Article

Inadequate Gestational Weight Gain and Exposure to Second-Hand Smoke during Pregnancy Increase the Risk of Low Birth Weight: A Cross-Sectional Study among Full-Term Infants

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Abstract: Despite the advancement of the healthcare system, low birth weight (LBW) remains as one of the leading causes of under-five mortality. This cross-sectional study aimed to determine the prevalence of LBW and its associated factors among 483 third trimester pregnant women recruited from six selected public health clinics in the Federal Territory of Kuala Lumpur and the state of Selangor, Malaysia. Pregnant women were interviewed for information on socio-demographic characteristics, smoking behaviour, and second-hand smoke (SHS) exposure at home and in the workplace. Information on the obstetrical history and prenatal care visits history were retrieved from the maternal medical records, while infant's birth outcomes were retrieved from infant medical records. The prevalence of LBW (<2.5 kg) in infants was 10.4%, with a mean birth weight of 3.0 [standard deviation (SD) 0.4] kg. Results from the multivariable logistic regression model showed that inadequate weight gained during pregnancy [odds ratio (OR) = 2.41, 95% confidence interval (CI) = 1.18–4.90] and exposure to SHS at home (OR = 1.92, 95% CI = 1.03–3.55) were significantly associated with LBW. In conclusion, pregnant women should monitor their rate of weight gain throughout pregnancy and avoid SHS exposure at home to reduce the risk of delivering LBW infants.

Keywords: low birth weight; infant; MICOS; gestational weight gain; exposure to second-hand smoke

1. Introduction

Birth weight is a vital parameter that reflects maternal nutritional status and well-being before and during pregnancy, as well as foetal growth and development. LBW is defined as the weight taken at birth of less than 2.5 kg by the World Health Organization (WHO) [1]. LBW is a significant global public health concern and has been identified as one of the leading causes of mortality and morbidity among children under five years of age [2,3]. Globally, it is estimated that more than 20 million infants are born with LBW each year [4]. The prevalence of LBW varies across regions, ranging from 7.9% in the regions of Northern America to 17.3% in the regions of Asia [3]. LBW is more common in developing than developed countries, consisting up to 95.6% of the global prevalence [5].

In Malaysia, the third National Health and Morbidity Survey (NHMS III) revealed that 9.7% of the children under five years of age were born with LBW [6]. The prevalence of LBW in Malaysia varies across states, ranging from 5.7% to 16.2% [6].

LBW is associated with a range of short- and long-term consequences, and these consequences may persist into adulthood [7]. The "Barker's hypothesis" or theory of "foetal and infant origins of adult disease" suggests that the in-utero environment and early infant health status can permanently program the growth and metabolism of the body, thereby influencing the development of chronic diseases in later life [8]. Evidence shows that LBW infants have a higher risk of getting illnesses, having congenital abnormalities, lower cognitive abilities, malnutrition, and impaired immune function, which increases the risk of infections [7,9–12]. Meanwhile, LBW was found to be associated with an increased risk of chronic diseases later in life including asthma, depression, type II diabetes, coronary heart disease, hypertension, stroke, insulin resistance, and cancers [7,13–17]. Considering both the short- and long-term consequences of LBW, it is therefore crucial to determine their risk factors, which may be targeted in future prevention strategies in order to reduce the risk of LBW in infants.

Findings from previous studies demonstrated that maternal factors including ethnicity, maternal age, educational level, employment status, monthly household income, household size, gravidity, and parity are important factors that are associated with LBW in infants [18–25]. Other factors including maternal pre-pregnancy body mass index (BMI), gestational weight gain (GWG), frequency of antenatal care visit, and environmental factors such as smoking behaviour and second-hand smoke (SHS) exposure during pregnancy are key modifiable risk factors of LBW [20,21,26–28]. Despite extensive research on LBW, findings remain inconclusive and there are limited studies assessing factors associated with LBW among full-term infants [29,30]. In addition, evidence on associations of the modifiable risk factors such as maternal pre-pregnancy BMI, GWG, and SHS exposure with LBW were mostly drawn from the developed countries [28,31–33]. In developing countries with a higher prevalence of overweight/obesity and smoking such as Malaysia, the contributions of maternal pre-pregnancy BMI, GWG, and SHS exposure on infant's birth outcomes may be more pronounced. Although the adverse effects of tobacco smoke exposure on LWB have been well-established [28,30,33], studies that assessed the associations between SHS exposure at home and in the workplace during pregnancy with LBW have been limited [34,35].

Therefore, the present study aims to determine the prevalence of LBW and its associated maternal and environmental risk factors among full-term infants. Identifying the risk factors of LBW could help to guide the development of prevention strategies in order to reduce the incidence of LBW and indirectly reduce childhood mortality and morbidity resulting from LBW.

2. Materials and Methods

2.1. Study Setting and Population

This cross-sectional study is part of the Mother and Infant Cohort Study (MICOS) that focused on the contribution of early nutrition on the development of malnutrition and allergic diseases in infants during the first year of life, whereby this paper is focused on the risk factors associated with LBW among full-term infants. The protocol of MICOS has been described elsewhere [36]. The present study was conducted at six selected public health clinics in the Federal Territory of Kuala Lumpur and the state of Selangor, Malaysia, from November 2016 to January 2018. A total of 535 pregnant women aged ≥ 18 years, ≥28 weeks of gestations, with a singleton pregnancy, and who have their regular prenatal care visits at the selected public health clinics, were recruited. Women with multiple pregnancies and a preterm birth at less than 37 weeks gestation were excluded from the study. The present study was approved by the Medical Research and Ethics Committee (MREC), Ministry of Health (MOH) Malaysia (Reference number: NMRR-16-1047-30685), and the Ethics Committee for Research Involving Human Subjects, Universiti

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Putra Malaysia (JKEUPM) (Reference number: FPSK (FR16) P006). Prior to the data collection, written informed consent was obtained from the pregnant women. Out of the 535 pregnant women who consented, 52 of them were excluded due to preterm delivery (n = 11), incomplete maternal data (n = 3), and lack of data on birth outcomes (n = 38). The final sample size was 483 mother–infant pairs, with a response rate of 90.2%.

2.2. Maternal Characteristics

Information on socio-demographic characteristics including maternal age, ethnicity, educational level, employment status, household size, and monthly household income were obtained from the pregnant women through a face-to-face interview. Meanwhile, information on obstetrical history including pre-pregnancy weight, height, last measured weight at the third trimester of pregnancy, gravidity, and parity were obtained from the maternal medical records. Pre-pregnancy BMI (kg/m^2) was calculated as pre-pregnancy weight (kg) divided by the square of pre-pregnancy height (m^2) and was then classified into underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obesity ($\geq$30.0 kg/m^2) [37]. Total GWG was calculated as the difference between the final recorded body weight at the last prenatal care visit and the pre-pregnancy weight recorded at the first prenatal care visit. Total GWG was then compared with the recommended range of weight gain based on their pre-pregnancy BMI using the 2009 Institute of Medicine (IOM) guidelines [38] and categorised into inadequate (gained weight less than the recommended range), adequate (gained weight within the recommended range), and excessive (gained weight more than the recommended range) GWG.

2.3. Prenatal Care Visit History

Information on prenatal care visit history including first prenatal care visit and the number of prenatal care visits were retrieved from the maternal medical records. First prenatal care visit was recorded as trimester of pregnancy in which the prenatal care was started, while the number of prenatal care visits was calculated as the total number of prenatal visits attended by the pregnant women (from the first attendance until the last attendance) at any primary healthcare facilities throughout their pregnancy.

2.4. Maternal Smoking and SHS Exposure during Pregnancy

Information on maternal smoking and SHS exposure during pregnancy were assessed using the Global Adult Tobacco Survey (GATS) Core Questionnaires developed by the Centre for Disease Control and Prevention (CDC) [39]. Maternal smoking during pregnancy (yes/no) was determined by the question "Do you currently smoke tobacco?" Exposure to SHS at home (yes/no) was defined as someone smoked inside the home of the pregnant women at least once a month, while exposure to SHS at the workplace (yes/no) was defined as someone smoked in indoor areas where the pregnant women work at least once a month.

2.5. Birth Outcomes

Information on birth outcomes, namely, gestational age at birth, infant's sex, and birth weight, were extracted from the infant medical records. Low birth weight was defined as weight at birth of less than 2.5 kg [1]. Prior to the bivariate and multivariate analyses [40], the birth weight categories, such as very low birth weight and LBW, are merged as LBW and normal birth weight, whereas high birth weight is excluded.

2.6. Statistical Analysis

Data were analysed using IBM SPSS Statistics version 22.0 software (SPSS Inc. Chicago, IL, USA). All continuous variables were tested for normality and the value of skewness within the range of $\pm$2.0 is considered as normally distributed [41]. Descriptive data for categorical variables were presented as frequencies and percentage, whereas continuous variables were presented as mean and standard deviation (SD). Simple logistic regression (SLR) analysis was used to determine the associations between each independent variable

(maternal age, ethnicity, educational level, employment status, household size, monthly household income, pre-pregnancy BMI, total GWG, gravidity, parity, first prenatal care visit, number of prenatal care visits, maternal smoking during pregnancy, and exposure to SHS at home and at the workplace during pregnancy) with LBW, respectively. Variables with a *p*-value of less than 0.25 in the SLR model were included in the multivariable logistic regression model [42]. The forward variable selection method was used in the multivariable logistic regression analysis to determine the associations between the selected variables and LBW. All assumptions for the multivariate logistic regression analysis were met, in which all data were normally distributed, the *p*-value for the Omnibus test was less than 0.05, the percentage obtained in the overall classification table was more than 80.0%, the *p*-value for the Hosmer and Lemeshow test was greater than 0.05, and the *p*-value for multicollinearity and interaction was greater than 0.8 [40]. Results were presented as odds ratio (OR) and 95% confidence interval (CI) and the level of significance was set at *p* < 0.05.

3. Results

3.1. Characteristics of the Pregnant Women

Characteristics of the pregnant women are shown in Table 1. Overall, the mean age of the pregnant women was 30.0 (SD 4.2) years old (range: 18.6–40.7 years). Majority of them were Malay (91.1%), attained tertiary education (82.2%), were working (68.3%), had a moderate (52.6%) to high (30.2%) monthly household income, and had a mean household size of 3.9 (SD 1.9) members. While 9.7% of women were underweight before pregnancy, 36.9% of them were either overweight or obese before pregnancy. Additionally, more pregnant women had inadequate weight gained (32.7%) compared to those with excessive weight gained (28.2%) during pregnancy. The present study consisted of 0.8% of pregnant women who were smokers. Meanwhile, 32.4% of the pregnant women were exposed to SHS at home and 26.4% of them were exposed to SHS at their workplace. Majority of the pregnant women started their first prenatal care visit at the first trimester (71.6%), followed by the second (26.5%) and third (1.9%) trimester of pregnancy, with a mean gestation of 11.2 (SD 5.0) weeks. On average, the pregnant women attended approximately 11 prenatal care visits during their pregnancy.

Table 1. Characteristics of the pregnant mothers (*n* = 483).

Variables	*n* (%)	Mean (SD)
Socio-demographic Characteristics		
Maternal age (years)		30.0 (4.2)
Ethnicity		
Malay	440 (91.1)	
Chinese	26 (5.4)	
Indian	11 (2.3)	
Others	6 (1.2)	
Educational level		
Secondary	86 (17.8)	
Tertiary	397 (82.2)	
Employment status		
Not working	153 (31.7)	
Working	330 (68.3)	
Household size (member)		3.9 (1.9))
Monthly household income (RM) [a]		
Low (<RM2300)	83 (17.2)	
Moderate (RM2300–RM5599)	254 (52.6)	
High (>RM5599)	146 (30.2)	
Obstetrical History		
Pre-pregnancy weight (kg)		59.3 (13.4)
Pre-pregnancy height (cm)		156.7 (5.7)

Table 1. *Cont.*

Variables	*n* (%)	Mean (SD)
Pre-pregnancy BMI (kg/m^2)		24.1 (4.9)
Underweight (<18.5)	47 (9.7)	
Normal (18.5–24.9)	258 (53.4)	
Overweight (25.0–29.9)	124 (25.7)	
Obesity ($\geq$30.0)	54 (11.2)	
Total gestational weight gain (kg)		12.2 (5.1)
Inadequate	158 (32.7)	
Adequate	189 (39.1)	
Excessive	136 (28.2)	
Gravidity		1.5 (1.5)
Primigravida	169 (35.0)	
Multigravida	314 (65.0)	
Parity		1.0 (1.2)
Nulliparous	205 (42.4)	
Primiparous	125 (25.9)	
Multiparous	153 (31.7)	
Maternal smoking during pregnancy		
Yes	4 (0.8)	
No	479 (99.2)	
Exposure to SHS at home (*n* = 472) [b]		
Yes	153 (32.4)	
No	319 (67.6)	
Exposure to SHS at workplace (*n* = 330) [c]		
Yes	87 (26.4)	
No	243 (73.6)	
Prenatal Care Visit History		
First prenatal care visit (week)		11.2 (5.0)
First trimester	346 (71.6)	
Second trimester	128 (26.5)	
Third trimester	9 (1.9)	
Total number of prenatal care visits		10.8 (3.0)

Note: RM: Ringgit Malaysia, BMI: Body mass index, SD: standard deviation. [a] 1 US dollar = RM 4.19 (as of 15 August 2020). [b] Sample size for exposure of second-hand smoke (SHS) at home varied (*n* = 472) because six pregnant mothers were divorced and unmarried. [c] Sample size for exposure of SHS at the workplace varied (*n* = 330) because 153 pregnant mothers were not working.

3.2. Birth Outcomes

Birth outcomes of the full-term infants are presented in Table 2. The mean gestational age at birth was 38.4 (SD 1.3) weeks. Among 483 infants delivered, 50.5% of them were girls, and the remaining 49.5% were boys. Overall, 10.4% of the infants had LBW, with a mean birth weight of 3.0 (SD 0.4) kg.

Table 2. Birth outcomes of the infants (*n* = 483).

Birth Outcomes	*n* (%)	Mean (SD)
Gestational age at birth (week)		38.4 (1.3)
Sex		
Boy	239 (49.5)	
Girl	244 (50.5)	
Birth weight (kg)		3.0 (0.4)
Extremely Low (<1.0)	0 (0.0)	
Very Low (<1.5)	3 (0.6)	
Low (<2.5)	47 (9.7)	
Normal (2.5–4.0)	428 (88.6)	
High (>4.0)	5 (1.1)	

3.3. Factors Associated with LBW

Results from the SLR analysis showed that low monthly household income (OR = 1.87, 95% CI = 0.23–0.97), inadequate gestational weight gain (OR = 2.28, 95% CI = 1.16–4.47), and being exposed to SHS at home (OR = 2.01, 95% CI = 1.09–3.69) were significantly associated with an increased risk of LBW (Table 3).

Table 3. Simple logistic analysis of maternal factors and low birth weight (LBW) (*n* = 478).

Variables	LBW (*n* = 50)	Normal (*n* = 428)	OR	95% CI	*p*-Value
Socio-demographic Characteristics					
Age (years)					
Mean (SD)	30.3 (4.8)	29.9 (4.1)	1.020	0.95–1.09	0.566
Ethnicity					
Malay	46 (92.0)	390 (91.1)	Reference	-	-
Chinese	1 (2.0)	25 (5.8)	0.339	0.05–2.56	0.295
Indian	2 (4.0)	8 (1.9)	2.120	0.44–10.28	0.351
Others	1 (2.0)	5 (1.2)	1.696	0.19–14.83	0.633
Educational level					
Secondary	14 (28.0)	72 (16.8)	Reference	-	-
Tertiary	36 (72.0)	356 (83.2)	0.520	0.27–1.01	0.055
Employment status					
Not working	18 (36.0)	134 (31.3)	Reference	-	-
Working	32 (64.0)	294 (68.7)	0.810	0.44–1.50	0.501
Household size (member)					
Mean (SD)	3.6 (1.3)	4.0 (2.0)	0.898	0.76–1.07	0.226
Monthly household income [a]					
Low (<RM2300)	14 (28.0)	69 (16.1)	1.870	0.23–0.97	0.041 *
Moderate (RM2300–RM5599)	22 (44.0)	230 (53.7)	0.881	0.84–4.15	0.124
High (>RM5599)	14 (28.0)	129 (30.1)	Reference	-	-
Obstetrical History					
Pre-pregnancy BMI					
Underweight (<18.5 kg/m^2)	6 (12.0)	40 (9.3)	1.283	0.50–3.31	0.605
Normal (18.5–24.9 kg/m^2)	27 (54.0)	231 (54.0)	Reference	-	-
Overweight (25.0–29.9 kg/m^2)	11 (22.0)	112 (26.2)	0.840	0.40–1.76	0.643
Obesity ($\geq$30.0 kg/m^2)	6 (12.0)	45 (10.5)	1.141	0.45–2.92	0.784
Total gestational weight gain (kg)					
Inadequate	26 (52.0)	131 (30.6)	2.276	1.16–4.47	0.017 *
Adequate	15 (30.0)	172 (40.2)	Reference	-	-
Excessive	9 (18.0)	125 (29.2)	0.826	0.35–1.95	0.662
Gravidity					
Primigravida	12 (24.0)	157 (36.7)	Reference	-	-
Multigravida	38 (76.0)	271 (63.3)	1.835	0.93–3.61	0.079
Parity					
Nulliparous	19 (38.0)	185 (43.2)	Reference	-	-
Primiparous	14 (28.0)	109 (25.5)	1.251	0.60–2.60	0.548
Multiparous	17 (34.0)	134 (31.3)	1.235	0.62–2.47	0.549
Maternal smoking during pregnancy					
Yes	0 (0.0)	4 (0.9)	<0.001	<0.001–<0.001	0.999
No	50 (100.0)	424 (99.1)	Reference	-	-
Exposure to SHS at home (*n* = 472) [b]					
Yes	22 (46.8)	128 (30.5)	2.007	1.09–3.69	0.025 *
No	25 (53.2)	292 (69.5)	Reference		
Exposure to SHS at workplace (*n* = 330) [c]					
Yes	10 (34.5)	77 (18.0)	1.517	0.68–3.41	0.312
No	19 (65.5)	222 (51.9)	Reference	-	-

Table 3. *Cont.*

Variables	LBW (*n* = 50)	Normal (*n* = 428)	OR	95% CI	*p*-Value
Prenatal care visit history					
First prenatal care visit					
First trimester	39 (78.0)	303 (70.8)	Reference	-	-
Second trimester	10 (20.0)	117 (27.3)	0.664	0.32–1.37	0.270
Third trimester	1 (2.0)	8 (1.9)	0.971	0.12–7.97	0.978
Total number of prenatal care visits					
Mean (SD)	10.2 (2.5)	10.9 (3.0)	0.931	0.84–1.03	0.159

* $p < 0.05$. [a] 1 US dollar = RM 4.19 (as of 15 August 2020). [b] Sample size for exposure of SHS at home varied (*n* = 472) because six pregnant mothers were divorced and unmarried. [c] Sample size for exposure of SHS at workplace varied (*n* = 330) because 153 pregnant mothers were not working. OR: odds ratio, CI: confidence interval.

Variables significantly associated with LBW in the SLR analysis with a *p*-value less than 0.25 were included in a forward multivariate logistic regression model. These variables were educational level, household size, monthly household income, total GWG, gravidity, exposure to SHS at home, and total number of prenatal care visits. Results of the multivariate logistic regression model (Table 4) showed that pregnant women with inadequate GWG (OR = 2.41, 95% CI = 1.18–4.90) and exposed to SHS at home (OR = 1.92, 95% CI = 1.03–3.55) during pregnancy were associated with a higher risk of LBW. The multivariate logistic regression model was statistically significant (χ^2 = 291.85, *p* = 0.004) and explained 5.8% of the variances in LBW.

Table 4. Factors associated with LBW in full-term infants (*n* = 478).

Characteristics of the Pregnant Mothers	OR	95% CI	*p*-Value
Total gestational weight gain (kg)			
Adequate	Reference		
Inadequate	2.41	1.18–4.90	0.016 *
Excessive	0.95	0.39–2.31	0.916
Exposure to SHS at home			
Yes	1.92	1.03–3.55	0.039 *
No	Reference		

Multivariate logistic regression model: χ^2 = 291.85, *p* = 0.004, Nagelkerke R square = 0.058, Cox and Snell R square = 0.028, Prediction accuracy based on overall classification table = 89.9%, Hosmer and Lemeshow test = 0.454. * $p < 0.05$.

4. Discussion

The present study revealed that about one in ten of the full-term infants were born with LBW. Inadequate GWG and exposure to SHS at home during pregnancy were the two main risk factors for LBW.

The prevalence of LBW reported in the present study was slightly higher than those reported in the NHMS III in Kuala Lumpur (7.2%) and Selangor (8.3%), Malaysia [6]. In contrast, our study reported a lower prevalence of LWB when compared to the global prevalence of LBW in the least developed countries (15.4%) [3] and other developing countries, including Indonesia (10.7%) [43], Nepal (12.0%) [21], and India (21.3%) [24]. Our study indicates that LBW remains an unsolved public health problem in Malaysia and continued efforts are needed to determine their modifiable risk factors which may be targeted in future prevention strategies.

The present study showed that pregnant women with inadequate weight gained during pregnancy were more likely to deliver an LBW infant. The association between inadequate GWG and a higher risk of LBW was also been observed among pregnant women with a normal pre-pregnancy BMI recruited from a government hospital in Turkey [32]. Similar findings were found in a retrospective study conducted among 7122 women in Slovakia that reported an increased risk of LBW among women with inadequate GWG [44].

The plausible underlying mechanism for the association between inadequate GWG and LBW remains unclear. Nutritional requirements increase during pregnancy to support both maternal and foetal growth. Inadequate GWG may reflect inadequate nutritional stores of the women during pregnancy, which failed to adequately satisfy the needs of both mother and foetus simultaneously. This could lead to maternal–foetal competition for available nutrients, and subsequently affects the birth weight of the infants [45,46].

Excessive GWG was prevalent in our study population. A significant positive association between GWG during pregnancy and birth weight was reported in previous studies [47–49], whereby a one kilogram increase in GWG was associated with about a 0.1 kg increase in birth weight [49]. Despite that, the present study did not observe a significant association between excessive GWG and LBW. Although the association was not significant, our results showed that 30.0% of the pregnant women who gained excessive weight during pregnancy delivered an LBW infant. It is possible that birth weight of the infants is not mainly influenced by GWG itself but is also influenced by other underlying factors which were not included in the present study, namely, food intake, physical activity, and the condition of placenta and amniotic fluid [38,50]. Therefore, there is a need to conduct further studies to determine other possible maternal factors and their confounders that are associated with LBW, especially the rate and pattern of GWG, as well as the condition of placenta and amniotic fluid. The examination of the associations between these factors and LBW is vital for the planning and enforcement of intervention programs and activities during prenatal care visits.

The present study shows that exposure to SHS at home was significantly associated with LBW. Consistent with the findings from several local studies in Malaysia, pregnant women who were exposed to SHS during pregnancy had a higher risk of delivering an LBW infant [35,51]. Bailey and colleagues reported that birth weight of the infants increased by about 0.4 kg when pregnant mothers refrained from being exposed to SHS [52]. The significant association between SHS at home and LBW can be explained by the adverse effects of SHS, in which the SHS contains multiple chemical components that are considered toxic to the foetus. These chemical components would impair the placenta and reduce the blood, oxygen, and nutrients being transferred to the foetus, which lead to growth restriction and hypoxia [49,53,54]. Inconsistent with previous studies, we found no significant associations between maternal smoking and exposure to SHS at the workplace during pregnancy with LBW [55,56]. Smoking was uncommon in our study populations and we found that only 0.8% of the women smoked during pregnancy. The small sample size for women who smoked during pregnancy in the present study may lead to a limited power to detect a statistically significant association. Although one in four of the pregnant women in the present study were exposed to SHS at their workplace, the smokers will usually smoke outside of the workplace. In the interim, most workplaces have enforced a law that prohibits smoking at the workplace, while some workplaces provide a smoking area for their employees who smoke.

Inconsistent with previous studies, we found no associations between any of the sociodemographic characteristics and obstetrical factors with LBW. It contradicted the findings from the previous studies in which pregnant women with older age, more household members, unemployed, and financially poor were associated with a higher risk of delivering an LBW infant [19,51]. Several local studies conducted among Malaysian pregnant women demonstrated that lower pre-pregnancy BMI, primigravida, and primiparous were associated with a higher risk of LBW [20,25,57]. The inconsistent results might be attributed to methodology differences across studies in terms of definitions for the variables, as well as the homogenous characteristics of pregnant mothers in the present study.

We found no significant association between prenatal care visit history and LBW in the present study, which contradicted the findings from previous studies that reported a lower risk of LBW among pregnant women who started their prenatal care visit earlier and had at least 4 prenatal care visits [21,51]. This contradicting finding might be attributed to the fact that pregnant women in the present study can fully utilise the knowledge or

advice given during a series of face-to-face or group counselling services regarding lifestyle, pregnancy, and delivery during prenatal care visits provided by the health professionals at the primary healthcare institutions, even though the pregnant women had fewer prenatal care visits. Previous studies showed that the counselling services provided by healthcare professionals play an important role in reducing the occurrence of health problems and improving the growth and development of the foetus [58–61]. Besides, pregnant women in the present study might have access to various pregnancy monitoring applications and social media (e.g., WhatsApp's, Instagram, and Facebook) that provide health information on pregnancy, which enable them to learn some nutrition knowledge and have invisible prenatal care visits to monitor the growth and development of their infants throughout pregnancy [62].

Several limitations need to be considered in the present study. Firstly, this was a cross-sectional study and the cause–effect relationships between the independent variables and LBW were unable to be determined. Secondly, this study was conducted among mother–infant pairs in Selangor and Kuala Lumpur, Malaysia, with an unbalanced proportion of ethnicity among respondents (91.1% Malay vs. 8.9% Non-Malay). Thus, findings from the present study may not be generalised to other populations. Thirdly, self-reported exposure to SHS may lead to underestimation or overestimation due to recall bias. Lastly, there is a discrepancy in the number of infants with LBW compared to those with normal birth weight. This discrepancy might reduce the power to detect some risk factors, for instance: socio-demographic characteristics (educational level, employment status, household size, and monthly household income), obstetrical history (pre-pregnancy BMI, gravidity, and parity), and prenatal care visit history (first prenatal care visit and number of prenatal care visits).

5. Conclusions

To conclude, one in ten of the full-term infants were born with LBW. Inadequate GWG and exposure to SHS at home during pregnancy were associated with a higher risk of LBW in infants. The present study suggests that women should monitor their rate of weight gain throughout pregnancy and avoid SHS exposure at home in order to reduce the risk of delivering an LBW infant. In addition, pregnant women should be informed about the importance of gaining sufficient weight throughout pregnancy and the adverse effects of SHS exposure at home during their routine prenatal care visit.

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