Oral Health and Mental Distress among Military Veteran Cancer Survivors: Insights from the 2016 Behavioral Risk Factor Surveillance System

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Objective: Mental health issues occur among service members and veterans (SMVs). A cancer diagnosis exacerbates these issues. Many veterans with poor mental health lack adequate dental care. We examined oral health and mental distress among SMV cancer survivors. **Methods:** We retrieved data from the 2016 Behavioral Risk Factor Surveillance System. We calculated the average number of mentally unhealthy days in the last 30 across categories of tooth removal (0, 1-5, ≥ 6 but not all, and all). We calculated state-based percentages of tooth removal (≥ 6 teeth) among SMV cancer survivors. **Results:** The greatest percentage of removal of ≥ 6 teeth among SMV cancer survivors occurred in Mississippi (50.3%), West Virginia (49.3%), and Kentucky (46.6%). Mental distress increased with the number of teeth removed. SMV cancer survivors with no history of tooth removal reported 2.08 mentally unhealthy days; 1-5 teeth removed, 2.34 days; ≥ 6 but not all, 3.20 days; and all teeth removed, 4.08 days. **Conclusion:** The history of ≥ 6 or more teeth removed increased SMV cancer survivor risk for mental distress. Tooth loss was particularly prevalent among veterans in the Mississippi Delta and Appalachia. Improving oral healthcare among veterans who are cancer survivors may reduce mental distress.

Key words: veteran health; oral health; mental distress; cancer survivors; military medicine; Behavioral Risk Factor Surveillance System (BRFSS)
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Oral health is an important indicator of overall health and well-being.[1] Because favorable oral health is integral to physiological functions such as chewing, swallowing, and digestion, and psychosocial functions of verbal and nonverbal expression, any oral disease or condition that disrupts these functions may cause anxiety, preempt social interaction, and interfere with eating, possibly resulting in nutritional insufficiency.[2-4] Historically, the Department of Veteran Affairs (VA) has had as part of its mission, clinical research and health education advances for dental care among veterans. Moreover, the VA has made dental care a key essential service readily available for veterans.[5] About 4 decades ago, there was a spike in the number of dental cases reported among veterans, especially dental caries and periodontal diseases with subsequent loss of teeth; however, through advances in dental services and a high level of dental care, responsive treatment has diminished caries and tooth loss in the veteran population.[6] Studies conducted in the veteran community aimed at assessing changes in oral health status and the risk factors involved have followed traditional epidemiological

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methods and indices for the identification of tooth loss, periodontal diseases, caries, oral tissue lesions, salivary flow, mastication, and dietary preferences, especially among healthy veterans. Additionally, a comparison of veterans to the non-veteran male population has shown that veterans tend to have more teeth, possibly due to the upgraded VA care and the attainment of higher education.[7] Substantive dental pain for persons serving currently in the military can affect the efficiency of the military force, and in view of this, the United States (US) Armed Services have long involved experts skilled in various types of diagnosis, treatment modalities, and preventive measures with respect to oral morbidity as a vital matter of necessity.[5] A further reason for focusing on veterans is that the VA is authorized to provide extensive dental care, especially for the fully disabled, although in other cases, the cost of treatment is limited or VA benefits do not fully cover the cost of dental care.[8]

Advanced dental disease can result in disfigurement, such as dento-facial abnormalities; when these occur, fear, anxiety, social avoidance, self-stigma, marked behavior change, and other personality disorders may result.[9,10] Moreover, tooth loss may affect phonation and subsequent embarrassment, and may predispose affected individuals to the situation of a foul-smelling oral cavity, with consequent isolation and avoidance of people.[9] Other side effects emanating from tooth loss may include a complex range of emotions such as the sadness, depression, and decreased self-confidence, or other conditions such as feeling old, having restricted food choices, avoiding laughing, eating or going out in public, and at times, being embarrassed of one's appearance in front of family members, partners, friends, and the public-at-large.[9]

Removal of a tooth, regardless of the cause, can lead to oral and facial changes in muscle tissues, nerves, and bone. Moreover, when the loss involves pairs of teeth, the ability to chew is grossly reduced, thereby limiting the choices of food with potential consequences of exposure to malnutrition if this restriction persists.[11] Other studies have established that dental anxiety is common among 10% to 20% of the adult population and is associated with adverse thoughts or feelings, sleep deprivation with associated frequent medication intake to remediate sleeplessness, obvious somatization symptoms with reduced social and occupational functions, unintended weight change, insomnia, loss of energy, and feelings of worthlessness and recurrent thoughts of suicide.[11,12-14]

Cancer survivorship following treatment by chemotherapy, radiation or both, especially of head and neck cancers, has been associated with oral side effects when new cell growth is halted, resulting in limited oral tissue growth and oral tissue repair. Sometimes cancer treatment triggers the normal bacterial commensals in the oral cavity leading to painful sores, severe infections, and tooth decay followed by tooth loss. Moreover, radiation of the neck and head region can directly affect, damage, or breakdown oral tissues, salivary glands, and bone marrow.[15] Radiation has been associated with mouth sores and dryness, sometimes leading to life-threatening infections affecting subsequent treatment options and overall health-related quality of life. Equally, cancer treatment has been associated with the suppression of the immune system because as the anticancer drugs intercede to halt cancer cell growth, normal cell growth is also affected, thereby interfering with the healing process of the sores and contributing to further opportunistic oral infections. This is the basis for a comprehensive oral evaluation in the month preceding the commencement of cancer treatment.[16,17]

METHODS

Study Design and Sample

For this study, we retrieved data from the US Centers for Disease Control and Prevention's (CDC) 2016 Behavioral Risk Factor Surveillance System (BRFSS).[18] The BRFSS is a survey of health behaviors, chronic health conditions, and utilization of preventive services among US adults, and is representative of residents in the 50 states and the District of Columbia. For 2016, the BRFSS contained data from 486,303 US residents, of whom 63,919 answered in the affirmative to the following question: "*Have you ever served on active duty in the United States Armed Forces, either in the regular military or in a National Guard or military reserve unit?*"

To isolate service members and veterans (SMVs) with a history of cancer, the following questions were used from the BRFSS: (1) "*Have you ever been told that you had skin cancer?*" and (2) "*Have you ever been told that you had any other types of cancer?*" The National Cancer Institute (NCI) suggests that

Table 1
Descriptive Statistics Representing Characteristics of SMV Cancer Survivors from the 2016 Behavioral Risk Factor Surveillance System

Variable	N or (Mean)	% or (SD)
Current Age	(71.700)	(9.024)
Male	15,650	94.000
White	15,345	93.600
Poverty	2787	19.700
Health Insurance Coverage	16,316	98.300
Current Smoker	1576	9.800
Current Binge Drinker	1118	7.100
Leisure Time Physical Activity	11,967	72.100
Last Dentist Visit: This Year	11,860	71.300
Last Dentist Visit: Within 2 Years	1339	8.000
Last Dentist Visit: Within 5 Years	1170	7.000
Last Dentist Visit: 5 or More Years Ago	2037	12.200
Last Dentist Visit: Never	78	0.500
Married	10,637	64.200
No Social Support	11,488	69.000
Two or More Cancer Types	401	2.407
Coronary Heart Disease	3065	18.700
Diabetes	3902	23.400
Depression	2438	14.700
Age at Cancer Diagnosis	(62.660)	(13.201)
Currently Receiving Cancer Treatment	165	1.000
Pain from Cancer	665	4.400
Live in a Rural Area	3495	21.000
Teeth Removed: None	4698	28.200
Teeth Removed: 1-5	5777	34.700
Teeth Removed: 6 or More, But Not All	3628	21.800
Teeth Removed: All	1937	11.600

"in cancer, a person is considered to be a survivor from the time of diagnosis until the end of life."[19] Therefore, SMVs who answered in the affirmative to either of the previously identified questions were categorized as cancer survivors (N = 16,643).

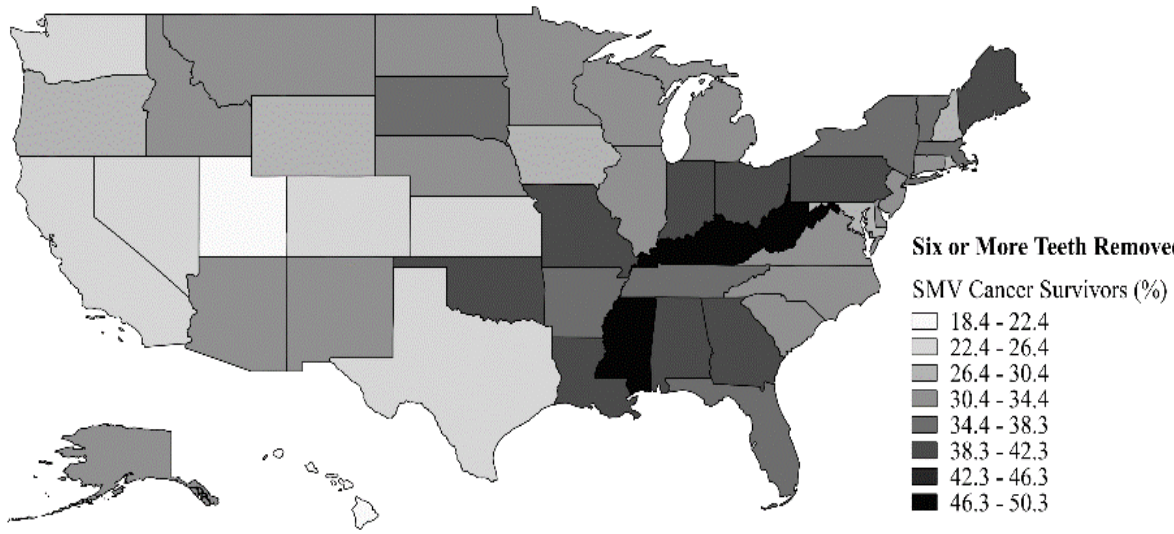
Independent and Dependent Variables

The primary dependent variable in the present study was mental distress. The dependent variable was operationalized with the following ratio-scaled question: "*Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?*" The primary independent variable in this study was tooth removal. The independent variable was operationalized with the following ordinal-scaled question: "*How many of your permanent teeth have been removed because of tooth decay or gum disease (none, one to 5, 6 or more but not all, and all)?*"

Control Variables

Mental health is affected by genetic factors, behavioral factors, physical health status, social fac-

Figure 1
Percent of SMV Cancer Survivors in Each State with a History of ≥ 6 Teeth Removed due to Tooth Decay or Gum Disease



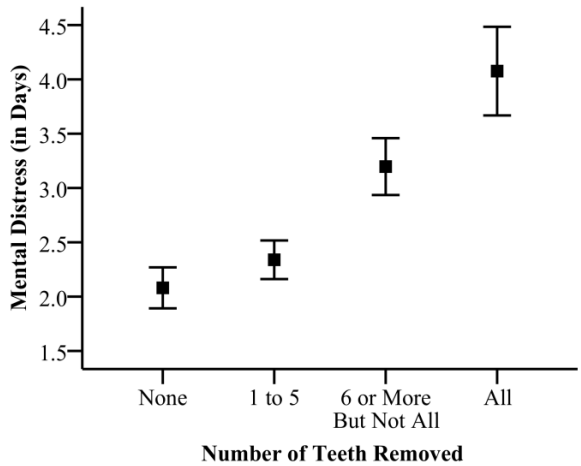
tors, economic factors, and environmental factors.[20] Therefore, several control variables were included to examine the unique contribution of oral health to mental health. We controlled for the following genetic factors: current age (ratio scale), sex (male or female), and race (white or other). We controlled for the following behavioral factors: current smoking status (yes or no), current binge drinking status (yes or no), engagement in leisure time physical activity (yes or no), and dentist visits (within the last year, within the last 2 years, within the last 5 years, more than 5 years ago, and never). We controlled for the following health status variables: previous diagnosis of coronary heart disease (yes or no), previous diagnosis of diabetes (yes or no), previous diagnosis of depression (yes or no), age at first cancer diagnosis (ratio scale), current cancer treatment (yes or no), and current pain from cancer (yes or no). We also controlled for social factors, including marital status (currently married or not currently married) and inadequate social/emotional support (yes or no). In addition, we controlled for the economic factors of poverty (code: income less than $25,000 USD per year = 1, income greater than $25,000 USD per year = 0) and health insurance coverage (yes or no). Finally, we controlled for one environmental variable (rurality) with rural-urban geographic designation measured via metropolitan status code (MSA) assignments. We coded respondents not residing within an MSA as living in a rural area.

Data Analysis

We calculated descriptive statistics (means, standard deviations, frequencies, and percentages) for all study variables. Furthermore, we calculated the average number of mentally unhealthy days in the last 30 days across categories of tooth removal (ie, none, one to 5, 6 or more but not all, and all). Using descriptive epidemiological methods,[21] state-based percentages of tooth removal (6 or more teeth) among SMV cancer survivors were calculated and subsequently plotted on a US state-boundary choropleth map – the shapefile for which was retrieved from the US Census Bureau[22] – with graduated symbols using Quantum GIS.[23]

Of prime interest in this study was the effect of tooth removal (independent variable) on mental distress among SMV cancer survivors (dependent variable). To explore the aforementioned relationship, we carried out ordinary least squares (OLS) multiple linear regression with heteroscedastic-cor-

Figure 2
Average Number of Mentally Unhealthy Days in the Last Month (with 95% CI) among SMV Cancer Survivors by History of Tooth Removal



rected standard errors.[24] The dependent variable, a continuous measure of mental distress, was $\log_{10}$ transformed so as to force a normal distribution on the model's error terms. We carried out multicollinearity diagnostics using variance inflation factors (VIFs), where a VIF < 5 indicated no multicollinearity.[25] Results showed that all VIFs were within normal ranges.

RESULTS

Table 1 provides descriptive statistics for all study variables. Regarding genetic factors, the sample was primarily white and male, with an average age of 72 years. Analysis of economic factors showed that less than 20% of the sample lived in poverty and 98% had some form of health insurance. Analysis of behavioral factors revealed that a small percentage of participants were current smokers or binge drinkers (ie, < 10%). Nearly three-fourths of the study sample self-reported leisure time physical activity in the past month and a dental visit within the last year. Analysis of the environmental variable (ie, rurality) revealed that 21% of the study sample lived in a rural area. Regarding social characteristics, 64% were married but 68% reported inadequate social/emotional support (ie, none). A small percentage (2.4%) of the sample had been diagnosed with more than one type of cancer. The average age at first cancer diagnosis among SMVs was 63 years. Only 1% of the sample reported currently undergoing cancer treatment and approximately 4% reported current pain from cancer. Of the 16,643 SMV cancer survivors in the study, 18.7% had coronary heart disease, 23.4% had diabetes, and nearly 14.7% had a previous diagnosis of depression.

Descriptive analysis revealed that 68.1% of the sample had at least one tooth removed in their lifetime due to tooth decay or gum disease (Table 1). Variation in the number of teeth removed was observed by state of residence (Figure 1), with the greatest percentage of removal of 6 or more teeth among SMV cancer survivors occurring in Mississippi (50.3%), West Virginia (49.3%), and Kentucky (46.6%).

Mental distress increased with the number of teeth removed (Figure 2). On average, SMV cancer survivors with (1) no history of tooth removal reported 2.08 mentally unhealthy days in the last month, (2) a history of one to 5 teeth removed reported 2.34 mentally unhealthy days in the last month, (3) a history of 6 or more, but not all, teeth removed reported 3.20 mentally unhealthy days in the last month, and (4) a history of all teeth removed reported 4.08 mentally unhealthy days in the last month.

Table 2 shows the results of the OLS multiple linear regression model. The omnibus model was statistically significant ($F_{(25, 16617)} = 198.939$, $p < .001$), and accounted for 23% of the variance in mental distress. After adjusting estimates for genetic factors, behavioral factors, health status, social factors, economic factors, and environmental factors, a history of 6 or more, but not one to 5 teeth removed increased an SMV cancer survivor's risk for mental distress. Specifically, based on unstandardized regression coefficients, having 6 or more (but not all) teeth removed was associated with a 1.002 increase in the number of days of mental distress within a month (compared to SMV cancer survivors with no history of tooth removal). Furthermore, having all teeth removed was associated with a 1.003 increase in the number of days of mental distress within a month (compared to SMV cancer survivors with no history of tooth removal).

Table 2
Standardized Beta Coefficients for Estimates of the Relationship between Tooth Removal and Mental Distress among SMV Cancer Survivors

	β	SE[a]	p
Current Age	–0.095	< .001	< .001
Male	–0.003	< .001	.609
White	–0.022	< .001	.002
Poverty	0.060	< .001	< .001
Health Insurance Coverage	–0.043	.001	< .001
Current Smoker	0.037	< .001	< .001
Current Binge Drinker	–0.004	< .001	.603
Leisure Time Physical Activity	–0.079	< .001	< .001
Married	–0.034	< .001	< .001
No Social Support	–0.002	< .001	.737
Two or More Cancer Types	0.017	.001	.013
Coronary Heart Disease	0.032	< .001	< .001
Diabetes	0.016	< .001	.018
Depression	0.394	< .001	< .001
Age at First Cancer Diagnosis	–0.002	< .001	.738
Current Cancer Treatment	0.003	.002	.613
Current Pain from Cancer	0.024	.003	< .001
Rural	–0.001	< .001	.957
Teeth Removed: 1-5	0.014	< .001	.088
Teeth Removed: 6 or More, But Not All	0.027	< .001	< .001
Teeth Removed: All	0.039	< .001	< .001
Last Dentist Visit: Within 2 Years	0.015	< .001	.036
Last Dentist Visit: Within 5 Years	0.002	< .001	.756
Last Dentist Visit: 5 or More Years Ago	0.001	< .001	.945
Last Dentist Visit: Never	0.008	.003	.224

Note.
Missing values were handled with multiple imputation.
[a] SE = Standard Error of the Unstandardized Beta Coefficient

DISCUSSION

As with the other aged groups, veterans have oral health issues especially with advancement in age and associated comorbid or multiple diseases including cancer and its related complications.[26] Two major findings in this study are: (1) the history of 6 or more teeth removed increased SMV cancer survivor risk for mental distress; and (2) tooth loss was particularly prevalent among veterans living in the Mississippi Delta Region and the Appalachian Region respectively.

Consistent with our findings, comorbid anxiety and depression have been independently associated with 6 or more teeth removed compared with 5 or fewer teeth removed, but not with edentulism.[11] People who lost their teeth due to any reason at all expressed a complex range of emotions such as a sadness, depression, and grief over the loss of an important part of themselves, among other things. Specific actions included isolation from public settings, restriction of certain foods, and self-stigmatization.[9] Also consistent with our findings, significant men-

tal illnesses prevalent in the veteran population such as depression, anxiety, posttraumatic stress disorder, and alcohol abuse, have strong associations with poor oral health status, including tooth loss.[13] Risk factors for oral diseases among elderly veterans include chronic non-communicable diseases such as stroke, diabetes, coronary heart disease, and depression, as well as behavioral lifestyle variables such as smoking and alcoholism, and demographic conditions such as poverty, lack of insurance coverage, poor oral health, and low education level.[7,27-29]

Additionally, as our data reveal, regardless of the overall progress achieved in oral health status in the country, people residing in Appalachia and the Mississippi Delta Region appear to have poorer oral health status compared with persons from other regions. For example, West Virginia, the only state with its entire location in Appalachia, ranks first with the highest rate of missing 6 teeth or more; it also ranks second in complete tooth loss among persons 65 years and older. Mississippi located in the Mississippi Delta Region, ranks second to West Virginia in terms of missing 6 teeth or more. and fourth in complete tooth loss. Similarly, 80% of the states with persons missing 6 or more teeth are in the Mississippi Delta Region or in Appalachia, findings that have been consistent since 2010. Other factors associated with the oral health disparities in these regions include individual attributes such as socio-economic status, use of tobacco, presence of oral bacteria, genetic factors, certain other health behaviors, and lack of dental insurance; other, perhaps broader factors important as determinants of the differences seen among persons in Appalachia, the Mississippi Delta Region, and the rest of US include whether fluoride is present in the water supply, as well as elements related to coal mining in the area, the cultural importance of oral health, available dentists and dental hygienist *per capita*, as well as education and income.[30]

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Since 2012, oral health has been one of the 12 leading health indicators for the nation.[31] Overall, 17 of the *Healthy People 2020* objectives relate directly to oral health.[31] The recently released *Healthy People 2030* document includes, among many others, oral health objectives to: reduce the proportion of adults with active or untreated tooth decay (OH-03), reduce the proportion of older adults with untreated root surface decay (OH-04), reduce the proportion of adults aged 45 years and over who have lost all their teeth (OH-05), reduce the proportion of adults aged 45 years and over with moderate and severe periodontitis (OH-06), increase the proportion of oral and pharyngeal cancers detected at the earliest stage (OH-07), increase use of the oral health care system (OH-08), increase the number of states and DC that have an oral and craniofacial health surveillance system (OH-D01), increase the proportion of people with dental insurance (AHS-02), reduce the proportion of people who can't get the dental care they need when they need it (AHS-05), and increase the proportion of people whose water systems have the recommended amount of fluoride (OH-11).[32]

Specific to the health policy of water fluoridation, as of 2016, 72.8% of persons in the US were served by community water systems with optimally fluoridated water. The Mississippi Delta Region encompasses parts of 8 US states – Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee.[33] Revised guidance on optimal fluoridation of water system specifies a level of 0.7 mg per liter,[34,35] down from the 1.2 mg per liter level that fueled opposition to fluoridation over concerns about the development of fluorosis in children (a condition of faint white spots on teeth that usually are noticeable only upon close inspection by a dental professional).[34] Of the 8 states in the Delta Region, 5 of them (Alabama, Arkansas, Louisiana, Mississippi, Missouri) are below this 0.7 mg/liter level, and the other 3 (Illinois, Kentucky, and Tennessee) are in borderline compliance with the recommendation.[36] As noted early, this geographic area includes 2 of the states with the highest levels of tooth loss among cancer survivors, as well as persons age 65 years and older.

The Appalachian Region includes 420 counties across 13 states – Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia – some of the same states that have portions of their territories in the Mississippi Delta Region.[37] Of these 13 states, only 2 (Ohio and Virginia) exceed the 0.7 mg/liter fluoridation standard; the remaining states either fall below the recommended standard (Alabama, Mis-

sissippi, Pennsylvania, West Virginia) or are in borderline compliance (Georgia, Kentucky, Maryland, New York, North Carolina, South Carolina, Tennessee). It is likely that a health policy for universal fluoridation would reduce lifelong tooth loss among both children and adults, including cancer survivors.

In their study of oral health among students by military service status in postsecondary settings, Albright et al[38] found that service member and veteran students were at greater risk for neglecting health behaviors associated with positive oral health; they were less likely to get dental exams; moreover, those who had been deployed previously were the least likely to practice good oral health. Thus, improving oral health may show a concomitant benefit in physical and mental health outcomes in this population; Albright et al's[38] results offer health specialists direction for working with service members and veterans on college campuses – especially given evidence that some veterans may hold stigmatizing attitudes toward mental health-seeking behaviors.[39]

Among veterans with serious mental health conditions, 60% have fair to poor oral health, and about 33% find it difficult to eat because of these issues.[40] Silk[41] reminds us of programs that can help veterans find dental care. For example, the National Veterans Foundation has a list of veterans who qualify for dental care.[42] Over 200 locations exist in the US for veteran dental services.[43] A nonprofit organization, Everyone for Veterans, connects low-income veterans with dentists who volunteer their services at no cost.[43]

Finally, we recommend the establishment of local dental public health programs to prevent tooth loss among veterans, such as ones offering awareness and advocacy through health education awareness and promotion programs on oral health, dietary control of sugar, acidic beverages, and routine brushing and flossing. Additionally, we recommend the provision of comprehensive dental insurance for veterans irrespective of the type of disability. Factors responsible for the disparities in Appalachia and the Mississippi Delta Region should be addressed accordingly such as community water fluoridation, early diagnosis and treatment of oral health diseases, health behavior change, and bridging previously identified gaps in education and services. If veterans are unaware of their oral health service options, their health advocates can refer them to federally qualified health centers, many of which provide oral health treatment services. At such facilities, veterans without dental insurance may see their payments determined, in part, based on income.[41] Moreover, health advocates may be able obtain oral health services for veterans from some dental and dental hygiene schools that offer free or reduced-fee services.[41]

Human Subjects Approval Statement

As secondary analysis of a publicly available data set, preparation of this paper did not require Institutional Review Board approval.

Conflicts of Interest Disclosure Statement

The authors have no conflict of interest to declare.

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