Original Article

The Effect of Second-Hand Smoke Exposure during Pregnancy on the Newborn Weight in Malaysia

Bachok Norsa'adah[1], Omar Salinah[2]

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[1] *Unit of Biostatistics and Research Methodology, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia*

[2] *Disease Control & Epidemiology Branch, Melaka Tengah Health Office, 75150 Melaka, Malaysia*

Abstract

Background: **There was strong evidence from studies conducted in developed countries that second-hand smoke (SHS) exposure is detrimental to the birth weight of newborn. This study was conducted to determine the effect of exposure to SHS smoke during pregnancy on the weight of newborns.**

Methods: **A retrospective cohort study was conducted. The exposed group consists of 209 postnatal women who experienced SHS exposure at home because of a husband or other housemate who smoked inside the house throughout the pregnancy. The non-exposed group included 211 women who did not experience SHS exposure at home or at work during pregnancy. We excluded non-Malay ethnicity, multiple births, and congenital defects.**

Results: **There was a significant difference in the adjusted mean birth weight between exposed infants [2893.0 g (95% confidence interval (CI): 2781.3, 3004.7)] and not exposed infants to SHS [3046.1 g (95% CI 2929.5, 3162.6) (P < 0.001)] after controlling for significant maternal factors. There was a 12.9 g (95% CI: 7.01, 18.96) reduction in birth weight for a corresponding increase in the exposure to the smoke of one cigarette (P < 0.001). The incidence of low birth weight (LBW) was higher in exposed women, [10% (95% CI: 5.94, 14.06)] compared to non-exposed women [4.7% (95% CI: 1.85, 7.55)].**

Conclusions: **This study found a significant association between SHS exposure during pregnancy and decreased birth weight.**

Keywords: *environmental tobacco smoke, low birth weight, passive smoking, prenatal exposure, second-hand smoke*

Introduction

The prevalence of smoking in Malaysia, as in many other developing countries, has been increasing. The Third National Health and Morbidity Survey in 2006 reported that the Malaysian prevalence of smoking among adults aged 18 years and older was 21.5%. The smoking rate was higher among males (46.4%) than females (1.6%) (1). Tobacco smoke contains many human carcinogens and toxic agents that are known or suspected to contribute to adverse human health effects (2).

There has been an increase in public health concern regarding the hazard of tobacco smoke experienced by non-smokers, an exposure known as second-hand smoke (SHS). Although the risk of diseases from SHS exposure is lower than the risk of active smoking, the proportion of people exposed to SHS is greater (3). A study conducted in Greece reported that the prevalence of active smoking during pregnancy was 36% compared to 94% were exposed to SHS, with 72% of the women exposed at home or 64% of them in a public place (4).

The strength of the effect of SHS is determined by the number of smokers and cigarettes, the smoking pattern, and the proximity to the smoker. Environmental factors including the volume of the polluted space, the ventilation system of the area and other factors affecting the removal of smoke can modify the smoke concentration in a given environment. The uptake of SHS depends on the breathing rate, airway geometry and other respiratory factors, and thus, modifies the dose of smoke received by the human body (5).

Birth weight is the most important determinant for the survival, health, growth and development of an infant. Low birth weight (LBW) is associated with fetal and neonatal mortality and morbidity, inhibited growth and cognitive development, and risk of chronic diseases in later life (6). There are many factors related to LBW, including socio-demographic factors, genetic and constitutional factors, nutrition, maternal morbidity, toxic exposures, obstetric factors and prenatal care. Smoke is considered a toxic agent to the fetus during pregnancy and an established, important and independent risk factor for LBW. Although the level of tobacco smoke exposure is lower in SHS exposure than in active smoking, the potential for biologic action is expected to be similar (7). The risk estimates for SHS exposure and LBW have generally been small, which is consistent with the expectation that exposure to SHS produces a smaller effect than exposure to active smoking. Most studies have shown a reduction in the mean birth weight and an increased risk for LBW among infants whose mothers were exposed to SHS (8,9). The mean birth weight of babies born to mothers exposed to SHS was 138 grams less than that of babies in non-exposed groups. Exposed women also had a significantly higher risk of having babies that were small for their gestational age (10). Furthermore, SHS also has adverse effects on other pregnancy outcomes such as spontaneous abortion, pre-term delivery, and small-for-gestation infant (10). Although an association between SHS exposure and birth weight has been established, most of the evidence was drawn from studies conducted in western and developed countries. In developing countries such as Malaysia, with higher smoking rates and poorer environmental conditions, particularly housing ventilation, the health effects of SHS exposure may be more pronounced. Many women are involuntarily exposed to SHS because the majority of smokers in Malaysia are males and the subsequent health implications apply not only to fetuses but also to women themselves. Furthermore, exposure to SHS can be prevented. Findings from this study should help increase awareness among physicians and patients about the importance of avoiding SHS exposure, particularly to those who are already at higher risk of poorer pregnancy outcomes.

This study was conducted to determine the association between exposure to SHS during pregnancy and newborn birth weight. Other objectives included determining the dose-response relationship between the number of cigarettes a woman was exposed to during pregnancy and newborn weight, and comparing the knowledge score on the health effects of smoking and SHS exposure between women exposed and unexposed to SHS during pregnancy.

Materials and Methods

The study design was a retrospective cohort. Exposure to SHS at home was defined as the exposure of a person to tobacco combustion products from smoking by a husband or other housemate who smokes inside the house when the subject is present. SHS exposure at the workplace was defined as breathing someone else's cigarette smoke for at least 15 minutes a day for at least three days a week (11). The exposed group consisted of women with SHS exposure at home throughout the whole pregnancy, with or without SHS exposure at workplace. Those living with a husband or others who were smokers but did not smoke indoors were excluded. The non-exposed group consisted of women who were not exposed to SHS at home or at the workplace.

We only included women who birthed singleton babies without congenital defects. To control for the confounding effect of maternal ethnicity on birth weight, only Malay women were included in the study. We excluded women with chronic medical conditions before and during pregnancy such as hypertension, diabetes mellitus, heart disease and renal disease, women who smoke or drank alcohol during pregnancy and those whose prenatal records were unavailable. Respondents were selected based on the inclusion and exclusion criteria among women who gave birth in one selected hospital.

The outcome of this study was the birth weight of newborns of exposed and non-exposed mothers. LBW is defined as weight at birth of less than 2500 g due to premature delivery of less than 37 gestational weeks or to intra-uterine growth retardation or both.

Data were collected by interviewing the selected women face to face by a single researcher. A structured questionnaire in Malay language was developed to obtain the required information, based on expert discussion and literature review. The questionnaire had four sections. Section A included information on the socio-demographic status of the mother. The variables of interest were age, level of education, occupation, and monthly household income. Section B included information on exposure status. The data queried were the location of exposure at home or at the workplace, duration of exposure based on the trimester, number of smokers living together, number of cigarettes smoked per day at home and duration (in hours) exposed at the workplace.

Section C included a questionnaire on knowledge. These questions consisted of 24 items with 6 domains involving knowledge of the harmful effects of smoking and SHS exposure on fetuses and children and in prohibited public areas for smoking. Responses included 'true', 'false' and 'don't know.' A correct response scored 2 points, an incorrect response scored 0 points and a 'don't know' response scored 1 point. The overall knowledge score was determined for each domain. The mean scores for overall knowledge in each area were compared between the exposed and non-exposed groups. The questionnaire was piloted among 50 pregnant women attending prenatal clinics in two health clinics. Item analysis was determined using internal consistency, reliability, Cronbach's alpha statistic and a corrected item correlation. The result of item analysis was 0.85.

Section D included the obstetric profiles and newborn information, which were collected from prenatal records, admission records and labor summary notes. The data collected included the date of last menstrual period (LMP), corrected date of ultrasound if LMP was uncertain, parity status, previous pregnancy outcomes, height, average weight gain, period of gestation (POA) at visit, total number of visits and maternal diseases during pregnancy. Labor summary notes were reviewed to collect information on newborn birth weight, date of delivery and the sex of the baby.

Average weight gain (kg/week) was calculated based on the difference between the weight at a visit and the weight at the previous visit divided by the total number of weeks between the two visits. Acute illness was defined as any acute diseases diagnosed during the current pregnancy, such as urinary tract infections or vaginosis. The outcome of interest of this study was the newborn birth weight in grams. Information on birth weight was gathered from the labor summary notes. The measurement of newborn birth weight was performed by the nurses on duty. There was only one scale used to weigh the newborns, and calibration of the machine was performed once daily.

Data entry and analyses were performed using the IBM SPSS version 20. Descriptive statistics such as the means and standard deviations (SD) for continuous variables and frequencies and percentages for categorical data were determined. Comparisons of variables between the exposed and the non-exposed groups were assessed by independent t tests for continuous variables and chi-square tests for categorical variables.

Analysis of covariance (ANCOVA) was used to compare the mean birth weights of the newborns between the exposed and non-exposed women while controlling for statistically significant maternal factors. Multiple linear regression was also used to determine the association between the number of cigarettes that generated SHS exposure and birth weight. The results were reported with adjusted β with 95% CI, t statistics and P values. Multiple binary logistic regression was used to determine the association between SHS exposure and LBW and results were reported as adjusted odds ratio and 95% confidence intervals (CI); the Wald test and *P* values The overall fitness of the model was determined using the Hosmer-Lemeshow goodness of fit test. For both multiple linear and logistic regression models, all possible two-way interactions and multicollinearity problems were checked.

Ethical approval for this study was obtained from the Research and Ethics Committee, School of Medical Sciences, Universiti Sains Malaysia. Written informed consent was signed by all the respondents in this study. All information was kept confidential and would not identify individual respondents.

Results

A total of 420 Malay women, 209 exposed, and 211 non-exposed were included in this study. All of the women in the exposed group were exposed to SHS at home and only eight (3.8%) of them were exposed both at home and in the workplace. Those exposed in the workplace were exposed to SHS during all three trimesters. Among those exposed at home, 198 (94.7%) women experienced exposure from their husband, and 50 (23.9%) women experienced exposure from other housemates. At home, 169 (80.9%) women were exposed to one smoker, 31 (14.8%) of women were exposed to two smokers, eight (3.8%) of women were exposed to three smokers and one (0.5%) woman was exposed to four smokers. One hundred thirty-five (64.6%) women were exposed to one to nine cigarettes per day, 55 (26.3%) women were exposed to 10 to 19 cigarettes per day and 19 (9.1%) women were exposed to 20 cigarettes or more per day. The median number of cigarettes was 6 (Inter Quartile Range 6). The distribution was skewed to the left, with the majority of women exposed to the low number of cigarettes.

Table 1 depicts the socio-demographic profiles of the exposed and non-exposed women.

The mean age of the exposed women was 28.4 years (SD 5.56), whereas the mean age of non-exposed women was 29.7 (SD 5.33), and this difference was statistically significant. There was no significant difference in the employment status between the two groups, but significant differences were observed between age groups, education levels, and monthly household income levels.

Table 2 compares the obstetric profiles between exposed and non-exposed women. There were no significant differences in the gestational duration, POA at booking, number of prenatal visits, height, average gestational weight gain, history of preterm birth, history of LBW, history of abortion or the sex of the baby. A significant difference was observed in the parity status between the two study groups. The exposed group had a significantly higher percentage of acute illness during the current pregnancy compared to the non-exposed group.

Mean birth weight in exposed and non-exposed women

A comparison of mean birth weight between exposed and non-exposed women is depicted in Table 3. The adjusted mean birth weight of the newborns was significantly lower for exposed women than for non-exposed women. The significantly associated maternal factors included gestational duration, maternal height, weight gain and parity status. These variables were controlled in the ANCOVA for the adjustment of mean birth weight of the newborns.

Dose response relationship between number of cigarette and birth weight

There was a significant reduction of 12.9 g (95% CI: 7.01, 18.96) in birth weight for each unit of exposure to a cigarette.

Incidence of low birth weight

Exposed women had a higher LBW incidence of 10% (95% CI 5.94, 14.06) compared to that in non-exposed women, which was 4.7% (1.85, 7.55). LBW was of moderate severity for women in both groups, with birth weights ranging from 1501 to 2499 grams. Of all LBW newborns, 10 (32.3%) were delivered prematurely. The proportion of premature delivery among LBW newborns was 33.8% for exposed women and 30% for non-exposed women.

Table 1: Socio-demographic profiles of 209 exposed and 211 non-exposed women to second-hand smoke

Socio-demographic profiles	Frequency (%)		χ^2stat (df)	*P* value
	Exposed (n = 209)	Non-exposed (n = 211)		
Age (years)	28.4 (5.56)[a]	29.7 (5.33)[a]	2.45 (418)[b]	0.015[b]
17–24	62 (29.7)	37 (17.5)	8.21 (2)	0.016
25–34	110 (52.6)	131 (62.1)		
35–44	37 (17.1)	43 (20.4)		
Education level			20.35 (2)	< 0.001
Primary	16 (7.7)	11 (5.2)		
Secondary	162 (77.5)	129 (61.1)		
Tertiary	31 (14.8)	71 (33.7)		
Occupation			0.61 (1)	0.436
Housewife	106 (50.7)	99 (46.9)		
Employed	103 (49.3)	112 (53.1)		
Monthly household income (RM)			16.85 (2)	< 0.001
< 1000	73 (34.9)	42 (19.9)		
1000 – < 2000	85 (40.7)	84 (39.8)		
2000 and above	51 (24.4)	85 (40.3)		

[a]Mean (Standard Deviation), [b]independent *t* test.
Abbreviation: RM = Ringgit Malaysia.

Association between SHS exposure during pregnancy and LBW

SHS exposure was not significantly associated with LBW and had a odds ratio of 1.37 (95% CI: 0.51, 3.65) after the adjustment of significant confounders included gestational duration, maternal height, previous history of LBW and parity status, as depicted in Table 4.

Knowledge score between exposed and non-exposed women

Table 5 compares the mean knowledge scores between exposed and non-exposed women. There was no significant difference in overall knowledge scores between these two groups. With regard to the domain of knowledge, the only significant difference was for the mean knowledge score on the effect of maternal smoking on pregnancy, for which non-exposed women had higher knowledge scores compared to exposed women.

Discussion

In this study, we observed significant differences in socio-demographic characteristics between women exposed and those unexposed

Table 2: Obstetric profiles of 209 exposed and 211 non-exposed women to second-hand smoke

Obstetric profiles	Frequency (%)		χ^2 stat (df)	*P* value
	Exposed (*n* = 209)	Non-exposed (*n* = 211)		
Parity status				
1	85 (40.7)	61 (28.9)	7.69 (2)	0.021
2–5	107 (51.2)	136 (64.5)		
6 and above	17 (8.1)	14 (6.6)		
Maternal height (cm)	154.0 (5.34)[a]	154.5 (6.43)[a]	0.88 (418)[b]	0.378[b]
POA at booking (week)	14.7 (5.81)[a]	14.3 (5.20)[a]	0.95 (418)[b]	0.342[b]
No of antenatal visits	9.7 (2.47)[a]	9.8 (2.20)[a]	0.53 (418)[b]	0.596[b]
Acute illness				
No	180 (86.1)	202 (95.7)	11.78 (1)	0.001
Yes	29 (13.9)	9 (4.3)		
Weight gain (kg/week)	0.44 (0.19)[a]	0.43 (0.18)[a]	0.28 (418)[b]	0.763[b]
Gestational duration	38.9 (1.35)[a]	39.0 (1.21)[a]	0.64 (418)[b]	
32–36	12 (5.7)	5 (2.4)	3.07 (1)	0.080
37 and above	197 (94.3)	206 (97.6)		
History of abortion				
No	186 (88.2)	182 (87.1)	0.11 (1)	0.739
Yes	25 (11.8)	27 (12.9)		
History of preterm birth				
No	200 (94.8)	197 (94.3)	0.06 (1)	0.812
Yes	11 (5.2)	12 (5.7)		
History of LBW				
No	192 (91.0)	188 (90.0)	0.13 (1)	0.716
Yes	19 (9.0)	21 (10.0)		
Sex of baby				
Boy	118 (56.5)	127 (60.2)	0.60 (1)	0.438
Girl	91 (43.5)	84 (39.8)		

[a]Mean (Standard Deviation), [b]independent *t* test.
Abbreviations: POA = Period of Amenorrhea, LBW = Low Birth Weight.

to SHS. The exposed women were found to be younger, less educated and to have lower household incomes, possibly reflecting a poorer socioeconomic status. Goel et al. found that women exposed to second-hand smoke were less educated, of higher parity and fewer were employed (10). Another study also reported that those exposed to SHS were younger and had fewer years of schooling (13). Many studies have highlighted the association between poor socioeconomic conditions (measured through low education level, occupation and household income) and low birth weight. This relationship stems primarily from the mother's poor nutrition

Table 3: Comparison of adjusted mean newborn birth weight (grams) between exposed and non-exposed women to second-hand smoke

Exposure status	Adjusted mean (95% CI)	Mean difference (95% CI)	*P* value[a]
Non exposed	3046.1 (2929.5, 3162.6)	−153.1 (−225.6, −80.6)	< 0.001
Exposed	2893.0 (2781.3, 3004.7)		

[a]ANCOVA adjusted for gestational duration, maternal height, weight gain and parity status.

Table 4: Association between second-hand smoke exposure during pregnancy and low birth weight

Variable	Adjusted OR (95% CI)	Wald test (df)	*P* value[a]
Second-hand smoke exposure	1.37 (0.51, 3.65)	1.15 (1)	0.973
Gestation (week)	0.59 (0.53, 0.66)	−5.67 (1)	< 0.001
Maternal height (cm)	0.96 (0.95, 0.97)	−3.03 (1)	0.001
History of LBW	2.60 (1.60, 4.16)	3.98 (1)	< 0.001
Parity status			
2–5	0.30 (0.20, 0.47)	−5.46 (1)	0.003
6 and above	0.14 (0.02, 1.10)	−1.87 (1)	0.060

[a]Multiple binary logistic regression.
Abbreviation: OR=Odds Ratio.

Table 5: Mean knowledge scores of the exposed and non-exposed women

Knowledge	Mean (SD)		*t* stat	*P* value*
	Exposed (*n* = 209)	Non-exposed (*n* = 211)		
Effect of smoking	6.84 (1.29)	6.91 (1.17)	0.60	0.548
Effect of smoking on pregnancy	5.60 (1.36)	5.88 (1.39)	2.07	0.038
Effect of second-hand smoke exposure	6.36 (1.58)	6.27 (1.51)	0.56	0.578
Effect of second-hand smoke exposure on pregnancy	5.12 (1.51)	5.36 (1.51)	1.60	0.110
Effect of second-hand smoke exposure on children	5.38 (1.31)	5.60 (1.32)	1.70	0.089
Smoking prohibited public places	6.74 (1.46)	6.58 (1.57)	1.05	0.299
Overall score	36.05 (5.54)	36.6 (5.51)	1.05	0.293

*Independent *t* test.

and health over a long period of time, including during pregnancy. There is also high prevalence of specific and non-specific infections or pregnancy complications among women in poverty (14).

Our study found that the husband was the main source of SHS exposure at home. Surprisingly, only a small proportion of women (3.8%) were exposed to SHS at work. Among the reasons for this small proportion were that some of the women worked on government premises where smoking was prohibited by law and many of the women worked as operators for multinational companies where designated areas for smoking were provided by the employer.

The total incidence of LBW in our study was 7.5%, which was lower than the 10% incidence of LBW in the general Malaysian population as estimated by UNICEF (6). The incidence of LBW in women with SHS exposure was 10%, compared to 4.7% among non-exposed women. These incidences were lower than those from a study among the Indian population, in which the incidence was 31.9% among the exposed and 17.2% among the non-exposed (10). This might be explained by the presence of many other risk factors in the Indian population, which is generally of a poorer socioeconomic status. Another study in Asia also reported a higher incidence than our study, with 12.6% in the exposed group and 7.7% in the non-exposed group (15).

Our study provides evidence on the effect of SHS exposure during pregnancy, with a decrease in newborn birth weight, as supported by other studies (9,16). The causal association was further strengthened by demonstrating a dose-response relationship. Infants born from women who were exposed to SHS had an average birth weight of 153.1 grams less than those born from non-exposed women. With an average exposure of one cigarette per day, a significant reduction of 12.9 g of birth weight was observed. In our study, the effect on birth weight was due to growth restriction rather than early delivery as the proportion of preterm deliveries was not significantly different between the exposed and non-exposed women, and the duration of gestation was adjusted for in the statistical analysis.

Women who were exposed to SHS for more than one hour per day at home or outside the home had babies who were 78.9 g lighter compared to non-exposed women (17). Martinez et al. reported a decrement of only 3.4 g birth weight with an average exposure of one cigarette per day, which was less than that observed in our study (18). It can be postulated that the larger decrement might result from higher tobacco consumption in Malaysia compared to western countries. Furthermore, our study found that a higher proportion of exposed women were from a lower socioeconomic status. Thus, they might have lived in a smaller house with poorer ventilation systems that did not permit the fast removal of smoke.

Many studies have shown a significant association between SHS exposure and LBW; however, our study did not. A comprehensive review of the literature on SHS and LBW indicates that all studies have found a small increase in the risk of LBW with SHS exposure (8,9,19). A meta-analysis by Windham et al. produced a small pooled risk estimate of only a 1.2 odds ratio (95% CI: 1.1, 1.3) for this association (8). A recent study also showed that exposed women were 1.6 times more likely to deliver LBW babies than non-exposed women (15).

One might question the clinical relevance of our study finding a decrement of 153.1 g in birth weight. While this decrease may not be clinically meaningful to normal birth weight babies, it might be to those babies who are already at risk due to the presence of other risk factors. A small excess risk contributed by SHS exposure could move these babies to a critically low birth weight. Furthermore, at the population level, a small change in average birth weight could affect large numbers of newborns because of the high frequency of SHS exposure.

A history of LBW in previous pregnancies is one of the most important risk factors for subsequent LBW (20). Our study showed a significant relative risk for LBW of 2.6 among those with a previous history of LBW. Maternal height was found to be significantly related to the risk of LBW. With an increase of one centimeter of maternal height, the risk of LBW was reduced by 4%. Height is influenced by both genetic and environmental factors. Parity was also found to be significantly associated with LBW in our study. The association with parity cannot be explained by age and socioeconomic status because these factors were controlled for in this study.

Our study did not find significant differences in the overall mean knowledge score between exposed and non-exposed women. The only significant difference was for the knowledge of the effect of maternal smoking on the fetus, for which non-exposed women had a higher mean score compared to exposed women. Our study showed that most women were aware of the health effects of active smoking on an individual. This most likely indicated the effectiveness of health promotion and information on cigarette smoking by the government. However, many women were not aware of the health effects of SHS exposure because this issue had not received similar attention. As evidence is accumulating on the harmful effects of SHS exposure and the large number of people exposed to SHS, the public must be educated on this issue. Knowledge of the harmful effects of SHS might help to reduce such exposure. However, knowledge might not necessarily reduce exposure, particularly in the home setting, unless smokers themselves are aware on the harmful effects of SHS and do not smoke at home. Studies have suggested that smoke-free homes not only protect non-smokers from SHS but also facilitate smoking cessation for adults (21). A study by Goel et al. among pregnant women in India found that more than 80% of the women in both an exposed and non-exposed group acknowledged that smoking was harmful to fetuses, but the proportion decreased to more than 20% in both groups when the women were asked about the risk of SHS exposure (10).

Several methods can be used for exposure assessment in population-based research, such as the measurement of indoor air concentrations, personal monitors, questionnaires and biological markers. This study did not use methods other than questionnaires for smoking exposure assessment because of limited resources. The advantages of cotinine in body fluids or hairs as biomarkers of SHS exposure include their relatively high sensitivity, their specificity for tobacco combustion and their accuracy of measurement methods at low concentrations (2). A study that used cotinine levels as a confirmation of exposure showed significant birth weight decrements (22). There was also a significant dose dependence on mean birth weight across the range of cotinine values (23).

Many recent studies have used biomarkers that provided an objective measurement for the assessment of SHS exposure. A study by Rebagliato et al. used questionnaires to collect information on the pattern of SHS exposure in the home, workplace and public places, together with salivary cotinine (24). Surprisingly, only exposure to SHS in public places was significantly associated with lower birth weight. Those who were exposed for more than 14 hours per week had infants who were 177.2 g lighter than those of non-exposed women. These findings suggest that exposure in public places might be associated with younger age or with certain social or lifestyle patterns that make them more exposed to SHS at public places. These findings might also be due to confounding effects that were not adequately controlled for.

Although the use of questionnaires to assess exposure might lead to a misclassification of exposure, misclassification is expected to be minimal in our study because measures were taken to prevent this. We assessed the women's exposure by collecting information on the smoking status of household members and exposure at the workplace, rather than using paternal smoking status alone. We also excluded those who had a husband who smoked outdoors rather than classifying them as non-exposed because these women might have a low level of exposure as smoke could still get into the house through windows and doors. Exposure to cigarette smoke might also occur in the non-exposed group from visitors and exposure at public places. However, due to its irregular pattern and lesser contribution over time, this exposure was assumed to be similar in both groups.

Information from questionnaires on the exposure to SHS is essentially data collection by proxy, as it involves questioning non-smokers about smoking histories of people with whom they live or work. Questionnaires can provide detailed information on SHS sources and the strength and duration of exposure. Questionnaire use is the least expensive method and thus is suitable for studies with large sample sizes. However, there are concerns associated with questionnaire assessment. A gold standard measurement with which validity can be tested is lacking and there are currently no commonly accepted standardized questionnaires. A misclassification of exposure may result from limited questions, the respondent's failure to recall exposure precisely and intentional false reporting (2). Different strategies have been used in an attempt to validate questionnaires but as mentioned earlier, there is no gold standard.

Nevertheless, several studies have found that self-reporting of SHS exposure is reasonably accurate. In a study by O'Connor et al., personal monitoring of air cotinine was compared with questionnaires to measure SHS exposure among 415 pregnant women (25). Women who reported SHS exposure had significantly higher levels of air cotinine compared with women reporting no exposure.

Another limitation of our study was recall bias that occurred while measuring the amount of exposure, as it was difficult to precisely estimate the amount of exposure based on the number of cigarettes per day, the number of hours of exposure, the number of smokers at home and exposure elsewhere. We presumed that the SHS exposure outside of the home would be similar in both groups. Furthermore, the housing conditions where smoking occurs play an important role in the concentration of SHS exposure, but this information was not collected. This was a retrospective cohort study in which the information on the exposure status and outcome were collected at the same time. As the exposure status throughout pregnancy was ascertained at the end of pregnancy, follow-up was either not needed or an assumption of a constant exposure status throughout pregnancy was made. Another weakness of our study was the fact we included the pre-term infants in our study. We recommended of exclusion of pre-term infants in the future study.

The findings of this study contribute to the pool of literature that demonstrates a significant association between SHS exposure during pregnancy and decreased birth weights. As no such study had previously been conducted locally, the present study provides evidence of such an association in a local setting. SHS exposure can be prevented. Given the harmful effects of SHS exposure, pregnant women should be advised to avoid it. Studies have shown that the major source of exposure was from home, but regulating the home as a smoking restricted area by law is rather impossible. Thus, efforts must be made to disseminate information to the public and to create awareness of the harmful effects, particularly to husbands and others who are in close proximity to pregnant women. Continuing support is needed to help smokers to quit smoking, as decreased smoking rates is the best means to eliminate SHS exposure. If quitting is not possible, they should be advised to reduce exposure by not smoking in the presence of pregnant women and not smoking indoors. There is also a need for health personnel attending pregnant women to integrate the information regarding SHS exposure during prenatal counseling. This is particularly important to those who are already at higher risk of poor pregnancy outcomes due to the presence of other risk factors because small excess risks from SHS exposure may produce a significant difference in risk status.

Future studies using biomarkers are recommended to quantify SHS exposure objectively. This will enable more precise interpretation of the health effects and allow valid comparisons with other studies using similar biomarkers. Environmental sampling should also be incorporated because it can provide objective information on the strength of exposures from different sources as biomarkers can only capture an overall exposure.

Conclusions

The prevalence of SHS in this study was 49.8%. There was a significant difference in the mean birth weight between women who were exposed or not exposed to SHS. There was also an inverse dose-response relationship observed between the amount of exposure and newborn birth weight. However, this study failed to demonstrate a significant association between SHS exposure during pregnancy and LBW

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Conflict of interest

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Authors' Contributions

Conception and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for the important intellectual content, final approval of the article and statistical expertise: BN, OS

Provision of study materials or patient, administrative, technical or logistic support, collection and assembly of data: OS

Correspondence

Dr Bachok Norsa'adah
MBBS (Flinders), MCom Med (Universiti Sains Malaysia), PhD (Universiti Kebangsaan Malaysia)
Unit of Biostatistics and Research Methodology
School of Medical Sciences
Universiti Sains Malaysia
16150 Kubang Kerian
Kelantan, Malaysia
Tel: +609 767 6827
Fax: +609 765 3370
Email: norsaadah@usm.my

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