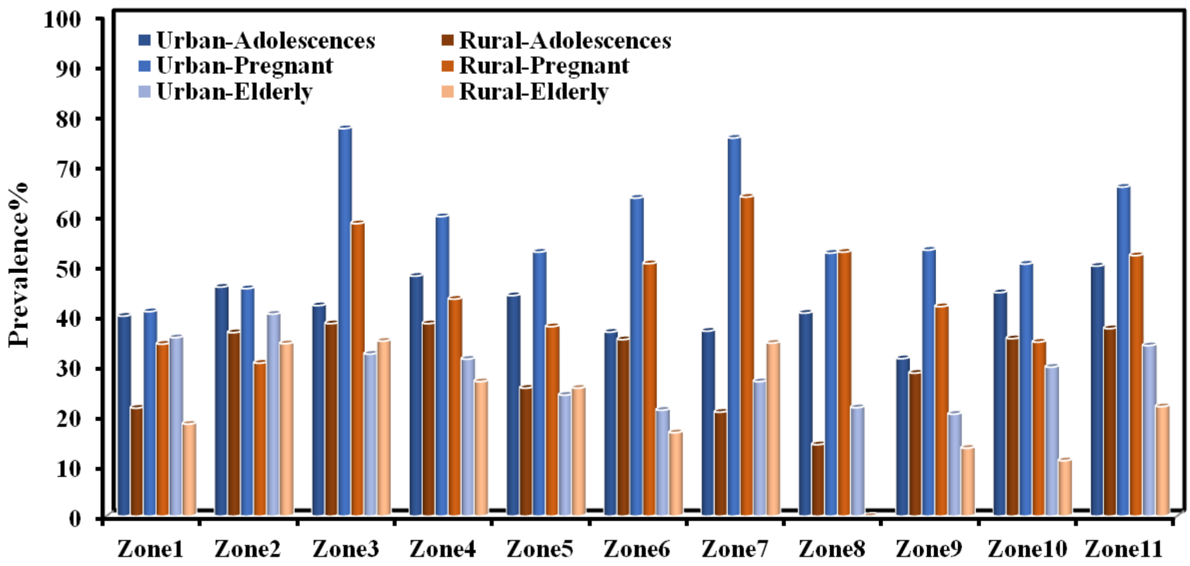

Figure 2 supplementary. The status of vitamin D deficiency in urban and rural Iranian adolescents, pregnant women and elderly groups; Study Poura, Spring 2012.

Zone1: Guilan, Mazandaran ; **Zone2**: west and yeast Azerbaijan, Ardabil ; **Zone3**: North khorasan, Golestan; **Zone4**: Semnan,razavi khorasan ; **Zone 5**: south khorasan, sistan and baluchestan ; **Zone 6**: yazd, kerman,esfahan and chahar mahal bakhtiari; **Zone 7**: bushehr,hormozgan and khuzestan; **Zone 8**: Tehran and alborz; **Zone 9**: ghom, zanjan, markazi and qazvin; **Zone 10**: ilam, kordestan,lorestan,Khuzestan,hamedan and kermanshah; **Zone 11**: fars, kerman and kohkelue and buyerahmad.

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