Australian and New Zealand Journal of Public Health

The *Australian and New Zealand Journal of Public Health* (previously the *Australian Journal of Public Health)* is the journal of the Public Health Association of Australia Inc.

Volume 26, Number 4 **August 2002**

The effect of a smoke-free law on restaurant business in South Australia

Melanie Wakefield

Centre for Behavioural Research in Cancer, Cancer Control Research Institute, The Cancer Council Victoria

Mohammad Siahpush, Michelle Scollo, Anita Lal

VicHealth Centre for Tobacco Control, Cancer Control Research Institute, The Cancer Council Victoria

Andrew Hyland

Department of Cancer Prevention, Epidemiology and Biostatistics, Roswell Park Cancer Institute, New York, United States

Kieran McCaul

Department of Public Health, University of Western Australia, Western Australia

Caroline Miller

Tobacco Control Research and Evaluation, Anti-Cancer Foundation of South Australia

Correspondence to:
Melanie Wakefield, Centre for Behavioural Research in Cancer, Cancer Control Research Institute, The Cancer Council Victoria, 100 Drummond Street, Carlton, Victoria 3053.
Fax: (03) 9635 5380; e-mail: melanie.wakefield@cancervic.org.au

The effect of a smoke-free law on restaurant business in South Australia

Melanie Wakefield

Centre for Behavioural Research in Cancer, Cancer Control Research Institute, The Cancer Council Victoria

Mohammad Siahpush, Michelle Scollo, Anita Lal

VicHealth Centre for Tobacco Control, Cancer Control Research Institute, The Cancer Council Victoria

Andrew Hyland

Department of Cancer Prevention, Epidemiology and Biostatistics, Roswell Park Cancer Institute, New York, United States

Kieran McCaul

Department of Public Health, University of Western Australia, Western Australia

Caroline Miller

Tobacco Control Research and Evaluation, Anti-Cancer Foundation of South Australia

Abstract

Background: Despite evidence to the contrary from overseas research, the introduction of smoke-free legislation in South Australia (SA), which required all restaurants to go smoke-free in January 1999, sparked concerns among the hospitality industry about loss of restaurant business. This study aimed to determine whether the law had a detrimental impact on restaurant business in SA.

Methods: Using time series analysis, we compared the ratio of monthly restaurant turnover from restaurants and cafés in SA to (a) total retail turnover in SA (minus restaurants) for the years 1991 to 2001 and (b) Australian restaurant turnover (minus SA, Western Australia and the Australian Capital Territory) for the years 1991-2000.

Results: There was no decline in the ratio of (a) SA restaurant turnover to SA retail turnover or (b) SA restaurant turnover to Australian restaurant turnover.

Conclusion: The introduction of a smoke-free law applying to restaurants in SA did not adversely affect restaurant business in SA.

(*Aust N Z J Public Health* 2002; 26: 375-82)

Research from the United States on the impact of restrictions on smoking in restaurants has repeatedly demonstrated that smoke-free laws do not reduce overall restaurant business, when examined by using restaurant sales tax data,[1-7] restaurateur reports,[8] change in employment of staff[9-10] or consumer surveys.[11-12] Yet, wherever laws that prohibit smoking in restaurants are proposed or enacted, the tobacco industry and local restaurant and hotel associations attempt to prevent the legislation being adopted or to weaken it, claiming its impact on business is likely to be negative.[13]

Australia has been no exception. In South Australia (SA), news coverage casting doubt on the wisdom and necessity of its smoke-free restaurant legislation implied that a restaurant "smoking ban would spell disaster".[14-16] Despite these vocal concerns, SA prohibited smoking in restaurants at the beginning of 1999. Legislation restricting smoking in workplaces and public places also came into effect in the Australian Capital Territory in 1995,[17] in Western Australia in 1999, in New South Wales in September 2000, in Victoria in July 2001, in Tasmania in September 2001 and has been mooted in Queensland. In the context of these developments, this paper aims to assess whether the introduction of complete restrictions on smoking in restaurants in SA was associated with a loss in restaurant business.

The SA legislation

In SA, legislation to create smoke-free restaurants was passed in February 1997, and enacted on 4 January 1999 as part of the State's Tobacco Product Regulation Act 1997.[18] The legislation was based on self-enforcement, with government officers responding to complaints and providing advice to proprietors. The Act provided for fines of up to $200 for smoking in a smoking-prohibited area and up to $1,000

Correspondence to:
Melanie Wakefield, Centre for Behavioural Research in Cancer, Cancer Control Research Institute, The Cancer Council Victoria, 100 Drummond Street, Carlton, Victoria 3053.
Fax: (03) 9635 5380; e-mail: melanie.wakefield@cancervic.org.au

Submitted: November 2001
Revision requested: April 2002
Accepted: May 2002

for a proprietor's failure to comply with the legislation.

The Act imposed complete restrictions on smoking in all enclosed public dining or café areas, but provided for some exemptions. Hotels, for example, were exempted if they had more than one public dining area or in the evenings when bands were playing. In the event that a licensed premise had two separately enclosed public dining areas, one of those areas could be prescribed as a smoking area by the licensee, if it also functioned as a bar. In the event that a licensed premise had only one enclosed public dining area, the licensee could permit smoking between the hours of 9 pm and 5 am, if the venue was being used for live entertainment and as long as meals were neither being served, nor available. In addition, premises that had only one public dining or café area were permitted to apply to the SA Minister for Human Services for an exemption to allow smoking in a sub-section of their public dining or café area. The conditions for granting exemptions include:

i) the display of signs;
ii) the installation, operation and maintenance of ventilation and air-conditioning equipment; and
iii) the maintenance of a bar or lounge area, or other area in which smoking will be permitted, as a distinct area separated by at least 1.5 metres from an area occupied by tables and chairs used for meals.[18]

The introduction of the legislation was accompanied by a mass-media public information campaign as well as information targeted to restaurant owners and managers, with a telephone hotline for further assistance.

Against the background of this legislative change, this paper examines the impact of complete smoking restrictions on restaurant retail turnover in SA.

Method

Data sources and variables

Data on restaurant sales were obtained from the Retail Trade Survey undertaken by the Australian Bureau of Statistics (ABS).[19] This survey aims to provide information about month-to-month movement of retail turnover across all retail sectors in States and Territories of Australia and Australia as a whole. Turnover consists of retail sales and wholesale sales. This includes takings from repairs, meals and hiring of goods (except for rent, leasing and hiring of land and buildings), commissions from agency activity (e.g. commissions received from collecting dry cleaning, selling lottery tickets, etc) and net takings from gaming machines. From July 2000, turnover includes the newly introduced goods and services tax. Approximately 6,600 enterprises (with at least one retailing location) representing approximately 20,000 shops or stores are in the survey sample each month. The sampling frame for the survey is the ABS Business Register, which sources its information about new businesses from those applying for group employer registration with the Australian Taxation Office.[19]

The survey design is based on stratified random sampling, such that all retailing enterprises have a chance of selection, not just those in major cities. Voluntary rotation techniques are used, with retailers participating in the survey for a three-year period. All enterprises are stratified according to their State of location, industry and employment.

While a self-completion reply-paid questionnaire is sent to a number of retailers, most retailers elect to provide the data by telephone. The ABS uses computer-assisted telephone interviewing techniques to collect these data. The information sought is collected under the authority of the Census and Statistics Act and the survey has a final response fraction of 99%.

Within the survey, turnover data are available for the category of 'restaurants and cafés'. The definition of cafes and restaurants used for the survey from the Australian and New Zealand Standard Industrial Classification (ANZSIC) is ANZSIC code 5730, defined as 'units mainly engaged in providing meals for consumption on the premises'. This class does not include premises mainly designed for take-away foods (which are not included as restaurants in the SA legislation, unless they provide sit-down dining facilities inside the establishment).

Turnover dollar figures used in this study have been adjusted for inflation using the consumer price index (CPI).[20] The data have also been seasonally adjusted by the ABS to remove systematic, calendar-related effects. These include increased spending in December as a result of Christmas, as well as trading day influences arising from the varying length of each month and the varying number of particular days in each month.

Following Glantz and Smith[1,2] to account for underlying economic trends, unemployment and population changes, we computed the following two ratios:

- ratio of monthly turnover for restaurants and cafés to total monthly retail turnover (minus restaurant and café turnover) for SA from April 1991 to April 2001; and
- ratio of monthly turnover for restaurants and cafés in SA to monthly turnover for restaurants and cafés in Australia from April 1991 to August 2000 (minus SA, Western Australia (WA) and the Australian Capital Territory (ACT)).

These two ratios, hereafter RATIO1 and RATIO2, would be expected to decrease if the implementation of the smoke-free policy had an adverse effect on restaurant sales. WA and ACT restaurant and café sales data were omitted from computation of RATIO2 since implementation of smoke-free policies in WA and the ACT occurred during the period under analysis and could have influenced the results. RATIO2 was computed only to August 2000, the month before implementation of smoke-free restaurant legislation in New South Wales.

Statistical analysis

We used 'interrupted time series analysis' (also referred to as 'intervention analysis') to estimate the effect on RATIO1 and RATIO2 of the smoke-free legislation in SA. In this analysis, RATIO1 and RATIO2 are two time series and smoke-free legislation is the intervention. Because of the presence of significant autocorrelation in most time series data, techniques such as ordinary least squares (OLS) regression often provide biased estimates of standard errors, which lead to incorrect tests of significance.[21] OLS has other serious shortcomings in dealing with time series.[22] Other proposed methods such as generalised least squares,[23-24] which purport to control for autocorrelation, are of limited use, since they make the unrealistic assumption that the structure of serial dependence is known.[25] Thus, interrupted time series analysts are recommended to use 'autoregressive integrated moving average' (ARIMA) models developed by Box and Jenkins[26-27] to identify the structure of the error term ('noise') and thus control for the factors inherent in the time series that affect its level.[21] Once these factors are controlled for and autocorrelation is modelled, the analyst will be able to provide an honest test of the effect of intervention on the behaviour of the time series. Accordingly, ARIMA models were used in this research, as explained in Appendix 1.

We examined three intervention models, based on the type of impact of the intervention on the time series: abrupt and permanent; gradual and permanent; and abrupt and temporary. Each model was tested separately. The first model suggests that intervention results in a sudden shift in the level of the time series, and that this shift will be permanent. The second model suggests that the intervention will gradually change the level of the time series, and that this accumulated effect will be permanent. Finally, the third model suggests that the intervention will result in a sudden change in the time series, but that this change will disappear in a relatively short period of time. The ARIMA procedure in SAS/ETS[28] was used for the analyses and parameter estimates were computed with the conditional least-squares estimation method.

Results

Figure 1 shows the plots of the CPI and seasonally adjusted restaurant turnover in SA from April 1991 to April 2001. The vertical line represents January 1999, when the smoke-free law (the intervention) came into effect. The average monthly turnover in the period before the introduction of the law was $29,852,000. This figure increased to $31,256,000 in the period after the law. The graph shows no trend to January 1994, followed by a declining trend until January 1999. Subsequently, there was an upward trend, indicating an increase in restaurant turnover. The plot of RATIO1 and RATIO2 are shown in Figures 2 and 3, respectively. The fluctuations in the two plots mirror each other and generally follow the pattern exhibited by restaurant turnover in Figure 1. However, the increase for RATIO2 is much less than for RATIO1 and monthly restaurant turnover.

Identification of RATIO1 and RATIO2

It is recommended that in interrupted time series analysis, only the data points before the intervention be used for the identification of the error process.[22,25,29] Accordingly, we used data prior to

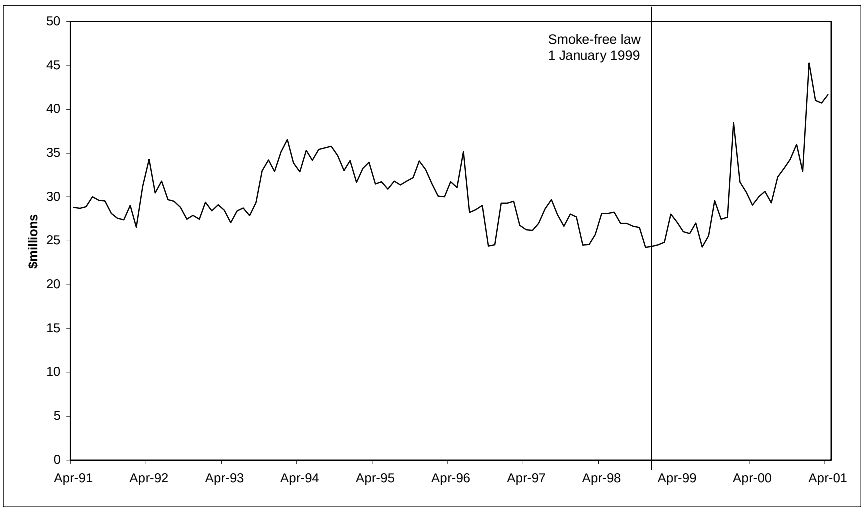

Figure 1: Monthly turnover for restaurants and cafes in SA, April 1991 to April 2001. (CPI and seasonally adjusted.)

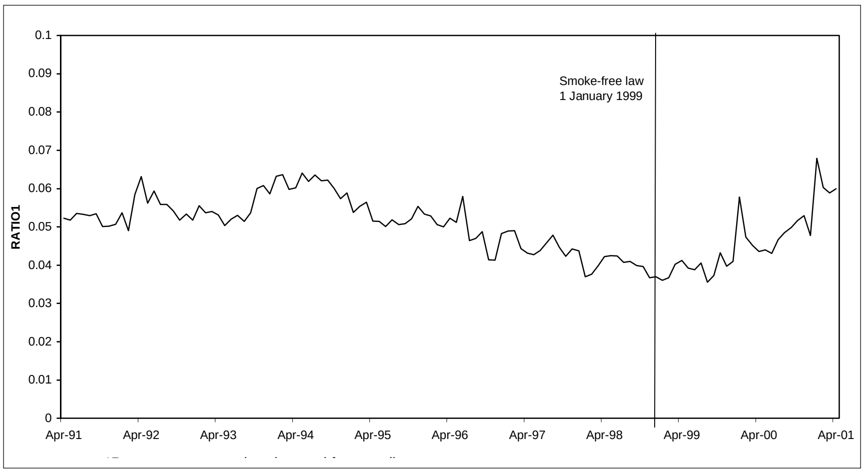

Figure 2: Ratio of SA restaurant sales to SA retail sales (RATIO1), April 1991 to April 2001. (Restaurant turnover is subtracted from retail turnover.)

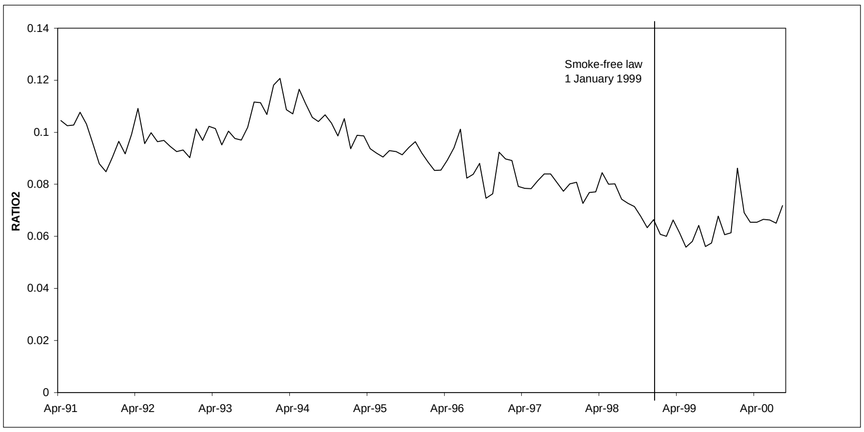

Figure 3: Ratio of monthly turnover for restaurants and cafes in SA to monthly turnover for restaurants in Australia (RATIO2), April 1991 to August 2000. (Minus SA, WA and ACT.)

January 1999 for identification. The autocorrelation function (ACF) for both series started with high positive values that gradually decreased to zero, indicating the presence of a trend or drift (known as nonstationarity). After first differencing, the slowly decaying pattern of ACF disappeared in both series. The ACF for RATIO1 dropped to zero after the first lag and the ACF for RATIO2 dropped to zero after the second lag. Given that all variables were seasonally adjusted, ACF showed no significant values at lags 12 and 24, which indicates that the current levels of the two time series were not correlated with their levels 12 and 24 months ago. The partial autocorrelation function (PACF) for both series tailed off exponentially. This pattern suggested that the process for RATIO1 was best described as ARIMA (0,1,1) and that the process for RATIO2 was best described as ARIMA (0,1,2). The numbers in parentheses indicate the order of the autoregressive, degree of differencing and order of moving average components of the time series process, respectively. The former model indicates: no autoregressive parameter, first differencing and a first order moving average process. The latter model indicates: no autoregressive parameter, first differencing and a second order moving average process. Q_6, Q_{12}, Q_{18} and Q_{24} were all non-significant for both series, suggesting that the residuals were white noise.

Intervention models

Tables 1 and 2 provide parameter estimates for the impact of smoke-free legislation on RATIO1 and RATIO2. The diagnostic test of the Q statistics shown in each table indicates that the residuals were not significantly different from white noise and so the models were statistically adequate. Each table provides a set of three models: model 1 is used to test the hypothesis of an abrupt and permanent impact; model 2 tests the gradual and permanent impact hypothesis; and model 3 tests the abrupt and temporary impact hypothesis. As explained further in Appendix 1, θ_0 is the intercept, θ_1 and θ_2 are the first and second order moving average parameters, ω is the impact of intervention at the moment of intervention and δ describes the rate of change in the level of the time series after the moment of intervention. Note that while estimation models for RATIO1 (see Table 1) contain θ_1, those for RATIO2 (see Table2) contain the additional second order moving average parameter θ_2. This follows from the process of identification explained above and indicates that while RATIO1 is affected by the random shock from the immediately previous time period, RATIO2 is affected by the random shocks belonging to both the first and second preceding time periods.

Because ω was not significant in any of the models, none of

Table 1: Conditional least squares ARIMA and transfer function estimates for the intervention model explaining the ratio of SA restaurant to SA retail turnover (RATIO1).

	Model 1[a]		Model 2[b]		Model 3[c]	
Parameters	**Coefficient**	***p***	**Coefficient**	***p***	**Coefficient**	***p***
θ_0	0.000	0.729	0.000	0.724	0.000	0.744
θ_1	0.436	<0.001	0.436	<0.001	0.439	<0.001
ω	-0.001	0.847	-0.001	0.794	-0.002	0.472
δ			-0.290	0.939	0.353	0.794
Q_6	6.24	0.284	6.28	0.280	6.34	0.274
Q_{12}	12.38	0.336	12.52	0.326	12.86	0.302
Q_{18}	18.21	0.376	18.33	0.368	18.49	0.368
Q_{24}	22.98	0.462	22.96	0.463	22.06	0.517

Notes:
(a) The model of abrupt and permanent impact: $(1 – B)Y_t = \theta_0 + (1 – \theta_1 B)a_t + \omega I_t$, where Y_t is RATIO1 at time t, and I_t is intervention dummy variable coded '0 = before intervention' and '1 = thereafter or at the moment of intervention'.
(b) The model of gradual and permanent impact: $(1 – B)Y_t = \theta_0 + (1- \theta_1 B)a_t + [\omega/(1 – \delta B)]I_t$, where Y_t is RATIO1 at time t, and I_t is intervention dummy variable coded '0 = before intervention' and '1=thereafter or at the moment of intervention'.
(c) The model of abrupt and temporary impact: $(1 – B)Y_t = \theta_0 + (1 – \theta_1 B)a_t + [\omega/(1 – \delta B)]I_t$, where Y_t is RATIO1 at time t, and I_t is intervention dummy variable coded '0 = before and after intervention' and '1 = at the moment of intervention'.

the three hypotheses could be supported. Note that the rate parameter δ was significant in model 3, Table 2. However, in the absence of a significant ω, the magnitude and significance level of δ is irrelevant to the test of the abrupt and temporary impact hypotheses. The non-significant ω in this model indicates there was no effect of the smoke-free policy and it would be nonsensical to conclude that this absence of effect diminished to zero at a significant rate. In short, the results of the analysis showed that the introduction of a smoke-free policy in restaurants in SA did not have an impact on the ratio of SA restaurant to SA retail turnover and the ratio of SA restaurant to Australian restaurant turnover.

Additional analyses were performed using SA State final demand, gambling revenue, and number of beds occupied in hotels/motels as control variables. None had a significant effect on RATIO1 and RATIO2, and the results reported above did not change.

Discussion

The results of these analyses suggest that the presence of a law prohibiting smoking in restaurants in SA was not associated with a decline in monthly restaurant turnover in that State.

There are a number of potential limitations to this study. First, data are self-reported by business owners and managers and, as is the case with all self-reported data, there may be misreporting of data, non-response, deficiencies in coverage, and processing errors. However, the ABS makes every effort to minimise reporting error by careful design of questionnaires, intensive training and supervision of interviewers and efficient data processing procedures. Furthermore, the survey has a response fraction of over 99%. Since information sought in the survey is collected under the authority of the Census and Statistics Act 1905, respondents who are directed in writing to provide the information are legally obliged to do so. We note that even though we used seasonally adjusted estimates of turnover, these adjustments do not eliminate the effect of irregular influences, such as abnormal weather and industrial disputes, that may influence turnover. However, while these influences may affect turnover for some individual months, it is unlikely that they have systematically influenced turnover before and after the smoke-free restaurant law.

One of the most obvious limitations of using aggregate information on restaurant turnover is that, if there are exemptions to the legislation whereby some restaurants allow smoking after the smoke-free law is implemented, migration of diners to or away from these restaurants cannot be detected. However, as of September 2000, there were 250 public dining areas (10% of all dining areas) with exemptions, most of which have been for restaurants in hotels or licensed clubs (Department of Human Services, personal communication, September 2000). This would be most unlikely to undermine the smoke-free status of restaurants as a whole after January 1999, so that the validity of the comparison before and after January 1999 is preserved.

We note that revenue from dining rooms in hotels and licensed clubs is not included in the category of 'cafés and restaurants', but is aggregated with information from 'hotels and licensed clubs' to contribute to a total turnover figure for these establishments, along with revenue from alcohol sales. This means that the total sales from dining-out activity are under-estimated in the data series for 'cafés and restaurants'. Some might argue that there might have been migration away from restaurants towards dining rooms of hotels and licensed clubs after January 1999, since although smoking was not permitted in these dining areas, it was still permitted in adjacent bar and gaming areas, creating a more accommodating environment for smokers. If this were the case, our data would have shown a disproportionate decline in restaurant turnover after the restaurant law took effect and we did not find this.

We considered a number of alternative interpretations of the findings. Lack of compliance with the law, through smokers continuing to smoke in restaurants even though the law was in

Table 2: Conditional least squares ARIMA and transfer function estimates for the intervention model explaining the ratio of SA restaurant to Australian restaurant turnover (RATIO2).

	Model 1[a]		Model 2[b]		Model 3[c]	
Parameters	**Coefficient**	***p***	**Coefficient**	***p***	**Coefficient**	***p***
θ_0	-0.000	0.251	-0.000	0.280	-0.000	0.200
θ_1	0.327	<0.001	0.329	<0.001	0.339	<0.001
θ_2	0.277	0.004	0.280	0.004	0.286	0.003
ω	-0.006	0.236	-0.006	0.286	-0.008	0.118
δ			0.029	0.974	0.918	<0.001
Q_6	5.54	0.237	5.50	0.240	5.54	0.236
Q_{12}	12.24	0.270	12.35	0.262	12.00	0.285
Q_{18}	15.74	0.471	15.92	0.458	15.60	0.4811
Q_{24}	18.66	0.666	18.78	0.659	18.38	0.683

Notes:

(a) The model of abrupt and permanent impact: $(1 - B)Y_t = \theta_0 + (1 - \theta_1 B - \theta_2 B^2)a_t + \omega I_t$, where Y_t is RATIO2 at time t, and I_t is intervention dummy variable coded '0 = before intervention' and "1 = thereafter or at the moment of intervention'.

(b) The model of gradual and permanent impact: $(1 - B)Y_t = \theta_0 + (1 - \theta_1 B - \theta_2 B^2)a_t + [\omega/(1 - \delta B)]I_t$, where Y_t is RATIO2 at time t, and I_t is intervention dummy variable coded '0 = before intervention' and '1 = thereafter or at the moment of intervention'.

(c) The model of abrupt and temporary impact: $(1 - B)Y_t = \theta_0 + (1 - \theta_1 B - \theta_2 B^2)a_t + [\omega/(1 - \delta B)]I_t$, where Y_t is RATIO2 at time t, and I_t is intervention dummy variable coded '0 = before and after intervention' and '1 = at the moment of intervention'.

effect, would have meant that there would have been no change in circumstance and thus no reason to look for any change in restaurant turnover. However, compliance with the law is high, as reported by the public and restaurant owners and managers.[30] This concurs with other studies of compliance in restaurants.[11,12,31,32]

It is possible that turnover could remain constant if there had been a decrease in the cost of dining out after the restaurant law took effect, resulting in greater dining-out activity, and concealing any effect of the smoke-free law. However, ABS consumer price index data on the cost of a meal in SA show no such decrease after the restaurant law. This can therefore be discounted as a viable alternative explanation.[33]

The findings from this study are consistent with other research from the United States using aggregate data on restaurant sales.[1-7] The findings are also consistent with reported data on dining out from the community and restaurateurs in South Australia.[30] While it is possible that some smokers may avoid, and persist in avoiding, smoke-free restaurants, the overwhelming evidence is that the percentage of smokers who do this is extremely small and is more than compensated for by increased patronage on the part of non-smokers.[11,12] Reviews of evidence from the most rigorous studies consistently suggest no overall adverse effect on smoke-free laws on restaurant trade.[13]

Given the weight of evidence, one begins to wonder why there is such intense opposition to the introduction of smoke-free laws in restaurants. There is similar resistance to the introduction of smoke-free laws in bars, despite evidence that they do not adversely affect hotel business[2,34,35] and improve bartenders' health.[36] Plainly, the creation of smoke-free restaurants sends a strong message that smoking around other people is socially unacceptable.[13] There is evidence from the United States that more extensive restrictions on smoking in public places, such as those that include restaurants, reduce uptake of smoking by teenagers and teenage smoking prevalence, perhaps because these restrictions make smoking seem less desirable to adolescents.[37,38] Importantly, the creation of smoke-free public places reduces opportunities to smoke. Smoke-free workplaces, for example, reduce daily consumption by current smokers and promote cessation.[39] Approximately 22.3% of the 2.7 billion fewer cigarettes consumed in Australia between 1988 and 1995 can be attributed to smoke-free workplaces.[39] Increasing restrictions on smoking in restaurants, hotels and nightclubs, can be expected to further reduce opportunities to smoke.[40]

In May 2001 in Australia, a non-smoking bar worker was awarded damages for laryngeal cancer caused by exposure to passive smoking in a Returned and Services League (RSL) club.[41] This case has resulted in considerably heightened interest and action on the part of many RSL clubs and other bars, and many now see legislative action in this area as inevitable.[42-46] Australian jurisdictions that are considering the extension of restrictions on smoking to these establishments ought to be encouraged by the findings of this study, in that they add further reason to expect no negative impact on business.

In conclusion, this study has shown that the introduction of a smoke-free law in SA has not adversely affected restaurant turnover. Restaurateurs and government policymakers in Australia should be reassured that they may adopt and maintain smoke-free legislation to protect non-smokers from exposure to secondhand smoke in restaurants without fear of adverse effects on patronage.

Acknowledgements

Funding for this project was provided by the South Australian Department of Human Services. We thank the ACT Department of Health and Community Care for providing funding to develop and refine the analytic method for this study.

References

1. Glantz SA, Smith LRA. The effect of ordinances requiring smoke-free restaurants on restaurant sales. *Am J Public Health* 1994;84:1081-5.
2. Glantz SA, Smith LRA. The effect of ordinances requiring smoke-free restaurants and bars on revenues: a follow-up. *Am J Public Health* 1997;87:1687-93.
3. Hwang P, Tobias S, Kohout S, et al. Assessment of the impact of a 100% smoke-free ordinance on restaurant sales. West Lake Hills, Texas 1992-1994. *MMWR Morb Mortal Wkly Rep* 1995;44:370-2.
4. Sciacca J, Ratcliff M. Prohibiting smoking in restaurants: effects on restaurant sales. *Am J Health Prom* 1998;12:176-84.
5. Goldstein A, Sobel R. Environmental tobacco smoke regulations have not hurt restaurant sales in North Carolina. *N C Med J* 1998;59:284-8.
6. Bartoch W, Pope G. The economic effect of smoke-free restaurant policies on restaurant business in Massachussetts. *J Public Health Manag Pract* 1999;5:63-73.
7. Hyland A, Cummings KM, Nauenberg E. Analysis of taxable sales receipts: Has the New York City Smoke-Free Air Act harmed the city's restaurant or hotel industries? *J Public Health Manag Pract* 1999;5:14-21.
8. Hyland A, Cummings KM. Restaurateur reports of the economic impact of the New York City Smoke-Free Air Act. *J Public Health Manag Pract* 1999;5:37-42.
9. Hyland A, Cummings KM. Restaurant employment before and after the New York City Smoke-Fee Air Act. *J Public Health Manag Pract* 1999;5:22-7.
10. Hyland A, Vena C, Cummings KM, Lubin A. The effect of the Clean Indoor Air Act of Erie County, NewYork, on restaurant employment. *J Public Health Manag Pract.* 2000;6:76-85.
11. Hyland A, Cummings KM. Consumer response to the New York City Smoke-Free Air Act. *J Public Health Manag Pract* 1999;5:28-36.
12. Corsun DL, Young CA, Enz CA. Should NYC's restaurateurs lighten up? Effects of the City's Smoke-Free Air Act. *Restaurant Management* 1996;April:25-33.
13. Glantz SA. Smokefree restaurant ordinances don't affect restaurant business. Period. *J Public Health Manag Pract* 1999;5:vi-ix.
14. Insight: Smoke Signals. *The Advertiser* (Adelaide) 1999 July 31.
15. Should our restaurants be smoke-free? *The Advertiser* (Adelaide) 1997 February 22.
16. Smoking ban would spell disaster. *The Advertiser* (Adelaide) 1997 February 19.
17. Goodin M. Clean indoor air legislation in Australia. *Tob Control* 1995;4:294-5.
18. *Tobacco Products Regulation Act 1997* (SA).
19. Australian Bureau of Statistics. *Retail Trade, Australia (8501.0)*. Canberra: AGPS, 2001 May.
20. Australian Bureau of Statistics. *Consumer Price Index (6401.0)*. Canberra: AGPS, 2001 August.
21. McCain J, McCleary R. The statistical analysis of the simple interrupted time-series quasi-experiment. In: Cook TD, Campbell DT, editors. *Quasi-Experimentation – Design and Analysis Issues for Field Settings*. Chicago: Rand McNally, 1979. p. 233-95.
22. McCleary R, Hay RA Jr. *Applied Time Series Analysis for The Social Sciences*. Beverly Hills: Sage Publications, 1980.
23. Hibbs DA Jr. Problems of statistical estimation and causal inference in time series regression models. In: Costner HL, editor. *Sociological Methodology 1973-74*. San Francisco: Jossey-Bass, 1974.
24. Ostrom CW Jr. *Time Series Analysis: Regression Techniques* 2nd ed. Beverly Hills: Sage, 1990.
25. McDowall D, McCleary R, Meidinger EE, Hay RA Jr. *Interrupted Time Series Analysis*. Newbury Park(CA): Sage Publications, 1980.

26. Box GE, Jenkins GM, Reinsel GC. *Time Series Analysis: Forecasting and Control*. New Jersey: Prentice Hall, 1994.
27. Box GEP, Jenkins GM. *Time Series Analysis: Forecasting and Control*. San Francisco: Holden-Day, 1976.
28. *SAS/ETS:* User's Guide 2nd ed. Version 6. Cary(NC): SAS Institute, 1993.
29. Bowerman BL, O'Connell RT. *Forecasting and Time Series: An Applied Approach*. Belmont(CA): Duxbury Press, 1993.
30. Miller C, Wakefield M, Kriven S, Hyland A. Evaluation of smoke-free dining in South Australia: support and compliance among the community and restaurateurs. *Aust N Z J Public Health* 2002;26:38-44.
31. Goodin M, McAllister I. Evaluating compliance with Australia's first smoke-free public places legislation. *Tob Control* 1997;6:326-31.
32. Chapman S, Borland R, Lal A. Has the ban on smoking in NSW restaurants worked? A comparative observational study of Sydney and Melbourne restaurants. *Med J Aust* 2001;174:512-5.
33. *Consumer Price Index by capital city, by group, subgroup and expenditure class.* Canberra: Australian Bureau of Statistics, 2001. Catalogue No.: 6455. 0.40.001.
34. Glantz SA. Effect of smoke-free bar law on bar revenues in California. *Tob Control* 2000;9:111-2.
35. Glantz SA, Charlesworth A. Tourism and hotel revenues before and after the passage of smoke-free restaurant ordinances. *J Am Med Assoc* 1999;281:1911-8.
36. Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after the establishment of smoke-free bars and taverns*. J Am Med Assoc* 1998;280:1909-14.
37. Chaloupka FJ, Grossman M. Price, tobacco control policies and youth smoking. *J Health Economics* 1997;16:359-373.
38. Wakefield MA, Chaloupka FJ, Kaufman NJ, Orleans CT, Barker DC, Ruel EE. Effect of restrictions on smoking at home, school and in public places on teenage smoking cross sectional study. *Br Med J* 2000;321:333-7.
39. Chapman S, Borland R, Scollo M, et al. The impact of smoke-free workplaces on declining cigarette consumption in Australia and the United States. *Am J Public Health* 1999;89:1018-23.
40. Philpot SJ, Ryan SA, Torre LE, Wilcox HM, Jalleh G, Jamrozik K. Effect of smoke-free policies on the behaviour of social smokers. *Tob Control* 1999;8:278-81.
41. Chapman S. Australian bar worker wins payout in passive smoking case. *Br Med J* 2001;322:1139.
42. Club bans smoking. *Sydney Morning Herald* 2001 May 12; p. 13.
43. Pubs resigned to ban on smoking. *The Age* 2001 May 7; p. 3.
44. Smoke award put heat on employers. *The Advertiser* (Adelaide) 2001 May 4; p. 14.
45. Smoking ban in pubs, clubs inevitable. *The Australian* 2001 May 4; p. 8.
46. More smoke bans on the way. *The West Australian* 2001 May 4; p. 16.
47. Ljung GM, Box GEP. On a measure of lack of fit in time series models. *Biometrika* 1978;64:517-22.

Appendix 1: autoregression, integration and moving average

We briefly explain the three components of ARIMA models: 'autoregression (AR)', 'integration (I)' and 'moving average (MA)'.

Let… Y_{t-1}, Y, Y_{t+1}, … denote observations at times … t-1, t, t+1, …. Let ..a_{t-1}, a_t , a_{t+1}… be random error (or 'random shock') which is randomly drawn from a normal distribution with zero mean and constant variance. The basic (first order) 'autoregressive' model is written as:

$Y_t = \theta_0 + \phi_1 Y_{t-1} + a_t$,

where θ_0 is the intercept parameter and ϕ is the first order autoregressive parameter to be estimated. This equation indicates that each observation in the time series is linearly dependent on its previous observation and the random shock. The process is called autoregressive because each value is regressed on its own lagged value. The basic (first order) 'moving average' model is written as:

$Y_t = \theta_0 + a_t - \theta_1 a_{t-1}$,

where θ_1 is the first order moving average parameter to be estimated. This equation indicates that each observation is dependent on the present and a portion of the previous random shock. The process is called moving average because each value is the weighted average of the present and recent random errors. The above two basic models can be expanded to include linear dependence on more distant observations and random shocks. For example, a second order autoregressive model and a second order moving average model are written as:

$Y_t = \theta_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + a_t$, and

$Y_t = \theta_0 + a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2}$.

The models can also be combined to represent mixed models. For example:

$Y_t = \theta_0 + \phi_1 Y_{t-1} + a_t - \theta_1 a_{t-1}$.

However, only rarely do social science time series require the use of mixed models.[41]

Time series frequently exhibit a trend or a drift, which is referred to as 'integration'. An integrated series either consistently moves in a specific direction (upward or downward), or shifts between upward and downward movements. An integrated time series must be made 'stationary' before autoregressive and moving average parameters (ϕ and θ) can be estimated. Stationarity or detrending is achieved by 'differencing' the time series, for example by transforming each observation (Y_t) to the difference between that observation and the previous observation ($Y_t - Y_{t-1}$).

The process of determining the correct model that describes a time series requires a procedure consisting of three steps: identification, estimation and diagnosis. This procedure is repeated until a satisfactory model is achieved. The inspection of autocorrelation and partial autocorrelation function (ACF and PACF), which describe the correlation of the series with its various lags, is instrumental in the process of identification. A satisfactory model is one whose residuals are 'white noise', i.e. the series is stationary and there is no indication of autocorrelation. The diagnostic Q statistics are commonly used to test the null hypothesis of white noise.[47] Each Q statistic is a chi-square statistic calculated from a set of six or more autocorrelations. For example, Q_6 is computed from the correlation coefficient of the time series with its first, second, third, fourth, fifth and sixth lags.

In interrupted time series analysis, once the error process of the time series is satisfactorily determined (i.e. the order of the autoregressive and moving average processes, and the degree of differencing is determined), an 'intervention component'[22] (also called a 'transfer function') needs to be identified. The intervention component describes the impact of the intervention on the time series. We examined hypotheses relating to three types of impact: abrupt and permanent; gradual and permanent; and abrupt and temporary.

Let N_t be the noise or the error component as specified by the ARIMA model described above, and I_t be the intervention dummy variable coded '0 = before the intervention' and '1 = at and after intervention'. The intervention model with an abrupt and permanent impact can be written as:

$Y_t = \omega I_t + N_t$,

where ω is the effect of intervention, i.e. the net difference in the level of the time series before and after the introduction of the intervention. The intervention component in this model is wI_t. The intervention model with a gradual and permanent impact can be written as:

$Y_t = [\omega/(1-\delta B)]I_t + N_t$.

The intervention component is $[\omega/(1-\delta B)]I_t$. As in the previous model, I_t is coded '0 = before the intervention' and '1 = after the intervention'. Here ω is the change in the level of time series at the moment of intervention, δ is a rate parameter describing how quickly (or slowly) the asymptotic impact (or eventual change) is realised, and B is the so-called 'backshift operator' such that, for example, $BY_t = Y_{t-1}$. The same intervention component can be used for the model with an abrupt but temporary effect, except that I_t should be coded such that '0 = before and after intervention' and '1 = during intervention'.[22,25,29] In an abrupt but temporary model ω is again the impact of intervention at the moment of intervention and δ is a rate parameter describing the pace at which the initial effect decays to zero.

Australian and New Zealand Journal of Public Health

The *Australian and New Zealand Journal of Public Health* (previously the *Australian Journal of Public Health)* is the journal of the Public Health Association of Australia Inc.

Volume 26, Number 4 **August 2002**

Contents

Journal contact details

Mail: *Australian and New Zealand Journal of Public Health, PO Box 351, North Melbourne, Victoria 3051.*

Street deliveries: *c/- SUBStitution Pty Ltd, 1st Floor,*
484 William Street, Melbourne, Victoria 3003.

Phone: *(03) 9329 3535* ***Fax:*** *(03) 9329 3550*

E-mail: *anzjph@substitution.com.au*

Internet: *www.phaa.net.au*

Article abstracts are available at www.phaa.net.au