# Legislation and smoking: assessing the impact of the English smoking ban on smoking behaviours.

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Despite being preventable, smoking is the cause of approximately a third of all cancers in the UK (DoH, 2000). On the 1st July 2007 a total ban on smoking in public places came into effect in England. Similar smoking bans had previously been introduced in Scotland on 26th March 2006 and Wales and N.Ireland on the 2nd and 30th of April 2007 respectively. Although the primary motivation for public smoking bans was to protect non-smokers from environmental tobacco smoke (ETS), an expected secondary outcome was that smokers would be motivated to quit smoking or at least to reduce their cigarette consumption. The objectives of this study are to determine whether reductions in smoking behaviours decreased more so after the smoking ban was introduced in England than before the ban using data from the British Household Panel Survey (BHPS). Comparative analyses for Scotland, Wales and N.Ireland are also carried out to determine if smoking bans had a similar impact on smoking behaviours to those observed in England.

A Cochrane review of the impact of legislative smoking bans noted that, whereas many studies had assessed changes in exposure to secondhand smoke and general health outcomes, there was a marked paucity of studies assessing changes in smoking behaviours (Callinan, Clarke, Doherty et al., 2010). Previous research suggests that smoking prevalence and intensity decrease significantly around the introduction of a smoking ban, but that changes level out over time (Fong et al 2006; Fowkes et al 2008; Hackshaw et al 2010; West, 2010). Thus, it is hypothesised that in 2007, just after the introduction of the smoking ban in England, the probability of being a smoker and smoking intensity will be lower than expected had the ban not been implemented. However, the rate of change in the probability of being a smoker and the rate of change in smoking intensity after the ban in England will not differ from changes over time prior to the ban. Similar results were expected for the comparative analyses.

The data for this study were from the BHPS, 1999 to 2008. Further details of the BHPS are available elsewhere (Taylor et al 2009). Respondents were excluded if they were of ethnic origin, had been on maternity leave or had worked in the Army during the course of the study. Person-year observations were retained where respondents had provided a full interview and were at least 18 years old. In October 2007 the new legal minimum age for the sale of tobacco was increased to 18 years of age in England, Scotland and Wales and since September 2008 in N.Ireland (DoH, 2007). Including 16-17 year olds in this study would lead to post-ban reductions in smoking prevalence and intensity being over-estimated.

The outcome variable ‘smoking status’ was defined as ‘smoker’ and ‘non-smoker’, based on self-reported responses to the question ‘do you smoke cigarettes?’ asked at each wave (0=non-smoker, 1=smoker). Smoking intensity was derived based on smokers’ responses to the number of cigarettes usually smoked per day, including self-rolled cigarettes. A response of zero was re-coded to missing and excluded from analyses.

Zero values may have been due to measurement error or may have been subjectively interpreted by respondents as smoking, on average, less than one cigarette per day. Preliminary analyses indicated that the distributions of smoking intensity were non-Normally distributed, with responses were heaped around multiples of five. Thus, the number of cigarettes smoked daily was re-coded such that 1=1-5 cigarettes, 2=6-10 cigarettes, and so on, up to 16=76-80 cigarettes.

Analyses were carried out separately for men and women and adjusted for age on 1st December in 1999, centred at 45 years and 'age squared'. The hypotheses were tested using a disjointed, piecewise growth curve model. Thus, two different smoking trajectories were estimated– one for the period before the ban and one for after the ban (Chou, Yang, Pentz et al., 2004).

For smoking status, a logistic regression model was estimated such that $Y_{ij}$ equalled 1 if a respondent j was a smoker at time i, and 0 otherwise. Let $\hat{p}$ = probability that $Y_{ij}$ =1. Then

$$\text{logit}\left(\frac{\hat{p}}{1-\hat{p}}\right) = S_1a_{1j} + t_{ij1}b_{1j} + S_2a_{2j} + t_{ij2}b_{2j}$$

where $t_{ij}$ represented the time of the measurement. The initial status and growth profiles were captured by $a_j$ and $b_j$ respectively for the pre- and post-ban periods. The dummy variable $S_1$ was 1 when $y_{ij}$ was measured pre-ban and 0 otherwise. The dummy variable $S_2$, was 1 when $y_{ij}$ was measured post-ban and 0 otherwise.

For smoking intensity, a linear regression model was estimated such that

$$Y_{ij} = S_1a_{1j} + t_{ij1}b_{1j} + S_2a_{2j} + t_{ij2}b_{2j} + \varepsilon_{ij}$$

where $Y_{ij}$ represented the outcome value for respondent j at time i. The interpretation of the parameters $t_{ij}$, $a_j$ and $b_j$ were as for the logit model, while $\varepsilon_{ij}$ was the residual variation, assumed to be Normally distributed with mean 0 and variance $\sigma_\varepsilon^2$.

Each increment of time represented one year. The models were estimated using generalised estimating equations (GEE) (Diggle, Heagerty, Liang et al., 2002). An unstructured 'working' correlation matrix was used for smoking status and the Stata default for a Gaussian distribution of an exchangeable 'working' correlation structure was used for smoking intensity. All analyses were carried out using Stata v.11 (Stata Corp, 2009).

**Results**

*Smoking status.*

As expected, the predicted probability of being a smoker in 2007, just after the ban, for both men and women was statistically significantly lower than the expected probability of being a smoker had the ban not been implemented (men: mean difference in logits=-0.08, 95% CI (-0.14, -0.02), p<0.001(one-tailed); women: mean difference in logits=-0.07, 95% CI (-0.13, -0.02), p<0.01 (one-tailed), Table 2).

The rate of change in the probability of being a smoker was expected to be the same during the pre-and post-ban periods. Among men, the risk of being a smoker fell over time during both periods but was not significantly different in comparison (mean difference in logits= 0.02, 95% CI (-0.08, 0.05), p>0.10 (two-

tailed)). In contrast, the rate of change for women in the probability of being a smoker during the post-ban period was significantly different compared to decreases during the pre-ban period (mean difference in logits = 0.06, 95% CI (0.01, 0.12), p<0.05 (two-tailed)).

Figure 1 shows that for men and women aged 45 years on 1st December 1999 the predicted probability of being a smoker was clearly decreasing over time prior to the ban. During the post-ban period, the probability of being a smoker for men continued to decline somewhat over time. Among women, the increasing probability of being a smoker post-ban suggested increased rates of relapse.

In comparative analyses, the predicted probability of being a smoker in the immediate period after a smoking ban was significantly lower than the expected probability of being a smoker only among N.Irish women (mean difference in logits = -0.08, 95% CI (-0.17, 0.01), p<0.05 (one-tailed)). As expected, post-ban changes over time in the predicted probability of being a smoker were the same as pre-ban changes over time for all comparative samples, except among Welsh men. For Welsh men, the probability of being a smoker remained stable over time post-ban. However, the post-ban slope was significantly different from the pre-ban slope (mean difference=0.08, 95% CI (0.01, 0.16), p<0.05 (two-tailed)).

*Smoking intensity.*

In line with the hypotheses, the predicted smoking intensity among men and women in 2007, just after the ban, was significantly lower than expected had the ban not been introduced (men: mean difference=-0.18, 95% CI (-0.29, -0.07), p<0.001 (one-tailed); women: mean difference=-0.09, 95% CI (-0.19, 0.01)), p<0.05 (one-tailed), Table 3).

Changes over time in smoking intensity prior to the ban were hypothesized to be the same as changes after the ban. Figure 2 shows that among male smokers, smoking intensity increased somewhat after the ban. However, the rate of change after the ban was not statistically significant different from rates of change prior to the ban (mean difference=0.12, 95% CI (-0.00, 0.25), p<0.07 (two-tailed)) (Table 3). In contrast, the rate of change in the number of cigarettes consumed by women decreased very slightly both before and after the ban. However, post-ban decreases over time were not significantly different from pre-ban decreases over time (mean difference = -0.06, 95% CI (-0.17, 0.06), p>0.10 (two-tailed)).

Predicted smoking intensity was only found to be significantly lower just after the smoking ban compared to expected smoking intensity had the ban not been implemented among Welsh men (mean difference = -0.34, 95% CI (-0.56, -0.11), p<0.001, (one-tailed)). No differences in changes over time before and after the ban were found for any of the comparative samples.

**Discussion**

In line with previous research, there were greater than expected decreases in smoking prevalence and smoking intensity in the immediate periods after the English ban. These decreases may have been as result of the ban providing a trigger for smokers to attempt quitting. As predicted, changes in smoking prevalence and intensity over time in general were not substantially different before and after the bans, suggesting a short term effect of the smoking bans. Comparative analyses were inconclusive.

These findings should be considered in light of some limitations. The BHPS is a generic survey, designed for understanding social and economic changes in the UK. As such, smoking status and the number of cigarettes smoked at each wave are self-reported and not bio-chemically validated. However, it has been shown that self-reports of smoking among adults (excluding pregnant women) are generally reliable (Rebagliato, 2002). Furthermore, smoking intensity was measured by the number of cigarettes smoked on average per day rather than a more comprehensive measure, such as the Fagerström Tolerance Questionnaire (Heatherton et al, 1991).

Additionally, there were only two data points available for estimating the post-ban trajectories. In the future, further follow-up data for the BHPS, to be subsumed into the Understanding Society study, may provide more conclusive evidence (Understanding Society, 2008). As with previous literature, it was not possible to isolate the effects of secular trends that may also have affected smoking behaviours after the ban came into force. Moreover, numerous individual and community-level interventions and national initiatives, such as the NHS Stop Smoking services, will have also played active roles in reducing smoking and smoking intensity. Although respondents acted as their own controls in this study, individual-level factors were not controlled for, such as a change of occupation.

Nevertheless, this study contributes important additional findings to the current literature on the impact of public smoking bans. Previous studies have mostly used cross-sectional data. Descriptive statistics of changes in the percentage of smokers (quitters) or average mean differences in the number of cigarettes consumed have been reported, and in some cases only for after a ban has been enforced (Fong et al, 2006; Fowkes et al 2008; Hackshaw et al 2010). In contrast, this study analysed panel data of repeated measures of smoking behaviours with relatively large sample sizes to compare smoking behaviours before and after the English smoking ban. Adjustments were made for correlations arising from repeated observations within individuals providing a more accurate assessment of the effectiveness of the smoking ban.

Of interest is the gendered patterning of responses to the smoking ban in England. At the time that the ban came into force, both men and women were slightly more likely than before to quit smoking or for continuing smokers to reduce smoking intensity. However, after the ban women may be more likely to relapse to smoking over time. In contrast, continuing male smokers tended to return to previous levels of smoking intensity, while the evidence suggests that smoking intensity was decreasing among women.

**Conclusions**

The initial response to the smoking ban was a reduction in the number of smokers or, among continuing smokers at least a reduction in smoking intensity, to levels lower than expected had the ban had not come into effect. Thus, the ban may have been the trigger for some smokers to reflect on their smoking habit and take the necessary action to either quit or cut down on the number of cigarettes smoked. Alternatively, the ban may have merely been a deterrent, making it more difficult for people to smoke. However, there is a danger that in the long term, reductions in smoking prevalence and smoking intensity may slow down or even increase if not checked by additional individual- and community-level interventions.

In the UK, continuing smokers and new smokers are increasingly enabled to maintain their right to smoke.

For example, the sale of smoke-free cigarettes and availability of outdoor (heated) areas that are not enclosed enough to be classified by law as 'enclosed'. Pro-smoking organisations argue that smokers have the right to consume tobacco at their leisure rather than to be restricted in where they can smoke (Freedom2Choose, 2010). It remains to be seen whether smokers' right to smoke in the future will be further regulated by, for example, outdoor, home and car smoking bans. (Levy, Romano and Mumford, 2004).

## Subtitle

An evaluation of the impact of the English smoking ban on smoking behaviours.

**Table 1: Frequencies (and percentages), (except where indicated), of smoking behaviours and age of English respondents from the BHPS.**

| | **Men** | **Women** |
|---|---|---|
| **Variables** | 1,987 men/19,378 person-year observations | 2,078 women/20,332 person-year observations |
| Smoking status | | |
| Non-smoker | 15,173 (78.33) | 15,930 (78.38) |
| Smoker | 4,198 (21.67) | 4,395 (21.62) |
| Total | 19,371 (100) | 20,325 (100) |
| Age at 1st December 1999 | mean=44.84, (s.d.=15.81) | mean=48.28, (s.d.=15.42) |
| Number of cigarettes | mean=15.85 (s.d.=8.94) | mean=14.51, (s.d.=7.65) |
| Number of cigarettes (interval scale) | mean=3.27, (s.d.=1.71) | mean=3.01, (s.d.=1.45) |

**Table 2: Logistic regression results for the probability of being a smoker before and after the English smoking ban.**

| | **Men** | | | **Women** | | |
|---|---|---|---|---|---|---|
| | **Logit estimate** | **95% CI** | **Odds** | **Logit estimate** | **95% CI** | **Odds** |
| Age-45 | -0.03*** | -0.04, -0.03 | 0.97 | -0.02*** | -0.03, -0.02 | 0.98 |
| Age-45 squared | -0.00 | -0.00, 0.00 | 1.00 | -0.00 | -0.00, 0.00 | 1.00 |
| ***Pre-Ban*** | | | | | | |
| Intercept | -1.16*** | -1.30, -1.03 | 0.31 | -0.98*** | -1.11, -0.86 | 0.37 |
| Slope | -0.05*** | -0.06, -0.04 | 0.95 | -0.04*** | -0.05, -0.03 | 0.96 |
| ***Post-Ban*** | | | | | | |
| Intercept | -1.62*** | -1.77, -1.03 | 0.20 | -1.41*** | -1.54, -1.27 | 0.25 |
| Slope | -0.03 | -0.09, 0.04 | 0.97 | 0.02 | -0.03, 0.07 | 1.02 |

*** p<0.001, ** p<0.01, * p<0.05

**Table 3: Linear regression results for smoking intensity before and after the English smoking ban**

| | Men | | Women | |
|---|---|---|---|---|
| | **Parameter estimate** | **95% CI** | **Parameter estimate** | **95% CI** |
| Age-45 | -0.00 | -0.01, 0.01 | 0.01 | -0.00, 0.01 |
| Age-45 squared | -0.002*** | -0.0015, -0.0011 | -0.00*** | -0.00, -0.00 |
| ***Pre-Ban*** | | | | |
| Intercept | 3.48*** | 3.30, 3.66 | 3.26*** | 3.12, 3.40 |
| Slope | 0.00 | -0.01, 0.01 | -0.01 | -0.02, 0.001 |
| ***Post-Ban*** | | | | |
| Intercept | 3.31*** | 3.11, 3.51 | 3.09*** | 2.93, 3.24 |
| Slope | 0.12 | -0.01, 0.25 | -0.07 | -0.18, 0.05 |

*** p<0.001, ** p<0.01, * p<0.05

**Figure 1: The predicted probability of being a smoker in England before and after the smoking ban.**

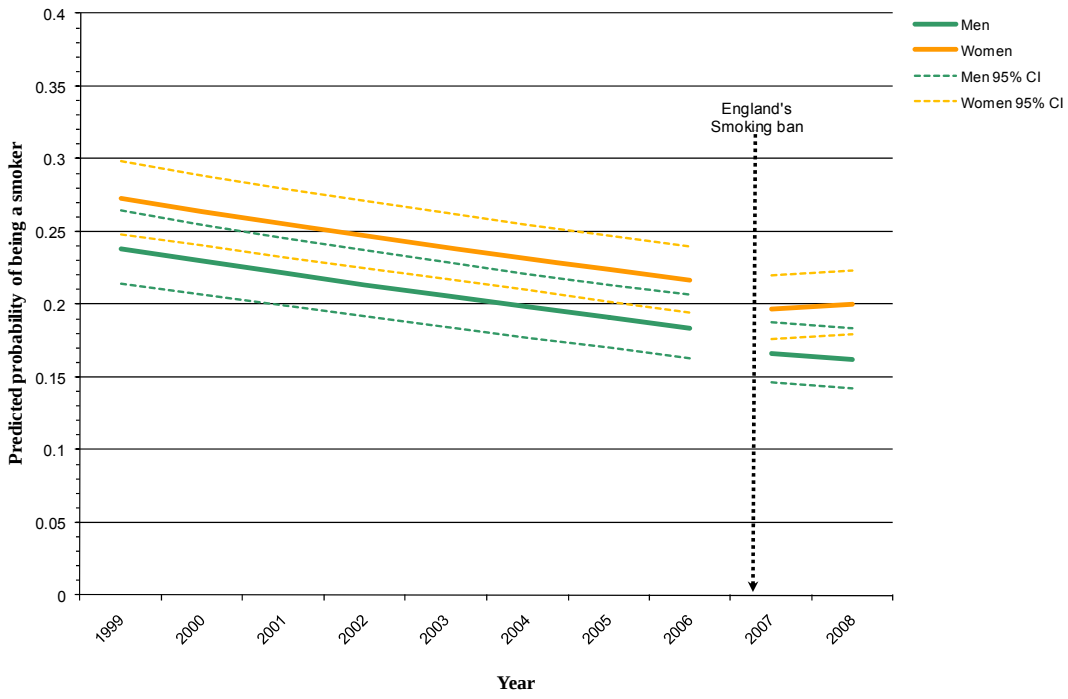
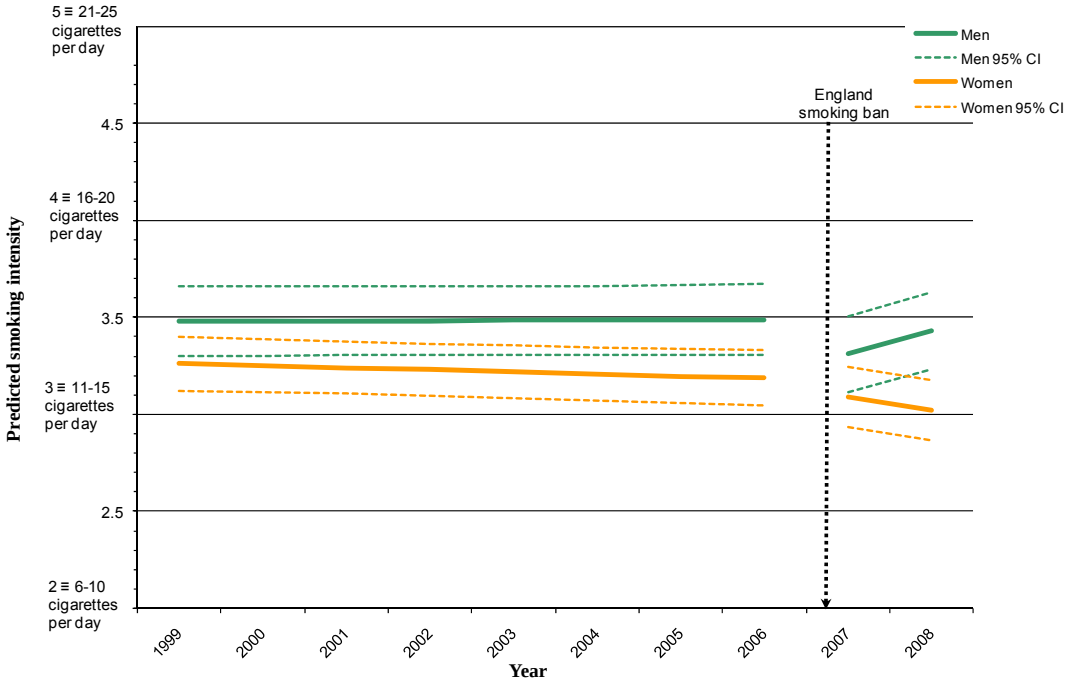


**Figure 2: Predicted smoking intensity in England before and after the smoking ban.**




## REFERENCES (RÉFERENCES)

Callinan, J. E., Clarke, A., Doherty, K., and Kelleher, C. (2010). Legislative smoking bans for reducing secondhand smoke exposure, smoking prevalence and tobacco consumption. *Cochrane Database of Systematic Reviews* 2010, Issue 4. Art.No.: CD005992. DOI:10.1002/14651858.CD005992.pub2.

Chou, C., Yang, D., Pentz, M. A., and Hser, Y. (2004). Piecewise growth curve modeling approach for longitudinal prevention study. *Computational Statistics, 46*, 213-225.

Diggle, P. J., Heagerty, P. J., Liang, K. Y., and Zeger, S. L. (2002). *Analysis of Longitudinal Data* (2nd edition). New York: Oxford University Press.

DoH (2000). *The NHS Cancer Plan.* TSO: London. Accessed 8th October 2007 at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4009609.

DoH. (2007). *The law for selling tobacco has changed*. Accessed 10th February 2010 at http://www.tobaccoagechange.co.uk/

Fong, G. T., Hyland, A., Borland, R., Hammond, D., Hastings, G., McNeill, A. et al. (2006). Reductions in tobacco smoke pollution and increases in support for smoke-free public places following the implementation of comprehensive smoke-free workplace legislation in the Republic of Ireland: findings from the ITC Ireland/UK Survey. *Tobacco Control, 15*(Suppl III), 51-58.

Fowkes, J. I., Stewart, M. C. W., Fowkes, G. R., Amos, A., and Price, J. F. (2008). Scottish smoke-free legislation and trends in smoking cessation. *Addiction, 103*(11), 1888-1895.

Freedom2Choose. (2010). *Freedom to Choose.* Accessed 20th May at http://www.freedom2choose.info/

Hackshaw, L., McEwen, A., West, R. and Bauld, L. (2010). Quit attempts in response to smoke-free legislation in England. . *Tobacco Control, 19*, 160-164.

Heatherton, T.F., Kozlowski, L.T., Frecker, R.C. et al (1991) The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire. *British Journal of Addiction* 86, 1119-1127.

Rebagliato, M. (2002). Validation of self-reported smoking. *Journal of Epidemiology and Community Health,* 56, 163-64.

Stata Corp. (2009). *Stata statistical software, Release 11.* College Stata. TX: Stata Corp LP.

Taylor, M. F., Brice, J., Buck, N. and Prentice-Lane, E. (2009). *British Household Panel Survey User Manual Volume A: Introduction, Technical Report and Appendices*. Colchester: Institute of Social and Economic Research, University of Essex.

Understanding Society. (2008). *Understanding Society.* Institute of Social and Economic Research, University of Essex. Accessed 5th August 2010 at http://www.understandingsociety.org.uk/

West, R. (2010). *Impact of the smoking ban on smoking prevalence in England.* Accessed 17th March 2010 at http://www.smokinginengland.info/