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Vitamin Deficiency Among the Elderly Institutionalized Patients

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Abstract

Objectives: Deficiency in vitamin D (Vit D) is usually associated with elderly patients. This chapter investigates its prevalence amongst the elderly in long-term care in Qatar.

Methodology: The research material included patient chart reviews, electronic data and other evidence-based research papers collated between April 2010 and April 2012. Geriatric patients 65 years and above in healthcare facilities in Qatar were considered as the sample group in this study; its results were analysed and compared, in order of diagnosed Vit D deficiency severity.

Results: The total number of patients studied was 889; 66% were female and 34% male, with an average age of 75 ± 8.7 years. The Vit D serum level mean baseline utilized was 24.4 ± 13.5 ng/ml; 72% of patients had Vit D deficiency with 31 and 30% being mildly and moderately deficient, respectively, while approximately 11% were severely deficient. A positive link was identified between HDL-C and Vit D levels $r < 0.17$, $P < 0.001$; however, HbA1c levels showed a negative link with Vit D $r < 0.15$, $P < 0.009$.

Conclusions: Vit D deficiency was found to be substantially high (72%) among the elderly in Qatar. This low level of Vit D was associated with higher HbA1c and lower HDL-C levels.

Keywords: elderly, institutionalized patients, geriatrics, vitamin D deficiency, comorbidities

1. Introduction

Vitamin D (Vit D) plays an important role in normal physiological function and is essential for bone mineralization [1]. Recently, Vit D deficiency is under consideration due to the fact that it has been associated with cardiovascular disorders, malignancy, fractures and deaths [2–4]. Vit D deficiency represents an important public health concern which is commonly observed worldwide [5–7]. Vit D deficiency remains an underrecognized problem in the general populace and is poorly defined in elderly patients. This phenomenon results from reduced capacity of the skin to produce vitamin D, low skin exposure, skin pigmentation, sunscreen use, skin covering clothes and a diet low in fish and dairy products. In the elderly the reduced dermal synthesis of vitamin D is unlikely to be compensated by dietary intake of vitamin D.

In a geriatric population, Vit D deficiency has been associated with poor muscular, physical and cognitive physical performance as well as falls and fractures [8]. In a study of community dwelling persons, performed in the Chianti area in the centre of Italy which has a mild pleasant climate and sunlit rural areas, Vit D deficiency was found to be significantly high. Vitamin D levels (VDL) noticeably lessens with age in both males and females alike, but then the decline starts substantially earlier and is sharper in females starting from the perimenopausal age. In males the decline in vitamin D levels becomes apparent 20 years later starting from their 70s, Vit D deficiency is significantly associated with aging and elderly patients who need hospitalization for longer periods and as a result more susceptible [9, 10].

Advanced age and low exposure to sunlight are the major factors associated with Vit D deficiency. Van der Wielen et al. [11] found that regardless of geographical location, free-living elderly (>70 years) living in 11 European countries are at substantial risk of inadequate Vit D status during winter and spring time and in the oldest and more obese subjects. In fact, 86% of these subjects with multiple risk factors were vitamin D deficient. Several studies have reported Vit D deficiency among different populations from the Middle East [12–15].

A report from Kuwait showed subclinical Vit D deficiency among veiled women [16]. Also, reports from Saudi Arabia demonstrated higher Vit D deficiency in Saudi women. The authors found female gender, sedentary lifestyle and low milk consumption to be independently associated with lower Vit D levels [17].

In a previous study from Qatar, El-Menyar et al. reported a high percentage (91%) of low Vit D level (<30 ng/ml) in adults (mean age: 49 ± 12 years); they also found a strong association between low Vit D and hypertension [14]. Several studies addressed the association between low Vit D and high triglyceride (TG) levels, low levels of high density lipoprotein (HDL-C) and the quality of HDL [18]. Furthermore, the interference of 'Vit D' in cholesterol synthesis and potential synergistic action with statins has been reported [18].

Vit D also plays a role in insulin secretion and therefore is associated with type 2 diabetes mellitus (T2DM). Earlier studies suggested a significantly higher risk of T2DM in Vit D-deficient patients [19, 20]. In contrast, Hidayat et al. [21] observed no significant association between

the incidence of T2DM and Vit D deficiency in an older population. Vit D insufficiency is frequently associated with abnormal bone metabolism including secondary hyperparathyroidism which leads to increase in bone turn over and bone loss particularly cortical bone. Patients with chronic kidney disease (CKD) have an exceptionally high rate of Vit D deficiency that is further exacerbated by their reduced ability to convert 25-(OH) Vit D into the active form: 1,25 dihydroxy-Vit D [22]. There are no studies in the elderly population in the Gulf region. Therefore, the present study was designed to assess the prevalence of Vit D deficiency and the associated risk factors among the geriatric population in Qatar.

2. Patients and methods

2.1. Significance for public health

Low vitamin D levels have been associated with causing a range of chronic conditions. A few studies have evaluated the prevalence of low vitamin D prominence in Middle Eastern countries like Qatar and its possible correlation with other causes of chronic disease.

Information available recognizes the high prevalence of vitamin D deficiency in Qatar and highlights the need to develop a nationwide illustrative study to evaluate further. Subsequently, the study may assist in the development of public health strategies for the prevention of diseases in Qatar.

2.2. Study setting

This study was conducted between April 2010 and April 2012 and involved data collected from elderly patients (65 years). Geriatric patients 65 years and above in healthcare facilities in Qatar were considered as the sample group; serum total 25-hydroxyvitamin D (25(OH) D) levels were measured, individual patient characteristics, treatment plans, treatment and results were analysed and compared in order of diagnosed Vit D deficiency severity. Patients who had not been screened for Vit D levels or who had incomplete data were excluded.

2.3. Measures

A data-extraction tool was developed that built in information relating to demographics, body mass index (BMI, calculated based on height and weight; kg/m²) and blood examinations (full blood count, serum albumin, calcium, phosphorus, comorbidities, medications, and outcome).

An immunoanalyser (Liaison, Diasorin Inc.) was used for the measurement of Vit D. 'It is an automated direct competitive chemiluminescence immunoassay (CLIA) for quantitative determination of total 25-OH Vit D in serum or plasma. The imprecision at 56 and 19 ng/ml as measured by coefficient of variation was 8.7 and 13.2%, respectively [14]'.

The Diazyme's 25(OH) D assay is one of the fast track diagnostic methods with complete testing results in less than 2 hours. 'The test is user-friendly, and can be performed manually or

easily adapted for use on a wide range of fully automated microtiter plate readers, making it suitable for use in laboratories of all sizes and with all manner of testing needs'.

Vit D deficiency was defined as level less than 30 ng/ml which was further subdivided into mild (20–29 ng/ml), moderate (10–19 ng/ml) and severe insufficiency (less than 10 ng/ml) [14, 21]. Patient characteristics and outcomes were analysed and compared according to the severity of Vit D deficiency. Patients after 6 months were re-evaluated for Vit D levels and all-cause mortality.

2.4. Statistical analysis

Where appropriate, data is presented as proportions, medians or mean \pm SD. Wherever applicable the continuous variables were analysed using Student's tests or one-way ANOVA. Also a non-parametric Mann–Whitney test was used for skewed continuous data. Definite variables among groups were compared using the chi-square test; estimating the associations between Vit D deficiency and demographic and clinical index. Age and its correlation with HDL-C, HbA1c and Vitamin D levels was also studied using Pearson's correlation method.

A two adjusted $P < 0.05$ was considered significant. All data investigation was carried out using the Statistical Package for Social Sciences version 18 (SPSS Inc., USA).

3. Results

The total number of patients studied was 889; 66% were female of which 77% were Qataris and 34% male, with the mean age of between 75 ± 8.7 years. The upper range of age limit among the study group was 107 years old male (see **Tables 1–3** below for results). Sixty per cent of the patients were recruited from Home Healthcare Services (HHS) followed by the out-patient (31.8%) and in-patient (7.2%) departments. Findings identified in terms of percentages were included; 24.4% had stroke (cerebrovascular accident) and 23.65% had coronary artery disease, respectively, 26.25% had dementia, 76.5% had hypertension, 63.2 % had type 2 diabetes and 47.5% dyslipidemia (see **Table 1**).

The Vit D serum level mean baseline utilized was, 24.4 ± 13.5 ng/ml; 72% of patients had Vit D deficiency with 31.4 and 29.6% being mildly and moderately deficient, respectively, while 10.8% were severely deficient (see **Table 1**).

As a result, 33.5% of patients were prescribed oral supplementation of Vit D. When tested at the follow-up 6 months later, Vit D levels available in 325 of these patients had increased to 28.5 ± 13.4 ($P < 0.001$).

Table 2 discusses the rate of recurrence and association of sociodemographic and clinical variables due to Vit D levels.

Vit D deficiency was common in females than males, mildly affected patients female to male percentage was 70.3 vs. 29.7%, moderate 68.5 vs. 31.5% and severe 70 vs. 30%, $P < 0.91$; though, this was not significant. Patients admitted to HHS had notably more Vit D deficiency than other admitting services; mildly affected patients female to male percentage was 54.2 vs. 45.8%, moderate 68.0 vs. 32% and severe 87.5 vs. 15%, $P < 0.001$.

Age (years)*	74.9 ± 8.7	Overall vitamin D levels*	24.4 ± 13.5
Female	589 (66.3%)	Optimal	175 (28.2%)
Unit		Mild deficiency	195 (31.4%)
Home care	421 (59.3%)	Moderate deficiency	184 (29.6%)
Out patient	283 (31.8%)	Severe deficiency	67 (10.8%)
In-patient	64 (7.2%)	Medication	
Nationality		Multi vitamin	147 (16.5%)
Qatari	655 (76.6%)	Proton pump inhibitors	304 (34.2%)
Non-Qatari	200 (23.4%)	Vitamin D 50000 IU (orally)	298 (33.5%)
Marital status		Calcium supplement	79 (8.9%)
Married	473 (60.1%)	Combined fosamax + Vit D	7 (0.8%)
Non-married	314 (39.9%)	Calcium + vitamin D	2 (0.2%)
Diagnosis		Baseline	
Hypertension	680 (76.5%)	Vitamin-D (ng/ml)*	24.4 ± 13.5
Diabetes mellitus (Type II)	562 (63.2%)	Calcium (mmol/L)*	2.3 ± 0.14
Dyslipidaemia	422 (47.5%)	Phosphorus (mmol/L)*	1.17 ± 0.29
Cerebrovascular accident	217 (24.4%)	Parathyroid hormone (pmol/L)**	65 (4-625)
Dementia	233 (26.2%)	Follow-up	
Coronary artery disease	210 (23.6%)	Vitamin-D (ng/ml)*	28.5 ± 13.4
Hypothyroidism	110 (12.4%)	Calcium (mmol/L)*	2.28 ± 0.2
Heart failure	37 (4.2%)	Phosphorus (mmol/L)*	1.19 ± 0.3
Renal dysfunction	99 (11.1%)	Parathyroid hormone (pmol/L)**	85 (4-848)
Fracture	32 (3.6%)	Mortality	11 (1.2%)
Traumatic injury	21 (2.4%)		
Aspiration pneumonia	24 (2.7%)		
Urinary tract infection	12 (1.3%)		

*Mean ± SD.

**Median (range).

Table 1. Demographics, clinical presentation and outcome in geriatric patients ($n = 889$).

	Vitamin D deficiency				<i>P</i>
	Optimal VDL (<i>n</i> = 175)	Mild (<i>n</i> = 195)	Moderate (<i>n</i> = 184)	Severe (<i>n</i> = 67)	
Gender					
Female	126 (72.0%)	137 (70.3%)	126 (68.5%)	47 (70%)	0.912
Male	49 (28%)	58 (29.7%)	58 (31.5%)	20 (30%)	
Unit					
HHS	66 (42.0%)	91 (54.2%)	102 (68.0%)	49 (87.5%)	0.001
Out patient	67 (42.7%)	55 (32.7%)	34 (22.7%)	5 (9.4%)	
In-patient	24 (15.3%)	22 (13.1%)	14 (9.3%)	2 (3.6%)	
Nationality					
Qatari	135 (79.4%)	146 (77.2%)	133 (75.6%)	49 (76.6%)	0.354
Non-qatari	35 (20.6%)	43 (22.8%)	43 (24.4%)	15 (23.4%)	
Marital status					
Married	104 (69.8%)	88 (52.0%)	89 (54.0%)	28 (43.8%)	0.008
Non-married	45 (30.2%)	81 (48.0%)	76 (46.0%)	36 (56.2%)	
Diagnosis (on-admission)					
Diabetes mellitus	107 (61.1%)	128 (65.6%)	124 (67.4%)	46 (68.7%)	0.566
Hypertension	135 (77.1%)	159 (81.5%)	148 (80.4%)	47 (70.1%)	0.217
Dementia	43 (24.6%)	60 (30.8%)	44 (23.9%)	16 (23.9%)	0.388
Coronary artery disease	37 (21.1%)	36 (18.6%)	49 (26.6%)	22 (32.8%)	0.055
Heart failure	7 (4.0%)	7 (3.6%)	11 (6.0%)	3 (4.5%)	0.703
Dyslipidaemia	85 (48.6%)	97 (49.7%)	95 (51.6%)	31 (46.3%)	0.879
Renal dysfunction	24 (13.7%)	15 (2.4%)	31 (5%)	10 (1.6%)	0.055
Cerebrovascular accident	46 (26.3%)	50 (25.6%)	47 (25.5%)	18 (26.9%)	0.996
Hypothyroidism	26 (14.9%)	33 (16.98%)	25 (13.6%)	11 (16.4%)	0.824
Fracture	6 (1%)	5 (7.7%)	9 (16.8%)	5 (14.9%)	0.302
Traumatic	2 (1.1%)	3 (1.5%)	9 (4.9%)	2 (3.0%)	0.100
Social admission	1 (0.6%)	2 (1.0%)	2 (1.1%)	3 (4.5%)	0.101
Aspiration pneumonia	5 (2.9%)	3 (1.5%)	4 (2.2%)	3 (4.5%)	0.565
Urinary tract infection	1 (0.6%)	4 (2.1%)	4 (2.2%)	0 (0.0%)	0.376

	Vitamin D deficiency				<i>P</i>
	Optimal VDL (<i>n</i> = 175)	Mild (<i>n</i> = 195)	Moderate (<i>n</i> = 184)	Severe (<i>n</i> = 67)	
Infected bedsores	1 (0.6%)	2 (1.0%)	2 (1.1%)	2 (3.0%)	0.461
Medication					
Multi vitamins	34 (19.4%)	41 (21.0%)	25 (13.6%)	15 (22.4%)	0.209
Proton pump inhibitors	52 (29.7%)	79 (40.5%)	76 (41.3%)	34 (50.7%)	0.038
Vitamin D 50,000 IU (Orally)	65 (37.1%)	81 (41.5%)	96 (52.2%)	39 (58.2%)	0.003
Calcium supplement	22 (12.6%)	21 (10.8%)	19 (10.3%)	8 (11.9%)	0.910
Fosamax + vitamin D	1 (0.6%)	1 (0.5%)	1 (0.5%)	0 (0%)	0.946
Calcium + vitamin D	0 (0%)	1 (0.5%)	0 (0%)	1 (1.5%)	0.237
Mortality	2 (1.1%)	1 (0.5%)	1 (0.5%)	0 (0%)	0.755

HHS: Home Healthcare Services.

Table 2. Comparison of qualitative variables according to vitamin D levels (VDL).

Further it was found that married patients had a considerably higher number of ideal Vit D levels. On admission, diagnoses were compared according to Vit D levels. Proton pump inhibitors $P < 0.038$ and oral Vit D supplementation $P < 0.003$ were prescribed and administered more in Vit D-deficient patients (see **Table 2**).

The mean blood glucose level was noticeably higher in the severe Vit D-deficient group compared to the ideal group 9.5 ± 5 vs. 7.2 ± 3.2 ng/ml, $P < 0.005$. The mean age was compared between the different Vit D-deficient groups, $P < 0.462$ (see **Table 3**).

In patients with T2DM and an estimated glomerular filtration rate (eGFR) ≥ 30 ml/min/1.73 m², the mean eGFR was 55.3 ± 8.5 ml/min/1.73 m². Note that 55 (19.9%) of those had kidney disease outcomes quality initiative CKD stage 1 disease (eGFR ≥ 90 ml/min/1.73 m²), 142 (51.4%) had stage 2 disease (eGFR 60–89 ml/min/1.73 m²) and 79 (28.6%) had stage 3 disease (eGFR 30–59 ml/min/1.73 m²). There was no considerable link between eGFR in type 2 DM and Vit D levels ($P = 0.43$). No correlation analysis was conducted between Vit D levels and eGFR in nondiabetic patients as the study population was negligible.

Figures 1 and **2** refer to the connection between Vit D deficiency and HDL-C and HbA1c. There was a positive link noted however between HDL-C and Vit D levels ($r = 0.173$, $P = 0.001$), whereas HbA1c levels indicated a negative association with Vit D levels ($r = 0.152$, $P = 0.009$).

Baseline	Vitamin D deficiency				P
	Optimal VDL (n = 175)	Mild (n = 195)	Moderate (n = 184)	Severe (n = 67)	
Age (years)	74 ± 8.4	75.3 ± 8.3	74.8 ± 7.6	75.5 ± 9.8	0.462
Body mass index	24.7 ± 5.7	23.1 ± 5.2	26.7 ± 6.5	27.2 ± 7.4	0.263
Vitamin D (ng/ml)	41.2 ± 11.5	24.6 ± 2.9	14.9 ± 2.9	6.5 ± 1.9	0.001
Calcium (mmol/L)	2.3 ± 0.14	2.28 ± 0.12	2.29 ± 0.15	2.26 ± 0.13	0.307
Cholesterol (mmol/L)	4.3 ± 0.9	4.4 ± 0.96	4.5 ± 1.2	4.5 ± 1	0.464
Triglycerides (mmol/L)	1.28 ± 0.65	1.38 ± 1.1	1.45 ± 0.7	1.53 ± 0.9	0.304
TSH (mIU/L)	2.2 ± 1.6	3.9 ± 8.9	3.8 ± 10.2	7.1 ± 17.8	0.081
ALP (IU/L)	82.4 ± 45.1	89.6 ± 57.8	99.3 ± 63.4	105 ± 84	0.049
Glucose (mmol/L)	7.2 ± 3.2	7.7 ± 3.7	8.2 ± 5.1	9.5 ± 5	0.005
HbA _{1c} (%)	7.05 ± 1.5	7.3 ± 1.4	7.2 ± 1.8	8 ± 1.9	0.034
LDL (mmol/L)	2.5 ± 0.73	2.6 ± 0.8	2.7 ± 1	2.8 ± 0.8	0.133
eGFR (ml/minute)	55.3 ± 8.5	47.9 ± 18.1	56.1 ± 6.7	50 ± 17.3	0.432
T4 (ng/L)	18 ± 17.5	16 ± 6.8	13.6 ± 2	12.9 ± 2.8	0.381
Phosphorus (mmol/L)	1.17 ± 0.2	1.2 ± 0.4	1.15 ± 0.3	1.05 ± 0.27	0.118
Parathormone (pmol/L)	96.8 ± 124.3	108.5 ± 105.3	161 ± 164	130.2 ± 104.7	0.212
Haemoglobin (g/dl)	12.1 ± 1.6	12 ± 1.8	12.1 ± 1.9	12.07 ± 1.7	0.959
HDL-C (mmol/L)	1.4 ± 0.9	1.3 ± 0.3	1.2 ± 0.4	1.1 ± 0.4	0.040
Ejection fraction (%)	51.9 ± 11.4	54.4 ± 5.5	53.4 ± 9.6	52.8 ± 8.2	0.916
Albumin (mmol/L)	38.4 ± 6.1	38.5 ± 4.5	38.2 ± 9.9	36.7 ± 5.2	0.344
Follow-up					
Vitamin D (2) (ng/ml)	38.2 ± 15.9	26.9 ± 9.4	25.6 ± 11.5	22.3 ± 13.8	0.001
Parathyroid hormone (pmol/L)	104 ± 81.8	122.2 ± 111.4	154.2 ± 171.9	151.7 ± 185.9	0.807
Calcium (mmol/L)	2.28 ± 0.13	2.32 ± 0.37	2.25 ± 0.15	2.27 ± 0.12	0.516
Phosphorus (mmol/L)	1.1 ± 0.25	1.2 ± 0.29	1.2 ± 0.23	1.2 ± 0.26	0.693
TSH: Thyroid stimulating hormone; ALP: Alkaline Phosphatase; LDL-C: low density lipoprotein cholesterol; HDL-C: High Density lipoprotein cholesterol; all variable are expressed as mean ± standard deviation; T4: Thyroxin; eGFR: estimated glomerular filtration rate.					

Table 3. Comparison of quantitative variables according to vitamin D levels (VDL).

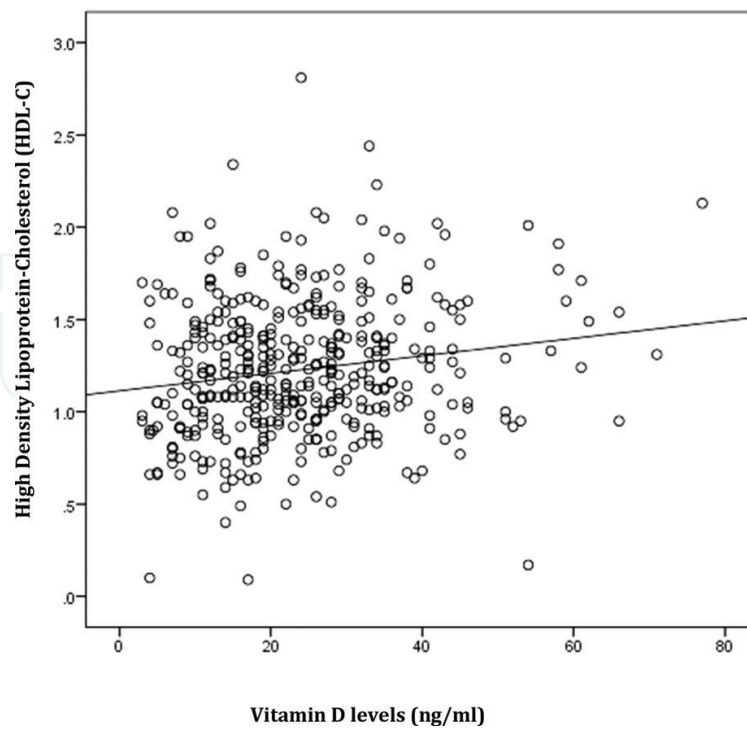


Figure 1. Correlation between HDL-C and vitamin D levels in geriatric patients.

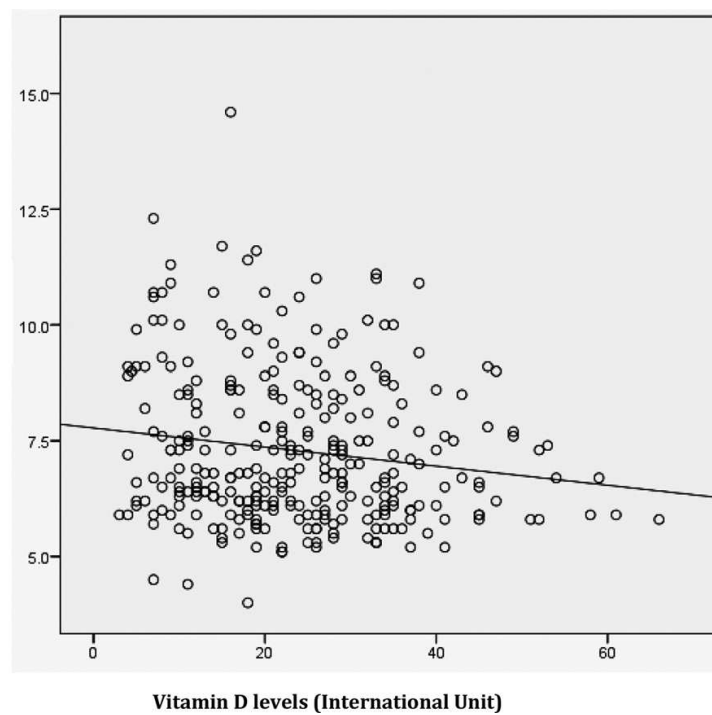


Figure 2. Correlation between type 2 DM patients HbA_{1c} and vitamin D levels in geriatric patients.

4. Discussion

It has been suggested that, lifestyle and socio-cultural practices may be related to the high Vit D deficiency reported among the young recently in Qatar [25]. However, the relationship between Vit D deficiency and its impact on the health of the elderly is still lacking.

Unfortunately, there are no accurate figures for the confident determination of vitamin D deficiency in Qatar due to the geographical and/or demographical nature of studies conducted [41].

However, centred on data gathered from a review of the system, about 90% of the Qatari population may be deficient in serum levels of the vitamin. This exclusive study from the region tries to address the impact of age, diabetic status and dyslipidaemia on Vit D deficiency among the geriatric population.

This study found the existence of an extraordinary large number of Vit D deficiency (71.8%) among the elderly in Qatar, which may be attributed to their limited exposure to sunlight as they age, generally due to the inactive lifestyle, clothing, extreme summers and minimal outdoor activity that characterises life in Qatar. A similar study in Indonesia found that 78.2% Vit D deficiency was present amongst its elderly population [21].

What is more, with increasing age the capacity of the skin to produce Vit D on sunlight exposure also decreases [23]. Likewise, advanced age reduces Vit D (1,25(OH)₂D) production by the kidneys [24]. Accordingly, physiological changes and climate conditions together with advanced age influence Vit D metabolism among the elderly [25]. In the elderly, Vit D deficiency is associated with an increased risk of falls, osteoporosis and fractures [26]. At present, investigation of plasma 25(OH)D is considered as a reliable marker for Vit D level assessment [27, 28, 43].

In our study, considerably more patients from the home-based run services had a Vit D insufficiency as well as severe Vit D deficiency in comparison to the in- and out-patient departments of hospitals ($P = 0.001$). This corroborates reports from western researchers that found a higher occurrence of Vit D insufficiency among communal living elderly [25]. However, in the U.S., Vit D insufficiency was incidentally lower in the elderly except in those patients who sustained hip fracture [25]. Lund et al. [29] found Vit D deficiency in 25% of hip fracture cases, of which 5% had severe Vit D deficiency. However, the incidence of hip fractures in our study (14.9%) was relatively lower compared with earlier studies [29].

The present study observed severe Vit D deficiency in 70% of elderly females. Even though the Qatar demographics showed that the sex ratio for male:female is 1.7:1. The majority of population assigned for this study is female patients; this was decided up on the willingness of participation. Other possible explanation for this might be due to the higher life expectancy in females [21]. Also, Indonesia reported a higher incidence of Vit D deficiency among its elderly females in comparison to elderly males. This high number of women with Vit D deficiency in the Middle East and Asia may be attributed to socio-cultural practices such as the use of the veil outside in the Sun.

Aging has been associated with T2DM [30]. Moreover, several epidemiological studies have found a negative correlation between T2DM, obesity and Vit D deficiency [31–33]. Mathieu et al. advocated Vit D supplementation for improving glucose tolerance in patients with Vit D deficiency [34]. Further, Hidayat et al. [21] reported that in overweight elderly patients, their high BMI was pointedly associated with an increased Vit D deficiency.

Our findings previously published online [35] confirm these earlier reports on the link between type 2 diabetes (T2DM), body mass index and Vit D deficiency. In this study, markers of T2DM (raised HbA1c and high fasting blood glucose levels) had a negative association with levels of circulating vitamin D3. It was observed that significantly high levels of blood glucose ($P < 0.005$) and HbA1c ($P < 0.03$) were associated with acute Vit D deficiency. Pittas et al. [36] in a double-blind, randomized, controlled trial reported that in healthy adults with impaired fasting blood glucose, supplementation with vitamin D may attenuate increases in glycaemia and insulin resistance that occur over time.

In addition, well documented also has been the association between low Vit D levels and chronic kidney disease (CKD). Previous research has shown that in a large majority of patients with advanced CKD (stage 2), their levels of Vit D have a tendency to be lower than the normal limit, although in patients with advanced CKD (stage 3 and 4), Vit D levels fell significantly [37, 38]. Furthermore, elderly patients (<65 years) are likely to have an increased association of Vit D deficiency and renal dysfunction with lower glomerular filtration rate (GFR) [39].

The present study showed that eGFR was not associated with Vit D levels. Our findings are consistent with an earlier study showing no association between an impaired eGFR and Vit D deficiency ($P < 0.432$) [40]. Fraser et al. [41] explored the role of serum 25(OH)D, parathyroid hormone and calcium in the development of cardiovascular sicknesses. A positive association was identified between HDL-C and 25(OH) D levels; considerably lower HDL-C levels were detected in patients with acute Vit D deficiency, consistent with the findings of Fraser et al. [41]. As a result, HDL-C levels and Vit D deficiency had a substantial opposite relationship, as patients with lower levels of HDL-C had acute Vit D deficiency. LDL-C and triglyceride were less in patients with acute Vit D deficiency in comparison to those with ideal levels [42].

New research has found in recent times that the presence of vitamin D receptors and the vitamin D activating enzyme (1-hydroxylase) in the brain has advised a possible role of vitamin D in cognitive function. It is suggested that the vitamin D receptor and catalytic enzymes are confined to a small area of the brain involved in complex planning, processing and the creation of new memories. These findings in theory link the role of vitamin D to cognitive impairment, depression and also multiple sclerosis. Although, the current findings cannot be supported as dementia is associated with severely low Vit D levels.

Epidemiological research recently has underlined the significance of Vit D and calcium supplementation for communal living, hospitalized and care home elderly. The vitamin D requirements may vary only based on customary calcium intake. The therapeutic potential of vitamin D will not be affected by age and sex difference but may be affected by ethnicity [44, 45].

Taking into consideration the socio-cultural and hereditary factors predominant in the Middle East, the proper controlling of Vit D deficiency together with metabolic disorders should be made an essential part of treatment for the ageing people. Additionally, the eluding of Vit D deficiency among the elderly may possibly be useful for the optimum managing of high-risk metabolic disorders such as diabetes mellitus and dyslipidaemia which in time will improve the care provided for the population.

This study exposed certain limitations, such as the lack of cause-specific mortality data, as well as details of Vit D supplementation. Another limitation was that the influence of seasons and Vit D deficiency was not considered in the analysis; as the study was retrospective in nature. Even though these limitations exist, the large sample size is representative of the geriatric population in the Middle East. Therefore, this study gives an understanding into the occurrence of Vit D deficiency and its attendant issues among the elderly in Qatar.

In conclusion, vitamin D as a nutrient performs several functions, fundamental to the biological system of the human body including the endocrine and metabolic systems. A large occurrence of Vit D deficiency was detected in the elderly. Vit D serum levels were lower, the wrong way round with HbA1c and HDL-C levels. The follow-up indicated a small but major improvement in Vit D levels after Vit D supplements had been administered. For that reason, further research is required to assess whether or not administering Vit D supplements improves low HDL-C levels and/or glycemic control in T2DM.

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