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Low Income as a Multiplicative Risk Factor for Oral Pain and Dental Problems among U.S. Veteran Smokers

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Abstract

Purpose—Compared to the United States (U.S.) general population, military veterans are at an increased risk of experiencing dental problems. This study documented associations between cigarette use and measures of dental/oral concern in a population of U.S. veterans who served in Iraq and Afghanistan.

Methods—A cross-sectional analysis of survey data from the Operation Enduring Freedom/Operation Iraqi Freedom (OEF/OIF) Veterans Health and Needs Study, a study of U.S. military veterans. Out of 5,000 surveys mailed to a random sample of OEF/OIF veterans, 1,161 surveys were completed and returned. Among study respondents, $N = 1,114$ had non-missing dental/oral pain data and were included for analysis. The survey also included smoking history and demographic information. Univariate and multivariate logistic regression analyses were used to cross-sectionally model the odds of experiencing dental/oral concerns as a function of smoking status. We also examined moderating effects of income and gender on the association between smoking and dental/oral concerns.

Results—In univariate and multivariate models, current smoking was associated with risk for dental/oral concerns. However, this association was qualified by a Smoking $\times$ Income interaction. For those earning above 20,000 USD, smoking was not associated with dental/oral concerns.

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Compliance with Ethical Standards

Research Involving Human Participants and/or Animals

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Durham Veterans Affairs Medical Center Institutional Review Board and the U.S. Office of Management and Budget (OMB 2900-0728) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Disclosure of Potential Conflicts of Interest

The authors Hicks, Wilson, Thomas, Dennis, Neal, and Calhoun declare that they have no conflicts of interest.

Among veterans with low income, smoking was associated with three times higher odds of increased dental/oral concerns. There was no significant Gender $\times$ Smoking interaction.

Conclusions—These findings underscore the relevance of factors that moderate the association between smoking and dental/oral concern, namely income. Findings also underscore the importance of interventions to mitigate income disparities in oral healthcare.

Keywords

veteran; tobacco; smoking; cigarettes; oral pain; nicotine

Introduction

Oral health significantly affects quality of life including choice of food selection, swallowing and interfering with activities of daily living [1]. Tobacco use has been empirically identified as a risk factor for the onset and exacerbation of oral pain and disease [2–9]. Additionally, smoking has been shown to be a risk factor for periodontal disease [1, 10] as well as oral cancer and pre-cancerous lesions [11, 12]. In fact, smokers have seven times the risk of developing poor oral health (i.e., periodontal disease, oral and throat cancers, oral fungal infection) compared to non-smokers [13]. In addition to the overwhelming oral/dental risk associated with smoking, it is also possible that the association between smoking and pain may be moderated by demographic factors, such as gender and income. Given the potential for exacerbating risk, it is essential to investigate the moderating impact of both gender and income on risk for dental/oral concerns associated with smoking.

Although relatively few studies have examined the association between tobacco use and oral pain or pain-related behavioral impacts, there is evidence that smoking is a risk factor for increased dental/oral concern including oral pain. For example, a longitudinal study of U.S. adults aged 45 years or older documented that smoking was associated with increased tooth pain and painful gums after accounting for sex, history of dental visits, financial status, dental insurance, education, oral hygiene [14]. Similar findings between current smoking and tooth pain were documented in a survey study of Swedish adults [14]. Oral pain patients who are current smokers experience greater pain intensity and pain interference than do both former smokers and never-smokers [15].

Regarding oral pain, there is some evidence that the association between smoking and pain may be moderated by demographic factors, such as gender. Data from the Florida Dental Care Study (FDCS) indicated that smoking increased the risk of tooth pain for men but not women [14].

Income may also be a moderating factor. Smoking is more common among those with low income and economic indicators (i.e., socioeconomic status, dental insurance coverage) are linked to oral health [16, 17]. Dental care is more difficult to access for those with low income; according to the Medical Expenditure Panel Survey [18], poor and low-income U.S. adults ages 21–64 are less likely to have private dental coverage and more likely to have no dental coverage than more affluent adults. It is possible that the effect of smoking on oral

health may be exacerbated among those with low income. More generally across high-income countries like the U.S., income inequality is highly associated with dental health. Specifically, in a study of 35- to 44-year-old adults living in high-income countries, evidence suggested that countries with high income inequality (such as the U.S.) had lower rates of dental treatment [19].

In the current study, our population of interest is U.S. military veterans who served during the era of recent wars in Iraq and Afghanistan. Although it has been shown that U.S. veterans are more likely to seek preventative health care than civilians, this population continues to have higher prevalence rates of disease burden and chronic medical conditions [20]. Smoking rates among returning Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) military personnel may be 50% higher than rates among non-deployed military personnel [21]. Among veterans who served during OEF and OIF, 40% have a lifetime history of smoking and almost 24% remain current smokers [22, 23]. Risk for initiating and continuing tobacco use is considerably increased by military service [24, 25, 23]. Moreover, those who use tobacco during military service often develop a lifelong pattern of consumption [25, 26]. In addition to high risk for smoking, U.S. veterans also have disproportionately high risk of economic adversity. Despite a generally lower risk for poverty, veterans are at greatly increased risk for homelessness compared to the general U.S. population [27].

The objectives of this study were 1) to determine the association between smoking status and dental/oral concern in U.S. veterans who served during wars in Iraq and Afghanistan, and 2) to measure potential moderating effects of sex and income on the association between smoking status and dental/oral concern. We hypothesized that current smoking would overall be associated with dental/oral concern. We further hypothesized two moderating effects: a) men would be more likely to experience dental/oral concern than women would, and b) low income would exacerbate the effect of smoking on dental/oral concern. To our knowledge, this study was among the first to document moderators of the impact of smoking on risk for dental concerns.

Methods

Design

A modified Dillman procedure was utilized in which all participants received a pre-alert letter, the survey, and if needed, a follow-up letter and duplicate survey [28]. The project was approved by the Durham Veterans Affairs (VA) Medical Center Institutional Review Board and the U.S. Office of Management and Budget (OMB 2900-0728).

Sample

Participants in the current study were drawn from the Operation Enduring Freedom/ Operation Iraqi Freedom Veterans Health and Needs Study which has been fully described elsewhere (see [29]). Briefly, a random sample of 5,000 United States (U.S.) veterans who served in Iraq or Afghanistan with a last known address in the VA Mid-Atlantic Region catchment area (North Carolina, the greater part of Virginia, and southeastern West Virginia)

was identified through a data use agreement with the VA Environmental Epidemiology Service. To be eligible for the study, veterans had to be eligible for VA healthcare and have a valid address in the U.S. Of the 5,000 veterans identified, 72 (1.4%) were determined to be ineligible (e.g., deceased, deployed) and 924 (18.5%) surveys were undeliverable (returned to sender). Of the 4,004 surveys that were delivered, 1,161 were completed and returned, resulting in a response rate of 29%. As described previously [29–31], demographic characteristics and clinical variables were compared between early responders (i.e., responders to the first survey wave; $n = 978$) and late responders (second wave; $n = 183$) as a proxy for non-response bias following the continuum of resistance model [32, 33]. As previously reported for this cohort, there were not differences between waves on the majority of demographic and clinical variables. There were some small, but statistically significant, differences between response waves in age and marital status. [29, 31, 30]. There were no differences in the proportion of smokers (early = 18%, late = 16%; OR = 0.93, 95% CI, 0.60–1.43) or proportion of those reporting dental/oral concerns (early = 25%, late = 28%; OR = 1.20, 95% CI, 0.84–1.72) between waves. Participants in the current study ($N = 1,114$) represent respondents with non-missing dental/oral concerns data.

Measures

Demographic variables—The survey assessed military rank during deployment and demographic variables including age, gender, and race.

Dental/oral concerns—Dental/oral concerns including oral pain were assessed with a single item, “Have you experienced any dental problems or pain during the last month?” Severity of symptoms was defined as *none*, *mild* (i.e., “just aware, but not slowed down by the symptom, or sufficient to take non-prescription drugs to relieve symptoms”), or *severe* (“sufficient to seek medical advice, take prescription drugs, miss work, or limit routine activities”). Given small cell size, or 6% of the sample ($n=65$), in the severe concerns category, participant responses for past-month dental/oral concerns were dichotomized to differentiate between no concerns (0) and any concerns (1).

Tobacco use—Cigarette smoking was assessed with a single item, “Have you ever smoked cigarettes?” Participants were classified based upon their response as either a never smoker (i.e., “no, never smoked”), former smoker (“yes, but no longer use at all) or current smoker (“yes, still smoking some days” or “yes, still smoking every day”).

Income—Annual income was assessed with a single item, “What was your approximate household income in 2008?” Participants were classified based upon their response as either low income (i.e., “less than 20,000 USD) or not low income (i.e., 20,000 USD or more). Poverty, as defined by the U.S. government, takes into account income and the number of people in the household. At 20,000 USD, families of three or larger are considered impoverished. The poverty level is 11,880 USD for one person and 16,020 USD for two people [34]. The 20,000 USD cutoff was chosen due to family size data being unavailable for this cohort. Recent national data on U.S. veterans (with deployment to Iraq or Afghanistan) suggests that 20,000 USD may be a good cutoff of low-income in this

relatively young population because greater than 65% of this veteran cohort earn at least 35,000 USD per year [35]

Mental health screen—Mental health screen was determined by participant ratings on the PTSD Checklist (PCL-5) [36] and the Patient Health Questionnaire-2 (PHQ-2) [37]. For the current study, a cutting score of 50 was used to determine probable PTSD [38, 39]. A cutting score of 3 was used for the PHQ-2 to indicate probable depression [40]. For data analysis, a positive mental health screen represents a score above 50 on the PCL-5 and/or a score above 3 on the PHQ-2.

Interest in VA Dental Services—Interest in VA dental services were measured by an item derived from a VA qualitative needs assessment [41]. Participants were asked, “How likely would you be to use the following services if they were offered by the VA?” Of the 25 services listed, this study focused on the item “dental exams,” for which interest was indicated on a 3-point scale. Responses were dichotomized to indicate *very likely or somewhat likely* (1) vs. *not likely* (0).

Data Analytic Plan

Sample characteristics were generated for the sample by smoking status. Missingness was assessed for any relationships with smoking status. Prior to data analysis, missing data were examined for systematic missingness. Among participants, 7.3% ($n = 81$) were missing at least one covariate data point, and there was no evidence of systematic missingness by past-month dental/oral concerns, smoking status, or income level. Therefore, missingness was addressed using multiple imputation (10 imputation datasets, using the Monte Carlo Markov chain method). Given that the outcome variable (dental/oral concerns) had two levels, logistic regression analyses were used to examine the relationship between current smoking status and dental/oral concerns, controlling for background variables. We specifically modeled the odds of experiencing dental/oral concerns in univariate, multivariate, and interaction models. Main effects were calculated for current smoking status, using demographic covariates (age, gender, ethnicity, enlisted rank, mental health screen, and income). To test the moderating effect of income on smoking status, we included a Smoking Status $\times$ Income interaction term in the final model. All statistical analyses were performed using SAS Version 9.4 (SAS, Inc. Cary, NC).

Results

Demographic characteristics of the sample are shown in Table 1. Almost half of the sample (44.1%) endorsed a lifetime history of smoking. One hundred ninety (17.1%) of the survey respondents indicated they were current smokers, 301 (27.0%) were former smokers, 598 (53.7%) had never been smokers, and smoking data were missing for 21 participants (1.9%) (Table 1). A majority of current smokers reported smoking daily (64.2%). Current smoking rates did not differ by gender and were 17.2% (men) and 18.8% (women). Nearly 1 out of every 10 survey respondents reported earning less than 20,000 USD per year (9.4%). Rates of current smoking significantly differed by income status, with 32.4% of low-income

veterans endorsing current smoking compared to 15.9% of veterans without low income ($\chi^2 = 17.89$, $p < .0001$).

One hundred forty-eight (30%) of the survey respondents who endorsed a lifetime history of smoking reported dental/oral concerns during the month prior to survey completion. Thirty-five percent ($n=66$) of current smokers and 27% ($n=82$) of former smokers endorsed dental/oral concerns during the month prior to survey completion. Among those who endorsed dental/oral concerns, 58% ($n=153$) stated that they would be very likely to use dental services if they were offered by the VA. Whereas, 28% ($n=73$) stated that they would be somewhat likely to use dental services if they were offered by the VA. Veterans who endorsed dental/oral concerns were significantly more likely to express intent (i.e., somewhat likely or very likely) to use VA dental services than those without dental/oral problems ($OR = 2.63$, 95% CI : 1.80–3.83).

All effect sizes are reported as odds ratios in Table 2, which can be interpreted as the relative odds (compared to the reference group) of reporting dental/oral concerns. In the univariate model, older age, enlisted rank, and low income (i.e., < 20,000 USD annually) were associated with higher odds of dental/oral concerns. White ethnicity was associated with lower odds of dental/oral concerns. In the multivariate model, older age, enlisted rank, and low income remained associated with higher odds of dental/oral concerns. In both the univariate and multivariate models, current smoking was associated with the odds of reporting dental/oral concerns.

In the interaction models (Table 2), there was not a significant Current Smoking $\times$ Gender interaction. However, there was a significant Current Smoking $\times$ Income interaction. To probe the interaction, we calculated and plotted the probability of reporting dental/oral concerns by smoking status and income (Figure 1). While there was no significant effect of smoking on dental/oral concerns for those without low income ($OR_{adj.} = 1.34$, 95% CI : 0.87–2.07), there was a strong effect of smoking on dental/oral concerns among low-income veterans. Compared to those who did not smoke, low-income veterans had odds of reporting dental/oral concerns that were four times as high ($OR_{adj.} = 4.14$, 95% CI : 1.66–10.29).

Discussion

The purpose of this study was to examine the association between cigarette use and dental/oral concerns in veterans with service in Iraq and Afghanistan. This study is among the first to demonstrate that low income strengthens the association between smoking and dental/oral concerns. We found that current smoking status was associated with an increased risk of experiencing dental/oral concerns, but only among those with low income. In contrast to previous research [14] there was not a significant smoking by gender interaction on dental/oral concerns outcomes.

Given that low-income individuals appear to be exceptionally to the effects of smoking on dental/oral concerns, this may indicate a need for more options for low-cost or no-cost dental treatment. Most oral diseases and conditions require professional dental care; however, for low-income individuals use of oral health services is diminished by high costs,

limited availability, and barriers to accessibility [42, 43]. There is a poor fit between both private and public dental practices and the general oral health needs of low-income populations. For example, for our particular study population, only veterans who are considered 100% disabled due to a service-connected injury are eligible for dental care through the VA [44]. As such, many low-income veterans are not eligible for VA dental benefits. The provision of dental care to homeless veterans has been shown to significantly increase their quality of life [45], and dental care has been previously identified as an important need for many veterans [46]. Increased access to preventative oral-health procedures and smoking cessation treatment may be especially beneficial for low-income veterans. If successful in the VA system, this type of program may be considered for wider use in the U.S.

In contrast to results of the FDCS which found an association between smoking and pain in men but not women [14], there was no evidence of a sex by smoking interaction in the current sample of veterans. While several studies have documented that women are more likely to report orofacial pain conditions than men, the evidenced for sex differences in orofacial pain have been mixed. In a U.S. representative sample from the National Health Interview Survey (NHIS), Lipton and colleagues [47] reported women were more likely to report toothache, oral sores, jaw joint pain, face pain, and burning mouth than men. Similar sex differences in the prevalence of orofacial pain have been documented in older populations [48, 49]. In contrast, several other studies [50, 51] have not found evidence of sex differences across a number of orofacial pain measures. More work is needed to examine the association between sex, pain and smoking among veterans.

Results of the current study are limited by cross-sectional data collection which does not permit assessment of causality. Although the response rate of the survey is consistent with other population-based mail surveys of Afghanistan/Iraq era veterans [29, 52], the low response rate and specificity of the sample may limit generalizability to other veteran, non-veteran, and non-U.S. populations. Additionally, dental/oral concerns severity was assessed with a single item. Future research would benefit from detailed, multi-method assessment of pain and pain-related functional impairment in a variety of samples.

Despite the limitations, the current study adds to the growing knowledge that smoking is significantly associated with increased pain. Tobacco use is a risk factor for the onset and/or exacerbation of dental/oral concerns [2–9]. There is a clear need to reduce smoking among low-income populations within the U.S. and in other low-, middle-, and high-income countries. Low-income populations are especially vulnerable to smoking-related morbidity. Increasing access to preventative oral health services for low-income populations could be an important buffer to the deleterious impact of smoking on oral health.

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Figure 1.

Probability of reporting dental/oral concerns by smoking status and income

Note: The low-income cutoff was determined by reported income < 20,000 USD.

Table 1

Prevalence of Smoking by Demographic Variables, Dental/Oral Concerns, and Income

Characteristic	Any Dental/Oral Concern N = 280	Current Smoker N = 190	Former Smoker N = 301	Never Smoker N = 598	Total N = 1114
Gender					
Men	223 (24.3%)	154 (17.2%)	253 (28.2%)	490 (54.6%)	917
Women	57 (29.5%)	36 (18.8%)	48 (25.0%)	108 (56.3%)	193
Race					
Black	66 (35.9%)	25 (14.1%)	35 (19.8%)	117 (66.1%)	184
White	180 (22.8%)	144 (18.5%)	226 (29.1%)	407 (52.4%)	790
Other*	20 (21.3%)	13 (13.8%)	28 (29.8)	53 (56.4%)	94
Age					
< 30	66 (24.2%)	73 (26.8%)	105 (38.6%)	94 (34.6%)	273
30–39	56 (20.2%)	43 (15.6%)	71 (25.8%)	161 (58.6%)	277
40	155 (28.1%)	71 (13.3%)	125 (23.5%)	337 (63.2%)	551
Military Rank					
Enlisted	233 (28.6%)	177 (22.1%)	247 (30.8%)	377 (47.1%)	814
Officer	42 (14.4%)	13 (4.59%)	53 (18.73%)	217 (76.7%)	291
MH Screen					
Positive	98 (42.6%)	59 (26.2%)	69 (30.7%)	97 (43.1%)	225
Negative	173 (20.4%)	129 (15.2%)	227 (26.8%)	491 (58.0%)	847
Income					
< 20,000 USD	46 (43.8%)	34 (32.4%)	33 (31.4%)	38 (36.2%)	105
20,000 USD	231 (23.3%)	154 (15.9%)	267 (27.5%)	549 (56.6%)	991

MH = Mental health

* Other includes American-Indian, Pacific Islander, Other

Table 2

Main Effects and Interaction Models Associated With Any Dental/Oral Concerns.

Variable	Univariate Model OR [95% CI]	Multivariate Model ^a OR [95% CI]	Interaction Model OR [95% CI]
Tobacco Use (Ref: never smoking)			
Current smoking	2.00 [*] [1.40, 2.86]	1.64 [*] [1.11, 2.42]	1.54 [0.96, 2.47]
Former smoking	1.39 [*] [1.00, 1.91]	1.30 [0.93, 1.84]	1.34 [0.95, 1.88]
Income < 20,000 USD (Ref: income ≥ 20,000 USD)	2.56 [*] [1.70, 3.87]	2.38 [*] [1.49, 3.79]	1.67 [0.95, 2.95]
Covariates			
Age	1.02 [*] [1.00, 1.03]	1.04 [*] [1.02, 1.06]	1.04 [*] [1.03, 1.06]
Female gender (Ref: male)	1.31 [0.93, 1.84]	1.41 [0.98, 2.04]	1.60 [1.06, 2.42]
White ethnicity (Ref: non-White)	0.68 [*] [0.50, 0.92]	0.79 [0.57, 1.10]	0.79 [0.57, 1.09]
Enlisted rank (Ref: officer)	2.33 [*] [1.63, 3.33]	2.02 [*] [1.36, 2.98]	2.02 [*] [1.37, 2.99]
MH screen (Ref: negative screen)	2.78 [*] [2.04, 3.78]	2.24 [*] [1.61, 3.11]	2.33 [*] [1.67, 3.25]
Interaction terms			
Current Smoking × Income < 20,000 USD	--	--	3.06 [*] [1.14, 8.17]
Current Smoking × Gender	--	--	0.54 [0.21, 1.37]

MH = mental health.

^a All main effects variables entered into model simultaneously.^{*} p < .05