Effects of the Irish Smoking Ban on Respiratory Health of Bar Workers and Air Quality in Dublin Pubs

Patrick Goodman[1], Michelle Agnew[2], Marie McCaffrey[3], Gillian Paul[4], and Luke Clancy[5]

[1]Dublin Institute of Technology, Dublin, Ireland; [2]Respiratory Laboratory, St. James's Hospital, Dublin, Ireland; [3]Health Service Executive, Environmental Health, Dublin, Ireland; [4]Trinity College, Dublin, Ireland; and [5]Research Institute for a Tobacco Free Society, Dublin, Ireland

Background: **Environmental tobacco smoke (ETS) causes disease in nonsmokers. Workplace bans on smoking are interventions to reduce exposure to ETS to try to prevent harmful health effects. On March 29, 2004, the Irish government introduced the first national comprehensive legislation banning smoking in all workplaces, including bars and restaurants. This study examines the impact of this legislation on air quality in pubs and on respiratory health effects in bar workers in Dublin.**
Methods: Exposure study. **Concentrations of particulate matter 2.5 μm or smaller ($PM_{2.5}$) and particulate matter 10 μm or smaller (PM_{10}) in 42 pubs were measured and compared before and after the ban. Benzene concentrations were also measured in 26 of the pubs.** Health effects study. **Eighty-one barmen volunteered to have full pulmonary function studies, exhaled breath carbon monoxide, and salivary cotinine levels performed before the ban and repeated 1 year after the ban. They also completed questionnaires on exposure to ETS and respiratory symptoms on both occasions.**
Findings: Exposure study. **There was an 83% reduction in $PM_{2.5}$ and an 80.2% reduction in benzene concentration in the bars.** Health effects study. **There was a 79% reduction in exhaled breath carbon monoxide and an 81% reduction in salivary cotinine. There were statistically significant improvements in measured pulmonary function tests and significant reductions in self-reported symptoms and exposure levels in nonsmoking barmen volunteers after the ban.**
Conclusions: **A total workplace smoking ban results in a significant reduction in air pollution in pubs and an improvement in respiratory health in barmen.**

Keywords: smoking ban; ETS exposure; health effects

On March 29, 2004, the Irish government introduced the world's first comprehensive national ban on workplace smoking (1). Ten years of partial and voluntary controls on workplace exposure to secondhand smoke had failed to protect all workers (2). Two all-party parliamentary committees reporting in 1999 (3) and 2001 (4) had recommended a total ban. The Public Health (Tobacco) Act 2002 and the Public Health (Tobacco) (Amendment) Act 2004 that followed (1) prohibit smoking in indoor workplaces, including bars and restaurants, to reduce the risks to workers' health. A number of other European countries, including Norway, Italy, Sweden, and Scotland, have subsequently introduced similar bans. Northern Ireland, England, and Wales plan to introduce bans in 2007 and France plans to introduce a ban in 2008. Interventions that aim to reduce exposure to known air pollutants can be expected to result in risk reduction (5, 6).

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Correspondence and requests for reprints should be addressed to Prof. Luke Clancy, B.Sc., M.D., Director, General Research Institute for a Tobacco Free Society, The Digital Depot, Thomas Street, Dublin 8, Ireland. E-mail:lclancy@tri.ie

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AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Bans on workplace smoking are known to reduce exposure of staff and patrons to environmental tobacco smoke, but little is known about the health benefits of such smoking bans.

What This Study Adds to the Field

A comprehensive workplace ban on smoking can significantly reduce the exposure of workers and patrons to environmental tobacco smoke. Respiratory health of workers can improve due to such smoking bans.

Nevertheless, there are few studies that have assessed health benefits associated with a workplace smoking ban (7–12). The benefits that accrue depend on the extent to which the intervention succeeds in reducing exposure and on the response of those exposed. The national smoking ban in Ireland afforded a unique opportunity to assess the effects of the ban, both on the exposure to environmental tobacco smoke (ETS) in bars and to evaluate any health benefits in a group of barmen who volunteered to participate in the study. The self-reporting of changes in symptoms is interesting and important, but it was believed necessary to validate these observations with quantitative measurements of changes in markers of exposure and in pulmonary function. Changes in pulmonary function, exhaled breath carbon monoxide (CO), and salivary cotinine, as markers of exposure, as well as self-reported respiratory symptoms and self-reported exposure level changes were measured in 81 barmen before and after the workplace smoking ban. It was also important to determine whether the smoking ban had the expected effect on air pollution in pubs and to quantify these changes. This study measures the changes in exposure to ETS in 42 pubs. Some of the results obtained have been published in abstract form (13, 14).

METHODS

Exposure levels were measured in Dublin pubs (n = 42) before the introduction of the smoking ban, and repeated in the same venues 1 year later. Bar staff volunteers (n = 81), from pubs mostly different from the 42 mentioned previously, were recruited through their trade union, Mandate, to partake in the health effects aspect of the study. Seventy-five volunteers completed both phases of the study but two were excluded from the analysis because they had changed their smoking status, which left 73 volunteers for analysis of health effects. Four volunteers came from one pub and two volunteers came from each of five pubs, with the remaining 59 volunteers coming from 59 different pubs. Sixty-five volunteers supported the introduction of the ban, five opposed, and three were undecided when entering the study.

Exposure Assessment

In the greater metropolitan area of Dublin, 42 public houses, licensed to serve alcohol, were studied. The venues were selected to encompass a wide variety of building structures and clientele, from central, north, and south city locations. Size, demographics, and socioeconomic factors were considered in the selection, as well as geographic location and size. This approach was pursued to ensure that a representative sample of the different types of public houses found in the city of Dublin was obtained.

On the basis of these criteria, the sample consisted of 21 pubs with a capacity of more than 50 customers and 21 with a capacity of fewer than 50 customers; 14 were located in the city center, 15 were in the north city suburbs, and 13 were in the south city suburbs. Concentrations of particulate matter 2.5 μm or smaller ($PM_{2.5}$) and 10 μm or smaller (PM_{10}) in 42 pubs were measured for a minimum period of 3 hours inside each venue, using a real-time optical-based light-scattering instrument (Aerocet Met One 531 aerosol particulate profiler; Met One Instruments, Inc., Grants Pass, OR), with readings being taken every 2 minutes throughout the monitoring period. Concurrent measurements of ambient benzene levels were also recorded, using a passive absorption diffusion tube, identical to those used in the PEOPLE (Population Exposure to Air Pollutants in Europe) project (15).

The benzene samplers were available only for the last 26 pubs monitored; they were analyzed by the Joint Research Centre laboratory of the European Commission in Ispra, Italy. The monitoring protocols adopted involved positioning the monitoring instruments at the center of the room at table height. The dimensions of each venue were noted, as well as the number of doors and whether any ventilation system was in operation. In addition, the number of people present was recorded each hour, and also the number of people who were smoking. The levels of PM_{10} and $PM_{2.5}$ were also recorded outside the premises both before and after the indoor monitoring for both pre- and postban parts of the study.

The 42 pubs were visited between October 2003 and March 2004, when the preban exposure measurements were recorded, and revisited 1 year later to measure the postban exposure levels. The follow-up measurements were made on the same day of the week, at the same time of day, and in the same month, 1 year from the original measurements. This controlled for the day of week, month (seasonal pattern), and time of day effects for each venue. The outside measurements were also repeated postban as in the preban period for comparison of prevailing ambient air pollution levels.

Health Effects Methodology

Eighty-one bar staff volunteers were recruited through their trade union, Mandate, to participate in the health effects study, after having responded to a request by letter from us, which was circulated by Mandate to its union membership. We accepted every worker who volunteered in time to allow us to complete the tests before the introduction of the ban, but we would have enlarged the study if there had been more volunteers. No financial inducements were offered.

The volunteers were all male. Mandate has approximately 1,100 members, of whom approximately 80% are male. Most of the female members are temporary or part-time workers. We do not know why there were no female volunteers, but we suspect that their status as described may have influenced their decisions because the employers were vehemently against the ban and warned of job losses (16).

It was decided for reliability and quality-control considerations that all subjects would be assessed in a recognized pulmonary function laboratory rather than performing limited breathing tests in the workplace or at home. This allowed us to measure a wider range of pulmonary function tests (PFTs) than would have been possible off-site, but may have limited the numbers of volunteers. On the other hand, it allowed the barmen to participate without the involvement of their employers.

We measured the following parameters: FEV_1, FVC, forced expiratory flow of 25 to 75% ($FEF_{25–75}$), peak expiratory flow (PEF), residual volume (RV), total lung capacity (TLC), and diffusion capacity for CO (DL_{CO}) using a Sensormedics Vmax machine (SensorMedics, Conshocken, PA). In addition, PEF was also measured using a Piko 1 peak flow meter (Ferraris, Hertford, UK). Exhaled breath CO was measured using a Micor Medical Micro CO meter (Micor, Kent, UK), and the percentage of carboxyhemoglobin was calculated. All of the PFTs before and after the ban were conducted by a single experienced respiratory technologist (M.A.) and were done in accordance with European Respiratory Society guidelines (17, 18).

The volunteers attended St. James's Hospital between September 2003 and March 2004 for the preban measurements; the follow-up measurements were conducted 1 year later, between September 2004 and March 2005. While at the hospital laboratory, participants were administered the International Union Against Tuberculosis and Lung Disease (IUATLD) (19) and California Environmental Protection Agency (CEPA) (20) questionnaires relating to their respiratory and sensory symptoms, similar to that used by Eisner and colleagues (7). Nonstimulated salivary samples for cotinine analysis were also obtained at the laboratory visits before and after the ban by a single investigator (G.P.) and processed as described by Allwright and coworkers (9).

Statistical Analysis

The mean mass concentrations of $PM_{2.5}$ and PM_{10} for each venue were analyzed using the paired-sample *t* test procedure comparing the means of the quantitative pairs of variables using SPSS software (version 11.0; SPSS, Inc., Chicago, IL).

For the purpose of analysis, the 73 bar staff volunteers were categorized as "never-smokers" (n = 34), "ex-smokers" (n = 31), and "current smokers" (n = 8). The PFT results were also analyzed for each parameter by comparing the predicted score for the pre- and postban periods using the paired-sample *t* test procedure. McNemar's nonparametric test for two related dichotomous variables for changes in responses using the chi-square distribution was used for the questionnaire data, where a volunteer reported the absence or presence of a symptom.

Markers of Exposure

Because the data for CO and cotinine exhibited skewed distributions, a nonparametric test (Wilcoxon signed rank) was applied to test any significant differences between the pre- and postban CO and cotinine levels.

RESULTS

Exposure

The exposure results as measured inside the 42 bars showed a statistically significant decrease after the introduction of the ban (Table 1). Complete pre- and postban benzene measurements were available for 26 pubs and also showed a statistically significant decrease after the introduction of the ban (Table 1). The ambient outdoor PM levels as measured outside each venue did not show any significant change between the pre- and postban periods (Table 1). The reduction in PM_{10} inside the bars was not

TABLE 1. $PM_{2.5}$, PM_{10}, AND BENZENE LEVELS IN PUBLIC HOUSES AND THE OUTDOOR ENVIRONMENT BEFORE AND AFTER THE INTRODUCTION OF THE WORKPLACE SMOKING BAN

	Preban (*SD*)	Postban (*SD*)	Change (%)	p Value
Public houses (n = 42)				
Ave $PM_{2.5}$	35.5 (17.8)	5.8 (2.2)	−83.6	< 0.01
Ave PM_{10}	72.1 (27.8)	45.5 (17.1)	−36.9	NS
Benzene (n = 26)	18.8 (14.0)	3.7 (1.6)	−80.2	< 0.01
Outdoor (n = 42)				
Ave $PM_{2.5}$	6.0 (0.8)	5.2 (0.1)	−13.6	NS
Ave PM_{10}	24.1 (19.3)	20.0 (5.0)	−17.4	NS
Benzene*		3.7		

Definition of abbreviations: Ave $PM_{2.5}$ = average amount of particulate matter 2.5 μm or smaller; Ave PM_{10} = average amount of particulate matter 10 μm or smaller; NS = not significant.

Values are given in μg/m³.

* Outdoor benzene mean value from PEOPLE (Population Exposure to Air Pollutants in Europe) project, April 28, 2004.

statistically significant. These results indicate that tobacco smoke was the major contributor to both $PM_{2.5}$ and benzene levels in pubs before the introduction of the workplace smoking ban. There was no smoking observed inside any of the 42 bars visited in the postban period, confirming full compliance.

Health Effects

All of the 81 volunteers completed a full set of PFTs preban, with 75 completing the postban measurements. Two subjects had changed their smoking status during the course of the study and were excluded from the analysis, leaving 73 bar staff (90%) who completed the study and were suitable for analysis. All of the volunteers were males working full time in pubs as their main form of employment. They had a mean age of 47.9 (22–68) years at the preban assessment. Among them, they had 2,298 years of exposure to ETS in their place of work (mean, 28.4 yr; range, 6–52 yr). The mean self-reported workplace exposure to ETS was 40.5 hours preban and 0.42 hours postban, showing a 99% reported decrease in exposure at work.

The total ETS exposure was 46.9 hours preban and 4.2 hours postban, showing a 90% decrease in total exposure. The exposure to ETS outside of work decreased from 6.4 hours preban to 3.7 hours postban (% change, −42%; $p \leqslant 0.01$). This is of interest because some feared that the ban could lead to increased exposure outside of work (21). FVC increased significantly in never-smokers and ex-smokers, whereas it declined in current smokers. Although FEV_1 did not change significantly in any group, it tended to increase in nonsmokers. The TLC increased in never-smokers and ex-smokers but not in smokers. Peak flow increased significantly in never-smokers, whereas the increase in ex-smokers was not significant, and it tended to decline in current smokers (Table 2). $FEF_{25–75}$ decreased in never-smokers and ex-smokers and was unchanged in smokers. There was no statistically significant change in RV in any group, although the RV in smokers tended to increase (Table 2). The mean DL_{CO} and the DL_{CO} corrected for percentage of carboxyhemoglobin show a statistically significant improvement of 5% for the never-smoker group, whereas the reduction in ex-smokers and smokers was not statistically significant (Table 2). Exhaled breath CO

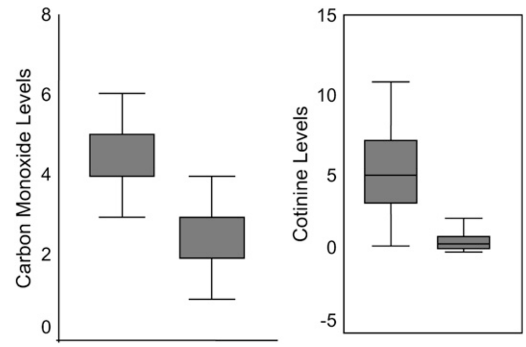

Figure 1. Whisker plot diagrams showing the medians and interquartile ranges of exhaled breath carbon monoxide levels (ppm) and salivary cotinine levels (ng/ml) before and after the workplace smoking ban (n = 73).

median values, with interquartile ranges (IQRs), were as follows: ppm, 4.0 (IQR, 3–5) and 2.0 (IQR, 2–3) in pre- and postban periods, respectively; the difference (−4.8) was statistically significant ($p < 0.001$) (Figure 1).

Salivary cotinine ng/ml median values, with IQRs, were as follows: 5.1 (IQR, 3.4–7.6) in preban and 0.6 (IQR, 0.3–1.3) in postban periods, respectively; the difference (−6.1) was also statistically significant ($p < 0.001$) (Figure 1). Median exhaled breath CO and salivary cotinine levels decreased by 79 and 81%, respectively, in never- and ex-smokers, but did not change significantly in current smokers.

Questionnaire Results

The questionnaire results obtained in this study (Tables 3 and 4) showed significant improvements in cough and phlegm production in nonsmokers (never- and ex-smokers combined) but not in smokers, whereas sensory irritant symptoms were improved in all subgroups, but smokers benefited less.

TABLE 2. RESPIRATORY FUNCTION PARAMETERS AND THE CHANGE BY SMOKING STATUS BEFORE AND AFTER INTRODUCTION OF THE WORKPLACE SMOKING BAN

	Total (*n* = *73*)			Never-Smokers (*n* = *34*)			Ex-Smokers (*n* = *31*)			Current Smokers (*n* = *8*)		
Parameters (*units*)	Pre	Post	p Value	Pre	Post	P Value	Pre	Post	p Value	Pre	Post	p Value
FEV_1, L/s	3.42	3.41	—	3.44	3.49	—	3.38	3.35	—	3.51	3.32	—
% pred	92.0	93.0	NS	92.0	94.0	NS	93.0	93.0	NS	88.0	84.0	NS
FVC, L	4.21	4.32	—	4.17	4.36	—	4.18	4.29	—	4.45	4.31	—
% pred	92.0	95.0	< 0.01	91.0	96.0	< 0.01	93.0	96.0	0.01	91.0	88.0	NS
FEV_1/FVC, %	81.0	78.0	< 0.01	82.0	80.0	< 0.01	81.0	78.0	< 0.05	79.0	76.0	0.03
PEF, L/min	500.7	508.8	—	506.6	530.0	—	505.7	515.0	—	489.1	481.3	—
% pred	94.0	97.0	< 0.01	94.0	99.5	< 0.01	96.0	98.0	NS	86.4	85.0	NS
$FEF_{25–75}$, L/s	3.50	3.24	—	3.68	3.41	—	3.42	3.11	—	3.41	3.20	—
% pred	87.0	80.0	< 0.01	89.0	83.0	0.04	87.0	79.0	< 0.01	78.0	73.0	NS
RV, L	2.14	2.17	—	1.98	1.97	—	2.20	2.24	—	2.54	2.70	—
% pred	99.0	100.0	NS	94.0	93.0	NS	101.0	101.0	NS	115	123	NS
TLC, L	6.42	6.55	—	6.24	6.38	—	6.46	6.58	—	7.03	7.10	—
% pred	91.0	93.0	< 0.01	90.0	92.0	0.02	92.0	94.0	0.04	95.0	96.0	NS
DL_{CO}, ml/min/mm Hg	28.7	28.5	—	27.9	29.5	—	28.9	28.7	—	29.2	27.2	—
corr DL_{CO}	29.1	28.7	—	28.1	29.6	—	29.2	28.8	—	30	27.8	—
corr Dl_{CO} ,% pred	93.0	94.0	NS	90.0	96.0	< 0.01	95.0	95.0	NS	88.0	83.0	NS

Definition of abbreviations: corr DL_{CO} = diffusing lung capacity for carbon monoxide corrected for carboxyhemoglobin; DL_{CO} = diffusing lung capacity for carbon monoxide; $FEF_{25–75}$ = forced expiratory flow 25 to 75%; NS = not significant; RV = residual volume; TLC = total lung capacity.

Analysis not done on the % pred values as predicted value varies with age. There was a one-year lapse between pre- and postban measurements.

TABLE 3. RESPIRATORY SYMPTOMS QUESTIONNAIRE DATA BEFORE AND AFTER THE WORKPLACE SMOKING BAN BY SMOKING STATUS

	Number Reporting Symptom			
	Preban	Postban	Change (%)	p Value
Q1. Have you had whistling/wheezing in your chest?				
Total nonsmokers (n = 65)	18 (28%)	15 (23%)	−17	NS
Smokers (n = 8)	6 (75%)	5 (63%)	−17	NS
Q2. Have you felt short of breath?				
Total nonsmokers (n = 65)	18 (28%)	10 (15%)	−45	NS
Smokers (n = 8)	4 (50%)	3 (38%)	−25	NS
Q3. Do you usually cough first thing in the morning?				
Total nonsmokers (n = 65)	21 (32%)	11 (17%)	−48	0.04
Smokers (n = 8)	6 (75%)	6 (75%)	0	NS
Q4. Do you cough at all during the rest of the day?				
Total nonsmokers (n = 65)	36 (55%)	22 (34%)	−39	< 0.01
Smokers (n = 8)	7 (88%)	7 (88%)	0	NS
Q5. Do you bring up phlegm?				
Total nonsmokers (n = 65)	44 (68%)	26 (40%)	−41	< 0.01
Smokers (n = 8)	7 (88%)	6 (75%)	−14	NS
Total reporting any respiratory symptom?	63 (86%)	45 (61%)	−28	< 0.01

Definition of abbreviations: NS = not significant.

DISCUSSION

This study shows that the workplace smoking ban in Ireland has significantly reduced the levels of both PM and benzene in the air in pubs. There was a dramatic reduction in exhaled CO levels and in salivary cotinine in barmen. The health of nonsmoking bar staff has improved in terms of pulmonary function and respiratory and irritant symptoms, whereas in smokers only irritant symptoms have improved, with other measured parameters showing a decline in the same period.

The rationale for using $PM_{2.5}$ and PM_{10} as markers of air pollution by secondhand smoke is that it is known that particles in this size range are responsible for excess mortality. We have previously shown that reduction of particle levels in ambient air resulted in marked health benefits in terms of respiratory and cardiovascular mortality (5, 6). It has been reported (22) that ETS particles are in the size range of 0.01 to 0.67 $\mu g/m^3$. The preban concentrations of $PM_{2.5}$ are comparable with the findings of Levy and colleagues (23), Lung and coworkers (24), and with those reported by Repace (25). Repace, however, reported values for $PM_{3.5}$ and the exposures relate to eight venues, all sampled during the same evening; this sampling period was significantly shorter than that used in our study in Dublin. These results confirm that the approach of a total ban on smoking in the workplace is successful in reducing the exposure of workers to particles. Previous studies (26, 27) have shown that partial bans do not work in this regard.

The volatile hydrocarbon benzene was used as a marker for carcinogenic substances, because cigarette smoke is a well-known

TABLE 4. IRRITANT SYMPTOMS QUESTIONNAIRE DATA BEFORE AND AFTER THE WORKPLACE SMOKING BAN BY SMOKING STATUS

	Number Reporting Symptom			
	Preban	Postban	Change (%)	p Value
Q1. In the past 4 weeks have your eyes been red/irritated?				
Never-smokers (n = 34)	20 (59%)	5 (15%)	−75	< 0.01
Ex-smokers (n = 31)	21 (68%)	2 (6%)	−90	< 0.01
Smokers (n = 8)	3 (38%)	1 (13%)	−67	NS
Q2. Have you had a runny nose, sneezing, or nose irritation?				
Never-smokers (n = 34)	22 (65%)	11 (32%)	−50	< 0.01
Ex-smokers (n = 31)	12 (39%)	9 (29%)	−25	NS
Smokers (n = 8)	8 (100%)	4 (50%)	−50	0.03
Q3. Have you had a sore or scratchy throat?				
Never-smokers (n = 34)	16 (47%)	7 (21%)	−56	< 0.01
Ex-smokers (n = 31)	15 (48%)	5 (16%)	−67	< 0.01
Smokers (n = 8)	4 (50%)	2 (25%)	−50	NS
Total reporting any irritant symptom?	64 (87%)	32 (43%)	−50	< 0.01

Definition of abbreviations: NS = not significant.

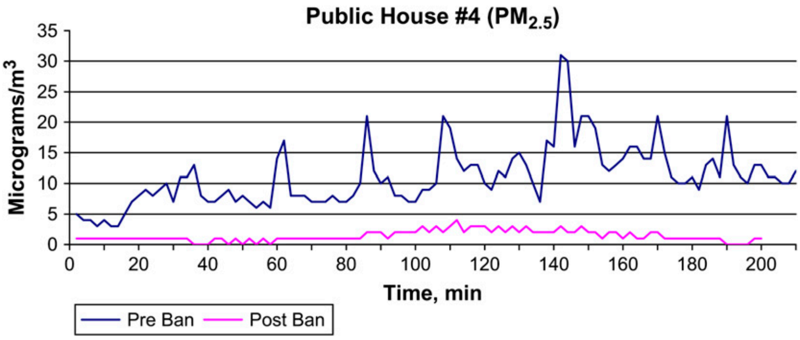

Figure 2. Example showing variation of particulate matter that is 2.5 μm or smaller ($PM_{2.5}$) levels in a Dublin pub during an evening before and after the introduction of the workplace smoking ban.

source of these substances, and we had already established ambient outdoor levels for benzene in Dublin. The postban levels were similar to ambient air levels, suggesting that the external contribution to indoor pub air benzene was not the source of the high levels seen before the ban. The reduction in benzene levels after the ban is similar to the drop in polyaromatic hydrocarbons reported by Repace (25).

The duration of monitoring was considered important because the particle levels vary with the number of customers smoking at any time, and with the variation in air movement (Figure 2), and short sampling times may therefore be unreliable as an indicator of overall exposure. Repace (25) reports on the change in particulate levels in hospitality venues in Delaware before and after a smoking ban, where he observed a 90% drop in $PM_{3.5}$ levels, which he attributed to ETS. The findings in our study for $PM_{2.5}$ are similar and consistent with those reported from Delaware. They are also consistent with the results presented by Mulcahy and colleagues (28) who reported a drop in $PM_{2.5}$ values for the pre- and postban exposures as measured for 4 minutes for each exposure period at nine public houses in Galway, Ireland. Mulcahy and coworkers (29) also reported on cotinine and nicotine levels before and after the Irish workplace smoking ban. Currently, there is no agreed-upon gold standard for the most appropriate markers or protocols for measurement of ETS (30) exposure, but these protocols and markers used in recent studies show encouraging agreement.

This study has also served to show that a workplace ban on smoking can have immediate beneficial effects on respiratory health. The acute improvements in self-reported respiratory and irritative upper airway symptoms are supported by the measurements of pulmonary function. A significant improvement in FVC and in gas diffusion ($D_{L_{CO}}$) suggests a real health gain. The somewhat counterintuitive findings of an apparent decline in small airway function, as reflected in the subdivisions of flow volume loops, may have to do with altered mechanics in small airways as suggested by the increase in FVC and TLC in nonsmokers and ex-smokers (Table 2), resulting in changed volume history. A similar finding seems to have occurred in a California study (7). It may also represent the reopening of small airways previously closed, thus contributing air at a lower flow rate. The results including an increase in $D_{L_{CO}}$, however, seem more in favor of an improvement in a mild restrictive effect of ETS than any change in an obstructive component.

The dramatic drop in exhaled breath CO may be of significance in terms of the short-term reduction in acute myocardial infarction seen in other studies, but we do not have this information in our study (8, 11). Longer term health benefits, such as in chronic obstructive pulmonary disease, asthma, and cardiovascular disease, need more prolonged studies but can be expected to occur given the known harmful effects of secondhand smoke (31). The reduction of benzene may be an indication of a reduction in the many other known carcinogens in secondhand smoke and may contribute to a reduction in lung cancer.

The cultural and social effects of this workplace ban on smoking are likely to be profound. Earlier, incomplete bans, such as the Finnish ban (32), have shown significant changes; however, the Irish ban, which was implemented to protect workers, including all service workers, recognizes the need for a change of mindset regarding all indoor spaces. Early results already show a significant change in attitude in smokers, with a majority of smokers now favoring the ban (33). Smoking prevalence estimates show a decline in smoking of 1.4% (34), which is more than three times the average Organisation for Economic Co-operation and Development (OECD) expected rate of decline in the same timeframe (35).

Results from data routinely collected by the Central Statistics Office show that employment in the hospitality sector has increased again after an initial drop and that tourism has also increased despite the predictions before the ban (36). Although smoking outside pubs is a new noticeable occurrence after the ban, limited data suggest that smoking outside pubs by customers visiting pubs is only a fraction of the numbers who smoked inside pubs before the ban (37).

The health effects results of this study are weakened by the fact that the bar workers were all volunteers and may not be fully representative of the exposed population. They were also all male. The sample size represents only approximately 10% of the male membership of the Irish trade union Mandate. The confidence in the magnitude of the health effects benefit is diminished by the uncertainty regarding the representativeness that a volunteer group poses. In addition, it was not possible to match the bar staff to the various pubs used as part of the exposure assessment because the pubs were selected as a representative sample of Dublin pubs to show how the levels of exposure changed over a whole series of venues, and the overlap with the volunteers was uncontrolled and only partial. The close correlation of the self-reported improvements in symptoms and reduction in exposure with the measured improvements in pulmonary function and markers of exposure is reassuring and extends our experience of the beneficial effects of workplace bans.

We conclude that a properly implemented comprehensive workplace ban on smoking, as introduced in Ireland, can achieve its primary aim. It can protect workers and others from exposure to the harmful particles, chemicals, and gases in secondhand smoke and result in immediate and significant health gain.

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