A Retrospective Study of Serum Vitamin D Levels in Veterans

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A medical record review at one VA medical center revealed below-normal vitamin D levels across all ages and ethnicities.

Vitamin D deficiency is commonly associated with bone disease, such as rickets in children and osteomalacia in adults. Recently, however, vitamin D also has been identified as a hormone that is vital for healthy immune functioning.

Over the past 3 decades, changes in societal attitudes toward the adverse effects of sun exposure have reduced our natural production of vitamin D and, subsequently, have decreased our serum levels. For example, we in the United States are likely to stay indoors and enjoy the air conditioning during hot, sunny months. When we do need to be outside for extended periods, we use sunscreen or clothing to protect our skin. Furthermore, we install glass in our buildings and in our cars that is designed to block ultraviolet B (UVB) rays that come from the sun.[1] Even our servicemen and women deployed in the deserts of Iraq and Afghanistan remain completely covered with clothing while outside. We take all these precautions because the same UVB rays that help your skin produce vitamin D also can cause sunburn and increase the risk of skin cancer.[2]

Inactive vitamin D3 (cholecalciferol) is a prohormone produced by the interaction of UVB light and the enzyme 7-dehydrocholesterol, primarily in the basal layer (stratum basale) of the epidermis.[3] This production of inactive vitamin D3 in the skin is the most important source of vitamin D in those whom receive a sufficient amount of sunlight.[4]

Vitamin D is described as a hormone because it acts on vitamin D receptors in many of the body's tissues to activate or suppress the transcription of target genes.[3] In addition to the regulation of calcium and phosphorus metabolism, and bone mineralization, vitamin D plays direct and indirect roles in many biological processes and is able to regulate over 220 genes.[5] Vitamin D is important in normal cell growth, in inhibiting the growth of abnormal cells, and in fighting cancer.[6,7] In one study, vitamin D supplementation also was associated with decreasing the likelihood of contracting influenza in an institutional setting during an epidemic.[8]

Insufficient vitamin D level has been known to contribute to musculoskeletal dysfunction, decreased bone density, and increased incidence of bone fractures.[9] Vitamin D deficiency also has been associated with cognitive impairment.[10] Finally, chronic musculoskeletal pain in various populations has been associated with low serum vitamin D level.[11]

Previous reports indicate that nearly 50% of patients who utilize U.S. VA health care facilities experience nonmalignant chronic pain.[12] In August 2008, the appearance of a noteworthy review article, which described the high incidence of vitamin D deficiency in patients with chronic pain and disability, led to a significant increase in the number of serum 25-hydroxy vitamin D (25[OH]D) levels drawn across all departments at the W.G. (Bill) Hefner VA Medical Center (VAMC) in Salisbury, North Carolina.[11] The purpose of this retrospective medical record review was to obtain a snapshot look at the incidence of abnormal vitamin D levels, which may be affecting our veteran population. We also sought to test for possible associations with certain demographic variables as well as medical conditions treated by Rehabilitation Medicine Service (RMS) providers.

METHODS

Between August 1, 2008, and November 10, 2008, 772 initial serum 25(OH)D levels were drawn and recorded at the W.G. (Bill) Hefner VAMC. Of the 772 drawings, 200 (25.9%) were ordered by RMS providers while the remaining levels (74.1%) were ordered by other medical providers located at the VAMC or at 3 VA satellite clinics in Charlotte,

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Table 1. Characteristics of the sample (n = 400)

Characteristic	n (%)	Mean vitamin D level, ng/mL (SD)
Sex		
Male	353 (88)	25.6 (11.1)
Female	47 (12)	25.5 (15.1)
Ethnicity		
White	259 (65)	27.6 (10.8)
African American	80 (20)	17.3 (8.4)
Other	61 (15)	25.5 (11.6)
Patient status		
RMS	200 (50)	24.6 (11.5)
Non-RMS	200 (50)	26.5 (11.7)
Diagnosis present		
Multiple sclerosis	2 (0.5)	19.1 (9.3)
Diabetes	88 (22)	23.8 (11.4)
Chronic pain	382 (96)	25.5 (11.6)

RMS = Rehabilitation Medicine Service.

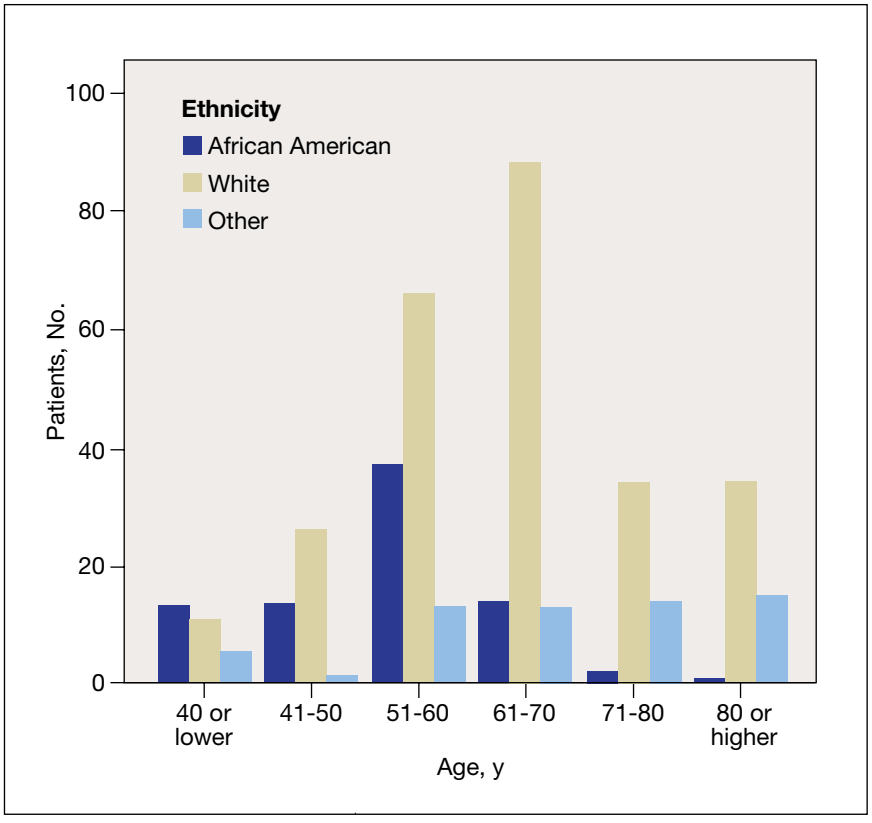

Figure 1. Distribution of ethnicities per age group.

Winston-Salem, and Hickory, all in North Carolina.

This retrospective study examined data from the medical records of the 200 veterans being treated by the RMS and the first 200 of the 572 non-RMS veterans whose vitamin D levels were drawn during the study period. The data from the non-RMS veterans were used to explore whether any trends in the data were specific to the RMS patients. The variables extracted from the patients' records included initial serum vitamin D level; diagnosis of chronic pain; diabetes (either insulin dependent or non-insulin dependent); multiple sclerosis; and demographic data (sex, ethnicity, and age). Because of missing data, ethnicity could not be determined for 58 veterans. For analysis purposes, we combined those 58 veterans with 1 Hispanic, 1 Asian, and 1 Native American into an ethnic group called "other."

The serum 25(OH)D samples were categorized into 3 levels based on reference values determined by Laboratory Corporation of America, where the samples were analyzed. The normal serum 25(OH)D level ranges from 32 ng/mL to 100 ng/mL, an insufficient level ranges from 20 ng/mL to 29 ng/mL, and a deficient level is < 20 ng/mL.[13] The data from the veterans' records were reviewed and recorded by 2 VAMC staff members who were not medical providers. No medical record or serum vitamin D level was excluded during data sampling or analyses.

Statistical analyses were performed using SPSS Statistics Version 19 (IBM Corporation, Armonk, New York). The analyses focused on determining the incidence of normal and abnormal vitamin D levels in this sample of veterans and testing the relationship between vitamin D level and certain medical diagnoses, RMS vs non-RMS

patient status, and demographic characteristics. Descriptive statistics were computed for all of the measured variables and chi-square (χ^2) values (at $P = .05$ significance level) tested for significant relationships.

RESULTS

The veterans in the study were predominantly male and white (Table 1). Incidence of multiple sclerosis and diabetes was low in the sample, but most of the patients had a chronic pain condition. Patients' ages ranged across 7 decades, with an average of 62 years (SD, 14 years).

The age distribution was found to vary among ethnic groups (χ^2 [400, 10] = 64.46, $P < .001$) (Figure 1). The percentage of African Americans in the younger age groups (aged 60 years or less) was greater (79%) than the percentage in the older age groups (21%). Forty percent of the whites were in the younger age groups, while 60% were in the older age groups. In general, the serum 25(OH)D values were skewed toward the low end of the scale, with a median value of 24.5 ng/mL (Figure 2). The mean serum 25(OH)D value for the total sample was 25.55 ng/mL (SD, 11.63 ng/mL). When the patients were categorized based on vitamin D level, 34% were found to be deficient (< 20 ng/mL) and 36% were found to be insufficient (20 ng/mL to 29 ng/mL).

When the vitamin D levels were compared based on RMS or non-RMS patient status, no significant relationship was obtained (χ^2 [400, 2] = 5.08, $P = .08$) (Table 2). A significant relationship was found, however, when vitamin D levels were compared across age ranges (χ^2 [400, 10] = 18.37, $P = .05$) and ethnic groups (χ^2 [400, 4] = 53.78, $P < .001$) (Figures 3 and 4).

There was a higher incidence of below-normal vitamin D levels compared with above-normal levels in all age groups. Where the groups differed, however, was in the relative degree of severity of the vitamin D deficiency. For those aged 51 to 60 years, there was a higher incidence of deficient levels compared with insufficient and normal levels of vitamin D. For the 61- to 70-year-old group, however, there was a higher incidence of insufficient levels compared with the other 2 categories. For the oldest and the 2 youngest age groups, there was a consistency in the number of veterans classified into

Table 2. Vitamin D level by RMS or non-RMS patient status (n = 400)

Vitamin D level	Patient status		Total
	Non-RMS	RMS	
Deficient, No. (%)	58 (14.5)	79 (20)	137 (34)
Insufficient, No. (%)	80 (20)	65 (16)	145 (36)
Normal, No. (%)	62 (15.5)	56 (14)	118 (30)
Total, No. (%)	200 (50)	200 (50)	400 (100)

RMS = Rehabilitation Medicine Service.

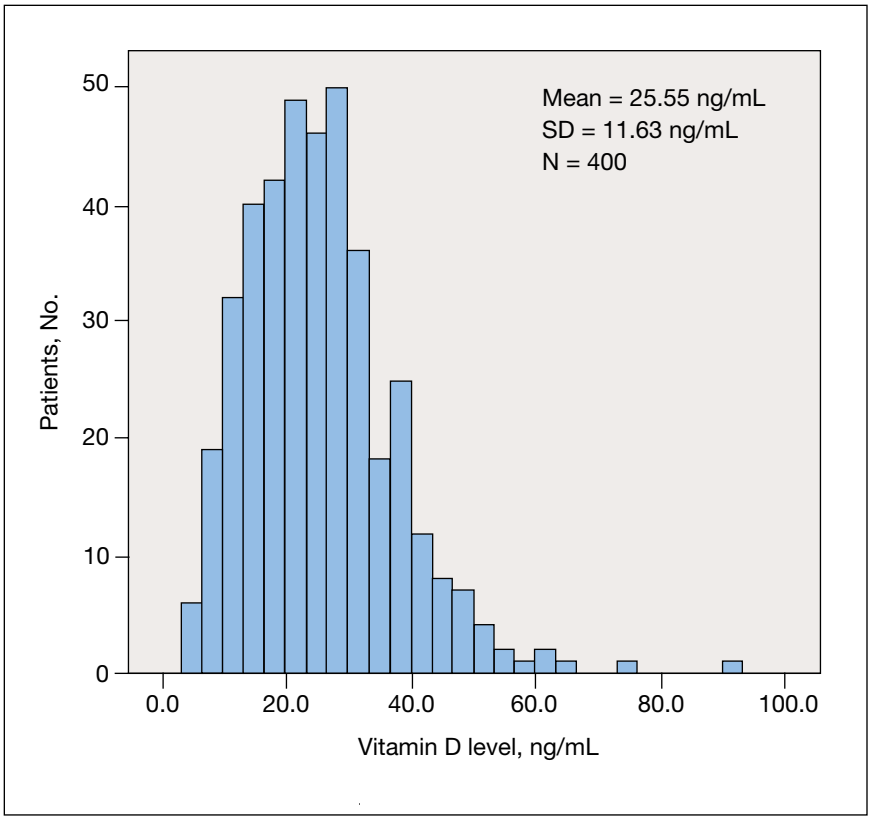

Figure 2. Distribution of serum vitamin D levels in total sample.

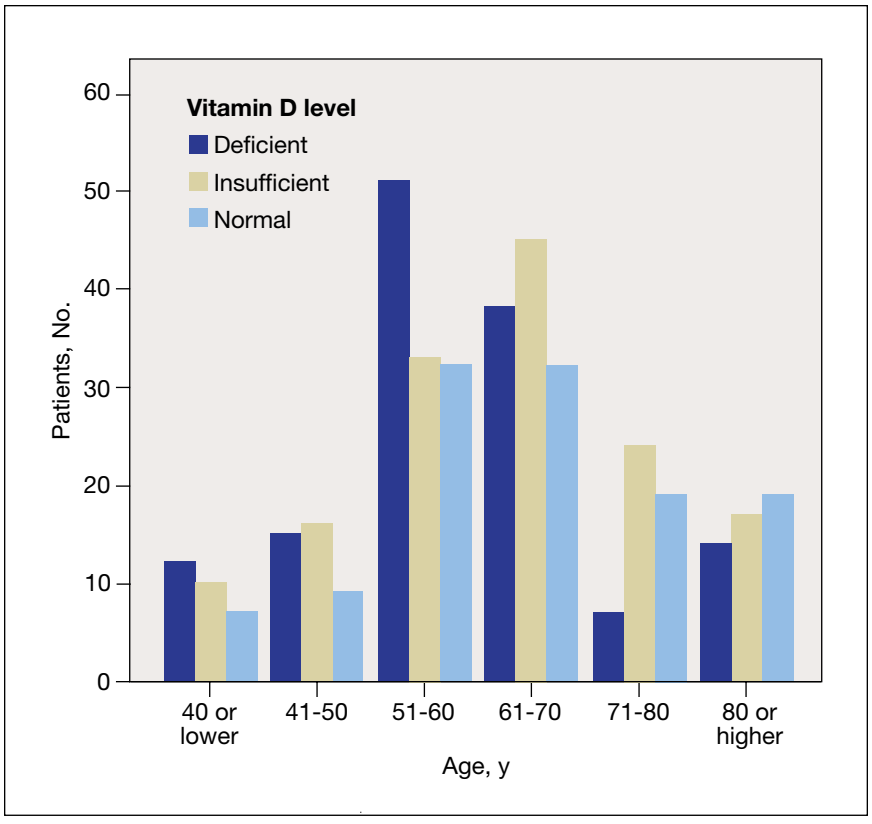

Figure 3. Distribution of vitamin D levels per age group.

each category.

African American veterans had a much higher rate of below-normal vitamin D levels (93%) when compared with whites (65%). Furthermore, in the African American group, most of the patients with below-normal levels were categorized as deficient, while the most prevalent category for the white group was insufficient.

Of the 400 serum 25(OH)D levels collected, 353 were from male veterans and 47 were from female veterans (12%). In the male group, 34% of the patients were categorized as vitamin D deficient and 36% were deemed insufficient. The female group had similar rates: 38% deficient and 36% insufficient. There was no significant relationship between sex and serum vitamin D level ($\chi^2 < 1$).

Diabetes was present in 88 of the 400 veterans in the study. Rates of deficient and insufficient vitamin D levels in veterans with diabetes were 40% and 39%, respectively. For those without diabetes, the rates were 33% and 36%, respectively. The mean serum vitamin D level in veterans with diabetes was 23.8 ng/mL (SD, 11.4 ng/mL), while the mean level in those without diabetes was 26 ng/mL (SD, 11.7 ng/mL). There was no significant relationship between presence of diabetes and vitamin D level (χ^2 [400, 2] = 3.57, P = .17).

Chronic pain was present in most of the patients in the sample, and for those with pain, 32% had a vitamin D level in the deficient range and 36% had a level in the insufficient range. Of the patients with no chronic pain, 44% were categorized as vitamin D deficient and 11% were classified as insufficient. There was no significant relationship between presence of chronic pain and vitamin D level (χ^2 [400, 2] = 5.29, P = .07). However, an odds ratio (OR) calculated from these data indicated that patients were almost 2 times more likely to develop a chronic pain condition when vitamin D levels were insufficient or deficient when compared with patients with normal levels of vitamin D (OR, 1.97).

Serum 25(OH)D levels in veterans who served in Operation Enduring Freedom (OEF) or Operation Iraqi Freedom (OIF) made up only a small portion of the total sample (18/400). Mean serum 25(OH)D levels in the OEF/OIF group was 25.9 ng/mL (SD, 12 ng/mL).

During the period in which data for this study was obtained (August 1, 2008, to November 10, 2008) there was increased awareness of the presence of widespread vitamin D deficiency and insufficiency in the veteran population at the W.G. (Bill) Hefner VAMC. In fact, during the 1-year period from August 1, 2008, to July 31, 2009, the number of 25(OH)D tests ordered by medical providers at this VAMC and its satellite clinics increased by a factor of almost 8 (Figure 5).

DISCUSSION

This review of 400 25(OH)D levels drawn at the W.G. (Bill) Hefner VAMC revealed 3 significant findings. (1) There were substantial rates of insufficient and deficient serum vitamin D levels across all groups examined. (2) A significant relationship was found between vitamin D level and age and ethnic background. Veterans between the ages of 51 and 70 years had the highest rate of below-normal vitamin D levels. When ethnic groups were compared, African Americans

had the highest rate of vitamin D deficiency (68% for African Americans, 23% for whites, and 33% for other ethnicity). (3) Most of the patients in the sample had a chronic pain condition and an OR showed a twofold likelihood of the presence of chronic pain among those with a vitamin D level below normal when compared with patients with a normal level.

Vitamin D level data points analyzed in this study were drawn from approximately mid-summer (August 1, 2008) to mid-fall (November 10, 2008), which represents the time of year when both the storage of vitamin D and serum 25(OH)D levels should be at their highest, based on average UVB exposure from the sun.

The most dramatic finding in this review is the very low serum 25(OH) D levels found in the African American veterans. This finding substantiates the fact that the darker one's skin pigmentation, the more difficult it is to absorb vitamin D from the sun. Increased pigmentation decreases both sun damage to the skin and the rate of production of cholecalciferol (vitamin D).[14]

The African American patients also were a younger group of veterans than the 2 other ethnic groups tested. Very few African American veterans were in the 71- to 80-year-old group (4%), and only 2% were in the group of 80 years and above. The relative lack of older African Americans in the study group may be the result of the shorter average life span of African Americans. Because vitamin D deficiency has been associated with greater risk of many diseases and increased mortality within many disease categories,[5] a greater rate of vitamin D deficiency in the African American group may contribute to greater mortality with advancing age and fewer African Americans in the 71 to 80 and 80+ age groups.

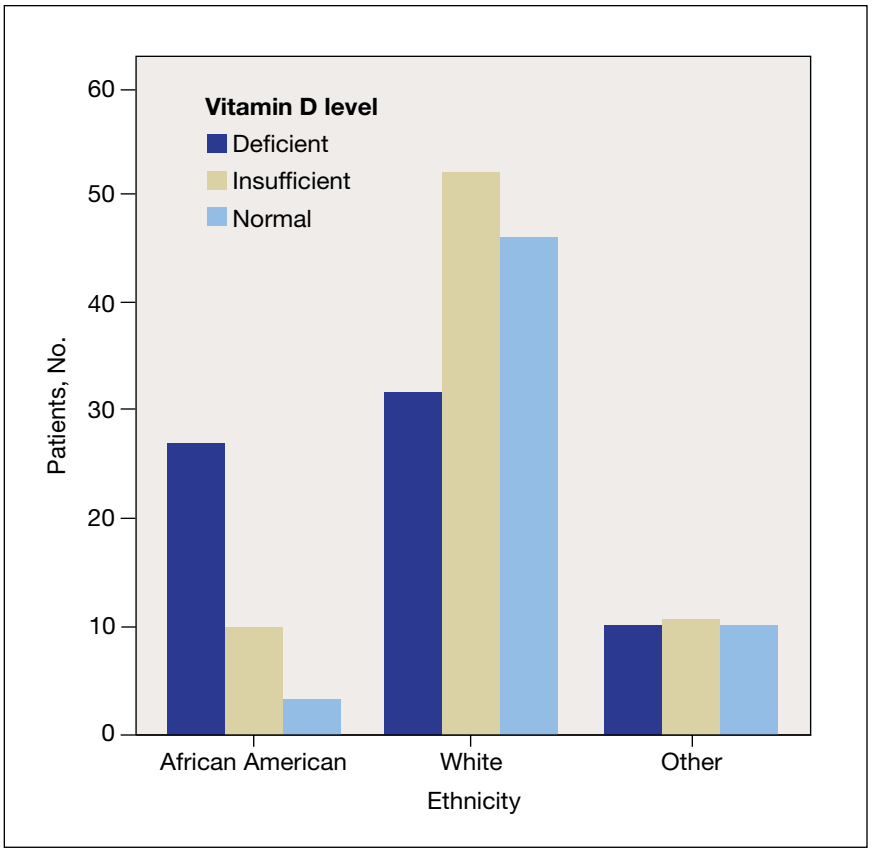

Figure 4. Distribution of vitamin D levels per ethnic group.

Another surprising finding was the variation in rates of deficient and insufficient vitamin D levels with regard to age. Some of the effect may have been, in part, a result of the disproportionately high number of African American veterans in the younger age groups and the low number in the older age groups.

In addition to possible reference laboratory errors, veterans were not screened for oral sources of vitamin D or excessive sun exposure immediately prior to when the serum vitamin D levels were drawn. This lack of prescreening contributed to underestimating the serum vitamin D status of a few veterans. RMS medical providers now have their patients stop all oral vitamin D supplements and avoid excessive sun exposure for 2 days prior to having their serum 25(OH)D levels drawn. Veterans also are instructed to take only water and medications on the morning of the blood test in order to prevent the ingestion of vitamin D-fortified foods. These steps, along with noting the time of year when the serum vitamin D levels are drawn, have helped us to better judge the stored vitamin D status of each veteran and initiate or adjust his/her vitamin D supplementation.

Laboratory Corporation of America changed their normal range for serum 25(OH)D level on March 20, 2006, from the range of 8.9 ng/mL to 46.7 ng/mL to the range of 32 ng/mL to 100 ng/mL.[13] This alteration was

Figure 5. Number of serum vitamin D levels drawn per month between August 1, 2008, and July 31, 2009 (including those that were analyzed between August 1, 2008, and November 10, 2008, in our medical record review), at the W.G. (Bill) Hefner VA Medical Center. *Data points for December 2008 and June 2009 were interpolated based on the months immediately preceding and following.

based on new research, which demonstrated that a level of 32 ng/mL represented the lower threshold for bone health. Normal does not always mean healthy. In our general population, it may be "normal," but certainly not healthy, to have many individuals with an insufficient or deficient serum 25(OH)D level.

During the period in which vitamin D levels were analyzed, August 1, 2008, to November 10, 2008, 4 medical providers in the RMS accounted for 25% of the serum 25(OH)D levels drawn at the W.G. (Bill) Hefner VAMC and its 3 satellite clinics, despite the RMS having a very small percentage of the total physicians. One possible explanation for this disproportionate number was an increasing RMS provider awareness of vitamin D insufficiency and deficiency in patients with chronic pain[11] and the presence of a large number of veterans treated in the RMS Clinic for severe pain issues.[15] Although the percentages of low serum vitamin D levels were similar in the RMS and non-RMS veterans—72% and 69%, respectively—there were more deficient RMS veterans (79/200) than deficient non-RMS veterans (58/200), and mean vitamin D levels were slightly lower in the RMS patients (24.6 ng/mL) than in the non-RMS patients (26.5 ng/mL).

Finally, patients with diabetes had the second highest rates of insufficient and deficient serum 25(OH)D levels (after African Americans): 82% were categorized as insufficient and 43% were considered deficient. Diabetic veterans' mean serum vitamin D level also was the second lowest at 23.8 ng/mL. Further prospective vitamin D studies will be needed to determine the incidence and prevalence of serum 25(OH)D deficiency and insufficiency in the veteran population and to establish the best serum levels needed to return these veterans to optimal vitamin D health.

CONCLUSION

Because low serum vitamin D level has been associated with higher mortality and many other diseases, including hypertension, cardiovascular disease, and cancer, correcting vitamin D deficiency and insufficiency should be a high priority.[5,13] Based on the results of our study, we conclude that U.S. veterans, especially African American veterans, should be screened for possible low serum 25(OH)D level. Those found to have a low level should be treated for this condition in order to reduce vitamin D deficiency-related illnesses, dis-

ability, and morbidity in the veteran population.

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Author disclosures

The authors report no actual or potential conflicts of interest with regard to this article.

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