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Original Article

Association of active and passive smoking with occupational injury in manual workers: a cross-sectional study of the 2011 Korean working conditions survey

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Abstract: This study was conducted to investigate the relationship of active and passive smoking with occupational injury among manual workers. Data from the 2011 Korean Working Conditions Survey were analyzed for 12,507 manual workers aged ≥15 yr. Overall, 60.4% of men and 5.8% of women were current smokers. The prevalence of injury was higher among never smokers who were exposed to secondhand smoke (SHS) (7.7% in men and 8.1% in women) than current smokers (4.2% in men and 4.1% in women). After controlling for potential confounders, in men, compared to those who never smoked and were not exposed to SHS, people who never smoked and were exposed to SHS (adjusted odds ratio (aOR)=3.7, 2.2–6.4) and current smokers (aOR=2.5, 1.6–3.8) were more likely to experience injury. Among women, the aORs of occupational injury were 8.4 (4.2–16.7) for never smoking women with occasional exposure to SHS and 3.5 (95% CI: 1.4–8.7) for current smokers, in comparison to never smoking women who were never exposed to SHS at work (reference group). The present study suggests that exposure to SHS is a possible risk factor of occupational injury for never smoking men and women.

Key words: Manual worker, Occupational injury, Korea, Secondhand smoke, Smoking

Introduction

Occupational injuries represent a major part of the injury burden to employees and employers, affecting

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people in the most productive years of their lives. In the United States alone, recent studies estimate that more than 3.0 million nonfatal workplace injuries occurred in private industry employees in 2013, with an incidence rate of 3.3 cases per 100 full-time workers[1]. The association between cigarette smoking and injury has been widely reported in different occupations[2–4] and an association was also found in a significant dose-response relationship with injury death in a meta-analysis[5]. Smokers are at greater risks of injury or death when compared to never smokers (RR=1.61 (1.44–1.81)) and former smokers (RR=1.39 (1.25–1.55))[5]. More recently, exposure to secondhand smoke (SHS) has been shown to represent an important risk factor for injury[4, 6]. In a general population, women are particularly vulnerable to the adverse health effects of cigarette smoking[7, 8]. Likewise, studies suggest that women working in manual trades are at greater risk than men for chronic musculoskeletal injuries[9]; recent research has demonstrated that women are at higher risk for injuries requiring first aid, medical treatment, and work restriction[10]. The risk of smoking and injury is more consistent across studies on men; however, studies do not consistently show that smoking confers an increased risk among women[4, 11]. This has stimulated speculation that both active and passive smoking and gender may have a role for occupational injury among manual workers.

Although anti-tobacco policies have been implemented worldwide, many countries in Asia and the Pacific are still battling a high prevalence of tobacco use, as nearly two-thirds of men in the Western Pacific region are current smokers[12]. As with other countries in the region, the smoking rate in the general Korean population is high. Workplace smoking ban legislation was enforced in Korea beginning in 2003, and the smoking rate of Korean men has been waning. However, it remains high; in 2009, 51.1% of adult male workers were smokers[13], and the rate among women has not decreased[14]. In addition, smoking rate differs widely across the two genders in Korea. The rate was estimated to be 42.3% for men and 5.6% for women between 2008 and 2010[15], and the smoking prevalence (51.8%) was higher among manual laborers compared to non-manual workers[16], particularly higher among women employed in manual work[14, 17]. Unlike smoking data, data on the extent or patterns of exposure to SHS in the region, including Korea, are limited. One study in Korea has indicated that 36.1% of non-smokers are exposed to SHS and suggested that women are more likely to be exposed to smoke[18].

Despite the number of studies that have concluded that SHS is a significant health hazard[19–21], most studies assessing the association between smoking and injury have not considered the contribution of SHS to injury. A study that documented the contribution of SHS to injury reported a non-significant increase in occupational injury among manual workers exposed to smoking[4], but no previous investigation has been done in Korea.

Due to a high prevalence of smoking and its effects on workers' health, this study was undertaken to investigate the association of both active and passive smoking with occupational injury among manual laborers in Korea.

Subjects and Methods

Study participants

This secondary data analysis involved a nationally representative sample of the 2011 (third) Korean Working Conditions Survey (KWCS) which was conducted on an economically-active population aged 15 yr or over, who were either employees or self-employed at the time of the interview; data were collected from 50,032 participants. Those who were retired and unemployed, as well as housewives and students, were excluded from the survey. The survey collected comprehensive data on job context, working time, risk factors, health and well-being, and other socioeconomic positions of workers through face-to-face interviews. Details of the survey are described elsewhere[22, 23]. A manual worker was defined as someone who was involved in occupation that requires the handling of heavy or average loads, on a regular basis, or occupation handling lighter loads, but in static postures. In particular, the occupation variable which included agriculture, forestry, and fishery workers, craft and related trades workers, plant and machine operators and assemblers, cleaners and helpers, and unskilled labor categorized all as manual workers. These workers were regarded as a high-risk group for work-related stress and health outcomes[24]. A total sample of 10,810 (sum of weights, N=12,507; 9,165 males and 3,342 females) respondents who were employed as manual laborers at the time of the interview were included in the final analysis. This homogenous sample would explain more individual and within-occupation variations in working condtions[25].

We used weighted data to reflect the sampling method and response rate and yield nationally representative estimates. The quality of the KWCS was assured by its high external and content validity and reliability[23]. In the third KWCS, using a seven-code recording method developed by the Standard Definitions (2011) of the American As-

sociation for Public Opinion Research (AAPOR)[26], a response rate of 35.4% and a contact rate of 56.6% were calculated. Trained interviewers were used to interview participants after getting written informed consent. The study protocol was approved by the institutional review board at Inha University, Incheon, South Korea.

Smoking

Questionnaires related to smoking gathered detail information on smoking habits, including smoking status (current, former, or never smoker), number of cigarettes smoked per day, and exposure to cigarette smoke from other people. Persons who were smoking at the time of the interview and had smoked 100 or more cigarettes in their lifetimes were classified as current smokers. Former smokers were those who did not smoke at the time of the interview and had answered "Yes" to the question, "Have you smoked at least 100 cigarettes in your lifetime?" Never smokers were persons who had smoked less than 100 cigarettes in their lifetimes.

Exposure to tobacco smoke from other people at work was assessed by the following question: Are you currently exposed to cigarette smoke by other people at work? The participants answered according to a seven-point scale that included the following answer choices: all of the working time, almost all of the working time, 3/4 of the working time, half of the working time, 1/4 of the working time, almost never, and never. These responses were classified into exposure to SHS (exposed for 1/4 or more of the working hours), and non-exposure (never exposed or almost never exposed)[27]. Moreover, smoking status was further separated into the following four subgroups: never smoker and no SHS exposure (reference group), never smoker and SHS exposure, former smoker, and current smoker.

Occupational injury

Occupational injury was defined using two questions: (1) "Over the past 12 months, have you had any health problems?" with eight answers (e.g., backache, muscular pains, stomach pains, overall fatigue, headaches, anxiety/depression, sleeping problems, and injury). (2) "Was your health problem associated with or caused by work?". Among the respondents, those who answered "yes" to question (1) with injury and "yes" to question (2) were used as the occupational injury group.

Covariates

We used several other potential confounding variables that were likely to be associated with injury globally and in Korea. Previously published studies that reported an association between smoking and occupational injury or variables that could be potential confounders to injury were also included in the analysis[4, 28]. The variables included age, educational attainment in years (≤9, 10–12, and ≥13), number of employees (≤5, 5–49, 50–299, and ≥300), employment status (regular vs. temporary), tenure of employment in years (<1, 1–9, and ≥10), working hours per week (<40, 40–48, 49–60, and ≥61), occupation (agricultural, fishery, and forest workers, craft and related trades workers, plant and machine operators and assemblers, elementary occupations, and armed forces occupations), shift work (yes vs. no), lifestyle, and physical/psychological conditions. Lifestyle factors included frequency of drinking (<1 per month, 1–4 per month, and ≥2 per wk). Physical/psychological conditions included obesity (yes vs. no), insomnia (yes vs. no), hypertension (yes vs. no), and depression (yes vs. no) (Table 1).

Statistical analysis

The appropriate sampling weights from the KWCS were applied to the results of this study in order to make the findings nationally representative. A χ^2 test was used to compare the prevalence of occupational injury by general and work-related characteristics and smoking status. To assess the associations of smoking with occupational injury and to control for the potential confounding variables, crude odds ratio (OR) and adjusted odds ratio (aOR) and their 95% confidence intervals (CI) were calculated using logistic regressions. The adjusted models were estimated after adjusting for all potential confounders as stated in the covariates section. All analyses were performed with IBM SPSS Statistics version 20 (IBM Inc., Chicago, IL, USA).

Results

Table 1 shows the distribution and prevalence of smoking by general characteristics and gender; all numbers reflect weighted frequencies. Of 12,507 participants, 688 (5.5%) had never smoked and had been exposed to SHS (441 (4.8%) of males and 247 (7.4%) of females). Moreover, 60.4% of males and 5.8% of females were current smokers. The average age of the never smokers who were exposed to SHS was lower than that of the former smokers for men; in contrast, for women, the average age was higher than that of former and current smokers.

There was a significant association between smoking status and the prevalence of occupational injury (p<0.001) (Table 2). The highest prevalence of occupational injury

Table 1. Characteristics (%) of survey respondents by smoking status

	Males				Females			
	Never		Former	Current	Never		Former	Current
	SHS−	SHS+			SHS−	SHS+		
Number of participants (%)*	1,726 (18.8)	441 (4.8)	1,467 (16.0)	5,531 (60.4)	2,804 (83.9)	247 (7.4)	98 (2.9)	193 (5.8)
Age (yr), mean (SD)	43.7 (13.8)	43.4 (13.2)	50.0 (13.3)	43.6 (12.0)	51.1 (12.5)	52.1 (11.2)	44.1 (10.9)	46.3 (12.5)
Educational status (yr)								
≤9	16.2	21.8	27.1	16.4	44.5	50.6	10.3	29.0
10–12	57.5	54.4	51.5	63.2	46.1	43.7	73.2	50.8
≥13	26.4	23.8	21.3	20.4	9.4	5.7	16.5	20.2
Hypertension (Yes)	7.6	10.2	12.7	5.4	10.7	17.8	7.2	9.8
Obesity (Yes)	3.0	3.4	4.7	1.2	1.6	4.5	4.1	3.1
Depression (Yes)	1.7	2.3	1.1	1.0	2.0	6.5	2.1	3.6
Insomnia (Yes)	3.1	1.8	3.5	1.7	2.6	7.3	0.0	4.7
Drinking frequency								
<1 per month	45.3	41.4	30.2	18.0	72.8	71.7	42.3	29.0
1–4 per month	32.8	36.2	37.8	34.9	19.6	16.2	39.2	42.5
≥2 per wk	21.9	22.4	32.0	47.1	7.7	12.1	18.6	28.5
Number of employees								
≤5	20.7	14.3	18.5	21.0	31.0	25.2	17.5	20.2
5–49	49.2	60.9	48.3	51.2	48.6	58.9	54.6	56.0
50–299	17.7	14.7	17.0	15.6	11.6	7.3	16.5	16.6
≥300	9.1	3.2	9.2	7.8	2.6	2.8	7.2	4.1
Missing	3.2	7.0	7.1	4.4	6.1	5.7	4.1	3.1
Employment status								
Regular	68.3	61.0	66.4	67.0	45.8	53.7	74.2	64.2
Temporary	31.7	39.0	33.6	33.0	54.2	46.3	25.8	35.8
Tenure (yr)								
<1	17.1	22.0	16.8	15.0	28.4	21.1	26.8	10.9
1–10	57.2	46.9	50.9	56.8	58.8	65.0	57.7	73.6
≥10	25.7	31.1	32.3	28.2	12.9	13.8	15.5	15.5
Working time (h/wk)								
<40	8.3	9.3	8.3	7.1	29.6	22.8	14.4	15.6
40–48	46.1	40.3	40.5	36.7	46.9	39.8	36.1	44.8
49–60	30.4	38.2	31.3	40.1	19.5	26.0	43.3	32.3
≥61	15.1	12.2	19.8	16.1	4.0	11.4	6.2	7.3
Shift work (Yes)	22.2	10.7	24.1	18.0	4.8	7.7	3.1	11.5
Occupation								
Agricultural, fishery, and forest workers	1.0	0.0	1.3	0.9	1.2	0.4	1.0	1.0
Craft worker	24.5	37.0	28.9	33.1	13.0	11.3	19.6	22.8
Machine operator and assembler	35.4	30.6	35.6	35.4	12.9	21.4	43.3	26.4
Elementary occupations	37.7	32.0	33.2	29.8	72.9	66.9	36.1	49.7
Armed forces	1.4	0.5	1.0	0.8	0.0	0.0	0.0	0.0

*All numbers reflect weighted frequencies

was observed among never smokers who were exposed to SHS (7.7% of males and 8.1% of females). In addition, in men, the injury prevalence was 1.5% in never smokers who were not exposed to SHS, 3.2% in former smokers, and 4.2% in current smokers. Similarly, in women, the prevalence was 0.7% in never smokers who were not exposed to SHS, 1.0% in former smokers, and 4.1% in current smokers.

Analyses according to work-related characteristics showed that the number of employees, employment status, job tenure, working time, and shift work were significantly associated with occupational injury in males. However, the prevalence of occupational injury for female workers

Table 2. Prevalence of occupational injury according to work-related characteristics and smoking status and stratified by gender

	Males				Females			
	N*	n*	%	*p*-value**	N*	n*	%	*p*-value**
Number of employees								
≤5	1,855	57	3.1	<0.001	989	9	0.9	0.025
5–49	4,658	208	4.5		1,669	31	1.9	
50–299	1,484	48	3.2		391	10	2.6	
≥300	736	10	1.4		94	0	0.0	
Missing	432	17	3.9		196	0	0.0	
Employment status								
Regular	6,130	197	3.2	<0.001	1,612	37	2.3	<0.001
Temporary	3,036	144	4.7		1,728	13	0.8	
Tenure (yr)								
<2	1,471	44	3.0	0.001	894	10	1.1	0.541
2–10	5,082	170	3.3		2,005	33	1.6	
≥10	2,613	127	4.9		440	6	1.4	
Working time (h/wk)								
<40	699	17	2.4	<0.001	932	3	0.3	<0.001
40–48	3,599	98	2.7		1,533	23	1.5	
49–60	3,372	166	4.9		717	15	2.1	
≥61	1,495	59	3.9		158	9	5.7	
Shift work								
No	7,385	305	4.1	<0.001	3,160	45	1.4	0.191
Yes	1,780	35	2.0		180	5	2.8	
Occupation								
Agricultural, fishery, and forest worker	87	4	4.6	0.072	39	1	2.6	<0.001
Craft worker	2,838	129	4.5		455	9	2.0	
Machine operator and assembler	3,225	113	3.5		507	19	3.7	
Elementary occupations	2,931	94	3.2		2,339	21	0.9	
Armed forces	86	2	2.3		0	0	0.0	
Smoking status								
Never								
Never and SHS (−)	1,726	26	1.5	<0.001	2,804	21	0.7	<0.001
Never and SHS (+)	441	34	7.7		247	20	8.1	
Former	1,467	47	3.2		98	1	1.0	
Current	5,531	234	4.2		193	8	4.1	

*All numbers reflect weighted frequencies. N represents the total sample size of a particular group, while n means the number of outcomes of interest (occupational injury). **Obtained by a χ^2 test or a Fisher's exact test.

was not significantly different according to job tenure and shift work. The association between occupation and occupational injury is significant in female subjects (p<0.001) and marginally significant in male (p=0.072).

Further analyses according to physical and lifestyle factors revealed that obesity, depression, insomnia, and alcohol consumption were significant factors associated with occupational injury in males. Conversely, age group, educational status, hypertension, and obesity were not significantly associated with injury in females (Table 3).

Table 4 shows the ORs of occupational injury in relation to smoking status and gender. The unadjusted ORs of occupational injury (OR=5.3, 3.1–8.9 for males and 11.8, 6.3–22.1 for females) were significantly higher for never smokers who were exposed to SHS compared to never smokers who were not exposed to SHS (reference group). Multivariable logistic regression analysis results indicated that these relationships were still significant after adjusting for potential confounders described in an earlier section. Compared to those who never smoked and were not exposed to SHS (reference group), people who had never smoked and were exposed to SHS were more likely to experience occupational injury (aOR=3.7, 2.2–6.4 in males and 8.4, 4.2–16.7 in females; p<0.001). Similarly,

Table 3. Prevalence of occupational injury by general characteristics stratified by gender

	Males				Females			
	N*	n*	%	*p*-value**	N*	n*	%	*p*-value**
Age (yr)								
≤29	1,198	36	3.0	0.001	228	5	2.2	0.443
30–39	2,231	76	3.4		327	8	2.4	
40–49	2,381	122	5.1		940	13	1.4	
50–59	2,165	75	3.5		1,068	14	1.3	
≥60	1,191	32	2.7		776	9	1.2	
Educational status (yr)								
≤9	1,679	83	4.9	<0.001	1,439	21	1.5	0.583
10–12	5,482	208	3.8		1,569	26	1.7	
≥13	2,005	49	2.4		332	3	0.9	
Hypertension								
No	8,503	309	3.6	0.172	2,970	46	1.5	0.485
Yes	663	31	4.7		370	4	1.1	
Obesity								
No	8,961	319	3.6	<0.001	3,274	47	1.4	0.276
Yes	204	21	10.3		65	2	3.1	
Depression								
No	9,057	329	3.6	<0.001	3,260	46	1.4	0.031
Yes	108	11	10.2		80	4	5.0	
Insomnia								
No	8,958	309	3.4	<0.001	3,240	46	1.4	0.061
Yes	208	32	15.4		100	4	4.0	
Drinking frequency								
<1 per month	2,403	72	3.0	0.012	2,314	27	1.2	0.006
1–4 per month	3,208	143	4.5		708	12	1.7	
≥2 per wk	3,553	125	3.5		318	11	3.5	

*All numbers reflect weighted frequencies. N represents the total sample size of a particular group, while n means the number of outcome of interest (occupational injury). **Obtained by a χ^2 test or a Fisher's exact test.

significant ORs were found for current smokers (aOR ranged from 2.5 to 3.5) in both men and women compared to never smokers who were not exposed to SHS (Table 4).

Discussion

To the best of our knowledge, this is the first study in Korea to use representative national data and to account for SHS while estimating the effect of smoking on occupational injury among manual workers. Results of the present analyses indicate an expected increase in the risk of occupational injury for never smokers who were exposed to SHS and current smokers among manual workers.

Our study has two major findings. First, never smokers who were exposed to SHS were more likely to have experienced a higher level of occupational injury when compared to those who were not exposed to SHS. Second, occupational injury had a stronger association with the never smokers who were exposed to SHS than with current smokers (aORs ranged from 3.7 to 8.4). Exposure to SHS could be a possible risk factor yielding a stronger association of injury among non-smokers employed in manual work settings. The results of this study suggest that tobacco control at the workplace is important to avoid injury.

In a previous study of small- and medium-scale enterprises in Japan[4], there was a non-significant increase in occupational injury in never smoking men and women who were regularly exposed to SHS. However, in the present study, we found a significant association between exposure to SHS in never smokers and occupational injury in both men and women.

An increased risk of occupational injury in smokers is in agreement with previous studies that considered various occupations[2, 3]. Compared to these previous studies, our study has investigated the effects of exposure to SHS among never smokers on occupational injury and also

Table 4. Unadjusted and adjusted odds ratios for occupational injury by smoking status and stratified by gender

Sex/Smoking status	N	Unadjusted		Adjusted*	
		OR	95% CI	OR	95% CI
Males					
Never					
Never and SHS (−)	1,726	1.0	1.0	1.0	1.0
Never and SHS (+)	441	5.3	3.1 to 8.9	3.7	2.2 to 6.4
Former	1,467	2.1	1.3 to 3.4	1.7	1.0 to 2.8
Current	5,531	2.8	1.9 to 4.3	2.5	1.6 to 3.8
Females					
Never					
Never and SHS (−)	2,804	1.0	1.0	1.0	1.0
Never and SHS (+)	247	11.8	6.3 to 22.1	8.4	4.2 to 16.7
Former	98	1.5	0.2 to 10.5	0.8	0.1 to 6.2
Current	193	5.6	2.4 to 12.8	3.5	1.4 to 8.7

*Adjusted for 10 yr age groups, educational level, obesity, depression, insomnia, drinking frequency, number of employees, employment status, tenure of employment, working hours, shift work, and occupation.

accounted for a wide range of potential confounders using the relatively large sample size and its representativeness of the Korean population.

The high prevalence of occupational injury among active smokers could be explained by the following reasons. First, smoking is associated with blurred vision or hearing dysfunction[29, 30] and may increase the chance of being injured. Second, active smokers may experience sleep problems, and they may also be more depressed, which may cause injury at work[31, 32]. One study has indicated that non-smokers exposed to SHS are likely to act similarly to active smokers and are therefore also at an increased risk of injury[3].

Current smokers had a significantly increased risk of injury, but the effect was smaller than that in never smokers who were exposed to SHS. One possible explanation is that current smokers may smoke during work to avoid sleepiness since nicotine increases alertness[33], but never smokers exposed to SHS could suffer only from the harmful effects of smoking and could be involved in accidents and injuries caused by active smokers, especially if they are sleepy. One further possibility is that never smokers who were exposed to SHS could not prevent exposure through their own effort and this may make them more stressed. Alternatively, current smokers may underreport their occupational injury because they may have difficulty recalling their injury. Further evidence is needed to confirm this finding.

The finding of increased risk among former smokers in men was consistent with several previous studies[4, 34], and this risk was lower than those of current smokers. The reduction in injury rates among former smokers compared to current smokers suggests a more direct effect from smoking itself. In contrast, former smoking women had no increase in risk to occupational injury. As only 2.9% of women were former smokers, this could lead to a low statistical result regarding the effect of former smoking.

In addition, this study found that occupational injury was associated with different factors for males and females. Obesity, educational status, age, insomnia, tenure, and shift of work were significantly associated with occupational injury in males. Other factors like depression, alcohol consumption, company size, employment size, working time, and occupation were associated with both males and females. A previous study reported that insomnia symptoms and younger ages were associated with occupational injury in males, and marital status, educational attainment, and insomnia symptoms affected females[35].

Limitations of the study

There are some potential limitations to this study. First, as a cross-sectional study, it is hard to establish a causal relationship between exposure and outcome variables. It is unclear whether workers experiencing exposure to SHS are more likely to report occupational injury, or if workers with occupational injuries will attribute their injury to exposure to SHS. However, the plausibility of our finding is strengthened through statistical adjustment for multiple potential confounders at different levels. Our findings are also largely consistent with theoretical expectations

and previous literature on closely related topics. Several prospective studies have confirmed the causal association of workplace exposure to SHS and health outcomes, especially regarding respiratory symptoms[20, 36].

Second, there is a possibility that a recall bias may have existed due to self-reporting one's smoking status and occupational injury. Current smokers may also be exposed to SHS, which may have led to an underestimation of the risk of occupational injury in smokers exposed to SHS. Although a meta-analysis of the validity of self-reported smoking reported high levels of sensitivity (87.5%) and specificity (89.2%), and self-reported exposure is a valid measure with self-reported levels being consistent with biological markers[37], the use of a self-reporting technique does carry the risk of misclassification[38]. Regarding the concern about the classification of exposure vs. non-exposure, more than 1/4 of the working time was designated as exposure to SHS at work and this gap between 1/4 of the working time and almost never may create a potential misclassification for SHS exposure. Our data regarding occupational injury including minor injury was determined using retrospective self-reporting questionnaire survey, and thus may be distorted by recall bias or misclassification and may be complicated by potential over- or under-estimations.

Third, the "healthy worker effect" may apply in this study. It may be possible that most susceptible workers or those who suffer most from SHS may change their job to avoid this exposure which may underestimate the relationship between smoking and occupational injury.

Fourth, in this study, some covariates, such as dominant influences of peer coworkers and exercise habits, were not included in the broad range of other potential confounders.

Finally, smoking exposure at home was not considered, which may under- or over-estimate the risk of occupational injury in never smokers.

Conclusions

We found an increased risk of occupational injury for never smokers who were exposed to SHS as well as for current smokers in manual workers. Although this study focuses on injury risk in manual workers, many of the jobs included herein are common in many manufacturing environments. Future research should not only address specific type of workers but also explore psychosocial demands of the workers that may have differential risks of occupational injury for smoking men and women. Our findings will support further steps towards the understanding of smoking-injury risk of working men and women and may guide interventions for effective tobacco control strategies at the workplace in order to prevent occupational injury.

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References

1) Bureau of Labor Statistics, U.S. Department of Labor Workplace Injuries and Illnesses-2013. http://www.bls.gov/news.release/pdf/osh.pdf. Accessed January 16, 2015.
2) Hartman E, Frankena K, Oude Vrielink HHE, Nielen M, Metz JHM, Huirne RBM (2004) Risk factors associated with sick leave due to work-related injuries in Dutch farmers: an exploratory case-control study. Saf Sci **42**, 807–23.
3) Wen CP, Tsai SP, Cheng TY, Chan HT, Chung WS, Chen CJ (2005) Excess injury mortality among smokers: a neglected tobacco hazard. Tob Control **14** Suppl 1, i28–32.
4) Nakata A, Ikeda T, Takahashi M, Haratani T, Hojou M, Fujioka Y, Araki S (2006) Non-fatal occupational injury among active and passive smokers in small- and medium-scale manufacturing enterprises in Japan. Soc Sci Med **63**, 2452–63.
5) Leistikow BN, Martin DC, Jacobs J, Rocke DM (1998) Smoking as a risk factor for injury death: a meta-analysis of cohort studies. Prev Med **27**, 871–8.
6) Calfee CS, Matthay MA, Eisner MD, Benowitz N, Call M, Pittet JF, Cohen MJ (2011) Active and passive cigarette smoking and acute lung injury after severe blunt trauma. Am J Respir Crit Care Med **183**, 1660–5.
7) Allen AM, Oncken C, Hatsukami D (2014) Women and smoking: the effect of gender on the epidemiology, health effects, and cessation of smoking. Curr Addict Rep **1**, 53–60.
8) Syamlal G, Mazurek JM, Dube SR (2014) Gender differences in smoking among U.S. working adults. Am J Prev Med **47**, 467–75.
9) Smith PM, Mustard CA (2004) Examining the associations between physical work demands and work injury rates between men and women in Ontario, 1990-2000. Occup Environ Med **61**, 750–6.
10) Tessier-Sherman B, Cantley LF, Galusha D, Slade MD, Taiwo OA, Cullen MR (2014) Occupational injury risk by sex in a manufacturing cohort. Occup Environ Med **71**, 605–10.
11) Hazes JM, Dijkmans BA, Vandenbroucke JP, de Vries RR, Cats A (1990) Lifestyle and the risk of rheumatoid arthritis: cigarette smoking and alcohol consumption. Ann Rheum Dis **49**, 980–2.
12) World Health Organization/Western Pacific Region Fact sheets: Smoking statistics. http://www.wpro.who.int/mediacentre/factsheets/fs_20020528/en/. Accessed January 20, 2015.
13) Jang TW, Kim HR, Choi SE, Yim HW, Lee HE, Myong JP,

Koo JW (2012) Smoking rate trends in Korean occupational groups: analysis of KNHANES 1998–2009 data. J Occup Health **54**, 452–8.
14) Khang YH, Yun SC, Lynch JW (2008) Monitoring trends in socioeconomic health inequalities: it matters how you measure. BMC Public Health **8**, 66.
15) Kim S (2012) Smoking prevalence and the association between smoking and sociodemographic factors using the Korean National Health and Nutrition Examination Survey Data, 2008 to 2010. Tob Use Insights **5**, 17–26.
16) Cho YS, Kim HR, Myong JP, Kim HW (2013) Association between work conditions and smoking in South Korea. Saf Health Work **4**, 197–200.
17) Khang YH, Cho HJ (2006) Socioeconomic inequality in cigarette smoking: trends by gender, age, and socioeconomic position in South Korea, 1989–2003. Prev Med **42**, 415–22.
18) Lee BE, Ha EH (2011) Exposure to environmental tobacco smoke among South Korean adults: a cross-sectional study of the 2005 Korea National Health and Nutrition Examination Survey. Environ Health **10**, 29.
19) Siegel M, Skeer M (2003) Exposure to secondhand smoke and excess lung cancer mortality risk among workers in the "5 B's": bars, bowling alleys, billiard halls, betting establishments, and bingo parlours. Tob Control **12**, 333–8.
20) Ho SY, Lam TH, Chung SF, Lam TP (2007) Cross-sectional and prospective associations between passive smoking and respiratory symptoms at the workplace. Ann Epidemiol **17**, 126–31.
21) Schwartz J, Graham RB, Richardson CG, Okoli CT, Struik LL, Bottorff JL (2014) An examination of exposure and avoidance behavior related to second-hand cigarette smoke among adolescent girls in Canada. BMC Public Health **14**, 468.
22) European Foundation for the Improvement of Living and Working ConditionsWorking conditions in Korea: Survey highlights. http://www.eurofound.europa.eu/pubdocs/2012/19/en/1/EF1219EN.pdf. Accessed January 15, 2015.
23) Kim YS, Rhee KY, Oh MJ, Park J (2013) The validity and reliability of the second Korean working conditions survey. Saf Health Work **4**, 111–6.
24) Lahelma E, Laaksonen M, Aittomäki A (2009) Occupational class inequalities in health across employment sectors: the contribution of working conditions. Int Arch Occup Environ Health **82**, 185–90.
25) de Lange AH, Taris TW, Kompier MA, Houtman IL, Bongers PM (2003) "The very best of the millennium": longitudinal research and the demand-control-(support) model. J Occup Health Psychol **8**, 282–305.
26) The American Association for Public Opinion Research Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys, 7th edition-2011. https://www.esomar.org/uploads/public/knowledge-and-standards/codes-and-guidelines/ESOMAR_Standard-Definitions-Final-Dispositions-of-Case-Codes-and-Outcome-Rates-for-Surveys.pdf. Accessed April 9, 2015.
27) Min KB, Park SG, Song JS, Yi KH, Jang TW, Min JY (2013) Subcontractors and increased risk for work-related diseases and absenteeism. Am J Ind Med **56**, 1296–306.
28) Lu ML, Nakata A, Park JB, Swanson NG (2014) Workplace psychosocial factors associated with work-related injury absence: a study from a nationally representative sample of Korean workers. Int J Behav Med **21**, 42–52.
29) Perkin GD, Bowden P, Rose FC (1975) Smoking and optic neuritis. Postgrad Med J **51**, 382–5.
30) Cruickshanks KJ, Klein R, Klein BE, Wiley TL, Nondahl DM, Tweed TS (1998) Cigarette smoking and hearing loss: the epidemiology of hearing loss study. JAMA **279**, 1715–9.
31) Nakata A, Ikeda T, Takahashi M, Haratani T, Fujioka Y, Fukui S, Swanson NG, Hojou M, Araki S (2005) Sleep-related risk of occupational injuries in Japanese small and medium-scale enterprises. Ind Health **43**, 89–97.
32) Nakata A, Takahashi M, Ikeda T, Hojou M, Nigam JA, Swanson NG (2008) Active and passive smoking and depression among Japanese workers. Prev Med **46**, 451–6.
33) Takahashi M, Tanigawa T, Tachibana N, Mutou K, Kage Y, Smith L, Iso H (2005) Modifying effects of perceived adaptation to shift work on health, wellbeing, and alertness on the job among nuclear power plant operators. Ind Health **43**, 171–8.
34) Sprince NL, Park H, Zwerling C, Lynch CF, Whitten PA, Thu K, Gillette PP, Burmeister LF, Alavanja MC (2002) Risk factors for machinery-related injury among Iowa farmers: a case-control study nested in the Agricultural Health Study. Int J Occup Environ Health **8**, 332–8.
35) Nakata A, Ikeda T, Takahashi M, Haratani T, Hojou M, Swanson NG, Fujioka Y, Araki S (2006) The prevalence and correlates of occupational injuries in small-scale manufacturing enterprises. J Occup Health **48**, 366–76.
36) Jaakkola MS, Jaakkola JJ, Becklake MR, Ernst P (1996) Effect of passive smoking on the development of respiratory symptoms in young adults: an 8-year longitudinal study. J Clin Epidemiol **49**, 581–6.
37) Patrick DL, Cheadle A, Thompson DC, Diehr P, Koepsell T, Kinne S (1994) The validity of self-reported smoking: a review and meta-analysis. Am J Public Health **84**, 1086–93.
38) Wells AJ, English PB, Posner SF, Wagenknecht LE, Perez-Stable EJ (1998) Misclassification rates for current smokers misclassified as nonsmokers. Am J Public Health **88**, 1503–9.