

# **How Smoke-free Laws Improve Air Quality: A Global Study of Irish Pubs**

***Feabhas ar an aer de bharr dhlíthe chosc an tobac: Staidéar  
Cuimsitheach ar Thithe Ósta na hÉireann***

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## Overview

When St. Patrick, known as the patron saint of Ireland, arrived in Ireland in the first half of the 5<sup>th</sup> century, tobacco was not known to Ireland or the rest of Europe. It wasn't until the middle of the 16<sup>th</sup> century that tobacco was introduced to this part of the world. Nearly 500 years later, smoking was banned in public places, making the air as clean as it was when St. Patrick arrived in Ireland.

In March 2004, the Republic of Ireland banned indoor smoking in all public spaces including restaurants and pubs. Many said that it could not be done, smokers would simply ignore the law and chaos and economic ruin would follow. Nearly two years later, the critics are silent, and hundreds of communities around the globe and nearly a dozen countries have followed Ireland's lead by adopting smoke-free legislation as the norm.

Irish pubs can be found in nearly every city in the world. Some are smoke-free, while others remain smoke-filled. We conducted a study to test the air quality of Irish pubs around the globe. Indoor air quality was assessed in 128 Irish pubs in 15 countries, between January 21, 2004 and March 10, 2006. Air quality was evaluated using an aerosol monitor which measures the level of fine particle (PM<sub>2.5</sub>) pollution in the air. Fine particle pollutants, such as those generated from burning cigarettes, are less than 2.5 microns in diameter. These fine particles are especially dangerous since they can be easily inhaled deep into the lungs and result in a variety of adverse health effects including cardiovascular disease, respiratory morbidity, and even death.

Testing sites included 41 smoke-free Irish pubs in the Republic of Ireland, the United States, and Canada, and 87 smoking-permitted Irish pubs located in Armenia, Australia, Belgium, China, England, France, Germany, Greece, Lebanon, Northern Ireland, Poland, Romania, and the United States

The results of the study found that, overall, the level of air pollution inside Irish pubs located in smoke-free cities was 93% lower than the level found in pubs in smoke-permitted cities. Specifically, the average level of indoor air pollution in Ireland's authentic smoke-free pubs was 91% lower than Irish pubs in cities that allow smoking.

No doubt St. Patrick would prefer to see those who wish to celebrate in his honor do so in a place where workers and patrons alike can breathe fresh air free from tobacco smoke pollution.

## Introduction

Secondhand smoke (SHS) exposure remains a major global public health concern that is entirely preventable.<sup>1</sup> SHS is a known human carcinogen containing at least 250 chemicals that are known to be toxic or carcinogenic<sup>2</sup>, and is responsible for an estimated 3,000 lung cancer deaths annually in never smokers in the U.S., as well as over 35,000 deaths annually from coronary heart disease in never smokers, plus respiratory infections, asthma, Sudden Infant Death Syndrome (SIDS), and other illnesses in children.<sup>3</sup> SHS is a major source of respirable suspended particles (RSPs). A specific category of RSPs, known as PM<sub>2.5</sub> (i.e. particulate matter less than 2.5 microns in diameter), are very small particles suspended in the air which pose dangerous health effects. In order to protect the public health, the EPA has set limits of 15 µg/m<sup>3</sup> as the average annual level of PM<sub>2.5</sub> exposure and 65 µg/m<sup>3</sup> 24-hour exposure.<sup>4</sup>

Dangers of SHS exposure are highest among restaurant and bar workers who typically have low levels of protection provided by smoking regulations.<sup>1,5-10</sup> The most effective method for reducing SHS exposure in public places are policies requiring smoke-free environments.<sup>11</sup> The World Health Organization (WHO) Framework Convention on Tobacco Control (FCTC) calls on governments to “protect all persons from exposure to tobacco smoke,” rather than just specific populations such as children or pregnant women (Guiding Principle 4.1). This protection should be extended, according to Article 8.2, “in indoor workplaces, public transport, indoor public places and...other public places.”<sup>12</sup>

In recent years, many U.S. states and cities have passed laws prohibiting smoking in workplaces including pubs and restaurants. In March of 2004, the government of Ireland banned smoking in worksites including public houses (pubs) making Ireland the first country to implement a nationwide policy. Given the smoking rates in Ireland and the association between smoking and visiting a pub, this was an historic event.

Previous studies in the U.S. have evaluated the impact of smoking legislation by measuring the difference in levels of RSPs between smoke-free venues and those that permit smoking.<sup>13-16</sup> Air quality assessment in Irish pubs showed a dramatic reduction in the presence of RSPs (PM<sub>10</sub> and PM<sub>2.5</sub>) following the implementation of the smoke-free law, with no adverse effects on business.<sup>17,18</sup> Despite claims that the law would not be adhered to and that it would have a negative impact on pub business, these have not been realized. Fong et al. reported high compliance with the Irish law,<sup>19</sup> and the Central Statistics Office (CSO) in Ireland recently reported a slight increase in the volume of bar sales between 2004 and 2005.<sup>20</sup>

Given the smoke-free policies in Ireland, a study of air pollution in Irish pubs globally provides an opportunity to assess the effectiveness of comprehensive smoke-free laws. The purpose of the study was to examine indoor air quality in a global sample of smoke-free and smoking-permitted Irish pubs. It was hypothesized that RSP levels, an important marker of secondhand smoke, would be significantly lower in smoke-free Irish pubs than in those pubs that allow smoking.

## **Methods**

### Overview

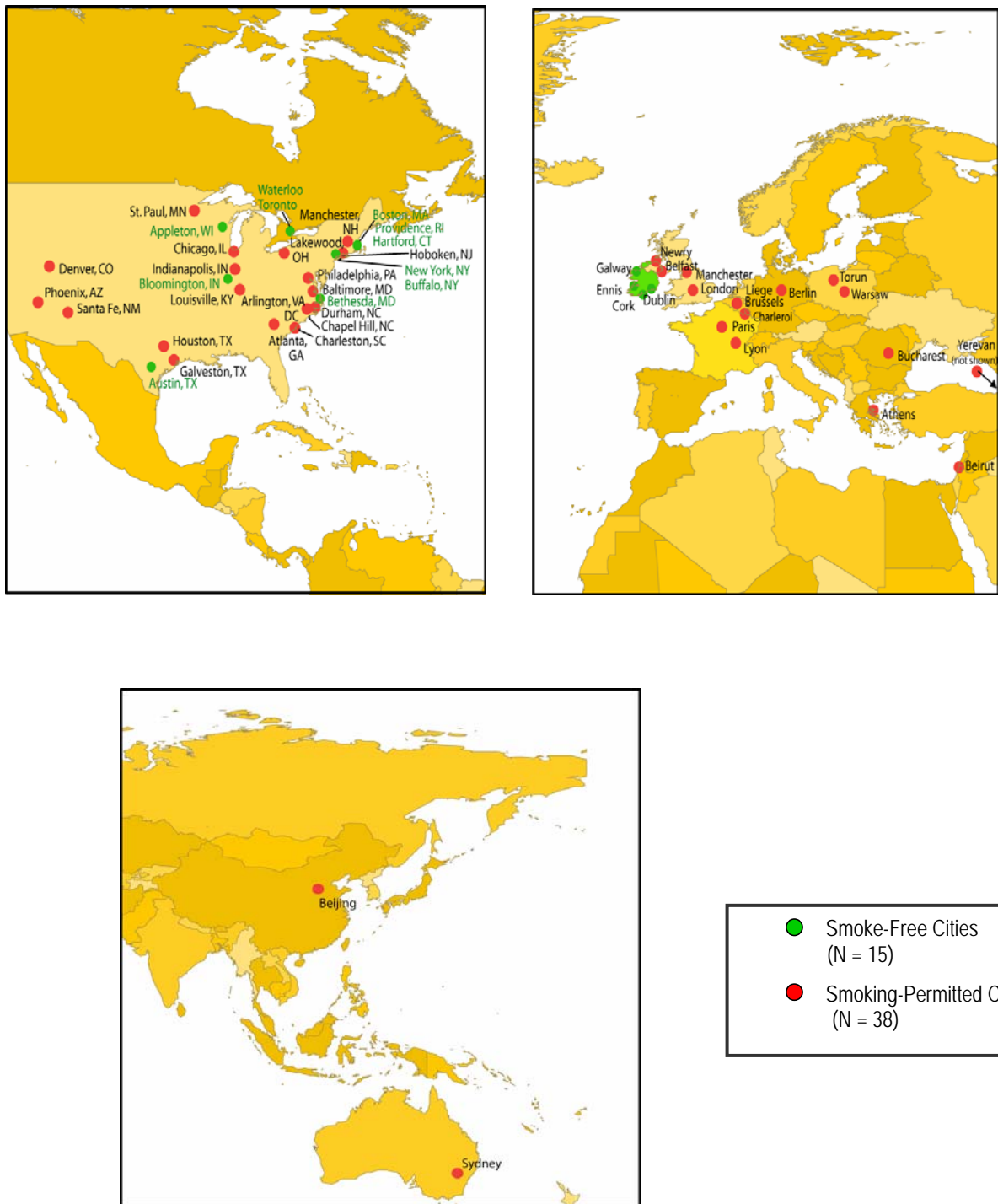
Between January 21, 2004 and March 10, 2006, air quality was assessed in 128 Irish pubs in 15 countries. The pubs were located in the Republic of Ireland, the United States, Canada, Australia, Northern Ireland, France, Lebanon, Belgium, Poland, Greece, Germany, China, England, Romania, and Armenia; Testing sites were conveniently selected by tobacco control professionals in their respective cities. Irish pubs were defined as those that served Irish beer on tap, and had an Irish name (e.g. Murphy's, O'Donnell's) or a visible statement that the venue was an Irish pub (e.g. exterior or interior sign with terms such as "Irish pub"). Testing was completed in smoking and smoke-free pubs on all the days of the week from afternoon onwards. Some pubs were individually-owned establishments and some were part of local or national chain entities.

Smoke-free Irish pubs were located in 3 cities and 1 town in the Republic of Ireland, (Cork, Galway, Dublin, Ennis), 2 cities in Canada (Toronto, Waterloo), and 9 US cities (Appleton, Austin, Bethesda, Bloomington, Boston, Buffalo, Hartford, Providence, New York City). Smoking-permitted pubs were located in 13 countries and 38 cities including Armenia (Yerevan), Australia (Sydney), Northern Ireland (Belfast, Newry), Germany (Berlin), Greece (Athens), Lebanon (Beirut), France (Lyon, Paris), Belgium (Brussels, Charleroi, Leige), Poland (Torun, Warsaw), China (Beijing), Romania (Bucharest), the United States (Arlington, Atlanta, Baltimore, Chapel Hill, Charleston, Chicago, Denver, Durham, Galveston, Hoboken, Houston, Indianapolis, Lakewood, Louisville, Manchester, Santa Fe, St. Paul, Philadelphia, Phoenix, Washington, D.C.) and England (London, Manchester) (see Figure 1).

### Measurement Protocol

A standard measurement protocol was used by data collectors across study sites. Establishments were tested for a minimum of 30 minutes. The number of people inside the venue and the number of burning cigarettes were recorded every 15 minutes during sampling. These observations were averaged over the time inside the venue to determine the average number of people on the premises and the average number of burning cigarettes. For most establishments, a sonic measure (Zircon Corporation, Campbell, CA) was used to measure room dimensions and hence the volume of each of the venues. When using the sonic measure to calculate room dimensions was not possible, room measurements were made through estimation.

**Figure 1. Locations of Irish pubs sampled**



A TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of respirable suspended particles (RSPs) in the air. The SidePak uses a built-in sampling pump to draw air through the device where the particulate matter in the air scatters the light from a laser to assess the real-time concentration of particles smaller than  $2.5\mu\text{m}$  in micrograms per cubic meter, or  $\text{PM}_{2.5}$ . The SidePak was calibrated against a laser photometer, which had been previously calibrated and used in similar studies. In addition, the SidePak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications.



The equipment was set to a one-minute log interval, which averages the previous 60 one-second measurements. Sampling was discreet in order not to disturb the occupants' normal behavior. For each pub, the first and last minute of logged data were removed because they are averaged with outdoors and entryway air. The remaining data points were averaged to provide an average  $\text{PM}_{2.5}$  concentration within the venue.

### Statistical Analyses

The primary goal was to assess the difference in the average levels of  $\text{PM}_{2.5}$  in a cross-sectional sample of smoke-free and smoking-permitted Irish pubs, which was assessed with the independent-samples t-test. Descriptive statistics including the venue volume, number of patrons, and average smoker density (i.e. number of burning cigarettes per  $100\text{ m}^3$ ) are also reported for each pub and averaged for all pubs. The active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in cubic meters ( $\text{m}^3$ ).

### **Results**

Table 1 provides a summary of the data collected in 128 Irish Pub including 25 authentic Irish pubs in the Republic of Ireland, 14 in non-smoking US cities, and 2 in Toronto, Canada. Eighty-seven smoking-permitted pubs were visited in 20 US cities, and 18 cities in other countries including Armenia, Northern Ireland, Greece, Germany, Lebanon, France, Belgium, Poland, China, England, Romania, and Australia. It should be noted that some cities will be subject to upcoming changes in smoking policies in their respective cities (London, Manchester (UK), Belfast, Newry, Hoboken, St Paul, Sydney).

The average size of the 128 pubs was  $935\text{ m}^3$ , with the smoke-free pubs being on average smaller than smoking-permitted pubs ( $427\text{ m}^3$  vs.  $1070\text{ m}^3$ ). The average number of patrons present during sampling was 59, and consistent with their smaller size, the smoke-free pubs had fewer people on average than the smoking-permitted pubs (50 vs. 64).

**Table 1. Summary of Each Irish pub Visited By Country and City**

Country	State/Region	City	Policy	N	Mean PM <sub>2.5</sub> Level
<b>US Smoke-free Pubs</b>	8	9		14	14
	Connecticut	Hartford	Yes	2	18
	Indiana	Bloomington	Yes	1	10
	Maryland	Bethesda	Yes	1	8
	Massachusetts	Boston	Yes	2	13
	New York	Buffalo	Yes	2	15
		New York City	Yes	2	17
	Rhode Island	Providence	Yes	1	3
	Texas	Austin	Yes	1	22
	Wisconsin	Appleton	Yes	2	17
<b>US Smoking Pubs</b>	18	20		48	271
	Arizona	Phoenix	No	3	142
	Colorado	Denver	No	4	87
	Georgia	Atlanta	No	2	267
	Illinois	Chicago ***	No	2	235
	Indiana	Indianapolis*	No	3	372
	Kentucky	Louisville*	No	5	342
	Maryland	Baltimore	No	1	87
	Minnesota	St. Paul***	No	4	276
	New Hampshire	Manchester	No	3	394
	New Jersey**	Hoboken	No	2	709
	New Mexico	Santa Fe	No	1	57
	North Carolina	Raleigh – Durham - Chapel Hill	No	2	170
	Ohio	Lakewood	No	3	425
	Pennsylvania	Philadelphia	No	2	293
	South Carolina	Charleston	No	3	236
	Texas	Galveston	No	2	363
		Houston*	No	1	108
	Virginia	Arlington	No	3	145
	Washington, D.C. ***	Washington, D.C. ***	No	2	184
<b>Ireland</b>		4		25	29
		Dublin	Yes	7	30
		Cork	Yes	6	32
		Ennis	Yes	4	32
		Galway	Yes	8	23
<b>Canada</b>		2		2	12
		Toronto	Yes	1	19
	Ontario	Waterloo	Yes	1	4
<b>Other Nations</b>		18		39	425
<b>Armenia</b>		Yerevan	No	1	498
<b>Australia</b>	New South Wales	Sydney	No	4	132
		Brussels	No	1	273
<b>Belgium</b>		Charleroi	No	1	876
		Liege	No	2	423
<b>China</b>		Beijing	No	1	145
<b>England****</b>		London	No	3	296
		Manchester	No	3	415
<b>France</b>		Paris	No	2	505
		Lyon	No	1	1051
<b>Germany</b>		Berlin	No	1	278
<b>Greece</b>		Athens	No	1	748
<b>Lebanon</b>		Beirut	No	2	730
<b>Northern Ireland****</b>		Belfast	No	7	353
		Newry	No	6	400
<b>Poland</b>		Torun	No	1	695
		Warsaw	No	1	538
<b>Romania</b>		Bucharest	No	1	623

\*Limited ban (i.e., smoking is banned only in stand-alone restaurants or eating establishments that derive less than 25% of sales from alcohol)

\*\*Statewide complete ban to be implemented spring 2006.

\*\*\*Citywide complete ban to be implemented March 31, 2006, winter 2007, and summer 2008, accordingly.

\*\*\*\*Nationwide complete ban to be implemented in 2007.

**Note: This data is to be interpreted cautiously. Testing sites were selected on a convenience basis and may not be representative of pubs in each locality.**

As shown in Figure 2, 87 pubs allowed smoking, and the average PM<sub>2.5</sub> level in these pubs was 340 µg/m<sup>3</sup> (SD = 270.4) ranging from 33 to 1320 µg/m<sup>3</sup>. The average PM<sub>2.5</sub> level in the 41 smoke-free pubs was 23 µg/m<sup>3</sup> (SD = 18.0) ranging from 3 to 96 µg/m<sup>3</sup>.



The level of indoor air pollution was 93% lower in the pubs that were smoke-free compared to those where smoking was permitted. The difference between the mean RSP levels was statistically significant ( $t = -10.881$ ,  $df = 88$ ),  $p < .001$ .

Figure 3 shows the average air pollution levels found in Irish pubs in the Republic of Ireland compared to those outside Ireland where smoking is permitted. The average PM<sub>2.5</sub> level in authentic Irish pubs was 29 µg/m<sup>3</sup>. The level of indoor air pollution was 91% lower in the Republic of Ireland's pubs than in US and international smoking- permitted pubs (340 µg/m<sup>3</sup>).

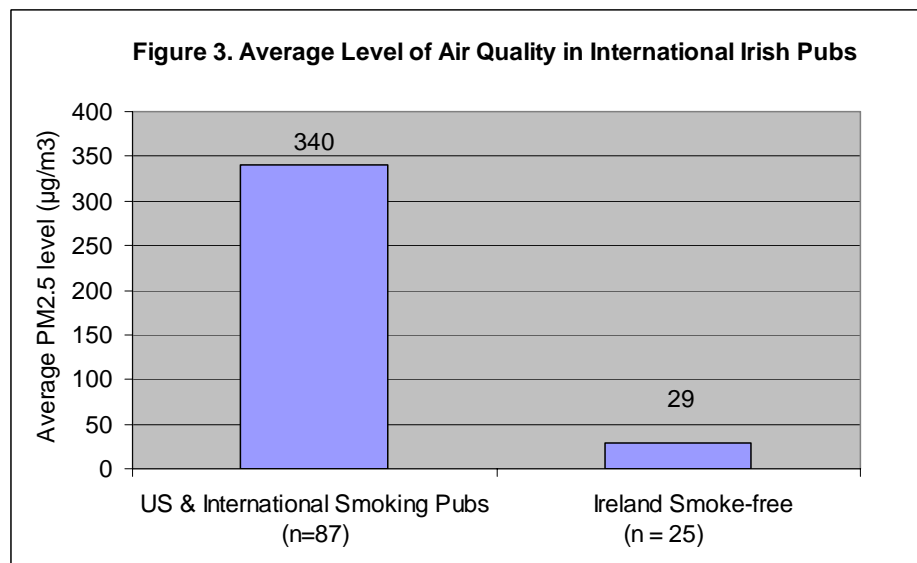


Figure 4 shows the average air pollution levels found in Irish pubs across world regions. The average PM<sub>2.5</sub> level in smoke-free Irish pubs in the U.S./Canada (14 µg/m<sup>3</sup>), and the Republic of Ireland (29 µg/m<sup>3</sup>) are significantly lower than levels in smoking-permitted pubs in the U.S. (271 µg/m<sup>3</sup>), other nations (China, Australia, Armenia, Lebanon) (328 µg/m<sup>3</sup>), Northern Ireland (375 µg/m<sup>3</sup>), and Europe (504 µg/m<sup>3</sup>).

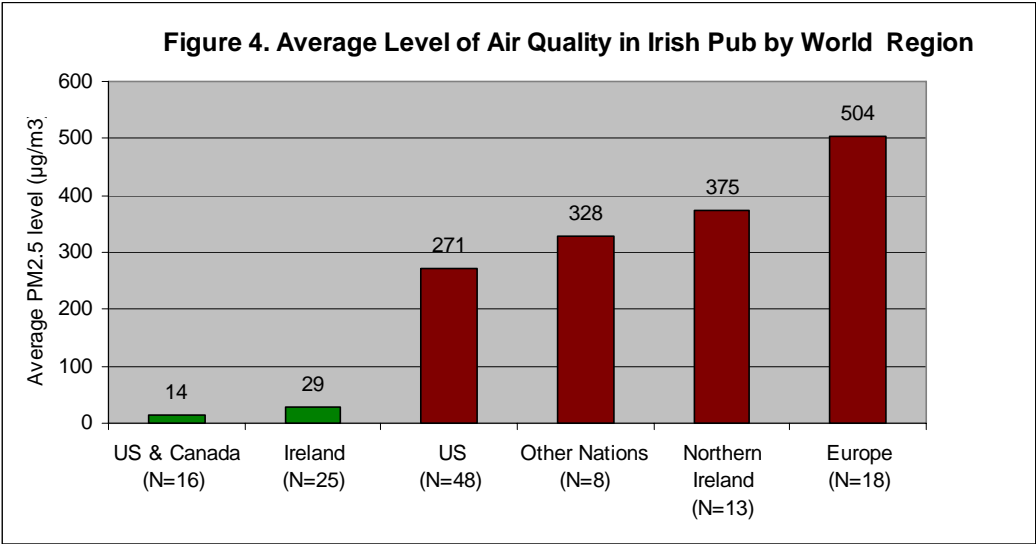
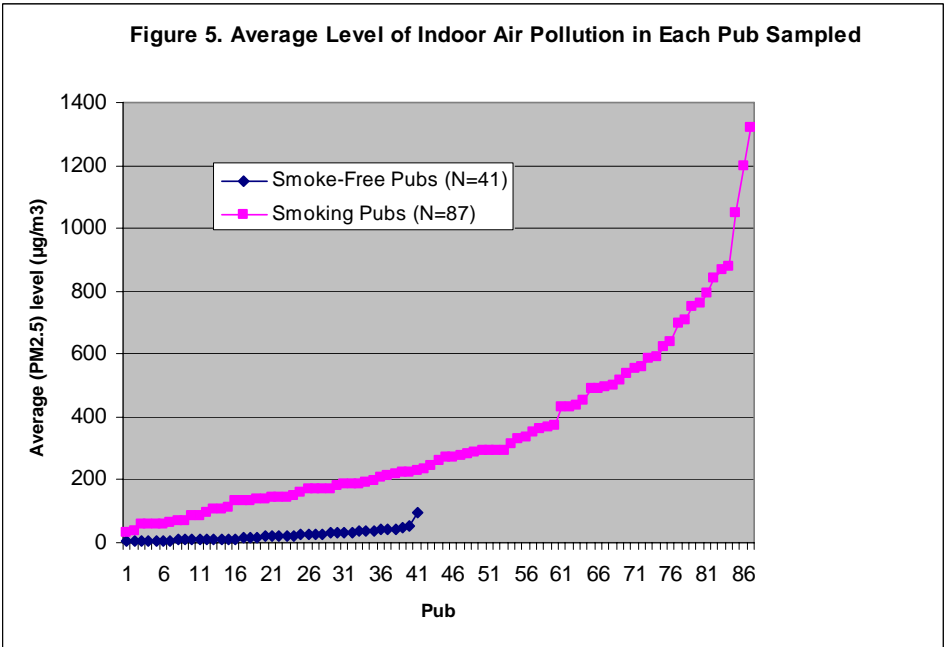
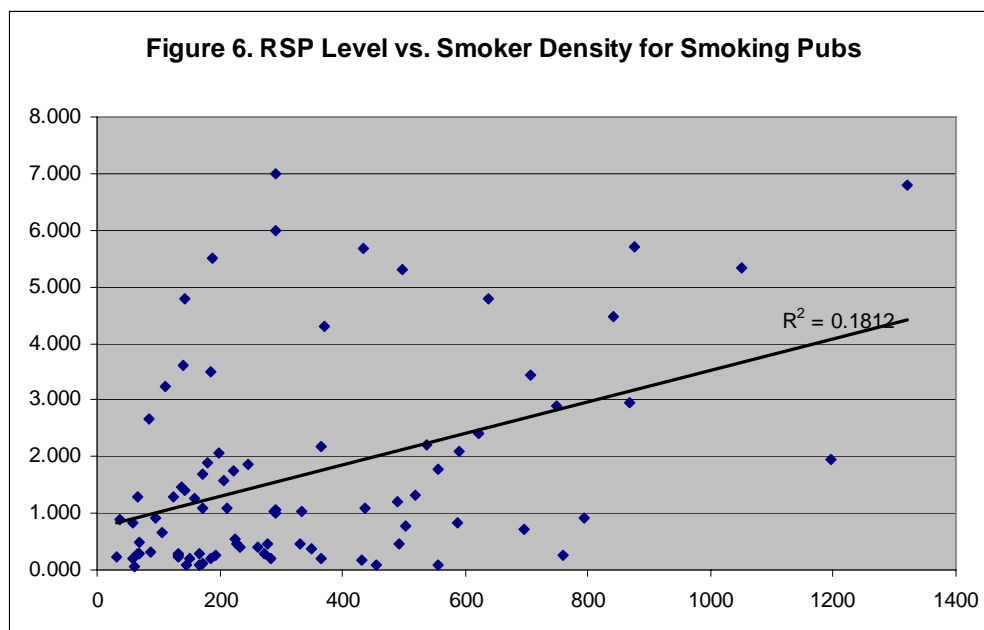


Figure 5 shows the average indoor air pollution level in each of the 87 smoking pubs tested. Average PM<sub>2.5</sub> levels in smoke-free pubs and smoking pubs ranged from 3 to 96 µg/m<sup>3</sup> and 33 to 1320 µg/m<sup>3</sup>, respectively. While the average level in all of the smoking-permitted pubs is 15 times higher than in smoke-free pubs Figure 5 shows that many pubs were much higher, with levels in excess of EPA standards. The EPA annual (15µg/m<sup>3</sup>) and 24-hour (65 PM<sub>2.5</sub> µg/m<sup>3</sup>) exposure limits were exceeded by 100% and 95% of the smoking-permitted pubs, respectively.



The average smoker density was much greater in the smoking permitted pubs (n = 87) (1.69 burning cigarettes per 100 m<sup>3</sup>) compared to the smoke-free locations (0.00 burning cigarettes per 100 m<sup>3</sup>). No smoking was observed in any of the pubs with smoke-free policies. As shown in Figure 6, average PM<sub>2.5</sub> levels were significantly positively correlated (r = 0.43, p < 0.01) with smoker density. Variation in amounts of ventilation (e.g. air conditioning, open doors/windows) may influence PM<sub>2.5</sub> levels. Testing did not control for ventilation or smoke that may have migrated from outdoors where smokers tend to smoke.



## Discussion

This study demonstrates that national and subnational smoking policies have dramatically improved indoor air quality in a sample of international Irish pubs. Indoor air quality testing indicated that, on average, levels of PM<sub>2.5</sub> in smoke-free Irish pubs (23 µg/m<sup>3</sup>) were 93% lower compared to smoking-permitted Irish pubs (340 µg/m<sup>3</sup>). These findings are consistent with other US studies that have examined changes in air quality to evaluate the impact of smoking legislation.<sup>14-16</sup> Studies conducted in the Republic of Ireland have shown similar reductions in small particles<sup>17</sup> as well as air nicotine concentrations.<sup>21</sup> The absence of smokers in smoke-free pubs indicates that workplace owners and patrons are complying with these laws, across the world.

Other studies have directly assessed the health effects of SHS exposure. One study found improvements in respiratory health among bartenders after the implementation of a statewide smoking ban,<sup>22</sup> and another study reported reductions in acute myocardial infarctions in patients admitted to a hospital after the implantation of a local smoking ban.<sup>23</sup> An examination of SHS exposure among workers following Ireland's comprehensive ban showed significant reductions in air nicotine and saliva cotinine.<sup>21</sup> Respiratory health studies in Ireland have shown results similar to California as well as dramatic reductions in exhaled carbon monoxide and ambient Benzene levels post the smoking ban.<sup>24</sup> According to Repace et al. (2006), RSPs are correlated with biological markers for exposure (e.g. nicotine, cotinine) which can be used to predict adverse health outcomes.<sup>25</sup> These results further confirm that these laws effectively reduce SHS exposure and can provide health benefits, worldwide.

Many US states and foreign countries have implemented policies for smoke-free workplaces including restaurant and pubs. The countries that currently have indoor smoking bans that cover pubs include: Ireland, Bhutan, Malta, Norway, Sweden, Italy, New Zealand and most recently, England (effective 2007), Scotland (upcoming), Northern Ireland (effective 2007) and Uruguay. U.S. states with smoke-free laws in workplaces including pubs are: California, Connecticut, Delaware, Maine, Montana (2009), New Jersey (April, 2006), New York, Massachusetts, Rhode Island, Utah (2009), Vermont, Washington. Washington DC and Puerto Rico have also passed such laws. Washington DC will extend to cover bars in January, 2007. Many U.S. communities have adopted local smoke-free laws. As of January 2006, 28% of the US population was covered by local or state-wide smoke-free bar laws, and almost 40% of the population was covered by any smoke-free law (i.e. workplace, restaurant, bar).<sup>26</sup>

There are limitations to this study. Convenience samples of Irish pubs and locations were used and thus, findings may not be representative of all Irish pubs. SHS is not the only source of indoor levels of PM<sub>2.5</sub> and other sources such as ambient particle concentrations, cooking, and migration of tobacco smoke pollution from outside could contribute to overall levels of indoor air pollution. We would expect, however, that other sources would be present in both smoke-free and smoking-permitted pubs and thus, differences in average PM<sub>2.5</sub> are largely attributable to SHS.

## **Conclusions**

Irish pubs in the Republic of Ireland and smoke-free “Irish pubs” elsewhere are significantly less polluted than “Irish pubs” that permit smoking. These findings underscore the importance of comprehensive smoke-free policies. National and subnational policies that prohibit smoking in public worksites, including restaurants and pubs, dramatically reduce secondhand smoke exposure and improve the health of workers and patrons.

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