



Original Article

The association between active smoking, smokeless tobacco, second-hand smoke exposure and insufficient sleep

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ABSTRACT

Background: Studies have shown that cigarette smoking is associated with sleep disorders in the general population. But studies examining the association between smokeless tobacco use, second-hand smoke exposure and insufficient rest/sleep are limited.

Methods: We examined the association between smoking, smokeless tobacco use ($n = 83,072$), second-hand smoke exposure ($n = 28,557$) and insufficient rest/sleep among adults aged ≥ 20 years in the state-based 2008 Behavioral Risk Factor Surveillance System. Exposure to second-hand smoke was defined as >1 day of exposure to cigarette smoking either at home or in the workplace in the preceding 7 days. Insufficient rest/sleep was defined as not getting enough rest/sleep everyday in the preceding 30 days.

Results: Compared to never smokeless tobacco users, the odds ratio (OR; 95% confidence interval [CI]) of insufficient rest/sleep was 1.16 (1.00–1.36) and 1.74 (1.37–2.22) among former and current users. Compared to non-smokers/non-smokeless tobacco users, the OR (95% CI) of insufficient rest/sleep for those who were both current smokers and current smokeless tobacco users was 2.21 (1.66–2.94). Regarding second-hand smoke exposure among non-smokers, those with second-hand smoke exposure had higher odds for insufficient rest/sleep than those without. In contrast, the odds of insufficient rest/sleep were similar among current smokers with or without second-hand smoke exposure.

Conclusions: In a multiethnic sample of US adults, compared to non-smokers/non-smokeless tobacco users, those who were both current smokers and current smokeless tobacco users had twice the odds of insufficient sleep. Second-hand smoke exposure was associated with insufficient rest/sleep among non-smokers.

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1. Introduction

Smokeless tobacco (including snuff, snus and chewing tobacco) is claimed to be a less harmful alternative for cigarette smoking and used in harm reduction strategy [1]. Compared to cigarette smoking, smokeless tobacco contains the same amount of (or more) nicotine and is just as addictive [2]. Recent studies conducted in the US and Europe have shown that smokeless tobacco increases the risk of coronary heart disease and stroke [2–5]. Insufficient rest/sleep is an emerging public health problem in the modern world [6] associated with diabetes [7], hypertension [8], obesity [9], depression [10] and cardiovascular disease [11]. Data from the 2008 Behavioral Risk Factor Surveillance System (BRFSS) showed that 11% of Americans reported insufficient rest/sleep for the preceding 30 days [12]. Cigarette smoking has been shown to be associated with a range of sleep disorders including shorter sleep duration [13], difficulty initiating and maintaining sleep [14,15], snoring [16] and daytime sleepiness [17]. Previous cross-sectional studies have reported

associations between active cigarette smoking and insufficient rest/sleep [18,19]. But the association between smokeless tobacco and insufficient rest/sleep has not been studied before.

In a similar vein, the association between second-hand smoke exposure and insufficient rest/sleep has not been consistent in previous studies. While studies among specific populations including pregnant women [20], working men [21], children with asthma [22] and pre-school children [23] reported a positive association between second-hand smoke and insufficient rest/sleep, Davila et al. reported that second-hand smoke exposure was not significantly associated with sleep disorders in the US general population, although active smoking was associated with sleep disorders [18]. In this context, we examined the association among active smoking, smokeless tobacco, second-hand smoke and insufficient rest/sleep in a large representative sample of US adults using the latest 2008 BRFSS data.

2. Methods

The BRFSS is an ongoing, state-based telephone survey conducted by random-digit dialing of non-institutionalized US adults

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aged ≥ 18 years in all 50 states, District of Columbia, Guam, Puerto Rico and US Virgin Islands. The details of the study design, questionnaire and methods are available online [24]. For the current study, we used data from the 2008 BRFSS survey. The questions to assess use of smokeless tobacco/other tobacco products and second-hand smoke exposure were offered to states as optional modules. Of the 414,509 participants, information on smokeless tobacco/other tobacco products was available for 91,155 participants, and information on second-hand smoke was available for 31,094 participants. After excluding participants who were pregnant, age < 20 years, and those with missing information on insufficient rest/sleep, smoking status and other important covariates, 83,072 provided data for the smokeless tobacco analysis and 28,557 provided data for the second-hand smoke analysis. Subjects were required to sign a consent form before their participation, and approval was obtained from the Human Subjects Committee in the US Department of Health and Human Service. This secondary data analysis was approved by the West Virginia University Institutional Review Board.

2.1. Outcome of interest

Insufficient rest/sleep was assessed from the question, “During the past 30 days, for about how many days have you felt you did not get enough rest or sleep?” For the current analysis insufficient rest/sleep was defined as not getting enough rest or sleep everyday in the preceding 30 days.

2.2. Measurement of exposure

Smoking status was categorized into never smokers (smoked < 100 cigarettes during their lifetime), former smokers (smoked ≥ 100 cigarettes lifetime and currently not smoking), current smokers (smoked ≥ 100 cigarettes lifetime and currently smoking). Use of smokeless tobacco was assessed from the questions, “Have you ever used smokeless tobacco products such as chewing tobacco, snuf or snus?” and “Do you currently use chewing tobacco, snuf or snus every day, some days or not at all?” Based on the responses, use of smokeless tobacco was categorized into never, former and current smokers. We assessed current use of tobacco products other than cigarettes (cigars, pipes, bidis, kreteks) from the question, “Do you currently use any tobacco products other than cigarettes?” with the response coded as a dichotomous variable (no, yes). Second-hand smoke exposure was assessed from the questions, “On how many of the past 7 days, did someone smoke in your indoor workplace while you were there?” and “On how many of the past 7 days, did anyone smoke in your home while you were there?” Participants were considered to be exposed to second-hand smoke if they reported > 1 day of exposure to cigarette smoking either at home or in the workplace in the preceding 7 days [25].

2.3. Assessment of covariates

Age, gender, race/ethnicity, alcohol intake, level of education, employment, physical activity and mental illness were assessed using a standardized questionnaire. Heavy alcohol drinking was defined as having more than 2 drinks per day for men and more than 1 drink per day for women in the past month. Education was categorized into below high school, high school, or above high school education. Employment status was categorized as employed, unemployed, retired, student/home maker or unable to work. Body mass index (BMI) was categorized into < 25 , 25–29, ≥ 30 kg/m². “No regular exercise” was defined as not participating in any physical activities such as running, calisthenics, golf, gardening, or walking for exercise in the past month. Individuals were

classified as having mental illness if they reported ever having been told by a doctor or other healthcare provider they had a depressive disorder (depression, major depression, dysthymia, or minor depression) or anxiety disorder (acute stress disorder, anxiety, generalized anxiety disorder, obsessive–compulsive disorder, panic disorder, phobia, posttraumatic stress disorder, or social anxiety disorder).

2.4. Statistical analysis

We examined the baseline characteristics of the study population by means or proportions as appropriate for the variable. We examined the association between categories of smoking, smokeless tobacco and insufficient rest/sleep in two logistic regression models: (1) unadjusted and (2) multivariate model adjusted for covariates previously shown to impact sleep including age, sex, race-ethnicity, education, employment status, heavy drinking, body mass index, no regular exercise and mental illness [10,26]. We initially examined the association among cigarette smoking, smokeless tobacco use and other tobacco use on sleep in separate multivariable models. However, cigarette smokers may also use smokeless tobacco. Such combined exposure to different tobacco products may be more strongly associated with insufficient rest/sleep than their individual association. Therefore, to examine the association between combined exposure to cigarette smoking and smokeless/other tobacco use and insufficient rest/sleep we defined four mutually exclusive tobacco use categories: non-smoker/non-smokeless tobacco user (referent), smokeless/other tobacco only, cigarette smoking only, and smoking and smokeless/other tobacco use. Then we examined the association between second-hand smoke exposure and insufficient rest/sleep using the same logistic regression models. Since we observed a positive association between second-hand smoke exposure and insufficient rest/sleep in preliminary analysis we proceeded to examine the joint effect of smoking and second-hand smoke on insufficient rest/sleep in four exposure categories: never/former smokers with no second-hand smoke exposure (referent), never/former smokers with second-hand smoke exposure, current smokers with no second-hand smoke exposure and current smokers with second-hand smoke exposure using the same regression models. To account for unequal probabilities of selection, oversampling and non-response, BRFSS survey weights were applied for all analyses using SUDAAN (version 8.0; Research Triangle Institute, Research Triangle Park, NC) and SAS (version 9.2; SAS Institute, Cary, NC) software.

3. Results

A majority of the study participants were non-Hispanic Whites, above high school educated, employed and were less likely to engage in physical exercises; 20.4% reported current cigarette smoking, 3.5% reported current smokeless tobacco use, 4.5% reported current other tobacco use and 12.5% of the participants reported having insufficient rest/sleep for 30 days. Selected baseline characteristics of the study population by categories of insufficient rest/sleep included for the analysis of smokeless tobacco are shown in Table 1. Those who reported having insufficient rest/sleep for 30 days were younger, more likely to be female, non-Hispanic blacks, high school or below educated, obese, had higher prevalence of mental illness and were less likely to engage in physical exercises.

The association between cigarette smoking, other types of smoking (cigar, beedi, etc.), ST use and insufficient rest/sleep is shown in Table 2. The prevalence of insufficient rest/sleep was lowest among never smokers and never ST users and highest among current smokers and current smokeless tobacco users.

Table 1
Baseline characteristics of the study population by categories of insufficient sleep.*

Characteristics	Insufficient rest/sleep <30 days (n = 73,835)	Insufficient rest/sleep for 30 days (n = 9237)	p-value†
Age, years	48.1 ± 0.1	44.3 ± 0.3	<0.0001
Women (%)	49.4 ± 0.41	55.2 ± 1.1	<0.0001
Race-ethnicity (%)			<0.0001
Non-Hispanic whites	68.7 ± 0.4	66.2 ± 1.1	
Non-Hispanic blacks	10.7 ± 0.3	13.1 ± 0.7	
Mexican Americans	15.1 ± 0.4	15.3 ± 1.0	
Others	5.4 ± 0.2	5.3 ± 0.6	
Education categories (%)			<0.0001
Below high school	10.6 ± 0.3	15.5 ± 0.8	
High school	27.8 ± 0.4	33.6 ± 1.0	
Above high school	61.5 ± 0.4	50.9 ± 1.1	
Employment status (%)			<0.0001
Employed	55.1 ± 1.1	61.6 ± 0.4	
Unemployed	5.2 ± 0.2	7.2 ± 0.7	
Student/home makers	10.3 ± 0.3	12.5 ± 0.8	
Retired	18.3 ± 0.2	11.1 ± 0.5	
Unable to work	4.6 ± 0.1	14.0 ± 0.7	
Heavy alcohol drinker (%)	5.0 ± 0.19	5.6 ± 0.5	0.27
No regular exercise (%)	24.7 ± 0.4	38.6 ± 1.1	<0.0001
Mental illness (%)	0.9 ± 0.04	1.7 ± 0.1	<0.0001
Body mass index (%)			<0.0001
Normal (<25 kg/m ²)	35.1 ± 0.4	29.6 ± 1.0	
Overweight (25–29.9 kg/m ²)	37.3 ± 0.4	33.1 ± 1.0	
Obese (≥30 kg/m ²)	27.6 ± 0.4	37.4 ± 1.1	

* Data presented are row percentages or mean values and corresponding standard error.

† p-value based on analysis of variance or chi-square test, as appropriate.

Compared with never smoking, both former and current smoking were positively associated with insufficient sleep in the multivariate-adjusted models (p-trend < 0.0001). Similarly, compared with those who have never used smokeless tobacco, former and current smokeless tobacco users had increased odds of insufficient rest/sleep (p-trend < 0.0001). The multivariate odds ratio (OR; 95% confidence interval [CI]) of insufficient rest/sleep was 1.16 (1.00–1.36) for former smokeless tobacco users and 1.74 (1.37–2.22) for current smokeless tobacco users. In Table 2 we also examined the

combined effect of smoking and smokeless tobacco use on insufficient rest/sleep. Compared to non-smokers/non-smokeless tobacco users, those who were both current cigarette smokers and current smokeless tobacco users had more than twice the odds of insufficient sleep (OR [95% CI] = 2.21 [1.66–2.94]).

In Table 3, we also examined the combined effect of smoking and second-hand smoke exposure on insufficient rest/sleep. Overall, 11.6% of the participants reported exposure to second-hand smoke including 19.5% of former smokers and 38.0% of current smokers. Compared to never smokers with no second-hand smoke exposure (referent), never/former smokers exposed to second-hand smoke had an increased odds of insufficient rest/sleep (OR [95% CI] = 1.29 [1.02–1.63]). In contrast, among current smokers, exposure to second-hand smoke had little effect on insufficient rest/sleep (OR = 1.77 vs. 1.83 among those with vs. without second-hand smoke exposure).

4. Discussion

In a contemporary multiethnic sample of US adults, we found that compared to non-smokers/non-smokeless tobacco users, those who were both current smokers and current smokeless tobacco users had more than twice the odds of insufficient sleep. This association was independent of age, sex, race-ethnicity, education, employment status, heavy drinking, body mass index and lack of regular exercise. In addition, we found that second-hand smoke exposure at home or work was associated with higher odds of insufficient rest/sleep among never and former smokers. In contrast, among current smokers, the odds of insufficient rest/sleep was not materially modified by second-hand smoke.

Consistent with previous studies, active smoking was associated with insufficient rest/sleep in the current study [14,17,21,27]. Effect of smokeless tobacco on sleep has not been studied before. To our knowledge this is the first study showing an association between smokeless tobacco and insufficient rest/sleep. Animal studies have reported sleep disturbances following parenteral administration of nicotine [28,29]. Several prospective studies have demonstrated an association between smokeless tobacco and cardiovascular disease [2–4]. Lee et al. conducted a review of published literature from Sweden and the US and

Table 2
Association between smoking, smokeless tobacco products and insufficient rest/sleep.

	No. at risk (n = 83,072)	Prevalence of (%) insufficient rest/sleep	Unadjusted odds ratio (95% confidence interval)	Multivariate adjusted odds ratio (95% confidence interval)*
<i>Cigarette smoking</i>				
Never smoker	43,478	9.4	1.00 (reference)	1.00 (reference)
Former smoker	24,222	10.0	1.09 (0.97–1.22)	1.25 (1.11–1.41)
Current smoker	15,372	17.8	2.04 (1.82–2.27)	1.83 (1.63–2.06)
<i>Smokeless tobacco (snuff, snus, chewing)</i>				
Never user	69,493	10.9	1.00 (reference)	1.00 (reference)
Former user	10,755	11.5	1.08 (0.94–1.24)	1.16 (1.00–1.36)
Current user	2824	14.8	1.67 (1.33–2.10)	1.74 (1.37–2.22)
<i>Current other tobacco smoking (cigar, beedi)</i>				
No	80,503	11.0	1.00 (reference)	1.00 (reference)
Yes	2569	13.5	1.22 (0.98–1.53)	1.32 (1.04–1.66)
<i>Current cigarette smoking/smokeless tobacco</i>				
Non-smoker/non-smokeless tobacco user	64,038	9.4	1.00 (reference)	1.00 (reference)
Smokeless/other tobacco only	3662	12.6	1.32 (1.08–1.62)	1.49 (1.20–1.84)
Cigarette smoking only	13,876	17.8	1.98 (1.78–2.21)	1.71 (1.53–1.91)
Both	1496	17.9	2.28 (1.73–3.01)	2.21 (1.66–2.94)

* Adjusted for age (years), sex (men, women), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Mexican Americans, others), education categories (<high school, high school, >high school), employment status (employed, unemployed, student/home makers, retired, unable to work), body mass index categories (<25, 25–29, ≥30 kg/m²), no regular exercise (yes, no), heavy drinking (no, yes), mental illness (no, yes). These models were not adjusted for fellow smoking variables to avoid multicollinearity (cigarette smoking in models involving smokeless tobacco and vice versa).

Table 3

Association between smoking, second-hand smoke exposure, and insufficient rest/sleep.

Smoking categories	Second-hand smoke exposure	No. at risk (28,557)	Weighted prevalence of (%) insufficient rest/sleep	Unadjusted odds ratio (95% confidence interval)	Multivariate adjusted odds ratio (95% confidence interval) ^a
Non-smoker ^b	Absent	21,126	9.1	1 (referent)	1 (referent)
	Present	2068	14.1	1.41 (1.13–1.77)	1.29 (1.02–1.63)
Current smoker	Absent	4288	16.5	1.99 (1.70–2.32)	1.83 (1.56–2.15)
	Present	1075	15.8	1.88 (1.44–2.44)	1.77 (1.35–2.32)

^a Adjusted for age (years), sex (men, women), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Mexican Americans, others), education categories (<high school, high school, >high school), employment status (employed, unemployed, student/home makers, retired, unable to work), body mass index categories (<25, 25–29, ≥30 kg/m²), no regular exercise (yes, no), heavy drinking (no, yes), mental illness (no, yes).

^b Includes never and former smokers.

reported increased risk of heart disease among non-smoking smokeless tobacco users in two US studies [2]. Boffetta et al., in a meta-analysis of observational studies from US and Sweden, found an association between smokeless tobacco and fatal myocardial infarction and stroke [3]. Critchley et al., in a systematic review of epidemiological studies on smokeless tobacco use, reported a modest association between smokeless tobacco and cardiovascular disease [4]. Hergens et al. studied 120,930 never smoking men working in Swedish construction industries. Thirty percent of men who reported using smokeless tobacco were at increased risk of developing hypertension compared to never smokeless tobacco users [30]. Second-hand smoke exposure was shown to be associated with sleep disorders among the working population [21], pregnant women [20] and children [22,23]. But in the 2005–2006 National Health and Nutrition Examination Survey, second-hand smoke was not significantly associated with sleep disorders among 4000+ adult participants [18]. The authors concluded that the inconclusive evidence between second-hand smoke and sleep disorders could be due to lack of awareness and under-reporting of sleep disorders (6.8%).

The mechanism through which active smoking affects sleep has been established [27,28,31–34]. Nicotine, the active component of cigarette smoke, stimulates the release of sleep regulating neurotransmitters including dopamine and serotonin, resulting in sleep disturbance [27,28]. Cigarette smoking is associated with disturbances in sleep architecture including lighter sleep, long latency in sleep initiation, decreased sleep efficiency and increased daytime sleepiness [27,34]. Nicotine dependence and nightly withdrawal are associated with anxiety and stress disorders [32]. Further, cigarette smoking impacts sleep by exacerbating respiratory symptoms [31] or contributing to sleep disordered breathing [33]. Nicotine withdrawal symptoms including anxiety, stress and restlessness affect sleep in former smokers [35]. Smokeless tobacco use is shown to produce hemodynamic changes including increase in heart rate, blood pressure [36] and increased oxidative stress in vitro [37]. The blood nicotine levels were shown to be similar after single exposure to cigarette smoking or smokeless tobacco [38]. Second-hand smoke exposure is speculated to affect sleep through nicotine stimulating effect [28], nicotine withdrawal during sleep [39], snore-related arousals [40] and impact on pulmonary function [41].

Strengths of our study include the large sample size, population-based study and information on potential confounders. Our study has several limitations. First, our assessment of exposure and outcome measurements based on self-reported questionnaire data may have resulted in misclassification bias. Second, the question to assess insufficient rest/sleep is subjective and does not distinguish between sleep restriction, poor sleep quality and insomnia. It is possible that blurring the lines between these distinct entities may lead to confusion and probably unnecessary angst about insomnia. As a measure of sleep restriction and poor sleep quality, our question on insufficient rest/sleep may be prone

to measurement error. This measurement error is likely to introduce non-differential misclassification. Third, there may be residual confounding from unmeasured variables (e.g., shift work, job stress) in the observed association between smokeless tobacco, second-hand smoke exposure and insufficient sleep. Finally, the cross-sectional nature of the study limits making causal inferences.

In summary, in a multiethnic sample of US adults we found that compared to non-smokers/non-smokeless tobacco users, those who were both current smokers and current smokeless tobacco users had more than twice the odds of insufficient sleep. Also, second-hand smoke exposure at home or work was associated with higher odds of insufficient rest/sleep among never and former smokers. Our findings may have important public health implications in quitting smoking and smoke control programs as we provide new insights into the role of smokeless tobacco use and insufficient sleep.

Conflict of Interest

There are no conflicts of interest related to this manuscript.

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References

- [1] Rodu B, Godshall WT. Tobacco harm reduction: an alternative cessation strategy for inveterate smokers. *Harm Reduct J* 2006;3:37.
- [2] Lee PN. Circulatory disease and smokeless tobacco in Western populations: a review of the evidence. *Int J Epidemiol* 2007;36(4):789–804.
- [3] Boffetta P, Straif K. Use of smokeless tobacco and risk of myocardial infarction and stroke: systematic review with meta-analysis. *BMJ* 2009;339:b3060.
- [4] Critchley JA, Unal B. Is smokeless tobacco a risk factor for coronary heart disease? A systematic review of epidemiological studies. *Eur J Cardiovasc Prev Rehabil* 2004;11(2):101–12.
- [5] Janzon E, Hedblad B. Swedish snuff and incidence of cardiovascular disease. A population-based cohort study. *BMC Cardiovasc Disord* 2009;9:21.
- [6] Institute of Medicine. Sleep disorders and sleep deprivation: an unmet public health problem. Washington, DC: The National Academies Press; 2006.
- [7] Copinschi G. Metabolic and endocrine effects of sleep deprivation. *Essent Psychopharmacol* 2005;6(6):341–7.
- [8] Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, et al. Short sleep duration as a risk factor for hypertension: analyses of the first national health and nutrition examination survey. *Hypertension* 2006;47(5):833–9.
- [9] Vorona RD, Winn MP, Babineau TW, Eng BP, Feldman HR, Ware JC. Overweight and obese patients in a primary care population report less sleep than patients with a normal body mass index. *Arch Intern Med* 2005;165(1):25–30.
- [10] Strine TW, Chapman DP. Associations of frequent sleep insufficiency with health-related quality of life and health behaviors. *Sleep Med* 2005;6(1):23–7.
- [11] Mullington JM, Haack M, Toth M, Serrador JM, Meier-Ewert HK. Cardiovascular, inflammatory, and metabolic consequences of sleep deprivation. *Prog Cardiovasc Dis* 2001;51(4):294–302.

- [12] Perceived insufficient rest or sleep among adults – United States, 2008. *JAMA* 2009; 302(23): 2532–9.
- [13] Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. *Am J Epidemiol* 2009;169(9):1052–63.
- [14] Wetter DW, Young TB. The relation between cigarette smoking and sleep disturbance. *Prev Med* 1994;23(3):328–34.
- [15] Mak KK, Ho SY, Thomas GN, Lo WS, Cheuk DK, Lai YK, et al. Smoking and sleep disorders in Chinese adolescents. *Sleep Med* 2010;11(3):268–73.
- [16] Franklin KA, Gislason T, Omenaas E, Jogi R, Jensen EJ, Lindberg E, et al. The influence of active and passive smoking on habitual snoring. *Am J Respir Crit Care Med* 2004;170(7):799–803.
- [17] Phillips BA, Danner FJ. Cigarette smoking and sleep disturbance. *Arch Intern Med* 1995;155(7):734–7.
- [18] Davila EP, Lee DJ, Fleming LE, LeBlanc WG, Arheart K, Dietz N, et al. Sleep disorders and secondhand smoke exposure in the US population. *Nicotine Tob Res* 2010;12(3):294–9.
- [19] Kaneita Y, Ohida T, Takemura S, Sone T, Suzuki K, Miyake T, et al. Relation of smoking and drinking to sleep disturbance among Japanese pregnant women. *Prev Med* 2005;41(5–6):877–82.
- [20] Ohida T, Kaneita Y, Osaki Y, Harano S, Tanihata T, Takemura S, et al. Is passive smoking associated with sleep disturbance among pregnant women? *Sleep* 2007;30(9):1155–61.
- [21] Nakata A, Takahashi M, Haratani T, Ikeda T, Hojou M, Fujioka Y, et al. Association of active and passive smoking with sleep disturbances and short sleep duration among Japanese working population. *Int J Behav Med* 2008;15(2):81–91.
- [22] Yolton K, Xu Y, Khoury J, Succop P, Lanphear B, Beebe DW, et al. Associations between secondhand smoke exposure and sleep patterns in children. *Pediatrics* 2010;125(2):e261–8.
- [23] Johansson A, Ludvigsson J, Hermansson G. Adverse health effects related to tobacco smoke exposure in a cohort of three-year olds. *Acta Paediatr* 2008;97(3):354–7.
- [24] Centers for Disease Control and Prevention (CDC). 2008 BRFSS overview, <http://www.cdcgov/brfss/technical_infodata/surveydata/2008/overview_08rtf>; 2009 [accessed 12.03.09].
- [25] State-specific secondhand smoke exposure and current cigarette smoking among adults – United States, 2008. *MMWR Morb Mortal Wkly Rep* 2009; 58(44): 1232–5.
- [26] Steptoe A, Peacey V, Wardle J. Sleep duration and health in young adults. *Arch Intern Med* 2006;166(16):1689–92.
- [27] Zhang L, Samet J, Caffo B, Punjabi NM. Cigarette smoking and nocturnal sleep architecture. *Am J Epidemiol* 2006;164(6):529–37.
- [28] Guzman-Marin R, Alam MN, Mihailescu S, Szymusiak R, McGinty D, Drucker-Colin R. Subcutaneous administration of nicotine changes dorsal raphe serotonergic neurons discharge rate during REM sleep. *Brain Res* 2001;888(2):321–5.
- [29] Salin-Pascual RJ, Moro-Lopez ML, Gonzalez-Sanchez H, Blanco-Centurion C. Changes in sleep after acute and repeated administration of nicotine in the rat. *Psychopharmacology (Berl)* 1999;145(2):133–8.
- [30] Hergens MP, Lambe M, Pershagen G, Ye W. Risk of hypertension amongst Swedish male snuff users: a prospective study. *J Intern Med* 2008;264(2):187–94.
- [31] Lewis DA. Sleep in patients with asthma and chronic obstructive pulmonary disease. *Curr Opin Pulm Med* 2001;7(2):105–12.
- [32] Mykletun A, Overland S, Aaro LE, Liabo HM, Stewart R. Smoking in relation to anxiety and depression: evidence from a large population survey: the HUNT study. *Eur Psychiatry* 2008;23(2):77–84.
- [33] Wetter DW, Young TB, Bidwell TR, Badr MS, Palta M. Smoking as a risk factor for sleep-disordered breathing. *Arch Intern Med* 1994;154(19):2219–24.
- [34] Jaehne A, Loessl B, Barkai Z, Riemann D, Hornyak M. Effects of nicotine on sleep during consumption, withdrawal and replacement therapy. *Sleep Med Rev* 2009;13(5):363–77.
- [35] Hughes JR. Effects of abstinence from tobacco: valid symptoms and time course. *Nicotine Tob Res* 2007;9(3):315–27.
- [36] Squires Jr WG, Brandon TA, Zinkgraf S, Bonds D, Hartung GH, Murray T, et al. Hemodynamic effects of oral smokeless tobacco in dogs and young adults. *Prev Med* 1984;13(2):195–206.
- [37] Yildiz D, Liu YS, Ercal N, Armstrong DW. Comparison of pure nicotine- and smokeless tobacco extract-induced toxicities and oxidative stress. *Arch Environ Contam Toxicol* 1999;37(4):434–9.
- [38] Benowitz NL, Porchet H, Sheiner L, Jacob III P. Nicotine absorption and cardiovascular effects with smokeless tobacco use: comparison with cigarettes and nicotine gum. *Clin Pharmacol Ther* 1988;44(1):23–8.
- [39] Moreno-Coutino A, Calderon-Ezquerro C, Drucker-Colin R. Long-term changes in sleep and depressive symptoms of smokers in abstinence. *Nicotine Tob Res* 2007;9(3):389–96.
- [40] Montgomery-Downs HE, Gozal D. Snore-associated sleep fragmentation in infancy: mental development effects and contribution of secondhand cigarette smoke exposure. *Pediatrics* 2006;117(3):e496–502.
- [41] Argacha JF, Xhaet O, Gujic M, Adamopoulos D, Beloka S, Dreyfuss C, et al. Nicotine increases chemoreflex sensitivity to hypoxia in non-smokers. *J Hypertens* 2008;26(2).