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The impact of smoke-free legislation on indoor air quality in bars in Northern Ireland

A study undertaken by the CIEH in partnership with Health Service Executive, University of Ulster and Public Health Agency

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Executive Summary

Northern Ireland (NI) introduced comprehensive smoking prohibitions on 30 April 2007. Smoking has been prohibited in 'enclosed' and 'substantially enclosed' public premises making virtually all enclosed public places and workplaces in NI smoke-free including pubs, night clubs, cafes, offices, work vehicles and factories.

This study aimed to assess the impact of the 2007 comprehensive smoke-free legislation in Northern Ireland on indoor air quality within licensed premises, and in particular bars. It forms part of an ongoing collaboration and professional linkage between environmental and public health within the Health Service Executive in Ireland and district councils and health bodies in NI, along with international research partners.

A three phased study (before, and at three and 12 months after the introduction of the legislation) of licensed bars was undertaken in a total of four geographical areas in Northern Ireland. Concentrations of PM_{2.5} were measured in a total of 76 bars pre introduction of legislation and three months following the introduction of legislation. The same measurements were taken in a total of 59 Bars 12 months after the introduction of the legislation. Airborne nicotine was measured in 51 bars pre legislation and in 50 bars three months post legislation in two of the four sampling locations. A questionnaire was also distributed to a member of staff in each of these 51 bars pre legislation and again three months post legislation.

The key findings can be summarised as follows:

1. Mean PM_{2.5} concentrations reduced significantly from 344.37 µg/m³ pre-legislation to 22.27 three months and 30.60 12 months after the introduction of legislation. This represents a 94% reduction in mean PM_{2.5} concentrations after three months and a 91% reduction in mean PM_{2.5} concentrations after 12 months.
2. Using the US EPA air quality index for outdoor air (EPA, 2003), air quality was classified as good in 99% and 97% of bars three and 12 months after the introduction of the legislation.
3. Mean air nicotine concentrations reduced significantly from 25.84 µg/m³ to 2.19 representing a 92% reduction in mean air nicotine concentrations.
4. The survey of bar staff highlighted a significant reduction in the number of health symptoms related to exposure to ETS. In addition, there was a 76% increase in the number of employees rating the indoor air quality as good.

Overall the study has demonstrated a significant positive impact on air quality in bars and the health risks associated with exposure to ETS. The introduction of this public health policy can be heralded a significant success in terms of protecting workers from the harmful effects of ETS. Compliance rates of 97% across Northern Ireland also suggest that the legislation has received widespread support among the general public and the proprietors of licensed premises. There is a need to build on this success, to further reduce the risk of exposing workers to ETS and other air pollutants. The following recommendations have been made to help facilitate this process:

1. A programme of air particulate monitoring should be developed in Northern Ireland. This should include the setting of standards to minimise exposure to air particulates in the workplace. Workplaces that are not classified as good or moderate in terms of the US EPA Air Quality Index (EPA, 2003) should be investigated to identify the source of PM_{2.5} pollution and develop interventions to eliminate them.
2. There is a need to investigate whether there is scope to modify existing legislation to provide more effective control on smoking outside premises. Consideration should be given to introducing outdoor smoking restrictions such as those introduced in other countries.

1. Introduction

1.1 Background

Environmental Tobacco Smoke (ETS) (also referred to as Second-Hand Smoke (SHS) or passive smoke), consists of a combination of mainstream smoke exhaled by the smoker and sidestream smoke from burning tobacco products. Whilst sidestream cigarette smoke is thought to be approximately four times more toxic than mainstream smoke (Schick and Glantz, 2005) the multiple components of both sources are carcinogenic and toxic and subsequently passive smoking is the third leading, but preventable cause of death worldwide (Raupach Et al. 2007). Clearly the level of exposure of persons to ETS is much greater in enclosed spaces. It is therefore believed that 'smoke-free public places and workplaces are the only practical way to effectively protect both employees and the public from the toxins in sidestream smoke' (Schick and Glantz, 2005).

Extensive epidemiological studies (Law et al. 1997, Hackshaw et al. 1997 and Pattenden et al. 2006) have shown that ETS is 'a substantial public health hazard' responsible for adverse health effects, increasing the risk to non smokers of lung cancer by 24% and ischaemic heart disease by 25% (SCOTH, 2004). With the risks of exposure to ETS established, much of today's research focuses on quantifying exposure to ETS using established airborne markers.

A growing number of studies (Bates et al. 2002, Eisner et al. 1998, Jamrozik, 2005, Jané et al. 2002, Siegel and Skeer 2003 and Hammond, 1999) have illustrated that those employed in the hospitality industry i.e. bars, restaurants and gaming establishments, are more substantially exposed to ETS in the workplace than those working in other environments.

In light of these findings, numerous countries have introduced smoking restrictions in the workplace (including bars, pubs and restaurants) to protect workers from the hazards attributable to ETS. Ireland was the first country to introduce such a legislation in 2004 with others including Italy, New Zealand, Norway, Sweden and more recently Scotland, Wales, Northern Ireland and England following.

The evaluation of changes in air quality and hence health impacts are an important facet of smokefree initiatives and a series of valid methodologies are now available to researchers (Hammond and Leaderer, 1987, Mulcahy et al, 2005b, Hyland et al, 2008).

Northern Ireland (NI) introduced comprehensive smoking prohibitions on 30 April 2007. As a result of the 'The Smoking (Northern Ireland) Order 2006' smoking was prohibited in 'enclosed' and 'substantially enclosed' public premises making virtually all enclosed public places and workplaces in NI smoke-free including pubs, night clubs, cafes, offices, work vehicles and factories (HMSO, 2006).

NI was able to learn through the previous experiences of colleagues in Ireland, particularly in terms of the groundwork that needed to be done with businesses on the ground in order to prepare for the introduction of the legislation, as well as the importance of research in providing evaluation of and evidence for the effect of the legislation. There has been, for some considerable time, strong professional linkages and collaboration between environmental and public health within the Health Service Executive in Ireland, district councils and health bodies in NI along with international research partners. This collaborative approach has been reflected and continued within this study.

1.2. Aims and objectives

The aim of the study was to assess the impact of the 2007 comprehensive smoke-free legislation in NI on indoor air quality within licensed premises, in particular bars. It is further hoped that the study, through adding to the evidence base, would help identify any further work needed to protect vulnerable populations from ETS exposure.

More specifically, the objectives of the study were to:

1. Assess the impact of the smoke free legislation on particulate matter (PM_{2.5})
2. Assess the impact of the smoke free legislation on air nicotine levels
3. Determine employees' attitudes and perceptions of second hand smoke before and after the introduction of the legislation.

2. Methodology

2.1 Background

To ensure ETS exposure was reliably and accurately quantified it was measured using two key indicators namely nicotine in its vapour phase, which is a specific marker of tobacco smoke, and Particulate Matter_{2.5} (PM_{2.5}), a more general measure of air pollutants. Both indicators have individually been accepted as valid markers (Valente et al. 2007, Cains et al. 2004, Mulcahy et al. 2005b).

2.2 Selection procedure

A three phased study was undertaken in a total of four geographical areas in Northern Ireland. The study was carried out prior to the introduction of legislation (March – April 2008), three months after the introduction (July 2008) and again 12 months after the introduction of legislation (April 2008). Dungannon and Ballymena were chosen to represent typical medium and large sized towns in Northern Ireland. Derry and Belfast were selected to represent typical city locations.

The evidence base indicates that in terms of workplaces, hospitality workers are the most highly exposed industry sector to ETS, which accounts for 54 deaths each year (Jamrozik, 2005). It was therefore decided to focus the study on licensed bars. Approval was obtained from proprietors either via letter, telephone contact or by visiting the premises. This was carried out prior to sampling. Sampling occurred during previously ascertained busy periods, predominantly Friday, Saturday and Sunday.

Concentrations of PM_{2.5} were measured in a total of 76 bars pre introduction of legislation, three months following the introduction of legislation and in a total of 59 bars 12 months after its introduction. Table 2.1 shows that the total sample of 76 bars in phase 1 and phase 2 comprised premises from each of the four geographical areas, Ballymena (n= 30) Derry City (n= 20) Dungannon (n= 12) and Belfast (n= 14). This study incorporated both rural and urban premises within Ballymena.

Airborne nicotine was measured in 51 bars pre legislation and in 50 bars three months post legislation in two of the four sampling locations (Ballymena and Derry) due to time restraints and availability of nicotine samplers (table 2.1). A questionnaire¹ was also distributed to a member of staff in each of these 51 bars pre legislation and again three months post legislation. The questionnaires were administered concurrently with the nicotine sampling.

Table 2.1: Sample Locations for PM_{2.5} and Air Nicotine Monitoring

Location	Before legislation		3 months after legislation		12 months after legislation	
	PM _{2.5}	Air Nicotine	PM _{2.5}	Air Nicotine	PM _{2.5}	Air Nicotine
Ballymena	30	32	30	32	27	-
Belfast	14	-	14	-	-	-
Derry	20	19	20	18	20	-
Dungannon	12	-	12	-	12	-
Total	76	51	76	51	59	-

¹ See Appendix 1

2.3 Measurements

PM_{2.5} was selected as it has been extensively used as an indicator of ETS (Valente et al. 2007, Semple et al. 2007a, Semple et al. 2007b, Mulcahy et al. 2005a, Mulcahy et al. 2005b) while nicotine in its vapour phase was chosen based on the fact that tobacco smoke is the only source of nicotine (unlike PM_{2.5} which has sources other than just tobacco smoke) and because nicotine is one of the major constituents of cigarette emissions (Nebot et al. 2005).

2.4 Particulate Matter_{2.5}

For the purpose of this research PM_{2.5} sampling was carried out in the four geographical areas before, three months after, and 12 months after the introduction of the smoke-free legislation. Every effort was made post legislation to replicate the collection methods used in the earlier study phase (i.e. day of week and time of day). As in Wilson et al (2007) particulate matter was measured covertly to capture 'normal' behaviour of patrons and staff i.e. so as not to increase or reduce normal smoking habits or alter operation of ventilation systems including opening or closing windows depending on employee/patron's attitude to the legislation.

Particulate matter was measured in each venue for a total of 30 minutes using a TSI SidePak AM510 Personal Aerosol Monitor (figure 2.1). The SidePak was factory calibrated prior to sampling, programmed to record data at one minute log intervals and the flow rate was set at 1.7 litres/minute. The 2.5 µm impactor fixed to the inlet of the SidePak ensured that particles greater than this size would not enter the device and would therefore not be recorded.

Figure 2.1: TSI SidePak AM510 Personal Aerosol Monitor



The sampling methodology was designed to ensure as far as possible that the integrity of the covert nature of the exercise was maintained. This was achieved through the patronisation of each premises and by concealing the SidePak in either a handbag or backpack with a length of Tygon™ tubing attached to the inlet of the SidePak while the other end protruded outside the bag. Fieldworkers choose (where possible) a central sampling location and positioned the bag containing the SidePak as close to respirable zone as possible usually placing it on a table or seat.

In addition to the PM_{2.5} measurements, observational data was recorded during the 30 minute sampling period including time of entry and exit of venue, ventilation provisions (i.e. windows open or shut), whether or not there was a lit fire and whether food was being served in sampling area. In addition, the number of patrons and the number of smokers (i.e.

with lit cigarettes) were recorded on entry to premises, 15 minutes later and on leaving the bar. The number of people smoking outside the bar was also noted. This information was stored on mobile phones carried by the research team, again to protect the necessity for covert integrity and avoid undue attention being drawn to the use of note paper and pen type recording.

Having measured and recorded the PM_{2.5} concentrations, the SidePak was connected to a PC and the data was downloaded using 'TrakPro' software. As with other studies using the TSI SidePak (Wilson et al, 2007), a calibration factor of 0.32 was applied to the particulate measurements. The mean PM concentrations were then calculated for each venue at each study phase. Statistical significance was assessed using a paired T test. The percentage decrease across all bars between pre and post legislation data was calculated as was the decrease for each individual premises.

In order to give comparative data PM_{2.5} concentrations were also measured in a number of enclosed public places in Ballymena that were pre-determined as being smoke-free, for example secondary school, library) therefore providing control samples. These measurements were taken both before and after the introduction of the legislation and were intended to determine the extent (if any) that seasonal factors had on the indoor air pollution.

The data was analysed using SPSS V15 which afforded comparison of PM_{2.5} concentrations pre and post legislation.

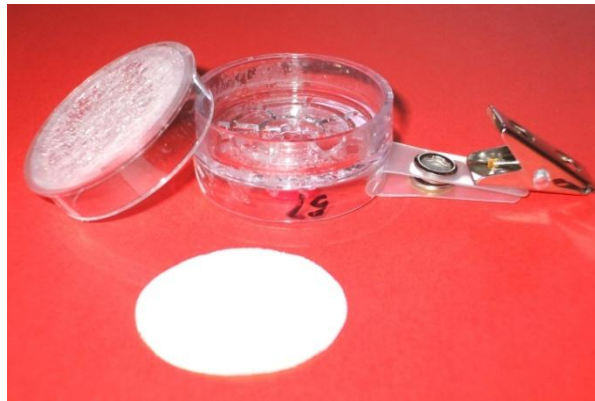
2.5 Nicotine concentrations

Nicotine sampling was carried out pre ban and three months post legislation. Again, every effort was made to replicate the collection methods used at the pre legislation study phase. Each of the participating venues (n=51) were contacted via telephone prior to carrying out nicotine sampling to advise owners/managers of the date and arrange a convenient time for the passive samplers (used to measure nicotine) to be placed within the bar. A minimum of six weeks was required following the implementation of the legislation before post legislation nicotine sampling could be carried out in order to ensure that the residual nicotine levels in the premises were minimised (Mulcahy et al, 2005b).

Nicotine was measured in its gaseous phase using passive samplers, each fitted with a filter paper treated with sodium bisulphate (figure 2.2). The samplers were positioned behind the bar in an area where air could flow freely- for the most part it was affixed to an optic bottle where it remained for a minimum of eight hours (Mulcahy et al, 2005b). This helped minimise the possibility of interference with the devices by customers as well as locating the samplers in an area regularly frequented by bar staff. An intermittent check was made during this period to ensure samplers had not been tampered with. These visits were covertly carried out by a member of the research team who had not previously installed the passive sampler within the individual bar. Observational data was recorded on three occasions during the eight hour period - when the samplers were placed in each bar, during the checks and when the samplers were collected. This data included number of patrons, number of smokers (i.e. number of lit cigarettes, inside and outside) and ventilation arrangements i.e. open windows and doors.

The data was analysed using SPSS V15 which afforded comparison of nicotine concentrations pre and post legislation.

Figure 2.2: Passive sampler used to measure Air Nicotine



Once removed from the bars, the filter papers were removed from the samplers and placed in Petri dishes. The Petri dishes were stored in a smoke-free environment before being sent to the University of California for analysis which was carried out using gas chromatography/mass spectrometry.

For quality assurance reasons, duplicate samplers were placed in three rural premises in Ballymena, selected at random. The duplicates were taken in rural premises as there were fewer rural premises therefore a greater availability of samplers to allow duplicates to be taken. In addition one 'blank' or unused filter paper was selected for every ten used, placed in a Petri dish and sent to the lab with the used filter papers for analysis.

2.6 Survey of bar staff

A short questionnaire was completed by a member of staff in those premises that participated in the nicotine sampling (n=51) pre ban and three months post ban. The questionnaire was designed to assess employees' attitudes towards second hand smoke, explore perceptions of the economic impact of the new legislation and determine the extent of self reported symptoms attributable to exposure to smoke in the workplace as well as assessing attitudes towards the introduction of the legislation. It has been recognised that this is beneficial to better understand the attitudes of bar owners and employees who are perceived to be less likely to welcome the new law (Tang et al. 2004 and Pursell et al. 2007).

The questionnaires were either self administered or administered by a member of the research team simultaneously with the placement of nicotine samplers in each of the bars. The last question asked the respondents to comment on the air quality during their shift that day and therefore this part was returned to the fieldworker at the time the nicotine samplers were being collected (at least eight hours later).

Sampling post legislation (both PM_{2.5} and nicotine) was conducted soon after the law was enacted as it was pertinent that questionnaires pre and post legislation were completed by the same respondents. The timing was to account for the transient nature of employment in the hospitality sector which has previously presented problems for other researchers who have employed longer follow up periods (Semple et al. 2007a).

The questionnaires were analysed using SPSS V15 which afforded comparison of frequencies between pre and post legislation data.

3. Impact on Particulate Matter_{2.5}

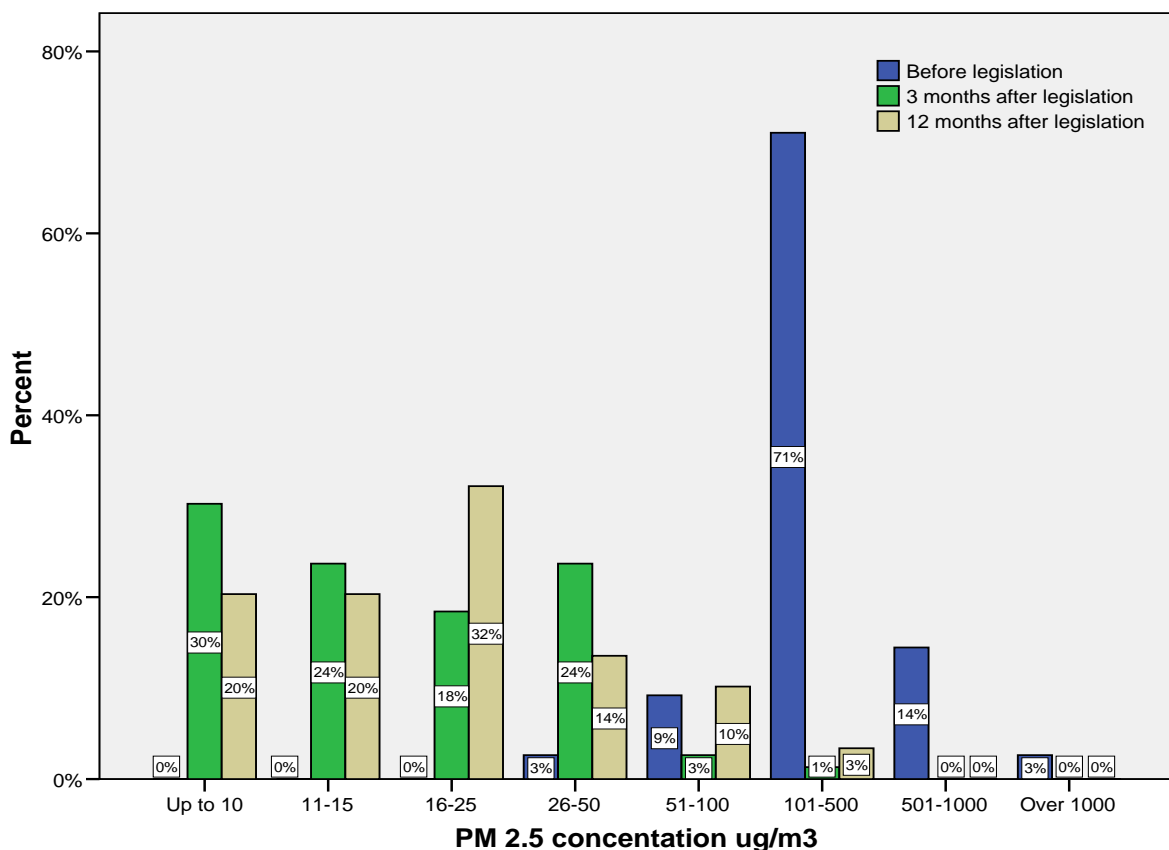
3.1 Introduction

In this section the results of the pre- and post legislation (three month and 12 month) PM_{2.5} measurements are presented. A total of 76 bars were sampled across four locations at phase 1 and 2 and a total of 59 bars sampled at phase 3. Analysis was carried out using paired analysis techniques to examine differences between the pre-legislation and three month post legislation stages and again between the pre legislation and 12 month post legislation stages.

3.2 PM_{2.5} concentrations

Figure 3.1 shows PM_{2.5} concentrations before, three months after, and 12 months after the introduction of the smoking legislation. Before the legislation, 97% of bars had PM_{2.5} concentrations above 50 µg/m³ with 88% having concentrations above 100 µg/m³. No bar had concentrations less than 25 µg/m³. Three months after the legislation, 72% of bars had PM_{2.5} concentrations of 25µg/m³ or less with 1% of bars having a concentration greater than 100 µg/m³. Twelve months after the legislation, 72% of bars had PM_{2.5} concentrations of 25µg/m³ or less with 3% of bars having a concentration greater than 100 µg/m³. Prior to the introduction of legislation 17% of bars had PM_{2.5} concentration over 500ug/m³ but post legislation no bar had concentrations above 500 µg/m³ (at three or at 12 months after the legislation).

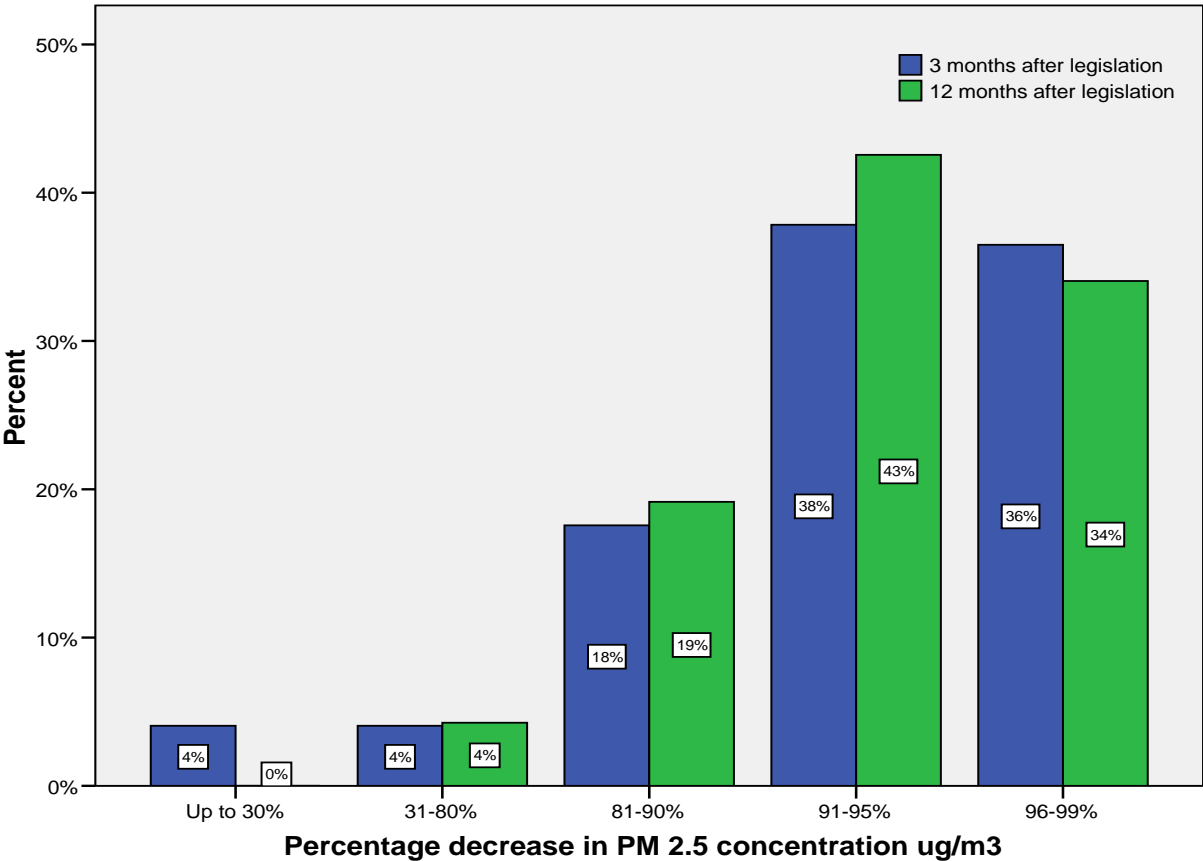
Figure 3.1: PM_{2.5} concentrations before and after the smoking legislation



Overall, mean PM_{2.5} concentrations reduced significantly from 344.37 µg/m³ (median = 275.84, SD = 260.01) pre-legislation to 22.27 three months (median= 14.27, SD = 34.48) and 30.60 12 months after the introduction of legislation (median= 17.07, SD = 45.05). This represents a 94% reduction in mean PM_{2.5} concentrations after three months (paired T test, p = 0.000) and a 91% reduction in mean PM_{2.5} concentrations after 12 months compared to pre -legislation data (paired T test, p = 0.000). There were no significant differences in mean PM_{2.5} concentrations at three months and at 12 months after the legislation (paired T test, p = 0.291).

The percentage decrease in PM_{2.5} concentrations is shown in figure 3.2. Three months after the introduction of smoke free legislation almost three quarters of bars (74%) experienced over a 90% decrease in PM_{2.5} concentrations, with decreases of less than 80% only experienced in 8% of bars. Likewise 12 months after the legislation, over three quarters of bars (77%) experienced over a 90% decrease in PM_{2.5} concentrations, with decreases of less than 80% only experienced in 4% of bars.

Figure 3.2: Percentage decrease in PM_{2.5} concentrations after the smoking legislation

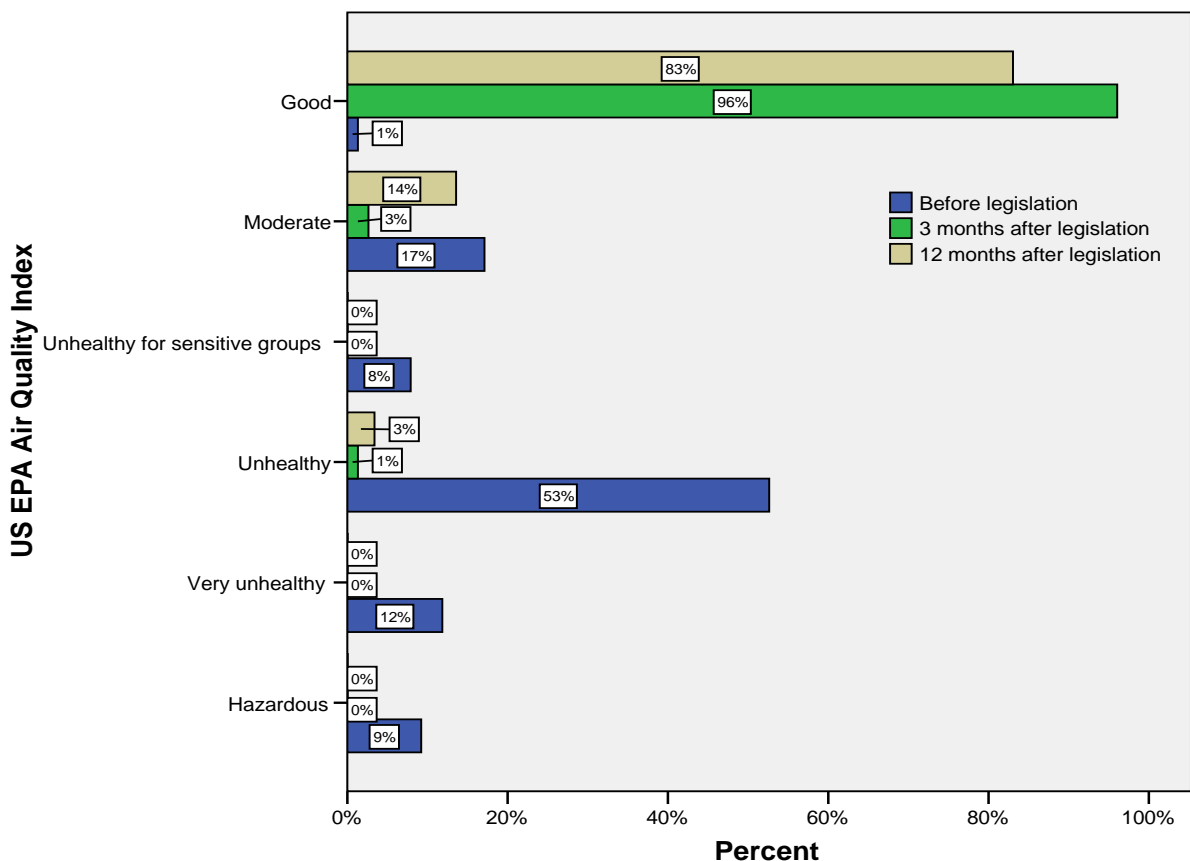


Concentrations in the control premises, which were assessed to account for seasonal factors, varied from 4.5 µg/m³ (office) to 19.0 µg/m³ (supermarket café) post legislation. Control samples provided a mean PM_{2.5} concentration of 7.4 µg/m³.

3.3 Air Quality Index

The US Environmental Protection Agency (EPA) has developed a 24 hour air quality index for PM_{2.5} which they use to classify outdoor air quality and its associated health effects (EPA, 2003). Figure 3.3 shows PM_{2.5} concentrations before and after the smoking legislation using this classification system (adapted for 8 hour exposure by multiplying index values by 3). Three months after the legislation, 99% of bars were classified as good or moderate (< 122 µg/m³), with 1% classified as unhealthy (>196 µg/m³). Twelve months after the legislation, 97% of bars were classified as good or moderate, with 3% classified as unhealthy. Differences in the classification of air quality were significant when comparing scores before the legislation with scores at three months (Wilcoxon Signed Rank Test, p = 0.000) and 12 months after the introduction of legislation (Wilcoxon Signed Rank Test, p = 0.000). Differences were not significant when comparing scores three months after the legislation with scores 12 months after the legislation (Wilcoxon Signed Rank Test, p = 0.178).

Figure 3.3: PM_{2.5} Air Quality Index before and after the smoking legislation



4. Impact on Air Nicotine

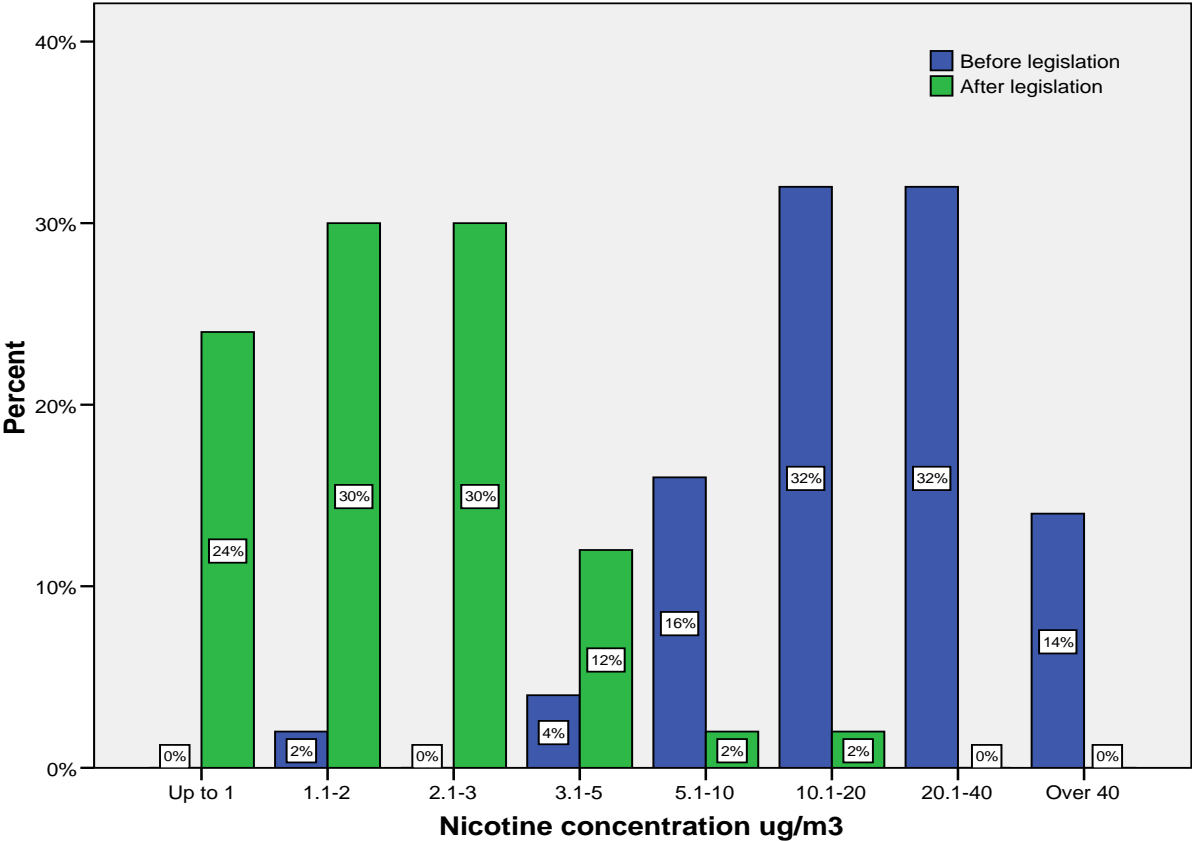
4.1 Introduction

In this section, the results of the pre and post legislation nicotine sampling are presented. Nicotine, in its gaseous phase, was measured in a total of 51 bars pre legislation and 50 bars (three months) post legislation. Statistical analysis was undertaken on the 50 bars that had both pre and post legislation data.

4.2 Air Nicotine concentrations

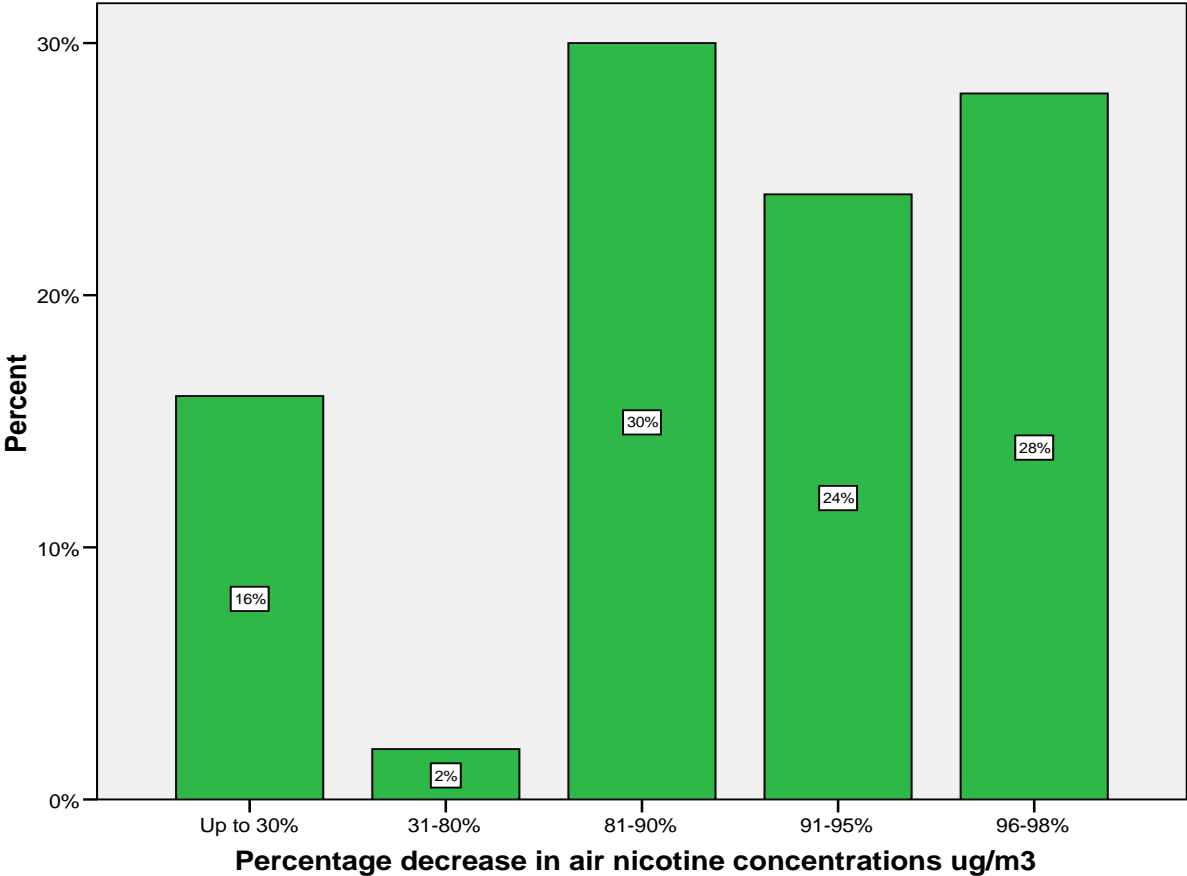
Figure 4.1 shows air nicotine concentrations before and after the introduction of the smoking legislation. Before the legislation, 78% of bars had air nicotine concentrations above 10 $\mu\text{g}/\text{m}^3$ with 94% having concentrations at the 'significant risk' (of lung cancer) level of 6.8 $\mu\text{g}/\text{m}^3$ or above (Repace et al, 1993, 1998, cited in Mulcahy et al. 2005b) and 14% having concentrations above 40 $\mu\text{g}/\text{m}^3$. After the legislation, 96% of bars had air nicotine concentrations at the 'significant risk' level of 6.8 $\mu\text{g}/\text{m}^3$ or less and 4% of bars having a concentration greater than 6.8 $\mu\text{g}/\text{m}^3$. The highest air nicotine value recorded pre legislation was 152.6 $\mu\text{g}/\text{m}^3$ whereas post legislation this was 15.7 $\mu\text{g}/\text{m}^3$.

Figure 4.1: Air Nicotine concentrations before and after the smoking legislation



Mean air nicotine concentrations reduced significantly from 25.84 $\mu\text{g}/\text{m}^3$ (median = 18.12, SD = 26.80) to 2.19 (median= 1.90, SD = 2.29) representing a 92% reduction in mean air nicotine concentrations (paired T test, p = 0.000). Nine bars (18%) experienced a decrease in air nicotine of 80% or less. Almost three quarters of bars (72%) experienced over a 90% decrease in air nicotine concentrations after the legislation (figure 4.2).

Figure 4.2: Percentage decrease in Air Nicotine concentrations 3 months after the smoking legislation



5. Survey of bar staff

5.1 Introduction

The questionnaire was completed by 51 respondents before the introduction of the smoking ban. In order to ensure the same respondents completed the questionnaire post legislation, their names had to be obtained. However 11 people refused to give their name leaving a potential 40 respondents that could be followed up post legislation. Of these 40, 31 completed the questionnaire three months post legislation. The results presented here are for the 31 respondents who completed questionnaires both before and after the smoking legislation. Half of the respondents (52%) were employed at locations in Ballymena town centre, with 42% at locations in rural areas surrounding Ballymena, and 7% in Derry city.

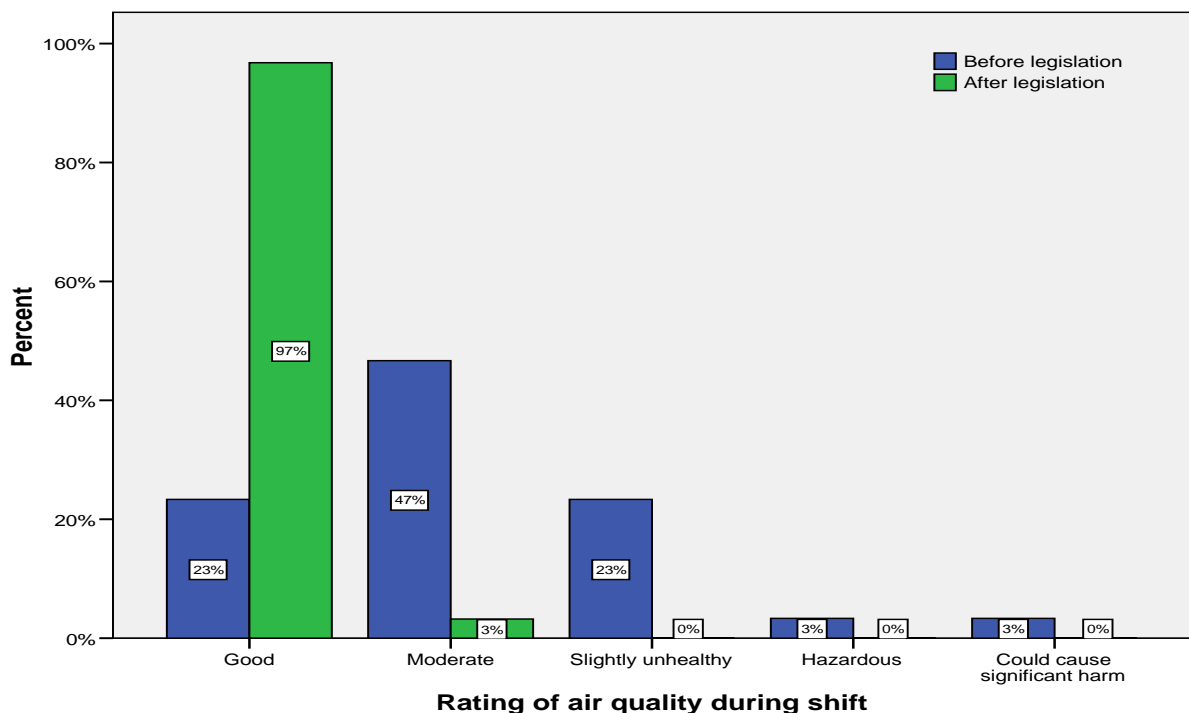
5.2 Background profile

All respondents were either bar staff, owners or bar managers. Over half (56%) were males and 36% were current smokers, with 42% of respondents having smokers living in their household.

5.3 Self reported assessment of air quality

Respondents were asked to rate the indoor air quality during their shift on that day (i.e. the day on which nicotine sampling was conducted before and after the introduction of the smoking legislation). There was a 76% (percentage point) increase in the number of people who thought air quality was good and a 92% decrease in the number of people who thought it was moderate following the implementation of the smoking legislation. No-one felt that the air quality was slightly unhealthy, hazardous or could cause significant harm following the introduction of the legislation (figure 5.1). These changes in perceptions of indoor air quality were statistically significant (Wilcoxon signed ranks test, $z = 4.225$, $p = 0.000$).

Figure 5.1: Hospitality workers self-reported assessment of Air Quality before and after the smoking legislation



5.4 Self reported symptoms

Before the introduction of the legislation 58% (n=18) of respondents reported experiencing symptoms or effects which they felt were directly related to being exposed to environmental tobacco smoke in the workplace. After the legislation, 16% (n = 5) reported experiencing symptoms or effects. This decrease was statistically significant (Chi square = 9.431, df = 1, p = 0.0021). Those respondents who reported experiencing symptoms/effects were asked to describe them (table 5.1). The main reported symptoms pre legislation were dry/sore eyes (29%), sore throat (19%) chesty/dry cough (19%) smell on clothes (16%). After the legislation, the main symptoms were sore throat (10%) and chesty cough (3%). The average number of health related symptoms before the legislation was 0.87 compared to 0.16 after the legislation.

Table 5.1: Symptoms/Effects experienced as a result of being exposed to Environmental Tobacco Smoke before and after the smoking legislation

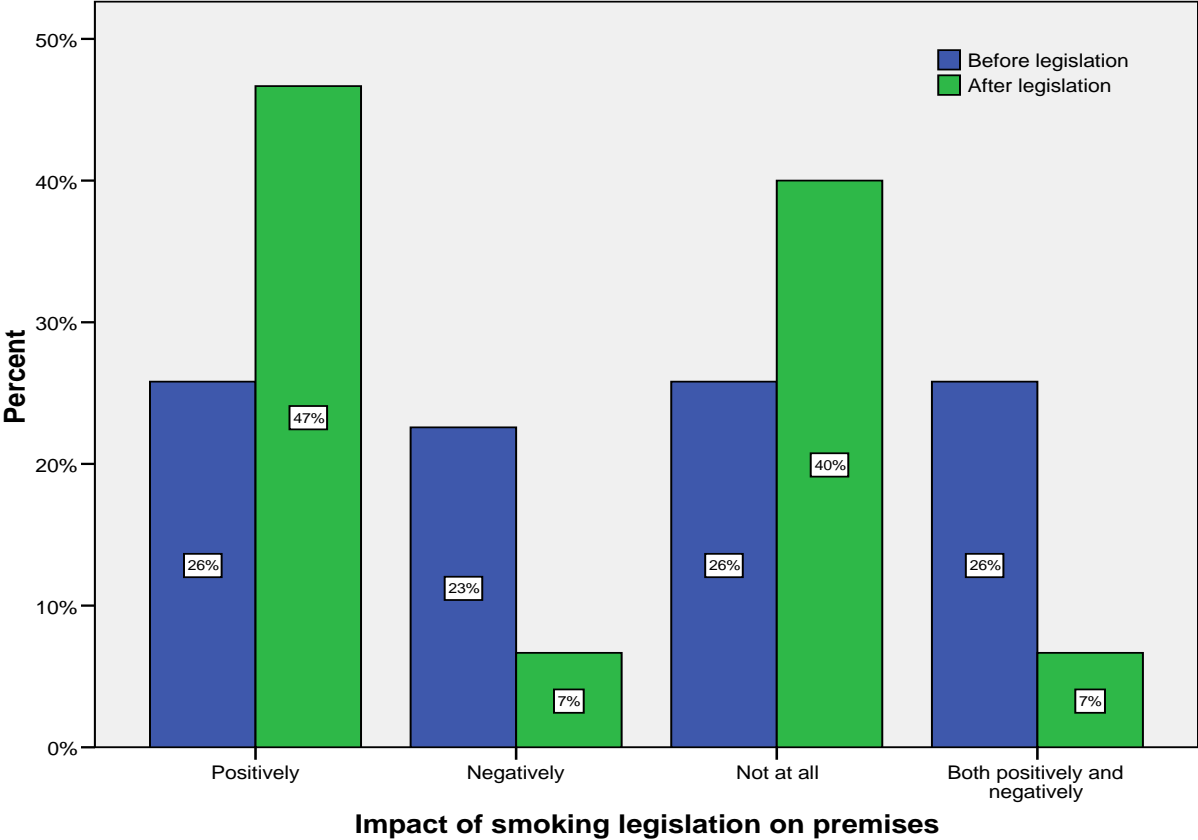
Symptoms/effects	Before		After	
	No.	%	No.	%
Cough (chesty/dry)	6	19	1	3
Asthma	2	7	1	3
Eyes (dry/sore)	9	29	0	0
Nose	2	7	0	0
Sore throat	6	19	3	10
Colds	1	3	0	0
Smell on clothes	5	16	0	0
Wheezing	0	0	0	0
Feeling choked up	1	3	0	0
Base	18		5	

* multiple response, therefore percentages may not add to 100%

5.5 Impact on premises

Respondents were asked how they felt the smoking legislation would impact on the premises (figure 5.2). Pre legislation results indicate a balanced response with very little variation in the number of people who anticipated the legislation would have either positive (26%), negative (23%), no effect (26%) or both a positive and negative (26%) impact on the premises. More notable variations were shown post legislation with a considerable increase in the number of respondents feeling the legislation had had a positive impact (45%) and a decrease in the number of respondents who thought it had had a negative impact (7%). Those believing the legislation would not have any impact (i.e. neither positive nor negative) increased to 39% post legislation. Changes in the proportion of respondents reporting a positive and a negative impact before and after the introduction of the legislation were not quite statistically significant (Fishers exact test, p = 0.0538).

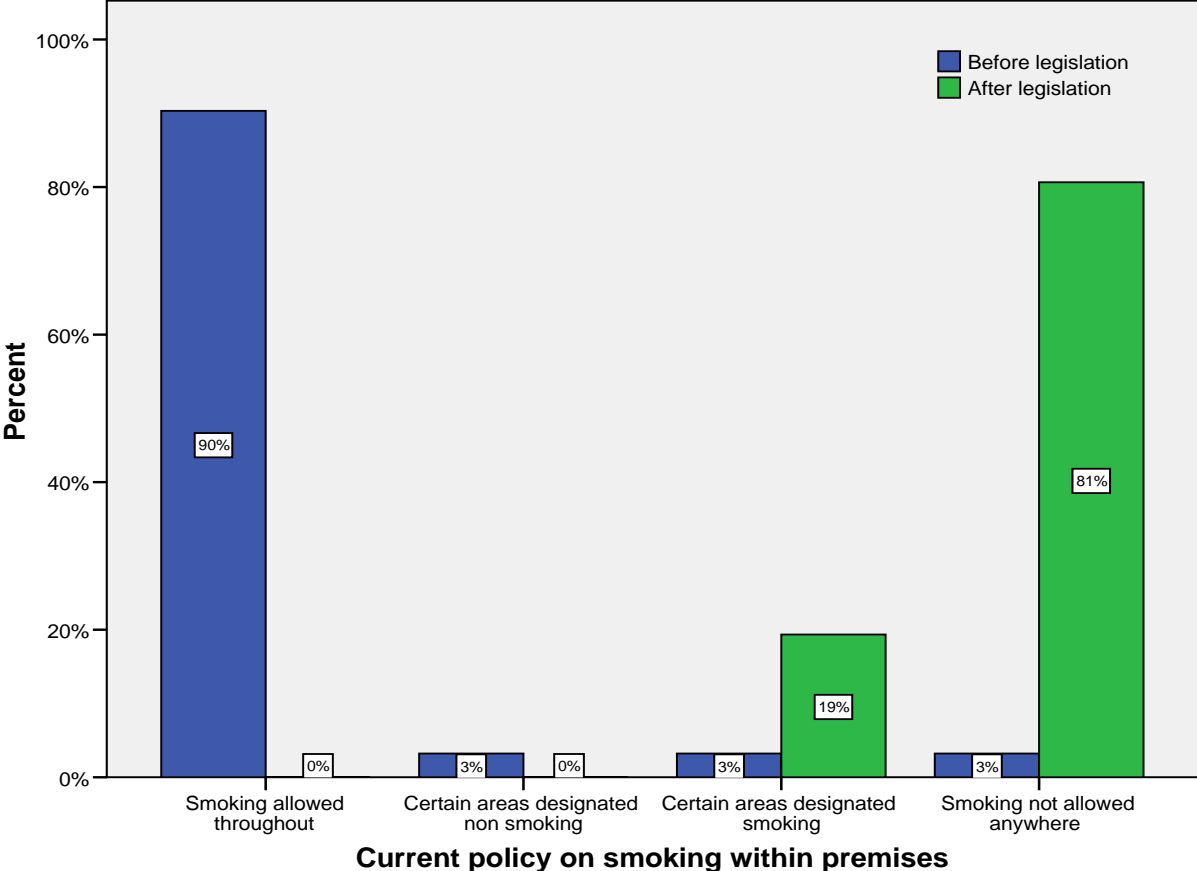
Figure 5.2: Impact of smoking legislation on premises before and after the smoking legislation



5.6 Smoking policy within premises

Figure 5.3 shows the smoking policy within premises before and after the introduction of the smoke-free legislation. It can be seen that 97% allowed smoking, with 90% allowing smoking throughout the premises. A minority (3%) did not allow smoking anywhere. After the introduction of legislation, 81% did not allow smoking anywhere, with 19% allowing smoking in designated smoking areas. The changes in the proportion of premises allowing smoking anywhere or in designated areas and not allowing smoking anywhere are statistically significant (Chi square = 38.15, df = 1, p = 0.000)

Figure 5.3: Current policy on smoking within premises before and after the smoking legislation



6. Discussion

6.1 Introduction

This study aimed to assess the impact of the 2007 comprehensive smoke-free law in Northern Ireland on indoor air quality. It involved measuring PM_{2.5} concentrations and vapour phase nicotine both pre and post legislation. It also assessed bar staff's attitudes to the smoking legislation before and after its introduction. The large number of bars sampled coupled with the utilisation of two reliable ETS indicators, ensures that the study can provide an accurate insight in the impact of the smoking legislation. The key issues arising from the results will now be discussed.

6.2 Impact on Particulate Matter _{2.5}

Exposure to PM_{2.5} can have a significant effect on health, both in the short and the long term. In particular, exposure has been shown to increase deaths from cardiovascular disease, respiratory disease, and lung cancer (Pope et al, 2002). This study has shown that there has been a 94% drop in PM_{2.5} levels three months after, and a 91% drop 12 months after the introduction of legislation prohibiting smoking in workplaces and enclosed or partially enclosed public places. It is anticipated that this reduction will significantly reduce health risks associated with exposure to PM_{2.5}. Pope et al (2002) estimate that for every 10 µg/m³ increase in PM_{2.5}, the relative risk from long term exposure increases by 6% for deaths from cardiopulmonary disease and 8% for deaths from lung cancer. Based on these estimates this study suggests (using mean PM_{2.5} concentrations at three and 12 months) that the long term exposure risks have reduced by as much as 191% for cardiopulmonary disease and 255% for lung cancer. These dramatic risk reductions help demonstrate how excessive PM_{2.5} levels were in bars prior to the introduction of the legislation. For example, in terms of the US EPA air quality index for outdoor air (EPA, 2003) the mean concentration before the legislation (344.37 µg/m³) is classified as unhealthy. Our findings show that after the legislation mean concentrations (22.27 µg/m³ at three months and 30.60 µg/m³ at 12 months) are classified as good, which is a complete reversal due to the introduction of the legislation. The index is shown in figure 6.1 to demonstrate the change in air quality since the introduction of the smoke-free workplaces. These changes in PM_{2.5} concentrations demonstrate that the legislation prohibiting smoking in the workplace has had a significant health benefit for bar workers and those employed in similar establishments.

Table 6.1: US EPA Air Quality Index (adapted for eight hour exposure)

	Levels of Health Concern	PM2.5 (µg/m ³)	Index Values	Cautionary Statements
3 months after legislation, mean = 22.3, 12 months after legislation mean = 30.6	Good	≤46	0-50	None
	Moderate	47-121	51-100	Unusually sensitive people should consider reducing prolonged or heavy exertion.
	Unhealthy for Sensitive Groups	122-196	101-150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Before legislation, mean = 344.4	Unhealthy	197-451	151-200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
	Very Unhealthy	452-751	201-300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
	Hazardous	≥751	≥301	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.

Source: adapted from EPA, 2003

Despite the significant reductions in PM_{2.5}, it is worth acknowledging there remains some scope to further reduce PM_{2.5} levels. Table 6.2 compares PM_{2.5} levels with studies in other countries that have assessed the impact of national workplace smoke-free legislation. Compared to studies that measured the geometric mean, it can be seen that concentrations in the current study (12 months after the legislation) were 145% higher than in New Zealand (Hyland et al, 2008) For studies that measured the mean, concentrations in the current study (12 months after the legislation) were 178% higher than England (Gotz et al, 2008). Compared to studies that measured the median, concentrations (12 months after the legislation) were 26% higher than New Zealand (Wilson et al, 2007). Despite PM_{2.5} results from this study being higher than in other regions it is important to acknowledge that the current study solely examined air quality in bars. In contrast to this, the other studies examined in table 6.2 have assessed air quality in a variety of different settings including restaurants, cafes etc and this may partially account for differences in air quality levels.

Table 6.2: Comparison of PM_{2.5} levels in countries that have introduced legislation prohibiting smoking in the workplace *

Country	Author	Sample	PM _{2.5} levels after legislation (µg/m ³)	
			Mean	Median
Northern Ireland (current study)	Grimley et al (2008)	76 bars in 2 cities and 2 towns (3 months after legislation)	22.3 15.5 (GM**)	14.27
Northern Ireland (current study)	Grimley et al (2008)	59 bars in 1 city and 2 towns (12 months after legislation)	30.6 19.6 (GM**)	17.07
Scotland	Semple et al (2007b)	41 bars in 2 cities	20.0	15.0
Republic of Ireland	Connolly et al (2006), Hyland et al (2008)	25 bars in 3 cities and 1 town	29 22 (GM**)	
England	Gotz et al (2008)	49 venues (public houses, bars clubs, bingo halls, private member clubs, cafes and betting shops) across 4 regions	11	
New Zealand	Wilson et al (2007)	34 pubs, restaurants and bars in 1 city	16	14
New Zealand	Hyland et al (2008)	44 venues (bars, restaurants, transportation and 'other')	8 (GM**)	
Uruguay	Hyland et al (2008)	66 venues (bars, restaurants, transportation and 'other')	18 (GM**)	

* Used TSI SidePak AM510 Personal Aerosol Monitor

** GM = Geometric mean

Although most studies in table 6.2 exhibit PM_{2.5} concentrations after national workplace bans which are well below the minimum standards set by the World Health Organisation (2006) and by the United Kingdom (Department for Environment, Food and Rural Affairs et al, 2007) for outdoor air (25 µg/m³), and are also classified as good by the US EPA Air Quality Index for outdoor air (EPA, 2003), it must be noted that there is no threshold concentration level of particulate matter that has no effect on health (World Health Organisation, 2005). It is therefore important that attempts are made to further reduce PM_{2.5} levels. In terms of the US EPA Air Quality Index (EPA, 2003) PM_{2.5} levels in two of the bars were classified as unhealthy 12 months after the legislation (198.9 µg/m³ and 289.7 µg/m³). Observational data obtained during sampling suggests that the location of a smoking shelter may have been the source of the problem in one bar, with no clear explanation for the other bar. However, in a number of bars, tobacco smoke was noted drifting inside through open doors and windows. In addition, other factors which are known to contribute to increased PM_{2.5} levels including traffic and cooking were observed. Exposure to PM_{2.5} can be from a number of sources, and it would be important to ensure that such exposure is minimised in workplaces through effective control of sources where possible due to the adverse health consequences (Pope et al, 2002). Currently, indoor workplaces are not routinely monitored for particulate matter in Northern Ireland. A programme of monitoring needs to be developed and standards set to minimise exposure to air particulates in the workplace. The results also highlight the issue of exposure to ETS from people smoking immediately outside bars and in designated smoking shelters. This is an area that may require further legislation (see section 6.3).

6.3 Impact on Air Nicotine

ETS is one of the main causes of preventable death worldwide (Raupach et al, 2007). As particulate matter (PM_{2.5}) can be from a number of sources, it was important for the study to isolate the impact of the smoking legislation on ETS. This was achieved by also measuring air nicotine, which is one of the main constituents of cigarette emissions (Nebot et al, 2005). This clearly demonstrated the impact of the smoking legislation on ETS exposure, with a significant 92% reduction in mean air nicotine concentrations.

The extent of the impact on air nicotine is shown in table 6.3, which compares the study findings with air nicotine studies using similar research methodologies. Compared to concentrations recorded after the introduction of the national workplace smoking legislation in the Republic of Ireland (Mulcahy et al, 2005b), mean nicotine concentrations are 367% lower and median nicotine concentrations are 213% lower in the current study. Compared to cities where there was no national smoking legislation (Nebot et al, 2005) median nicotine concentrations are 6321% lower than Austria which exhibited the highest concentrations and 900% lower than Italy which exhibited the lowest concentrations. It is clear that the Northern Ireland workplace smoking legislation has had a dramatic effect on air nicotine concentrations, with concentrations being considerably lower than those experienced in comparable studies.

Table 6.3: Comparison of Air Nicotine levels in studies employing similar research methodologies

Country	Author	Sample	Air Nicotine levels (µg/m ³)	
			Mean	Median
Northern Ireland* (current study)	Grimley et al (2008)	50 bars in 1 city and 2 towns (3 months after legislation)	2.19	1.90
Republic of Ireland*	Mulcahy et al (2005b)	20 bars in 1 city	10.23	5.95
Austria	NeBot et al (2005)	22 bars/discos in 1 city		122
Paris	NeBot et al (2005)	3 bars/discos in 1 city		59
Italy	NeBot et al (2005)	19 bars/discos in 1 city		19
Spain	NeBot et al (2005)	3 bars/discos in 1 city		91

* concentrations after the introduction of a national smoking prohibition.

The changes in air nicotine concentrations also translate into a significant reduction in terms of lung cancer risk for those employed in bars and similar establishments. Air nicotine concentrations before the legislation in 94% of bars placed workers at a 'significant risk' (at or above 6.8 µg/m³) as defined by the US Occupational Safety and Health Administration (Repace et al, 1993, 1998, cited in Mulcahy et al. 2005b). After the legislation, air nicotine concentrations in 4% of bars placed workers at 'significant risk'. Thus, the risk of lung cancer has been significantly reduced, although not totally eliminated suggesting some scope for further improvement. Repace et al (2006) note that if ETS odour can be smelt, then it is at harmful levels. There is therefore a challenge to policy makers to strive to develop ways to further reduce exposure to ETS. As with the legislation in the Republic of Ireland (Mulcahy et al, 2005b), Norway (Ellingsen et al., 2006), and New Zealand (Wilson et al, 2007), this raises the issue of smoke infiltration from outside bars. This does warrant further investigation as it is not addressed in the current legislation. Policy makers need to investigate whether there is scope to modify existing legislation to provide more control on smoking outside premises. The current lack of legislation in this area could potentially have long term health implications for workers, particularly those who have to stand at entrances (e.g. security staff, hotel porters etc). Consideration should be given to introducing outdoor smoking restrictions such as those introduced in other countries. For example, Wilson et al (2007)

notes that in the US, there are jurisdictions that prohibit smoking 15 metres from the entrance or exit of an establishment, and also prohibit smoking from outdoor patio areas. They also note that similar restrictions are in place in, or in parts of other countries (e.g. Singapore, Canada, Australia).

6.4 Survey of bar staff

Although the sample size of the survey of bar staff was somewhat small (n= 31), it nevertheless does provide a useful insight in terms of the impact of the legislation on those employed in bars. It demonstrates that the improvements in air quality (both in terms of fine air particulates and air nicotine concentrations) do appear to be having a positive impact on the work environment, and the health of workers. Three months after the legislation, virtually all bar staff (97%) rated the indoor air quality during their shift as good, which represented a 76% (percentage point) increase. There was also a significant decrease in the average number of health symptoms experienced by bar staff which they felt was directly related to being exposed to environmental tobacco smoke. Similar reductions in health symptoms have also been reported in other studies of national smoking bans (Allwright et al, 2005, Eagan et al, 2006). This is very promising as it shows that the prohibition of smoking in the workplace has led to almost immediate self reported health benefits, in addition to the potential reduced long term risks on cancer and heart disease for bar staff.

7. Conclusions and recommendations

In conclusion, the study has shown that the introduction of legislation in Northern Ireland prohibiting smoking in workplaces in 2007 has led to a significant reduction in the level of exposure to ETS in the workplace. Self reported health improvements have already been experienced by those employed in bars. The introduction of this public health policy can be heralded a significant success in terms of protecting workers from the harmful effects of ETS. Compliance rates of 97% across Northern Ireland (Department of Health, Social Services and Public Safety, 2008) also suggest that the legislation has received widespread support among the general public and the proprietors of licensed premises. There is a need to build on this success, to further reduce the risk of exposing workers to ETS and other air pollutants. The following recommendations have been made to help facilitate this process:

1. A programme of air particulate monitoring should be developed in Northern Ireland. This should include the setting of standards to minimise exposure to air particulates in the workplace. Workplaces that are not classified as good or moderate in terms of the US EPA Air Quality Index (EPA, 2003) should be investigated to identify the source of PM_{2.5} pollution and develop interventions to eliminate them.
2. There is a need to investigate whether there is scope to modify existing legislation to provide more effective control on smoking outside premises. Consideration should be given to introducing outdoor smoking restrictions such as those introduced in other countries.

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Appendix 1

Questionnaire for Research on the Ban on Smoking in Public Places

March 2007

This is a confidential questionnaire. Results will only be seen by members of the research team.

Individuals' results or opinions will not be identifiable in any report produced from this research.

We have asked for your name and the name of your workplace as we would like to ask you a few follow up questions in approximately 8 weeks time, in order to assess the impacts of the ban on Smoking in Public Places.

Name:

Premises:

ABOUT YOU

1. Have you ever smoked a cigarette, a cigar or a pipe?

Yes No

2. Do you currently smoke cigarettes or cigars or a pipe?

Yes No

3. If yes to above question on average how many cigarettes / cigars / pipes of tobacco do you smoke each day?

	Number smoked in a day
Cigarettes	
Cigars	
Pipes	

4. How many smokers live in your household?

0 1 2 3 4 or more

ABOUT SMOKING IN THE PREMISES YOU WORK IN

5. Please describe the type of premises in which you work

Pub selling food cooked on premises

Pub, no food sales

6. Which of the following best describes the current policy on smoking within these premises.

Smoking is allowed throughout

Certain areas are designated non smoking

Certain areas are designated smoking

Smoking is not allowed anywhere in the venue

If certain areas are designated as non smoking could you tell us where these areas are?

At the bar

Only where food is served

Other (please tell us where)

ABOUT YOUR WORK PATTERNS AND YOUR VIEWS ON TOBACCO SMOKE AND THE NEW SMOKING LEGISLATION

7. What are your current main duties in this bar?

8. Please tick which of the following best describes the length of your shifts.

Up to 4 hours	4-8 hours	8-12 hours	Over 12 hours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9. Do you experience any symptoms or effects that you feel are directly related to being exposed to tobacco smoke?

Yes No

If Yes please describe these symptoms/effects and when you suffer them.

10. How do you feel the smoking ban will impact on the premises? (NOTE: Can include both positive and negative views)

Positively?
How?

Negatively
How?

Not at all

11. Have you had any feedback, positive or negative, from customers on their views on the new legalisation?

Yes No

If yes, what are these views?

Positive

Negative

On balance would you say that the majority of views are

Positive or Negative

12. Are you aware that legislation will be in place from 30th April and that this will restrict smoking in most enclosed workplaces and public places?

Yes No

If yes tell us how you became aware of this

13. What time are you working until today?

14. We will be carrying out air monitoring today and would like to ask you about your views of the air quality inside the premises today whilst you are at work. Can you please complete the box below at the end of your working day and leave this questionnaire for collection later this evening.

How would you rate the air quality in your bar during the time you worked?

Rating	Please tick below
Good	
Moderate	
Unhealthy	
Unhealthy for sensitive groups e.g asthmatics	
Very Unhealthy	
Hazardous	
Very Hazardous	
Significant harm	

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