MILITARY MEDICINE, 177, 1:70, 2012

Vitamin D Testing Patterns Among Six Veterans Medical Centers in the Southeastern United States: Links With Medical Costs

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ABSTRACT Veterans have a profound degree of vitamin D deficiency that may contribute to adverse health outcomes. Some veterans, especially African Americans at high risk of vitamin D deficiency, may not be receiving appropriate attention. We hypothesized variations in vitamin D status and monitoring across six different VAMCs and that these differences are associated with health care costs. A retrospective analysis of the medical data in the Veterans Integrated Service Network 9 (Southeastern United States) was performed, yielding a sample of 15,340 veterans. Monitoring of vitamin D, vitamin D levels, and medical costs and services in all categories varied greatly by site. Memphis tested vitamin D levels less often despite the increased minority presence and high levels of deficiency. Vitamin D deficiency and lack of monitoring predicted increased inpatient health care costs at all sites, but did not fully account for site-cost variations in controlled analyses. Vitamin D deficiency remains a significant problem among veterans in the Southeastern United States and is closely linked to increased health care costs. We recommend protocols that recognize site differences and facilitate testing and monitoring of vitamin D levels, especially in high-risk groups of veterans.

INTRODUCTION

Vitamin D deficiency is a global phenomenon that has become more marked in recent years.[1] It is estimated that this deficiency may promote many chronic ailments including an increase in autoimmune diseases and certain types of cancer.[2] Moreover, recent evidence points to possible survival and longevity benefits with higher vitamin D levels[3] as well as emerging cardiovascular benefits.[4] Consequently, the health care costs of vitamin D deficiency have been estimated in the billions of dollars.[5] In a study of veterans from a single site, health care costs were significantly linked to vitamin D deficiency, although seasonal variation in vitamin D status was not accounted for in that analysis.[6]

Testing and monitoring of vitamin D status to confirm maintenance of a vitamin D replete state in veterans has been suboptimal.[7,8] The lack of clear guidelines for testing and monitoring vitamin D status may contribute to this phenomenon. We hypothesized that there would be a wide variation in monitoring of vitamin D status, as well as in actual vitamin D levels, across different Veterans Medical Centers. Furthermore, we also postulated that the variations in vitamin D monitoring and levels are closely linked to health care costs and service utilization across the Veterans Medical Centers. Thus, the present investigation was undertaken to study the differences in vitamin D testing patterns and their relation to health care costs across the six Southeastern U.S. Veterans Medical Centers in Veterans Integrated Service Network 9 (VISN 9).

METHODS

Participants and Procedures

The study was conducted at a Veterans Administration facility. The Research and Development committee at the VA Medical Center as well as the Institutional Review Board at the affiliated university approved procedures and protocol. Patient data from six VA Medical Centers located in the Southeastern United States in VISN 9 from October 2004 to December 2008 were included. During this period, there were 409,791 individuals seen at the six VA Medical Centers.

Serum 25(OH)D was determined via immunochemiluminometric assay (Labcorp, Burlington, North Carolina). Vitamin D was examined as both a continuous and dichotomous variable with deficiency classified as $25(OH)D < 20$ ng/mL,[9] and all vitamin D values for each patient were recorded along with the month of assessment. For each patient, the initial value and highest value were noted. Additional data extracted included age, gender, body mass index (BMI), number and length of inpatient stays, and number of clinic visits in the 1 year following the vitamin D test. Total costs for each patient in all inpatient and outpatient categories of service over a 1-year period following the vitamin D draw were also recorded. The costs were estimated by the technical guidelines via the Decision Support System and Clinical National Data Extracts standardized by the VA.[10] Latitude was determined by zip codes as tabulated from the VA Planning System Support Group Website.[11]

Patients with an available 25(OH)D and data for all variables of interest were included in the analysis. The initial search produced 15,340 such patients from the Veterans Medical Centers at Huntington, West Virginia; Lexington, Kentucky;

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The contents of this paper do not represent the views of the Department of Veterans Affairs or the U.S. Government.

Louisville, Kentucky; Memphis, Tennessee; Mountain Home, Tennessee; and Tennessee Valley, Tennessee.

Data Analysis

Data were obtained electronically through a database query after removal of personal information, and statistical analyses were performed using SPSS (SPSS, version 14.0; Chicago, Illinois). All variables were checked for outliers and normality of distribution before analyses were performed. Outlying values on vitamin D level were identified and recoded to three standard deviations above the mean for subsequent analysis. Correlations, logistic regressions, t tests, and χ^2 analyses were used to answer the questions of interest. To determine if the cost differences among sites could be explained by vitamin D levels, analyses were run separately for total inpatient costs and outpatient costs, and were controlled for latitude of residence and season of vitamin D draw as they are potentially associated with vitamin D levels.

RESULTS

Background characteristics by VA site are presented in Table I. The average age was greatest in Lexington and least in Tennessee Valley, whereas the BMI was greatest in Tennessee Valley and least in Memphis. The male predominance was most marked in Mountain Home and least in Huntington. Memphis had the highest percentage of non-White veterans, whereas Huntington had the highest percentage of White veterans.

Significant differences among the test sites on all vitamin D variables were found as shown in Figures 1–3. The initial 25(OH)D levels were lowest in Louisville and Lexington, and highest in Huntington and Mountain Home (Fig. 1). The percent of vitamin D deficient patients on initial testing were highest in Louisville and lowest at Mountain Home (Fig. 2). Even the highest average 25(OH)D noted was still indicative of a significant vitamin D deficiency at all sites, especially in Memphis (33.9%) (Fig. 2). Three sites conducted at least one follow-up vitamin D test on at least two-thirds of tested patients, whereas 1 site (Memphis) followed up on less than half (Fig. 3).

Across the six sites, there were also significant differences in cost and service utilization as shown in Figures 4 and 5. The total inpatient and outpatient costs at Mountain Home were notably lower compared to other sites, whereas Lexington and Louisville had the highest costs in both categories (Fig. 4). In fact, total inpatient costs at Mountain Home were 50% or more lower than the same costs in Lexington, Louisville, and Memphis. Mountain Home, in particular, had the lowest percent of patients requiring an inpatient stay, whereas Louisville had the highest (Fig. 5).

Because the ultimate goal of the study was to determine if cost differences across site may be due in part to differences in vitamin D status and monitoring, the next issue examined was whether vitamin D status and monitoring truly were associated with cost and service utilization parameters. Figures 6–9 depict these relationships. Total outpatient costs were significantly higher for those who were vitamin D deficient, compared with those who were not, with costs 20% higher for those who were deficient (Fig. 6). Interestingly, greater levels of monitoring were associated with higher, rather than lower, total outpatient costs (Fig. 6), possibly because those with follow-up testing received this service as part of a primary care or pharmacy visit. Indeed, when the two highest cost outpatient services, primary care and pharmacy, were examined individually, those with two or more follow-up vitamin D tests had the highest costs in both these categories (Fig. 7). Inpatient costs were highest for those who were vitamin D deficient and those who had no follow-up vitamin D testing (Fig. 6). In looking at the two highest inpatient cost categories, laboratory and pharmacy, the same pattern was evident. Costs in these two inpatient categories were twice as high among those who were vitamin D deficient, compared with those who were not. In addition, receiving at least one follow-up vitamin D test was associated with a more than 50% reduction in inpatient laboratory and pharmacy costs, compared with those with no follow-up testing (Fig. 8).

The same pattern of relationships for vitamin D status and monitoring as were seen for costs were also observed for service utilization—specifically number and length of inpatient hospitalizations. As shown in Figure 9, vitamin D deficient patients were more likely than nondeficient patients to have had at least one inpatient hospitalization. Length of hospitalization, when one did occur, was also found to be longer for those who were deficient compared with those who were not

TABLE I. Sample Descriptives by Veterans Medical Center Site

Background Characteristic	Full Sample (N = 15340)	Huntington, West Virginia (1) (n = 299)	Lexington, Kentucky (2) (n = 832)	Louisville, Kentucky (3) (n = 1486)	Memphis, Tennessee (4) (n = 1427)	Tennessee Valley, Tennessee (5) (n = 4358)	Mountain Home, Tennessee (6) (n = 6938)
Age[a]	66.5 (22–107)	67.2	70.9	69.7	67.7	64.6	66.3
BMI[b]	28.8 (11.5–66.2)	28.8	29.0	28.7	27.9	29.1	28.8
Gender (% Male)[c]	93.2	82.2	94.3	93.3	88.8	91.0	96.3
Race (% White)[d]	88.2	97.0	90.4	84.8	64.3	83.9	96.1

[a] $F = 62.4$, $p < 0.001$; all pairwise group differences significant except 1 vs. 4 and 6; 2 vs. 3 (post hoc Tukey HSD at $p < 0.05$). [b] $F = 8.2$, $p < 0.001$; the only significant pairwise group differences were 4 was significantly lower than all other sites except 1 (post hoc Tukey HSD at $p < 0.05$). [c] $\chi^2 = 270.4$, $p < 0.001$; all pairwise group differences significant except 2 vs. 3. [d] $\chi^2 = 1320.7$, $p < 0.001$; all pairwise group differences significant except 1 vs. 6, and 3 vs. 5.

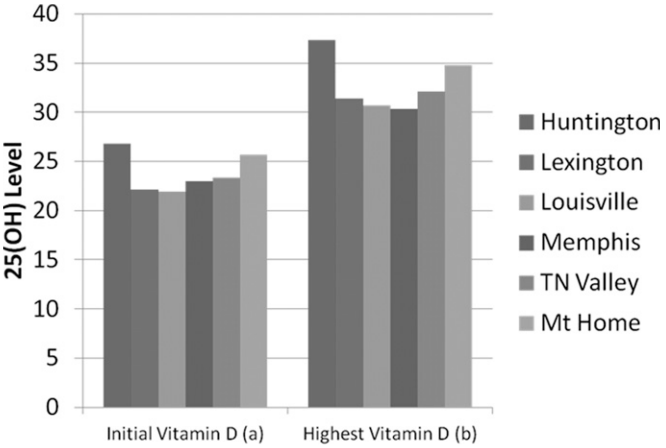

FIGURE 1. Veterans Medical Center site differences in vitamin D levels. (a) Initial Vitamin D. $F = 46.4$, $p < 0.001$; pairwise comparisons revealed that almost all of the sites were significantly different (except Lexington was not significantly different from Louisville, and Memphis was not significantly different from Tennessee Valley). (b) Highest Vitamin D. $F = 43.6$, $p < 0.001$; pairwise comparisons revealed that all of the sites were significantly different (except Louisville was not significantly different from Lexington or Memphis, and Lexington was not significantly different from Tennessee Valley).

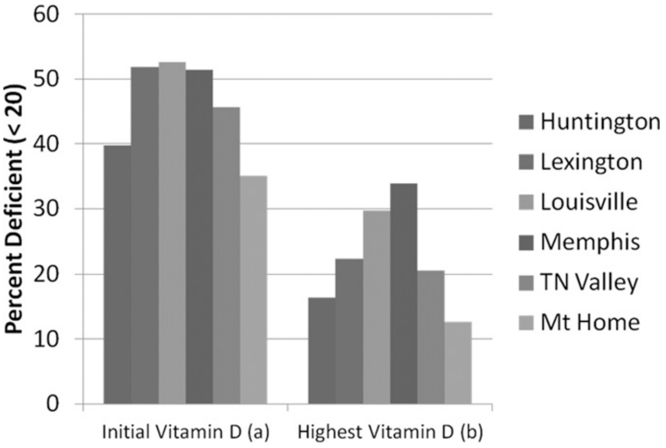

FIGURE 2. Veterans Medical Center site differences in vitamin D deficiency status. (a) Initial Vitamin D. $F = 308.8$, $p < 0.001$; pairwise comparisons revealed that almost all of the sites were significantly different (except Lexington was not significantly different from Louisville or Memphis). (b) Highest Vitamin D. $F = 514.5$, $p < 0.001$; pairwise comparisons revealed that all of the sites were significantly different.

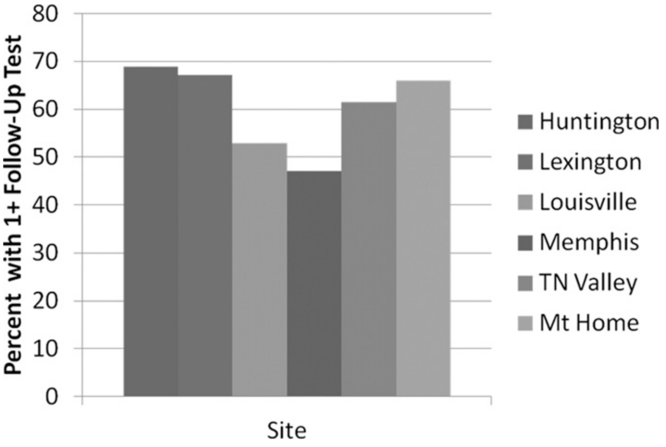

FIGURE 3. Veterans Medical Center site differences in vitamin D monitoring. $F = 227.4$, $p < 0.001$ for average difference between the six sites; pairwise comparisons revealed that almost all of the sites were significantly different (except Huntington, Lexington, and Mountain Home were not significantly different from one another).

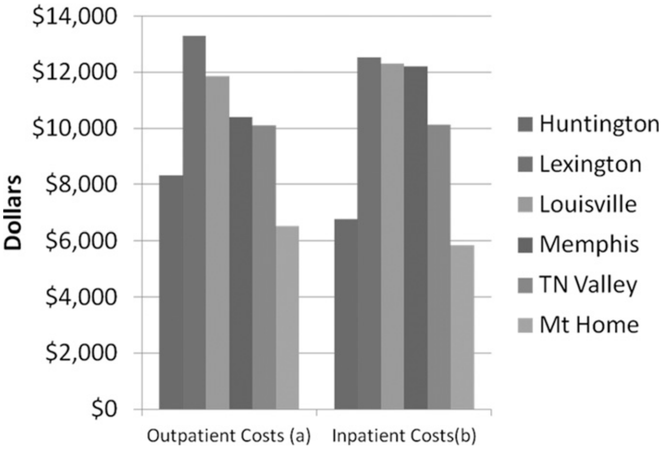

FIGURE 4. Veterans Medical Center site differences in per patient costs. Site averages of total per patient costs. (a) Outpatient Costs. $F = 111.0$, $p < 0.001$; pairwise comparisons revealed that almost all of the sites were significantly different (except Memphis and Tennessee Valley were not significantly different from each other). (b) Inpatient Costs. $F = 22.1$, $p < 0.001$; pairwise comparisons revealed that almost all of the sites were significantly different (except Louisville was not significantly different from either Lexington or Memphis).

deficient (9.0 vs. 7.7 days, $p < 0.05$). As also shown in Figure 9, those with no vitamin D follow-up testing were nearly 30% more likely than those with follow-up testing to have had an inpatient hospitalization. Length of stay was also significantly longer for this group, compared with those who had one, two, or more follow-up tests (9.2, 8.2, and 7.0 days, $p < 0.01$).

Because the largest absolute effect for both vitamin D status and monitoring was on inpatient costs, we examined the joint effect of the two vitamin D variables on total inpatient costs (Fig. 10). As can be seen, while being deficient and having no follow-up testing were both independently associated with higher costs, those who were deficient and had no follow-up testing had costs 70% or more higher than those who were only deficient or only had no follow-up testing, and almost 300% higher than those who were not deficient and had follow-up testing.

The final analyses examined whether vitamin D deficiency status and monitoring could account for the significant cost differences across the six VA sites. Logistic regression analyses were run separately for total inpatient costs and total outpatient costs (Table II). In each case, the analysis was controlled for latitude of residence and season of vitamin D draw. Highest vitamin D level and monitoring status were included, and the final controlled association between site and each of the two cost variables was examined. Although vitamin D

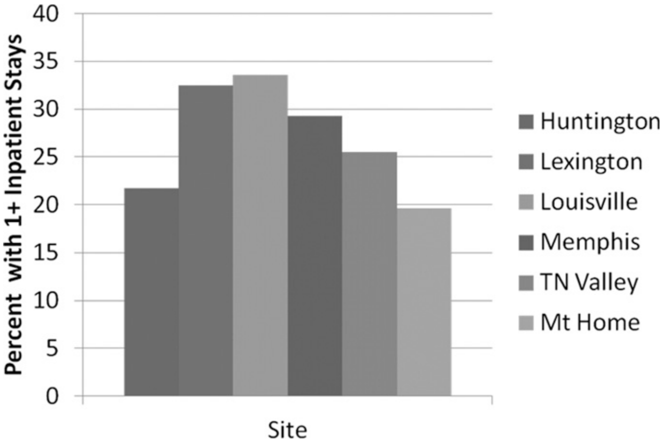

FIGURE 5. Veterans Medical Center site differences in inpatient stays. $F = 209.5$, $p < 0.001$ for average difference between the six sites; pairwise comparisons revealed that almost all of the sites were significantly different (except Huntington and Lexington were not significantly different from one another).

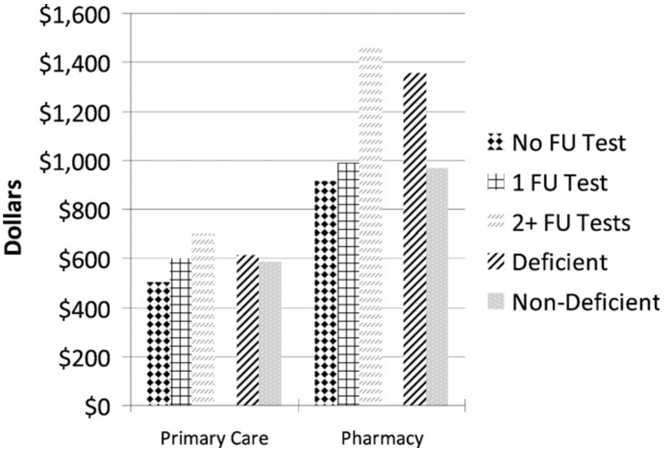

FIGURE 7. Specific outpatient per patient medical cost differences by vitamin D monitoring and status. Site averages of total per patient costs. All differences significant at $p < 0.001$, except deficiency status differences for primary care costs, which were significant at $p < 0.05$.

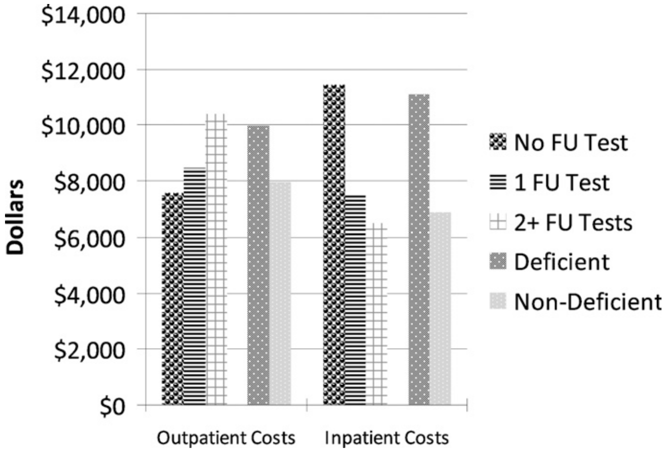

FIGURE 6. Total per patient medical cost differences by vitamin D monitoring and status. Site averages of total per patient costs. All differences significant at $p < 0.001$.

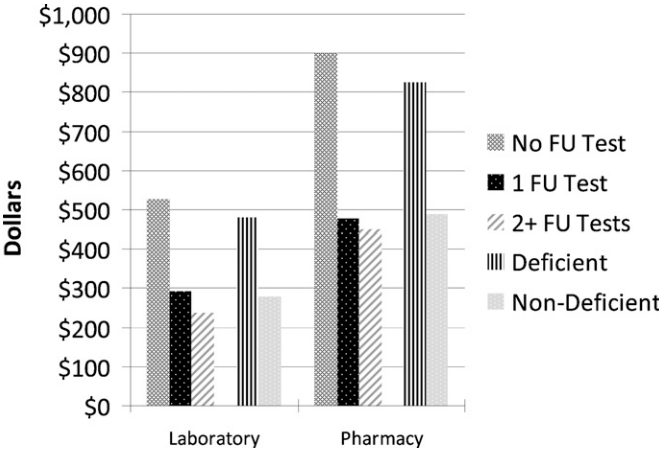

FIGURE 8. Specific inpatient per patient medical cost differences by vitamin D monitoring and status. Site averages of total per patient costs. All differences significant at $p < 0.001$, except deficiency status differences for primary care costs, which were significant at $p < 0.05$.

levels and monitoring accounted for a significant amount of variance in both inpatient and outpatient costs after accounting for latitude and season, significant site differences remained after adjusting for vitamin D levels, indicating that site cost differences cannot be totally explained by differences in vitamin D status and monitoring. A graphic representation of the effect of both sites and the vitamin D variables on inpatient costs is presented in Figures 11 and 12. As seen in Figure 11, the inpatient cost differences across site are somewhat driven by vitamin D deficiency status. This is evident by the fact that there are generally bigger cost differences between deficient and nondeficient patients than there are across the sites within each deficiency status. Although the effect is not as pronounced, the same pattern of associations is also seen for vitamin D monitoring (Fig. 12). With one site exception (Mountain Home), bigger cost differences exist between patients who had no follow-up testing and those who did, than across sites within each deficiency status. Thus, when patients are not vitamin D deficient and their status is monitored with follow-up testing, inpatient costs are lower, regardless of the VA site where they receive care.

DISCUSSION

To our knowledge, this is the first published report detailing hypothesized significant differences by site of service in vitamin D status and vitamin D testing patterns among veterans in the Southeast United States while accounting for seasonality and latitude of residence. Vitamin D deficiency is more prevalent in ethnic minorities, and Grant et al[12] have postulated that much of the chronic disease burden that is encountered in these groups may relate to vitamin D deficiency. In a study limited to male veterans in the Southeastern United States, the frequency of testing and monitoring for vitamin D status in African Americans was significantly less than for

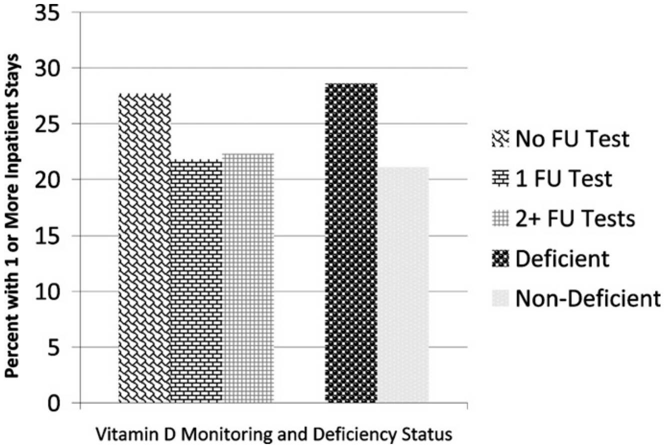

FIGURE 9. Inpatient stay differences by vitamin D monitoring and status. All differences significant at $p < 0.001$, except those with 1 follow-up test and those with two or more tests, which were not significantly different from each other.

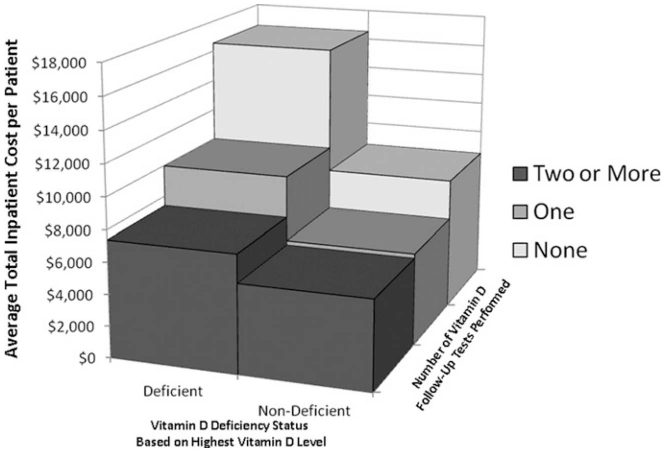

FIGURE 10. Joint effect of initial vitamin D status and level of monitoring on inpatient costs.

white Americans.[13] As such, it was concerning that Memphis with its greater minority population and one of the highest vitamin D deficiency rates, similarly had the lowest rate of follow-up testing of any of the six VA sites.

This study extends prior work done at a single site indicating that, as expected, vitamin D deficiency is associated with significantly increased health care costs and service utilization involving both inpatients and outpatients. Moreover, unlike the prior study, seasonality was factored into our analysis. The veterans with more vitamin D tests had higher outpatient costs in many categories, possibly indicating that the number of tests may be a marker for a greater level of care in general. However, lack of vitamin D follow-up was associated with higher inpatient costs. This suggests that lack of follow-up of vitamin D may have significant negative health consequences, perhaps leading to increased costs and service utilization as an inpatient.

TABLE II. Vitamin D Related Site Differences in Cost Outcomes After Control for Potential Confounders

Outcome Predictor	*F* change	*p*	Beta	*p*
Total Outpatient Costs				
Confounding Factors	20.84	<0.001		
Latitude			0.05	<0.001
Season of Vitamin D Draw			0.02	0.089
Vitamin D Variables	55.30	<0.001		
Highest Level[a]			–0.03	<0.001
Follow-up (%1 + follow-up Tests)			0.09	<0.001
Site	41.08	<0.001		
Total Inpatient Costs				
Confounding Factors	1.06	0.348		
Latitude			0.01	0.483
Season of Vitamin D Draw			0.01	0.201
Vitamin D Variables	47.06	<0.001		
Highest Level[a]			–0.04	<0.001
Follow-up (%1 + follow-up Tests)			–0.05	<0.001
Site	9.83	0.002		

Regression analyses entering latitude and season on the first step, vitamin D level and follow-up on the second step, and VA medical center site on the final step. [a]Highest vitamin D level for each patient.

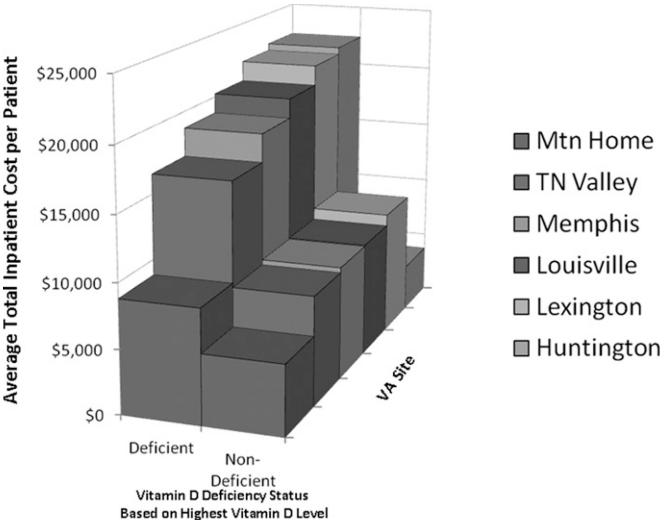

FIGURE 11. Total inpatient costs by VA site and vitamin D deficiency status.

The reason for the wide variation in vitamin D status and monitoring among the different medical centers is not entirely clear. It may represent the lack of standardized guidelines with regard to vitamin D. Pepper et al[14] identified 36 different vitamin D prescribing regimens. Optimal regimens have not been clearly defined. Daily oral administration of vitamin D was more effective than weekly or monthly administration in nursing home residents.[15] Annual high doses (500,000 IU) of oral vitamin D have been associated with increased risk of falls and fractures.[16] Moreover, although 50,000 IU weekly of

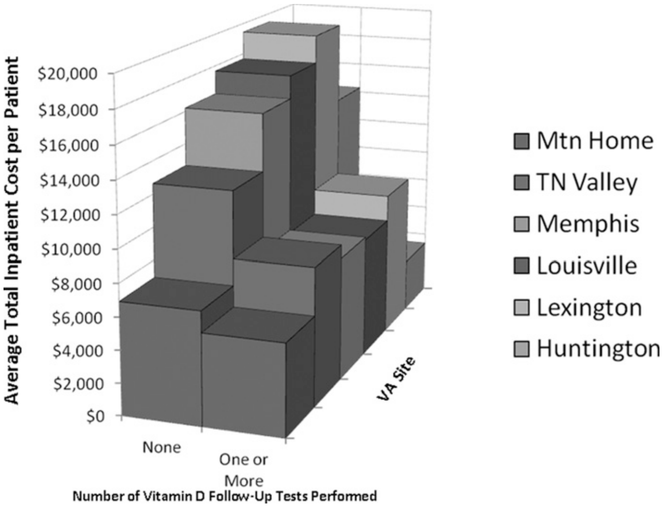

FIGURE 12. Total inpatient costs by VA site and vitamin D monitoring.

ergocalciferol is commonly used for treating vitamin D deficiency, cholecalciferol has been proposed as a more suitable agent.[17] Regardless of the reason for the disparities in vitamin D status and monitoring across sites, the current study suggests that these factors may play a role in the cost of care differences across the six VA medical centers.

The divergent results seen with latitude and seasonality as contributors to health care costs suggest these factors are likely to be less significant than actual vitamin D status to health care costs and service outcomes in veterans. Although seasonality has been widely accepted as a major contributor to variance in vitamin D status, recent studies refute this belief to a large extent. In a study in Israel, hypovitaminosis was common across all seasons.[18] Levis et al[19] reported that vitamin D deficiency is common in Miami and patients see only a modest increase in vitamin D levels in the summer.

This study has several limitations because of its retrospective nature. Management of vitamin D status in the private sector could not be accounted for, but may have influenced findings related to both total costs and monitoring, as some veterans have both private and VA health care providers. It is possible that the study sample may not be representative of all veterans and may be skewed more toward a more symptomatic group that was more likely to be tested for vitamin D deficiency. Moreover, similar to other studies,[20] only 3.7% of the veterans seen during this period were included in this study because of the small number of veterans tested for vitamin D. The possibility that vitamin D status is a marker for chronically ill patients exists; however, this is not likely the explanation since similar degrees of vitamin D deficiency have been noted in many apparently healthy populations across the globe.[21] Prospective studies are needed to confirm applicability of these findings to all veterans.

The recent report by the Institute of Medicine focused on bone health and suggested very modest doses of vitamin D3, e.g., 600 IU as adequate for overall health.[22] However, the Institute of Medicine report has been criticized by many learned authorities as deficient in many areas.[23,24] The important metric of 25(OH)D often requires a variable dose of D3 supplementation and does need to be customized on an individual basis. Both vitamin D receptor polymorphisms[25] and variations in vitamin D receptor binding protein[26] can influence vitamin D status. The highest values in our study averaged across the current study sites were barely in the normal range (30–100 ng/mL). Moreover, it is clear that ethnic minorities are likely to need considerably more in terms of D3 supplementation to achieve normal 25(OH)D levels.[27] The development of formal guidelines for testing, monitoring, and treatment of vitamin D deficiency is long overdue. The VA health care system outperforms Medicare advantage plans with apparently less variability in health care delivery,[28] however, our data suggest, as far as vitamin D is concerned, considerable variability exists among Veterans medical centers. The Endocrinology Division at Mountain home VAMC has made a concerted effort to educate local health care providers regarding vitamin D deficiency over the past few years. We believe similar efforts at other VA sites would be a fruitful endeavor. Additional studies maybe fruitful in further isolating which factors are responsible for the wide variation in health care costs among medical centers which geographically are not markedly dissimilar. Appropriate guidelines for managing vitamin D status may have substantial impact, if implemented in veterans. Factors that are site specific as well as those which influence vitamin D status such as race and obesity need to be weighted appropriately.

CONCLUSIONS

Findings from the current study as well as previous research suggest that vitamin D deficiency is highly prevalent in veterans in the Southeastern United States and contributes to increased health care costs. In addition to vitamin D, site-specific differences also contribute to inpatient and outpatient cost variations. Wide variability in vitamin D status and monitoring was evident across the 6 different sites. The reduced sampling for vitamin D in Memphis, given its high prevalence of African Americans, needs to be evaluated. Prospective studies are urgently needed to confirm that achieving a vitamin D replete state can reduce health care costs, as the potential savings in health care dollars are likely to be considerable and are of special significance in the current economic climate. Pending such studies, given the minimum cost of vitamin D replacement, emerging benefits, and the very low risk of toxicity, we agree with the recent Endocrine Society recommendations for daily intake of 1000 to 2000 IU D3.[29] Although vitamin D testing is not cheap, we believe a check of 25[OH]D levels once or twice yearly is a reasonable compromise until stable and appropriate levels are documented, at which time yearly checks would be reasonable. Starting patients on 1000 to 2000 IU D3 daily may assist in reducing the number of vitamin D tests needed. Immediate implementation of this recommendation is highly desirable.

ACKNOWLEDGMENTS

Alan N. Peiris acknowledges use of resources at Mountain Home VAMC in completion of this project. The expeditious services of the Library staff at Mountain Home VA and affiliated sites are also gratefully acknowledged.

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