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STUDY OF SECONDHAND TOBACCO SMOKE CONCENTRATION IN CAR DURING ACTUAL DRIVING CONDITION

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ABSTRACT

Secondhand tobacco smoke (SHS) is a toxic air contaminant that contributes to multiple, preventable adverse health outcomes. SHS exposure is associated with cardiovascular disease, cancers, and respiratory and reproductive problems. To help promote more effective protection through legislation, health communication strategies, or behavioural interventions, data demonstrating the adverse effect of SHS on air quality in cars are needed. Secondhand tobacco smoke in a car under actual driving conditions will be monitored by measuring respirable suspended particles (RSPs) of less than 2.5 microns in diameter. Driving trials will be conducted, using smokers as driver. Five smoking conditions (parked non smoking, drive non smoking, drive active smoking, immediate drive post-smoking and parked smoking period) were crossed with several ventilation conditions (2 front rear window open, all 4 window open, 2 front rear window slightly open with air conditioned and , 2 front rear window slightly open without air conditioned) during actual driving. Smoking under this several ventilation conditions of car resulted in expected increased of SHS and RSPs covaried in a predictable manner according to ventilation condition and smoking phase.

Keywords: *tobacco smoke, secondhand tobacco smoke, respirable suspended particles*

INTRODUCTION

Secondhand tobacco smoke (SHS) is also known as environmental tobacco smoke (ETS), passive smoking, involuntary smoking and perhaps a more descriptive term, tobacco smoke pollution. Regardless of what been called, SHS contain harmful chemicals and SHS exposure is associated with cardiovascular disease, cancer and respiratory and reproductive problems [1]. According the fact about smoking in Malaysia, Malaysian people spent RM 8.59 million every day to buy cigarette [2]. Estimated about 60-75% cigarette smoke would be inhaled by people who do not smoke. Usually smokers have habit to smoke in car when feeling sleepy, stress or anxiety. Smoking in motor vehicle compartment potentially can expose passenger in a car to very high concentration of the pollutants from SHS.

Respirable Suspended Particulate (RSP) refers to only those particulates that are small enough to reach the lower airways of the human lung. There are many interpretations as to the maximum particle size that such deposition occurs [3][4]. Some investigator use very conservative value of 3µm others use values of 0 or 15 µm. For particulate matter arising solely from SHS the distinction is probably not significant since virtually all SHS particulate matter in the submicron size range However, many indoor air particulate much larger than this. Some investigators use the term “respirable” to refer to only those particles less than 2.5 µm in diameter (the so called fine fraction) [5][6][7].

Particulate matter found in indoor air can be composed of both solid and liquid phase material. Solid can be either symmetrically or irregularly shaped. Indoor air particulates can be present in many forms, including mold spores, insect, animal dander, solid particulates such as dust and infiltrated diesel exhaust, inorganic aerosol (sulfates) and consumer product spray. SHS RSP is comprised of liquid or waxy droplets although there are some data that suggest that the droplets may contain very small amounts of cigarette ash, which act as condensation nuclei [3]. SHS RSP particle size range is taken as < 2.5 micrometers [1]. In this study, the notation $PM_{2.5}$ is represents particles less than 2.5 micrometers in aerodynamic diameter.

The significance of the study is to help promote more effective protection through legislation, health communication strategies, or behavioral interventions, data demonstrating the adverse effect of SHS on air quality in cars. This research also can give awareness to community about smoking threat in car toward passenger.

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METHDOLOGY

Vehicle that has been use in this study is Perodua Kelisa EZi 1.0 car. This car is chosen because the common usage among Malaysian people. Additionally, the small volume of the car would be an interesting subject for this study. A volunteer smokers age 22 years old representing an adult smoker was selected as the driver of the car.

The SHS RSP in car was measured using TSI DUSTTRAK Aerosol Monitor. The device is portable, battery-operated laser photometer with real time mass concentration readout and data logging capability. The monitor provides reliable exposure assessment by measuring particle concentration corresponding to respirable size PM_{10}, $PM_{2.5}$ or $PM_{1.0}$ size fractions. This device is also able to detect carbon monoxide (CO) concentrations. The DUSTTRAK Aerosol Monitor was zero-calibrated prior to each sampling session and set so that data were averaged and logged over 1-minute intervals. The air flow rate was set at 1.7 L/min. The cigarettes used for all data measurement was Dunhill Light.

The DUSTTRAK Aerosol Monitor was positioned in the first location at the rear passenger seat opposite the driver's side of the vehicle, measured 27 cm from the car roof. This height is chosen to represent the nose level of adult passenger. The second location is also 27 cm from the car roof in the middle of the back seat of the car. The measurement in this two location had to been done separately due to only one device is available.

This experiment was conducted in actual driving condition starting from main campus UTHM and moved to road in Parit Raja and Sri Gading. The condition of the road is straight and data collected on off peak hours. Route with traffic light is avoided to reduce traffic emission from entering the vehicle when stopped at traffic signal. The vehicle speed also is fixed to 60 to 70 km/hour.

STUDY DESIGN

A study design of five smoking phase were crossed with four ventilation conditions was employed. The fives smoking conditions were parked non smoking, drive non smoking, drive active smoking, immediate drive post-smoking and parked smoking period. While 4 ventilation conditions were 2 front rear window open, all 4 window open, 2 front rear window slightly open with air conditioned and, 2 front rear window slightly open without air conditioned. Before altering the ventilation condition, a 10-minute washout period was performed to eliminate the SHS, by driving with all windows open. The study design for each ventilation condition is summarized in Table 1.

Table 1: Study design for each ventilation condition

Ventilation Condition:		
Time (min)	**Action**	**Condition**
0-10	• Car in static condition • Monitoring RSP level in car before start driving	Parked (non-smoking)
10-20	• Car moving 60-70 km/h • Monitoring RSP level before smoking period	Drive (non-smoking)
20-25	• Car moving 60-70 km/h • Smoke one cigarette • Monitoring SHS RSP level during smoking period	Drive (active smoking)
25-30	• Car moving 60-70 km/h • Post smoking monitoring	Drive (post-smoking period)
40-45	• Car stopped • Smoke one cigarette • Monitoring SHS RSP level during static condition	Parked (active smoking)
45-60	Washout period	

The five smoking phase was selected to compare and get the significant correlation of the RSP level before and after smoking period. While parked smoking period represent RSP level exist during static condition encounters at traffic lights or traffic congestion.

The four ventilation conditions were employed to represent likely real-life driving conditions. Window "open" required the windows to be lowered half way, or approximately 25 cm. This arrangement allowed for a high degree of air flow. Window "slightly open" required window to be lowered 5 cm. It is plausible that this setting is often used by smokers under inclement weather conditions, such as rain or cold. The chosen ventilation conditions therefore reflected a range of driver ventilation settings that were easily replicable.

RESULTS AND DISCUSSION

Average real time plots of RSPs concentration measured from the front rear seat opposite the smoking driver is presented in Figure 2. As expected, RSPs concentration are lowest during all four windows are half open. The increase of RSPs concentration was the greatest during 2 front rear windows are slightly open without air conditioned.

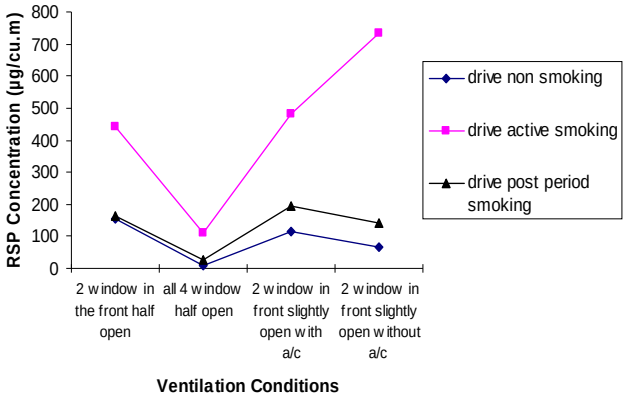

Figure2: RSPs concentration measured from the front rear seat opposite the smoking driver

Average real time plots of RSP concentration measured from the middle backseat location is presented in Figure 3. Different scenarios are detected in this case, where the substantial increase of RSP were significant during 2 front rear window are slightly open with air conditioned. This may caused by RSPs are pushed to backseat area by the effect of the air conditioned resulting in a greater value of RSPs concentration in the middle backseat measurement.

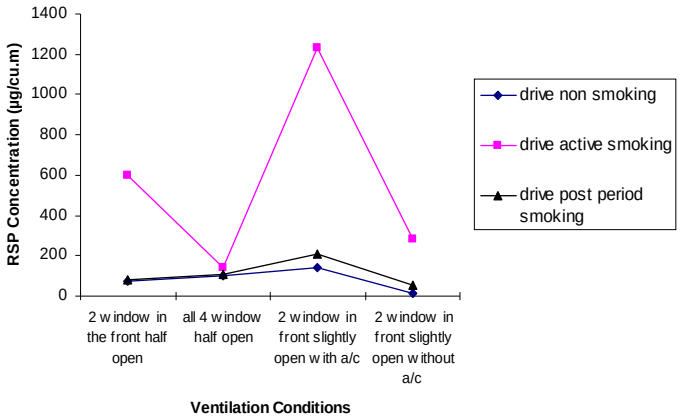

Figure3: RSPs concentration measured from middle backseat location

Apart from RSP, Carbon Monoxide (CO) also arises from smoking cigarette. However, RSP and CO can also arise from other sources, most notably traffic emissions. Therefore, it is possible that RSP and CO reading is

influence from the ambient traffic conditions or from the vehicle's exhaust system. While this source cannot be ruled out conclusively, the observation of low RSPs level during non-smoking driving suggest that vehicle emissions played a negligible role. Although a clear correlation between RSP and smoking phases are detected, CO concentrations on this study failed to give any significant correlations during actual driving conditions. A logical explanation for this is that this very light gas-phase compound might be more easily removed or diluted by air flow than heavier particle such as RSPs [1]. A significant correlation of CO can be observed only during smoking in static condition car. Thus, as shown in Figure 4, CO level at the middle back seat are lower that the front rear seat, except during 2 front rear window are slightly open with air conditioned where the CO level are slightly higher. This also caused by the similar effect of the air conditioned that pushed CO compound to the backseat area.

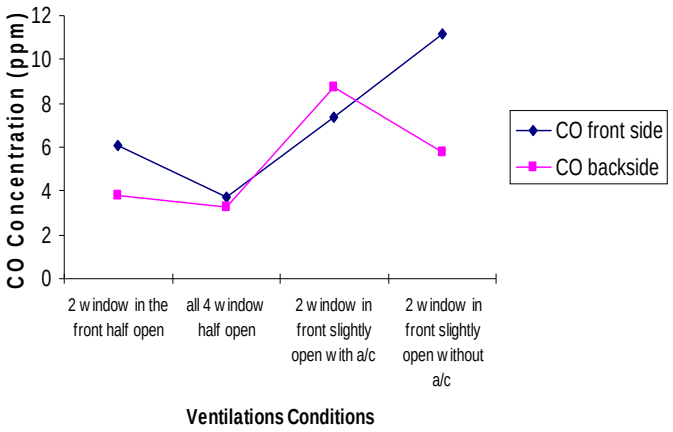

Figure4: CO concentration measured from the front rear seat opposite the smoking driver and the middle backseat location

Health standard regarding SHS generated RSPs, in vehicle during actual driving condition are still not available. However, health standard by the U.S Environmental Protection Agency's suggest air quality index rates of 24 hour exposure to $PM_{2.5}$ concentration of >40 µg/cu.m as unhealthy for sensitive group such as children and elderly and >250 µg/cu.m as hazardous for all individuals [8].

From this study, by deducting the RSPs concentration of non-smoking driving condition from RSPs concentration during active smoking and post smoking driving, the projected SHS RSP cause by smoking one cigarette can be calculated. SHS RSPs for both measuring location is presented in Figure 5 and Figure 6 below.

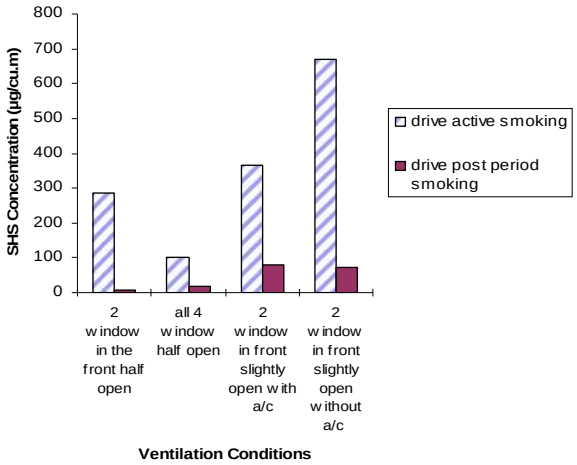

Figure 5: SHS RSPs concentration measured from the front rear seat opposite the smoking driver

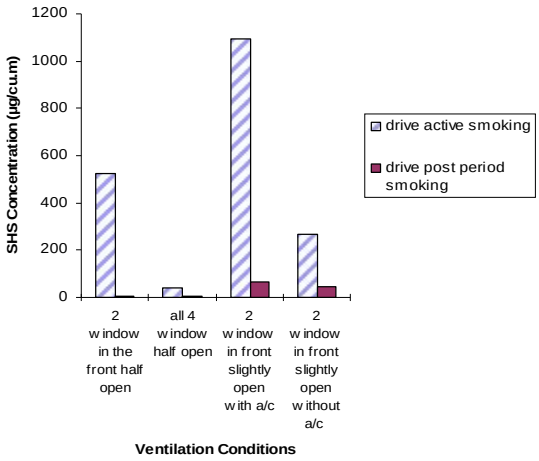

Figure 6: SHS RSPs concentration measured from middle backseat location

Although health standard by the U.S Environmental Protection Agency's [8] is for 24 hour average concentration, these data reveals alarming RSP levels generated from smoking single cigarettes for only 5 minutes in a car. The 24 hour exposure to $PM_{2.5}$ concentration of >350 µg/cu.m consider as very hazardous and >500 µg/cu.m as significant harm condition [8]. These graphs clearly shows that for all the ventilation conditions measurement that had been execute in this study, lowering all 4 windows during active smoking is the only ventilation condition acceptable to reduce the SHS RSP to the acceptable level.

CONCLUSIONS

From this study, it might be implied that all 4 windows opened or adequate ventilation in moving vehicle is able to help maintain exposure of SHS RSP exposure at an acceptable level. Extra caution should be made when smoking under cold or rainy condition in when only slight window opening is applicable. Children or elderly sitting at the back seat of car should be consider during smoking since their body are more sensitive towards smaller amount of RSP concentrations. Thus, it is recommended that smoking in car should only applicable if all the windows are opened to minimize the risks to the passengers. Hopefully this study would give an insight on the SHS RSP level in moving vehicles in order to promote protection through legislation, health communications strategies or behavioural intervention where such data are needed.

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