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Exposure to tobacco secondhand smoke and its associated factors among non-smoking adults in smoking-restricted and non-restricted areas: findings from a nationwide study in Malaysia

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ABSTRACT

Objectives Secondhand smoke (SHS) has been associated with increased morbidity and mortality. Therefore, the aims of the paper are to assess SHS exposure among non-smoking adults in Malaysia attending various smoking-restricted and non-restricted public areas according to the Control of Tobacco Product Regulations (CTPR) as well as its relationship with various sociodemographic variables.

Design Data were extracted from a cross-sectional study, the Global Adults Tobacco Survey (GATS) 2011 which involved 3269 non-smokers in Malaysia. Data was obtained through face-to-face interviews using a validated pre-tested questionnaire. Factors associated with exposure to SHS were identified via multivariable analysis.

Results The study revealed that almost two-thirds of respondents were exposed to SHS in at least one public area in the past 1 month, with a significantly higher exposure among males (70.6%), those with higher educational attainment (81.4%) and higher income (quintile 1%–73.9%). Besides, the exposure to SHS was almost four times higher in non-restricted areas compared with restricted areas under the CTPR (81.9% vs 22.9). Multivariable analysis revealed that males and younger adults at non-restricted areas were more likely to be exposed to SHS while no significant associated factors of SHS exposure was observed in restricted areas.

Conclusions The study revealed the prevalence of SHS exposure was higher among Malaysian adults. Although smoke-free laws offer protection to non-smokers from exposure to SHS, enforcement activities in restricted areas should be enhanced to ensure strict public abidance. In addition, legislation of restricted areas should also be extended to greatly reduce the SHS exposure among non-smokers in Malaysia.

Strengths and limitations of this study

- ► The representativeness and adequacy of sample size as well as the high response rate enable generalisation of findings to the Malaysian population.
- ► Face-to-face interview approach employed in the study will increase the quality of the data.
- ► Under-reporting or over-reporting might occur as the period of the study was for the 1 month prior.
- ► Only seven 'types of public areas' were included in the study, exposure in other restricted and non-restricted areas was not extensively investigated.
- ► Objective measurement of exposure to SHS among non-smokers (eg, carbon monoxide in expired breath air, cotinine (a nicotine metabolite)) was not carried out.

INTRODUCTION

Secondhand smoke (SHS) is composed of side stream smoke (the smoke released from the burning end of a cigarette) and exhaled mainstream smoke (the smoke exhaled by the smoker).[1] There are more than 200 of these chemicals, confirmed carcinogens and respiratory toxins (eg, benzene, 1,3-butadiene, formaldehyde, mercury and hydrogen cyanide).[2] Exposure to SHS could affect the health of an individual. Epidemiological studies revealed that SHS exposure causes an increased risk of lung cancer by 20% to 30%,[3] heart disease by 25% to 30%,[4] stroke by up to 82%[5] and an increased risk of other non-fatal respiratory illnesses.[4] In addition it has been shown to have adverse effects on reproduction and associated with sudden infant death syndrome (SIDS).[3 4] Furthermore, SHS has also been associated with recurrent wheezing, respiratory illnesses, decreased lung function and asthma,[6 7] as well as chronic respiratory symptoms among adults.[8] Annually

600 000 deaths were reported globally due to exposure to the SHS.[9 10]

Prohibition of smoking in public areas was among the public health policies to reduce exposure to SHS in public areas apart from de-normalising smoking behaviour. Studies revealed that the implementation of this policy has reduced the exposure of adults and children in Scotland to SHS by 39%,[11] and reduced the active smoking rate among smokers.[12] In addition, the implementation of smoke-free policies has also significantly reduced the salivary and urinary cotinine (a metabolite of nicotine) among non-smokers in all countries, namely the USA, Canada, Scotland, Uruguay and Ireland.[13–18] Furthermore, the measurement of air quality in public areas revealed a significant reduction of several chemical components available in SHS.[19 20] Also, smoke-free laws also reduced the quantity of cigarettes smoked,[21] increased the intention to quit smoking among smokers[22] and increased the proportion of smoking cessation.[23] More importantly, smoke-free regulation has been shown to significantly reduce the number of hospital admissions for heart attacks and asthma-related diseases, and premature births.[24–26] The systematic reviews of Frazer *et al* in 2010 and 2016 revealed that the smoke-free policy significantly reduces the mortality related to smoking illness and improves the outcome of cardiovascular health outcome.[27] The policy had been identified as a non-price measure which will reduce the mortality and morbidity due to smoking-related diseases.[28]

The Malaysian government through the Ministry of Health, also implemented similar measures to protect non-smokers from exposure to SHS in public areas with the introduction of smoking prohibition in public areas via the Control of Tobacco Product Regulations (CTPR) 1993. Eight areas were restricted (entertainment centres or theatres, hospitals or health clinics, public lifts, air-conditioned eating places, public vehicles, building of Island & Peninsular Kuala Lumpur, of Malaysia property developer) and in any area of the petrol station and Esso tower building, Kuala Lumpur). This was later expanded to other public areas through the amendment of the provision to the CTPR in 1997 until 2017.[29–37] The expansion of smoke-free public areas was in line with the provision of Article 8 of the Framework Convention on Tobacco Control (FCTC)[38] which was rectified by the Malaysian government in 2005. As of 2017, 29 types of public areas and nine localities had been declared as smoking-restricted areas (online supplementary appendix 1). This regulation was supported by enforcement by authorised officers with frequent visits to ensure that the public abides by this provision.

Although the smoking prohibition policy had been implemented over the past two decades and studies elsewhere show its efficacy to reduce the exposure of non-smokers to SHS,[20 22] the effect of smoke-free policies on SHS exposure in Malaysia has not been studied. Knowledge on the effect of exposure to SHS will assist policy makers in planning and formulating suitable policies, as well as measuring and strengthening existing policies and regulations. In addition, it will ensure the allocation of human and material resources to reduce SHS among the Malaysian public. This paper intends to narrow the knowledge gap with the illustration of SHS exposure in various public areas (restricted and non-restricted) and social demographic variation of exposure among Malaysians to SHS.

METHODS

Data for this paper was derived from the Malaysian Global Adult Tobacco Survey (GATS) which was carried out from October 2011 to January 2012. The study utilised a cross-sectional design and three-stage sampling proportionate to size to obtain a representative sample of Malaysians aged 15 years and above. The first strata consisted of 15 states in Malaysia, while the second stage was the division of urban and rural areas by each state. Enumeration blocks (EBs) which is an artificial geographical area created by the Department of Statistics consisted of 80 to 120 living quarters based on the 2010 population census, was the primary sampling unit (PSU) and living quarters (LQs) were the secondary sampling unit. One household member aged 15 years and above from the selected LQs was selected by the simple random sampling method based on a random number generated by handheld devices.

The face-to-face interview approach by trained research assistants was used to obtain data from selected respondents. Detailed information regarding the purpose of the survey was explained to the respondents. Their participation was on a voluntary basis and they had the right not to answer any question as well as withdrawing from the study at any juncture. All information given was treated as confidential and utilised for research purposes only. The interview session only started after written consent was obtained from the selected respondents. For respondents aged below 18 years' old, written consent was obtained from their parent or guardian in addition to permission by the respondent. Details of the methodology is published by Azahadi *et al*.[39] Ethical approval was granted by the Malaysia Research Ethical Committee, Ministry of Health, Malaysia.

The study instrument was a questionnaire adopted from GATS, translated and pre-tested before use. It consists of nine components, namely social demographics, smoking status, type of tobacco product used, exposure to SHS at home, work and selected public areas, expenditure on cigarettes, knowledge of smoking hazards and SHS, intention to quit, exposure to tobacco product advertisements and information regarding the hazards of tobacco products.

The smoking status of respondents was evaluated by several items: 'Do you currently smoke?'; 'Do you use any smokeless tobacco?'; 'Do you use any sisha?'; 'Do you use any bidi?'; and 'Do you use any electronic cigarettes?' Respondents who answered 'not at all' to all the

items were classified as 'non-smokers' while those who answered 'daily or less than daily' were categorised as 'current smokers'. Only non-smokers were included in the analysis for exposure to SHS. Exposure to SHS was determined by items 'Have you visited these public areas: (1) government offices; (2) health facilities (including a hospital or clinic); (3) public transport terminal; (4) air-conditioned shopping complex; (5) bar or night club; (6) cafe/coffee shop/bistro; and (7) non-air-conditioned restaurant during the last 1 month?' Respondents who answered 'No', 'Don't know' or 'refused to answer' were excluded from further analysis. Those who answered 'Yes' to any area/s mentioned were asked if they had seen anyone smoking during their visit(s) in any of those seven areas. Respondents who answered 'Yes' were considered as being exposed to SHS. Those who were exposed to SHS at government offices/health facilities/public transport terminal/air conditioning shopping complexes were further categorised as exposed to SHS in restricted non-smoking areas. In the same way, those who answered 'Yes' to (1) bar or night club (2) cafes/coffee shop/bistro and (3) restaurant without air-conditioning were classified as exposure to SHS in non-restricted areas.

The independent variables were social demographics, namely, gender, ethnicity, educational attainment (which was divided into four categories; no formal education, primary education, secondary school and tertiary), age group (15–24 years' old, 25–44 years' old, 45–64 years' old and 65+) and locality (urban/rural), while income level was measured using Wealth Index, a proxy measure for respondents' socioeconomic status was constructed using principal component analysis with information on household ownership of assets.[40] Assets included were electricity, flush toilet, fixed telephone, cellular telephone, television, radio, refrigerator, car, moped/scooter/motorcycle, washing machine, etc. The sample was divided into quintiles, from quintile one (highest) to quintile five (lowest). Marital status of respondents was classified as single, married and widow/widower/separated.

Data was cleaned prior to analyses. It was weighted, by taking into account study design, non-response and social characteristics (gender, residence, age group, educational attainment, ethnicity) based on the Malaysia population census 2010. Descriptive statistics were utilised to describe the social demographic characteristics of the respondents. Cross-tabulation was used to describe the proportion of respondents to SHS exposure at various public places. Multivariable logistic regression was run to determine the association between various social demographic backgrounds with SHS exposure in restricted and non-restricted public areas. We reported 95% CI without P values as the large sample size could generate significant results even if statistical differences or associations were small. All analyses were carried out by using SPSS statistical software version 20.

RESULTS

A total of 5112 eligible Malaysian adults aged 15 years and above were recruited into the study and 4250 of them consented to participate and completed the interview, giving a response rate of 83.1%. Out of the 4250 respondents, 3269 of them were non-smokers (76.9%, 95% CI 74.8 to 78.8). The proportion of female non-smokers was significantly higher compared with males (98.7%, 95% CI 98.0 to 99.1 vs 56.1%, 95% CI 52.7 to 58.9). Those from the youngest (15–24 years; 83.3%, 95% CI 79.7 to 86.4) and oldest age group (65+; 85.0%, 95% CI 80.1 to 88.8) also reported a significantly higher proportion of non-smokers compared with those of 25 to 44 years' old (71.0%, 95% CI 67.8 to 73.9). Similarly, the proportion of non-smoking participants were higher in those with tertiary educational attainment (84.7%, 95% CI 80.1 to 88.4) and higher income group (quintile 1: 82.9%, 95% CI 79.3 to 86 and quintile 2: 80.8%, 95% CI 76.9 to 84.2) (table 1).

Table 2 shows that almost two-thirds of non-smokers (63.6%, 95% CI 60.6 to 66.2) were exposed to SHS in one or more public area during the past 1 month. The exposure among males was significantly higher compared with that among females (70.9%, 95% CI 66.5 to 74.9 vs 59.1%, 95% CI 55.7 to 62.4). In addition, respondents from urban areas, with higher educational attainment and income also reported a higher proportion of exposure to SHS. However, older respondents reported lower exposure compared with their younger counterparts (15–24 years, 72.1%, 95% CI 67.4 to 76.3; 25–44 years, 67.9%, 95% CI 63.8%, 95% CI 63.8 to 71.5; 45–64 years, 54.4%, 95 CI% 49.9–58.8; and 65+, 37.3%, 95% CI 29.1% to 46.1%).

Exposure of non-smokers to SHS was significantly higher in non-restricted public areas compared with restricted areas, in which the proportion of exposure was approximately four times higher than that reported in restricted areas (81.9%, 95% CI 79.5 to 84.1 vs 22.9%, 95% CI 20.4 to 25.5). Further analysis of exposure to SHS in restricted areas revealed that the level of exposure was significantly lower in healthcare facilities (8.7%, 95% CI 6.9 to 10.8) compared with indoor shopping complexes (13.6%, 95% CI 11.7 to 15.7), government offices (20.0%, 95% CI 16.4 to 24.2) and public transport (27.9%, 95% CI 22.5 to 34.0). No significant difference was observed among all social demographic characteristics to SHS in non-restricted areas except for the younger age group of 15–24 years (30.2%, 95% CI 25.6 to 35.3). The study also revealed that the level of SHS exposure to the three non-restricted smoking areas were almost similar for all respondents from different social demographic backgrounds (table 3)

Multivariable logistic regression analysis revealed that the likelihood of exposure to SHS in restricted public areas were almost similar across all social demographic variables, while for the non-restricted area, non-smokers from the younger age group (15–24, Adjusted odd ratio (AOR) 5.07, 95% CI 2.18 to 11.7; 25–44. AOR 3.12,

Table 1 Sociodemographic characteristic of non-smokers respondents aged 15 years and above in Malaysia

Demographic characteristic	n*	N† (in thousands)	%	95 CI	
				Lower	Upper
Gender					
Male	1144	5938	56.1	52.7	59.4
Female	2125	9887	98.7	98.0	99.1
Age group (years)					
15–24	605	4745	83.3	79.7	86.4
25–44	1284	6063	71.0	67.8	73.9
45–64	1026	3764	77.3	74.1	80.2
65+	354	1252	85.0	80.1	88.8
Residence					
Urban	1616	11 485	77.3	74.6	79.8
Rural	1653	4340	75.7	73.3	78.0
Education level					
Less than primary	520	1605	80.3	75.8	84.1
Primary	834	3170	75.7	72.1	79.0
Second/high school	1031	4770	74.9	71.9	77.6
College or above	264	1472	84.7	80.1	88.4
Ethnicity					
Malay	1931	9143	75.4	72.7	77.9
Chinese	553	3226	84.6	80.5	88.0
Indian	213	1552	80.4	73.6	85.8
Other	572	1903	70.0	64.7	74.9
Quintile income level					
Q 1	698	4941	82.9	79.3	86.0
Q 2	689	3832	80.8	76.9	84.2
Q 3	601	3004	71.8	67.1	76.0
Q 4	628	2281	73.0	68.1	77.5
Q 5	603	1578	68.0	62.9	72.7

*n, sample.
†N, estimated population.

Table 2 Exposure to SHS in at least one public place by social demographic

Demographic characteristic	n*	N† (in thousands)	%	95 CI	
				Lower	Upper
Gender					
Male	667	3847	70.9	66.5	74.9
Female	972	5320	59.1	55.2	62.4
Age group (years)					
15–24	347	3139	72.1	67.4	76.3
25–44	749	3759	67.9	63.8	71.5
45–64	441	1846	54.4	49.9	58.8
65+	102	423	37.3	29.1	46.1
Residence					
Urban	945	7182	67.9	64.5	71.2
Rural	694	1985	51.6	47.8	55.3
Education level					
Less than primary	142	5010	34.0	27.8	40.7
Primary	493	2615	59.3	54.9	63.6
Second/high school	764	4448	68.1	64.2	71.7
College or above	237	1590	81.4	75.6	86.1
Ethnicity					
Malay	946	5083	63.1	59.6	66.4
Chinese	948	2192	70.8	65.9	76.0
Indian	130	1004	68.6	59.7	76.3
Other	227	887	49.1	42.6	55.6
Quintile income level					
Q 1	476	3406	73.9	69.1	78.2
Q 2	406	2040	69.4	64.7	73.7
Q 3	308	1705	62.6	57.1	67.8
Q 4	267	1085	52.2	46.1	58.2
Q 5	179	511	36.3	30.6	42.4

*n, sample.
†N, estimated population.

95% CI 1.51 to 6.45; 45–64, AOR 2.08, 95% CI 1.10 to 3.93; 65+ as reference) and males (AOR 1.46, 95% CI 1.03 to 2.05) were more likely to be exposed to SHS in the past 1 month (table 4).

DISCUSSIONS

This is, to our knowledge, the first report on exposure to SHS in various public areas among a representative sample of the Malaysian adult population after two decades of anti-smoking law implementation. The study reveals that almost two out of three (66.7%) Malaysian adolescents (below the age of 19 years' old) and adults were exposed to SHS in at least one public area investigated during the 1 month prior to the study. This is similar (66%) to that reported in Spain,[41] but lower compared with that reported by Xiao *et al*[42] among non-smokers aged 15 years and above in China: 72.4% (95% CI 70.4 to 74). Interestingly, it is higher than that reported among non-smokers in Cambodia[43] and the EU,[44] which were 37.4% and 29.0%, respectively. The proportion of SHS exposure by gender was almost two times higher compared with that reported globally (70% vs 33% for males; 59% vs 31% for females).[45] The different proportion of exposure might be due to different social norms in related countries, as an existing anti-smoking norm might reduce the likelihood of smoking in public areas. In addition, different anti-smoking laws/policies might be another contributing factor for this difference in the proportion of exposure to SHS. Hence, further studies are required to

Table 3 Self-reported exposure to secondhand smoke (SHS) among non-smokers in selected restricted and non-restricted areas

	Self-reported exposure to secondhand smoke, % (95% CI)								
	Restricted area					Non-restricted area			
Demographic Characteristic	At least one	Government office	Healthcare facilities	Indoor shopping complexes	Public transportation	At least one	Restaurants	Bar/night clubs	Cafes/coffee shops/bistros
Overall	22.9 (20.4 to 25.5)	20.0 (16.4 to 24.2)	8.7 (6.9 to 10.8)	13.6 (11.7 to 15.7)	27.9 (22.5 to 34.0)	81.9 (79.5 to 84.1)	71.0 (67.7 to 74.0)	78.7 (64.2 to 88.4)	84.9 (52.1 to 87.3)
Gender									
Male	21.4 (18.6 to 24.4)	20.1 (16.0 to 25.0)	7.8 (5.4 to 11.2)	11.7 (9.2 to 14.9)	33.5 (23.4 to 45.4)	87.6 (85.0 to 89.8)	73.1 (69.2 to 76.6)	81.4 (62.4 to 92.0)	85.0 (81.7 to 87.8)
Female	23.2 (20.2 to 26.6)	19.8 (14.7 to 26.2)	9.4 (7.1 to 12.4)	15.4 (12.9 to 18.3)	25.4 (19.6 to 32.2)	80.5 (77.1 to 83.4)	68.4 (63.8 to 72.8)	70.2 (46.6 to 86.4)	84.7 (80.8 to 87.9)
Age group (years)									
15–24	30.2 (25.6 to 35.3)	24.1 (16.2 to 34.3)	2.3 (7.9 to 18.7)	17.8 (13.7 to 22.6)	31.8 (23.2 to 41.7)	86.0 (82.1 to 89.2)	72.6 (66.7 to 77.8)	81.2 (58.7 to 92.9)	86.3 (81.1 to 90.3)
25–44	21.9 (19.0 to 25.0)	20.9 (16.3 to 26.4)	8.4 (5.9 to 11.6)	12.6 (10.3 to 15.4)	30.12 (22.1 to 39.6)	85.3 (82.3 to 87.9)	72.6 (68.4 to 76.3)	80.3 (61.5 to 91.2)	83.9 (79.4 to 87.5)
45–64	14.4 (11.7 to 17.6)	14.4 (9.6 to 20.9)	6.3 (4.3 to 9.1)	8.8 (6.5 to 11.9)	14.7 (9.0 to 23.2)	83.6 (80.0 to 86.6)	67.6 (61.9 to 72.7)	–	86.9 (82.8 to 90.1)
65+	16.8 (10.9 to 24.8)	23.3 (12.7. to 39.7)	7.9 (3.6 to 16.5)	19.0 (9.8 to 33.5)	20.2 (8.8 to 39.9)	70.8 (60.0 to 79.7)	55.4 (39.9 to 70.0)	–	75.1 (63.5 to 83.9)
Residence									
Urban	23.2 (20.5 to 26.0)	21.5 (17.0 to 26.9)	9.2 (7.0 to 12.1)	14.3 (12.1 to 16.9)	27.5 (20.8 to 35.4)	85.8 (83.3 to 88.1)	71.3 (67.4 to 75.0)	80.8 (64.1 to 90.8)	85.6 (82.0 to 88.6)
Rural	19.7 (16.8 to 23.1)	15.4 (11.4 to 20.6)	7.3 (5.3 to 10.0)	10.9 (8.4 to 14.1)	29.1 (22.4 to 36.9)	80.2 (76.9 to 83.1)	69.6 (64.9 to 74.0)	63.3 (36.9 to 83.6)	82.5 (79.1 to 85.4)
Education level*									
Less than* primary	14.7 (10.6 to 19.9)	16.0 (7.7 to 30.2)	5.6 (3.1 to 10.1)	14.2 (8.4 to 23.0)	17.2 (9.6 to 28.8)	81.6 (74.1 to 87.3)	68.8 (55.3 to 79.7)	–	82.4 (73.7 to 88.6)
Primary	19.1 (15.7 to 23.1)	24.3 (16.6 to 34.0)	7.4 (4.8 to 11.3)	12.3 (9.1 to 16.4)	22.9 (14.8 to 33.6)	82.8 (78.4 to 86.4)	67.9 (61.6 to 73.5)	–	84.3 (78.6 to 88.8)
Second/high school	19.1 (16.2 to 22.5)	17.5 (13.1 to 22.9)	8.0 (5.4 to 11.8)	10.0 (7.9 to 12.6)	29.3 (20.0 to 40.6)	85.0 (81.9 to 87.7)	72.3 (67.5 to 76.6)	88.5 (74.5 to 95.3)	85.9 (82.1to 88.9)
College or above	22.5 (16.9 to 29.3)	18.4 (11.4 to 28.3)	8.9 (4.9 to 15.7)	15.2 (10.4 to 21.7)	20.7 (17.4 to 45.8)	83.3 (77.5 to 87.9)	68.4 (60.4 to 75.5)	–	80.4 (71.1to 87.3)
Ethnicity									
Malay	22.6 (19.9 to 25.6)	22.6 (18.2 to 27.6)	8.8 (6.8 to 11.4)	12.7 (10.4 to 15.4)	27.9 (21.3 to 35.6)	84.6 (82.2 to 86.7)	75.1 (71.2 to 78.6)	64.1 (40.6 to 82.3)	84.0 (80.5 to 87.0)
Chinese	18.7 (14.7 to 23.6)	12.8 (6.8 to 22.8)	7.7 (4.5 to 12.7)	14.7 (11.0 to 19.4)	21.8 (11.1 to 38.4)	86.9 (82.5 to 90.3)	58.0 (51.3 to 64.5)	86.8 (61.1 to 96.5)	88.3 (82.8 to 92.6)
Indian	30.2 (22.5 to 39.1)	18.3 (9.5 to 32.1)	14.9 (7.3 to 28.1)	17.9 (11.0 to 27.6)	35.1 (22.6 to 50.1)	84.4 (76.9 to 89.8)	74.8 (65.0 to 82.7)	–	79.4 (68.8 to 87.1)
Other	20.2 (16.0 to 25.3)	16.4 (8.9 to 28.2)	3.8 (1.7 to 8.6)	12.9 (8.6 to 18.8)	28.0 (20.3 to 37.4)	79.6 (73.1 to 83.1)	69.8 (61.8 to 76.7)	65.5 (30.8 to 89.0)	87.1 (80.2 to 91.9)
Income level									
Q 1	24.3 (20.6 to 28.3)	17.9 (12.4 to 25.2)	8.7 (5.7 to 13.2)	15.5 (11.9 to 19.9)	26.9 (16.7 to 40.3)	85.5 (81.8 to 88.6)	68.3 (62.5 to 73.7)	76.4 (54.2 to 89.8)	85.1 (79.9 to 89.1)
Q 2	24.5 (20.4 to 29.1)	19.7 (13.4 to 28.0)	7.7 (4.6 to 12.7)	15.7 (12.0 to 20.3)	30.1 (20.6 to 41.6)	84.3 (80.7 to 87.4)	67.8 (61.7 to 73.4)	–	83.1 (77.3 to 87.0)
Q 3	19.7 (16.0 to 24.2)	25.4 (16.7 to 36.7)	10.0 (5.9 to 16.5)	14.9 (10.9 to 20.0)	31.6 (20.0 to 46.2)	84.5 (80.5 to 87.8)	68.1 (61.1 to 74.4)	–	86.4 (79.3 to 91.4)
Q 4	19.3 (15.2 to 24.2)	15.8 (8.1 to 28.7)	10.4 (5.7 to 18.0)	10.9 (7.0 to 16.6)	23.8 (14.6 to 36.2)	85.3 (79.8 to 89.5)	72.1 (62.1 to 80.3)	–	84.1 (75.4 to 91.1)
Q 5	21.1 (16.0 to 27.2)	18.3 (7.8 to 37.3	5.9 (3.2 to 10.8)	12.3 (5.7 to 24.7)	24.3 (16.5 to 3434)	81.0 (74.2 to 86.3)	65.0 (52.6 to 75.7)	–	79.2 (66.0 to 88.1)

Table 4 Multivariable analysis of non-smoker exposure to secondhand smoke in restricted and non-restricted public area

	Exposure to secondhand smoke					
	Restricted area			Non-restricted area		
	AOR	95% CI		AOR	95% CI	
Variable		Lower	upper		Lower	Upper
Gender						
Female	Ref			Ref		
Male	0.89	0.66	1.12	1.46	1.03	2.05
Locality						
Urban	Ref			Ref		
Rural	0.90	0.67	1.21	0.79	0.57	1.10
Ethnicity						
Chinese	Ref			Ref		
Malay	1.18	0.80	1.73	0.70	0.48	1.03
Indian	1.72	0.98	1.64	0.86	0.46	1.59
Others	1.03	0.65	1.64	0.49	0.28	0.85
Education attainment						
College and above	Ref			Ref		
No formal education	0.56	0.29	1.08	1.62	0.78	3.40
Primary school	0.69	0.44	1.07	1.16	0.69	1.98
Secondary school	0.64	0.43	0.94	1.14	0.76	1.74
Age group						
65+	Ref			Ref		
15–24	1.59	0.68	3.75	5.07	2.18	1.73
25–44	1.32	0.70	2.50	3.12	1.51	6.45
45–64	0.82	0.45	1.49	2.08	1.10	3.93
Marital status						
Married	Ref			Ref		
Single	1.36	0.86	2.15	0.92	0.51	1.65
Widow/er/separated	1.24	0.76	2.03	0.68	0.44	1.06
Quintile income group						
Q 1	Ref			Ref		
Q 2	1.12	0.79	1.60	0.95	0.65	1.39
Q 3	1.05	0.70	1.57	1.04	0.67	1.64
Q 4	0.74	0.49	1.13	1.15	0.65	2.03
Q 5	1.05	0.66	1.69	0.74	0.39	1.38

elucidate the real factors for the differences in exposure to SHS reported.

There were no significant differences in SHS exposure in restricted areas among urban and rural dwellers, after controlling for potential confounders. In contrast, urban dwellers were significantly more likely to be exposed to SHS in non-restricted areas compared with their rural counterparts. This could be possibly due to the fact that restaurants, bar/night clubs and cafes/coffee shops/bistros were less readily accessible in rural areas. On the other hand, no significant differences in SHS exposure were observed across ethnic categories, in both restricted and non-restricted areas. One of the possible explanations is that, regardless of ethnicity, most of the restricted areas (healthcare facilities, indoor shopping complexes and public transport) and non-restricted areas (restaurants and cafes/coffee shops/bistros) were commonly visited or patronised by Malaysians.

Respondents from the younger age group reported higher exposure to SHS in non-restricted areas. This finding is in line with that by Li *et al*[46] among women in China, in which the level of exposure decreased from 66.8% in those aged 18 to 24 to 38.9% among those aged 65 and above. The finding might be because the

respondents of the younger age group mostly consist of those who are productive and economically active, therefore they are more mobile and visit public areas more often compared with their counterparts from lower education, lower income and older age groups. Furthermore, the public areas under investigation (eg, coffee houses and bistro) were premises which were tailored to attract the younger age group.

Male respondents were more likely to be exposed to SHS in non restricted areas in univariate and multivariate analysis compared with females. The finding is in line with Rudatsikira *et al*[43]), Li *et al*[46] and Desalu *et al*[47]) who reported a higher proportion of SHS exposure among non-smoking males in Cambodian adults residing in two cities in Nigeria and adults in north-east China, respectively. This might be due to males being more mobile compared with females in view of their nature of occupation which require them to travel more. In Malaysia, males tend to socialise more compared with females as it is reflects the patriarchal society of Malaysia. In addition, non-smoking males might befriend those who are smokers in view of the high prevalence of smokers among males (45%) in Malaysia and therefore increases the likelihood of exposure to secondhand smoke.[48]

Exposure to SHS was significantly lower in restricted areas compared with non-restricted areas. This is consistent with several previous studies.[19 49–53] All studies revealed that laws significantly reduced exposure to SHS in a variety of public places, especially bars, restaurants and outdoor patios of these premises. These reductions in public-place exposure are observed for both smokers and non-smokers. Multivariable analysis, which showed no difference in the likelihood among various socioeconomic backgrounds to SHS exposure support the notion that smoke-free areas offer protection to non-smokers from SHS exposure (table 5).

Among the restricted areas, non-smokers reported the lowest exposure to SHS in health facilities, followed by air-conditioned shopping centres, government offices and public transport. Similar findings were also reported from the Global Adult Tobacco Survey (GATS) in the Philippines in 2010.[54] This could be due to the majority of health personnel being aware of the dangers of smoking and SHS which translate to their attitude and behaviour towards smoking, therefore creating a non-smoking social norm among their fraternity. This reduces the likelihood of smoking behaviour and increases the advising of those who smoke in the hospitals/health facilities to smoke elsewhere. The respondents who visited the hospitals/health facilities usually consist of those who seek treatment, hence their health condition might not permit them to continue their smoking behaviour. Teh *et al*[55] also reported that a majority of the public perceived that hospitals/health facilities were premises which provided treatment and therefore inappropriate for anyone to practice an unhealthy lifestyle. In addition, respondents who visit the hospitals were mostly from the older age group with less likelihood to be smokers in view of the lower prevalence of smoking among older Malaysians (16.4%)[56]

The low prevalence of SHS exposure among non-smokers in the shopping centres (approximately one in ten or 10%) might be due to central air-conditioning systems utilised in most Malaysian shopping centres whereby any cigarette smoking within the premises created a nuisance to the public, and their reactions serve as a deterrent for smokers to smoke. In addition, the management of these shopping centres usually try to take all necessary measures to retain their customers through a conducive and cosy environment for shopping. One of the approaches was to ensure the conducive environment for visitors via a smoke-free environment. In addition, owners' fear of being fined for having people smoking in their premises could be another possible reason for the finding in this study.

More than one-fifth and almost one-third of non-smokers were exposed to SHS in the past 1 month during their visit to a government office and use of public transport, respectively. The high exposure was rather surprising in view of the area and the facility having been designated as smoke-free over the past 20 years. This is a clear indication of non-compliance to the legislation.

Among the smoking-restricted areas, it is noteworthy that public transport and government offices had been reported to have the highest level of SHS exposure. These findings may indicate a debilitated enforcement of smoke-free regulations in those areas. In Malaysia, the Environmental Health Officers or Assistant Environmental Health Officers (EHO/AEHO) who are involved in law enforcement, are unable to perform their task as regularly and frequently as needed as they are overwhelmed by other routine surveillance activities for both communicable and non-communicable diseases.[57] However, further investigations from multiple angles, such as the person who smokes in the restricted areas (either government officers in government premises or drivers of public transport), level of awareness on SHS exposure among the public and assessment on the level of enforcement activities as well as adequacy of enforcement officers in anti-smoking programmes are urgently required to elucidate the contributing factors for the present findings.

Of note, although the present study analysed 6-year-old data from GATS 2011, however, this should not be an issue of concern that the data is out of date and may not reflect the current smoking phenomena in Malaysia, since the smoking profile among Malaysian adults was comparably similar in GATS 2011 and the National Health and Morbidity Survey (NHMS) in 2015. For instance, the overall prevalence of smoking was 23.1% (95% CI) in 2011 compared with 22.8% (95% CI). Moreover, the prevalence of smoking also did not vary significantly by socio-demographics in 2011 and 2015. In addition, we have analysed the smoking profile in Malaysia from 1985 to 2015: the results showed that Malaysia is still at Stage II of the cigarette epidemic model developed by Lopez *et al*[58] which evidently indicated that the smoking

Table 5 Previous studies showed the effectiveness of smoking-free regulation

Author/s	Approach	Finding
Azagba 51	Regression modelling based on 89743 respondents participated in the 2005–2012 Canadian Tobacco Use Monitoring Survey to determine the effect of smoke-free regulation.	A reduction of 25% and 21% of SHS was reported in Alberta and Nova Scotia, respectively, after the implementation of smoke-free regulation.
Park *et al*[19]	Urine cotinine concentration was investigated among 4612 non-smoking Korean citizens (aged 19 or older) who participated in the first stage of the Korean National Environmental Health Survey between 2009 and 2011.	A total decrease of 2.79 ng/mL (54.7%) urine cotinine among non-smokers was observed.
Sureda *et al*[49]	Self-reported exposure to secondhand smoke (at home, the workplace, during leisure time, and in public/private transport vehicles) was measured, and the metabolite of nicotine (cotinine) in the collected salivary sample was also determined among a representative sample of non-smokers (aged 16 years and above) in a cross-sectional survey between 2004–2005 prior to the implementation of smoke-free regulation and was repeated in Barcelona, Spain in 2011–2012, after the implementation of smoke-free laws	The self-reported exposure to secondhand smoke had reduced significantly from 75.7% (95% CI: 72.6 to 78.8) in 2004–2005 to 56.7% (95% CI: 53.4 to 60.0) in 2011–2012. Specifically, a reduction of 4.9%, 5.4%, 8.6% and 22.4% of SHS exposure were observed at home, work/education venue, public transport during leisure time, respectively. The geometric mean of salivary cotinine had also decreased significantly from 0.93 ng/mL at baseline (2004–2005) to 0.12 ng/mL after legislation (P<0.001).
Ye *et al*[50]	A repeated cross-sectional study was conducted among respondents aged 16 years and above in Guangzhou, China to determine the exposure to SHS (self-reported) before (2009) and after implementation of smoke-free regulation.	A significant decrease of 8.5% of overall exposure to SHS (from 58.8% to 50.3%) was reported after the implementation of smoke-free regulation, with more than 30% of reduction reported in cultural venues, commercial venues and in government offices.
Fernández *et al*[53]	Two cross-sectional studies among nationally representative sample of Spanish adults aged 18 years and above were conducted in 2006 and 2011 to determine SHS exposure after the introduction of new smoke-free regulation.	The study revealed that there was a significant reduction of SHS exposure after the implementation of smoke-free regulation, from 71.9% (95% CI: 70.1 to 73.7%) in 2006 to 45.2% (95% CI: 43.1 to 47.3%) in 2011. Self-reported exposure of SHS at home had decreased from 29.2% to 12.7% and SHS exposure at work/education venues had reduced from 56.2% to 32.2% Similarly, exposure to SHS in transport vehicles/stations also decreased from 40.6% in 2006 to 12.7% in 2015.
Kim *et al*[52]	A four-time point (pre- and post-regulation at bars≥150 m^2, ≥100 m^2, and in all bars) and two-time point (post-regulation of bars≥100 m^2 and post-regulation of all bars) measurement of PM 2.5 were carried out in Seoul and Changwon, respectively using a portable real-time aerosol monitor (AM510; TSI Inc., Shoreview, MN, USA).	The geometric mean of the indoor PM2.5 concentrations at all bars had decreased from 98.4 µg/m^3 pre-regulation to 79.5, 42.9 and 26.6 µg/m^3 after the ban on smoking in bars of≥150 m^2, ≥100 m^2 and all bars, respectively.

prevalence and profile have not changed since 1985. Therefore the present findings which derived from the GATS in 2011 is still valid and of relevant. Besides, there was also evidence that smoke-free regulation in Malaysia had not changed substantially from 1993 to 2017 (online supplementary appendix 1). Therefore, the effect of the variation in smoke-free legislation over the years against SHS exposure would not pose a great concern in view of the insignificant changes in smoke-free regulations in Malaysia.

The strengths of the present study were the representativeness and adequacy of sample size as well as a high response rate which enabled generalisation of findings to the Malaysian population. Furthermore, a face-to-face interview approach compared with self-administered could also increase the quality of the data. Nonetheless, the present study was also subjected to few limitations. First, under-reporting or over-reporting might occur as this was a cross-sectional study at a 1-month period. Second, a comprehensive observation and concrete conclusion on SHS exposure in smoking-restricted and non-restricted areas could not be made due to the inclusion of only seven types of public areas in the present study. Third, the exposure to SHS was determined based on the observation by respondents which was rather subjective compared with objective measurement of SHS exposure. Therefore, future studies should include more public areas (both smoking-restricted and non-restricted) and employ objective measurement for SHS exposure such as measurement of carbon monoxide or cotinine (a nicotine metabolite) in the expired breath air, or measurement of air quality for chemicals related to SHS. However, previous studies had found satisfactory validity of self-reported SHS exposure.[59 60]

The findings from the study add to the body of evidence that the prohibition of smoking in public areas will reduce the exposure to SHS.[19 20 41] Therefore, more public areas should be nominated as non-smoking areas to further reduce the exposure to SHS among the public and to create an environment which is not conducive for smoking. However, the sizeable reported exposure to SHS by non-smokers demands stricter and more frequent enforcement of the provision under the current anti-smoking law to ensure all restricted areas are to be 100% smoke-free.

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Exposure to tobacco secondhand smoke and its associated factors among non-smoking adults in smoking-restricted and non-restricted areas: findings from a nationwide study in Malaysia

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