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<tr>
<td><strong>Author(s)</strong></td>
<td>Allwright, Shane; Paul, Gillian; Greiner, Birgit A.; Mullally, Bernie J.; Pursell, Lisa; Kelly, Alan; Bonner, Brendan; D'Eath, Maureen; McConnell, Bill; McLaughlin, James P.; O'Donovan, Diarmuid; O'Kane, Eamon; Perry, Ivan J.</td>
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Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study


Abstract

Objectives To compare exposure to secondhand smoke and respiratory health in bar staff in the Republic of Ireland and Northern Ireland before and after the introduction of legislation for smoke-free workplaces in the Republic.

Design Comparisons before and after the legislation in intervention and control regions.

Setting Public houses in three areas in the Republic (intervention) and one area in Northern Ireland (control).

Participants 329 bar staff enrolled in baseline survey; 249 (76%) followed up one year later. Of these, 158 were non-smokers both at baseline and follow-up.

Main outcome measures Salivary cotinine concentration, self-reported exposure to secondhand smoke, and respiratory and sensory irritation symptoms.

Results In bar staff in the Republic who did not themselves smoke, salivary cotinine concentrations dropped by 80% after the smoke-free law (from median 29.0 nmol/l (95% confidence interval 18.2 to 43.2 nmol/l)) to 5.1 nmol/l (2.8 to 13.1 nmol/l) in contrast with a 20% decline in Northern Ireland over the same period (from median 25.3 nmol/l (10.4 to 59.2 nmol/l) to 20.4 nmol/l (13.2 to 33.8 nmol/l)). Changes in self reported exposure to secondhand smoke were consistent with the changes in cotinine concentrations. Reporting any respiratory symptom declined significantly in the Republic (down 16.7%, −26.1% to −7.3%) but not in Northern Ireland (0% difference, −32.7% to 32.7%). After adjustment for confounding, respiratory symptoms declined significantly more in the Republic than in Northern Ireland and the decline in cotinine concentration was twice as great.

Conclusion The smoke-free law in the Republic of Ireland protects non-smoking bar workers from exposure to secondhand smoke.

Introduction

In response to the evidence on the adverse effects of passive smoking on health, on 29 March 2004 the Republic of Ireland introduced a comprehensive smoke-free law, covering all indoor workplaces, including bars and restaurants. Introduction of this legislation in the Republic but not in neighbouring Northern Ireland, with its comparable population, environment, and culture, was a form of “policy randomisation,” creating a natural experiment for identifying effects of the new law.

To date few studies have investigated whether legislation for smoke-free workplaces protects the health of workers. Cross-sectional surveys before and after similar legislation in Finland in 1995 showed a decline in self reported exposure to secondhand smoke in workers from several non-hospitality workplace settings. Some of the highest and most sustained occupational exposures to secondhand smoke occur in bar staff with non-smoking areas providing only limited protection. Carbon monoxide concentrations in pubs in Galway indicated high exposure in Irish bar workers. Eisner and colleagues examined 53 bar staff in San Francisco one month either side of the 1998 statewide law in California banning smoking in bars. They concluded that the law was associated with a rapid improvement in respiratory health.

We examined the impact on bar staff of a national workplace smoke-free law by using laboratory assessment of exposure to secondhand smoke and by controlling for unrelated secular trends. We compared exposure to secondhand smoke and respiratory health in bar staff in rural and urban areas of the Republic of Ireland before and after the law and compared these changes with changes observed in Northern Ireland.

Methods

We enrolled staff working in pubs in the Republic and Northern Ireland in a baseline survey in the six months leading up to the ban (September 2003 to March 2004) and followed them up one year later (September 2004 to March 2005) to assess changes in exposure to secondhand smoke and symptoms (natural experiment).

Sample selection

Three areas in the Republic (Dublin, Cork, and County Galway) were selected to represent different types of pub environment, together with one area in the north west of Northern Ireland. Sampling procedures were adapted to local circumstances to maximise follow-up. In Dublin, we selected city centre and suburban pubs. The main trade union for Dublin bar workers (Mandate) forwarded our letter asking members to contact the research team if they were interested in participating. All pubs on randomly selected streets in Cork city were invited to participate and up to two bar staff were randomly selected from each pub. In Galway, we identified rural and family owned pubs by selecting electoral districts with populations of less than 1500. In Northern Ireland, we selected pubs from Derry City Council area and the adjoining rural Strabane and Limavady Council areas. All staff present in the Galway and Northern Ireland pubs on the day of the survey were asked to participate.

Although we enrolled both smokers and non-smokers, this analysis is restricted to participants who were non-smokers at both baseline and follow-up.
Conduct of survey
We invited Dublin bar staff to a hospital respiratory laboratory for salivary cotinine testing and administration of the questionnaire. Bar staff from the three other areas and the few Dublin staff who did not wish to attend the laboratory were interviewed in their workplace (pub). Most follow-up interviews were conducted in the same month as the baseline survey; at least two attempts at contact were made. GP trained all the interviewers.

Exposure to secondhand smoke
Salivary cotinine—Non-stimulated saliva samples (about 1 ml) were collected according to the protocol used in the Health Survey for England. Samples were frozen and sent in batches to ABS Laboratories, London, who performed cotinine assays blind to the research team. The assay has a limit of detection of 1 ng/ml and a sensitivity of 10 ng/ml, which is comparable to other methods.14 We used versions of generalised estimation equations for multiple regression (for changes per person in cotinine before and after the ban) and for Poisson regression equations for multiple regression (for changes per person in respiratory and sensory symptoms) at follow-up versus at baseline, together with the inclusion of both time varying covariates (such as hours worked in the past two days) and time constant covariates (such as sex), limits modelling possibilities to specific forms of generalised estimation equations. We used versions of generalised estimation equations for multiple regression (for changes per person in cotinine before and after the ban) and for Poisson regression (rate ratio for changes per person in the reported numbers of symptoms before and after the ban) using Stata 9 (StataCorp, College Station, TX). All covariates were tested in the models, but we retained only those that proved significant, plus age and sex. Interaction terms between region and time period were always controlled internally. Uni-

Statistical analysis
A nationally representative survey of the US population used 85.2 nmol/l (15 ng/ml) serum cotinine as a cut off for distinguishing smokers from non-smokers. Heavy exposure to secondhand smoke, however, may produce saliva concentrations as high as 177.8 nmol/l (31.3 ng/ml). Given the high exposures in bar workers, and as salivary concentrations are 25% higher than serum concentrations, we defined non-smokers as those who reported being former smokers or who had never smoked and had salivary cotinine concentration <113.6 nmol/l (20 ng/ml). We excluded people who claimed to be non-smokers but had salivary cotinine concentration ≥113.6 nmol/l as we considered them to be active smokers.

To measure any changes, we analysed symptoms individually, grouped into two dichotomous variables (any respiratory symptoms and any sensory symptoms), and as two symptom scores (total number of respiratory symptoms and total number of sensory symptoms reported by each individual).

Analyses (changes within pairs) were restricted to participants who took part in both baseline and follow-up surveys, who were still working in a pub, and who did not change their smoking status between baseline and follow-up. In before and after comparisons, differences between groups in characteristics that did not change, such as age and length of time in the bar trade (all increase by one year) and sex, are controlled internally. Univariate and bivariate analyses were conducted with JMP 5.0.1 (SAS Institute, Pacific Grove, CA), SPSS 12.0.1 (SPSS, Chicago, IL) and Mathematica 5.2 (Wolfram Research, Champaign, IL). As the data were skewed, we have presented medians and interquartile ranges for continuous data. We compared paired differences using Wilcoxon signed rank test or McNemar’s χ² test for bivariate analyses and non-paired differences using Wilcoxon rank sum test, Pearson χ², or Fisher’s exact test.

The requirement to compare the Republic with Northern Ireland while simultaneously testing outcomes (continuous—such as cotinine—or count—such as number of symptoms) at follow-up versus at baseline, together with the inclusion of both time varying covariates (such as hours worked in the past two days) and time constant covariates (such as sex), limits modelling possibilities to specific forms of generalised estimation equations. We used versions of generalised estimation equations for multiple regression (for changes per person in cotinine before and after the ban) and for Poisson regression (rate ratio for changes per person in the reported numbers of symptoms before and after the ban) using Stata 9 (StataCorp, College Station, TX). All covariates were tested in the models, but we retained only those that proved significant, plus age and sex. Interaction terms between region and time period were always fitted and retained in the model if the associated P value was less than 0.10.

Results
We enrolled 329 bar staff at baseline and 249 in the follow-up survey (table 1). Forty eight were not eligible for follow-up, 23 could not be contacted after several attempts, and nine refused, giving a follow-up rate of 89% of those eligible or 76% overall in the Republic, and 88% and 71% in Northern Ireland. In total 226 participants in the baseline survey and 213 in the follow-up survey provided analysable saliva samples; 205 provided analysable samples in both surveys.

Most participants (161/249, 65% at baseline) were non-smokers. We restricted analyses to the 158 who were still...
non-smokers at follow-up. Most participants were men. Participants from the Republic were older and had been working in the current pub for longer (table 2).

Those not followed up (n = 80) were significantly younger and more likely to be women, to smoke, to have worked for a shorter time in the current bar, and to have said they had asthma diagnosed by a physician than those followed up (data not shown).

Salivary cotinine concentrations declined significantly in both regions, but with a much greater decline in the Republic (86% v 20% in Northern Ireland). Cotinine concentrations for almost all the non-smokers in the Republic (106/111) fell compared with 14 out of 20 in Northern Ireland.

Self reported exposure to secondhand smoke was high before the ban, with smoke at work accounting for by far the greatest exposure (table 3). Work related exposure dropped to a far greater extent in the Republic (median of 40 v 0 hours in the past week, P < 0.001) than in Northern Ireland (median 42 v 40 hours, P = 0.02). Exposures outside work also dropped significantly in the Republic (median 4 v 0 hours, P < 0.001) but increased in Northern Ireland (0 v 25.3 hours, P = 0.41).

At baseline 65% of non-smokers in the Republic reported one or more respiratory symptom (table 4). This dropped by 25% to 49% (P = 0.001) at follow-up. After the ban, significantly fewer reported cough during the day or night (P = 0.004) or production of phlegm (P = 0.002). Similarly, after the ban, reporting any sensory symptom dropped from 67% to 45% (P < 0.001), reflecting significant declines in reporting red eyes (P < 0.001) and sore throat (P = 0.004). In Northern Ireland, the proportion reporting any respiratory symptom was lower at baseline (45%) than in the Republic and remained at 45% after the ban, although reporting any sensory symptom declined from 75% to 55% (P = 0.13).

We modelled changes in cotinine concentrations and in the number of respiratory and sensory symptoms (table 5). After adjustment for relevant covariates, cotinine concentrations in non-smokers in the Republic dropped by 71% (from 35.8 to 10.2 nmol/l), more than twice as much as in Northern Ireland (34% from 35.2 to 22.7 nmol/l) (table 6).

Table 2 Baseline characteristics of non-smoking* bar staff enrolled in both baseline and follow-up surveys. Values are medians (interquartile ranges) unless stated otherwise

<table>
<thead>
<tr>
<th>Republic of Ireland (n=138)</th>
<th>Northern Ireland (n=29)</th>
<th>P value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>45.5 (35.0-54.9)</td>
<td>38.1 (29.9-43.8)</td>
</tr>
<tr>
<td>No (%) of women</td>
<td>23 (17)</td>
<td>25 (22)</td>
</tr>
<tr>
<td>Hours worked/week in current job</td>
<td>40 (38.0-50.0)</td>
<td>40 (21.5-58.8)</td>
</tr>
<tr>
<td>No (%) with history of asthma diagnosed by physician</td>
<td>15 (11)</td>
<td>1 (5)</td>
</tr>
<tr>
<td>No (%) currently receiving asthma prescription</td>
<td>9 (7.9)</td>
<td>0</td>
</tr>
</tbody>
</table>

*Non-smoker defined as participants who said they did not smoke or had given up and had salivary cotinine concentrations <113.6 nmol/l. Excludes participants who changed smoking status between surveys.

†P value for comparison of medians (Wilcoxon rank sum test) and categorical variables (Pearson x² or Fisher’s exact test) at baseline and follow-up.

Table 3 Exposure to secondhand smoke in non-smokers* at baseline and follow-up surveys in the Republic of Ireland (n=138) and Northern Ireland (n=20). Values are medians (interquartile ranges) unless stated otherwise

<table>
<thead>
<tr>
<th>Republic of Ireland</th>
<th>Baseline</th>
<th>Follow-up</th>
<th>P value†</th>
<th>Difference (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self reported exposure:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours exposed at work (pub or bar) during past 7 days</td>
<td>40 (38-50)</td>
<td>0</td>
<td>&lt;0.001</td>
<td>-22.7</td>
</tr>
<tr>
<td>Hours exposed outside work (domestic or social) during past 7 days</td>
<td>4 (0-10)</td>
<td>0 (0-2)</td>
<td>&lt;0.001</td>
<td>-1.75</td>
</tr>
<tr>
<td>No (%) living with smoker</td>
<td>37 (26.8)</td>
<td>36 (26.1)</td>
<td>0.79</td>
<td>-0.7</td>
</tr>
<tr>
<td>Hours worked in past 2 days</td>
<td>13 (9.1-19.5)</td>
<td>13 (7.1-18)</td>
<td>0.01</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Northern Ireland</th>
<th>Baseline</th>
<th>Follow-up</th>
<th>P value†</th>
<th>Difference (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self reported exposure:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours exposed at work (pub or bar) during past 7 days</td>
<td>42 (15-55)</td>
<td>40 (6.5-45)</td>
<td>0.02</td>
<td>-3</td>
</tr>
<tr>
<td>Hours exposed outside work (domestic or social) during past 7 days</td>
<td>0 (0-10)</td>
<td>2.5 (0-18)</td>
<td>0.41</td>
<td>-2.5 to 7.5</td>
</tr>
<tr>
<td>No (%) living with smoker</td>
<td>6 (30)</td>
<td>6 (31.6)</td>
<td>1.00</td>
<td>-0.9 to 19.9</td>
</tr>
<tr>
<td>Hours worked in past 2 days</td>
<td>12 (0-19)</td>
<td>10 (4-14)</td>
<td>0.63</td>
<td>-1.25 to 3.3</td>
</tr>
</tbody>
</table>

| IG-95% interquartile range. |
| No (%) of women living with smoker | 6 (30) | 6 (31.6) | 1.00 | -0.9 to 19.9 |
| Hours worked in past 2 days | 12 (0-19) | 10 (4-14) | 0.63 | -1.25 to 3.3 |

§Differences refer either to medians or percentages

The unexpected improvements in Northern Ireland may be explained by a decline in the pub trade. At follow-up, participants from Northern Ireland reported working fewer hours in the past two days (12 hours v 10, table 3). An economic downturn in the north west region,11 avoidance of drink driving, and stricter enforcement of regulations on underage drinking may be contributory factors. Some of the same factors may also
Table 4 Respiratory and sensory irritation symptoms at baseline and at follow-up surveys among non-smokers* in the Republic of Ireland and Northern Ireland (n=138 and 20). Values are numbers (percentages) unless stated otherwise

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Republic of Ireland</th>
<th>Northern Ireland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Any symptom</td>
<td>93 (67)</td>
<td>65 (49)</td>
</tr>
<tr>
<td>Eyes, red or irritated</td>
<td>57 (41)</td>
<td>19 (14)</td>
</tr>
<tr>
<td>Nose, runny or sneezing</td>
<td>61 (44)</td>
<td>48 (35)</td>
</tr>
<tr>
<td>Throat, sore or scratchy</td>
<td>46 (33)</td>
<td>26 (19)</td>
</tr>
</tbody>
</table>

Table 5 Modelled changes in non-smokers. Figures are regression coefficients (95% confidence intervals) for cotinine concentrations and rate ratios (95% confidence intervals) for respiratory and sensory symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Republic of Ireland</th>
<th>Northern Ireland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression coefficient or rate ratio (95% CI)</td>
<td>P value</td>
</tr>
<tr>
<td>Cotinine concentrations (nmol/l) (n=131)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region (Republic/Northern Ireland)</td>
<td>0.022 (−1.56 to 1.16)</td>
<td>0.978</td>
</tr>
<tr>
<td>Time period (follow-up:baseline)</td>
<td>−1.99 (−3.64 to −0.36)</td>
<td>0.017</td>
</tr>
<tr>
<td>Live with smoker (yes/no)</td>
<td>1.62 (0.62 to 2.62)</td>
<td>0.002</td>
</tr>
<tr>
<td>Hours worked in past 2 days</td>
<td>0.07 (0.03 to 0.11)</td>
<td>0.011</td>
</tr>
<tr>
<td>Age (years)</td>
<td>−0.03 (−0.07 to 0.001)</td>
<td>0.553</td>
</tr>
<tr>
<td>Sex (female: male)</td>
<td>0.84 (−0.28 to 2.16)</td>
<td>0.134</td>
</tr>
<tr>
<td>Interaction between region and time period</td>
<td>−2.40 (−4.18 to −0.62)</td>
<td>0.008</td>
</tr>
<tr>
<td>Constant</td>
<td>6.19 (4.25 to 8.12)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Preliminary results from Norway show significant reductions in both respiratory and sensory symptoms.24

Strengths of study

We managed to enrol a large number of bar staff and our follow-up rate was high. The study evaluated a national law, bar staff were enrolled from three differing areas, and the inclusion of Northern Ireland allowed us to control for secular trends unrelated to the legislative change and hence estimate how much of the change was due to the new law.

In bodily fluids, cotinine, with a half life of around 20 hours, is a good indicator of exposure to smoke over the previous two to three days. We used a combination of cotinine and self reported exposure as this is considered the best way of estimating exposure.24

The substantial declines in personal exposure of bar staff reported here are corroborated by measurements of particulate concentrations in pubs. Significant reductions (typically 60-80%) were observed after the introduction of the workplace smoking

Comparison with other studies

There have been few follow-up studies of bar workers. The San Francisco study was small, based in a single city, and did not include biomarkers for assessment of secondhand smoke.11

Follow-up studies in New York20 and Norway26 were not focused (exclusively) on bar staff and had lower follow-up rates. None included a control population.

In the San Francisco study,11 we found dramatic decreases in self reported exposure to secondhand smoke at work and reductions in respiratory and sensory symptoms. The reductions in salivary cotinine concentrations in non-smoking hospitality workers in New York12 were of a similar magnitude to those in our study. They reported significant reductions in the numbers of sensory symptoms but not of respiratory symptoms.

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What is already known on this topic
Secondhand smoke has adverse effects on health, including respiratory health.

Smoke-free policies are associated with decreased exposure in the hospitality sector and possibly a rapid improvement in respiratory health in bar workers, though the size of these effects relative to underlying trends is unknown.

What this study adds
After the introduction of comprehensive smoke-free workplace legislation in the Republic of Ireland, exposure to secondhand smoke and respiratory symptoms declined in non-smoking bar staff.

The reductions were significantly higher than the unanticipated reductions observed in the control region.

Limitations of study
The lack of national or regional sampling frames precluded random sampling. The low take up at baseline, a feature of other studies in this setting, reflects the pervasive anxiety in the trade at that time about the impending ban. Because we used volunteer sampling, the cotinine concentrations and frequencies of symptoms reported here may not be generalisable. By choosing different types of pub from urban and rural areas, however, we have provided an overall picture of the impact of the ban.

The small number not followed up differed from the overall group but this does not compromise study validity because of the paired design. Although the numbers enrolled from Northern Ireland were small, they were sufficient to detect significant changes.

Recommendations for further research
Although perceived health is important, objective testing of lung function and longer follow-up are required to assess the long term impact of the ban. Our results suggest that home exposure may have declined after the ban. Incorporation of testing of salivary cotinine concentrations in children into national longitudinal studies would be an objective way to monitor future exposures in countries considering the introduction of similar legislation. Secondhand exposure to smoke in exempted workplaces (such as prisons, psychiatric institutions, and hospices) should be monitored to assess the need for protection of their staff.

Implications of findings
The smoke-free workplace law in the Republic of Ireland has provided protection for one of the most heavily exposed occupational groups by reducing their exposure to secondhand smoke both in and out of the workplace. The reduced exposure has led to a decline in respiratory and sensory symptoms in non-smokers. The increase in support for the law in the Republic since its introduction, even among smokers, underpins its effectiveness.

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The smoke-free workplace law in the Republic of Ireland has provided protection for one of the most heavily exposed occupational groups by reducing their exposure to secondhand smoke both in and out of the workplace. The reduced exposure has led to a decline in respiratory and sensory symptoms in non-smokers. The increase in support for the law in the Republic since its introduction, even among smokers, underpins its effectiveness.

These findings have implications for policy makers and legislators in other countries currently considering the nature and extent of their smoke-free workplace legislation.

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Contributors: All authors reviewed and approved the final version of this manuscript. SA conceptualised the study and was involved in and coordinated all aspects of the study. All the analyses, wrote all drafts of the paper, and is guarantor. GP participated in design, preparation of study materials and protocol, data collection, data entry/editing, interpretation, and preparation of drafts. BJM and LP participated in design, preparation of study materials and protocol, data collection, data entry/editing, and preparation of drafts. AK was statistical adviser, conducted statistical modelling, and participated in the interpretation. MTE participated in data collection, data entry/editing, and commented on drafts. EOF participated in design and data collection and commented on drafts of the manuscript. JPM&C participated in the research design and protocol preparation and commented on drafts. DOD participated in the research design and protocol preparation, contributed to preparation of study materials, and commented on drafts. BB, BMcC, and JIP participated in design and commented on drafts.

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Competing interest: SA is a member of the Board of the Irish Office of Tobacco Control (unpaid position). JIP is chairman of the Irish Research Institute for a Tobacco Free Society.

Ethical approval: Research ethics committee of the Faculty of Public Health Medicine, Royal College of Physicians of Ireland; the St James’s Hospital and Federated Dublin Voluntary Hospitals joint research ethics committee; the clinical research ethics committee of the Cork Teaching Hospitals; and the healthcare committee and senior management team of the Western Health and Social Services Board and the Western Investing for Health Partnership.

Papers


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