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REVIEW

Are there health benefits associated with comprehensive smoke-free laws

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Abstract
Introduction In the past few years, comprehensive smoke-free laws that prohibit smoking in all workplaces have been introduced in many jurisdictions in the US, Canada, and Europe. In this paper, we review published studies to ascertain if there is any evidence of health benefits resulting from the implementation of these laws.
Methods All papers relating to smoke-free legislation published in or after 2004 were considered for inclusion in this review. We used Pubmed, Google scholar, and Web of Science as the main search tools. The primary focus of the paper is on health outcomes, and thus many papers that only report exposure data are not included.
Results Studies using subjective measures of respiratory health based on questionnaire data alone consistently reported that workers experience fewer respiratory and irritant symptoms following the introduction of smoke-free laws. Some studies also found measured improvements in the lung function of workers. However, the most dramatic health outcome associated with smoke-free laws has been the reduction in myocardial infarction in the general population. This outcome has been observed in the US, Canada, and Europe, with studies reporting reductions of between 6 and 40%, post-legislation, the larger reductions being mostly from studies with smaller population groups. The evidence as to whether these smoke-free laws have helped smokers to stop smoking or to reduce tobacco consumption is less clear.
Conclusions There is now significant body of published literature that demonstrates that smoke-free laws can lead to improvements in the health of both workers who are occupationally exposed and of the general population. There is no longer any reason why non-smokers should be exposed to SHS in any workplace. We recommend that all countries adopt national smoke-free laws that are in line with article 8 of the WHO Framework Convention on Tobacco Control that sets out recommendations for the development, implementation, and enforcement of national, comprehensive smoke-free laws.

Keywords Smoking policies · Smoke-free laws · Tobacco consumption

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Introduction

In recent years, we have seen smoke-free laws introduced, in various jurisdictions in the US, Canada, Europe, and across the world (Table 1). A number of studies have shown that the exposure to particulates (fine and ultra-fine) and to various other components of tobacco smoke, such as benzene, have dropped by between 80 and 90% following the introduction of a smoke-free law (Connolly et al. 2009; Goodman et al. 2007; Gorini et al. 2008; McNabola et al. 2006; Repace 2004; Semple et al. 2007a, b; Waring and Siegel 2007). Although these studies have shown that exposure has been reduced, the other important question that needs to be answered is: *Is there any evidence of health benefits associated with these reductions in exposure due to*

Table 1 Countries/locations and dates of smoking legislation (workplace smoking bans)

Ireland	29 March 2004
Norway	01 June 2004
Bulgaria	01 January 2005
Italy	10 January 2005
Belgium	01 January 2006
Spain	01 January 2006
Scotland	26 March 2006
Luxembourg	05 September 2006
Lithuania	01 January 2007
Wales	02 April 2007
Northern Ireland	30 April 2007
England	01 July 2007
Iceland	01 June 2007
France	01 February 2007
Finland	01 June 2007
Estonia	05 June 2007
The Netherlands	01 July 2008
Portugal	01 January 2008
Malta	05 October 2005
Slovenia	05 August 2007
Sweden	01 June 2005
New Zealand	10 December 2004
California, USA	01 January 1998
Delaware, USA	27 November 2002
New York	24 July 2003
Massachusetts, USA	04 July 2004
Georgetown, USA	01 October 2005
Alberta, Canada	01 January 2008
British Columbia, Canada	31 March 2008
Newfoundland and Labrador, Canada	01 July 2005
Northwest Territories, Canada	May 2004
Nova Scotia, Canada	01 April 2008
Nunavut Territory, Canada	01 February 2004
Ontario, Canada	31 May 2006
Quebec, Canada	31 May 2006
Yukon, Canada	15 May 2008
Western Australia	31 July 2006
Tasmania, Australia	01 January 2006
ACT, Australia	01 December 2006
Bermuda	01 April 2006
Isle of Man	30 March 2008
Colombia	04 December 2008
Guatemala	20 February 2009
Mexico City	26 February 2008
Mexico	24 January 2008
Uruguay	29 February 2008
Kenya	08 July 2008
Niger	15 May 2006
Federal Capital Territory, Nigeria	31 May 2008
South Africa	2007
Hong Kong	01 January 2007
Singapore	01 July 2007
Taiwan	June 2007
Iran	22 December 2007
Argentina (6 provinces and 16 municipalities)	2005 (in Santa Fe); 2006 (Cordoba, Nequen, Tucaman); 2008 (Entre Rios, Mendoza)

the smoke-free laws. This paper reviews the evidence from the published literature.

Background

Most of the studies on smoke-free laws have focussed on measuring levels of particulates in bars and restaurants and staff exposure in these venues, it was felt that workers in the hospitality sector had the greatest exposure to second hand smoke (SHS). This was also the employment sector where there was the greatest opposition to the implementation of smoke-free laws. Some studies have also measured cotinine: a sensitive, and tobacco specific, biomarker of second hand smoke (SHS) exposure in non-smokers, both in occupational groups and in the general population. Where comprehensive smoke-free laws have been introduced, reductions of between 70 and 90% in cotinine levels have been observed in workers from the hospitality sector (Allwright et al. 2005; Ellingsen et al. 2006; Farrelly et al. 2005; Gotz et al. 2008; Semple et al. 2007a; Valente et al. 2007). Most recently, Fernández et al. (2009) have assessed the impact of the Spanish smoke-free legislation, which allowed premises to opt for one of three levels—a complete ban; a partial ban with designated smoking areas; and no smoking restrictions at all**.** They found that cotinine concentrations decreased by 56% in workers from venues with a total ban, 28% in venues with a partial ban and by 11% where there were no smoking restrictions, confirming that comprehensive smoke-free legislation provides the greatest protection from SHS exposure for workers.

Large differences in population level exposure have also been observed. For example, an analysis of the US National Health and Nutrition Examination Survey (NHANES) found that the cotinine concentrations of adults living in counties with extensive smoke-free laws were 80% lower than adults living in counties with no smoke-free laws (Pickett et al. 2006). While three other studies have found reductions in cotinine of between 40 and 50%

in both adults (Centers for Disease Control 2007; Haw and Gruer 2007) and children (Akhtar et al. 2007) in the general population directly associated with implementation of comprehensive smoke-free laws. However, cotinine measures by themselves do not provide any direct evidence of the accrual of health benefits.

This paper concentrates on published studies, which provide evidence of health effects in workers, or the general population, in a state or country following the implementation of smoke-free laws in the workplace. The following four health outcomes are consider: (1) changes in self-reported irritant or respiratory symptoms derived from questionnaire data; (2) measured changes in respiratory health of workers or the general population; (3) cardiovascular health effects as reported in workers and or the general population; (4) changes in smoking prevalence, or tobacco consumption.

Methodology

The US surgeon general published a comprehensive report in 2006 on the effects of passive smoking (US Surgeon General 2006), which considered the published literature up to 2004. This paper focuses on publication from 2004 to mid 2009, which report on the health effects associated with smoke-free laws, although not exclusively. This time frame is appropriate as most of the national comprehensive smoke-free laws have been introduced since 2004. The smoke-free laws and when they were introduced are listed in Table 1.

The main searches were conducted using PubMed, Google Scholar, and Web of Science and Science direct, and particular reference was also given to the journal "*Tobacco Control*". The authors of this work have been previously published in this area and so are also familiar with the literature.

Only papers containing information relevant to the four categories of health outcome, listed above, were selected for inclusion in this review. In addition, some papers deemed to make an important contribution to our knowledge, are also included.

Exposure to particles and health effects

It is well known that exposure to particulate pollution is known to have adverse health effects, and that those most exposed appear to have the greatest adverse health effects (Committee on the medical effects of air pollutants 1995; Dockery et al. 1993; Pope and Dockery 2006). If one can reduce the exposure of the general population to particulates, is there any evidence that there are health benefits. Pope showed that total mortality in Utah Valley, US decreased by 3.2% in line with a reduction in particulate pollution levels during a strike in a local mill (Pope et al. 1992). We have also shown that total mortality in Dublin, Ireland fell by 5.7% following a ban on coal sales. However, the fall in cardiovascular mortality was more marked at 10.3% (Clancy et al. 2002). There is significant evidence that exposure to fine particulate pollution is associated with adverse cardiovascular effects (Clancy et al. 2002; Committee on the medical effects of air pollutants 1995; Pope et al. 1992; Pope and Dockery 2006; Samet et al. 2000; Schwartz and Morris 1995).

Tobacco smoke consists of fine and ultrafine particles, when we specifically consider literature relating to the exposure of non-smokers to second hand smoke, there is evidence to show it is associated with adverse cardiovascular effects (He et al. 1999; Heidrich et al. 2007; McElduff et al. 1998; Otsuka et al. 2001; Raupach et al. 2006; Stranges et al. 2006). Hill et al. (2004) demonstrated that never-smokers living with smokers had a reduced life expectancy, again confirming the health risks of exposure to passive smoking. Ong and Glantz (2004) predicted that smoke-free workplaces would lead to a significant health care saving, and that most of this benefit would accrue from improved cardiovascular health among non-smokers, because of the removal of their passive exposure.

In the rest of this paper, we examine the evidence from the published literature about the impact of smoke-free laws on health.

Questionnaire based respiratory health outcomes

A total of seven relevant respiratory articles were found. In general, health outcomes (mainly respiratory and sensory symptoms) were ascertained using subjective measurements. We included papers that reported questionnaire-based health outcomes. The results to date are mainly reported from European countries, with comprehensive smoke-free laws in place, and also a few from US states, counties and cities.

A study in the Republic of Ireland, where a fully comprehensive workplace smoke-free law has been in place since March 2004 reported a significant decline of 17% in bar workers reporting any respiratory symptom 6 months after implementation of their smoke-free law compared with no decline in Northern Ireland among randomly selected non-smoking bar staffs, where no ban was in place at the time (Allwright et al. 2005). A longer follow-up study in Dublin (Goodman et al. 2007), reported a 28% drop in self-reported respiratory symptoms and a 50% drop in irritant symptoms among bar staff a year after the introduction of a workplace smoke-free laws. In Norway, a

19% drop in respiratory symptoms was observed 5 months post the ban, among workers in the hospitality industry (Eagan et al. 2006). An even greater decline of 50% in respiratory and sensory symptoms was reported after a 12-month follow-up, post the Swedish ban among non-smoking gaming workers (Larsson et al. 2008). In Spain, which does not have a comprehensive smoke-free laws in place, reported a maximum decline of 72% in self-reported respiratory symptoms 12 months post the ban in a follow-up study among hospitality workers (Fernández et al. 2009). In Scotland, a significant drop in self-reported symptoms of 26% was observed as early as 1 month post the ban (Menzies et al. 2006), although seasonal factors as an alternative explanation of these early results cannot be ruled out, Ayres et al. (2009) report a 56% reduction in 'phlegm production in non-smokers. Interestingly, they also found an improvement in reported respiratory symptoms in smokers, with the proportion reporting wheezing falling from 48% at baseline immediately before the ban to 31%, 1 year later. Goodman et al. (2007) also reported improvements in self-reported symptoms in smokers (bar staff), but due to the small numbers of smokers involved, those results were not statistically significant.

Effects on measured lung function

Three published studies were identified that examined the impact of smoke-free laws on lung function. Various measurement parameters were used including forced expiratory volume in 1-s (FEV_1), and forced vital capacity (FVC). Studies have also assessed peak expiratory flow rate (PEF), forced mid-expiratory flow rate ($FEF_{25–75}$), and total lung capacity (TLC), and Carbon Monoxide transfer (DLCO). Skogstad et al. (2006) studied cross shift changes in lung function in bar workers before and after the introduction of the Norwegian legislation. They found significant reductions in cross shift changes in lung function in non-smokers (FEV_1, $FEF_{25–75}$) and asthmatics (FEV_1, $FEF_{25–75}$, FVC). Interestingly, smokers also showed an improvement but only in cross shift changes in PEF. Although cross shift changes in lung function fell after the legislation was introduced, with the exception of PEF, absolute values for the other lung function measures were also lower post-legislation. These findings may be explained by the lower mean outdoor temperature of 3°C, during the follow-up period, compared with 12°C at baseline. A study of Scottish bar workers (Menzies et al. 2006) also found a 5.1% increase in FEV_1 2 months post-legislation. However, as in the Norwegian study, seasonal confounders between baseline and follow-up (temperature and rates of respiratory infection) provide an alternative explanation of the observed improvements in respiratory health. The only published study that controlled for seasonal effects was conducted in Ireland which followed up bar workers exactly 1 year after baselines measures were taken in never-smokers, there were small, but significant, increases in predicted FVC, PEV, FEF, and TLC post-legislation. In ex-smokers, there were significant improvements in all measures, except PEF, but no significant changes in lung function measures were observed for smokers (Goodman et al. 2007).

Cardiovascular effects

Most of the published studies on cardiovascular admissions are retrospective studies, and lack detailed information on smoking status, and in particular information on exposure to SHS. Nonetheless, there is a striking consistency in the study findings.

There is now a growing body of evidence that suggests that reducing exposure to passive smoking results in a decrease in cardiovascular events, Lemstra et al. (2008) report on a 13.5% drop in acute MI in Saskatoon Canada in the period following regional smoke-free laws. This was accompanied by a drop in smoking prevalence. In the US, a number of studies have demonstrated reduced acute cardiovascular events. Sargent et al. (2004) reported a 40% fall in MI admissions for Helena Montana when smoke-free laws were implemented in the city, while a more recent study from Pueblo, CO, USA (Bartecchi et al. 2006) reports a reduction of 27% in acute MI admissions in the 18 months following a city wide smoke-free laws compared to the 18 months pre ban, and their follow up extending the post-ban period to 3 years shows a further 19% reduction in acute MI admissions which were not observed in two control areas. Additional publications from the US report similar findings. In Indiana, Seo and Torabi (2007) report a significant drop in acute MI admissions among non-smokers in Munroe County where a smoke-free law had been introduced, while in Delaware county where no ban was in place there was no significant change in acute MI admissions. In New York State, Juster et al. (2007) report an 8% drop in acute MIs associated with a statewide smoke-free law, and they attribute this to a saving of $56 M in health care expenditure. Khuder et al. (2007) reported that there was a 39% drop in acute coronary heart disease in Bowling Green, Ohio, within 1 year of the implementation of smoke-free laws, and that this increased to a 47% fall 3 years after the ban. Over the same time period, there was a significantly smaller reduction in the neighboring Kent county in Ohio, which was used as a control.

Studies from Europe also report reduction in acute cardiovascular events, Barone-Adesi (2006) reported an 11% decrease in acute MI admissions, based on a population of 4

million people in the north of Italy, most of the observed decrease was in people under the age of 60 and was in non-smokers, which they suggest was due to the reduction in passive smoking exposure. Cesaroni et al. (2008) studied acute coronary events (out of hospital deaths and acute admissions) in the 35–84 age group in Rome following the Italian smoke-free laws, they reported a drop of between 7.9 and 11.2% in these acute coronary events. Also, from Italy, Vasselli et al. (2008) report that acute MI based on data from 4 regions were 13% below what was expected, they say most of this decrease was in men of working age. More recently, in a prospective multi-centre study of admission to general hospital for acute coronary syndrome in Scotland, Pell et al. (2008) found a 17% reduction following the smoke-free laws, while no such drop was observed in England, where no ban was in place at the time. The greatest drop in the admissions was among former smokers (19%), and never smoked (21%), while for current smokers it was 14%.

Smoking prevalence and tobacco consumption

The primary reason for smoke-free laws is the protection of workers from the adverse health effects of second hand smoke, which is known to cause lung cancer, heart attacks, stroke, and chronic bronchitis as well as exacerbating asthma and being associated with a myriad of irritant symptoms. Nevertheless, it is of interest to examine what impact the legislation has had on smoking prevalence and tobacco consumption. Table 2 lists the published studies to date (Braverman et al. 2008; Elton and Campbell 2008; Fernando et al. 2007; Fong et al. 2006; Gallus et al. 2006; Keizer et al. 2009; Lemstra et al. 2008; McCaffrey et al. 2006; Mullally et al. 2009) where some aspects of prevalence were addressed usually in terms of exposure as a measure of compliance with the law but none of these fully address the question as to weather these laws reduce national prevalence of smoking. In Ireland, there was a decline in heavy smoking and a definite increase in demand for cessation services in the year before the ban was introduced in March 2004, but no significant overall change in national prevalence. This is not as surprising as it might appear at first sight, because in the lead up to the introduction of the smoking ban, there was a great public debate accompanied by considerable media activity and a well worked out implementation plan, which included reference to the "Quitline" and smoking cessation services. Another aspect of this that may have some credence is that the attitude of smokers before the ban was that they would not be able to smoke after the ban. While it is true that they would not be able to smoke in the workplace after the ban, they could and did find alternative places to smoke when the ban was introduced.

An unintended consequence of the Irish legislation has been a proliferation of out door smoking areas. At first, it was argued that this would not be utilized in Ireland because of the high rainfall but in the event, these areas have become very popular. There was also a worry that smoking in the home might increase, but this has been shown not to occur in countries where this has been tested (Akhtar et al. 2007; Elton and Campbell 2008). It was also observed in Ireland from a survey of children conducted after the ban, that there was a very significant drop in the prevalence of smoking in both girls and boys but particularly in girls (Clancy et al. 2008). It is clear that looking at the serial surveys, all these cannot be attributed solely to the ban but it may have played its part. If this is so, then one of the most interesting impacts of the smoke-free legislation is the "denormalisation" of smoking? It must be hard for children to think that there is anything wrong with smoking if they see it going on in public places and in sights of entertainment as well as at home and indeed in cars, so anything that reduces this perception is likely to have an effect on prevalence in the longer term. It does not seem very likely that addicted smokers would stop in great numbers because of not being able to smoke during work and this is in general what has been found although the table shows that there have in fact been some decreases in prevalence in some groups although this is far from universal (Braverman et al. 2008; Cesaroni et al. 2008; Fernando et al. 2007; Fong et al. 2006; Keizer et al. 2009; McCaffrey et al. 2006; Menzies et al. 2006; Mullally et al. 2009; Pell et al. 2008). It is clear that the introduction of smoke-free laws provides an opportunity to increase the uptake of cessation services but for this to happen such services must be available and accessible which unfortunately is not the rule.

Discussion

It is clear that following workplace smoke-free laws, there are remarkably consistent results (Allwright et al. 2005; Eagan et al. 2006; Goodman et al. 2007; Larsson et al. 2008; Menzies et al. 2006; Valente et al. 2007) on self-reported improvements in respiratory and irritant symptoms. Studies consistently find reductions in symptoms of between 20 and 50%. Although these are subjective data, if workers feel better, we argue this should be considered as a positive health outcome.

Studies that have measured changes in pulmonary function are fewer in number but those, which have been published report improvements in respiratory health of bar workers, as pulmonary function declines with age, an improvement in respiratory health over time would not be expected. The improvements in the lung function of non-smokers add further weight to the argument smoke-free

Table 2 Studies that report the effect of legislation restricting smoking in the workplace on self-reported smoking prevalence (2004 onwards)

Reference/Country	Study participants	Study design	Smoking legislations	Method of determining exposure to SHS	Levels of exposure reported
Fong et al. (2006) Ireland and UK [51]	1,679 adult smokers aged ≥18 years from Ireland ($n = 1,071$) and UK ($n = 608$); 1,185 completed the survey Pre-ban: December 2003–January 2004 Post-ban: December 2004–January 2005	Prospective cohort study	29 March 2004—Republic of Ireland implemented comprehensive smoke-free legislation in all workplaces, including restaurants and pubs, with no allowance for designated smoking rooms and few exemptions	Respondents' reports of smoking in key public venues	Restaurants, Ireland Pre-ban: 85%; Post-ban: 3% ($P < 0.0001$) Bars/pubs, UK Pre-ban: 78%; Post-ban: 62% ($P < 0.001$) Workplaces, Ireland Pre-ban: 62%; Post-ban: 14% ($P < 0.0001$) Bars/pubs, UK Pre-ban: 37%; Post-ban: 34% ($P = 0.462$) (adjusted OR = 8.89; 95% CI = 8.14–9.33, $P < 0.0001$)
McCaffrey et al. (2006) Ireland [52]	38 public houses (129 staffs pre-ban and 118 post-ban), not randomly selected in Dublin city Pre-ban: October 2003–March 2004 Post-ban: October 2004–March 2005	Cross-sectional study with exposure measures before and after legislation among customers in public houses	29 March 2004—Republic of Ireland	The number of smokers was expressed as a percentage of the number of customers present in the public house	Pre-ban: 17.2% (5–51%) Post-ban: 3.8% (0–20%) ($P = 0.001$)
Fernando et al. (2007) New Zealand [53]	Nonsmokers living or working in a nonsmoking environment aged 24–45 years, randomly selected bars in three cities Pre-ban: July–September 2004 and again in October/November Post-ban: Same times in 2005	Panel study with exposure measures before and after legislation	10 December 2004—Smoking not permitted in any indoor place of work including bars, restaurants, and hotels	Count of the number of cigarettes lit in three 10 min intervals	Pre-ban 2004 (Winter): 889 (Spring): 928 Post-ban 2005 (Winter):0 (Spring): 1

Table 2 continued

Reference/Country	Study participants	Study design	Smoking legislations	Method of determining exposure to SHS	Levels of exposure reported
Braverman et al. (2008) Norway [54]	1,525 food service workers, two-stage national random sample (first through register and second stage through telephone/internet) Pre-ban: May 2004 (T1) Post-ban: September/October 2004 (T2) and May 2005 (T3)	Follow-up study with exposure measures before and after legislation	1988—Norway enacted comprehensive legislation on smoking in public places; restaurants and bars exempt Revision of Environmental Tobacco Smoke Act was proposed. Total smoking ban in bars, nightclubs, and restaurants enacted 1 June 2004	Respondents' reports on general current smoking status (daily, occasional, nonsmoker) and, for smokers, about the average number of cigarettes smoked daily and smoking prevalence at work	Across all three data points ($n = 579$) Pre-ban T1 General daily: 50.8% General occasional: 6.6% At work daily: 44.7% At work occasional: 8.6% Per-capita cigarettes: 8.07 Post-ban T2 (T1–T2) T3 (T2–T3) General daily: 47.2% ($P < 0.005$) 47.2% NS General occasional: 7.8% 8.6% At work daily: 38.5% ($P < 0.001$) 40.2% NS At work occasional: 12.8% 11.1% Per-capita cigarettes: 6.93 ($P < 0.001$) 7.13
Keizer et al. (2009) Switzerland [55]	85 health care staff and 134 psychiatric in-patients post-ban and 110 and 91 pre-ban, respectively, in Geneva through questionnaire-based surveys Pre-ban: Autumn 2001 Post-ban: October 2005–January 2006	Pre-post independent intervention design	In January 2002, a compulsory partial ban for all the inpatient psychiatric units Only one room per unit, in which a ventilation system was installed, was made available for smokers	Respondents' reports on CURRENT SMOKER: at least 100 cigarettes in lifetime/at least 1 cigarette per day during 6 months/smoking during the period of survey and the consumption of cigarettes	Pre-ban: Staff ($P = 0.94$) 30.8% In-patients ($P = 0.54$) 72.1% Post-ban: Staff ($P = 0.94$) 29.9% In-patients ($P = 0.54$) 65.2% Quantity of smoke: Decreased $P < 0.0001$ (both)

Table 2 continued

Reference/Country	Study participants	Study design	Smoking legislations	Method of determining exposure to SHS	Levels of exposure reported
Mullally et al. (2009) Ireland [56]	107 bar workers of Cork city and 1221 general population selected randomly from a national telephone monthly survey Pre-ban: January–March 2004 Post-ban: January–March 2005	Follow-up study of bar workers and cross-sectional design for national sample	29 March 2004—Republic of Ireland implemented comprehensive smoke-free legislation in all workplaces, including restaurants and pubs, with no allowance for designated smoking rooms and few exemptions	Respondents' reports on smoking behavior and on consumption of cigarettes per day	Pre-ban: Bar workers ($P = 0.51$) 51.4% General population ($P = 0.055$) 28.3% Per day consumption: Bar workers 18.1 General population 16.9 Post-ban: Bar workers ($P = 0.51$) 48.6% General population ($P = 0.055$) 24.8% Per day consumption: Bar workers ($P < 0.001$) 13.9 General population ($P = 0.19$) 16.0
Elton et al. (2008) England [57]	3,500 eligible sample randomly selected from the PCT Exeter database in Bury Pre-ban: March–April 2007 Post-ban: October–November 2007	Cross-sectional postal survey of two independent samples	Following on from the Health Act of 2006, on 1 July 2007,smoking was not permitted in most fully and substantially enclosed public places in England	Respondents' reports on smoking behavior and on proportion of heavy smokers (≥20 cigarettes/day)	Pre-ban: Age-Standardized (NS): 22.4% Heavy smokers ($P = 0.04$): 27.6% Post-ban: Age-Standardized (NS): 22.6% Heavy smokers ($P = 0.04$): 21.8%
Lemstra et al. (2008) Saskatoon, Canada [41]	1,377 pre-ban and 312 post-ban samples were recruited Pre-ban: July 2000–June 2004 Post-ban: July 2004–June 2005	Retrospective survey of hospital discharge records	Ban: 1 July 2004	Respondents' reports on smoking rates	Pre-ban (95% CI): 24.1% (20.4–27.7%) Post-ban (95% CI): 18.2% (15.7–20.9%)

Table 2 continued

Reference/Country	Study participants	Study design	Smoking legislations	Method of determining exposure to SHS	Levels of exposure reported
Gallus et al. (2006) Italy [58]	3 surveys, each survey included >3,000 subjects aged ≥15 years, representative sample Pre-ban: March–April 2004, Post-ban: 2005 and 2006 Comparative surveys: 2001–2003 DOXA	DOXA, the Italian branch of the Gallup International Association conducted this multi-stage random sampling, employing ad hoc trained interviewers, using a structured questionnaire annually	10 January 2005—A smoking ban in all indoor public places was enforced in Italy	Respondents' reports on smoking status and number of cigarettes consumed per day	2004 Current smokers 26.2% Per day consumption 15.4 2001–2002 Change in rates 27.8% 2005 Current smokers 25.6% Per day consumption 14.6 2003–2004 Change in rates 27.0% 2006 Current smokers 24.3% Per day consumption 13.9 2005–2006 Change in rates 25.0%* *$P < 0.05$

laws improve health. These respiratory results, both questionnaire based and those from pulmonary function testing very similar to the early studies from California by Eisner et al. (1998).

The most striking results published to date, which are consistent from both the US, Canada and from a number of European countries, are the marked improvement in the cardiovascular health of the population as a whole, and with significant reductions in acute myocardial infarction (AMI) reported in all studies. Reductions range from between 6 and 40%, with the larger reductions being reported mostly from studies with smaller population sizes. What is most marked about these reductions in MI is that they are in the general population, most of whom are non-smokers and demonstrate a clear benefit from the removal of SHS exposure for the population as a whole. In particular, one can have great confidence in these results as some studies (Bartecchi et al. 2006; Lemstra et al. 2008; Pell et al. 2008) have shown that in neighboring counties where there was no smoke-free laws, they did not observe the same reduction in MI.

There is, however, quite a large range in the observed decreases reported for acute cardiovascular event, the earlier studies in the US, which report the largest decreases (Bartecchi et al. 2006; Khuder et al. 2007; Sargent et al. 2004; Seo and Torabi 2007), in general related to small population groups, with local legislation at county level. The results from New York (Juster et al. 2007), which had significantly larger population numbers, report an 8% drop, which is considerably lower than that reported in the other US studies, however, in New York, there had been a series on smoke free legislation introduced over a number of years, which may have contributed to the smaller decrease reported.

The results reported from the European studies (Barone-Adesi et al. 2006; Cesaroni et al. 2008; Pell et al. 2008; Vasselli et al. 2008) all report reduction is acute cardiovascular events of below 20%. The results from Canada (Lemstra et al. 2008) are also of a similar magnitude. It has to be noted that not all the studies are reporting the exact same outcomes, and not all are using the same age groups, and there is also some uncertainly as to smoking status, this will certainly account for some of the differences in the reported results.

Three recent studies have attempted to investigate the differences in change in acute myocardial infarctions (MI), reported in the various smoking ban studies, each of these three studies involved a re-analysis or meta analysis of the already published data. Gasparrini et al. (2009) reanalyzed the data for Tuscany and they report that the reductions in acute MI are sensitive to the choice of analysis model used, and they conclude that the plausible effects for acute MI reductions could be lower than some of the estimates so far reported.

Meyers et al. (2009) conduced a meta analysis of the published studies from the US, Canada, and Europe, and they report an overall 17% reduction in acute MI associated with smoking bans, although they were unable to fully explain the differences in the reported reductions.

Lightwood and Glantz (2009) also conducted a meta analysis of the published literature on acute MI and smoking bans, they conclude that the reduction in acute MI are consistent once one take account of the follow-up periods. They concluded that in countries with strong smoke free laws that there is rapid and substantial benefits in terms of reduced MIs and that these benefits grow with time. This work may help explain the big differences in the report acute MI results from the various studies (Barone-Adesi et al. 2006; Bartecchi et al. 2006; Cesaroni et al. 2008; Juster et al. 2007; Khuder et al. 2007; Lemstra et al. 2008; Pell et al. 2008; Sargent et al. 2004; Seo and Torabi 2007; Vasselli et al. 2008).

Recently, Richiardi et al. (2009) investigated the plausibility of these reported reductions in acute cardiovascular events. Using simulations, and published relative risk associated with active and passive smoking, they estimate that reductions of between 5 and 15% in acute cardiovascular events are to be expected following implementation of legislation. This is consistent with the recent findings from Europe (Barone-Adesi et al. 2006; Cesaroni et al. 2008; Pell et al. 2008; Vasselli et al. 2008), Canada (Lemstra et al. 2008) and the US (Juster et al. 2007).

The evidence is quite clear that comprehensive workplace smoke-free laws, not only improve the health of non-smoking workers, but also the cardiovascular health of the general population is also improved due to removal of the exposure of the general population to SHS in bars and restaurants.

A desirable effect of a comprehensive smoke-free law would be that it would reduce the smoking prevalence of the general population, while there is evidence of this from some studies, the outcomes differ quite a lot from place to place. It is, however, anticipated that as smoke-free laws become more established, that younger people will be less likely to commence smoking, and that over time a reduction in prevalence will occur in all locations with a comprehensive smoke-free laws, and other legislation relating to a ban on advertising etc. This is in anticipation of a cultural shift resulting in the "denormalisation" of smoking in general society. We have reported evidence of a reduction in smoking prevalence in young children in Ireland following the smoke-free laws (Clancy et al. 2008).

Conclusions

We conclude that there is now significant and consistent evidence from around the world which shows that

comprehensive smoke-free laws aimed at protecting the health of workers are associated with improvements in the respiratory health of those workers, both self-reported and measured, we also conclude that these smoke-free laws have resulted in a significant reduction in the cardiovascular health burden of the general population in the regions where they have been introduced. We also conclude that these smoke-free laws may contribute to a reduction in the prevalence of smoking.

Article 8 of the WHO Framework Convention on Tobacco Control (FCTC) sets out recommendations for the development, implementation and enforcement of national, comprehensive smoke-free laws. To date, the WHO FCTC has been adopted by 164 countries. There is no doubt that comprehensive smoke-free laws are associated with significant health benefits. We believe that the evidence is such that there is now no valid excuse for countries not to implement comprehensive smoke-free laws and failure to do so, will mean continuing to put the health of both workers and the general population at risk.

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