ZITA MEDICAL MANAGEMENT

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ΦΑΡΜΑΚΕΥΤΙΚΗ, 37, ΙΙ, 2025 | 103-115 ΑΡΘΡΟ ΕΠΙΣΚΟΠΗΣΗΣ

PHARMAKEFTIKI, 37, II, 2025 | 103-115 REVIEW ARTICLE

A Review in Vitamin D Deficiency in Iraq Prevalence, Distribution and Associated diseases

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DOI: 10.60988/p.v37i2.83

KEY WORDS: vitamin D; Iraq; Vitamin D related diseases; prevalence

ARTICLE INFO:
Received: November 23, 2024
Revised: February 7, 2025
Accepted: March 1, 2025
Available on line: June 16, 2025

ABSTRACT

Despite Vitamin D being known as the sunshine vitamin, low levels of vitamin D are reported continuously in majority of middle eastern countries. Interest in vitamin D levels have been growing considerably throughout the years and understanding the relation with vitamin D and similar populations has been crucial for the overall health benefits of individual patients. Iraq being a middle eastern country is divided into 2 different climatic provinces thus vitamin D levels may differ between populations living in the north vs. those in the southern area in hotter desert climate. This review is limited to the prevalence of vitamin D deficiency studies done in various cities in Iraq among different populations (adults, children, pregnant, those suffering from similar chronic diseases i.e. diabetes mellitus, inflammatory bowel disease and asthma/allergic rhinitis) living in different cities and published between the years 2019 to 2024. In short, it is essential to identify candidates who are at high risk of developing vitamin D complications for screening, monitoring and treating.

1. Introduction

Vitamin D deficiency (VDD) is considered a major global pandemic, with approximately 1 billion individuals suffering from low levels of vitamin D[1]. Consequences of VDD have affected all age groups; infants, children, adults and elderly and especially for pregnant and individuals with chronic disease. Ultimately VDD can lead to decrease in bone

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mineral density causing osteomalacia and rickets. In addition, VDD has been implicated with muscle weakness, falls, acute respiratory infection(s) and may cause more chronic diseases[1,2]. Vitamin D deficiency can be associated with many reasons that limit sun exposure, since sunlight is important for ultraviolet-B (UV-B) production of vitamin D through the skin. Limitations to sun exposure may be due to; current lifestyle choices as reduced activity outdoors, environmental factors as living in a geographical area with limited sunlight and/or high pollution, and inadequate exposure to sunlight (especially for middle eastern women whom cover up to 90% of their bodies due to cultural reasons)[1,3].

Middle eastern countries are known to be arid with long summers and hot desert climate. The assumption that vitamin D levels are adequate due to availability of sunlight compared to other more cooler countries has been proven false over the years. A current study had found that up to 80% of individuals residing in middle eastern countries suffer from vitamin D deficiency compared to less than 20% in Northern Europe and 30-60% in Western, Southern and Eastern Europe[4].

Iraq, however, is divided into 2 main climatic provinces; the moister northeast and the warmer arid plains including the desert[5]. Cities as Duhok, Mosul, Erbil and to a certain extent Sulaymaniyah are considered to be moister more cooler cities compared to Baghdad and Basrah.

Impact of sanctions in 1990 in Iraq led to increasing the occurrence of rickets (vitamin D deficiency) in children, this led to humanitarian proposals of supplementation, however due to lack of funds could not be implemented[6]. In addition, the majority of previous studies targeted a specific population in Iraq i.e. women and/or children. This may be assumed due to the previous knowledge on the importance of vitamin D levels in children due to rickets and in women of child bearing age. Although the main target of another study in Karbala, Iraq were menopausal women, they also collected samples from women and men of a range of ages. It concluded that severe vitamin D deficiency was found in 40%, 15%, 12% and 23.3% in postmenopausal women, women of child bearing age, young men and older men respectively[7].

The main aims of this review are; 1) to sort through the literature available and find appropriate research based on vitamin D deficiency in the major cities of Iraq, 2) to compare results of similar studies between the various climates and diseases available, and their effect on vitamin D levels within the population 3) to identify gaps that may be present in current literature available with suggestions on improvement.

2. Methods

A search of literature was done using google scholar and PubMed as source of literature. A Custom range of only literature published (independent on year of sample collection) within last 5 years (between years of 2019-2024) were included. The main keywords in identifying suitable research were; Vitamin D deficiency, Iraq, prevalence, level, Erbil, Mosul, Baghdad, Basrah and Duhok were initially selected. The main focus was to find similar articles of similar focus groups conducted but in different cities and geographical areas, this included studies done on children, pregnant women, levels of vitamin D in the general population and those suffering from chronic illnesses as diabetes mellitus (DM), allergic rhinitis (AR) and inflammatory bowel disease (IBD). Summary of the inclusion and exclusion criteria along with final selected number of studies can be seen in table 1 below.

3. Results- Vitamin D levels

3.1. General Population

In terms of the general population residing in major cities of Iraq, a cautionary note should be indicated in relation to not only the age of the sample groups but also gender. In addition, remarks

should be inputted at time of collection of blood sample; whether they are collected during the hot summer months indicating more sunlight exposure, and possibly higher vitamin D levels or winter months. Summary of vitamin D levels seen in Table 2: Overview of studies in different cities in Iraq and association with different diseases highlighting Prevalence of Vitamin D deficiency Published between 2019- 2024.

3.1.1 Duhok and Zaxo

A recent study conducted in Duhok and Zaxo used a sample size of 1143 volunteers varying in age between 9 months and 86 years old. When comparing vitamin D deficiency of the general population findings were 44.9% vitamin D deficient in Duhok and 38.19% deficient in Zaxo. The same study compared vitamin D levels according to 4 age groups; less than 20, 20-40 years, 41-60 years and greater than 60 years old. Findings found VDD in 44.14%, 46,23%, 36.44% and 30% respectively. Association between gender and vitamin D levels were also evaluated, prevalence of VDD in males was found to be 37.8% compared to 43.03% deficiency in females[9] .

A similar study compared vitamin D levels between healthy individuals between the ages 18-70 years old in Duhok. This study indicated an exclusion criterion of importance which excluded any individuals taking vitamin D supplementation, suffering from chronic/endocrine diseases and/or on drug therapy. In addition, samples were obtained during the winter months where sunlight exposure is less compared sunlight exposure during other months of the year. No significant difference of vitamin D levels were found when comparing age, however in general VDD between males and females was 53% and 58%, respectively[10].

3.1.2 Baghdad

Al-Hussaini, conducted a research based on the evaluation of vitamin D levels and compared the levels between males and females aging between 18-80 years old in Baghdad. A sample size of 300 (150 males and 150 females) were obtained throughout the entire year and is not pin pointed towards a specific season. A vast amount of 84% of males vs. 89.33% of females were found to have deficient vitamin D levels[11].

3.1.3 Basrah

Vitamin D levels were also investigated in Basrah, one of the hottest cities in Iraq. Serum was collected from patients but excluded any patients suffering from vitamin D related diseases as diabetes, malignancy chronic liver or renal disease and those taking vitamin D supplementation. A sample size of 252 was collected; 204 females and 48 males. Study compared vitamin D levels between genders and also age groups. Samples were characterized into 3 age groups; below 20, 20-40 years and above 40 years old which showed VDD at 37%, 42% and 37% respectively. At the same time, vitamin D levels were compared between genders; females showing 45% deficient and males 17% deficient. Overall, the entire study showed that VDD throughout entire sample was approximately 39%[12] .

3.2 Children

In terms of studies determining vitamin D levels targeted specifically towards children, numerous studies indicated prevalence of vitamin D deficiency. However, studies not only targeted healthy children but the correlation of vitamin D level with different disease(s).

3.2.1 Mosul

One recent study evaluated vitamin D levels in healthy primary school children aging between 6 to 12 years old in Mosul. A total of 1072 samples were collected between the months of February until May of 2019. Overall, a total of 640 samples

(59.7%) were found to have deficient levels of vitamin D. Comparison of vitamin D levels between females and males, left bank of Mosul and right bank of Mosul, and parental education of students were also evaluated. Evidence found there was no significant difference in vitamin D levels based on gender, location of residence and status of parental education[13].

3.2.2 Duhok

In Duhok, a study suggested there was a significant correlation between VDD and children with Type 1 diabetes mellitus (T1DM). Vitamin D levels was determined among children aging between 5 – 15 years old suffering from T1DM. Samples were collected between the months of February to August 2016. The study was directed towards diabetic children, thus, the exclusion of patients with any other acute or chronic diseases and those receiving multivitamins or vitamin D supplementation were omitted. A vast majority of 90% of the cases indicated having VDD compared to control group of only 6% being deficient[14].

Another study in Duhok evaluated vitamin D levels of children less than 5 years old having been admitted to the hospital suffering from severe acute lower respiratory tract infection (LRTI). Samples were collected between June 2017 – June 2018. Controls were chosen randomly and collected from healthy children of similar age group visiting Heevi hospital with their parents during the study. Overall evidence found there was no significant difference between vitamin D levels of the cases and controls and with VDD in about 14% of all the samples taken (control + case)[15].

3.2.3 Misan

The assessment of vitamin D levels in toddlers and infants with iron deficiency (ID) and iron deficiency anemia (IDA) was conducted in Misan. A total of 190 samples during the period of July to December 2019 were collected; 35 ID, 60 IDA and 95 healthy infants/toddlers of same age group. Patients suffering from febrile illness, malnutrition, chronic diseases and those taking any form of supplementation were excluded from the study. A total of 60% with ID and 70% with IDA were found to have deficient levels of vitamin D[16].

3.3 Vitamin D studies in diseases and/or status

3.3.1 Diabetes

In terms of individuals suffering from type 2 diabetes mellitus (T2DM), vitamin D levels were assessed in a number of studies in different cities.

3.3.1.1 Duhok

In Duhok, a sample size of 310 was collected between the months of February to July 2018. The cases included were above 25 years old and had T2DM only taking oral antidiabetic agents or on a diet. The exclusion of patients with end stage renal disease, chronic liver disease, malignancies, bone diseases, history of drug use as; insulin, anticonvulsants, anemia, type 1 diabetes mellitus, pregnant and patients taking any form of supplementation. A total of 71% of cases were found to have VDD compared to 40.6% in control group, with a significant difference of ($p<0.001$)[17].

3.3.1.2 Baghdad

Two similar studies were conducted in Baghdad, one study collected samples from a private hospital while the other collected samples from the public national diabetes center. The study conducted on samples from private hospital also correlated the effects of vitamin D levels with lipid profile. A total of 257 patients with T2DM age between 26 – 80 years old and 40 healthy participants were included in the study. Results showed 34.6% of patients with T2DM were vitamin D deficient. From these results, further investigation found that 96.8% of those with vitamin D deficiency and T2DM were uncontrolled diabetic patients

Table 1. Summary of data collection

Stage 1- Initial Search	
Data Bases	PubMed, Google Scholar
Custom Range	2019-2024
Keywords	("Vitamin D deficiency") AND ("Iraq" OR "prevalence level" OR "Erbil" OR "Mosul" OR "Baghdad" OR "Basrah" OR "Duhok")
Results	13,600

Stage 2- Screening of Results	
Filter	Remove of Duplicate
Filter	Title and abstract reviewed to identify whether meets inclusion and exclusion criteria
Results	145

Stage 3- Inclusion and Exclusion criteria	
Inclusion criteria	- Language: English - Context within Iraq and cities within both North and South of Iraq - Vitamin D deficiency within certain context and groups; children, pregnant women, diabetes mellitus, allergic rhinitis and inflammatory bowel disease
Exclusion criteria	- Studies published before 2018 - Other disease not mentioned in inclusion criteria - Studies in non-major cities
Results	20

(uncontrolled glycemia). Furthermore, there was no significant difference in vitamin D deficiency between case and control, however, when correlating only case group there were significant differences of vitamin D levels between male vs female ($p<0.001$) and age group; less than 55 vs greater than or equal to 55 ($p<0.001$)[18]. A total of 100 samples with T2DM and 100 health control samples were collected from the public national diabetes center from the period of October 2018 – June 2019. Results showed a significant difference of P=0.0001 decrease in average levels of 25 (OH) D3, with mean value of (7.373 ± 4.44ng/ml) in patients compared to (14.752 ±5.87ng/ml) in the control group. However, these results showed abnormal vitamin D levels in both groups as normal vitamin D levels should be greater than 30 ng/ml[19].

3.3.2. Defects to airway diseases (Asthma, Rhinitis and/or smokers)

3.3.2.1 Duhok

A study in Duhok, assessed vitamin D levels in smokers. A total number of 410 samples were observed; 240 non-smokers and 170 smokers between the period of September 2018 until May 2019. Due to culture, since female smokers are limited, the inclusion criteria were only male smokers aged between 30 -60 years old with normal fasting glucose levels. Samples with chronic

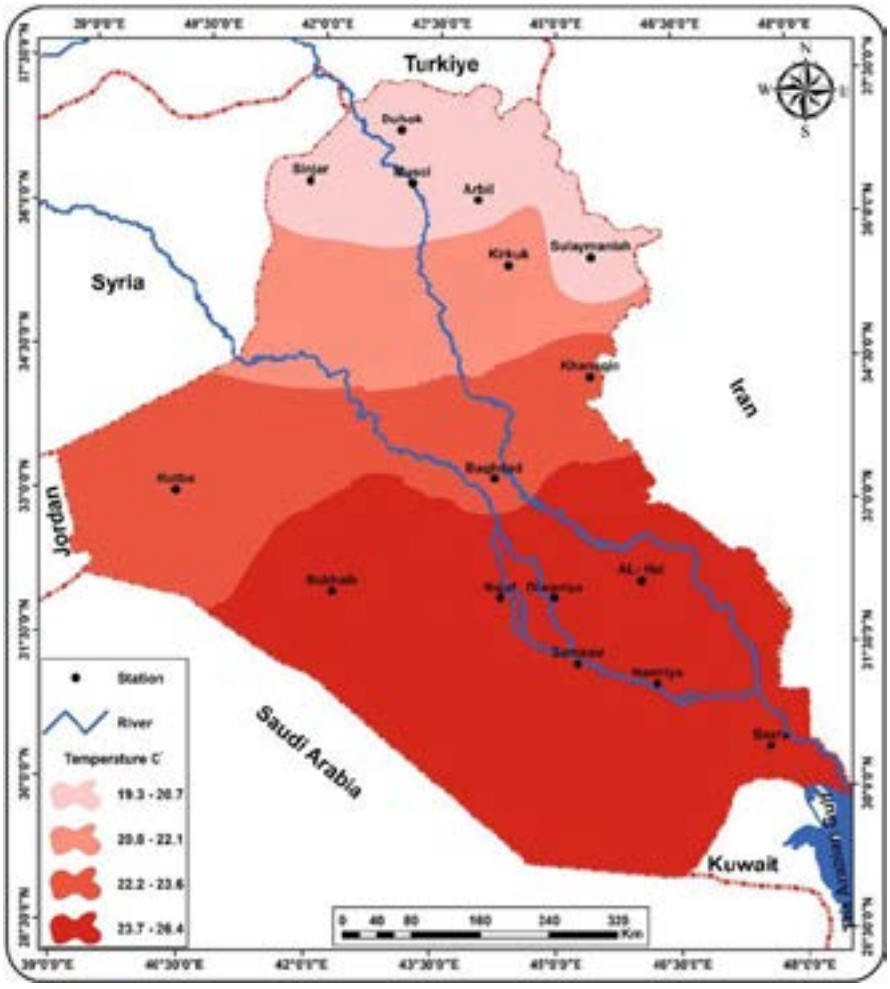

Figure 1. *Map of Iraq showing the difference in heat/temperature between south and northern cities. Adapted from book "The Geography of Iraq. World Geography book series". Chapter on "Climate of Iraq"* [8].

vascular diseases, endocrine metabolic disorders, malignancy, and individuals using lipid lowering agents, antihypertensive agents and supplementations were excluded from the study. A total of 42 smokers (25%) had VDD compared to the control group of only 7.6%[20].

3.3.2.2 Baghdad

In Baghdad, vitamin D levels were assessed in asthmatic patients admitted to the chest disease department. A total of 61 patients were included in the study (26 females and 35 males). Assessment of vitamin D levels found 6.6% of samples were very severely deficient and 37.7% were deficient[21] .

3.3.2.3 Mosul

In terms of allergic rhinitis, a study in Mosul determined vitamin D levels in patients ranging from 20 – 50 years old. A total of 99 samples were analyzed; 49 cases with allergic rhinitis (AR) and 50 healthy individuals as control group. Samples

were obtained between the months of March and October 2018. In addition, this study has an exclusion criterion of; body mass index (BMI) greater than 26 kg/m2, inflammatory/immunological conditions, chronic illnesses (DM, abnormal vitamin D metabolism), and the exclusion of individuals taking vitamin D supplementation, antihistamines, steroids, and/or chemotherapeutic agents. The AR group found 93% to be vitamin D deficient and 56% of the same group showed to be severely deficient in vitamin D levels[22].

3.3.3 Vitamin D levels in Inflammatory bowel disease (IBD)

Vitamin D levels were assessed in patients with inflammatory bowel disease (ulcerative colitis (UC) and/or Crohn's disease (CD)). Two different studies in Duhok and Erbil compared vitamin D levels between control groups and patients with IBD. In Duhok, samples were collected between the months of February and May of 2018, whereas in Erbil sample collection was with a period of a year between July 2021 and July 2022. A total of 82.4% of patients in Duhok had vitamin D deficiency and it is important to note that not a single sample had vitamin D sufficient levels, i.e; the remaining were insufficient. In Erbil, 50% of the patients had deficient vitamin D levels; 44.8% deficient with UC and 87.5% deficient with CD[26,27] .

3.4. Vitamin D levels in Women; pregnant, infertile and menopausal

3.3.3.1 Baghdad

Literature on similar focus/target groups on pregnant and/or infertile women and vitamin D levels was less common. None the less, studies based on association between vitamin D levels and unexplained infertility was done in Baghdad in healthy women of child bearing age between 15 – 43 years old who were unable to conceive despite having an active sexual lifestyle and were deemed otherwise healthy due to exclusion of any smokers, or individuals who had endometriosis, ovarian lumps, hyperprolactinemia and hypogonadism. In addition, the sperm of their partners were also analyzed and findings were normal. Samples were collected during April 2019 – April 2020, a total of 60 cases were collected and 50% were found have Vitamin D deficient levels compared to 23% deficiency in the control group[23].

3.4.2 Basrah and Sulaymaniyah

Vitamin D levels were assessed in pregnant women in the cities of Basrah and Sulaymaniyah. Both studies had similar inclusion of women being pregnant within their 1st and 2nd trimester and not taking any vitamin D supplements with an age of no more than 40 in Sulaymaniyah and no more than 35 in Basrah. Vitamin D deficiency was found in 45.1 % and 71.3% of the cases in Basrah and Sulaymaniyah respectively[24,25]. Another study in Basrah, measured vitamin D levels in menopausal women aging between 46 – 65 years old. A total amount of 200 samples were collected in a year from the months of September 2019 to September 2020. A large percentage of 83% of menopausal women were found to have vitamin D deficiency. Generally, vitamin D deficiency have been shown to be associated with infertility, however clinical trials are very limited in humans[28].

4. Discussion

Vitamin D deficiency has been found in not only individuals who seem otherwise healthy but also in patients with more chronic and/or severe diseases. The lack of vitamin D may lead to more severe complications. Several studies in various cities in Iraq have correlated the low levels of vitamin D with different chronic diseases.

In comparison of studies that have been conducted within the general population of a city, deficiency levels significantly vary between the capital city, Baghdad with approximately 86.6% deficient compared to Duhok and Basrah with 44.9% and 39% respectively[9,11,29]. However, the majority of

Table 2. Overview of studies in different cities in Iraq and association with different diseases highlighting Prevalence of Vitamin D deficiency Published between 2019- 2024

City/ time of sample collection	Sample Size	Inclusion criteria	Method Used	Central measure (ng/ml)	Prevalence %	Reference
Duhok and Zaxo Jan. – Sept 2019	1143	General population	ELISA	N/A	Duhok 44.9% Zaxo 38.19%	(9)
Duhok Dec. 2019 – Mar. 2020	391 (172 M + 219 F)	Healthy individuals Age 18-70	ELISA	M 23.9 ±16.41 F 21.24 ± 15.65	M 58% F 53%	(10)
Baghdad	300 (150 M + 150 F)	Healthy individuals Age 18-80	FINECARE	N/A	M 84% F 89.33%	(11)
Basrah	252 (48 M + 204 F)	General population	ECL	N/A	39% entire sample M 17% F 45%	(12)
Mosul Feb. – May 2019	1072	Primary school children Age 6-12	ELFA	12.3 ± 8.2	59.7%	(13)
Duhok Feb. 15 2016 – Aug. 15 2016	100 (50 case + 50 control)	T1DM Age 5-15 years	Atomic absorption spectro-photometry	Case 6.068 ± 2.45 Control 21.1 ± 9.23	90% case 12% control	(14)
Duhok June 2017 - June 2018	100 (50 case + 50 control)	Severe Acute LRTI Less than 5 years old	Radio - immunoassay kit	Case 32.8 ± 27.38 Control 48.23 ± 59.1	14% overall (case + control)	(15)
Misan July – Dec. 2019	190 (35ID + 60IDA + 95 control)	ID IDA Toddlers and infants	ELFA	ID 14.8 ± 4.5 IDA 11.5 ± 2.7 Control 34.1 ± 5.5	60% ID 70% IDA Control 30.5%	(16)
Duhok	310 (155 case	T2DM	ELISA	N/A	71% case 40.6%	(17)

Feb. – July 2018	+ 155 control)	Only taking oral antidiabetic agents or on diet > 25 years old			control	
Baghdad Dec. 2022 – Mar. 2023	297 (257 case + 40 control)	T2DM Age 26 – 80	Afias kit	Case 35.37 ± 0.83 Control 36.12 ± 2.13	34.6% (from these 96.8% uncontrolled glycemia)	(18)
Baghdad October 2018 – June 2019	200 (100 case + 100 control)	T2DM	ELISA	Case 7.373 ± 4.44 Control 14.75 ± 5.87	N/A	(19)
Duhok Sept. 2018 – May 2019	410 (170 case + 240 control)	Smokers Male Age 30 – 60 Normal FBG	ELISA	N/A	Case 25% Control 7.6%	(20)
Baghdad Aug. 2017 – Apr. 2018	61 (35 M + 26F)	Asthma Age 6 -18	ELFA	N/A	37.7% and 6.6% very severely deficient	(21)
Mosul March – October 2018	99 (49 case + 50 control)	Allergic rhinitis Age 18-55	Immunoassay using Dimension® Suite from Siemens	N/A	Case 93% 56% severely deficient Control 34%	(22)
Baghdad April 2019- April 2020	120 (60 case + 60 control)	Unexplained infertility Age 15-43	FIA on i-CHROMA™ AFIAS auto-analyzer	N/A	Case 50 % Control 23%	(23)
Basrah January 1st 2023- June 30th 2023	102	Pregnant Age not greater than 50	FIA	N/A	45.1%	(24)
Sulaymaniyah Dec. 2018 – Feb. 2019	261	Pregnant (no more than 24 weeks) Age not greater than	Roche Cobas e411 immunoassay analyzer	N/A	71.3%	(25)

		40				
Basrah Sept. 2019 – Sept. 2020	200	Menopause Age 46-65	ELISA	N/A	83%	(3)
Duhok Feb. – May 2018	145 (68 case (24M + 44F) + 77 control)	IBD Age > 18	Radio-immuno assay	Case 9 ± 5.72	Case 82.4% Control 23.4% *no case had sufficient Vit. D level Most severe and mild deficient	(26)
Erbil July 2021 – July 2022	146 (58 UC + 8 CD + 80 control)	IBD	ELISA	Case 19.74 ± 8.25 Control 22.74 ± 7.31	Case 50% (UC 44.8% and CD 87.5%) Control 42.5%	(27)

Note: in children deficiency of Vitamin D less than 12 ng/ml

N/A Data not available, M Male, F Female, ELISA Enzyme linked immunosorbent assay, FIA Fluorescence immune assay, ELFA enzyme linked fluorescent assay, ECL electrochemiluminescence, T1DM type 1 diabetes mellitus, T2DM type 2 diabetes mellitus, LRTI Lower respiratory infection, ID iron deficiency, IDA iron deficiency anemia, IBD inflammatory bowel disease, UC ulcerative colitis, CD Crohn's disease.

deficient samples within the desert region of Basrah were those of females, further investigation noted that Vitamin D levels were lower than anticipated and may be due to cultural reasons as majority of females cover up to 90% of their bodies when leaving the house and have limited exposure to the otherwise sunny desert climate. This suggests that while geographic location (such as being in a sunny region) may increase the potential for Vitamin D synthesis, cultural practices that limit skin exposure could counteract this natural benefit. In contrast, in cities like Baghdad compared to Basrah, where cultural practices might allow more skin exposure, higher deficiency levels could reflect other factors (e.g., diet, lifestyle, health issues).

Establishment of numerous conclusions indicating inverse relation between Vitamin D levels and type 2 diabetes and other metabolic syndromes as type one diabetes[30] were observed in the cities of Duhok and Baghdad. In Duhok, 90% of children with T1DM and 71% of adults with T2DM had deficient levels of vitamin D[14,17]. These results were found to be consistent with a previous study that was conducted in Erbil to measure vitamin D levels of children with T1DM, results concluded a significant difference between the 62% VDD cases vs 38% VDD controls group[31]. However, 2 similar studies in Baghdad measured vitamin D levels in adult patients with T2DM, but their results were not similar to one another.[18] found only 34.6% of individual's with T2DM suffered from deficient vitamin D levels, these findings were not consistent with those of[19] who found abnormally low vitamin D levels with a mean of only (7.373 ± 4.44). A number of factors can be considered as why these numbers were not consistent with each other or with previous studies. Abu-Shana, collected samples between the months of December to March, this period is considered winter and sunlight exposure is less compared to summer months, in addition there

was no exclusion criteria thus the assumption was thought that sample cases could have been on vitamin D supplementation leading to higher vitamin D levels than anticipated (Abu-Shana et al., 2024). Variability of results and purposed literature may be assumed to be due to a number of factors, further analysis of data and interpretation leads too; a lack of stringent exclusion criteria which can introduce bias within individual studies these could be; variation in exposure to sunlight (whether geographically located, season of sample collection and everyday lifestyle), dietary habits and cultural practices.

Sources of vitamin D in addition to sunlight can be found in daily foods that are consumed on a daily basis. Patients suffering from intestinal bowel disease (IBD) are known for their lack of vitamin D levels this could be due to multiple reasons; dietary restrictions and impaired absorption of nutrients within the intestine[32]. Correlation of low vitamin D levels and IBD was found by both[26,27]. In fact, the study in Duhok found that a vast 82.4% of patients were vitamin D deficient and no patient had sufficient vitamin D level greater than 30ng/ml. These results coincide with the assumption that impaired nutrient absorption with patients suffering from IBD lead to exacerbating deficiency of vitamin D.

5. Conclusion

Maintenance of adequate Vitamin D levels are important not only to prevent osteomalacia and rickets but also has been found to have inverse relation with a large number of diseases as; diabetes mellitus, inflammatory bowel disease, allergic rhinitis, iron deficiency, etc. This inverse relation has been thought to increase the severity of disease or may lead to more complications. Whether low levels of vitamin D results from a chronic disease or itself represents a factor of the cause of the disease still remains unclear.

Although Iraq is considered to be in the middle east, there was no significant difference between the various studies conducted throughout the different cities of the country and confirmed that low levels of vitamin D is a global pandemic independent on the climate of where an individual might live. Public health strategies could focus on raising awareness about the importance of sunlight exposure for vitamin D synthesis, particularly for women in areas like Basrah. Educational campaigns could be tailored to address cultural practices and provide alternative ways to ensure adequate vitamin D intake, such as through fortified foods or supplements.

Furthermore, for future studies it is important to exclude samples on vitamin D supplements or any other form of multivitamin supplementation to have more clear precise results for comparison. In addition, further studies should be taken into place to determine whether the sunny summer climate has significant effect on vitamin D levels compared to winter months within the same city. Overall vitamin D levels should be continuously monitored independent on age and/or gender and may have detrimental effects if not sufficiently increased.

Given the variability in deficiency levels across regions, further research is needed to understand the combined effect of cultural, environmental, and lifestyle factors on vitamin D status. Additionally, considering other variables such as diet and socioeconomic status would offer a more comprehensive understanding.

Finally, public health efforts should also focus on high-risk groups as those with IBD and DM, and show awareness on importance of sufficient vitamin D levels and advocate for sufficient sun exposure, appropriate supplementation and dietary adjustments to improve vitamin D status and potentially mitigate related health conditions. □

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