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Maternal Passive Smoking before and during Pregnancy and the Avoidance of Secondhand Smoke

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Abstract

There are no previous studies on Secondhand Smoke (SHS) exposure among Chinese pregnant women in the Macao Special Administration Region of China. Due to cultural factors and to a limited tobacco control policy, this group of women is particularly vulnerable to SHS exposure. The aim of the present study was to examine SHS exposure before and during pregnancy, the actions taken to avoid exposure, and the risk factors of maternal SHS exposure in Macao. This was a retrospective cross-sectional study, which was conducted in a postnatal ward of a public hospital in Macao from August to October 2012. A self-administered questionnaire was completed by 679 non-smoking postpartum women. The prevalence of SHS exposure was 49.8%. The proportion of spouses and family members who smoked around the women, of households that allowed smoking at home, and the duration and frequency of maternal SHS exposure throughout pregnancy was 49.8% (n=660). The proportion of participants who took action to avoid exposure during pregnancy (94.9%) also significantly increased when compared to before their pregnancy (84.1%). Risk factors of maternal SHS exposure included working in casinos/entertainment venues, the smoking status of family members, the participants' level of education, confidence in avoiding SHS exposure, and working status. Completely smoke-free work sites and home environments should be promoted to protect maternal and fetal health.

Keywords: Secondhand smoke exposure; Passive smoking; Pregnant women; Secondhand smoke exposure

Introduction

There is a great deal of evidence showing that tobacco and Secondhand Smoke (SHS) cause death and illness [1]. Both maternal smoking and SHS exposure during pregnancy are harmful to maternal and fetal health [2,3]. A moderately positive association between maternal SHS exposure and birth defects was noted in a large population-based, multisite, case-controlled study conducted by Hoyt et al. [4]. In a systematic review and meta-analysis, it was concluded that pregnant women who had been exposed to SHS before and during their pregnancy were 23% more likely to experience stillbirth and 13% more likely to give birth to a child with a congenital malformation [5]. SHS exposure might also have other harmful effects on pregnant women, such as delayed conception, altered menstrual cycles, early pregnancy loss, and preterm delivery [6].

It was estimated that more than one-third of all women worldwide are regularly exposed to SHS [7]. The situation is worse in developing countries, where up to half of pregnant women are frequently exposed to SHS [8]. China is the largest producer and consumer of tobacco in the world [9]. The prevalence of SHS exposure among pregnant women was found to be up to 73% at home, 65% at the workplace, and 83% in public areas in China [10]. The percentage of those who would manifest SHS avoidance behavior varied from 10 to 70% [10]. In a traditional Chinese family, women would prefer not to exhibit any SHS avoidance behavior because of male superiority and the importance of family harmony in Chinese culture [11]. Poor SHS avoidance behavior was associated with low self-efficacy in avoiding exposure to SHS, a low level of education, living with a smoking spouse or family, and pregnant women being smokers [12-14].

Macao was a Portuguese colony before 1999, after which it became one of the two special administrative regions of China. Since 2012, smoking has been officially banned in most indoor public places in Macao except in casinos and some other entertainment venues [15]. In Macao, a quarter of employed women of reproductive age are working in the entertainment field, where smoking is allowed [16,17]. The literature has indicated that women can control their exposure to smokers near them, and thus avoid being exposed to SHS. There are only a limited number of studies examining the relationship between SHS exposure and avoidance behavior before and during pregnancy. The large number of women who work in casinos where smoking is allowed also suggests a need to conduct such a study in Macao. Accordingly, the aim of the present study was to investigate maternal passive smoking before and during pregnancy and maternal avoidance of SHS in Macao, and the risk factors of maternal passive smoking. It is believed that the findings will be of benefit in developing health education and tobacco control policies in Macao and other countries.

Methods

Design and participants

This was a retrospective cross-sectional study. It was conducted in the postnatal ward of a public hospital in Macao. This hospital contains 472 beds and provides acute, specialist outpatient, and inpatient comprehensive medical services. Macao has one public and two private hospitals, two of which offer obstetric services. There are approximately 5,800 newborns each year and about 50% of the deliveries occur in the public hospital [16,17]. A consecutive sampling method was adopted, whereby every subject who met the criteria for inclusion in this study during the period between August and October 2012 was approached to participate in it. We sought to determine the SHS exposure rate among pregnant women. According to relevant research data, rates of SHS exposure in Macao and neighboring areas range from 57.2% to 75.1% [18-20], the level of the sampling error is

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± 5%, the standard value of the confidence level at 95% is 1.96, and the size of the sample would range from 288 to 377. After considering the response rates, the estimated size of the sample for this study was determined to be 368 to 481 [21].

Eligibility

There were 757 subjects who met the following criteria for inclusion: (1) postnatal women, (2) non-smokers, (3) those could read Chinese or communicate in Cantonese or Mandarin, (4) those who had been delivered of a live infant within 24 or 48 hours in the study hospital between August and October 2012, and (5) those who had completed at least 50% of the questionnaire.

Recruitment and data collection procedures

Four nurses from the research team distributed the questionnaire to the patients after explaining the study to them, screening them for eligibility, and obtaining their written consent to take part in the study. During the study period, postnatal women were approached 24 or 48 hours after they had given birth *via* a normal spontaneous vaginal delivery or a caesarian delivery. All of the eligible postnatal women were invited to participate in this study. After obtaining the consent of each participant, one of the four nurses gave the participant a self-administered questionnaire at the study site.

Instruments

A self-administered questionnaire was developed to collect data. It contained 11 items on SHS exposure before and during pregnancy and 12 items on maternal SHS avoidance efficacy, attitude, and behaviour towards SHS, with SHS being regarded as a mixture of two forms of smoke, namely, mainstream smoke, which is the smoke exhaled by a smoker; and sidestream smoke, which is the smoke from the lighted end of a cigarette, pipe, or cigar, or from the burning of tobacco [22]. These items were adopted from previous studies [23,24]. For instance, to measure avoidance efficacy, the respondents were asked to rate their behaviour in relation to the following statements: "I always avoid secondhand smoke environments. I am…"; "I deliberately avoid my friends when they are smoking near me. I am…"; "I deliberately avoid my family members when they are smoking near me. I am…"; and "I deliberately avoid any smokers when they are smoking in public places. I am…". Items on maternal avoidance efficacy, attitude, and behaviour towards SHS were rated on a 5-point scale, from 1 to 5, where higher scores represent higher self-efficacy, a more positive attitude, and better avoidance behaviour. The content validity of the questionnaire was assessed by three experts (CVI=0.94). The reliability of the questionnaire was assessed by 30 women who had been post-partum for less than one-and-a-half years (test-retest coefficient ≥ 0.7).

Data analysis

The Statistical Package for the Social Sciences (SPSS) 21.0 was used for the statistical analyses. The data were summarized using descriptive statistics. A Wilcoxon signed-ranks test or a paired sample t-test was used to compare SHS exposure before and during pregnancy. A one-way Analysis of Variance (ANOVA) or independent samples t-test was used to identify variables that were significantly associated with maternal SHS exposure. A negative binomial regression analysis was used to examine the predictive values of variables that were identified as being associated with SHS exposure. The confounding effects can potentially be adjusted in the regression analysis; therefore the effects of confounding factors can be eliminated and controlled [25].

Definition of variables

The variables in (Table 1 and Table 2) on the demographic characteristics of the participants were drawn from section 5 of the questionnaire. They

Characteristics	n (%)	Mean ± SD
Age (16-44)		29.56 ± 3.62
16-19	8 (1.2)	
20-29	354 (52.3)	
30-39	300 (44.3)	
40-44	15 (2.2)	
Resident status		-
Macao	559 (82.4)	
Mainland China	118 (17.4)	
Others	1 (0.1)	
Marital status		-
Married	648 (95.4)	
Unmarried	31 (4.5)	
Cohabitation with spouse		-
No or occasional	50 (7.4)	
Yes	628 (92.6)	
Years of cohabitation with spouse		4.90 ± 3.62
5 or less	419 (66.9)	
06-Oct	160 (25.6)	
11 or more	47 (7.5)	
Employment status		-
Unemployed	228 (33.6)	
Employed	451 (66.4)	
Work in casinos/entertainment venues	153 (33.9)	
Level of education		-
Illiterate or primary school	6 (0.9)	
Secondary school	346 (51.0)	
University	294 (43.3)	
Master's or above	33 (4.9)	
Spouse's level of education		-
Illiterate or primary school	26 (3.9)	
Secondary school	330 (49.0)	
University	281 (41.7)	
Master's or above	37 (5.5)	
Monthly household income (Mop)#		-
5,000 or below	15 (2.2)	
5,100-10,000	77 (11.4)	
11,000-20,000	181 (26.8)	
21,000-30,000	133 (19.7)	
31,000 or above	269 (39.9)	
Gestational weeks		38.94 ± 1.75
<37	33 (5.0)	
≥ 37	622 (95.0)	
Gravidity		2.03 ± 1.20
1	300 (44.2)	
2	185 (27.3)	
3 or above	193 (28.5)	
Parity		1.51 ± 0.68
1	399 (58.8)	
2	219 (32.3)	
3 or above	60 (8.9)	
Sources of exposure to passive smoking		**-**
Passers-by on streets	529 (77.9)	
People in public places	431 (63.5)	
Relatives or friends	179 (26.4)	
Spouse	150 (22.1)	
Colleagues	126 (18.6)	
Family members	91 (13.4)	
Rarely exposed to passive smoking	32 (4.7)	
Note: #U.S.$1 is rated at Mop$7.7546. *p<.05, **p<.01, ***p<.001		

Table 1: Demographic characteristics of the participants (N=679).

Variables	Regression model				
	Correlation coefficient (Spearman's rho)/Median (Interquartile range)	β	Sig.	95% CI	
				Lower	Upper
Age	0	0.002	0.92	-0.037	0.042
Resident status					
Macao (referent)	1.3 (0-79)	-	-	-	-
Mainland China/ Others	0 (0-22.7)	-	0.65	-0.32	0.51
Marital status					
Married (referent)	0 (0-58.5)	-	-	-	-
Unmarried	8 (0-177)	-0.33	0.37	-1.03	0.38
Cohabitation with spouse					
No or occasional (referent)	7.2 (0-167.7)	-	-	-	-
Yes	0 (0-58.5)	-0.071	0.79	-0.59	0.45
Current employment status					
Unemployed (referent)	0 (0-19.3)	-	-	-	-
Employed	3.2 (0-152)	0.98	<0.001	0.63	1.34
Level of education					
Illiterate or primary school (referent)	40 (9.5-305)	-	-	-	-
Secondary school	6.2 (0-228)	-1.98	0.013	-3.55	-0.42
University	0 (0-21.4)	-2.69	0.001	-4.29	-1.09
Master's or above	0 (0-3.5)	-4.44	<0.001	-6.24	-2.64
Spouse's level of education					
Illiterate or primary school (referent)	10 (0-79)	-	-	-	-
Secondary school	4.7 (0-187.5)	-0.096	0.83	-0.95	0.76
University	0 (0-19.8)	-0.95	0.028	-1.79	-0.1
Master's or above	0 (0-13.2)	-1.59	0.004	-2.68	-0.5
Parity					
1 (referent)	0 (0-40)	-	-	-	-
2	0.7 (0-160)	-0.35	0.092	-0.76	0.057
3 or above	0.9 (0-80.8)	-1.32	<0.001	-1.92	-0.72
Gestational weeks					
<37 (referent)	6 (0-123)	-	-	-	-
≧37	0 (0-60)	-1.28	<0.001	-2.01	-0.56
Confidence in avoiding smoking	-0.41	-0.41	<0.001	-0.58	-0.24
Maternal response to smoking					
No action (referent)	3.4 (0-68.8)	-	-	-	-
Leave the venue	0.6 (0-58.5)	0.64	0.041	0.025	1.26
Open windows and doors	140 (0-1400)	1.25	0.009	0.32	2.19
Ask the smoking person to leave	0.6 (0-86.3)	1.41	<0.001	0.65	2.16
Ask the smoking person to stop smoking	0 (0-57)	0.52	0.13	-0.15	1.2
Sources of exposure to passive smoking					
Relatives or friends					
No (referent)	0 (0-44.3)	-	-	-	-
Yes	6.2 (0-97.5)	1.11	<0.001	0.8	1.41
Spouse+Family members					
No (referent)	0 (0-30.6)	-	-	-	-
Yes	19.5 (0-190)	0.97	<0.001	0.51	1.43
Public places					
No (referent)	0 (0-21.5)	-	-	-	-
Yes	3.2 (0-74)	1.48	<0.001	1.14	1.81
Private offices					
No (referent)	0 (0-40)	-	-	-	-
Yes	6.5 (0-94.4)	0.85	<0.001	0.54	1.15
Casinos/ Entertainment venues					
No (referent)	0 (0-17.7)	-	-	-	-
Yes	19.5 (0-376.5)	0.71	<0.001	0.35	1.07
People in public places					

No (referent)	0 (0-37.5)	-	-	-	-
Yes	3.2 (0-82)	0.49	0.003	0.17	0.8
Schools or educational facilities					
No (referent)	0 (0-56.6)	-	-	-	-
Yes	4.4 (0-75.6)	-0.96	<0.001	-1.37	-0.54
Friends' homes					
No (referent)	0 (0-38.5)	-	-	-	-
Yes	12.8 (0-101.6)	-0.67	<0.001	-0.98	-0.35
Passers-by on streets					
No (referent)	3.3 (0-163.3)	-	-	-	-
Yes	0 (0-50)	-0.41	0.008	-0.72	-0.11
Government offices					
No (referent)	0 (0-52)	-	-	-	-
Yes	19 (0-84.8)	0.33	0.14	-0.1	0.76
Public transport					
No (referent)	0 (0-54.1)	-	-	-	-
Yes	3 (0-61.5)	0.11	0.46	-0.19	0.41
Colleagues					
No (referent)	0 (0-40)	-	-	-	-
Yes	22.8 (0-500)	-0.17	0.32	-0.49	0.16
Restaurants or bars					
No (referent)	0 (0-49.7)	-	-	-	-
Yes	3.3 (0-69.2)	-0.16	0.28	-0.44	0.13
Rarely exposed to passive smoking					
No (referent)	1.3 (0-68.3)	-	-	-	-
Yes	0 (0-0)	-0.4	0.27	-1.11	0.31
Family members' smoking habits					
None (referent)	0 (0-37.3)	-	-	-	-
Yes, but away from the maternal presence	6.2 (0-78)	0.035	0.84	-0.3	0.37
Yes, and around the maternal presence	68.3 (0-473)	0.68	0.02	0.11	1.25
Spouse's smoking habit					
Never smokes (referent)	0 (0-38.3)	-	-	-	-
Smokes, but never at home	6.5 (0-114)	0.6	0.017	0.11	1.09
Smokes at home at specified times	36.5 (0.9-489)	0.5	0.3	-0.45	1.46
Smokes at home, but at specified places	12.7 (0-140)	-0.16	0.52	-0.63	0.32
Smoke at any place, any time	243.5 (14.5-421.5)	-0.21	0.71	-1.32	0.9
Smoking rules at home					
People can smoke at home (referent)	87.8 (0-307.5)	-	-	-	-
People can smoke at specified places only	12.7 (0-146.4)	-1.16	0.001	-1.82	-0.5
No smoking is allowed	0 (0-19.5)	-3.08	<0.001	-3.73	-2.43
Spouse smokes by your side					
Never (referent)	0 (0-41)	-	-	-	-
Sometimes	22.8 (0-198)	-0.55	0.029	-1.04	-0.056
Often/ Always	280 (58.5-1296)	0.62	0.14	-0.21	1.45
Gravidity					
1 (referent)	0 (0-25)	-	-	-	-
2	1.3 (0-85.3)	0.39	0.067	-0.027	0.8
3 or above	3.4 (0-182)	0.65	0.01	0.15	1.14

Table 2: Negative binomial regression model for all of the variables related to secondhand smoke exposure throughout pregnancy.

are defined as follows: Age: the participant's age group; Resident status: being a citizen of the area; Marital status: whether one has entered the state of marriage; Cohabitation with spouse: the condition of living with a spouse; Years of cohabitation with spouse: the number of years that one has lived with a spouse; Employment status: details of working status; Level of education: the level of formal education received by the participant; Spouse's level of education: the level of formal education received by the participant's spouse; Monthly household income: the level of household income as stated in Macao pataca.

Other variables in (Table 1 and Table 2) on details of the pregnancy and postnatal condition of the participants were drawn from section 3 of the questionnaire. They are defined as follows: Gestational weeks: length of gestation; Gravidity: the number of times that the participant has been pregnant; and Parity: the number of times that the participant

has given birth to a fetus with a gestational period of 24 weeks or more. The variable on sources of exposure to passive smoking was drawn from questions A3 to A8 of section 1 of the questionnaire. Another two variables in (Table 2), about the participant's confidence and response in avoiding SHS, were respectively drawn from questions A16 and A6 of section 1 of the questionnaire. They are defined as follows: Confidence in avoiding smoking: the participant's degree of confidence that he/she would be able to avoid SHS when encountering it; and Maternal response to smoking: how the participant would act to avoid SHS. As for the variables in (Tables 3-5), the meaning of each is clear from its name.

Secondhand smoke exposure	Throughout pregnancy		Before pregnancy	During pregnancy	
	n (%)	Mean ± SEM	Mean ± SEM	Mean ± SEM	*t-value*
Average number of hours of passive smoking daily (*n*=670)	-	-	2.09 ± 3.26	1.14 ± 2.51	-11.34***
Average number of days of passive smoking per week (*n*=670)	-	-	3.14 ± 2.78	1.96 ± 2.43	-15.50***
Total number of hours of passive smoking throughout pregnancy (*n*=660)	-	229.62 ± 607.06	-	-	-
No exposure	331 (50.2)	-	-	-	-
0.1-229.7 hrs	217 (32.9)	-	-	-	-
229.8-836.9 hrs	45 (6.8)	-	-	-	-
>870 hrs	67 (10.2)	-	-	-	-
*p<.05, **p<.01, ***p<.001					

Table 3: Secondhand smoke exposure before, during, and throughout pregnancy.

Smoke exposure	Before pregnancy	During pregnancy	
	n (%)	n (%)	z-value
Spouse's smoking habit (*n*=656)			-6.68***
Never smokes	402 (59.4)	420 (63.9)	
Smokes, but never at home	54 (8.0)	48 (7.3)	
Smokes at home at specified times	18 (2.7)	9 (1.4)	
Smokes at home, but at specified places	127 (18.8)	168 (25.6)	
Smokes at any place, any time	76 (11.2)	12 (1.8)	
Family members' smoking habits (*n*=652)			-5.32***
None	417 (61.8)	408 (62.2)	
Yes, but away from the maternal presence	156 (23.1)	191 (29.1)	
Yes, and around the maternal presence	102 (15.1)	57 (8.7)	
Smoking rules at home (*n*=650)			-9.72***
People can smoke at home	128 (19.2)	44 (6.7)	
People can smoke at specified places only	229 (34.4)	261 (39.7)	
No smoking is allowed	309 (46.4)	352 (53.6)	
Spouse smokes by side (*n*=668)			-9.97***
Never	460 (67.8)	547 (81.9)	
Sometimes	146 (21.5)	107 (16.0)	
Often	51 (7.5)	7 (1.0)	
Always	21 (3.1)	7 (1.0)	
Maternal response to smoking (n=659)			-7.55***
No action	107 (15.9)	34 (5.1)	
Leave the venue	438 (65.0)	479 (72.4)	
Open windows and doors	51 (7.6)	20 (3.0)	
Ask the smoking person to leave	45 (6.7)	68 (10.3)	
Ask the smoking person to stop smoking	31 (4.6)	59 (8.9)	
Others	2 (0.3)	2 (0.3)	
Places where you are exposed to passive smoking#			
Public places (n=640)	497 (76.5)	438 (68.1)	-7.61***
Casinos/Entertainment venues (n=647)	446 (67.8)	308 (47.5)	-11.34***
Restaurants or bars (n=635)	402 (62.6)	301 (47.2)	-9.91***
Friends' homes (n=628)	315 (49.7)	240 (38.1)	-6.95***
Private offices (n=627)	292 (45.9)	241 (38.3)	-7.35**
Public transport (n=624)	263 (41.5)	233 (37.2)	-4.28***
Government offices (n=624)	119 (18.8)	97 (15.4)	-3.68***
Schools or educational facilities (n=624)	87 (13.8)	75 (12.0)	-2.92*
*p<.05, **p<.01, ***p<.001. **Note:** #For "Places where you are exposed to passive smoking," the answers are not mutually exclusive, but yes/no for each.			

Table 4: Comparison of secondhand smoke exposure before and during pregnancy.

Factors	Mean total hours of SHS exposure throughout pregnancy ± *SD*	One-way ANOVA/t-test	Multiple linear regression (*n*=603)		
				95% confidence interval	
			Beta	Lower	Upper
Casinos/Entertainment venues (n=660)		t=9.686***	0.43***	226.42	317.12
Yes	785.9 ± 878.2				
No	68.8 ± 371.3				
Family members' smoking habits (n=639)		F=7.720***	0.12**	49.79	185.72
None	170.5 ± 465.7				
Yes, but away from the maternal presence	302.1 ± 767.2				
Yes, and around the maternal presence	479.3 ± 869.8				
Maternal level of education (n=660)		F=8.514***	-0.11**	-188.2	-41.27
Illiterate or primary school	133.8 ± 239.0				
Secondary school	344.0 ± 751.9				
University	115.6 ± 376.2				
Master's or above	60.6 ± 325.3				
Confidence in avoiding passive sources of smoking (n=659)		F=27.779***	-0.10**	-134.95	-20.05
Lots of confidence	61.6 ± 268.3				
Have confidence	176.1 ± 551.1				
Average	267.4 ± 572.0				
Little confidence	416.2 ± 639.4				
Lack of confidence	1285.0 ± 1495.2				
Working status (n=660)		t=-4.936***	0.07*	0.54	163.21
None	81.3 ± 490.1				
Yes	304.3 ± 645.6				
*p<.05, **p<.01, ***p＜.001					

Table 5: Risk factors of secondhand smoke exposure during pregnancy.

Results

Demographic characteristics

Out of 770 postnatal women who were approached, 13 did not meet the inclusion criteria because of their smoking status. Among the 757 eligible subjects, 692 (91.4%) agreed to participate in the present study. Of these 692 women, 13 were unable to complete at least 50% of the questionnaire. In the end, 679 (89.7%) completed questionnaires were collected. In reviewing the records, no differences were observed between the non-participants and participants of the present study in age, marital status, and parity.

The participants' demographic characteristics are summarized in (Table 1). Their mean age was 30. Most of them were married, lived in Macao, had at least a secondary school education, and had a monthly household income of over 11,000 MOP (US$1,419). The average number of weeks of gestation was 39. The average gravidity and parity were 2 and 1, respectively.

*Formula for total number of hours of passive smoking throughout pregnancy=No. of hours exposed to passive smoking per day × No. of days exposed to passive smoking per week × No. of gestational weeks

Smoking status of spouse and household members, and SHS exposure before and during pregnancy

Although 679 completed questionnaires were collected, fewer than 679 cases appear in the results shown in (Tables 3-5), because data for some of the variables were missing when the statistical analyses were conducted. Listed in (Table 3) are the total number of hours of passive smoking throughout pregnancy, and a comparison of the average number of hours per day and number of days per week of passive smoking before and during pregnancy. The average number of hours of maternal SHS exposure per day, and the average number of days of maternal SHS exposure per week dropped during pregnancy.

The smoking status of the spouse and household members of the participants and the participants' SHS exposure differed significantly before and during pregnancy (Table 4). The proportion of spouses who smoked at any place at any time, the proportion of family members who smoked around the pregnant participants, and the proportion of households that allowed smoking at home dropped during pregnancy. More participants took action to avoid SHS during pregnancy when compared with the time before their pregnancy. About half of the participants were not exposed to passive smoking throughout their pregnancy. For those who were exposed to SHS during pregnancy, the average duration of exposure throughout their pregnancy was 229.62 ± 607.06 hours. The most common places of exposure to SHS were public places. The most common sources of SHS were passers-by in the street and people in public places.

Risk factors of maternal SHS exposure

Five risk factors of maternal SHS exposure were identified (Table 5). They were: working in casinos/entertainment venues, the smoking habit of family members, the participants' level of education, confidence in avoiding sources of passive smoking, and working status. The regression model with these factors explained 26% of the total variance, $F(5,597)=42.53$, $p<0.001$. All variables associated with the dependent variables that showed significance were included in the negative binomial regression model. After adjustments, the following variables remained statistically significant: the participants' level of education, working status, the smoking habits of family members and spouse, confidence in avoiding sources of passive smoking, the maternal response to passive smoking, and sources of passive smoking.

Discussion

This is the first study to consider the SHS avoidance behaviors of pregnant women in Macao, in which SHS exposure was measured comprehensively before and during pregnancy, by frequency in days and duration in minutes, and in all areas and from all sources. The results show a significant reduction in SHS exposure during pregnancy. Still, the

prevalence of SHS exposure was 50%, 29% of spouses smoked at home, and 46% of households allowed smoking at home during pregnancy. In a randomized controlled trial that aimed to help spouses of non-smoking pregnant women to quit smoking, 22% of the spouses in the control group and 30% in the intervention group had attempted to stop smoking [26]. Interventions such as giving advice and educational booklets to spouses regarding the health risks to pregnant women of SHS exposure can be useful in helping spouses to quit smoking, thereby reducing the SHS exposure of their pregnant wives.

Five risk factors of SHS exposure were identified: working in casinos/entertainment venues, the smoking habits of family members, the participants' level of education, confidence in avoiding sources of passive smoking, and working status. Among these five predictors, we could conclude that the participants' level of education was the main factor that affected their choice of job. If the participants were working, they mostly worked in casinos/entertainment venues. The strongest predictor of SHS exposure that was found was working in casinos/entertainment venues. In Macao, smoking has been officially prohibited in indoor restaurants, food premises, beverage establishments, and karaoke establishments since 1st January 2012; the same law has been applied to casinos since 1st January 2013 and to indoor bars, nightclubs, saunas, and massage parlors from 1st January 2015 [27]. However, the ban on smoking is partial in casinos, with smoking being allowed in up to half of the area of a casino and there is no legal requirement to provide separate smoking and non-smoking areas [28]. This study was conducted soon after the law banning smoking was implemented. It can provide baseline data for comparisons with the results of future similar studies in order to evaluate the impact of the law banning smoking.

In our study, we found that confidence in avoiding sources of passive smoking predicted exposure to SHS. The same result was also found in studies conducted in the West [29]. If the participants were working in casinos/entertainment venues, and if, in addition, a member of their family had the habit of smoking, it would be hard from them to avoid being exposed to SHS in their work or home environment, even if they were confident about being able to avoid passive smoking in other places. Therefore, only smoke-free legislation can help these workers to reduce the socially unhealthy sanctioning of SHS exposure and allow them to adopt corresponding protective actions to avoid such exposure in their workplace [30]. Interventions for smoking cessation should target all smoking family members who live with a pregnant woman. Relapse-prevention strategies should also be introduced to sustain the effects of smoking cessation interventions [31]. An exploratory study by Loke et al. revealed that Chinese men would spontaneously quit smoking during their wife's pregnancy; therefore, this would be the golden time to introduce a smoking cessation intervention to the smoking husbands of pregnant women, as this is the time when they would be most likely to quit smoking [32].

This study has several limitations. These include the cross-sectional design, which was of no use in determining the relationship of cause-and-effect between actions taken to avoid SHS exposure and the duration of the SHS exposure, and avoidance behavior before and during pregnancy. The self-reported retrospective data on SHS exposures that were collected may have led to a recall bias; however, as most pregnant women were highly conscious of the need to avoid harmful exposure to SHS for the wellbeing of their developing baby, most participants were probably able to accurately recall their SHS exposure during pregnancy [33]. This study was carried out in a public hospital, which may not represent the situation of pregnant women in China.

Conclusion

It was found in this study that there was a significant reduction in SHS exposure during pregnancy, but that there is room to improve the situation at home and within the family. Interventions can be useful in helping spouses and family members to quit smoking. Our study also found that more participants took action to avoid SHS during pregnancy. However, they may have difficulty doing so in the workplace. Working in casinos and other entertainment venues was found to be a risk factor for SHS exposure. The health of pregnant women working there can only be protected by completely forbidding smoking in their working venues.

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Authors' Contributions

All of the authors took part in the conception and design of the study. In-Hong Fong, Chi-Heng Wong, I-Man Ho, and Iong-Ha Leong carried out the recruitment of the subjects, analyzed the data, and drafted the manuscript. YW Mak supervised the implementation of the study, and critically reviewed and finalized the paper.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethical Considerations

This study was approved by the ethics committees of The Hospital Conde de S. Januário and The Hong Kong Polytechnic University. Informed consent was obtained from each participant. Participation was voluntary and there were no repercussions to the participant from withdrawing at any time. All data were kept confidential.

References

1. https://www.who.int/en/news-room/fact-sheets/detail/tobacco
2. Do EK, Green TL, Prom-Wormley EC, Fuemmeler BF (2018) Social determinants of smoke exposure during pregnancy: Findings from waves 1 & 2 of the Population Assessment of Tobacco and Health (PATH) Study. Prev Med Rep 12: 312-320.
3. Thacher JD, Gehring U, Gruzieva O, Standl M, Pershagen G et al. (2018) Maternal Smoking during Pregnancy and Early Childhood and Development of Asthma and Rhinoconjunctivitis – a MeDALL Project. Environ Health Perspect 126: 047005.
4. Hoyt AT, Canfield MA, Romitti PA, Botto LD, Anderka MT et al. (2016) Associations between maternal periconceptional exposure to secondhand tobacco smoke and major birth defects. Am J Obstet Gynecol 215: 613.e1-613.e11.
5. Leonardi-Bee J, Britton J, Venn A (2011) Secondhand smoke and adverse fetal outcomes in nonsmoking pregnant women: a meta-analysis. Pediatrics 127: 734-741.
6. Meeker JD, Benedict MD (2013) Infertility, pregnancy loss and adverse birth outcomes in relation to maternal secondhand tobacco smoke exposure. Curr Women's Health Rev 9: 41-49.
7. World Health Organization (2013) WHO recommendations for the prevention and management of tobacco use and second-hand smoke exposure in pregnancy.
8. Siddiqi K (2019) Protecting women and children from second hand tobacco smoke: a public health priority. Pak J Chest Med 25: 1-2.
9. World Health Organization (2017) Western Pacific Region, Tobacco - China's addiction to an outdated and impoverishing economy.
10. Zhang L, Hsia J, Tu X, Xia Y, Zhang L et al. (2015) Exposure to secondhand tobacco smoke and interventions among pregnant women in China: a systematic review. Preventing Chronic Disease 12: E35.
11. Xu X, Rao Y, Abdullah AS, Sharma M, Guo JJ et al. (2017) Preventive behaviours in avoiding indoor secondhand smoke exposure among pregnant women in China. Tob Control 26: 483-484.

12. Chi YC, Sha F, Yip PS, Chen JL, Chen YY (2016) Randomized comparison of group versus individual educational interventions for pregnant women to reduce their secondhand smoke exposure. Medicine (Baltimore) 95: e5072.

13. Tong VT, Dietz PM, Rolle IV, Kennedy SM, Thomas W et al. (2015) Clinical interventions to reduce secondhand smoke exposure among pregnant women: a systematic review. Tob Control 24: 217-223.

14. Suriani I, MZ NA, Aidalina M, Al Sidek NDAB, Ramalingam DR (2017) Knowledge, attitude and practices on secondhand smoking among women who are exposed to secondhand smoking at home and at workplace. Int J Public Health Clin Sci 4: 66-76.

15. Tobacco Prevention and Control Office (2011) Tobacco Control Implementation Guidelines - Places of Entertainment, Macao Health Bureau of Macao.

16. https://unstats.un.org/unsd/dnss/docViewer.aspx?docID=513#start

17. Sockrider MM, Hudmon KS, Addy R, Dolan Mullen P (2003) An exploratory study of control of smoking in the home to reduce infant exposure to environmental tobacco smoke. Nicotine Tob Res 5: 901-910.

18. Su FC, Lee MC, Hsieh WS, Chhang PJ, Gou YI et al. (2007) The effect of prenatal and postnatal environmental tobacco exposure on infant health. The Taiwan Public Health 26: 472-478.

19. Yao T, Lee AH, Mao Z (2009) Potential unintended consequences of smoke-free policies in public places on pregnant women in China. The Am J Prev Med 37: S159-S164.

20. Yang L, Tong EK, Mao Z, Hu TW (2010) Exposure to secondhand smoke and associated factors among non-smoking pregnant women with smoking husbands in Sichuan Province, China. Acta Obstet Gynecol 89: 549-557.

21. Chow S, Shao J, Wang H (2008) Sample size calculations in clinical research. 2nd (edn), Chapman & Hall/CRC Biostatistics Series: p. 85.

22. https://www.cancer.org/cancer/cancer-causes/tobacco-and-cancer/secondhand-smoke.html

23. Mak YW, Loke AY, Abdullah AS, Lam TH (2008) Household smoking practices of parents with young children, and predictors of poor household smoking practices. Public Health 122: 1199-1209.

24. Mak YW, Loke AY, Lam TH, Abdullah ASM (2005) Validity of self-reports and reliability of spousal proxy reports on the smoking behavior of Chinese parents with young children. Addict Behav 30: 841-845.

25. Pourhoseingholi MA, Baghestani AR, Vahedi M (2012) How to control confounding effects by statistical analysis. Gastroenterol Hepatol Bed Bench 5: 79-83.

26. Loke AY, Lam TH (2005) A randomized controlled trial of the simple advice given by obstetricians in Guangzhou, China, to non-smoking pregnant women to help their husbands quit smoking. Patient Educat Couns 59: 31-37.

27. Tobacco Prevention and Control Office (2011) Tobacco Control Implementation Guidelines - Places of Entertainment, Macao Health Bureau of Macao.

28. Health Bureau (2012) Tobacco Control Legislations: New Tobacco Control Law-Guidelines and Leaflets, Macao Macao Speical Adminstrative Region.

29. Blake SM, Murray KD, El-Khorazaty MN, Gantz MG, Kiely M et al. (2009) Environmental tobacco smoke avoidance among pregnant African-American nonsmokers. Am J Prev Med 36: 225-234.

30. Haw SJ, Gruer L (2007) Changes in exposure of adult non-smokers to secondhand smoke after implementation of smoke-free legislation in Scotland: national cross sectional survey. Brit Med J 335: 549.

31. Zhou Y, Mak Y, Ho G (2019) Effectiveness of Interventions to Reduce Exposure to Parental Secondhand Smoke at Home among Children in China: A Systematic Review. Int J Environ Res Public Health 16: E107.

32. Loke AY, Mak YW, Lau PY (2012) Predictors of spontaneous smoking cessation among Chinese men whose wives are pregnant. Matern Child Health J 16: 1247-1256.

33. Ward C, Lewis S, Coleman T (2007) Prevalence of maternal smoking and environmental tobacco smoke exposure during pregnancy and impact on birth weight: retrospective study using Millennium Cohort. BMC Public Health 7: 81.