Title

The Association Between Occupational Exposures and Cigarette Smoking Among Operating Engineers

Journal
Archives of Environmental & Occupational Health, 69(3)

ISSN
1933-8244

Authors
Hong, OiSaeng
Duffy, Sonia A
Choi, Seung Hee
et al.

Publication Date
2014-07-03

DOI
10.1080/19338244.2013.763760

Peer reviewed

Published in final edited form as:
Arch Environ Occup Health. 2014 ; 69(3): . doi:10.1080/19338244.2013.763760.

The association between occupational exposures and cigarette smoking among operating engineers

OiSaeng Hong, RN, PhD, FAAN[1,*], **Sonia A. Duffy, RN, PhD, FAAN**[2], **Seung Hee Choi, RN, PhD**[3], and **Dal Lae Chin, RN, PhD**[1]

[1]School of Nursing, University of California San Francisco, San Francisco, CA

[2]University of Michigan University of Michigan, Nursing, Otolaryngology, Psychiatry & VA Center for Clinical Management Research, VA Ann Arbor Healthcare System

[3]School of Nursing, University of Michigan, Ann Arbor, MI

Abstract

The purpose of this study was to determine the relationship between occupational exposures and cigarette smoking among operating engineers. A cross-sectional survey was conducted with operating engineers (N=412) from a mid-western state in the United States. The survey included validated questions on cigarette smoking, occupational exposures, demographics, comorbidities, and health behaviors.

About 35% were current smokers. Those exposed to asphalt fumes, heat stress, concrete dust, and welding fumes were less likely to smoke (OR=.79; 95CI: .64–.98). Other factors associated with smoking included younger age (OR=.97; 95CI:.94–.99), problem drinking (OR=1.07; 95CI:1.03–1.12), lower Body Mass Index (OR=.95; 95CI:.90–.99), and being separated/ widowed/ divorced (OR=2.24; 95CI:1.19–4.20). Further investigation is needed for better understanding about job specific exposure patterns and their impact on cigarette smoking among operating engineers.

Keywords

Smoking; Occupational exposure; Blue-collar workers; Operating engineers

Introduction

Blue-collar workers are at significant risk for cancer in that 35% are current smokers compared to 20% of white-collar workers.[1] Compared to other workers, blue-collar workers are more likely to smoke and are less successful in quitting despite a similar rate of quit attempts.[1,2] Cigarette smoking is the health behavior that has the single largest impact on health inequalities.[1]

The high rate of smoking among blue-collar workers is of particular concern given that many are exposed to occupational carcinogens, such as silica, diesel exhaust, fumes, and asbestos, which might increase disease risks associated with smoking.[3] While many have studied on factors contributing to elevated tobacco use in blue-collar workers, limited research has focused on work environment that may influence workers' smoking. From an analyses of the U.S. National Health Interview Survey, Sterling and Weinkam[4] found that

*Corresponding Author: OiSaeng Hong, RN, PhD, FAAN, Professor & Director of Occupational and Environmental Health Nursing Graduate Program, School of Nursing, University of California, San Francisco (UCSF), 2 Koret Way, Room N 531D, San Francisco, CA 94143-0608, oisaeng.hong@nursing.ucsf.edu.

smoking was much more prevalent among workers who were also more exposed to hazards (such as irritating, toxic dusts, and fumes) in the workplace and much less prevalent among those less exposed to such hazards. Sorensen et al.[5] reported that blue-collar workers reporting exposure to chemical hazards on the job were significantly more likely to be smokers than were unexposed workers. Similarly, in a recent examination of data from building trades workers (N=1,817), Chin and her colleagues[6] found that exposures to dust and chemicals at work were significantly associated with an increased likelihood of current smoking. On the other hand, Okechukwu et al.[7] found no significant difference in the association between exposure to occupational hazards (e.g., dust, chemicals, noise and ergonomics strain) and smoking among blue-collar workers.

Operating engineers (those who are responsible for the operation of heavy earth moving equipment to construct buildings, bridges, and roads) have a high percentage of smoking[8] and are at particular risk for cancers of the lung,[9] head and neck,[10] and trachea and bronchi.[11] Operating engineers are also exposed to a variety of occupational hazards at work. Hence the purpose of this study was to determine the relationship between occupational exposures (e.g., asbestos, asphalt fumes, benzene, lead/lead paint, silica, solvents, etc.) and cigarette smoking among operating engineers, controlling for other covariates known to be associated with cigarette smoking.

Method

Study Design and Participants

The cross-sectional survey was conducted among operating engineers in a mid-western state in the United States. The study participants were recruited from 16,000 workers in the entire state of Michigan attending either a 3-year apprenticeship program or an 8-hour Hazardous Materials (HAZMAT) training during the Winter of 2008. The instructor for the HAZMAT course explained the study and passed out the survey packets, including a study information sheet, questionnaire, and return envelope, until a quota of 500 was reached. Ninety percent of the operating engineers who were asked to participate agreed and returned the self-administered survey. Among the returned surveys, two were incomplete and 86 had missing data on either smoking status or occupational exposures or other covariates, thus 412 were included in the analysis in the present study. All participants received a $10 gasoline gift card for completing the survey. All study protocols were approved by the University of Michigan Institutional Review Board.

Measures

Dependent Variable: Smoking Status—Smoking status was measured by a single question which asked them to circle the best answer: (1) I currently smoke cigarettes, (2) I have smoked in the past, but quit within the last month, (3) I have smoked in the past, but quit within the last six months, (4) I have smoked in the past, but quit within the last year, (5) I have smoked in the past, but quit over a year ago, and (6) I have never used tobacco products. According to a 30-day prolonged abstinence measure,[12] smokers were defined as those who currently smoked or those who had smoked in the past but quit within the last month.

Independent Variable Occupational Exposures—Nine different hazards that are common to heavy equipment operators in construction were included: asbestos, asphalt fumes, benzene, concrete dust/milling, heat stress, lead/lead paint, silica, solvents, welding fumes, and others. These measures were taken from the Occupational Safety and Health Administration (OSHA) form (http://www.oshatrain.org/pages/library.html).[13] The participants were asked to select (yes/no) all types of occupational hazards to which they had ever been exposed. Types of hazards were grouped into two distinct categories using Explanatory Factor Analyses (EFA) as described in the statistical analysis and result sections. EPA, a statistical technique within factor analysis, is based on common factor model and its overall goal is to identify underlying relationships among measured variables.[14] Thus, we chose EFA to reveal common factor structure that may exist among those occupational exposure variables.

Covariates—Since demographic characteristics have shown significant association with smoking,[1,15–18] age, sex, race, marital status, and educational level, and years of experience on the job were included as covariates. Medical comorbidities and depression have also been shown to influence smoking,[19,20] hence, **medical comorbidities** were assessed by the question (i.e., "Have you ever been diagnosed or treated for any of the following health problems?") with the list of diseases (cancer, lung disease, heart disease, high blood pressure, stroke, psychiatric problems, diabetes, arthritis, and other) with a yes/no response.[21] These conditions were then totaled and dichotomized into two groups: people who reported no medical comorbidity and those who reported one or more comorbid conditions. **Depression** was measured using the 20-item, validated Center for Epidemiologic Studies/Depressed Mood Scale (CES-D).[22] Possible scores range from zero to 60 with a cut-off score of 16 or higher indicating depression. The reliability of the measure in the present study was Cronbach's $\alpha = .74$.

Since earlier studies reported that health-related behaviors would influence smoking,[23–28] this study included several behavioral variables such as problem alcohol drinking, BMI, and sleep quality. **Alcohol drinking** was measured by the 10-item validated Alcohol Use Disorder Identification Test (AUDIT).[29] Possible scores range from zero to 40 with a cut-off point of eight or higher indicating problem drinking. The reliability of the measure in the present study was Cronbach's $\alpha = .81$. **BMI (**weight in kilograms divided by the square of height in meters) was calculated based on self-reported height (without shoes) and weight. **Sleep quality** was measured by the 6-item, validated Medical Outcomes Study (MOS) sleep scale.[30] The reliability of the measure in the present study was Cronbach's $\alpha = .72$.

Data Analysis

Descriptive statistics (frequencies, means, and percentages) were computed for all variables. Internal consistency reliability for each scale was examined using Cronbach's alpha coefficients. Associations between the dependent variable and the independent variables were assessed using Chi-square, Spearman's rho correlation coefficients for categorical variables and Pearson correlation coefficients for continuous variables.

Participants' responses for nine occupational exposures were subjected to a series of EFA to group them in logical manner. EFA was done using oblique rotation (direct oblimin). Oblique rotation does not impose the restriction that factors be orthogonal so results in terminal factors after oblique rotation are, in general, correlated with each other.[31] The following principles guided EFA: (1) a minimum eigenvalue of 1 as a cutoff value for extraction, (2) the point of discontinuity of the scree plot, and (3) a criterion of .30 as an acceptable minimum loading.[32,33]

Using a listwise deletion method, multivariable logistic regression analyses were conducted with two factors of occupational exposures and significant covariates in bivariate analyses. Assessment for multicollinearity was conducted first to check for high intercorrelations among independent variables. Since age and years of job experience was highly correlated (r=.64, p<.001), only age was included in the final multivariable model. Using the rule of 10 participants per factor for regression analysis,[34] there was sufficient power to include over 14 variables since there were 142 smokers and 270 non-smokers. Analyses were conducted using the Statistical Package for the Social Science (SPSS) version 19. A value of $p<.05$ was considered to be significant.

Results

Characteristics of the participants

The characteristics of the study participants are shown in Table 1. Participants were predominantly middle aged (mean age=43.2 years), male (91.2%), and white (91.8%). About 67.6% of the participants were married and 59.8% had a high school education or less. The majority (81.3%) of the participants worked more than 10 years. Approximately 34.5% (142/412) were current smokers. Almost half (46.7%) screened positive for depressive symptoms (≥16scores), and 31.2% scored positive for problem drinking (≥8scores). The mean BMI was 30.2, and the majority of the participants were overweight (25–29.9, 41.1%) or obese (≥30, 42.8%). Mean of sleep quality was 70.4, a bit lower when compared to population norms of 72.[30]

Figure 1 shows the distribution of self-reported occupational hazardous exposures. The participants were exposed to various occupational hazards: heat stress (75.7%), concrete dust/milling (75.5%), welding fumes (71.4%), asphalt fumes (63.6%), solvents (58.0), silica (56.8%), asbestos (51.2%), lead/lead paint (40.3%), and benzene (37.9%).

Two factors of occupational exposures

Simple bivariate correlations among the nine items ranged from *spearman's rho*=.20 to .53 for the study sample. Consistent positive intercorrelations were found among the items. The appropriateness of the correlation matrix for factor analytic methods was determined by computing Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. Bartlett's test of sphericity can be used to test the hypothesis that the correlation matrix is an identity matrix. The value of the test statistic for sphericity was large ($\chi^2=956.446$) and the associated significance levels were small ($p<.001$) for the study participants. The KMO measure of sampling adequacy is an index for comparing the observed correlation coefficients and the partial correlation coefficients. Reasonably large values for the KMO coefficient are needed for factor analysis of the variables.[32] The value of the KMO statistics for the study participants was .87. These two measures confirmed that the items cohered psychometrically and the use of the factor model was appropriate for these data.[32]

Principal components factor analysis with oblique rotation (direct oblimin) yielded two-factor solution as summarized in Table 2. All of nine exposure variables loaded strongly on only one of the two factors with loadings of .46 or greater. Exposure Factor 1 included five types of occupational hazards: lead/ Lead paint, asbestos, benzene, solvents, and silica. Exposure Factor 2 had four types of hazards: asphalt fumes, heat stress, concrete dust, and welding fumes. The two factors explained 54.21% of variance (41.1% and 13.1% by Exposure Factor 1 and 2, respectively).

Bivariate relationships with smoking

Bivariate relationships of cigarette smoking with the independent variables (exposure factors 1 and 2) and covariates are summarized in Table 3. Both occupational exposure factor 1 and 2 showed significant inverse relationships to smoking, indicating that workers who reported more occupational exposures were less likely to smoke (p=.006, p=.001). Among other covariates, age, marital status, job experience, medical comorbidities, alcohol use, and BMI were significantly associated with smoking. Compared with non-smokers, smokers were more likely to be younger (p=.015), to be separated/widowed/divorced (p=.015), to have fewer years of job experience (p=.020), to have no medical comorbidities (p=.023), to have higher alcohol use (p<.001), and to have lower BMI (p<.001). There were no differences in gender, race, and educational level between smokers and non-smokers. Interestingly, no significant differences were found in depressive symptoms between smokers and non-smokers (16.80 vs. 16.31, p=.519). Both groups included equally high percentages of workers with depression (47.4% vs. 46.3%). In addition, the two groups did not show differences in sleep quality.

Multivariable Logistic Regression Analysis

The results of the multivariable logistic regression analysis for Occupational Exposure Factors are summarized in Table 4. While Occupational Exposure Factor 1 (Lead/ Lead paint + Asbestos + Benzene + Solvents + Silica) was not significantly associated with current smoking, Occupational Exposure Factor 2 (Asphalt fumes + Heat stress + Concrete dust + Welding fumes) was significantly associated with smoking (OR=.79; 95% CI: .66–.95, p=.012). Two demographic factors were significant correlates of smoking: younger workers were more likely to smoke than older workers (OR=.97; 95% CI: .94–.99, p=.033) and workers who were separated/widowed/divorced were more likely to smoke compared to those who were married (OR=2.24; 95% CI: 1.19–4.20, p=.013). Two health behavior factors were also significantly associated with smoking: BMI (OR=.95; 95% CI: .90–.99, p=.015) and problem drinking (OR=1.07; 95% CI: 1.03–1.12, p=.001). As expected, the participants with lower BMI and higher AUDIT scores (indicating problem drinking) were more likely to smoke. Medical comorbidities were not significantly associated with current smoking.

Discussion

The present study is one of the first ones to examine the relationship between specific occupational hazardous exposures and smoking among operating engineers. The study found exposures to certain type of hazards (Asphalt fumes + Heat stress + Concrete dust + Welding fumes) demonstrated an inverse relationship to operating engineers' smoking (i.e., workers with higher exposure to occupational hazards were less likely to smoke). This finding contradicts earlier work that reported higher exposure to occupational hazards, such as chemicals and dust, was associated with increased current smoking among workers,[4–6] albeit previous studies did not include specific types of occupational hazards and several of these studies are old.

In talking with our community partners at the operating engineers training site to explain these results, hazards such as heat stress, asphalt fume, and concrete dust are more related to outdoor road work which is highly physical and labor intensive. Since asphalt and concrete dry quickly, operating engineers must work very quickly and may not have time to take a smoking break. It is also possible that operating engineers who require labor intensive work might be more health conscious because losing their health may mean losing their work. Thus, they may be less likely to smoke to maintain good physical health to enhance their work performance. An additional anecdotal explanation from workers was that one of their asphalt concrete companies has a no smoking policy, which might have influenced at last some of the operating engineers' smoking behavior.

Recent work by Chin and her colleague[6] showed that workers with greater concern about their exposure to occupational hazards were less likely to smoke. The current study did not assess operating engineers' concerns about hazardous exposures on the job and its relationship with smoking. However, it may be possible that operating engineers in the study became more concerned about their health when they were exposed to visually recognizable hazards such as asphalt fumes, heat stress, concrete dust, and welding fumes, thus they had a

NIH-PA Author Manuscript

NIH-PA Author Manuscript

less likelihood of smoking. Workers' concerns about their exposures to hazardous agents at work may be an important influence in smoking behavior.

Interestingly, exposure to the other types of hazards (lead/ lead paint, asbestos, benzene, solvents, and silica) did not affect operating engineers' smoking. While we did not find scientific explanation for this interesting finding, we have a few plausible explanations that came from field workers. These hazards are related more to building and demolition work than road work. Operating engineers who are involved in building and demolition work often having long periods of idle time waiting for parts or sitting around for other trade workers to complete their jobs before performing their tasks. This waiting period may provide operating engineers with ample opportunities to smoke. Another possibility is that, compared to the other group of exposures, these hazards (lead/ lead paint, asbestos, benzene, solvents, and silica) are less visible to the naked eye. Therefore, workers may be less aware of their exposures to those hazards. Therefore, smoking cessation interventions raising workers' consciousness of the synergic effects of occupational hazards with smoking on developing pulmonary diseases would be beneficial for operating engineers exposed to those less visible hazards.

The present study shows that operating engineers have a 35% smoking prevalence, which is consistent with the national trend for construction workers or other blue collar worker groups. Even though the prevalence of current smoking among US adults (aged 18 years or older) has declined during the past four decades from 40% in 1964[35] to 19% in 2010,[36] smoking prevalence was highest among construction workers (38.8%) and lowest among workers employed in the health diagnosing professions (5%), with blue collar occupations often having a greater than 30% smoking prevalence.[37] However, it is a concern that the high prevalence (35%) of smoking found in the present study is much higher than that of the general working population (19.6%),[15] in particular, white-collar workers (20.3 %).[1]

Worksite smoking policies such as smoke free workplaces can reduce cigarette smoking during working hours,[38] decrease workers' exposure to second hand smoking,[39,40] and reduce relapse among smokers who have recently quit. [41] However, as reported earlier, blue-collar workplaces are less likely to have smoke free policies in place.[42–45] Furthermore, certain groups of workers including operating engineers work outside; thus, they are not subject to indoor air policies on the prohibition of cigarette smoking.

Younger age was significantly associated with current smoking, which supports previous research findings.[1,15,16] The present study also found separated/widowed/divorced workers were significantly more likely to smoke than married ones, which is consistent with previous studies.[17,18] The protective effect of marriage on smoking may be because marriage is a marker of social support. Worksite smoking cessation interventions that include social support may enhance quit rates as previous studies have shown that that social support was likely to improve smokers' intention to quit smoking, confidence in the ability to quit smoking, and actual success in quitting smoking.[46–48]

The strong association between smoking cigarettes and problem drinking has been reported in many studies.[24,25,27] It is important to assess the drinking patterns of smokers to improve quitting smoking. The present study also found that current smokers had lower BMI, which is consistent with the reports of previous studies.[23,26]

Limitations

This was a cross-sectional study therefore the direction of causality cannot be determined. The study was conducted with operating engineers who were predominantly white males working in one state in the Midwestern region of the US, thus the findings cannot be generalized to all operating engineers. Occupational exposure was assessed based on the operating engineer's self-report with no objective work environment surveillance data. While we used validated instruments to assess other covariates, such as alcohol drinking, depression, sleep quality, all data was collected as self-report and may not be as accurate as clinical assessment. Nonetheless, the study contributes valuable information with regards to our limited knowledge on occupational exposures among a large group of workers.

Conclusion

Occupational exposure to certain types of hazards (asphalt fumes, heat stress, concrete dust, and welding fumes) that are more likely to occur during road work were significantly inversely associated with smoking. Exposure to other types of hazards (lead/ lead paint, asbestos, benzene, solvents, and silica) showed no association with operating engineers' smoking behavior. The findings of this study suggest that the type of workers' jobs may influence their smoking rates. More studies need to be conducted to better understand job specific exposure patterns and their impact on cigarette smoking among operating engineers.

Acknowledgments

The authors gratefully acknowledge funding from the P30-Michigan Center for Health Intervention (MICHIN), supported by the National Institute of Health/National Institute of Nursing Research (NIH/NINR) (Grant Number: P30NR009000). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH/NINR. The authors would like to acknowledge the operating engineers who participated in this study.

References

1. Barbeau EM, Krieger N, Soobader MJ. Working class matters: Socioeconomic disadvantage, race/ ethnicity, gender, and smoking in NHIS 2000. Am J Public Health. 2004; 94(2):269–278. [PubMed: 14759942]
2. Giovino, GA.; Pederson, L.; Trosclair, A. The prevalence of selected cigarette smoking behaviors by occupational class in the United States. Washington, DC. Paper presented at the Work, Smoking, and Health: A NIOSH Scientific Workshop; 2000.
3. Oliver LC, Miracle-McMahill H, Littman AB, Oakes JM, Gaita RR Jr. Respiratory symptoms and lung function in workers in heavy and highway construction: A cross-sectional study. Am J Ind Med. 2001; 40(1):73–86. [PubMed: 11439399]
4. Sterling T, Weinkam J. The confounding of occupation and smoking and its consequences. Soc Sci Med. 1990; 30(4):457–467. [PubMed: 2315728]
5. Sorensen G, Stoddard A, Hammond SK, Hebert JR, Avrunin JS, Ockene JK. Double jeopardy: Workplace hazards and behavioral risks for craftspersons and laborers. Am J Health Promot. 1996; 10(5):355–363. [PubMed: 10163305]
6. Chin DL, Hong O, Gillen M, Bates MN, Okechukwu CA. Cigarette smoking in building trades workers: The impact of work environment. Am J Ind Med. 2012; 55(5):429–439. [PubMed: 22392815]
7. Okechukwu CA, Krieger N, Chen J, Sorensen G, Li Y, Barbeau EM. The association of workplace hazards and smoking in a U.S. multiethnic working-class population. Public Health Rep. 2010; 125(2):225–233. [PubMed: 20297749]
8. Duffy SA, Missel AL, Waltje AH, Ronis DL, Fowler KE, Hong O. Health behaviors of Operating Engineers. AAOHN Journal. 2011; 59(7):293–301. [PubMed: 21688764]
9. Stern F, Haring-Sweeney M. Proportionate mortality among unionized construction operating engineers. Am J Ind Med. 1997; 32(1):51–65. [PubMed: 9131212]
10. Boffetta P, Richiardi L, Berrino F, et al. Occupation and larynx and hypopharynx cancer: an international case-control study in France, Italy, Spain, and Switzerland. Cancer Causes Control. 2003; 14(3):203–212. [PubMed: 12814199]

11. Wang E, Dement JM, Lipscomb H. Mortality among North Carolina construction workers, 1988–1994. Appl Occup Environ Hyg. 1999; 14(1):45–58. [PubMed: 10730138]
12. Prochaska JO, Velicer WF, Fava JL, Rossi JS, Tsoh JY. Evaluating a population-based recruitment approach and a stage-based expert system intervention for smoking cessation. Addict Behav. 2001; 26(4):583–602. [PubMed: 11456079]
13. Occupational Safety & Health Administration (OSHA). [Accessed November, 18, 2012] OSHAcademy library and resources. n.d. http://www.oshatrain.org/pages/library.html
14. Norris M, Lecavalier L. Evaluating the use of exploratory factor analysis in developmental disability psychological research. J Autism Dev Disord. 2010; 40(1):8–20. [PubMed: 19609833]
15. Centers for Disease Control and Prevention (CDC). Current cigarette smoking prevalence among working adults--United States, 2004–2010. MMWR Morb Mortal Wkly Rep. 2011; 60(38):1305–1309. [PubMed: 21956406]
16. Nordstrom B, Kinnunen T, Utman C, Krall E, Vokonas P, Garvey A. Predictors of continued smoking over 25 years of follow-up in the normative aging study. Am J Public Health. 2000; 90(3):404–406. [PubMed: 10705859]
17. Lee S, Cho E, Grodstein F, Kawachi I, Hu FB, Colditz GA. Effects of marital transitions on changes in dietary and other health behaviours in US women. Int J Epidemiol. 2005; 34(1):69–78. [PubMed: 15231759]
18. Nystedt P. Marital life course events and smoking behaviour in Sweden 1980–2000. Soc Sci Med. 2006; 62(6):1427–1442. [PubMed: 16162388]
19. Duffy SA, Biotti JK, Karvonen-Gutierrez CA, Essenmacher CA. Medical comorbidities increase motivation to quit smoking among veterans being treated by a psychiatric facility. Perspect Psychiatr Care. 2011; 47(2):74–83. [PubMed: 21426352]
20. McClave AK, Dube SR, Strine TW, Kroenke K, Caraballo RS, Mokdad AH. Associations between smoking cessation and anxiety and depression among U.S. adults. Addict Behav. 2009; 34(6–7):491–497. [PubMed: 19217720]
21. Mukerji SS, Duffy SA, Fowler KE, Khan M, Ronis DL, Terrell JE. Comorbidities in head and neck cancer: Agreement between self-report and chart review. Otolaryngol Head Neck Surg. 2007; 136(4):536–542. [PubMed: 17418247]
22. Radloff LS. The CES-D Scale. Applied Psychological Measurement. 1977; 1(3):385–401.
23. Canoy D, Wareham N, Luben R, et al. Cigarette smoking and fat distribution in 21,828 British men and women: A population-based study. Obes Res. 2005; 13(8):1466–1475. [PubMed: 16129730]
24. Dawson DA. Drinking as a risk factor for sustained smoking. Drug Alcohol Depend. 2000; 59(3):235–249. [PubMed: 10812284]
25. Falk DE, Yi HY, Hiller-Sturmhofel S. An epidemiologic analysis of co-occurring alcohol and tobacco use and disorders: Findings from the National Epidemiologic Survey on Alcohol and Related Conditions. Alcohol Res Health. 2006; 29(3):162–171. [PubMed: 17373404]
26. Lahti-Koski M, Pietinen P, Heliovaara M, Vartiainen E. Associations of body mass index and obesity with physical activity, food choices, alcohol intake, and smoking in the 1982–1997 FINRISK Studies. Am J Clin Nutr. 2002; 75(5):809–817. [PubMed: 11976153]
27. Leeman RF, McKee SA, Toll BA, et al. Risk factors for treatment failure in smokers: Relationship to alcohol use and to lifetime history of an alcohol use disorder. Nicotine Tob Res. 2008; 10(12):1793–1809. [PubMed: 19023831]
28. Wetter DW, Young TB. The relation between cigarette smoking and sleep disturbance. Prev Med. 1994; 23(3):328–334. [PubMed: 8078854]
29. Saunders JB, Aasland OG, Babor TF, de la Fuente JR, Grant M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption--II. Addiction. 1993; 88(6):791–804. [PubMed: 8329970]
30. Hays RD, Martin SA, Sesti AM, Spritzer KL. Psychometric properties of the Medical Outcomes Study Sleep measure. Sleep Med. 2005; 6(1):41–44. [PubMed: 15680294]
31. Kim, JO.; Mueller, CW. Introduction to factory analysis: What it is and how to do it. Newbury Park, CA: SAGE Publications, Inc; 1978.
32. Brzoska, P.; Razum, O. Validity issues in quantitative migrant health research: The example of illnes perceptions. New York: Peter Lang; 2010.

33. Nunnally, JC.; Bernstein, IH. Psychometric theory. New York, NY: McGraw-Hill; 1994.
34. Harrell FE Jr, Lee KL, Mark DB. Multivariable prognostic models: Issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. Stat Med. 1996; 15(4): 361–387. [PubMed: 8668867]
35. U.S. Department of Health and Human Services (U.S. DHHS). Reducing the consequences of smoking: 25 years of progress; A report of the Surgeon General. Rockville, MD: U.S. Department of Health and Human Services, CDC; 1989.
36. CDC. Vital signs: Current cigarette smoking among adults aged ≥18 years—United States, 2005–2010. MMWR Morb Mortal Wkly Rep. 2011; 30(35):1207–1212.
37. Lee DJ, Fleming LE, Arheart KL, et al. Smoking rate trends in U.S. occupational groups: The 1987 to 2004 National Health Interview Survey. J Occup Environ Med. 2007; 49(1):75–81. [PubMed: 17215716]
38. Fichtenberg CM, Glantz SA. Effect of smoke-free workplaces on smoking behaviour: Systematic review. BMJ. 2002; 325(7357):188. [PubMed: 12142305]
39. Arheart KL, Lee DJ, Dietz NA, et al. Declining trends in serum cotinine levels in US worker groups: The power of policy. J Occup Environ Med. 2008; 50(1):57–63. [PubMed: 18188082]
40. Hammond SK, Sorensen G, Youngstrom R, Ockene JK. Occupational exposure to environmental tobacco smoke. JAMA. 1995; 274(12):956–960. [PubMed: 7674526]
41. Yasin SM, Moy FM, Retneswari M, Isahak M, Koh D. Timing and risk factors associated with relapse among smokers attempting to quit in Malaysia. Int J Tuberc Lung Dis Jul. 2012; 16(7): 980–985.
42. Gerlach KK, Shopland DR, Hartman AM, Gibson JT, Pechacek TF. Workplace smoking policies in the United States: Results from a national survey of more than 100,000 workers. Tob Control. 1997; 6(3):199–206. [PubMed: 9396104]
43. Plescia M, Malek SH, Shopland DR, Anderson CM, Burns DM. Protecting workers from secondhand smoke in North Carolina. N C Med J. 2005; 66(3):186–191. [PubMed: 16130941]
44. Shopland DR, Anderson CM, Burns DM, Gerlach KK. Disparities in smoke-free workplace policies among food service workers. J Occup Environ Med. 2004; 46(4):347–356. [PubMed: 15076653]
45. U.S. DHHS. The health consequences of involuntary exposure to tobacco smoke: A report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, CDC; 2006.
46. Westmaas JL, Bontemps-Jones J, Bauer JE. Social support in smoking cessation: reconciling theory and evidence. Nicotine Tob Res. 2010; 12(7):695–707. [PubMed: 20513695]
47. Mermelstein R, Cohen S, Lichtenstein E, Baer JS, Kamarck T. Social support and smoking cessation and maintenance. J Consult Clin Psychol. 1986; 54(4):447–453. [PubMed: 3745596]
48. Sorensen G, Emmons K, Stoddard AM, Linnan L, Avrunin J. Do social influences contribute to occupational differences in quitting smoking and attitudes toward quitting? Am J Health Promot. 2002; 16(3):135–141. [PubMed: 11802258]

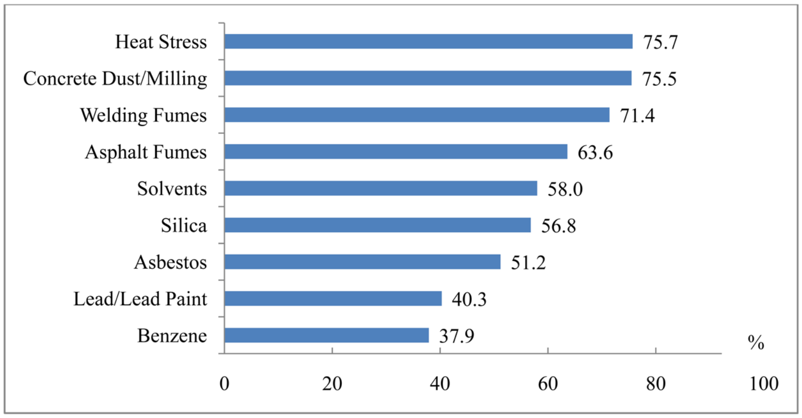

Figure 1.
Occupational exposures among operating engineers (N=412)

Table 1

Characteristics of the Study Participants (N=412)*

Characteristics	Mean ± SD (Range)
Age	43.24 ± 9.28 (18 – 70)
CES-D (Depressive symptoms)	16.48 ± 6.56 (0 – 45)
AUDIT (Alcohol problems)	6.01 ± 5.51 (0 – 29)
BMI	30.20 ± 5.95 (18.26 – 58.25)
Sleep quality	70.44 ± 16.78 (0 – 100)
	N (%)
Smoking Status	
Current smokers	142 (34.5)
Non-smokers	270 (65.5)
Gender	
Male	363 (91.2)
Female	35 (8.8)
Race	
White	359 (91.8)
Non-white	32 (8.2)
Marital status	
Married	271 (67.6)
Separated/ Widowed/ Divorced	66 (16.5)
Non-married	64 (16.0)
Education	
High school or lower	239 (59.8)
College or higher	161 (40.3)
Job experience	
Up to 9 years	75 (18.8)
10 or more years	325 (81.3)
Medical comorbidities	
None	196 (49.1)
One or more	203 (50.9)
CES-D (Depressive symptoms)	
Yes (≥16scores)	182 (46.7)
No (<16scores)	208 (53.3)
AUDIT (Alcohol problems)	
Yes (≥8scores)	124 (31.2)
No (<8scores)	273 (68.8)
BMI	
Underweight (<18.5)	1 (0.3)
Normal (18.5–24.9)	63 (15.9)
Overweight (25–29.9)	163 (41.1)

Characteristics	Mean ± SD (Range)
Obese (≥30)	170 (42.8)

*Note.

Participant numbers in each variable do not always add up to the total number of participants because of missing data

Table 2

Factor Analysis of Occupational Exposure (N=412)

Occupational Exposure	**Exposure Factor 1**	**Exposure Factor 2**
Lead/Lead paint	.859	
Asbestos	.764	
Benzene	.747	
Solvents	.531	
Silica	.455	
Asphalt Fumes		.814
Heat Stress		.812
Concrete Dust/Milling		.636
Welding Fumes		.587

Table 3

Bivariate Relationship of Predictors with Smoking (N=412)

	Smokers (n=142, 34.5%)	Non-smokers (n=270, 65.5%)	P-value *
	Mean (SD)	Mean (SD)	
Age	41.63 (8.91)	44.05 (9.38)	.015
CES-D (Depressive symptoms)	16.80 (7.85)	16.31 (5.79)	.519
AUDIT (Alcohol use)	7.71 (5.97)	5.14 (5.07)	<.001
BMI	28.62 (5.35)	30.96 (6.08)	<.001
Sleep Quality	68.22 (17.44)	71.58 (16.35)	.057
Occupational Exposure Factor 1[a]	2.11 (1.84)	2.62 (1.74)	.006
Occupational Exposure Factor 2[b]	2.54 (1.44)	3.03 (1.21)	.001
	N (%)	N (%)	P-value
Gender			
Male	119 (90.2)	244 (91.7)	.737
Female	13 (9.8)	22 (8.3)	
Race			
White	111 (88.1)	248 (93.6)	.098
Non-White	15 (11.9)	17 (6.4)	
Educational level			
High school or less	84(63.6)	155 (57.8)	.315
College or more	48(36.4)	113 (42.2)	
Marital status			
Married	82 (61.7)	189 (70.5)	
Separated/ Widowed/ Divorced	32 (24.1)	34 (12.7)	.015
Never married	19 (14.3)	45 (16.8)	
Job experience			
Up to 9 years	34 (25.6)	41 (15.4)	.020
10 or more years	99 (74.4)	226 (84.6)	
Medical comorbidities			
None	76 (57.6)	120 (44.9)	.023
One or more	56 (42.4)	147 (55.1)	

[a] Occupational Factor 1: Lead/Lead paint + Benzene + Asbestos + Solvents + Silica

[b] Occupational Factor 2: Asphalt fumes + Heat stress + Concrete dust +Welding fumes

[*] P-value for t-test or chi-square test

Table 4

Multivariable Logistic Regression (N=412)

	Odds ratio	95% CI	P-value
Occupational Exposure Factor 1[a]	.99	.85 – 1.16	.956
Occupational Exposure Factor 2[b]	.79	.64 – .98	.033
Age (continuous)	.97	.94 – .99	.033
Marital status			.009
Married (Reference)			
Separated/Widowed/Divorced	2.24	1.19 – 4.20	.013
Never married	.61	.30 – 1.23	.163
Medical comorbidities			
None (Reference)			
One or more	.76	.47 – 1.23	.269
Alcohol drinking (AUDIT) (continuous)	1.07	1.03 – 1.12	.001
BMI (continuous)	.95	.90 – .99	.015

[a]Occupational Factor 1: Lead/Lead paint + Benzene + Asbestos + Solvents + Silica

[b]Occupational Factor 2: Asphalt fumes + Heat stress + Concrete dust +Welding fumes