

Secondhand smoke at work

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Purpose of review

Secondhand smoke (SHS) exposure in the workplace remains common and has important acute and chronic health effects. The present study reviews the recent evidence linking workplace SHS exposure with poor health and the benefits of smoke-free workplace legislation.

Recent findings

Workplace SHS exposure continues to occur in many parts of the United States and around the world. Occupational SHS exposure has been linked to serious chronic health effects including lung cancer, cardiovascular disease, chronic obstructive pulmonary disease, and poor general health. Smoke-free workplace laws rapidly reduce workplace SHS exposure and improve respiratory health including symptoms and lung function. Smoke-free workplace legislation is also expected to reduce the chronic health effects of passive smoking, including cardiopulmonary disease and lung cancer.

Summary

Occupational exposure to SHS has serious negative health consequences and will shorten lifespan. Smoke-free workplace legislation should be universally adopted around the world.

Keywords

chronic obstructive pulmonary disease, cigarette smoking, myocardial infarction, tobacco smoke pollution

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Introduction

Secondhand smoke (SHS) is a complex mixture of more than 4000 chemical compounds, including potent respiratory irritants such as sulfur dioxide, ammonia, formaldehyde, and acrolein [1,2]. Evidence is now conclusive that SHS exposure causes major disease and shortens the lifespan. The recent historic Surgeon General's report on involuntary exposure to tobacco smoke concluded that SHS causes lung cancer, coronary heart disease, and premature death [3]. Consequently, legislation that eliminates public smoking will reduce the burden of chronic disease and premature mortality. The workplace, which is a major source of SHS exposure, is a particularly important target for prevention.

The workplace remains a common source of secondhand smoke exposure

In economically developed countries, adults spend the majority of their time indoors (approximately 90%). Consequently, pollution of the indoor environment has substantive effects on health. In households and workplaces that allow smoking, SHS exposure is often the major source of indoor pollution.

Although the prevalence of SHS exposure is declining in the United States, Canada, Europe, and many other economically developed nations, many persons continue to be exposed [4–6]. After the home, the workplace is the major source of involuntary exposure to tobacco smoke for most adults [3,7]. In certain workplaces, employees are exposed to very high levels of SHS [8]. Bar and tavern workers, in particular, are exposed to high ambient levels of SHS, up to four to six times higher than in other workplaces [9]. To prevent the adverse health effects of passive smoking, the workplace remains a high priority for smoke-free legislation.

A population-based study from Finland, which enacted the 1995 Tobacco Control Act that restricted smoking in most workplaces (excluding restaurants), found that the prevalence of workplace SHS exposure of one or more h/week decreased by nearly three-fold among nonsmokers [10]. Both women and men experienced similar benefit. Importantly, the prevalence of exposure also declined among smokers, albeit to a lesser degree (about two-fold). Nonetheless, this and other studies show that workplace SHS exposure continues to occur [11].

Smoke-free workplace legislation is highly effective for reducing SHS exposure [12]. The most effective legislation bans smoking in all workplaces on a national level. Ireland was the first country to implement a national smoking ban; other countries have followed their lead. In other countries, such as the United States, smoke-free workplace legislation has been more piecemeal, with state and local laws prohibiting indoor smoking to a greater or lesser extent. In California, for example, there are several exceptions to the law: hotel lobbies and warehouses, which result in continued workplace SHS exposure.

Other factors determining the prevalence of workplace passive smoking exposure include the type of workplace (higher levels of exposure in office than nonoffice workplaces) and the workplace smoking policy [13]. The lowest levels of SHS exposure are found in workplaces that completely ban smoking, intermediate levels in those that restrict smoking, and highest levels in those that allow smoking.

Workplace smoking and chronic health effects

SHS exposure has been definitively and causally related to many severe adverse health effects, including lung cancer and cardiovascular disease. Evidence continues to build about the specific linkages between occupational SHS exposure and negative health consequences. Several studies published during the past year continue to elucidate the deleterious health effects of workplace SHS exposure.

Although active smoking is the major risk factor for chronic obstructive pulmonary disease (COPD), the role of other exposures in causing the disease is increasingly recognized [14*].

A recent study from China evaluated the impact of SHS exposure, including workplace exposure, on the risk of developing COPD [14*,15]. This study used baseline data from 15 379 never smoking participants in the Guangzhou Biobank Cohort study from southern China who were of age 50 years or greater (most were women) [15]. Passive smoking was measured by a questionnaire that ascertained passive smoking during childhood and adulthood (at home and work). The study outcomes were chronic respiratory symptoms (cough, phlegm production, or dyspnea) and COPD defined as forced expiratory volume in 1 s (FEV₁)/forced vital capacity (FVC) less than 0.70 (only 6497 individuals with valid spirometry were included in the COPD outcome). Multivariable analysis was used to control for age, sex, educational level, exposure to occupational dust, and indoor pollutants such as biomass smoke. Cumulative passive smoke

exposure during adulthood, which combined duration of exposure in years and average intensity of passive smoking in hours/week, was associated with COPD. In terms of total exposure (home and work), the highest category of passive smoking (>5 years of at least 40 h/week of total exposure) was associated with a greater risk of COPD [odds ratio (OR) 1.48; 95% confidence interval (CI) 1.18–1.85]. The highest workplace exposure category was also related to a greater risk of COPD (OR 1.5; 95% CI 1.14–1.97).

Another study evaluated the impact of heavy workplace passive smoke exposure among 61 never smoking flight attendants who worked in aircraft cabins before the smoking ban on commercial aircraft (range of 3–45 years of preban employment) [16*]. The flight attendants had normal FEV₁, FEV₁/FVC, but they had more subtle evidence of airway obstruction including decreased flow rate at mid-lung and low-lung volumes, curvilinear flow-volume curves, and evidence of air trapping. In addition, the flight attendants had significantly decreased diffusing capacity ($77.5 \pm 11.2\%$ predicted normal) with 51% having a diffusing capacity below their 95% normal prediction limit. The present study provides additional evidence that heavy occupational SHS exposure may increase the risk of developing COPD.

SHS exposure has been established as a cause of cardiovascular disease. Emerging evidence indicates that smoke-free workplace laws reduce the risk of adverse cardiovascular events [17,18]. A recent study [19**] evaluated the impact of the national legislation banning smoking in public places in Scotland on hospitalization for acute coronary syndrome. Data were prospectively collected on all patients admitted to nine Scottish hospitals for acute coronary syndrome during a 10-month period before passage of the smoke-free law and the same period after the law went into effect. These hospitals comprised 64% of all admissions for acute coronary syndrome in Scotland. After the smoke-free law was implemented, SHS exposure decreased among current nonsmokers compared with the period before the ban. In never smokers, the proportion with no recent SHS exposure increased from 52–78%; the benefit was similar among ex-smokers (52–79%). SHS exposure reduction occurred in the workplace, other public places, and pubs, contributing to the overall exposure reduction. And of course pubs are public places for the general public, and workplaces for employees. This observed reduction in SHS exposure was paralleled by a reduction in serum cotinine (a biomarker of SHS exposure).

The reduction in SHS exposure was associated with a decreased risk of acute coronary syndrome. The overall number of admissions for acute coronary syndrome decreased by 17% (95% CI 6–18%), compared with a

4% reduction in England that continued to allow public smoking. The proportional reduction in hospital admissions for acute coronary syndrome decreased most among current nonsmokers (21% reduction in never smokers, 19% in former smokers), but smokers also benefited (14% reduction).

A recent meta-analysis examined studies of smoke-free legislation on the risk of acute myocardial infarction [20]. The primary outcome measure was the ratio of community rates of acute myocardial infarction after implementation of legislation divided by the rate when public smoking was allowed. The overall summary effect was a 17% reduction in the rate of hospitalization for acute myocardial infarction after workplace smoking restrictions went into effect (95% CI 13–20% reduction). The benefit appeared to increase over time to approximately 36% at 3 years.

Recent data indicate two additional important points about the relationship between SHS exposure and cardiovascular disease. First, new data indicate that SHS exposure has deleterious cardiovascular health effects among current smokers. Smokers are at substantive risk from exposure to SHS and benefit from its cessation [19^{••},21]. Second, new data indicate that brief, low-level exposure can confer substantive risk of cardiovascular events and mortality [22[•]].

Occupational SHS exposure has been associated with other cardiovascular health effects. A study of 79 non-smoking flight attendants who were heavily exposed to SHS prior to the in-flight tobacco ban found that the highest level of cumulative workplace SHS exposure was related to an increased prevalence of current systemic hypertension (six times higher risk in the highest versus lowest exposure group) [23]. There was, however, no impact on hemodynamic measurements at rest or with exercise. The present study suggests that remote heavy exposure to SHS can have lasting cardiovascular effects on health.

The cumulated evidence now indicates that SHS exposure is a cause of lung cancer [3]. A recent meta-analysis [24] evaluated the specific contribution of workplace smoking to the risk of lung cancer based on 22 studies: 24% increase (95% CI 18–29% increase in risk). A doubling of risk (201%) was observed for workers who were highly exposed to SHS (95% CI 33–260% increase in risk). During the past year, a population-based case-control study [25[•]] from Hong Kong also found an association between workplace SHS exposure and the risk of adenocarcinoma of the lung. Compared with the unexposed, individuals who had ever been exposed to passive smoking at work had a greater risk of lung adenocarcinoma (OR 1.68; 95% CI 1.00–2.83). There

was clear evidence of exposure–response relationship for duration of exposure and a metric that combined duration of exposure with number of smokers in the workplace (OR 2.32 for the highest category; 95% CI 1.11–4.87). Taken together with prior evidence, this latest study further supports a causal relationship between workplace SHS exposure and lung cancer.

A recent study [26[•]] used direct indoor air sampling methods and mathematical modeling to estimate the impact of SHS exposure among Pennsylvania casino workers on mortality.

The investigation measured respirable suspended particles (RSPs), particulate polycyclic aromatic hydrocarbons (PPAHs), and carbon dioxide inside and outside casinos. Urine cotinine was measured in three patrons. An exposure response model estimated the excess mortality due to SHS exposure. Passive smoke exposure in casinos was very high: PPAH and RSP concentrations in casinos were four and six times higher than outdoor levels. Among patrons, the mean urine cotinine increased 1.9 ng/ml after a visit of approximately 4 h consistent with substantive SHS exposure. The model estimated that SHS exposure will cause an excess of six Pennsylvania casino workers per year, which is five times higher than the death rate from mining disasters in the state.

Workplace passive smoking also appears to have more global impact on health. A cross-sectional study [27] was conducted to evaluate impact of SHS exposure on the risk of poor self-reported general health (very poor or poor versus good or very good) in a variety of small and medium workplaces in Japan. Among lifetime never smokers, occasional workplace SHS exposure was associated with a greater risk of poor perceived general health compared with no exposure (OR 1.50, 95% CI 1.02–2.11). Although the risk estimate for regular SHS exposure was elevated, the confidence interval did not exclude one. These results suggest that workplace passive smoking may have a deleterious impact on perceived general health, which complements the studies linking SHS exposure to the development of specific health conditions such as COPD, cardiovascular disease, and lung cancer.

Smoke-free workplace legislation reduces secondhand smoke exposure

Legislation that prohibits workplace smoking has dual benefit; it reduces SHS exposure among employees and among patrons of the establishment. Hospitality workers, in particular, have been a large focus of research evaluating the health benefits of smoke-free workplace laws.

Hospitality workers are persons who work in bars, taverns, pubs, restaurants, cinemas, bowling alleys,

casinos, bingo halls, and other customer entertainment industries. These workers are often exposed to extremely high levels of SHS. Bar and tavern workers, in particular, are exposed to SHS levels that are four to six times higher than in other workplaces [9,28,29]. Peak SHS exposures may reach extremely high levels, as much as 10 times the levels found in office workplaces or in the home [30]. Consequently, hospitality workers may be particularly susceptible to the acute and chronic health effects of SHS exposure and may experience a large health benefit from smoke-free workplace laws.

Smoke-free workplace legislation is effective for reducing workplace passive smoke exposure. In California, we originally reported that the statewide workplace smoking ban reduced self-reported occupational SHS exposure from a median of 28–2 h/week (total exposure decreased from a median of 40–10 h/week) [31]. Since that original publication, many studies have documented the effectiveness of smoke-free workplace laws in the United States and around the world. Recently, a study using a similar design in Washington, D.C., found that bar employees experienced a marked reduction in SHS exposure after the law went into effect (median weekly SHS exposure decreased from 30–0 h/week) [32[•]]. Decreased self-reported SHS exposure was paralleled by a sharp decrease in salivary cotinine (median levels decreased from 2.11 to 0.29 ng/ml).

Other studies have demonstrated that smoke-free policy dramatically reduces indoor air pollution. A recent study [33] evaluated indoor air pollution in 128 Irish pubs from 15 different countries around the world. Indoor air testing found that the mean levels of indoor fine particulate pollution (PM_{2.5}) were 93% lower than in smoke-free Irish pubs compared with those that permitted smoking (23 versus 340 µg/m³). Other studies published during the past year also demonstrated the effectiveness of smoke-free workplace legislation for reducing indoor levels of SHS and occupational exposure to SHS (self-reported exposure and biomarkers of exposure such as cotinine) [6,34,35,36[•],37–41]. Taken together, the worldwide literature establishes the unequivocal efficacy of smoke-free workplace legislation for reducing occupational exposure to passive smoking.

Smoke-free workplaces legislation benefits respiratory health

Passive smoking will cause sensory irritation symptoms in nearly all persons, which include eye, nose, or throat irritation. Mucous membrane irritation causes the specific symptoms of itchiness, redness, or tearing of the eyes, rhinorrhea, nasal stuffiness, pharyngeal irritation, and pharyngeal pain. SHS also causes symptoms referable to irritation of the upper and lower respiratory tract. Common

symptoms are cough, cough with sputum production, wheezing, chest congestion, or dyspnea. With persistent SHS exposure, chronic bronchitis may develop.

California prohibited smoking in all bars and taverns effective 1 January 1998 (which extended a previous general workplace smoking ban). Using a case-crossover design, we studied the effects of the smoke-free workplace law on the respiratory health of 53 bartenders [31]. After prohibition of smoking, self-reported workplace SHS exposure sharply declined from a median of 28–2 h/week. Thirty-nine (74%) of the 53 bartenders reported at least one respiratory symptom at baseline (including cough, dyspnea, and wheezing), whereas only 17 (32%) were still symptomatic at follow-up. Of the 39 bartenders reporting baseline symptoms, 23 individuals (59%) no longer indicated any respiratory symptoms after prohibition of smoking ($P < 0.001$). We estimated that a 5-h reduction of workplace SHS exposure was associated with a lower risk of respiratory symptoms at follow-up (OR 0.7; 95% CI 0.5–0.9), after controlling for upper respiratory infections and reduced personal cigarette smoking. The majority also reported sensory irritation symptoms (77%), which largely resolved after the smoke-free workplace law went into effect (19% at follow-up, reflecting a 78% reduction).

After prohibition of workplace smoking, pulmonary function also rapidly improved. We observed an improvement in mean FVC (189 ml; 95% CI 82–296 ml) and mean FEV₁ (39 ml; 95% CI –30 to 107 ml). Complete cessation of workplace SHS exposure was associated with an even greater pulmonary function improvement.

During the past year, additional studies have confirmed the respiratory health benefits of smoke-free workplace laws [32[•],36[•],37,42]. A longitudinal study [36[•]] from Scotland examined the impact of the national smoking ban on 371 bar workers recruited from 72 bars. At 1-year follow-up, the proportion of bar workers experiencing any respiratory symptom decreased from 69 to 57%; sensory irritation symptoms declined from 75 to 64%.

The cumulative literature indicates that smoke-free workplace laws rapidly improve the respiratory health of hospitality workers (within 8 weeks) and that this benefit is durable when evaluated 1 year later. Moreover, these laws are supported by the majority of the public and public opinion typically becomes increasingly positive following implantation of public smoking bans [40,43,44].

Smoke-free workplace laws reduce direct smoking

Establishment of smoke-free workplaces has another critical public health benefit that is to increase smoking

cessation among active smokers [45,46**]. Those who continue to smoke reduce their daily cigarette consumption. In Norway, for example, a national smoking ban reduced active and passive smoking in hospitality workers [46**]. At 4 months after the law went into effect, there were substantive decreases in the prevalence of daily smoking (absolute decrease -3.6%), daily smoking at work (-6.2%), and the average number of cigarettes smoked by continuing smokers (-1.6; $P < 0.01$ in all cases). These benefits were maintained at 1-year follow-up. Smoke-free workplace laws, by reducing passive and active smoking, will lead to substantive health benefits for the population.

Conclusion

The workplace is an important source of SHS exposure. Occupational SHS exposure has been linked with important chronic health effects including lung cancer, cardiovascular disease, impaired lung function, and COPD. Smoke-free workplace legislation is highly effective for reducing passive smoke exposure. These laws are expected to improve respiratory health, prevent chronic disease, and extend lifespan. Important health benefits occur quickly, after only 1 month of a smoke-free workplace. The cumulative body of research, which has established the serious adverse health effects of passive smoking, provides a powerful rationale for prohibiting smoking in all workplaces.

Acknowledgement

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