

ACOSH

Australian Council on Smoking and Health

SECONDHAND SMOKE IN CAFES, PUBS AND CARS

Full Report

Introduction

Environmental tobacco smoke (ETS) is the toxic combination of exhaled mainstream smoke from an active smoker and sidestream smoke emitted from the lit end of a cigarette.^{1,2} Exposure to ETS has been established as a serious health risk and a cause of premature death and disease among children and adults.²

Over the past few decades regulations have been introduced to reduce non-smokers' exposure to ETS in workplaces, restaurants and more recently in clubs and pubs. Despite these advances, ETS exposure remains a major public health issue. Recently released research by Holman and Gray at the University of WA showed that at least one child under the age of five is treated every day at Perth's public hospital emergency departments as a result of exposure to ETS.³

In Western Australia, non-smokers are still exposed to ETS in the alfresco areas of many hospitality venues and other public places. The inside of cars is also another space where children and others may be exposed to ETS. For children with parents or others who smoke, the car is a confined space where they may be exposed to high levels of ETS. Some smoking parents may believe that opening a window will be enough to clear the smoke from the car and prevent passengers' exposure to ETS. Recent evidence indicates that this is not the case.⁴

The Western Australian Parliament will soon debate amendments to the Tobacco Products Control Act 2006, which include a ban on smoking in alfresco dining and outdoor areas of pubs and clubs, in private cars when children are present, and in other specified public places.

The Australian Council on Smoking and Health (ACOSH) has been gathering data to demonstrate the potential for ETS exposure in these areas. The aim of these studies was to measure particulate matter (PM) concentrations in venues where smoking restrictions do not yet exist. These include alfresco areas of hospitality venues and private cars.

METHODS

Study 1: Air Quality Testing in Hospitality Venues

Protocol:

Particulate matter with an aerodynamic diameter of ≤ 2.5 microns (PM-2.5) was measured in various venues using the TSI SidePak AM510 air monitor ('SidePak'). These venues included cafes and pubs around Perth that feature outdoor seating areas

where smoking is permitted. A minimum of 15 minutes of PM measurements were collected in each venue during times that smokers were present. All measurements were collected in the outdoor area. A data sheet (Appendix A) was completed by the tester during each sampling period. Data collected included the time when each smoker lit up and, where possible, the tester also recorded when the smoker stopped smoking. Other data collected included venue type, characteristics of the outdoor area, patron information, pedestrian and road traffic and weather characteristics including the level of wind present.

Venues:

12 cafes and 16 pubs were selected and visited. The local government areas where testing took place were:

- City of Mandurah (5 venues)
- City of Melville (1 venue)
- City of Nedlands (1 venue)
- City of Perth (7 venues)
- City of Subiaco (4 venues)
- City of Swan (1 venue)
- City of Stirling (6 venues)
- Town of Victoria Park (3 venues).

Testing was conducted between December 2008 and February 2009.

Particulate measurements:

The SidePak can measure PM concentrations of various size ranges. We chose PM-2.5 as all tobacco smoke particles are within that size range.⁵ Although particulates of that size are released by multiple sources they are given off by burning tobacco in large quantities⁶ and PM-2.5 is considered a suitable marker for ETS.⁶ This size range is consistent with previous research measuring tobacco-related PM using the same equipment.⁴

The SidePak inlet was fitted with the PM-2.5 impactor and the air flow of the SidePak was set at 1.7 litres per minute. The SidePak was zero-calibrated every three weeks during the testing period.

The SidePak was positioned in a handbag with just the end of the intake tube sticking out to collect the air. The handbag was positioned over the tester's shoulder or on a seat – as close to breathing space as possible while remaining inconspicuous so as not to interfere with normal behaviour. The SidePak was set to record PM level readings at one minute intervals for the duration of the test.

Study 2: Air Quality Testing in a Car

Protocol:

PM-2.5 measurements were collected using the SidePak (as above) inside a car with a smoker. The car used in the study was a 2002 Toyota Echo hatchback. PM concentrations were tested under two conditions:

- 1) All car windows closed and the car was turned off.
- 2) Only the driver's window was fully open while the car was driven in normal driving conditions around suburban streets.

In both testing conditions, the smoker was the only person in the car and sat in the driver's seat. The fan and air-conditioning were off during both testing conditions. The open end of the SidePak tube was positioned at head height of the passenger seat directly behind the driver. This seat is often used as the child seat as it is thought to be the safest position in the car.

Data analyses:

1. Data preparation (Study 1 and 2)

Test data were downloaded from the SidePak to an excel spreadsheet. Data were copied into SPSS version 17 for analysis. The one minute logging intervals produced one data point for each minute of testing. The information from the data sheet (Appendix A) was entered into SPSS alongside the SidePak data.

The SidePak gives readings of milligrams of particles per cubic metre of air. To convert values to the standard way of reporting air pollution and indoor air quality, in micrograms per cubic metre of air ($\mu\text{g}/\text{m}^3$), the values were multiplied by 1000.

2. Statistical analyses

Study 1:

The data were coded in two ways. Initially, each minute of data was coded as 'smoker present' (coded as 1) or 'no smoking' (coded as 0). The 'smoker present' code was given from the closest minute to when a smoker was recorded as having lit up. If the time the smoker finished smoking was recorded, the data was coded as 'no smoking' from the next minute. If this was not recorded, a cigarette was assumed to take 4 minutes to smoke from lighting up to butting out. The duration of four minutes was selected based on the average smoking time of 4.15 minutes in research conducted through the UWA School of Paediatrics and Child Health (Sunalene Devadason, personal communication). Second, the data were re-coded as 'no smoking', 'one smoker' or 'two or more smokers'. This was to determine if there was a dose-response relationship for PM-2.5 with the number of smokers.

The particulate concentrations were not normally distributed and could not be transformed to achieve a normal distribution. Therefore, nonparametric tests were conducted using raw data. These tests included a Mann-Whitney U test to compare the mean airborne particle level for periods with 'smoker present' with all 'no-smoking' periods across all venues. A Wilcoxon Signed Ranks test was used with paired data to compare smoking and non-smoking periods at the same venue. This was to ensure results would not be strongly influenced by a large difference at just one venue. To investigate if there was a dose-response relationship depending on the number of smokers, a linear regression and a Kruskal-Wallis test was conducted using three categories of data ('no-smoking', '1 smoker only' and '2 or more smokers'). Finally, multiple linear regression models were constructed to determine if smoking affected PM-2.5 concentrations controlling for other factors. Separate models were constructed for smoking as a 2 and 3 category variable. Other factors included in the models were the average number of patrons at each venue, whether roof coverings were present, type of street the venue was located (e.g., busy main road), level of road traffic and wind.

Study 2:

The data were coded as 'no smoking' (coded as 0) or 'active smoking' (coded as 1). Descriptive statistics were calculated.

RESULTS

Study 1:

For the 28 venues 545 minutes of SidePak data were logged in total, including 157 non-smoking minutes and 388 smoking minutes. The number of minutes of data collected from each venue ranged between 14 and 28 minutes, with a mean of 19.46 minutes. Descriptive statistics and frequencies of the variables were calculated and are summarised in Table 1.

At 27 of the venues visited, ten or less people were observed to smoke during the testing periods. At 21 of these venues, five or less people were observed to smoke during the testing period.

The Mann-Whitney U test showed that the airborne particle level was statistically significantly higher during the 'smoker present' periods compared to the 'no smoking' periods, $z = -11.360, p < .001$. The average airborne particle level during the 'no smoking' minutes was $12.45 \mu\text{g}/\text{m}^3$. The average airborne particle level during the minutes where a smoker was present and actively smoking was $44.53 \mu\text{g}/\text{m}^3$.

Twenty-two venues were included in the paired analysis. Six venues did not have any 'no smoking' minutes and were therefore excluded. The Wilcoxon Signed Ranks test found a statistically significant difference was found between the average 'smoker present' and 'no-smoking' minutes, $z = -3.815, p < .001$.

PM-2.5 concentrations for the three categories are presented in Table 2. The amount of time with no, one and two or more smokers were 157, 156 and 224 minutes, respectively. It was unclear how many smokers were present during eight minutes of testing so data from those eight minutes were excluded from the analyses. PM-2.5 concentrations were $12.45 \mu\text{g}/\text{m}^3$, $33.08 \mu\text{g}/\text{m}^3$ and $53.12 \mu\text{g}/\text{m}^3$, respectively. The Kruskal-Wallis test showed that there were statistically significant differences in PM level when no, one and two or more smokers were present, $X^2(2, N=537) = 141.349, p < .001$.

The linear regression gave evidence of a dose-response relationship between the number of smokers present and PM (using raw data). The number of smokers present accounted for 12.5% of the variance in the airborne particle level. The number of smokers present (0, 1, 2+) significantly predicted the airborne particle level, $(F(1,535)=76.759, p < .001)$.

Multiple linear regression models were constructed using a Stepwise variable entry method (using raw data). The variables included in the models were the number of smokers (0, 1, 2+), average number of patrons, roof covering, type of street the venue was located on, level of road traffic and wind level. The model containing all the variables predicted 24.1% of the variance in PM level, $(F(6,530)=27.994, p < .001)$. After controlling for the other variables, the number of smokers (0, 1, 2+) remained a significant predictor of PM level, explaining 12.5% of the variance in PM level. The number of smokers was the greatest contributor of all the modelled variables in explaining the variance in PM level.

Table 1. Descriptive statistics of hospitality venue data (in $\mu\text{g}/\text{m}^3$ to two decimal points).

Smoking condition	Range	Mean (95%CI)	Median
No smoking	3.00 - 128.00	12.45 (11.83-13.07)	8.00
One or more smokers present	4.00 - 444.00	44.53 (42.30-46.76)	26.00
One smoker present only	4.00 - 227.00	33.08 (31.43-34.73)	18.00
Two or more smokers present	4.00 - 444.00	53.12 (50.46-55.78)	31.00

Study 2:

In condition one of the car study, two cigarettes were smoked. One was lit at the beginning of the test and the second cigarette was lit 10 minutes into the test. Fourteen minutes of data were collected, including 10 minutes of active smoking and 4 non-smoking minutes. Descriptive statistics for the airborne particle level were calculated. All descriptive statistics calculated for the car testing data are summarised in Table 2. Over the 14 minutes of testing, the maximum airborne particle level was $17,602\mu\text{g}/\text{m}^3$. The minimum airborne particle level was $1,240\mu\text{g}/\text{m}^3$. The average airborne particle level over the 14 minutes was $8,400\mu\text{g}/\text{m}^3$ (rounded to nearest whole number).

When the smoker was not actively smoking during condition one, the minimum airborne particle level recorded was $6950\mu\text{g}/\text{m}^3$ during minute six. The maximum level was $11,437\mu\text{g}/\text{m}^3$ in minute 8. The average level over the four non-smoking minutes was $10,066\mu\text{g}/\text{m}^3$. This represents the smoke from the first cigarette that could not escape because the windows were closed.

Airborne particle levels during condition one increased to a maximum of $17,602\mu\text{g}/\text{m}^3$ during minute 14 when the smoker was actively smoking.

In condition two, two cigarettes were smoked. One cigarette was lit at the beginning of the test and the second cigarette was lit six minutes into the test. Fifteen minutes of data were collected, including 11 minutes of active smoking and 4 non-smoking minutes. Descriptive statistics for the airborne particle level were calculated. Over the 15 minutes of testing, the maximum airborne particle level was $529\mu\text{g}/\text{m}^3$. The minimum airborne particle level was $14\mu\text{g}/\text{m}^3$. The average airborne particle level over the 15 minutes was $227\mu\text{g}/\text{m}^3$ (rounded to nearest whole number).

When the smoker was not actively smoking during condition two (driver's window open), the average airborne particle level recorded was $187\mu\text{g}/\text{m}^3$.

The highest airborne particle level recorded was $529\mu\text{g}/\text{m}^3$ during minute one when the smoker was actively smoking. The average airborne particle level when the smoker was actively smoking was $242\mu\text{g}/\text{m}^3$ (rounded to nearest whole number).

Table 2. Descriptive statistics of car testing data (in $\mu\text{g}/\text{m}^3$ to two decimal points).

Condition	Range	Mean (95% CI)	Median
1. Windows closed	1,240.00 - 17,602.00	8,399.71 (7979.72-8819.70)	9688.00
1. Windows closed (active smoking)	1,240.00 - 17,602.00	7,733.30 (7346.63-8119.97)	7073.00
1. Windows closed (no smoking)	6950.00 - 11,437.00	10,065.75 (10569.04-9562.46)	10938.00
2. Driver's window open	14.00 - 529.00	227.07 (238.42-215.72)	226.00
2. Driver's window open (active smoking)	14.00 - 529.00	241.64 (229.56-253.72)	232.00
2. Driver's window open (no smoking)	36.00 - 296.00	187.00 (177.65-196.35)	208.00

Discussion:

Both studies demonstrated that smoking, even in outdoor venues, can significantly increase airborne PM-2.5 levels. In cars in particular, PM-2.5 concentrations were shown to reach dangerously high levels when a smoker was present.

There are no guidelines or standards presently available for short term exposure to PM-2.5. Australia's National Air Quality Standards (NAQS) set an advisory reporting standard for PM-2.5 of 25µg/m³ over a one day period.⁷ The Air Quality Index produced by the US Environmental Protection Agency (EPA) indicates the level of risk associated with increasing PM-2.5 concentrations.⁸ These two guides were used to assist interpretation of the results of the current study.

Outdoor hospitality venues

When no smokers were present, the average airborne particle level was 12.45µg/m³ which fits within the 'good' range of the US EPA Air Quality Index. The average level of airborne particles given off by just one smoker was 33.08µg/m³. This is within the moderate range of the Air Quality Index and would be enough to put particularly sensitive people at risk of respiratory symptoms. When two or more people were smoking in the alfresco area, the average level of airborne particles was significantly higher at 53.12µg/m³. The US EPA warns that airborne particles at this level may be a risk to sensitive groups including children, seniors and anyone with heart or lung disease.

At all but one of the hospitality venues where airborne particle measurements were taken, ten or less people were observed to smoke during the testing periods. At 21 of the venues, five or less people were observed to smoke. The airborne particle measurements therefore reflect the ETS produced by only a small number of smokers. ETS levels would be expected to be much higher in situations where more smokers were present.

The results suggest that even in outdoor well-ventilated areas, ETS levels can be high enough to be a health risk to others nearby.

Cars

With all the car windows closed, the airborne particle level reached $17,600\mu\text{g}/\text{m}^3$ after just 14 minutes. The peak airborne particle level was 70 times over the $>251\mu\text{g}/\text{m}^3$ the EPA Air Quality Index consider to be hazardous. Even after just one minute of smoking, the airborne particle level was already 5 times the hazardous level. Airborne particle levels considered hazardous carry a caution to all people, but particularly to children, older adults and those with heart and lung disease.

Airborne particle levels were still worryingly high with the driver's window completely open and the car in motion. When the driver was smoking, the airborne particle level reached $529\mu\text{g}/\text{m}^3$, over twice the level the EPA classify as hazardous. Even with the window open, the car in motion and no lit cigarette, the residual smoke from the previous cigarette remained in the car at an average airborne particle level of $187\mu\text{g}/\text{m}^3$. This was within the 'very unhealthy' range of the Air Quality Index ($151-250\mu\text{g}/\text{m}^3$).

The airborne particle levels measured in each test were produced by only two cigarettes. In situations where more than one passenger is smoking or over longer journeys when more cigarettes may be consumed, the airborne particle level would be expected to be significantly higher.

The measurements obtained highlight the potentially significant threat to children's health that ETS in private cars presents. Prolonged or regular exposure by children (or adults) to airborne particle levels as measured in the current study is potentially a serious health risk.^{2,9} The results support previous research on ETS exposure in cars which has shown that passengers may be exposed to unsafe levels of ETS when the driver smokes in the car.⁴ The results highlight the need for the introduction of measures to reduce children's exposure to ETS in the car, as contained in the amendments to the Tobacco Products Control Act 2006 which propose to ban smoking in cars when children are present.

Limitations

Some of the potential limitations of the data suggest that the findings may be an underestimation of the level of PM produced by smokers in outdoor venues. During the air quality testing, smokers were positioned at varying distances, angles and wind direction (e.g., upwind or downwind) from the SidePak. This may have influenced the extent to which the SidePak recorded the PM.

In the hospitality venues, it was not always possible to record exactly when smokers stopped smoking (i.e. finished the cigarette or left the premise) due to blocked vision of the smoker, trying to be inconspicuous and having multiple smokers to observe at one time. The lack of precision around the time taken to smoke a cigarette (e.g., individual variation in smoking behaviours) and the imperfection of the data coding procedure (e.g., due to ambient smoke which remains in the area after a cigarette is butted out) may artificially increase the background air particle levels in the 'no smoking' condition and somewhat wash out the air particle levels in the 'smoker present' condition.

Baseline PM measurements were not taken in either study. Future research would be strengthened by recording PM measurements when no smokers are present so as to estimate PM levels from non-tobacco sources. Other sources of air pollution may also have affected SidePak readings (e.g. exhaust fumes from vehicles); however, analyses attempted to control for the influence of other pollution sources. Most other pollution sources are not expected to have varied significantly within the short testing periods and are therefore not expected to have had a significant impact on the results. The lack of baseline data in study 2 prohibited meaningful statistical analyses from being conducted on the data.

Future research on PM levels in cars could investigate other testing conditions, for example, testing the PM level with the driver's window open only slightly. Having the driver's window completely down during condition two may have allowed more smoke to escape undetected and therefore washed out some of the effect.

References

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