Chapter 7
The effect of mandated smoking restrictions on smoking behaviour

Introduction

The primary reason for smoking restrictions is to protect nonsmokers from secondhand tobacco smoke (SHS). Restrictions on smoking also help make tobacco use less socially acceptable and reduce opportunities to smoke. Therefore, it would be expected that besides protecting nonsmokers, smoking restrictions would also tend to reduce smoking prevalence and consumption in smokers. The purpose of this chapter is to further explore if and how mandated restrictions in various settings (e.g. public places, workplaces) might act in this manner, and to present results from a number of studies that have investigated this issue. Smoking restrictions in the home are by agreement among household members, and are considered separately in Chapter 8.

Methodological issues

Identification of relevant literature

A preliminary search of the Web of Science, covering the publication period from January 1, 1990 to March 30, 2008, including the title subjects (TS) ('Smoke Free' SAME ban*) OR TS=('Smoke Free' SAME polic*) OR TS=('Smoke Free' SAME legislation) OR TS=('Smoke Free' SAME Law*), generated a preliminary, extensive list of articles. Papers identified from this search were reviewed for relevance to the topic of the effect of smoking restrictions on smoking behaviour. Additional searches of PubMed paired various permutations of smoke-free (e.g. smoking restrictions, smoking rules, etc.) with words describing venues (e.g. workplaces, worksites, homes (Chapter 8), schools, etc.) and words related to smoking behaviour (e.g. smoking prevalence, smoking initiation, cigarette consumption, smoking cessation, etc.). Several studies that were particularly appropriate were used as templates to extract "related articles." These lists of related articles were then scanned for additional relevant studies. More pertinent articles were found in the references cited by the studies already identified. These were obtained and examined for further citations until no further studies were identified. While this procedure does not ensure that all relevant studies were captured, it goes well beyond a single set of search criteria.

Typical study designs

There are several typical study designs found in the body of research summarised in this chapter. These are commented on throughout, but a few general characteristics of such studies are mentioned briefly here.

Some studies compare smoking behaviour before and following the implementation of new smoking restrictions. Unless a comparable group of people, not subject to the new restrictions, is available for comparison purposes, it cannot be decided whether any changes observed in the group subject to the new restrictions resulted from the restrictions or were simply following a population secular trend. Using multiple observation points before the new restrictions were implemented would help establish any existing secular trend. In some cases, changes are studied using data from large, cross-sectional population surveys, conducted before and after the new restrictions. This approach assumes that no changes in the composition of the population have occurred that might be related to smoking behaviour. In population studies, changes in

population composition could be from immigration or emigration, and in surveys of worksites, those who quit or take a job in a given workplace might self select according to workplace smoking policy. Advantages of the cross-sectional approach are that the surveys are usually large and representative of the population.

Single cross-sectional population survey samples cannot establish causality, but only identify associations. For instance, while people subject to smoking restrictions might smoke less, it may be because of the restrictions, or because of some other characteristic (e.g. higher socioeconomic status or health consciousness) that is related both to their likelihood of smoking and to their being in a situation where smoking is or is not restricted. These cross-sectional studies examined the correlation between the presence of smoking restrictions and such outcomes as smoking status, consumption, making a recent quit attempt, or intention to quit smoking. These measures are described in Appendix 2.

In other studies, a cohort of subjects interviewed before the new smoking restrictions were implemented is followed-up again months or years later and re-interviewed. The cohort (or longitudinal) approach usually involves fewer subjects, and while this design is particularly appropriate for studying changes in individuals' smoking behaviour over time (e.g. cessation), typically a significant percentage of the subjects is lost to follow-up. If the group lost differs in some important respect (e.g. propensity to quit smoking or switched to a job where smoking is not restricted) to the group successfully followed, the results can be compromised. Behavioural outcomes typically examined in these longitudinal studies were changes in consumption and in smoking status.

Conventions for reporting results

Many of the studies reviewed used some form of multivariate logistic regression analysis to relate smoking restrictions to various aspects of smoking behaviour. Unless otherwise specified, the results cited in this chapter are adjusted odds ratios (OR) together with their 95% confidence intervals (CI). Typically, such analyses adjusted for a number of demographic and other factors. Generally, if the odds ratio fails to include 1.0, it is statistically significant. In a few cases, rounding leads to a value of 1.0 as the upper or lower 95% confidence limit, but if the author indicated that the odds ratio was significant, it is reported as significant here. Most of theses studies do not report p-values for the odds ratios if they give 95% confidence intervals. Report of actual p-values or p-value thresholds were more common in studies employing multiple linear regression models. In this chapter, results are reported as the authors presented them.

Scope of chapter

The prevalence of workplace smoking restrictions and who is subject to them is described in Chapters 5 and 6, and issues related to economic impact are presented in Chapter 4. Here the focus in on how smoking restrictions in the workplace and in other settings might affect both adult and youth smoking behaviour.

The first section below looks at changes in smoking behaviour following the implementation of new laws restricting smoking. It also reviews studies that correlate the strength and breadth of smoking restrictions in specific localities to the smoking behaviour of the residents there, both adults and youth. The second section is concerned with the effect of workplace smoking policies on workers' smoking behaviour, and the last section examines the evidence for an effect of smoke-free school campuses for everyone, not just students, on youth smoking behaviour.

Mandated restrictions on smoking and population level smoking behaviour

There are two types of studies that address the impact of mandated restrictions on smoking behaviour: those that compare pre-law and post-law smoking behaviour within a specific population subject to a new law, and those that correlate variable strength and extent of local laws restricting smoking with smoking behaviour in the same localities. This section reviews both types of studies.

Pre- versus post-law studies

Most studies of the assessment of changes after the implementation of local, regional, or national anti-smoking laws (such as those implemented in Ireland, Italy or

Norway) or comprehensive tobacco control programmes (such as those implemented in the USA: California, Massachusetts or New York City) have used data collected on a periodic basis in health interview surveys or in more specific tobacco surveys. These studies select representative samples of the adult population (mostly ≥18 years), with comparable methods and measures across time.

In some studies, the analysis is limited to simple before and after comparisons of adult smoking prevalence, but a number of studies analysed trends over time, including estimates from several surveys before and after the law or programme was implemented. A few studies have combined data from different surveys to reconstruct birth and age-cohorts for the analysis of smoking prevalence and cessation over longer periods of time. Some studies have modeled the effect of the law or the total programme by means of indicator variables for when the intervention commenced in the regression models used for the statistical analysis. Also, a few evaluations have used 'control groups' (comparison populations not exposed to the law or programme), or other designs such as prospective cohort studies. The studies in each section below are discussed in order according to the time the new law was implemented.

Before/after law implementation comparisons

Two articles have evaluated the effects of smoking restrictions using two independent cross-sectional surveys: one before and one after the implementation of a new law restricting smoking. These were in Madrid Region, Spain (Galàn *et al.*, 2007), and Scotland, UK (Table 7.1), and assessed the entire population (Haw & Gruer, 2007). Another study (Braverman *et al.*, 2008) used a longitudinal sample to look for changes in smoking behaviour in hospitality workers following law implementation.

In Spain, a comprehensive law on smoking prevention and control implemented in 2006 included a prohibition on smoking in all enclosed workplaces, with the exception of the hospitality sector. The law called for only partial restrictions in the hospitality sector with venues larger than 100m^2 mandated to be smoke-free, but owners could decide to have separated, ventilated smoking areas of less than 30% of the total floor area. In venues <100m^2, however, smoke-free environments were not compulsory and depended on the owner's decision. An early evaluation of the impact of the law on secondhand smoke (SHS) exposure at the population level in the Region of Madrid (including the city of Madrid) included information on the prevalence of smoking (Galàn *et al.*, 2007). Using the continuous Behavioural Risk Factors Survey System, two independent telephone surveys were carried out among the adult (18-64 years) population before the law (October-November 2005; n=1750) and after the law (January-July 2006; n=1252). The surveys collected information on active and involuntary smoking. The prevalence of smoking was similar both before (31.7%) and after the law (32.7%) was implemented.

In Scotland, a law to prohibit smoking in virtually all enclosed places and workplaces including bars, restaurants, and cafes was implemented by March 2006. The comprehensive evaluation of the impact of the law (Haw *et al.*, 2006) has included the assessment of changes of the exposure to SHS of the adult population (Haw & Gruer, 2007). From this study, the short-term effect of the law on smoking prevalence in the adult population can be derived, although the study was designed to assess SHS exposure (self-reported in a questionnaire and measured by means of saliva cotinine concentrations). Two independent cross-sectional surveys among representative samples of the adult (18-74 years) population were conducted before (September-November 2005 and January-March 2006; n=1815) and after (September-December 2006 and January-April 2007; n=1834) the law was implemented. No apparent short-term changes in the adult tobacco use prevalence among Scottish adults was found: the prevalence of smoking (cigarettes, pipes, or cigars) was 35.6% in the pre-law survey and 35.1% in the post-law survey.

These two studies (Galàn *et al.*, 2007; Haw & Gruer, 2007) were designed to assess changes in SHS exposure, and from questions used to characterise smoking status, smoking prevalence rates can be derived. However, the articles did not include a specific analysis of smoking prevalence beyond presenting the prevalence rates within a descriptive table (Galàn *et al.*, 2007) or within a descriptive paragraph in the results section (Haw & Gruer, 2007).

Table 7.1 Studies comparing smoking behaviour pre- and post-implementation of new laws restricting smoking

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Single cross-sectional pre- versus post- new law comparisons of population smoking prevalence							
Galán *et al.*, 2007 Madrid Region, Spain	Adults (18-64 years). BRFSS surveys before/after law. 2 surveys; n0=1750; n1=1252	Pre-law Oct-Nov 2005 Post-law June-July 2006	Comprehensive law covering all enclosed places, with partial restrictions in hospitality venues, effective Jan 2006	Smoking prevalence	Simple, no adjustment for covariates (see comments)	Smoking prevalence pre-law (31.7%) and post-law (32.7%) were not statistically different.	Response rates: 77% pre- and 66% post-law. The paper is aimed at evaluating changes in SHS exposure in different settings, but it also presents smoking prevalence.
Haw & Gruer, 2007 Scotland, UK	Adults (18-74 years). Face-to-face at-home interviews. 2 surveys: n0=1815; n1=1834	Pre-law Sept 2005-Mar 2006 Post-law Sept 2006-April 2007	Comprehensive law including smoking prohibition in hospitality venues, effective March 2006	Prevalence of tobacco use (cigarettes, pipes, or cigars)	Simple, no adjustment for covariates (see comments)	Tobacco use prevalence pre-law (35.6%) and post-law (35.2%) were not statistically different.	Response rates around 70%. The paper is aimed at evaluating changes in SHS exposure, but it also presents tobacco use prevalence.
Longitudinal study pre- versus post- new law comparisons of hospitality workers							
Braverman *et al.*, 2008* Norway	Longitudinal study of 1525 restaurant and bar employees.	Pre-law and 4 and 11 months post-law	Comprehensive smoke-free policy, June 2004	Smoking prevalence and daily cigarette consumption	No covariates	Significant declines in prevalence and consumption were identified from baseline to 4 months, with behaviour stable between 4 and 11 months. Prevalence of daily smoking declined 3.6%, daily smoking at work declined by 6.2%, the number of cigarettes smoked by continuing smokers declined 1.55 CPD, and the number of cigarettes smoked at work by 1.63 CPD. Occasional smoking was stable across all three survey waves.	Analysis of sample attrition suggested results unaffected. Attrition mostly due to job changing. The authors suggested that the stable rates between 4 and 11 months indicate that the initial drop was because of the law, and not a result of a secular trend for decreased smoking

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Multiple cross-sectional population surveys or other data pre- and post- new law							

Heloma *et al.*, 2001;
 	
Heloma & Jaakkola, 2003.
 	
Helsinki metropolitan area, Finland
	Adult employees.
	Trends.
	Sample of workplaces (n=8).
	Self-administered questionnaire.
	Before/after law.
	
	3 surveys:
	n0=880;
	n1=940;
	n2=659
		1994-5;
		1995-6;
		1998.
		
		Law passed on March 1995
			Smoking prevalence
			
			Mean number cigarettes smoked
				Simple analysis, by sex.
				
				No adjustment for potential confounders
						Prevalence smoking
						1994-5: 29.8%
						1995-6: 24.6%
						1998: 25.2%;
						p trend <0.05
						
						Mean cigarettes smoked
						1994-5: 19 CPD
						1995-6: 16 CPD
						1998: 16 CPD
						
						Smoking at work
						1994-5: 83.1%
						1995-6: 47.4%
						1998: 31.1%;
						p trend <0.05
							2 papers (2001 & 2003) with results 1 year after and 3 years after the law.
							
							Response rates: 69%; 74%; not known 3rd survey.
							
							Reduction significant only among men (33.1%; 26.9%; 24.8%), whilst increase among women (22.0%, 18.4%; 21.1%)

Galeone *et al.*, 2006 Italy (country-wide)	Changes in indicators of tobacco consumption and NRT use. Trends. Pre/post law.	Monthly sales Jan 2005 through Nov 2005	Comprehensive smoke-free policy, Jan 2005	Cigarettes sales (in Kg), per capita sales (packs per capita) and sales of NRT products	No covariates, differences not statistically analysed	Decline cig sales: -5.7% Decline per capita consumption: -6.6% (previous declines before law were 2.8% between 2003 and 2004, and 1.3% between 2002 and 2003) Increase in sales of NRT products: 10.5%.	

Gallus *et al.*, 2007
 	
Italy (country-wide)
	>15 years.
	Face-to-face interview.
	Before/after law.
	
	3 surveys:
	n0=6534;
	n1=6585;
	n2=6153
		2001-2;
		2003-4;
		2005-6.
		
		Law effective Jan 2005
			National law prohibiting smoking in all enclosed workplaces (smoking areas allowed in hospitality sector under strict conditions)	Adult smoking prevalence
				
				Mean CPD
					Simple analysis, by sex and age
					
					No adjustment for potential confounders
						Prevalence smoking
						2001-02: 27.8%
						2003-04: 27.0%
						2005-06: 25.0%;
						p<0.05 versus 2003-4
						
						Mean cigarettes smoked
						2004: 15.4 CPD
						2006: 13.9 CPD
						Not statistically tested
							Response rate: quota sample
							Reduction significant in men (2003-04 versus 2005-06: 31.7% versus 29.0%), but not in women (22.5% versus 21.2%), and in <45 years (32.4% versus. 30.0%), but not ≥45 years (20.5% versus 20.2%).

Table 7.1 Studies comparing smoking behaviour pre- and post-implementation of new laws restricting smoking

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Multiple cross-sectional population surveys or other data pre- and post- new law							
Edwards *et al.*, 2008 New Zealand (country-wide)	Overview evaluation NZ Smoke-free Environments Amendment Act (SEAA) 2003. Annual cross-sectional population surveys conducted as part of the evaluation.	1997-2005	SEAA 2003	Adult and youth prevalence and cigarette consumption (sales)	Only qualitative comments regarding smoking behaviour presented	There did not appear to be any discernable effect of SEAA on adult smoking prevalence or overall cigarette consumption. Youth prevalence declined, but not differently than what would be expected from on-going trend.	
Office of Tobacco Control, 2007 Ireland	Monthly surveys (n=1000) of persons aged 15+ years	June 2003 to Dec 2007	Comprehensive smoke-free law March 2004	Running average of smoking prevalence	No statistical analysis presented	Prevalence: March 2004: 25.5% March 2005: 23.8% April 2006: 24.5%	Short-term decline appeared to be partially reversed.
Studies where laws restricting smoking were part of multiple tobacco control measures implemented. Generally, studies involved multiple, representative cross-sectional population surveys							
Emmanuel *et al.*, 1988 Singapore	Pre-post cross-sectional surveys of persons aged 15 years and older, n=92 500 in 1984 n=78 600 in 1987	1984-1987	National Smoking Control Programme of 1986	Adult and youth smoking prevalence, per capita tobacco consumption	Simple comparisons pre versus post new law	**Adult** (15+ years) prevalence 1984: 19.0% 1987: 13.6%, p<0.01 **Youth** (15-19 years) prevalence 1984: 5.1% 1987: 2.9%, no p-value reported Per capita consumption 1984: 3.21 kg/person 1987: 2.38 kg/ person, no p-value reported	
Pierce *et al.*, 1998b; Gilpin *et al.*, 2001 California versus rest of USA	18+ years. Different health and tobacco interview surveys: NHIS, CTS, BRFS/CATS,	1982-1999 (tobacco sales) 1978-1999 (adult smoking prevalence)	California Tobacco Control Programme (1989). Includes new taxes on cigarettes, laws restricting	Per capita cig consumption (1983-1999) Adult (≥18 y) smoking prevalence (1978-1999)	Prevalence standardised for age, race, and education level. Piecewise linear regression	Pre-programme annual rate of decline in per capita consumption was -0.46/ packs in CA, and -.35 in the rest	

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Studies where laws restricting smoking were part of multiple tobacco control measures implemented. Generally, studies involved multiple, representative cross-sectional population surveys							
Pierce *et al.*, 1998b; Gilpin *et al.*, 2001 California versus rest of USA	and CPS. Tobacco sales from the Tobacco Institute		smoking, mass media, local media, local agency actions, research, and school education programmes.	Several periods: pre-programme 1978-1989; early period 1989-1993; middle period 1994-1996, late period; 1996-1999		of the USA. In the early period these rates were significantly different at -0.58 versus -.40. In the middle period the rates of -.16 and -0.7 were not significantly different, but in the later period, they were: -1.56 versus -0.78. Only in the early period was the rate of annual decline in prevalence different from that in the rest of the USA (-1.01 versus -0.51).	
Laugesen & Swinburn, 2000 New Zealand	Annual cross-sectional surveys of 10 000+ persons aged 15+ years each year	1985-1998	Tobacco Control Programme of 1985-1998	Adult and youth smoking prevalence, per capita tobacco consumption	Simple comparisons and comparisons of trends in New Zealand and other countries with comparable data over this period	**Adult** (15+ years) prevalence 1985: 30% 1998: 26% **Youth** (15-24 years) prevalence 1985: 35% 1998: 29% Per capita consumption 1985: 2493 1995: 1472	New Zealand ranked 8th in the extent of decline in adult prevalence among 21 countries. It ranked 3rd in the decline of youth prevalence among 17 countries with comparable data. In 1995 New Zealand was second lowest in per capita consumption.
Biener *et al.*, 2000. Massachusetts (MA), USA; with comparison to rest of states, excluding California	Adult population (18-64 years) Trends. Telephone interview. BRFSS survey. Sample size around 1500 subjects (between	Adult smoking prevalence: 1989-1999	MA Tobacco Control Programme: 1: mass media campaign; 2: services (treatments, youth programmes, telephone	Adult (≥18 years) cigarette per capita consumption Adult smoking prevalence	Simple trend analysis Simple linear regression with splines	Before 1993 (tax operating), the decline was similar in MA (-15%) and the comparison states (-14%) (annual decline of 3-4%). In 1993, MA decline was 12%,	

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Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Studies where laws restricting smoking were part of multiple tobacco control measures implemented. Generally, studies involved multiple, representative cross-sectional population surveys							
Biener *et al.*, 2000. Massachusetts (MA), USA; with comparison to rest of states, excluding California	1221 in 1989 to almost 1800 in 1997; with 4944 subjects in 1999). Data tobacco sales from the Tobacco Institute		counseling educational materials); 3: promotion of local policies The MA TC programme funding comes from a surcharge of 25 cents per dollar implemented in January 1993			compared to 4% in the comparison states, followed by a continuous 4% year decline in MA versus just 1%/year in the rest of the states. Decline in smoking prevalence in MA from 24% in 1989 to 19% in 1999, with a significant slope of -0.43% /year (-0.66 to -0.21%/year) after 1992. Decline in rest of the USA from 25% to 23.5% in 1992, and no significant changes thereafter (slope after 1992 of -0.03).	
Helakorpi *et al.*, 2004, 2008 Finland (country-wide)	15-64 years. Trends. Self-administered postal questionnaire. Pool of surveys (~5000 subjects per year, 33 080 men and 34 991 women)	1979 to 2002	Tobacco Act (1976)	Smoking prevalence by birth cohorts by sex	Age, period, and cohort analysis, by sex, and by SES (second paper) Logistic regression to assess the effect of age, cohort, and the 1976 Tobacco Act	**Paper 1.** Prevalence declined concurrent to 1976 Tobacco Act in men and women OR men=0.74 ($p<0.05$) OR women* cohort=0.45, 0.34, and 0.26 ($p<0.05$). **Paper 2.** Men, declining cohort trend in all SES groups. Women, increasing in early cohort and declining thereafter.	Average response rate 70% men and 79% women. Second paper adds socioeconomic status by means of record linkage (health interview-census): entrepreneur, farmer, upper white collar, lower white collar, blue collar. * Values correspond to birth cohorts: 1961-1965, 1966-1970, 1971-1975 respectively

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Studies where laws restricting smoking were part of multiple tobacco control measures implemented. Generally, studies involved multiple, representative cross-sectional population surveys							
Frieden *et al.*, 2005 Centers for Disease Control and Prevention, 2007c New York City	Adult (≥18 years). BRFSS surveys and ad hoc surveys. Telephone questionnaire. Multi-language Approximately 10 000 subject per survey.	"Background" prevalence from 1993-2001 surveys. Pre-law survey: 2002; post-law 2003. Centers for Disease Control and Prevention paper adds surveys for 2005 and 2006	Tobacco Control strategy, including: 1: Increased tax; 2: Smoke-free Air Act 2002 (March 2003) for all indoor workplaces; 3: guidelines to physicians + NRT; 4: education through broadcast and print media; 5: systematic evaluation (surveys)	Adult smoking prevalence	Analysis by age groups, race/ ethnicity, sex, district, income, education, place of birth. Changes in % from rate ratios, derived from ORs calculated by means of age-adjusted logistic regression models.	No changes in smoking prevalence during the 10 years preceding the 2002 programme (21.5%) Smoking prevalence: 2002: 21.6% (23.4% men; 19.8% women); 2003: 19.2% (21.6% men; 17.2% women); 11.3% decrease ($p<0.05$) Significant decrease in men and women, all age groups except ≥65 years (larger at 18-24 years), all race groups (significant only among non-Hispanic blacks and Hispanics), all education groups (larger and significant only for "some college").	Response rates 2002-2003: around 60%. The groups that experienced the largest declines in smoking prevalence were young people, women, people in lowest and highest income brackets, people with higher educational levels, and heavy smokers. Centers for Disease Control and Prevention paper with 2005 and 2006 data confirms previous findings 2002: 21.6% 2005: 18.9% 2006: 17.5% Decrease in men and women, all age groups (2002-2006), and all educational groups (larger among more educated).
				% heavy smokers (>10 CPD)		Decrease in heavy smoking from 8.0% (2002) to 6.2% ($p<0.05$).	
				Average CPD		Decrease from 11.2 CPD (2002) to 10.6 CPD (2003).	

Table 7.1 Studies comparing smoking behaviour pre- and post-implementation of new laws restricting smoking

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Incidence of smoking cessation, no direct evaluation of new laws restricting smoking							
Gilpin & Pierce, 2002a USA	20-50 years. Trends. (7 surveys from 1965 to 1992). Face-to-face at-home questionnaire. Pool of surveys yielded 140 199 subjects.	1950-1990	Partial restrictions in 1978, 1986, and 1988	Incidence of quitting smoking	Analysis by age, sex, ethnicity, and educational level	Increase in quitting from <1% to 5%. Gender differences occurred following the beginning of public health campaigns (danger to the fetus). Quitting increased among younger smokers in the 1970s, around nonsmokers' rights movement. Quitting incidence was larger among more educated subjects (some college).	Effect of smoking restrictions or campaigns not directly assessed with statistical models.
Schiaffino *et al.*, 2007 Spain	≥20 years. Trends. 5 surveys (1993, 1995, 1997, 2001, and 2003). Face-to-face at-home. Pool of surveys yielded 33 532 subjects.	1965-2000	Partial restrictions in 1978, 1986, and 1988	Incidence of quitting smoking	Analysis by age, sex, and educational level	Increase in quitting incidence 20-50 years: men (0.5% to 4.9%) women (1.1% to 5.0%) Larger increases ≥50 years, 8% by 2000. Differences according to education: level-off in men and women with primary or less than primary education, while cessation incidence among more educated continued to increase.	Effect of restrictions not assessed in models. No clear pattern according to laws and decrees passed. None of them prohibited smoking in workplaces or promoted NRT treatments.

Reference Location	Population and design	Year of assessment	Type of intervention (law)	Outcomes assessed	Covariates and analysis	Results	Comments
Respondent report/perceptions regarding changes in smoking due to law							
Hammond *et al.*, 2004 Ontario, Canada	191 former smokers who quit before and after new law	2001	Before and after law (January 2000) restricting smoking and requiring new warning labels on cigarette packages	Cite restrictions as motivation to quit Cite warning labels as motivation to quit	Logistic regression adjusted for age, sex, CPD prior to quitting, and number of years smoked. Indicator variable included for quit pre- and post-law	Increase in those citing smoking restrictions as motivation OR=3.06; 95% CI=1.02-9.19 Increase in those citing warning labels as motivation OR=2.78; 95% CI=1.20-5.94	
Fong *et al.*, 2006 Ireland	Representative longitudinal sample of the adult ≥18 years) smoking population (n=1679) before law and followed-up after law (n=769)	Dec/Jan 2003-04 and Dec/Jan 2004/05	Before and after new law (implemented March 2004)	In smokers (n=640): Had the law made them more likely to quit? Had the law made them cut CPD? In quitters (n=119): Had the law made them more likely to quit? Helped them to stay quit?	Report of simple percentages and 95% CIs	 46% (41-50%) 60% (55-65%) 80% (71-88% 88% (81-95%)	

*Braverman study not cross-sectional
BRFS/CATS = Behavioral Risk Factor Survey/California Adult Tobacco Survey
BRFSS = Behavioral Risk Factor Surveillance System
CPD = Cigarettes per day
CPS = Current Population Survey
CTS = California Tobacco Survey
NHIS = National Health Interview Surveys
SES = Socioeconomic status
SHS = Secondhand smoke

If the studies were designed to assess changes in SHS exposure, they might not have been adequately powered (sample size too small) to detect changes in prevalence. In both studies, moreover, the post-law survey was conducted within a year after law implementation (six months in Spain and within the first year in Scotland) so that there was limited likelihood of observing any potential effect of the restrictions on smoking prevalence.

The short-term effects of Norway's comprehensive clean air policy, that took effect in June 2004, were evaluated (Braverman *et al.*, 2008). A longitudinal sample of randomly selected restaurant and bar employees was used; subjects were interviewed at baseline immediately before the policy and at four and 11 months afterwards. Sample attrition was considerable, but extensive analyses of those followed and not followed led the researchers to conclude that it was unlikely that attrition would affect the study results. Restaurant and bar employees were chosen for study, because they are relatively younger (changes in smoking would have long-term health benefits), they have historically experienced high levels of exposure to SHS in the workplace, and they have relatively higher smoking rates than the general population (52.9% daily versus 26.3% in a similarly aged group from the general population). Significant declines in prevalence and consumption were identified from baseline to four months, with behaviour stable between four and 11 months. Prevalence of daily smoking declined 3.6 percentage points, daily smoking at work declined by 6.2 percentage points, the number of cigarettes smoked by continuing smokers declined 1.55 cigarettes per day (CPD), and the number of cigarettes smoked at work by 1.63 CPD. Occasional smoking was stable across all three survey waves. The authors concluded that the stable rates between four and 11 months mean that the initial drop was real and not just a result of a secular trend for decreased smoking.

While the longitudinal study (Braverman *et al.*, 2008) found a short-term effect, the repeated cross-sectional studies did not. In the cross-sectional approach, cessation would have to offset initiation and relapse of former smokers to current smoking to show an effect, but the longitudinal study involved only smokers at baseline, so a change in prevalence in the same subjects would be due to cessation, assuming no bias due to sample attrition.

Trends from multiple cross-sectional surveys before/after new laws

A number of studies have evaluated pre-post legislation changes in the prevalence of smoking using trends across time by means of repeated representative population cross-sectional surveys (Table 7.1). Two of these papers present Finnish data with reference to smoking in workers in Metropolitan Helsinki (Heloma *et al.*, 2001; Heloma & Jaakkola, 2003). Other papers are from New Zealand (Edwards *et al.*, 2008) and Italy (Galeone *et al.*, 2006; Gallus *et al.*, 2007). Online data are available for Ireland (Office of Tobacco Control, 2007).

In March 1995, an amendment to the previous 1976 Tobacco Act took effect in Finland. The 1995 Act prohibited smoking in all workplaces; however, the employer could implement it by means of a total prohibition or by allowing designated smoking rooms with separate ventilation systems and lower air pressure. The 1976 law prohibited smoking in most public places, along with a number of other tobacco control measures.

Studies to evaluate the short-term (one year) (Heloma *et al.*, 2001) and long-term (three years) (Heloma & Jaakkola, 2003) impact of the new law implemented in 1995 were conducted among representative samples of the working population in the Helsinki Metropolitan area. Repeated independent cross-sectional surveys were conducted among employees in a sample of nine medium-sized and large workplaces (eight participating in the three surveys), including 880 workers at baseline before the law in 1994-95, 940 workers in 1995-96 one year after the law, and 659 workers three years after the law. Information on smoking status, including mean CPD and whether smokers smoked at work were collected using a self-administered questionnaire. The main results indicate a significant trend for a reduction in smoking prevalence, from 29.8% at baseline to 24.6% and 25.2% at short- and long-term post legislation. However, this reduction was only present among men (33.1% at baseline, 26.9% at one year later, 24.8% at three years, *p for trend* =0.026), but not among women (22.0% at baseline, 18.4% at one year, 26.1% at three years, *p for trend* =0.128). Cigarette consumption

declined from 19 CPD at baseline to 16 CPD at three years after the law (difference not statistically tested). With regard to smoking during work shifts, a substantial reduction was observed; while 83.1% of smokers said they smoked at work before the law, this percentage was reduced to 47.4% and 31.1% at the short- and long-term evaluations (*p for trend* <0.05).

A recent paper provides an overview of evaluations of the implementation of the New Zealand 2003 Smoke-free Environments Amendment Act (SEAA) (Edwards *et al.*, 2008). SEAA introduced a range of tobacco control measures, including smoke-free schools and early childhood centers beginning in January 2004, and it extended smoke-free status to nearly all other indoor workplaces, including bars, casinos, members' clubs, and restaurants in December 2004. As part of the evaluation, the effects on smoking behaviour were mentioned briefly. Based on a series of annual cross-sectional smoking surveys in random samples of the population, the authors stated:

> "Youth smoking rates decreased significantly between 2004 and 2005, but in line with long-term trends with no discernable effect of the SEAA. There was also a small reduction in reported parental smoking in the year 10 survey between 2004 and 2005. The per capita release of tobacco onto the New Zealand market (a marker for overall consumption) was fairly constant from 2003-5, with no evidence of any change in 2005 following implementation of the SEAA."

These comments do not suggest a notable impact of SEAA on smoking behaviour. Other effects reported included reductions in socially-cued smoking in hospitality settings, increased calls to the national quitline, and the dispensing of vouchers for nicotine replacement therapy (NRT) via the quitline service.

Ireland implemented its smoke-free law in March 2004. The Office of Tobacco Control conducts monthly quota telephone surveys of 1000 persons aged 15 years or older. Results are weighted to standard demographics and a 12-month running average is computed to smooth the data (Office of Tobacco Control, 2005). After June 2003, the first month depicted in the smoothed trend plot, smoking prevalence increased to 25.5% in March 2004. It then declined fairly steadily to 23.8% in March 2005, but increased again to 24.5% in April 2006. Between then and July 2007, it remained fairly steady at between 24.5% and 24.8%. Another decline was apparent beginning in August 2007 that brought prevalence down to 24.0% by December 2007, the latest point plotted (Office of Tobacco Control, 2007). Thus, there appeared to be a short-term effect by one year post-law implementation (decline by 6.7%) that was partially reversed by two years. No statistical testing was reported.

Beginning in January 2005, smoking in Italy was prohibited in all indoor public places including cafes, restaurants (except for a few separate and regulated smoking areas), airports, railway stations, and all public and private indoor workplaces. An early evaluation of the Italian anti-smoking law (Galeone *et al.*, 2006) included a short-term trend analysis of indicators of tobacco consumption and sales of nicotine replacement therapies. During the 11 months following implementation of the law (January-November 2005), total sales of cigarettes decreased in Italy by 5.7%, in comparison with the same period in 2004 before the law. Accordingly, the adult per capita sales of cigarettes packs decreased by 6.6% between 2004 and 2006, while declines before 2004 were lower (1.3% between 2002 and 2003, and 2.8% between 2003 and 2004). Finally, total sales of nicotine replacement products was 10.8% higher between January and September 2005 compared to the same period in 2004 before the law took effect.

For the initial evaluation of the impact of the new comprehensive legislation, data were examined from three independent cross-sectional surveys conducted in 2004, 2005, and 2006, and for comparative purposes, earlier data from 1990 and 2001-2003 surveys (Gallus *et al.*, 2007). These surveys were conducted among representative samples of the adult (>15 years) Italian population by means of face-to-face at-home interviews. Data were combined to compute prevalence estimates for the periods 2001-2002 (6534 subjects), 2003-2004 (6585 subjects), and 2005-2006 (6153 subjects). A simple analysis by sex and age showed that smoking declined from 26.2% (30.0% in men and 22.5% in women) in 2004 to 25.6% (29.3% in men and 22.2% in women) in 2005, and to 24.3% (28.6% in men and 20.3% in women) in 2006, with an

acceleration in the decreasing rate from 2004 onward. Using the earlier 1990 data, up until the law came into force in 2004, smoking prevalence declined by 0.40% per year (0.53% in men and 0.25% in women), and thereafter, smoking prevalence declined by 1.08% per year (1.11% in men and 1.03% in women). When three subsequent two-year calendar periods were considered, a significant difference between 2003-04 and 2005-06 was present in men (31.7% versus 29.0%), but not in women (22.5% versus 21.2%), and also in subjects aged <45 years (32.4% versus 30.0%), but not ≥45 years (20.5% versus 20.2%). While no significant differences were found between smoking prevalence in 2001-02 versus 2003-04, mean CPD decreased from 15.4 (16.7 in men and 13.7 in women) in 2004 to 13.9 (15.1 in men and 12.4 in women); however, statistical tests were not reported. It appears that the new law may have led to an acceleration of an existing downward trend, at least for some demographic groups.

Changes in smoking behaviour in programmes where smoking restrictions were only one strategy used to reduce health effects from tobacco use

A number of localities have included restrictions on smoking in public and private places as one component of a multi-component effort to reduce tobacco use. While in some cases the introduction of the laws restricting smoking occurred during a period when other tobacco control strategies were more or less at a relatively steady state, in other cases, implementation of new laws occurred at the same time as other new tobacco control measures, such as cigarette excise tax increases or new anti-tobacco media campaigns. Thus, it is not generally possible to attribute any changes in population smoking behaviour to the new laws restricting smoking. The studies described below also appear in Table 7.1.

Two studies examined the effect of the 1976 Tobacco Control Act in the patterns of ever smoking among Finnish adults by sex and birth cohort (Helakorpi *et al.*, 2004) and by sex, birth cohort and socioeconomic groups (Helakorpi *et al.*, 2008). The 1976 Act prohibited smoking in most public places (including public transport), prohibited the sale of tobacco products to those aged 16 years and younger, required health warnings on tobacco packages, and funded tobacco-related health education and research. The researchers pooled annual nationwide postal cross-sectional surveys (from 1978 to 2001/2002) with random samples of about 5000 subjects, totaling 33 080 men and 34 991 women for analysis. From respondents' smoking histories, they constructed age-cohort ever smoking prevalence rates for men and women. In the first article (Helakorpi *et al.*, 2004) the authors assessed the independent contribution of age, cohort, and the 1976 Tobacco Control Act by means of logistic regression models. A significant decline in the prevalence of ever smokers concurrent with the 1976 Tobacco Act was present in men (OR=0.74; 95% CI=0.68-0.81) for the Tobacco Act term after adjusting for cohort and age profile, indicating reduced ever smoking after compared to before the law was implemented. In women, an interaction term between the Tobacco Act and the cohort trend was included in the model, and a decline in the prevalence of ever smokers concurrent with the Tobacco Act was clear (OR=0.45; 95% CI=0.35-0.57, OR=0.34; 95% CI=0.26-0.45, and OR=0.26; 95% CI=0.19-0.36 for the three birth cohorts studied). These effects were for the entire programme, not just the new smoking restrictions.

In the second paper (Helakorpi *et al.*, 2008) the authors extended the previous analysis by stratifying by socioeconomic status (from Census data) according to a person's life cycle stage (family member, student, pensioner, economically active, etc.), occupational status (self-employed, employee, unpaid family worker), and nature of occupation (upper white collar workers-upper level employees, lower white collar workers-lower level employees, blue collar workers-manual workers, farmers, and entrepreneurs-otherself-employed). In all socioeconomic groups a declining cohort trend was observed among men, with significant reduced odds ratios for the pre-post 1976 Tobacco Control Act effect in all socioeconomic groups (OR=0.52; 95% CI=0.40-0.66 in upper white collar workers, OR=0.55; 95% CI=0.44-0.68 in lower white collar workers, OR=0.76; 95% CI=0.65-0.88 in blue collar workers, and OR=0.66; 95% CI=0.45-0.97 in entrepreneurs), except farmers (OR=0.89; 95% CI=0.60-1.33). In women, however, an increasing trend in prevalence was present in the earliest cohort, but a declining trend was observed thereafter.

From 1985 to 1998, New Zealand undertook an extensive tobacco control programme that included increased, but not total restrictions, on smoking in enclosed public and workplaces, restrictions on tobacco advertising and sponsorships, increased taxation of tobacco products, regulation of nicotine and tar yields in manufactured cigarette brands, stronger warnings on cigarette packaging, school-based education programmes, a prohibition on the sale of tobacco products to those under age 16 years, and public education through both paid advertising campaigns and news items (Laugesen & Swinburn, 2000). However, the paid advertisements were limited because of cost. The campaign effect was evaluated by annual cross-sectional population surveys (1985 through 1995) of 10 000+ persons age 15 years and older, and data were compared to available published data from other Organization for Economic Cooperation and Development (mostly European) countries. Adult smoking prevalence fell from 30% in 1985 to 26% in 1998, and was then the eighth lowest among 21 comparison countries. Youth (15-24 years) prevalence decreased from 35% to 28% over this period. Among the 17 comparison countries with data for this age group, New Zealand ranked third in the rate of decline. The decline was also observed among the Maori population, which was an important programme goal, but, in general, the declines were greater among the higher educated. Between 1975 and 1985 adult per capita tobacco consumption fell 23%, and nearly doubled to a 45% decline from 1985 to 1995. The adult per capita consumption level in 1995 was second lowest behind Sweden among the comparison countries.

In 1986, Singapore introduced a coordinated tobacco control programme that sought to denormalise tobacco use with its theme, "Towards a Nation of Non-Smokers" (Emmanuel *et al.*, 1988). The programme aimed both to prevent youth smoking, encourage smokers to quit, and protect the rights of nonsmokers. Tobacco control measures included restriction of smoking in public and workplaces, restriction of tobacco advertising, increased excise duties on imported cigarettes, and provision of cessation assistance. Educational programmes in schools, clubs, worksites, and within the community also were undertaken. Cross-sectional population-based surveys (1984: n=92 500; 1987: n=78 600) indicated that smoking prevalence (age 15 years and older) fell from 19.0% in 1984 to 13.6% in 1987, or 28% ($p<0.01$). Per capita tobacco consumption also fell 26% over this period from 3.21 Kg/person in 1984 to 2.38 Kg/person in 1987. Youth (15 to 19 years) smoking prevalence fell from 5.1% to 2.9% over this period. No statistical tests were reported for youth prevalence or per capita consumption. Declines in prevalence were observed for all age groups, genders, and ethnic groups. Smoking prevalence had already been declining in Singapore prior to this tobacco control effort; the rate of decline increased during the campaign.

Repeated cross-sectional surveys and trends in per capita cigarette sales in California, and the rest of the USA, were used to evaluate California's Tobacco Control Programme (Pierce *et al.*, 1998b; Gilpin *et al.*, 2001). Both smoking prevalence (standardised to account for changes in the population composition) and per capita cigarette consumption declined faster in California compared to the rest of the USA following programme implementation, which included a new excise tax ($0.25/pack), a media campaign, and funding for local level (county) efforts to reduce smoking. Pre-programme (1983-1988), the annual rate of decline in per capita consumption was 0.46/packs in California, and 0.35 in the rest of the USA. In the early period (1990-1993) these rates were significantly different at 0.58 versus 0.40/packs/year. The decline appeared to halt from 1994 to 1998 when funding for the media and local efforts was substantially reduced. Then in 1995, California implemented its smoke-free workplace policy (that exempted bars and clubs until January, 1998), and lawsuits initiated and won by non-profit organisations (e.g. American Heart Association, American Cancer Society, American Lung Association) against the state restored programme funding in late 1996. From 1998 to 1999, per capita cigarette consumption resumed its decline at 1.56 packs/year, significantly different from the 0.78 packs/year decline in the rest of the USA. Annual pre-programme prevalence declines were nearly the same for California and the rest of the USA (0.77% and 0.78%, respectively). From 1989 to 1993, prevalence declined significantly faster in California than in the rest of USA (by 1.01% and 0.51% annually, respectively). However, thereafter

the annual rates of decline did not differ significantly. Nevertheless, compared to pre-programme levels, prevalence by 1993 declined by 24% in California compared to 17% in the rest of the USA. It cannot be determined whether the new smoke-free workplace law, or other factors such as the restoration of programme funding, was responsible for the new downturn in cigarette consumption. However, if smoking restrictions tend to decrease consumption more than they do prevalence, the results described above are consistent with that hypothesis.

Massachusetts implemented its own tobacco control programme in 1994, using funds from a new $0.25/pack cigarette tax. The Massachusetts programme was media led, but included efforts to prevent youth initiation and promote adult smoking cessation. A statewide law prohibiting smoking in indoor workplaces was not implemented until July 2004. However, there was an increase in the number of local laws restricting smoking in public places from programme inception through passage of the state law. Analyses of per capita cigarette consumption from tobacco sales data showed downward trends in Massachusetts (3-4%/year) and the rest of the USA, omitting California (4%/year) (Biener *et al*., 2000). In 1993, the decline was 12% in Massachusetts compared to 4% in the comparison states. Thereafter (to 1999), the decline was 4% in Massachusetts compared to 1% in the comparison states. Repeated cross-sectional surveys indicated that smoking prevalence declined in Massachusetts from 24% in 1989 to 19% in 1999, with a significant decline of 0.43%/year (95% CI=-0.66, -0.21%/year) with no significant downward slope in the comparison states.

Between 2002 and 2003, New York City undertook a number of tobacco control activities: a large increase ($1.42/pack) in the excise tax on cigarettes; implementation of a new law that restricted smoking in all indoor workplaces, including restaurants and bars; an emphasis on the treatment of nicotine dependence; and a complementary media campaign that focused heavily on the health risks of SHS and the health benefits of smoking cessation. Using repeated cross-sectional surveys, the impact of these measures on smoking prevalence was evaluated (Frieden *et al*., 2005). After nearly a decade of stable adult smoking prevalence, between 2002 and 2003 (pre- to post-programme implementation), prevalence dropped from 21.6% to 19.2%, or by 11%. A subsequent analysis of later survey data (Centers for Disease Control and Prevention, 2007c) showed a further decline in prevalence to 18.9% in 2005 and to 17.5% in 2006. Another study conducted in New York City monitored sales of nicotine replacement products (gum and patches) weekly from July 2001 to February 2004 (Metzger *et al*., 2005). Trend analyses indicated a significant increase in sales of these products during the weeks of the cigarette tax increase and of the smoke-free workplace law implementation. These immediate increases tended to taper off in the following weeks, but the increases were larger and remained higher longer for higher-resource areas of the city.

Several other US states (e.g. Oregon and Arizona) have implemented comprehensive tobacco control programmes that included laws restricting smoking, and again significant declines in smoking behaviour were observed pre- to post-programme implementation (Center of Disease Control and Prevention, 1999; Porter *et al*., 2001).

Incidence of smoking cessation in countries with tobacco control measures including smoking restrictions

Two studies (Table 7.1), one in the USA (Gilpin & Pierce, 2002a) and the other in Spain (Schiaffino *et al*., 2007), analysed time trends in the incidence of successful quitting (i.e. the ratio of those newly successfully quit each year to those eligible to quit at the beginning of the year). This approach, using incidence quit rates for short periods (annual or bi-annual), allows rapid shifts in successful cessation to be identified in population subgroups (by sex, age, race, and educational level) potentially resulting from varied intervention strategies.

In the USA, annual cessation incidence rates were computed from 1950 to 1990 using pooled data from seven National Health Interview Surveys conducted between 1965 and 1992 (Gilpin & Pierce, 2002a). The age when regular smoking began and when cessation occurred, together with the survey year, allowed the year of these events to be determined. Each survey considered between 10 000 and 80 000 respondents; 140 199 ever smokers aged 20-50 years old were included in the analyses. Overall, incidence increased from

<1% in 1950 to 5% in 1990. Gender differences were seen following the beginning of public health campaigns of the mid 1960s (e.g. emphasising the dangers of smoking to the fetus). Younger adult smokers appeared to show increased quitting in the 1970s, around the beginning of the nonsmokers' rights movement in the USA, where proponents lobbied for smoke-free public and workplaces with local success in many cases. The pattern of quitting in middle-aged African Americans was similar to whites, although at reduced levels. Cessation incidence rates were higher among more educated subjects, regardless of age, during the 1970s and 1980s.

In Spain, biannual quitting incidence rates were computed from 1965 to 2000 according to sex, age, and educational level, using pooled data from five National Health Interview Surveys conducted between 1993 and 2003 (Schiaffino *et al.*, 2007). Altogether the analyses included 33 532 ever smokers aged >20 years with complete information on smoking history and educational level. The incidence of quitting smoking, for those age 20 to 50 years, increased from 0.5% in 1965-1966 to 4.9% in 1999-2000 in men, and from 1.1% in 1965-1966 to 5.0% in 1999-2000 in women. For those aged >50 years, larger increases in the incidence of quitting were observed (from 0.4% to 8.7% in men and from 7.9% to 8.8% in women). Educational disparities were present: by the last decade, a levelling off of cessation rates was apparent in both men and women aged 20 to 50 years with lower educational levels, while cessation rates among those with higher educational attainment continued to increase. No clear changes in cessation incidence rates were observed surrounding the tobacco control laws passed between 1978 and 1997. However, none of these laws included prohibition of smoking in enclosed public or workplaces.

In both studies above (Gilpin & Pierce, 2002a; Schiaffino *et al.*, 2007), no direct analysis of the effect of public health campaigns, comprehensive programmes or mandated smoking restrictions were included in any statistical models.

Report/perceptions about changes in smoking behaviour due to law

Two studies (Table 7.1) asked smokers how new laws affected their smoking behaviour (Hammond *et al.*, 2004; Fong *et al.*, 2006). Researchers contacted 191 former smokers in southwestern Ontario, Canada in October 2001 and compared former smokers who had quit before the new law (restricting smoking and requiring warning labels on cigarette packages) to those who had quit following the new law, which was implemented January 2001 (Hammond *et al.*, 2004). From logistic regression analyses, that adjusted for age, sex, CPD prior to quitting, and number of years smoked, those who quit following the new law were 3.06 (95% CI=1.02-9.19) times more likely to cite the law as a motivation for quitting than those who quit earlier, and were 2.78 (95% CI=1.20-5.94) times more likely to cite the warning labels as a motivation.

The self-reported behavioural changes among Irish smokers were investigated (Fong *et al.*, 2006). A representative sample of the adult (≥18 years) smoking population was identified in Ireland (n=1679) before the comprehensive law restricting smoking became effective (December 2003-January 2004); subjects (n=769) were re-contacted from December 2004 to January 2005 after the law was implemented in March 2004. Relevant questions asked of Irish smokers at follow-up (n=640) included whether the law had made them more likely to quit smoking (46% (95% CI=41-50%)), or made them cut down on the number of cigarettes they smoke (60% (95% CI=55-64%)). Former smokers were asked whether the law made them more likely to quit (80% (95% CI=71-88%)), and helped them stay quit (88% (95% CI=81-95%)). Numbers in parentheses are percentages of the relevant subgroup and 95% confidence intervals.

These two studies indicate that smokers notice new laws and perceive that they motivate them to change their smoking behaviour. However, these studies are not direct measures of current population smoking behaviour before and after the law took effect, and possibly overstate the affect of the new laws on smoking behaviour.

Summary

The studies that assessed smoking behaviour before and after the implementation of a new law restricting smoking can at least identify that any change in smoking behaviour observed occurred following implementation of the law. Multiple surveys before the law can establish that the changes observed

following the law were not just a continuation of an ongoing secular trend. However, if other interventions occurred simultaneously with the introduction of the new law, any changes cannot be definitely attributed to it. The results from two cross-sectional studies concerning changes in smoking behaviour pre- to post- new laws failed to find a significant decline in smoking prevalence early after the law took effect. However, these studies were designed to assess changes in exposure to SHS and may not have been appropriately powered to detect differences in smoking prevalence. The study using a longitudinal sample of hospitality workers did find an early and significant decrease in smoking prevalence and cigarette consumption.

Results from the five studies with multiple pre- and/or post-law surveys were mixed. Of the four that reported changes in adult smoking prevalence, two found a significant overall difference and one study did not provide a statistical test. Two of these studies examined prevalence changes by sex and found greater changes in men than in women, and one also showed greater changes in younger compared to older smokers. While changes in consumption were examined in four studies, no significant change was reported in one study, and the declines were not tested in the others, although they appeared to be meaningful. One study reported a decline in youth prevalence, but indicated that the decline was not different from the secular trend. Increases in nicotine replacement sales were noted in two studies, but again no statistical test was performed.

However, in locations with multiple tobacco control efforts that included smoking restrictions, significant declines in prevalence and consumption for both the short- and long-term were consistently observed following programme implementation compared to earlier. Two studies also reported declines in youth smoking prevalence, but no statistical tests were performed. Sales of nicotine replacement products increased significantly in the one study that reported this outcome.

Correlative studies

A number of articles were identified that related the strength and extent of local laws regarding smoking in public places to the smoking behaviour of adults or youth. About half of these articles are econometric analyses, and several of these studies published in 1990 or later utilised data collected in the USA earlier than 1990 (Wasserman *et al.*, 1991; Chaloupka, 1992; Chaloupka & Saffer, 1992). In the 1970s, 1980s, and into the 1990s, laws governing smoking in public places in the USA were not widespread and tended to be weak compared to present day standards. Typically they covered specific public places such as buses or trains, elevators, health care facilities, student smoking in schools, government workplaces, restaurants, or private workplaces. Also, restrictions generally did not imply a total prohibition. For instance, restrictions in restaurants might dictate separate sections for smokers and nonsmokers, but without separate ventilation.

The econometric studies employed specialised multivariate regression techniques and generally considered many different model formulations that omitted or included certain sets of variables. These studies were mainly concerned with estimating the price-elasticity of demand for cigarettes; the percent decrease in cigarette consumption that would result from a 10% increase in cigarette prices. However, these studies also included variables for the strength or extent of laws restricting smoking, and some also included other tobacco-control-related factors. The econometric studies generally report regression coefficients together with t-statistics and their corresponding p-values at the <0.10, <0.05, or <0.01 levels of statistical significance. All dollar ($) amounts included in the models were adjusted for inflation.

Other studies relating the extent and strength of clean air laws to smoking behaviour tended to use standard logistic regression analyses (categorical outcomes such as smoking status) or multiple linear regression (continuous variables such as daily cigarette consumption) and considered fewer model formulations. In the subsections below and in Appendices 3 and 4, the word “analysis” is used in a very general sense, and only if the study used a different (usually simpler) method than outlined above is a description provided. The studies reviewed below are presented under two headings, econometric and other studies, in roughly chronological order of data collection. Most of the studies controlled for demographic factors and other types of policies,

such as taxation, that might affect smoking behaviour.

Econometric studies

Table 7.2 summarises the results of the econometric studies reviewed which are described in detail in Appendix 3. These studies, all from the USA, matched data on smoking restrictions at the local level to survey data that included information about where the respondent resided. These studies employed a number of strategies to capture the scope and strength of local ordinances restricting smoking in public and workplaces. In some studies, a set of indicator variables was included, one for each possible venue such as private worksites, restaurants, government worksites, healthcare facilities, grocery stores, schools, and other public places. Some used multilevel indicators for strength of the ordinance in each venue considered. In other cases, the set of indicator variables was reduced to three or four (e.g. workplaces, restaurants, other places). Other studies constructed an ordered categorical variable where the highest level was reserved for workplaces, the next highest for localities with no workplace restrictions but many restrictions in other public places, the next lower level for those with no workplace restrictions and only a few restrictions in other public places, and the lowest level for localities with no restrictions at all on smoking. Still others analysed a 'continuous' index to capture both the scope and strength of the local laws.

The indicator variables tended to be correlated with one another; for example, localities with workplace restrictions tended to have smoking restrictions in other venues as well. Thus, an ordered categorical or index variable probably gives a better representation of both law scope and/or strength. However, the quality of these index schemes for grading local ordinances might depend on the decision rules used for scoring the individual local laws.

The summary (Table 7.2) shows that all of the studies found at least some relationship between the variables for smoking restrictions and the smoking behaviour considered. When a set of variable was used, it may have only been for one or two of them that were significantly related (see Appendix 3). Most of the studies evaluated some measure of cigarette consumption and seven of eight found some association of smoking restrictions with this outcome. Only one study examined smoking cessation (Tauras & Chaloupka, 1999b), and it only found an effect for females working in workplaces with smoking restrictions. All but one of the six studies that examined smoking prevalence concerned youth. While all of the youth studies found an association, the one adult-only study did not.

Data were examined on self-reported smoking status and cigarette consumption among current smokers from the National Health Interview Surveys (NHIS) of 1970, 1974, 1976, 1979,1980, 1983, and 1985 for adults (n=207 647), and from the National Health and Nutrition Examination Survey (NHANES) II conduced from 1976 to 1980 for adolescents (n=1960) (Wasserman *et al*., 1991). Information on smoking restrictions was merged into the survey datasets by location and was formulated as an index: 1=restricted smoking in private workplaces; 0.75=restricted smoking in restaurants, but not private worksites; 0.50=restrictions in at least four public places, other than private workplaces or restaurants; 0.25=restrictions in one to three of these public places; 0=no restrictions. The adult regression model included year, log cigarette price by year, income by year, family size, log family size, education, and education by year, sex, age, birth cohort, sex by age, birth cohort by age, non-white race/ethnicity, and marital status, as well as the regulation index, which was significantly ($p<0.05$) related to lower reported cigarette consumption among current smokers, but not to being a current smoker. The teen model included year, log cigarette price by year, family size, log family size, family income, household head education level, sex, age, non-white race/ethnicity, and a variable about restrictions on sales of cigarettes to minors, as well as the regulation index. In this analysis, the index was significantly ($p<0.01$) related to being a current smoker but not to cigarette consumption.

The effect of regulations regarding smoking in public places on average self-reported cigarette consumption for adult males and females, separately, using NHANES II data collected from 1976 to 1980, was studied (Chaloupka, 1992). In this analysis the smoking restrictions were coded separately (binary variables) as nominal (restrictions in one to three public places not including restaurants or private workplaces), basic (restrictions in four or more

Table 7.2 Summary of econometric studies relating scope and strength of smoking restrictions to smoking behaviour

Reference	Population	Type of ordinance variable	Outcomes			
			Prevalence	Consumption	Cessation	Other
Wasserman *et al.*, 1991	Adults	Ordered categorical	NS	SIG		
Wasserman *et al.*, 1991	Youth	Ordered categorical	SIG	NS		
Chaloupka,1992	Total*	Four indicator variables		SIG		
Chaloupka & Saffer, 1992	Total*	Two indicator variables		SIG		
Keeler *et al.*, 1993	Adults	Index		SIG		
Chaloupka & Grossman, 1996	Youth	Five multi-level variables	SIG	SIG		
Chaloupka & Wechsler, 1997	College students	Three binary Ordered categorical	SIG NS	SIG NS		
Lewit *et al.*, 1997	Youth	Index	SIG			NS-intent to smoke among nonsmokers
Tauras & Chaloupka, 1999a	Youth	Ordered categorical	SIG	SIG		
Tauras & Chaloupka, 1999b	Young Adults	Three binary Ordered categorical			NS-quit at follow-up NS-males; SIG-females	
Tauras, 2005	Youth	Five indicator variables				NS-transition from non-daily to daily smoking SIG-transition from light to heavy daily smoking NS-transition from mode-rate to heavy daily smoking

*Total = when per capita consumption is analysed, it is for the entire population

SIG = significant difference in smoking behaviour indicated between workers with and without workplaces smoking restrictions. All significant differences were in the direction of reduced smoking (i.e. less consumption, more quitting) in workplaces with restrictions. NS = no significant difference. No entry means that the outcome was not considered.

public places not including restaurants or private workplaces), moderate (restrictions in restaurants but not private workplaces), or extensive (restrictions in private workplaces). Variables for current, past, and next year cigarette prices, and past and next year consumption were also included in the regression analysis. Whether or not all respondents or just ever smokers (zero cigarettes per day) were analysed, the variable for basic regulations was significantly related to reduced consumption overall ($p<0.01$). When male and female ever smokers were analysed separately, the basic restrictions variable was only significant for males. The authors concluded that stronger than basic restrictions are unlikely to impede smoking further.

Data were analysed from 1970 to 1985 on a state level (50 US states as data points) basis (Chaloupka & Saffer, 1992). They were gathered from various sources and included cigarette prices, tobacco production, three variables related to export and import of cigarettes (smuggling), income, percent of the population who were Mormons or Southern Baptists, the percentage of the population who voted, the percent divorced, and the percent unemployed. The dependent variable in the regression analysis was cigarette sales per capita, and restrictions were handled as two separate binary variables. One variable was coded one if the state restricted smoking in at least four public places (including restaurants but not private workplaces) and zero otherwise, and the other was coded one if smoking was restricted in private workplaces and zero otherwise. Both restriction variables were significantly ($p<0.01$) related to lower per capita cigarette sales. Another analysis involved simultaneous equations with sales as the dependent variable in one equation, and each restriction variable as the dependent variable in the other two equations. All other variables including sales or restrictions, as appropriate, were included as independent variables. These simultaneous equations also adjusted for the other factors mentioned above. Public place laws were significantly ($p<0.01$) related to reduced sales, while higher cigarette prices were related to private place laws. The authors concluded that laws restricting smoking are more likely to be passed in states with higher cigarette prices, and that passing more smoking restrictions may not decrease cigarette sales.

Another time series analysis examined monthly per capita cigarette consumption in California from 1980 to 1990 (Keeler *et al.*, 1993). This study used a regulation index that accounted for the percent of the state's population affected by smoking restrictions and the strength of the restrictions for the population covered. The index was computed on a monthly basis from data in an NHIS report and from a telephone survey of local health departments. The regression models included the average of Arizona and Oregon taxes divided by the California tax, federal tax, per capita income, cigarette price, state tax, and a time trend. The results, without the time trend included, showed a strong effect for the regulation index on lower per capita consumption ($p<0.001$). However, when the time trend was included in the model, the regulation index was no longer significant, and other terms in the model (e.g. cigarette tax) also became less significant. Most of the tax increase occurred in 1989, following Proposition 99. However, models based on the period up to two months before the new tax produced very similar results. The authors suggest that while including a time trend to account for secular changes in smoking behaviour is standard, its effect is questionable. The time trend appears to capture the long-term effects inherent in regulation, price, and other factors.

The relation of young adult smoking behaviour to cigarette prices and clean indoor air laws was the subject of several analyses, which involved longitudinal samples of high school seniors followed periodically as part of the Monitoring the Future project (Tauras & Chaloupka, 1999a,b; Tauras 2005). The data analysed were collected from 1976 to 1993. All of these studies considered venues possibly subject to smoking restrictions: private worksites, restaurants, government worksites, healthcare facilities, grocery stores, and other public places. Each subject was matched to the restriction indicators by locality and time of response to the Monitoring the Future surveys. The studies also included a number of variables from the survey and at the locality level such as age, sex, income, college (attending less than half time, attending half time, attending full time), religiosity, marital status, household composition, region, cigarette prices, etc.

One of the studies (Tauras, 2005) examined transition from non-daily to daily smoking, from light smoking (1-5 CPD) to moderate (6-10 CPD),

or transition from an average of 10 CPD to heavy smoking (20+ CPD). In regression models, the smoking restriction variables (private workplace, restaurants and other public places) were significantly ($p<0.01$) associated with reduced transition from light to moderate smoking, but not to the other transitions examined.

Smoking status and consumption among current smokers was examined in another of the studies (Tauras & Chaloupka, 1999a). Here, the authors formed an index from the individual venue restrictions variables; 0=no restrictions, 1=nominal restrictions (other public places), 2=basic restrictions (health care facilities, grocery stores, government worksites), 3=moderate restrictions (restaurants but not private worksites), and 4=extensive restrictions (private worksites). The index variables were preferred because of multiple collinearities among the separate binary indicator variables. In all the regression models considered, the clean air index variable was significantly ($p<0.01$) related to both less current smoking and reduced daily cigarette consumption. The authors also discussed that many previous researchers may have computed price elasticities of demand for cigarettes that were inflated, because they did not control for clean indoor air laws. There is a correlation between these factors, and variance attributable to the clean indoor air laws was confounded with that for cigarette prices.

The third paper examined smoking cessation among young adults by sex (Tauras & Chaloupka, 1999b). In this study, the clean indoor indicators were used in a different manner: in one model the index was considered; in another analysis three indicators were used (private workplace, restaurants, all other venues); and in the third analysis the index without the workplace indicator was used, along with a second variable computed as the interaction between work status of the respondent and private workplace restrictions. For males, none of the clean indoor air variables significantly predicted cessation in their respective models. For females, the interaction variable was significant ($p<0.01$); indicating that employed females working in worksites where smoking was restricted were more likely to quit.

Another study using a different data source, the 1993 Harvard College Alcohol Study, also examined smoking behaviour among 16 570 college students in 140 four-year colleges in the USA (Chaloupka & Wechsler, 1997). The authors analysed any smoking in the past 30 days, and an ordered variable for amount smoked per day: 0=none, 1=light (1-9 CPD), 2=moderate (10-19 CPD), and 3=heavy (20+ CPD). A set of binary indicator variables for restrictions on smoking in various venues and a composite index were analysed as in the Wasserman *et al.* (1991) study. Other variables analysed included local cigarette prices, age, sex, race/ethnicity, marital status, religiosity, parental education, on-campus residence, fraternity or sorority membership, and employment. Several additional variables characterised the college: co-ed, private, commuter, rural, with a fraternity or sorority, and region. In probit regression models, including only the individual venue binary variables, restrictions in restaurants were fairly consistently ($p<0.10$) related to both less current smoking and lower amount smoked. School smoking restrictions were significant ($p<0.10$) for lower consumption. The index variable was not significant in any of the models analysed. The authors suggested that the restaurant variable might reflect restrictiveness of smoking in general within the communities.

Investigators analysed data on 15 432 ninth graders gathered in 1990 and 1992, as part of the Community Intervention Trial for Smoking Cessation (COMMIT) in 21 communities in the USA and Canada (Lewit *et al.*, 1997). This study included a broad set of variables related to tobacco control policy: price, clean indoor air policy, school smoking policy, school anti-tobacco classes, minimum age of purchase requirements, vending machine restrictions, limits on free cigarette sample distributions, anti-tobacco media exposure, and pro-tobacco media exposure. Analyses also controlled for sex, age, race/ethnicity, whether the community was part of the COMMIT intervention, and year. The clean indoor air variable was a composite score of three separate indices related to workplaces, restaurants, and other public places, with the individual indices capturing both the relative frequency of venue type, the extent (number of public places), and the restrictiveness (allowed or prohibited areas) of the laws in each community. The composite index ranged from 2 to 46, with a mean of 28.8 and standard deviation (SD) of 10.6. The

dependent variables analysed were any smoking in the past 30 days, and among nonsmokers, in the past 30 days their intention to smoke in the future. In the multiple logistic models including all the variables, the school smoking policy variable ($p<0.10$), but not the clean indoor air policy variable showed some relation to lower current smoking; however, neither the school nor the clean indoor policy variables appeared related to intention to smoke. Minimum age of purchase and cigarette prices were related to reduced smoking, while pro-tobacco media and paradoxically anti-tobacco media were related to increased smoking.

Eight, tenth and twelfth graders (n=110 717), from Monitoring the Future surveys conducted in 1992, 1993, and 1994, were the subject of another study (Chaloupka & Grossman, 1996). The authors analysed any smoking in the past 30 days, and a self-reported measure of daily cigarette consumption. A set of five variables captured the fraction of the population in each adolescent's place of residence subject to restrictions on smoking in private workplaces, restaurants, retail stores, schools, or other public places. Other locality variables analysed included a set related to cigarette prices, a set related to restrictions on youth purchase of cigarettes, whether a portion of cigarette tax revenue is devoted to tobacco control activities, and whether a locality has any laws protecting smokers. Individual level variables included age, sex, weekly income (work and/or allowance), race/ethnicity, marital status of youth, parental education, family structure, work status of mother, whether youth had siblings, average hours of work weekly, rural residence, and religiosity. When each restriction variable was analysed separately along with all the other variables listed above, limitations on smoking in private workplaces, restaurants, and retail stores were negatively associated with lower current smoking ($p<0.01$). Restrictions in private workplaces and restaurants were also related to reduced cigarette consumption ($p<0.01$). However, when all five of the restriction variables were included together, only restrictions in workplaces ($p<0.05$) was significantly related to lower current smoking, but restaurant restrictions, school smoking restrictions, and other public place restrictions were still related to reduced consumption ($p<0.01$).

Other studies

A number of other studies have also investigated the relationship between smoking restrictions and smoking behaviour. These studies differ from the econometric data in that they generally involved more recent data and used somewhat different analytical approaches. These studies are summarised in Table 7.3 and described in detail below and in Appendix 4. As for the econometric studies, data on laws and individuals were matched by locality and most studies used an index of some sort to rate the scope and strength of the local laws restricting smoking. All four of the studies that examined smoking prevalence found a significant effect, as did the three studies that studied consumption. The studies that looked at cessation were mixed. Three studies examined transitions in the smoking uptake process, and at least for some transitions, each study found a significant effect.

Aggregate state level adult smoking prevalence and quit ratio estimates from the 1989 Current Population Survey and Tobacco Institute tax reporting sales data (to estimate per capita cigarette consumption), were linked to cigarette prices and strength of clean indoor air legislation (Emont *et al.*, 1993). Fifty one data points were analysed; the 50 US states and the District of Columbia. State clean air laws were classified as in Chaloupka (1992). The hypotheses of lower adult smoking prevalence, higher quit ratio, and lower per capita cigarette consumption were tested using a Jonckhere test for ordered data; in this case, the increasing restrictiveness of the clean air laws. This bivariate test was significant for prevalence ($p<0.001$), for per capita consumption ($p<0.005$), and for the quit ratio ($p<0.00005$). Mean prevalence ranged from 28% for the states with no restrictions to 24.5% for those with extensive restrictions. Analogous ranges for per capita consumption and the quit ratios were 118.6 packs/person/year to 105.3/ packs/person/year, and 43.5% to 49.6%. The bivariate Pearsons's correlations of cigarette prices to the three outcome variables were also significant ($p<0.001$). No state or individual level control variables were included in this study.

In contrast, data were compiled for a multitude of variables on all 50 US states and the District of Columbia covering the period from 1970 to 1995 (Yurekli & Zhang, 2000).

Table 7.3 Summary of other studies relating scope and strength of smoking restrictions to smoking behaviour

Reference	Type of variable	Outcomes				
		Prevalence	Consumption	Cessation	Initiation	Other
Emont *et al.*, 1993	Four indicator variables as for Chaloupka (1992)	SIG	SIG	SIG-quit ratio		
Yurekli & Zhang, 2000	Index		SIG			
Moskowitz *et al.*, 2000	Ordered categorical			SIG-recent cessation		SIG-report of workplace policy
Wakefield *et al.*, 2000a	Index	SIG			SIG-transitions on uptake continuum	
Stephens *et al.*, 2001	Index	SIG-males and females	SIG-females not males			
Viehbeck & McDonald, 2004	Index			NS		
McMullen *et al.*, 2005	Index	SIG-youth NS-adults				
Siegel *et al.*, 2005	Ordered categorical				SIG-becoming an established smoker	
Albers *et al.*, 2007	Ordered categorical			SIG-attempt NS-quit at follow-up		
Siegel *et al.*, 2008	Ordered categorical				SIG-transition from experimentation to established	

SIG = significant difference in smoking behaviour indicated between workers with and without workplaces smoking restrictions. All significant differences were in the direction of reduced smoking (i.e. less consumption, more quitting) in workplaces with restrictions. NS = no significant difference. No entry means that the outcome was not considered.

The main purpose of this study was to gauge the impact of cigarette smuggling on excise tax revenue. However, also included in the analyses of per capita cigarette consumption was a variable for clean indoor air laws. A state level index was constructed that considered both the time people spent in venues subject to regulations and the strength of such regulations. The value of the variable changed over time in states as they adopted broader or strict regulations. Other variables compiled and analysed included per capita disposable income, price of cigarettes, cigarette tax, percent of the state population with at least a bachelor's degree, percent of the state that is Native American, African-America, Asian, of Mormon religion and unemployed, per capita expenditures on tourism, and a set of variables related to smuggling. They constructed a number of linear regression models including and omitting various sets of variables, but the variable for the clean indoor air laws was included in all the models and significant ($p<0.05$) in them all for reduced per capita consumption. From the final model, the researchers estimated that without such laws, total demand for cigarettes would have been 4.5% greater in 1995.

A study in California related the strength of community ordinances regulating smoking in the workplace to both report of a workplace smoking restriction and recent smoking cessation (Moskowitz *et al.*, 2000). Data from 4680 employed current and recent former smokers from the 1990 California Tobacco Survey were linked by workplace zip code (postal code) to a database with rankings of the strength of local ordinances (none, weak, moderate, strong). In a multivariate analysis adjusting for age, sex, race/ethnicity, education, type of work area, and workplace size, those working in a community with a strong ordinance were 1.61 (95% CI=1.20-2.15) times more likely to report that their workplace had a smoking policy than those in communities with no ordinance. Even those working in communities with moderate ordinances tended to be more likely to report a workplace policy. Further, a strong ordinance was associated with cessation in the past six months; the adjusted odds ratio was 1.52 (95% CI=1.14-1.71) compared to those working in a community with no ordinance. Moderate or weak ordinances had smaller odds ratios with lower 95% confidence intervals of about 0.95-2.00.

Researchers appended data on cigarette prices and price increases, and the percentage of provincial populations covered by no-smoking bylaws to data records from a nationwide survey of 11 652 Canadians conducted in 1991 (Stephens *et al.*, 1997). In a logistic regression of current smoker (coded 0) versus nonsmoker (coded 1) that adjusted for demographics (age, sex, marital status, and education) and the price variables along with significant interactions, the odds ratio of being a nonsmoker for the no-smoking bylaw variable was 1.21 (95% CI=1.08-1.36); for price it was 1.26 (95% CI=1.11-1.43), but changes in price were not significant. The authors repeated their analyses with data from the 1990 survey and attained essentially the same results.

Another analysis was conducted by the same group using data from another population survey conducted in 1995 and 1996 (Stephens *et al.* 2001). Data from 14 355 persons aged 25 years and older were analysed. This time they used a somewhat broader set of policy variables, analysed men and women separately, and constructed models for smoking status and for reported daily cigarette consumption by current smokers. The policy variables included were a dummy for a tax cut enacted in some localities (for analysis of consumption), current cigarette prices, expenditures for tobacco control in the previous year, a rating of strength of municipal no-smoking bylaws, signage requirements (no smoking signs), and strength of provisions for enforcement. The bylaw strength, enforcement and signage requirements were scored separately for 12 venues and the results summed. Strength codes were: 0=no limits on smoking, 1=designated smoking areas required or allowed, and 3=area smoke-free. Signage received a point for using both words and symbols and a point for requirements at doorways and entrances. Points for enforcement were given as 1 for specifying a designated enforcement official and 1 for fines that escalate with repeated offences. For both men and women in a logistic regression, cigarette price was positively related to being a nonsmoker (men OR=1.02; 95% CI=1.00-1.03; women OR=1.01; 95% CI=1.00-1.02). For women, the variable for the clean air bylaw was also significant, 1.02 (95% CI=1.00-1.04). For men, the clean indoor air variable was not significant, but the provisions for signage (OR=1.25; 95% CI=1.01-1.55) and enforcement (OR=1.21; 95% CI=1.00-1.46) were.

The public education expenditure variable was also significant for men. In a multiple linear regression analysis of daily cigarette consumption, the tax cut indicator, but not current cigarette prices, was significant for both men ($p<0.01$) and women ($p<0.05$), although an interaction term for these two variables was significant ($p<0.001$ for men and $p<0.07$ for women). Those subject to the tax cut smoked more. Again, the clean air bylaw variable was significant for women ($p<0.05$) but not for men, with women who were subject to these laws smoking less.

A Canadian study, using data from 2001, failed to demonstrate a significant association between municipal smoke-free laws and being a former smoker (Viehbeck & McDonald, 2004). In this study, the strength of ordinances regarding smoking in all public places (e.g. bars, restaurants, public auditoriums, etc.) was linked by postal code of residence. Law strength was actually an indication of extensiveness (number of public places covered). Enforcement and signage scoring was also added into the scale and was determined similar to the earlier study (Stephens *et al*., 1997). Communities with strong laws (top tertile of law strength scale) were matched to communities of similar socioeconomic status with weak or no bylaws (bottom tertile). Data from 9249 current and former smokers were analysed in a multivariate logistic regression analysis; the adjusted odds of being a former smoker were 0.95 (95% CI=0.82-1.11) if the communities had strong ordinances versus if they had no or weak ordinances.

A smoking regulation index, based on state laws effective in 1996 from records maintained by the Centers for Disease Control and Prevention, was merged into survey data from 17 287 US high school students in 202 schools by the location of the school (Wakefield *et al*., 2000a). Successive stages of a smoking uptake continuum and any smoking in the past 30 days was looked at. The smoking uptake continuum included stages for non susceptible never smokers (strong intentions not to smoke in the future), susceptible never smokers (weak intentions not to smoke in the future, or had taken a puff on a cigarette), early experimenters (had puffed on a cigarette, but not in the past 30 days and had weak intentions not to smoke in the future, or had smoked a whole cigarette but not in last 30 days and had strong intentions not to smoke in the future), advanced experimenters (had smoked a whole cigarette, but not in the past 30 days and had weak intentions not to smoke in the future, or had smoked in the past 30 days, but not 100 cigarettes in their lifetime), and established smokers (had smoked at least 100 cigarettes in their lifetime irrespective of future intentions). The models included grade, sex, race/ethnicity, adult smokers in the home, sibling smokers, living in a smoke-free home, attending a smoke-free school, and strength of enforcement of such a policy. The regulation index was significantly associated with reduced advanced experimentation versus early experimentation, and with less established smoking versus advanced experimentation. It also was associated with less smoking in the past 30 days. Similar trends were also present in the analysis of the first two and second two stages on the smoking uptake continuum, but they failed to reach statistical significance.

A study of US states examined multiple population surveys conducted between 1996 and 1999, and related adult and youth (12-17 years) smoking prevalence, to an index of the strength of clean indoor air laws in each state (McMullen *et al*., 2005). The index was complex and summed scores for nine venues according to whether the venue was unrestricted to being completely smoke-free (0-4 points). Some categories (e.g. worksites, childcare facilities) could receive a bonus point if the surrounding area was also smoke-free. The maximum score could be 42, and averaged 8.7 in 1993 to 10.98 in 1999. These analyses used multiple linear regression models that adjusted for state poverty rates and cigarette excise taxes. It was found that the index was significantly related to the percentage of indoor workers reporting a smoke-free workplace ($p<0.01$), and to reduced youth ($p<0.01$), but not adult smoking prevalence ($p<0.07$) in linear regression models. Their analysis included 51 data points; one for each US state and the District of Columbia.

Massachusetts investigators used longitudinal population data to examine the association between baseline local laws restricting smoking in restaurants to both adult and youth smoking behaviour (Siegel *et al*., 2005, 2008; Albers *et al*., 2007). At the time of the baseline survey in 2001-2002, such restrictions varied

widely among Massachusetts towns. Data on regulations from 351 cities and towns were categorised as strong (no smoking allowed in restaurants and no variances allowed), medium (smoking restricted to separately ventilated area or variances allowed), and weak (smoking in designated areas without separate ventilation or not restricted). The survey included a cohort of 2623 youth aged 12-17 years, who were not already established smokers at baseline; data from the smoking restrictions were appended to the survey data by zip code (Siegel *el al*., 2005). The main outcome variable was progression to being an established smoker during the two-year follow-up period. An established smoker is defined as someone who has smoked at least 100 cigarettes in his or her lifetime. Using a generalised estimating equations logistic regression model, the researchers controlled for a number of individual and town level characteristics. Individual characteristics included age, sex, race/ethnicity, smoking experience at baseline (non-susceptible never smoker, susceptible never smoker, puffer, experimenter, smoked in last 30 days), having close friends who smoke, exposure to anti-smoking messages at school, having smokers in the household, the education level of the adult informant (gave permission for adolescent to be interviewed), and household income. Besides strength of smoking restrictions in restaurants, town level variables included percentage of residents who are college graduates, percentage of voters voting in favor of a voter initiative to increase cigarette taxes and expand state tobacco control efforts, percentage of residents who are white, percentage of residents who are youth, number of restaurants in town (<5, ≥5), and population size (<20 000, 20 000-50 000, >50 000). After adjusting for all these factors, compared to adolescents living in towns with weak regulations, those living in towns with strong ordinances were 0.39 (95% CI=0.24-0.66) less likely to progress to being an established smoker. A medium strength ordinance was not protective.

Further analyses of a subsequent follow-up of these same adolescents after another two years (n=2217) used the same control variables, and again found the association of strong regulations to impeded progression (OR=0.60; 95% CI=0.42-0.85) to established smoking. It was determined that the transition interrupted was the one from being an experimenter to becoming an established smoker (Siegel *et al*., 2008). Strong, but not weak, regulations were related to reduced transition from experimenting to established smoking (OR=0.53; 95% CI=0.33-0.86), but there was no significant relation regarding the transition from never smoking to any experimentation (OR=1.18; 95% CI=0.94-1.49). The findings suggest that reduced exposure to smokers in communities might reduce adolescents' perceptions of smoking prevalence, and affect their perceptions of the social acceptability of smoking. Both of these factors lead to reduced smoking initiation.

Adult smokers (n=1712) in these same households were also followed-up two years after the baseline survey (Albers *et al*., 2007). They were asked about their perceived social acceptability of smoking in restaurants and bars and quitting behaviour (making a quit attempt or being quit at follow-up). Analyses controlled for age, sex, race/ethnicity, education, household income, marital status, children <18 years in the household, and baseline level of addiction. This time, using hierarchical linear models to adjust for individual and town level characteristics, a strong restaurant regulation was predictive of making a quit attempt (OR=3.12; 95% CI=1.51-6.44), but not of being quit when interviewed again. There was a marginal effect with respect to perceptions about the social acceptability of smoking.

While these three longitudinal studies have the advantage of knowing the status of a community before observing future smoking behaviour, it is likely that the restaurant restriction variable is a proxy for an overall community sentiment unfavorable to smoking. Thus, it may not be just the restrictions themselves that are influencing smoking behaviour, but the norms inherent in these communities.

Summary

While not every correlative study (econometric and others) found an association between the strength and/or extent of laws prohibiting smoking in public places and smoking behaviour, most (17 of 19) of them did, at least in a particular subgroup or for a specific behaviour. The measures of law strength and extent differed among the studies reviewed, as did the smoking behaviours considered. Nevertheless, these studies cannot

determine whether it is localities with strong anti-smoking norms, and thus less smoking, that are more likely to adopt laws restricting smoking, or whether such laws lead to reduced smoking. Even the longitudinal data from Massachusetts cannot definitively attribute the effects noted to the laws, as other normative influences may have been associated with the existence of the laws.

Workplace smoking restrictions

Workplace smoking restrictions might be implemented either to conform with a law mandating them, or because of a policy voluntarily adopted by individual worksites. Most of the studies reviewed later in this section took place during a time when local or state-wide mandated restrictions were not widespread.

Why workplace restrictions might affect smoking behaviour

It would be expected that smokers not being able to smoke whenever they want during the workday would have some affect on their smoking behaviour. At the least, they would have to plan ahead for when they would be able to smoke. They might think about having a last cigarette in their cars or even on their way from the parking lot or transportation center to the workplace before entering. They would also have to leave their work area and make their way to an area where smoking was allowed or go outside to smoke during breaks. A total prohibition on smoking indoors would probably have a greater impact on choice of when and where to smoke, than a lesser restriction that allowed smoking in certain common or designated areas.

With their limited options for smoking, they also might be inclined to smoke fewer cigarettes during the workday. Also, if they do not witness others smoking, they may experience fewer cues to smoke. If they do not compensate by smoking more otherwise, their daily consumption might decline.

Some smokers may quit rather than put up with the inconvenience that smoking restrictions would impose. Further, if consumption is reduced, some smokers might find it easier to eventually successfully quit (Farkas *et al.*, 1996; Pierce *et al.*, 1998c). More subtle factors may also encourage cessation. A smoker might never think about quitting if smoking was considered acceptable everywhere in the workplace. Restrictions communicate the idea that it is not acceptable to smoke in the presence of nonsmokers, and perhaps not at all, which might stimulate thoughts about quitting. Also, the image of addicts huddled outside by the building entrance getting their nicotine fixes might not fit some smokers' self images, leading them to consider quitting. Once quit, the smoker might find it easier to remain abstinent in a smoke-free environment; cues to smoke from smokers smoking would be less (Payne *et al.*, 1996; Shiffman *et al.*, 1996).

Smoking restrictions might also affect the transition from experimental or intermittent smoking to daily smoking among young adults (Hill & Borland, 1991; Pierce *et al.*, 1991; Trotter *et al.*, 2002). There is evidence that some smoking initiation during young adulthood occurs in the workplace (Hill & Borland, 1991). While they are now of legal age to smoke, if smoking was not perceived as a normative behaviour, or no smoking was observed in the workplace or on college campuses, fewer young adult never smokers might initiate, and those who have already initiated and who smoke intermittently might be less likely to transition to daily smoking (Pierce *et al.*, 1991). Also, those already smoking daily may adapt to a lower consumption level (lower tolerance level) if they could not smoke anytime they wished. By providing fewer cues to smoke, smoking restrictions in bars and clubs might also hinder both initiation and transition to heavier levels of smoking (Trotter *et al.*, 2002).

Previous reviews of the effects of workplace restrictions on smoking behaviour

Seven published reviews of the effects of workplace smoking restrictions on smoking behaviour were located (Brownson *et al.*, 1997; Eriksen & Gottlieb, 1998; Chapman *et al.*, 1999; Hopkins *et al.*, 2001; Fichtenberg & Glantz, 2002; Levy & Friend, 2003; Moher *et al.*, 2005). These reviews considered basically two types of studies: analyses of workers employed in specific individual worksites, or analyses of workers from population surveys who were asked about smoking restrictions in their workplaces. Altogether 36 separate studies of the first type were reviewed, only one was considered by all seven previous reviewers, three by six of the reviews, 10 by five, three by four,

four by three, eight by two and eight by only one.

The literature databases searched and study selection criteria varied among the reviews. Sample sizes for the studies reviewed tended to be modest (in general, <300 workers), and most concerned the relatively short-term (<12 months). The most recent data reported in any of these reviewed papers were collected in 1995. For these reasons, rather than re-reviewing all 36 of these relatively old, small studies, the results and conclusions of the reviewers regarding this general type of study are summarised below. Current smoking prevalence and cessation are related outcomes, and some studies examined one but not the other. Cross-sectional evaluations pre- and post- or just post-implementation of restrictions were more common to evaluate prevalence, and longitudinal studies tended to evaluate quitting, but studies based on retrospective recall were inclined to evaluate both.

Nineteen such studies were reviewed and indicated that most (17 of 18 that evaluated this outcome) showed a significant decrease in cigarette consumption following implementation of the smoking restrictions (Brownson *et al.*, 1997). Also, most showed a decline in smoking prevalence or an increase in quitting (17 of 19 that evaluated this outcome); little is known about the longer-term effect. Eriksen & Gottlieb (1998) evaluated 23 studies and their table appeared more complete and comprehensive than any of the other reviews, although the discussion in the text was more limited. Results were similar to the Brownson *et al.* (1997) review; 16 of 17 found reduced consumption after implementation of workplace smoking restrictions, and 9 of 17 found some evidence for reduced prevalence or increased quitting (by 5% or more). Both these reviews endeavored to be as comprehensive as possible, and did not exclude studies based on study design criteria. A number of the studies were single surveys of respondents' perceptions of changes in their behaviour in response to the workplace smoking restrictions.

The review by Chapman *et al.* (1999) considered only studies (n=15) with information on completely smoke-free workplaces. They categorised the studies into three sub-types: prospective cohort studies (n=9), studies with cross-sectional pre- and post-evaluations (n=2), and studies where workers recalled their smoking behaviour before the workplace smoke-free policy took effect, and provided current information after working under the smoke-free policy (n=4). The authors noted that all of these studies showed declines in daily cigarette consumption rates, but fewer than half (5/14) showed declines in smoking prevalence or increases in quitting. Based on these observations, the authors concluded that smoke-free workplace policies reduced smoking. The authors then used six of the nine prospective cohort studies to estimate a mean change in daily cigarette consumption. The other three did not report these data sufficiently for inclusion in the calculation. The result was decrease of 3.5 CPD or a 20.7% decrease in daily cigarette consumption; the percentage decline ranged from 5% to 52.6%. If heavier smokers quit their jobs because of the smoke-free policies and were not surveyed again, this estimate may be high. Not enough data were reported in the nine cohort studies to estimate a mean decline in prevalence.

One review included just eight studies of this type, out of about 50 that they identified, due to stringent inclusion criteria ("least suitable study design" – did not include a control group or a pre-post comparison), but a perusal of the excluded article titles suggested that many did not evaluate smoking behaviour (Hopkins *et al.*, 2001). All eight of the studies reviewed showed a significant decline in cigarette consumption following implementation of restrictions. In the four studies that examined quitting, three showed a significant effect, but in the six studies that examined prevalence, only three detected a significant decline. The reviewers concluded that smoking restrictions appear to reduce cigarette consumption and increase cessation, but the effect on prevalence is less consistent.

Another review considered the same three study subtypes as the Chapman *et al.* (1999) review, and considered eight prospective cohort studies, seven sequential cross-sectional, and six retrospective cross-sectional (Fichtenberg & Glantz, 2002). Two papers included more than one type of study. Of the 14 studies that evaluated consumption, 12 showed a reduction, but only 3 of 16 showed a significant reduction in prevalence. They included all the studies that reported on declines or differences in consumption or prevalence to compute their estimate

of an aggregated decline of 3.1 CPD and of 3.8 percentage points in prevalence with a smoke-free workplace. They concluded that smoke-free workplaces do influence smoking behaviour.

In another review, all of the previous reviews were investigated, but only those studies (n=19) that had been conducted in the USA were selected for summary (Levy & Friend, 2003). The rationale was to minimise possible cultural differences in response to workplace smoking restrictions by focusing on one country. As for the other reviews, they express more confidence in the effect of smoking restrictions on reduced cigarette consumption (12 of 14 studies) than on increased quitting or reduced smoking prevalence (12 of 19). Some interesting points are made about such studies. By comparing results by length of follow-up, it was observed that reductions in quantity smoked appeared greatest relatively early (within 6 months) following implementation of smoking restrictions, while the effects on quit rates were more apparent over the longer-term, either from studies with repeated follow-ups or with follow-ups after one year from imposition of the restrictions. They comment regarding the considerable variation in study results that likely stems from differences in sample size, time of follow-up, type of industry, differences in how behaviour is measured, and differences in extent of restrictions and the presence of other ongoing interventions. In particular, they note that the type of workplace or industry (typically hospitals or government agencies) where the studies were conducted might limit the ability to generalise from the results. Such industries may attract mainly nonsmokers so that restrictions might be more enforceable, and the smokers in these settings might be more susceptible to pressure to change their behaviour.

In the most recent article, multiple strategies for reducing smoking in the workplace were reviewed, including a section on the imposition of smoking restrictions (Moher *et al.*, 2005). The inclusion criteria were more strict than in the other reviews; to be included, the study must have used pre- and post-measures of smoking behaviour (n=14). Two studies included a control group, but in both cases this consisted of only one workplace. Thus, any change over time in the control could either be from a secular trend or to some characteristic of the worksite. Three of the studies reviewed used cross-sectional pre- and post-measures and the others all used a prospective cohort design. Several of the studies also included other strategies for encouraging smokers to quit smoking; some included policies that were less than a completely smoke-free policy regarding smoking indoors. Declines in cigarette consumption during working hours after restrictions were implemented were noted in 9 of 11 of the studies that evaluated this outcome; smaller decreases were seen in overall daily consumption in eight studies, and three studies reported no change or a slight increase in daily consumption. Of the 10 studies that considered prevalence, five showed a decline and five showed no change. One study found higher quit rates during the evaluation period in those working under a smoke-free policy compared to a control group without smoking restrictions. A number of the studies reviewed did not statistically test the changes observed. The authors concluded that the evidence was 'not consistent' for decreased cigarette consumption, and 'conflicting' for decreased prevalence with smoking restrictions.

Both the Chapman *et al.* (1999) and Fichtenberg & Glantz (2002) reviews used their estimates to gauge the economic impact to the tobacco industry of smoking restrictions. Chapman *et al.* (1999) calculated the revenue currently lost to the tobacco industry because of current smoking restrictions and if all workplaces became smoke-free. With the level of implementation of smoke-free policies introduced in Australia in 1995, the retail value lost sales total $90 (95% CI: 77.4, 100.7) millions of which 18.5% represented lossess to the industry. If all workplaces became smoke-free, the annual loss would be $171 (95% CI=147-191) million US$ in the USA and A$274 million in Australia. There would be a reduction in tax revenue as well (Chapman *et al.*, 1999). According to Fichtenberg & Glantz (2002), if all workplaces became smoke-free, per capita consumption would drop by 4.5% in the USA and by 7.6% in the UK. These reductions would cost the tobacco industry $1.7 billion and £310 million annually in lost sales, equivalent to increasing the tax on cigarettes by $1.11 and £4.26 per pack, respectively.

Only the review by Chapman *et al.* (1999) mentioned the possibility that smokers working in smoke-free workplaces may be able to

smoke their cigarettes sufficiently 'harder' so that they can maintain their accustomed nicotine levels by smoking fewer cigarettes. This is often called compensatory smoking (Scherer, 1999). Smoking a cigarette 'harder' can be accomplished by taking more puffs, taking deeper puffs, or smoking more of the cigarette. Several studies evaluated smokers' reported consumption on work days and non-work days with mixed results; a few found an increase in consumption on non-workdays, a few found no change, and a few found a decrease. It is likely that for some smokers, the 3.5 or 3.1 CPD less for workers in smoke-free worksites that was estimated from the Chapman *et al.* (1999) review, and the one by Fichtenberg & Glantz (2002), is within the realm of possible compensatory smoking (smoking 'harder').

Another issue not addressed in any of these reviews was workers leaving a smoke-free workplace to smoke. Such behaviour would both reduce the effect of smoke-free policies on cigarette consumption, and perhaps cost the employer in terms of unauthorised breaks. A survey of smokers working in smoke-free workplaces assessed this behaviour (Borland *et al.*, 1997). Of those who smoked during working hours (88%), consumption averaged 5.4 (SD=4.21) cigarettes during work breaks each day. Overall, 39% of workers said they left workplace premises to smoke. This occurred at least once a day during tea/coffee breaks for 25% of smokers, at lunch for 40% of smokers, and during work time for 13%. Factors related to this behaviour mainly related to level of addiction. The authors concluded that smoke-free workplace policies would be more effective in reducing smoking if "exiled smoking" could be reduced.

Population surveys

All but the review by Moher *et al.* (2005) also included a few studies based on population survey data. Employed respondents were asked about their workplace situation, and those working in a smoke-free environment were compared to those working under partial or no smoking restrictions. Altogether, 11 population studies were reviewed previously (Brenner & Mielck, 1992; Wakefield *et al.*, 1992; Kinne *et al.*, 1993; Woodruff *et al.*, 1993; Patten *et al.*, 1995; Glasglow *et al.*, 1997; Biener & Nyman 1999; Evans *et al.*, 1999; Farkas *et al.*, 1999; Farrelly *et al.*, 1999; Longo *et al.*, 2001). Of these, two were reviewed in four of the previous reviews, two by three, three by two, and four in only one, likely due to later publication date. Other population studies (n=13) have been published subsequently (Pierce *et al.*, 1998c, 2009; Gilpin *et al.*, 2000, 2002a; Bauer *et al.*, 2005; Shields, 2005, 2007; Shavers *et al.*, 2006; Shopland *et al.*, 2006; Morozumi & Ii, 2006; Burns *et al.*, 2007; Lee & Kahende, 2007; Messer *et al.*, 2008).

Table 7.4 briefly summarises the results of all the population studies, which are described in detail in Appendix 5. All but three (Biener & Nyman, 1999; Shields 2005; Messer *et al.*, 2008) of these 24 population studies found a significant association between workplace smoking restrictions and some facet of smoking behaviour. The negative studies only examined cessation. Of the 17 studies that compared cigarette consumption according to the presence or level of smoking restrictions, all but one (Brenner & Mielck, 1992) found significantly lower consumption among smoking workers in workplaces with restrictions. Smoking prevalence in the sample of workers was examined by eight of the studies, and two failed to find a significant association (Patten *et al.*, 1995; Shavers *et al.*, 2006). Making a recent quit attempt was examined in six studies, and three of these failed to find a higher rate among smokers working under restrictions (Bauer *et al.*, 2005; Shavers *et al.*, 2006; Messer *et al.*, 2008). Twelve studies reported on recent quitting (continuous abstinence of varying length when interviewed), and three of these (Biener & Nyman, 1999; Shields *et al.*, 2005; Messer *et al.*, 2008) failed to find significantly higher rates among workers with smoking restrictions. Several studies examined other outcomes: duration of smoking (Burns *et al.*, 2007), progress toward cessation (Pierce *et al.*, 1998c), and intent-to-quit (Woodruff *et al.*, 1993), and found significant pro-health associations of these outcomes with workplace smoking restrictions.

However, cross-sectional population studies cannot determine whether it is the type of workplace or worker characteristics (e.g. employing predominately white or blue collar workers) that are responsible for any observed association, or whether smokers in these environments do indeed alter their smoking behaviour because of the restrictions.

Table 7.4 Summary of results of 24 longitudinal and cross-sectional population studies examining associations between (all) worksite smoking policies and smoking behaviour

Reference	Locale	Occupation analysed	Outcome				
			Cigarette consumption	Smoking prevalence	Quit attempt	Cessation	Other
Longitudinal studies							
Patten *et al.*, 1995	California, USA		SIG	NS			
Glasglow *et al.*, 1997	USA		SIG		SIG	SIG	
Pierce *et al.*, 1998a	California, USA						SIG-progress toward cessation
Biener & Nyman, 1999	Massachusetts, USA					NS	
Longo *et. al.*, 2001	USA	yes				SIG	
Bauer *et al.*, 2005	USA and Canada	yes	SIG		NS	SIG	
Shields *et al.*, 2005	Canada					NS	
Shields *et al.*, 2007	Canada	yes	SIG			SIG	
Cross-sectional studies							
Brenner & Mielck, 1992	Germany		NS		SIG	SIG	
Wakefield *et al.*, 1992	Australia	yes	SIG				
Kinne *et al.*, 1993	Washington, USA	yes	SIG-males only	SIG			
Woodruff *et al.*, 1993	California, USA		SIG	NS			SIG-intent to quit
Farkas *et al.*,1996, 1999	California, USA	yes	SIG		SIG	SIG	
Farrelly *et al.*, 1999	USA	yes	SIG	SIG			
Evans *et al.*, 1999	USA	yes	SIG	SIG			
Gilpin *et al.*, 2000	California, USA		SIG	SIG			
Gilpin & Pierce, 2002b	California, USA		SIG				
Shavers *et al.*, 2006	USA	yes	SIG	NS	NS		
Shopland *et al.*, 2006	USA	yes	SIG			SIG	
Morozumi *et al.*, 2006	Japan		SIG	SIG		SIG	
Lee *et al.*, 2007	USA					SIG	
Burns *et al.*, 2007	Colorado, USA						SIG-smoking duration
Messer *et al.*, 2008a	USA				NS	NS	
Pierce *et al.*, 2009	USA		SIG				

SIG = significant difference in smoking behaviour indicated between workers with and without workplaces smoking restrictions. All significant differences were in the direction of reduced smoking (i.e. less consumption, more quitting) in workplaces with restrictions. NS = no significant difference. No entry means that the outcome was not considered.

More educated individuals generally smoke less and are more inclined to quit than those less educated (Pierce *et al.*, 1989; Escobedo & Peddicord, 1996; Centers for Disease Control and Prevention, 1999; Gilpin & Pierce, 2002b; Schulze & Mons, 2005; Federico *et al.*, 2007); thus, technical and professional businesses would be expected to employ more nonsmokers, and the smokers they do employ might smoke less and be more motivated to quit than would workers employed in factories or warehouses. Also, in the absence of a law requiring indoor workplaces to be smoke-free, workplaces that are smoke-free may be so because their highly educated workforce comprised mainly of non-smokers demanded it. All of the population studies included education and/or income as covariates, which could account to some extent for this possible source of confounding, and a number of the studies explicitly included a variable for occupation (see Table 7.4).

Rather than review all of the population studies in detail, the next sections describe results from the few published longitudinal surveys (Patten *et al.*, 1995; Glasglow *et al.*, 1997; Biener & Nyman, 1999; Bauer *et al.*, 2005), including one that is not, strictly speaking, a population survey, but was nevertheless a survey of workers (Longo *et al.*, 2001). Also described are a couple of cross-sectional studies that employed novel analytical strategies in an attempt to account for possible industry or worker effects that might possibly explain the observed results of less smoking in workplaces with restrictions (Evans *et al.*, 1999; Farrelly *et al.*, 1999). The longitudinal design can compare changes in smoking behaviour over time between smokers working in an environment where smoking is restricted or not. The other cross-sectional surveys are described in detail in Appendix 5.

Longitudinal studies

One of the studies investigated in several of the previous review articles, conducted a cross-sectional comparison of smoking cessation among 1469 current and former smokers who worked in hospitals, to 920 who worked in other employment settings (Longo *et al.*, 1996). Hospitals in the USA were mandated to be smoke-free by 1993, but many went smoke-free earlier. The post-smoke-free policy quit ratios (quit since policy imposed / all ever smokers) were higher among the hospital workers and tended to increase with time since the policy took effect. The subjects of this cross-sectional study became the basis for a cohort interviewed one or two times later up to 1996 (Longo *et al.*, 2001; Appendix 5). Using the last follow-up data available, the time post-policy differed for each subject, so a Cox proportional hazard model was constructed for time to quit post-policy with censored observations as appropriate. The adjusted hazard ratio for quitting was 2.29 (95% CI=1.56-3.37) for the hospital compared to other workers, after adjusting for employee group (blue collar, clerical, white collar), education, age, sex, and education. Unadjusted quit ratios computed for groups with data at increasing time points post-policy showed increased quitting for both the hospital and other workers, and up through 84 months, these differed significantly, with the hospital workers showing consistently ever higher quit ratios. After that, sample sizes were small. Simple relapse rates at the follow-up surveys were compared for those not smoking at baseline, but were not found to be significantly different. At the first follow-up, nearly the same percentages of those in the hospital and other group were smoking again, 19.3% and 20.4%. At the second follow-up, these rates were 19.3% and 24.5%, respectively. Thus, these data suggest that while a smoke-free workplace might prompt quitting, it may not help prevent relapse among those initially quit.

A longitudinal sample of 1844 adult indoor workers (follow-up rate 50%) were asked about the smoking restrictions in their workplaces in both 1990 and 1992 (Patten *et al.*, 1995). A smoke-free work area (not a completely smoke-free workplace) was reported by 57% of the sample in 1990 and by 67% in 1992. California did not mandate that all indoor workplaces be smoke-free until 1995. This study assessed changes in smoking status and cigarette consumption among four groups: work area under no restrictions both years, work area smoke-free in 1992 but not 1990, work area smoke-free in both years, work area smoke-free in 1990 but not in 1992. Besides smoking prevalence, the study assessed change in smoking status (smoker to nonsmoker or nonsmoker to smoker) from 1990 to 1992, and changes in daily consumption among those smoking in either year, with zero imputed if they were not smoking in a given year. Two multivariate analyses, adjusting for age, sex, education, and race/ethnicity, were

conducted for consumption with increases or decrease (by 5 CPD or not smoking) from 1990 to 1992 as the dependent variable.

Smoking prevalence changed over time with work area restriction category (overall chi-square, $p<0.06$), but separate analyses of changes within category showed no significant difference because of small samples sizes. The group working in a smoke-free work area both years showed a decline in prevalence from 18.3% to 16.3%. Where the work area was smoke-free in 1992 but not 1990, prevalence changed from 20.3% to 19.1%. The group working in unrestricted work areas showed no change (~26.6% in both years). The group that worked in a smoke-free area in 1990 but not 1992, actually showed an increase in prevalence from 15.3% to 23.1%.

The groups that included those with smoke-free work areas in 1992 showed about double the rates of change in status from smoker to nonsmoker (about 18%) than the other groups (about 8%). Change in status from nonsmoker to smoker was highest (38%) in the group with a smoke-free work area in 1990 but not 1992. Some of this change may be relapse among former smokers and some may be initiation. This percentage ranged from 9% to 11% in the other groups. The overall chi-square for the analysis of change in status was $p<0.05$.

There was a small but significant decline in consumption (0.90 CPD) for the group with smoke-free work areas in both years. The group with a smoke-free work area in 1990 but not in 1992 showed a non-significant increase of 4.25 CPD. These changes may be due to changes in prevalence and not to changes in consumption among continuing smokers. The multivariate analysis indicated that working in a smoke-free work area in 1990 but not 1992 was inversely associated with a decrease in consumption compared to having restrictions in both years. Overall, the results of this analysis suggest that moving from a job where smoking is not allowed in the work area to one where it is may increase smoking. The evidence for the opposite effect was less consistent.

The above study prompted investigators in Massachusetts to analyse their longitudinal population survey data in a similar fashion (Biener & Nyman, 1999), although they had even a smaller sample size (n=369). Two-thirds of smokers who were workers at baseline in 1993 were able to be contacted again in 1996. The outcome of interest was smoking cessation (a report of smoking "not at all" when interviewed again). Smoke-free workplaces were contrasted to all others (including those with partial restrictions), and categorised as continuously smoke-free, became smoke-free, or not smoke-free. Analyses adjusted for sex, age, education, smoking level at baseline (<15 versus 15+ CPD), and intent to quit within 30 days. Although the odds ratio for the group continuously working in a smoke-free environment was 2.0 (95% CI=0.7-6.0), it was not statistically significant compared to cessation in the group working continuously under no restrictions. For a new smoke-free workplace, the odds ratio was 1.4 (95% CI=0.3-6.1). Only being a light smoker or intending to quit were significantly associated with cessation at follow-up. An additional analysis substituted exposure to SHS (exposure variable codes as: continuously low, became low, became high, continuously high) for workplace smoking policy. If exposure was continuously low or became low, cessation was higher, 6.99 (95% CI=1.79-27.3) and 6.44 (95% CI=1.04-28), respectively, compared to continuously high. The authors concluded that problems with enforcement of smoke-free policies may be partly responsible for the lack of a cessation effect.

A secondary analysis of longitudinal data from the Community Intervention Trial for Smoking Cessation (COMMIT) examined employed smokers (n=8271) interviewed in 1988 and again in 1993 (Glasglow *et al.*, 1997). Worksite smoking policy was categorised as prohibiting smoking, allowing it only in designated areas, and allowing it everywhere. This study analysed cessation by follow-up, quit attempts, and cigarette consumption in continuing smokers and smokeless tobacco use. Multivariate analyses adjusted for sex, age, race/ethnicity, education, income, cigarette consumption in 1988, desire to quit, and number of past quit attempts. Compared to those working where smoking was allowed everywhere, those working where it was prohibited were 1.27 times more likely to be quit at follow-up ($p<0.05$). Designated areas were not significantly associated with increased quitting. However, both a designated area (1.16 times higher) and a smoke-free workplace (1.27 times higher) were significant when compared to where it was allowed everywhere

($p<0.05$). Both conditions were also associated with reduced cigarette consumption, by 1.17 (designated area), and by 2.78 (smoke-free) CPD. Smokeless tobacco use at follow-up was unrelated to smoking policy at baseline.

Another analysis of cohort data from COMMIT assessed the longer-term effects of working under a smoke-free workplace policy (Bauer *et al.*, 2005). A subset (n=1967) of smokers was identified who were initially interviewed in 1988, re-interviewed in 1993 and 2001, and who worked indoors in both years. These participants provided information about their employer's smoking policy in both 1993 and 2001. The proportion of these smokers working in a completely smoke-free environment increased markedly, from 27% in 1993 to 76% in 2001. Two different classifications taking account of worksite policy in both years were constructed. One was a three-level variable: maintained no restrictions or regressed from partial to none, maintained partial restrictions or regressed from smoke-free to partial, and maintained smoke-free status or changed to smoke-free. The other variable had nine levels, ranging from worked under no restrictions in both years to worked in a smoke-free workplace in both years. The study analysed several outcomes: quit for at least six months at follow-up, making a serious attempt to quit between surveys (including all those quit at follow-up), daily cigarette consumption and smokeless tobacco use, and adjusted for age, sex, race/ethnicity, education in 2001, desire to quit in 1988, number of previous quit attempts in 1993, amount smoked in 1993, and occupation in 2001.

For the three-level outcome, compared to the first category, the likelihood of quitting for six months was 1.73 (95% CI=0.96-3.11) higher for the second level, and for those working under smoke-free conditions at follow-up, it was 1.92 (95% CI=1.11-3.32) higher. Workplace smoking restrictions did not predict making a quit attempt. However, those in the third category, but not the second, showed a significant decline in daily consumption of 2.57 CPD ($p<0.05$) compared to those in the first category. For the nine-level categorisation, those working in a smoke-free workplace at both surveys were 2.29 (95% CI=1.08-4.45) more likely to be quit, and smoked 3.85 ($p<0.05$) fewer cigarettes than those working under no restrictions at both times. Lower levels of the categorisation were not associated with being quit for at least six months. Again, for the nine-level variable there was no significant relation of worksite restrictions to making a serious quit attempt. For daily consumption, the beta coefficients for the intermediate categories of worksite restrictions were less than for full restrictions, and were significant for the categories where the workplace was smoke-free at follow-up or for partial restrictions at both times. These results suggest that there may be a longer-term effect of smoke-free workplaces on successful cessation and consumption, and that smoke-free workplaces might help someone remain abstinent rather than prompt a quit attempt. Very few smokers (n=6 or 0.3%) indicated that they had switched jobs to avoid smoking restrictions in their workplace. Also, in 2001 only about 1% of the workers reported using smokeless tobacco at least three times per week, indicating no significant shift to this tobacco type as a result of working where smoking was not allowed.

Cross-sectional studies

An example of a study that went to considerable length to account for a possible "type-of-industry" effect is the one that analysed 1992-93 Current Population Survey data (Farrelly *et al.*, 1999). Smoking prevalence was examined in nearly 100 000 non-self-employed adult (18+ years) indoor workers, and daily cigarette consumption in a subset of nearly 25 000 current smokers according to the level of restrictions on smoking in their workplaces. These were categorised into four levels: no restrictions, partial work area/common area restrictions, work area prohibition and partial common area restrictions, and completely smoke-free. Besides being asked about workplace restrictions on smoking, respondents provided information on their sex, age, race/ethnicity, educational attainment, marital status, number of persons in their households, urban/rural status, state, income, hours worked per week, and type of industry where they worked (seven categories: wholesale/retail trade; manufacturing; transportation; common utilities, including communications; medical services; finance, insurance, and real estate; and other professions, including law, education, architecture, etc.).

In an analysis that included all these variables, a smoke-free work area was only about half as strongly related (coefficients in model) to smoking prevalence as a fully smoke-free workplace. Model coefficients indicated that a smoke-free work area was associated with lower smoking prevalence by 2.6 (95% CI=1.7-3.5) percentage points, and a fully smoke-free workplace policy by 5.7 (95% CI=4.9-6.5) percentage points compared to no restrictions. Lesser restrictions were unrelated. For daily consumption among current smokers, the pattern was similar. For a completely smoke-free workplace policy, cigarette consumption was 2.7 (95% CI=2.3-3.1) CPD lower, for a smoke-free work area it was 1.5 (95% CI=1.1-1.9) CPD lower, and for partial restrictions it was 0.6 (95% CI=0.1-1.1) CPD lower compared to no restrictions. These results suggest a dose-response relationship between level of smoking restrictions and smoking behaviour.

The large sample sizes afforded by national surveys allow for sub-group analyses. Separate multivariate analyses were conduced within subgroups (e.g. sex, age group, race/ethnicity group, education group, industry group, etc.) and included all other factors as covariates. The difference in prevalence and consumption for workplaces that were completely smoke-free versus those with no restrictions were reported. Although the magnitude of the difference (smoke-free versus no restrictions) in prevalence or consumption varied among the subgroups analysed, in each one those working in smoke-free work-places showed a significantly lower smoking prevalence, and smoking workers showed significantly lower daily cigarette consumption than those in workplaces with no restrictions. The differences tended to be greater in specific education (e.g. those without a high school diploma) or industry groups (e.g. wholesale retail trade), with higher relative prevalence or consumption rates overall. It is possible that smoke-free workplaces have a greater impact on smokers who smoke more.

In the second study, a standard analysis was performed of both adult smoking prevalence and smoker's cigarette consumption that adjusted for age, age squared, family size, log income, region, education, race/ethnicity, city size, marital status, cigarette tax, occupation, and year (Evans *et al*., 1999). Worksites were categorised as smoke-free work areas, having restrictions in other indoor areas, or no restrictions. The primary data source was the 1991 and 1993 NHIS that included 18 090 indoor workers. Results indicated that smoking prevalence among indoor workers in smoke-free work areas was 5.7 percentage points less than among indoor workers working under no smoking restrictions, and smokers in smoke-free work areas smoked 2.5 CPD less. The remainder of the paper presents a multitude of analyses trying to dispute this result. The highlights are summarised below.

First, the findings were replicated using the 1992/1993 CPS (n>97 000 indoor workers). Then additional analyses were conducted to explore whether this result was due to excluded variable bias; that is, if a worker's unobserved propensity to smoke is related to having a smoke-free workplace, the results reported above are biased. The NHIS includes a comprehensive set of variables about respondent health and lifestyle, and if healthier workers or those with healthy lifestyles (including not smoking) tend to congregate in smoke-free workplaces. Including these variables and interactions with worksite policy should diminish the effect, but the original estimates proved robust. Other models included such factors as duration of employment at the current worksite (perhaps newer employees sought out worksites that were either smoke-free or not), or whether the worksite had unions, and again the results were unchanged. Next, it was determined that worksite size was the factor that was most related to whether or not the worksite was smoke-free; workplaces with more than 50 workers (22%) were more likely to be smoke-free. All possible worker characteristics were explored in small versus larger worksites. The differences were minimal, even for smoking prevalence, and when they included worksite size in the model, again it did not alter the effect. Another analysis included the number of hours worked; cigarette consumption was inversely related to number of hours worked if the workplace was smoke-free. Taken together, these results are fairly convincing for a causal effect: smoke-free workplaces have led workers to smoke less. A final analysis of data from other sources correlated the prevalence of worksite smoking policies, which increased from 25% in 1985 to 70% in 1993, to smoking prevalence trends among workers and non-workers. If indeed smoke-free workplaces

reduce smoking prevalence by 5.7%, the observed widening discrepancy in the downward trend in smoking prevalence between workers and non-workers is completely explained by the rise in workplace smoking restrictions.

The detailed analyses employed by the above two studies suggest that declines in smoking behaviour occur in all types of workplaces, regardless of size, type of occupation or industry, and health consciousness. Thus, the generally consistent findings from all the other cross-sectional surveys likely identify real differences in smoking behaviour between those employed in smoke-free workplaces compared to those working in workplaces with lesser or no restrictions.

Shifts from cigarettes to other forms of tobacco as a result of workplace smoking restrictions

The analyses of the COMMIT longitudinal sample described above, failed to find any noticeable shift to smokeless tobacco use among smokers at baseline who became subject to smoke-free workplaces (Glasgow *et al.*, 1997; Bauer *et al.*, 2005). However, if smokeless tobacco, particularly Snus, is successfully marketed as a way for smokers to maintain access to nicotine during the workday without having to go outside or leave the premises to smoke, aggregated tobacco use may not decline as a result of smoke-free workplace policies. Smokers who might have quit because of the smoke-free policies, might choose to use smokeless products when they cannot smoke, but continue to smoke cigarettes when they can.

Summary

There appeared to be a fairly strong consensus among the previous reviews of worksite-based studies that workplace smoking restrictions lead to smokers reducing their daily cigarette consumption. These reviews were not as ready to claim an effect on smoking prevalence or cessation, because of very mixed results from the individual studies. Again, there were different study designs, smoking behaviour definitions, and categorisations of workplace smoking policy. The more inclusive the review, the more likely it was to conclude that the policy affected behaviour.

It would be expected that if partial restrictions are associated with reduced smoking, including this group with those having no restrictions in an analysis of smoke-free workplaces, versus all others, might limit the ability of the analysis to detect an association. There was some evidence that smoke-free work areas or completely smoke-free worksites might reduce daily cigarette consumption in the shorter-term with a cessation effect more likely to be observed in the longer-term. In general, smokers who have lower daily cigarette consumption find it easier to successfully quit.

The results from the population surveys of smokers working and not working under smoking restrictions were generally consistent with the worksite-based studies concerning the finding of reduced daily cigarette consumption. Further, among the population studies, there was a more consistent trend for lower smoking prevalence or higher rates of cessation among workers in workplaces with restrictions. While these mostly cross-sectional studies cannot prove that workplace smoking restrictions reduce smoking, two such studies provided additional evidence for a causal effect: one by examining smoking behaviour differences within industries which should employ similar workers, and the other by convincingly ruling out an effect for other worker or worksite characteristics that might have produced the observed results.

Smoking restrictions in schools

Besides the home, children and adolescents spend a good portion of their time at school. Therefore, this section focuses on the potential effect on student smoking of a complete prohibition on smoking for everyone, including adults, on school campuses compared to lesser or no restrictions.

Why school smoking restrictions might affect youth smoking behaviour

The traditional rationale for instituting a prohibition on smoking for students on school campuses is related to smoking prevention. If society thinks it is harmful for adolescents to smoke, and anti-tobacco curricula are used in its schools, then adolescents should not be given the conflicting message that it is permissible to smoke on school property. Furthermore, if such rules are well enforced, the availability of cigarettes and the opportunity for students to smoke is diminished, and even if they experiment outside of school, their progression to regular smoking might be impeded or at least

delayed. Finally, if students do not see other students smoking on campus, they may perceive a relatively lower adolescent smoking prevalence, and such perceptions are associated with reduced smoking uptake. There is a large body of research on the effect of smoking prohibitions for students in secondary schools. The results have been mixed, with the extent and type of enforcement (punitive or cessation focused) or the combination (or not) of smoking policies with anti-tobacco curriculum the subject of most investigations.

More recently, the school has also been seen as a workplace, and especially in indoor areas, there is the rationale to prohibit smoking for everyone, including teachers, staff, and visitors to protect the health of nonsmokers. However, if smoking is prohibited indoors and not outdoors on campus, the effect might be that students would see many more adults smoking on campus. A study of seven European countries indicated that national and school policies restricting teacher smoking are negatively associated with students' seeing teachers smoking indoors, but positively associated with seeing them smoke outdoors (Wold *et al.*, 2004b). Four countries had no policies regarding teacher smoking. Only one of the countries studied (Finland) prohibited smoking by teachers outside buildings on campus; it restricted it indoors (presumably to rooms to which students had no access). This study did not examine student smoking behaviour.

Teachers are important role models for students (Bewley *et al.*, 1979; Poulsen *et al.*, 2002), and students are well aware of the hypocrisy of forbidding students to smoke, but allowing teachers or other adults to smoke on campus. In California, students who smoked were less likely to support smoke-free school policies if they perceived that teachers smoked on campus (adjusted OR=0.40; 95% CI=0.20-0.82) (Trinidad *et al.*, 2005).

The review presented in the next section is confined to the relatively few studies to date that address the issue of the effect on student smoking of completely smoke-free schools, where no one including teachers, staff, or visitors is allowed to smoke on campus (Table 7.5).

Results for studies examining the association of smoke-free schools with youth smoking behaviour

The prevalence of student smoking in secondary schools is related to a multitude of factors and varies widely depending both on the characteristics of the students and of the school (Aveyard *et al.*, 2004; Sellström & Bremberg, 2006). School level factors associated with student smoking prevalence include urban location, a school health policy, an anti-smoking policy, a good school climate, and a high average socioeconomic status (Sellström & Bremberg, 2006). Because of such differences, recent studies of school smoking policies have tended to use hierarchal statistical models that account for both school and student level characteristics. Studies that did not use a hierarchical analytic approach will be discussed in the text and in Table 7.5 before the studies that did. To date, all of the studies related to this topic have been cross-sectional.

Data for 2464 students aged 16-17 years in 74 secondary schools and colleges in England and Wales were analysed (Charlton & While, 1994). In 1990, school directors filled out questionnaires concerning their school's smoking policies, and these were related to student smoking (at least weekly) and daily cigarette consumption separately in the secondary schools and colleges. Although some sample sizes were small, prevalence was 16% for students in smoke-free schools, 24% if staff but not students could smoke, 27% if staff not permitted to smoke but students are, and 34% if both staff and students could smoke. After adjusting for age, whether a best friend smokes, and whether a sibling smokes, it appeared that removal of staff smoking was associated with reduced current smoking in colleges, but not in schools. Because there was no suggestion from bivariate analyses that total daily consumption (school and non-school hours) was related to smoking policy, the authors did not perform a multivariate analysis.

Variables for student smoking policy, staff smoking policy, visitor smoking policy, and the presence of no-smoking signs were evaluated in a study of 26 429 students from 347 secondary schools in Australia (Clarke *et al.*, 1994).

Table 7.5 Studies examining the association of school smoke-free policies for everyone with youth smoking behaviour

Reference Location	Population	Year	Definitions of smoking	School level characteristics other than smoking policy	Individual level characteristics	School policy	Analysis	Results	Comments
No hierarchical analyses									
Charlton & While, 1994 England and Wales UK	2467 students 16-19 years in 74 schools and colleges	1990	At least weekly. Daily cigarette consumption also analysed	None in multivariate analysis	Age, best friend smokes, sibling smokes	Allowed for students and staff; not allowed for students, but allowed for staff; allowed for students but not for staff; not allowed for anyone.	Separate logistic regression analyses were conducted for secondary school and college students.	Prohibition for staff, but not students significantly associated with reduced smoking for college students (p=0.034), but not for secondary school students.	The smoking policy was unrelated to cigarette consumption for both secondary and college students.
Clarke *et al.*, 1994 Australia	26 429 students 12-17 years from 347 schools	1990	1 or more cigarettes in last week	Gender and age composition of school, school type, urban versus rural, staff smoking prevalence, and others related to school organisation	None	Three variables: staff smoking policy (not allowed, some areas, no restrictions), visitor policy (same categories as above), no smoking signs around school (none, few, most parts).	Bivariate analysis of variance of school level characteristics. Separate analyses by grade level (7-8, 9-10, 11-12).	None of the smoking policy variables considered were significantly related to student smoking.	Smoking was prohibited for students in nearly all schools.
Wakefield *et al.*, 2000a USA	17 287 students 14-17 years from 202 schools	1996	Continuum: non susceptible, susceptible, early experimenter, advanced experimenter, established smoker. Any smoking in past 30 days	Restrictions on smoking in public places from other sources was merged into the dataset	Adult smokers in home, living siblings smoking, living in a smoke-free home, gender, race/ethnicity, and grade in school	Smoke-free for everyone versus lesser restrictions, level of enforcement of complete ban	Multivariate logistic regressions of each smoking stage level compared to lower level and of any smoking in the past 30 days.	A smoke-free school was not significant for the various transitions. However, an enforced smoke-free policy was. It was also significant for lower likelihood of being a current smoker OR=0.86; 95% CI=0.77-0.94	

Table 7.5 Studies examining the association of school smoke-free policies for everyone with youth smoking behaviour

Reference Location	Population	Year	Definitions of smoking	School level characteristics other than smoking policy	Individual level characteristics	School policy	Analysis	Results	Comments
No hierarchical analyses									
Osthus *et al.*, 2007 Norway	16-20 years. 2400 current and former senior high students	2004	Daily smoking	School type (preparation for manual work, preparation for university)	Sex, age, work status	Smoke-free for everyone versus some restrictions versus no restrictions. Prevalence was 16%, 45%, and 40% for the policy types.	Separate multivariate logistic regression analyses for current and former students	Current students: OR=0.3;95% CI=0.1-0.5 smoke-free versus no restrictions Former students OR=0.2; 95% CI=0.1-0.8 smoke-free versus no restrictions. Lesser restrictions not significant.	No interaction effect between policy type and school type was examined, so it is unknown whether the policy effect was present to the same extend in each school type.
Hierarchical analyses									
Moore *et al.*, 2001 Wales, UK	15-16 years. 1246 students in 55 schools	1998	Weekly smoking Daily smoking	None	Mother's smoking, parents' expectations of school achievement, gender, socioeconomic status, school performance, alienation from school, best friend smokes	Strong: written policy about prohibition for everyone; Average: prohibition for everyone but not written for at least one group; Weak: no policy, or only policy for students. Also, whether policy strongly enforced or not for students and for teachers	Individual level characteristics associated with smoking in multivariate logistic regression were then included in the hierarchical models.	Average (OR=2.04; 95% CI=1.04-4.00) or weak (OR=2.77; 95% CI=1.25-6.12) policies were significantly associated with increased daily smoking, but not for weekly smoking. Strong enforcement for students was significantly related to both daily (OR=1.52; 95% CI=1.03-2.243) and weekly (OR=1.49; 95% CI=1.01-2.20) smoking. Strong enforcement for teachers was not significantly	Policy strength and enforcement were highly correlated, so they were not analysed in the same models.

Reference Location	Population	Year	Definitions of smoking	School level characteristics other than smoking policy	Individual level characteristics	School policy	Analysis	Results	Comments
Hierarchical analyses									
Moore *et al.*, 2001 Wales, UK								related to either daily or weekly student smoking.	
Kumar *et al.*, 2005 USA	14 125 middle school students in 126 schools, and 21 621 high school students in 223 schools	1999 and 2000	Daily smoking, and attitude toward adult daily smoking	Public versus private, urbanicity, school size, aggregated parental education attainment. Year also included in full models	Grade in model for high school students, parental education, student race/ ethnicity, and sex	3 variables: good monitoring of school policy prohibiting student smoking; strict consequences for student violation of smoking rule; teachers not permitted to smoke anywhere on school premises	Separate analyses for middle and high school students. Each policy variable analysed separately, then all three together, and finally with all other school and individual-level variables in hierarchical analyses.	For middle schoolers, monitoring was significantly related ($p<0.01$) to reduced daily smoking at all levels of analysis. For high schoolers, staff policy was significantly related ($p<0.05$) to reduced smoking in the final model with all factors included.Severity of consequences was significantly related to reduced smoking in individual and multiple policy models ($p<0.05$), but not in the full model.	There were no variables included for smoking among parents, siblings or friends.
Barnett *et al.*, 2007 Quebec, Canada	763 students aged 13 years in 50 schools, and 768 students aged 16 years in 57 schools	1999	Daily smoking, not daily but in last 30 days, no smoking in past 30 days	Urban or rural, private or public, income in area of school	Sex, parents smoke daily, siblings smoke daily, live with both parents	3 variables: students can smoke outdoors, staff can smoke indoors, staff can smoke outdoors	Preliminary analyses identified individual, policy and other school level characteristics to include in final separate hierarchical models for age and sex groups.	Staff allowed to smoke outdoors was significantly related ($p<0.05$) to increased daily smoking in 13-year-old girls.	Sample sizes were relatively small for the age-sex subgroup analyses (<406 students). Student smoking policy was not significant in preliminary analyses.

Smoking cigarettes in the past week was bivariately (analysis of variance) related to these policy variables, as were other school level characteristics (sex composition; urban versus rural location; school type (government, Catholic or independent); proportion of students in level 7-10; proportion of students in level 11-12; school uniform compulsory; prefects selected by principal, staff or students; student representative on school council, etc.). None of the smoking policy variables was related to student smoking in any of the grade levels analysed (7-8, 9-10, or 11-12). No factor analysed was consistently related across all three grade level groups, but type of school (government, Catholic, or independent) showed the largest F-ratios in the analyses of variance for the 7th and 8th graders and for the 9th and 10th graders.

In 1996, a study conducted in the USA contrasted a completely smoke-free policy for everyone on campus to lesser or no restrictions for different levels of adolescent (14-17 years) smoking (Wakefield *et al.*, 2000a). The 17 287 adolescents were either nonsusceptible never smokers, susceptible never smokers, early experimenters (puff in the past but not in last 30 days and weak intentions regarding future smoking, or a whole cigarette in past 30 days but strong intentions about not smoking again), advanced experimenters (a whole cigarette but less than 100 in lifetime and weak intentions not to smoke in future), or established smokers (had smoked at least 100 cigarettes in lifetime). Any smoking in the past 30 days was also analysed. Besides the smoke-free school variable, there was a school level variable for strength of policy enforcement and for smoking restrictions in public places in the town were the school was located, obtained from external sources. Individual characteristics analysed included grade, sex, race/ethnicity, adult smoker in the home, sibling smoker, and home smoking restrictions. Multiple logistic regression analyses compared each smoking level to the one previous to it. Only for the transition to established smoking from advanced experimentation was a smoke-free school policy significant and it was positively associated with this transition (OR=1.22; 95% CI=1.07-1.37). However, a strongly enforced smoke-free policy was significantly related to reduced transition in every analysis, including the one of smoking in the past 30 days (OR=0.86; 95% CI=0.77-0.94). Thus, it is not sufficient for there to be a smoke-free policy for everyone; the policy must be consistently enforced.

Daily smoking in 2400 current and former students (aged 16-20 years) from Norwegian schools, with three levels of smoking policies in 2004, was evaluated (Osthus *et al.*, 2007). Schools were classified as having smoke-free campuses, lesser smoking restrictions, or no smoking restrictions. For the three policy types, overall (current and former students) smoking prevalence was 16%, 45%, and 40% respectively. Separate multivariate analyses for current and former students adjusted for sex, age, work status, and school type (preparation for manual labour or for attending a university). For the current students, a smoke-free policy compared to no restrictions was associated with reduced daily smoking (OR=0.3; 95% CI=0.1-0.5). A similar relationship was present for former students (OR=0.2; 95% CI=0.1-0.8). The odds ratios for a less than smoke-free policy were not significant. The authors did not examine an interaction between school and policy type, so it is unknown whether the policy affect was present equally for both school types.

The remainder of the studies used a hierarchical analysis. A survey of 11th graders in 55 randomly selected schools in Wales, classified school smoking policy as strong, average, or weak based on separate questionnaires completed by the head teacher and the teacher responsible for health education (Moore *et al.*, 2001). A strong school policy was defined as a clearly written policy prohibiting smoking by students and staff anywhere on the school premises. An average policy also required the campus to be smoke-free, but the written policy was not clear and/or did not specifically mention all groups. A weak policy was defined as one that only covered students or where there was no policy at all. Whether or not the policy was consistently enforced for students and for teachers was analysed as two separate variables. In schools where there was a strong policy, mean daily smoking prevalence was 9.5% (95% CI: 6.1-12.9%). For those with an average policy it was 21.0% (17.8-24.2%), and for those with a weak policy it was 30.1% (23.6-36.6%). Weekly smoking prevalences for these policy categories were 17.1% (14.1-20.0%), 25.5% (21.7-29.2%), and 34.7% (24.7-44.7%), respectively. For daily smoking, students in schools

with high enforcement for students showed a prevalence of daily smoking of 17.7% (13.4-22.0%) compared to 23.7% (20.2-27.2%) in schools with low enforcement. The comparable data for weekly smoking were 22.7% (18.3-27.0%) and 28.6% (24.0-33.2%), respectively. The student smoking prevalence for low and high enforcement of teacher smoking was not very different (Moore *et al.,*2001).

In the above study, preliminary logistic regression analyses identified student level characteristics that were related to report of daily or weekly smoking. These included sex, mother's smoking, parents' expectations about school performance, best friend's smoking, and alienation from school. Preliminary analyses also examined the school smoking policy variables. For daily smoking, an average or weak policy was related to increased smoking, and strong student enforcement marginally related to reduced smoking. Enforcement for teachers was not significantly related. For weekly smoking, the policy level and student enforcement variables were significant. Because the enforcement and policy level variables were highly related, separate hierarchical models analysed each. Compared to a strong policy, an average (OR=2.04; 95% CI=1.04-4.00) or weak (OR=2.77; 95% CI=1.25-6.12) school policy was still significantly related to increased daily smoking. In the separate model, low enforcement for students was also related to increased daily smoking (OR=1.52; 95% CI=1.03-2.24). For weekly smoking, policy level was unrelated, but low enforcement for pupils was marginally related (OR=1.49; 95% CI=1.01-2.20). Based on their findings, the authors suggest that wider introduction of smoke-free school policies might help reduce teenage smoking.

Monitoring the Future school survey data were used to examine the relationship of school smoking policies to student daily smoking in middle (8th grade) and high school students (10th and 12th grades) in over 37 000 students from 342 schools in the USA (Kumar *et al.*, 2005). The study also analysed students' attitudes toward adult daily smoking. Separate variables accounted for three facets of school smoking policy: strength of monitoring for violations of school policy against student smoking, severity of consequences for student violations, and whether staff were permitted to smoke anywhere on school property. These and other school level factors were determined from questionnaires answered by an administrator at each participating school. Student level variables were demographics (gender, race/ethnicity, parental education), and other school level factors besides smoking policy were school type (public or private), school size, urbanicity, year of survey, and aggregated (from student's report) parental education attainment.

In the above study, models first considered only each separate smoking policy variable, then all three simultaneously, and finally hierarchically all school level and individual level factors. For middle-school students, strong monitoring of student smoking was the only significant policy variable related to daily smoking ($p<0.001$ in the individual model, $p<0.01$ in the policy and full models). However, in the full model, the beta coefficient for staff smoking (0.22) was actually larger than for this same variable (0.19) in the analysis of high school students. In the high school students, staff smoking was significant in the full model ($p<0.05$), but not in the individual or combined policy analyses. Severity of consequences was significant individually ($p<0.01$) and in the policy model ($p<0.01$), but not in the full model. In the analyses of attitudes toward adult smoking, for the middle school students, the staff smoking variable was significant individually ($p<0.05$) and in the policy model ($p<0.05$), but lost significance in the full model. The opposite was true for the high school students: staff smoking was not significant in the individual or policy models, but was significant in the full model ($p<0.05$). Neither of the other two school policy variables was significant in any of the analyses of attitudes for either middle or high school students. The authors conclude that staff who smoke are likely poor monitors and should be provided with smoking cessation programmes.

In separate school samples of 763 13-year-old and 768 16-year-old Quebec students, school smoking policies were related to student smoking (Barnett *et al.*, 2007). The study assessed smoking policy for staff indoors, for staff outdoors, and for students indoors. Among 13-year-olds, daily smoking prevalence was 6.1% if students were permitted to smoke, versus 3.4% if they were not permitted to smoke. Related to staff smoking indoors, these prevalences were 4.3% versus 5.8%, and to staff smoking outdoors they were 6.5% versus 2.3%. The prevalences for

less than daily smoking were similar regardless of policy. For the 16-year-olds, daily smoking prevalence was 23.6% if students could smoke outside, versus 20.8% if they could not. For staff smoking indoors these percentages were 28.1% versus 20.9%, and for staff smoking outdoors they were 23.3% and 22.8%. Again, the prevalence of less than daily smoking did not vary much according to policy.

Because there were some interactions by sex for individual level characteristics, the final hierarchical models in the above study analysed daily smoking in each sex-age group separately, resulting in fairly small sample sizes (n=357-405). Individual level variables included in the final models were daily smoking by parents and daily smoking by siblings, but neither of these variables was significant in any analyses. Other school level factors included were public versus private and rural versus urban school status, and both these variables were significantly related to daily smoking in all analyses. Based on the preliminary analyses, the hierarchical models only examined daily smoking, and only policy for staff outdoors for 13-year-old girls, and policy only for staff indoors for 16-year-old boys. Staff being permitted to smoke outdoors was significantly related to 13-year-old girls daily smoking prevalence ($p<0.05$). Staff being permitted to smoke outdoors was not significantly related to daily smoking among the 16-year-old boys. The authors emphasise the sex differences, but concluded that smoke-free schools might aid in the prevention of adolescent smoking.

Summary

To date there are only a few studies that have addressed the possible effect of a completely smoke-free school campus for everyone, including teachers and other adults, on youth smoking behaviour. All of the studies were cross-sectional. Because school level characteristics are related to student smoking prevalence, hierarchical analyses that properly account for such potential confounding factors are most appropriate for evaluating the effect of a smoke-free school policy. While the results from the few such studies employing this approach appear somewhat promising, more research is required. Nevertheless, regardless of the effect of a smoke-free school on smoking behaviour, such restrictions can be justified on the grounds that they potentially reduce exposure to SHS in the school setting.

Chapter summary

Smoking restrictions as one component of a comprehensive tobacco control programme

In localities where new laws were part of multiple tobacco control efforts, there was clear and consistent evidence for a change from prior ongoing trends. However, if multiple tobacco control measures are instituted simultaneously, attribution of the change to a new law restricting smoking is not possible.

Pre-post new law studies

Reviewed studies that assessed smoking behaviour before and after the implementation of new laws restricting smoking in public and workplaces were analytically weak and produced mixed results; some provided no statistical evaluation even though differences or trends appeared to be present.

Correlative studies

Nearly all the studies correlating the extent and strength of laws restricting smoking with various aspects of smoking behaviour found the expected associations. Localities with relatively stronger restrictions in more places, or that covered a greater proportion of the population generally showed lower adult and youth prevalence rates and reduced cigarette consumption. Whether localities with strong anti-smoking norms were more likely to pass such regulations or the regulations led to reduced smoking, is unknown.

Workplace studies

At a more individual level, studies of workers subject to restrictions in the workplace indicate that new restrictions reduce smokers' cigarette consumption by 2-4 CPD. Whether or not the reduction in daily cigarette consumption is sufficient to make the smokers less addicted, and therefore more likely to quit in the future, is unknown, but some evidence exists that the cuts in consumption in the shorter-term may lead to increased cessation in the longer-term.

Population studies

Population studies, even the cross-sectional ones, that adjusted for worker characteristics, including demographics and occupation, are likely minimally biased. Nearly all these studies found that smoke-free workplaces were more associated with decreased smoking among workers than partial restrictions.

Smoke-free school policies

To date, there are limited data concerning the effect of a completely smoke-free campus for everyone, students and adults, on adolescent smoking behaviour. Not witnessing teachers smoking on campus may reinforce school level anti-smoking norms and lead to reduced adolescent smoking initiation, but further research is required to explore this issue.

Conclusions

1. The different lines of evidence reviewed indicate that workplace smoking restrictions reduce cigarette consumption among continuing smokers.
2. The evidence from earlier studies concerning reduced prevalence and/or increased cessation is less clear. However, more recent evidence suggests that smoke-free workplaces reduce prevalence and increase quitting.
3. Correlative studies indicate an association between the strength and scope of laws restricting smoking in public and workplaces and reduced youth tobacco use.
4. When smoking restrictions are part of a comprehensive tobacco control programme, significant declines in smoking behaviour are observed. However, not all of the decline can be attributed to the smoking policies.
5. Few appropriate studies have assessed whether a smoke-free school campus for everyone, including adults and visitors, reduces smoking among students.

Recommendations

1. Smoking restrictions for public or workplaces should prohibit smoking completely if they are to have an optimal impact on reducing smoking behaviour, as well as reducing exposure to SHS.
2. To have optimal effect, smoke-free policies should be part of comprehensive tobacco control programmes aimed at reducing the adverse health effects from tobacco use.
3. Since much of what is known regarding the effect of smoking restrictions on smoking behaviour is from developed countries, further research on this topic is needed that involves multiple nations from different stages of the tobacco epidemic.