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The Association Between Second Hand Smoke and Low Birth Weight and Preterm Delivery

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Abstract To determine the association between maternal exposure to SHS and low birth weight and preterm delivery. This cross-sectional study was carried out in the four main governmental hospitals dealing with deliveries in the north of Jordan. A consecutive 8,490 women who delivered in these hospitals between April 2007 and September 2007 were included in the study after excluding those who reported active smoking during the current pregnancy. Pre-structured questionnaire and review of hospital records were used to collect data about maternal background, obstetric history, medical history, and data related to second hand smoke exposure. Overall, 13.8% of women gave birth to a preterm baby and 10.0% gave birth to a low birth weight baby. About 12.6% of women who were exposed to SHS delivered low birth weight babies compared to 7.7% for non exposed women. The rate of preterm delivery among the exposed group was significantly higher than that among the non-exposed group (17.2 vs. 10.6%). In the multivariate analysis, exposure to SHS during pregnancy was significantly associated with increased odds of low birth weight (OR = 1.56 (95% CI 1.31, 1.89)) and preterm delivery (OR = 1.61 (95% CI: 1.30, 1.99)). Exposure of women to SHS during pregnancy is associated with increased odds of low birth weight and preterm delivery. Health care professionals should carry out educational programs to increase awareness and understanding of pregnant women and their husbands about the harmful effects of second hand smoke on birth outcomes.

Keywords Low birth weight · Preterm delivery, pregnancy · Second hand smoke

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Introduction

Second hand smoke (SHS) exposure has harmful impacts on public health [1] and potential adverse reproductive health effects and pregnancy outcomes [2]. Nicotine and carbon monoxide decrease availability of oxygen for the fetus, resulting in low fetal tissue oxygenation [3, 4]. Recent studies showed that the prevalence of second hand smoke among women varies between populations. Nakamura et al. [5] found that 35.9% of Brazilian pregnant women were passive smokers and Goel et al. [6] found that 24% of Indian women were exposed to SHS.

Smoking in pregnancy is associated with many complications for both mother and newborn including fetal growth restriction [7–9], spontaneous abortion [5], preterm delivery [2, 10] and sudden infant death syndrome with

significant perinatal mortality and morbidity [8, 11]. Whereas more studies are available on the effect of active smoking on reproductive health and pregnancy outcomes than studies on the effect of exposure to SHS, recent studies have found an association between maternal exposure to SHS and adverse reproductive effects or pregnancy outcomes. However, there is a lot of controversy about the effect of SHS during pregnancy on birth outcomes [12, 13]. Windham et al. [13] conducted a meta-analysis of their own and all 22 previous studies from 1966 to 1995 and showed that these studies were inconsistent on the effects of maternal exposure to SHS on pregnancy outcomes. However, the findings of this review [13] are biased because the authors searched only two databases for studies published before 1995.

The majority of studies on the health effects of SHS among non-smoking pregnant women had been conducted in the Western and developed countries [6]. To our knowledge, little is known about the effect of SHS during pregnancy on birth outcomes in Middle East countries including Jordan. In this study we focused on the effect of SHS during pregnancy on low birth weight and preterm delivery because of the continuing controversy and the inconsistent findings of previous studies. Therefore, this study was conducted to determine the association between maternal exposure to SHS and low birth weight and preterm delivery.

Methods

Participants

This cross-sectional study was carried out in the four main governmental hospitals dealing with deliveries in the north of Jordan, namely Princess Bade'ah hospital, Jarash hospital, Al-Eman hospital, and Al-Ramtha hospital. In the year 2007, the number of deliveries was 8,563 in Princess Bade'ah hospital, 2,775 in Jarash hospital, 2,366 in Al-Eman hospital, and 2008 in Al-Ramtha hospital. The total number of deliveries in the four hospitals (15,712) in 2007 constituted 63.0% of the total deliveries in the north of Jordan. A consecutive 8,490 women who delivered in these hospitals between April 2007 and September 2007 were included in the study after excluding those who reported active smoking during the last pregnancy. Non-Jordanian women and women with multiple pregnancies were excluded. Our sample size exceeded the minimum required sample size of 7,354 needed to detect an odds ratio of 1.2 as a measure of the association between exposure to SHS and preterm delivery using the power of 90% and level of significance of 0.01. All women agreed to participate and gave verbal consent at the time of data collection.

Data Collection

Shortly after delivery, and within 24 h of delivery, mothers answered a pilot tested structured questionnaire administered by trained personnel in the maternity ward. The questionnaire consisted of questions concerning mother's age, education, employment, total family income, residency in rural or urban areas, exposure to SHS during pregnancy, blood group, history of preterm birth delivery, history of low birth weight delivery, history of urinary tract infections or candidal vaginosis during pregnancy, parity, and onset of prenatal care. Chronic illnesses were abstracted from maternal records. Complicated pregnancies by one or more antenatal medical condition, including diabetes (pre-existing and gestational), hypertension**,** and anemia were evaluated. Prepregnancy height (cm) and weight (Kg) were self-reported. Information on pregnancy and neonatal outcomes was collected by the trained midwives in the maternity ward. Birth weight, gender and gestational age at birth were obtained from obstetric records.

Definition of Variables

Self-reported SHS exposure at home (by either a spouse or other household member) or at work (in either a smoke-regulated environment or unregulated) was obtained through asking this question "During most of your pregnancy, would you say you were in contact with persons who smoked cigarettes, such as friends, coworkers, or family members". The response for this question was documented as yes/no.

Age was defined as the age of mother in completed years at the time of delivery. Estimated gestational age was calculated as the interval between the date of delivery and the date of recalled last normal menstrual period. When the last normal menstrual period date was missing, a clinical estimate of gestational age was used instead. Parity was categorized as: no previous pregnancies, one or two previous pregnancies, and three or more previous pregnancies. Birth outcomes of interest in this study (the dependent variables) were preterm delivery (live infant delivered at $<$37 weeks' gestation) and low birth weight (live infant weighting $<$2,500 g at birth) [14–16].

Statistical Analysis

The Statistical Package for Social Sciences software (SPSS, version 15) was used for data processing and data analysis. Characteristics of subjects' variables were described using frequency distribution. Chi-square test was used to compare proportions of preterm and low birth weight deliveries between women according to selected characteristics. The association between exposure to SHS

(independent variable) and the preterm delivery and low birth weight delivery (dependent variables) were tested in the multivariate analysis after adjusting for possible predictors and confounders using binary logistic regression. A separate analysis and model was developed for each outcome after testing for the assumptions of binary logistic regression including the multicollinearity. A variable was entered into the model if the probability of its score statistic was less than the entry value of 0.05, and was removed if the probability was greater than the removal value of 0.1. All variables that remained significant in the multivariate analysis constituted the reference model. The effect of SHS was assessed by what it added to the equation of the reference model at its point of entry. This was repeated for each outcome variable. A *P*-value of less than 0.05 was considered statistically significant.

Results

Participants' Characteristics

This study included 8,490 Jordanian women aged between 14 and 50 years with a mean (SD) of 27.1 (6.4) years. About 59.9% of women had high school education or less and only 15% were employed. Less than one-third (29.2%) had a history of abortion, 10.6% had a history of premature delivery, and 12.2% had a history of low birth weight delivery. The socio-demographic, anthropometric and relevant characteristics of the participants are shown in Table 1. A total of 4,125 (48.6%) women were exposed to SHS and 4,365 (51.4%) women were not exposed to SHS during their last pregnancy. The majority (90.1%) of women exposed to SHS reported exposure at home, 2.9% were exposed at work, and 7.0% were exposed at home and work. About 96.0% of women reported that the source of exposure in home was the husband.

Table 1 Socio-demographic, anthropometric and relevant characteristics of the participants

Variable	*n*	(%)
Age (years)		
≤20	823	9.7
21–29	4,967	58.5
30–34	1,527	18.0
35–39	784	9.2
≥40	389	4.6
Level of education		
<High school	2,691	31.7
High school	2,391	28.2
>High school	3,408	40.1
Residence area		
City	4,782	56.3
Village	3,708	43.7
Occupation		
Employed	1,287	15.2
Unemployed	7,203	84.8
Family income (JD)[a]		
<200	4,038	47.6
≥200	4,452	52.4
Height (CM)		
<156	2,206	26.0
156–160	2,384	28.1
161–165	1,758	20.7
>165	2,142	25.2
Body mass index		
Normal	2,157	25.4
Underweight	87	1.0
Overweight	4,078	48.0
Obese	2,153	25.4
Parity		
Primiparaus	2,382	28.1
1 or 2	3,069	36.1
>2	3,039	35.8
Exposure to second hand smoke		
Yes	4,365	51.4
No	4,125	48.6

[a] 1 JD = 0.71 US $

Low Birth Weight and Preterm and Delivery According to SHS

Overall, 13.8% of women gave birth to a preterm baby and 10.0% gave birth to a low birth weight baby. About 12.6% of women who were exposed to SHS gave a low birth weight baby compared to 7.7% for non exposed women. The average (SD) birth weight in Kg for children of exposed women (3.06 (0.56)) was significantly lower (*P*-value < 0.005) than that for children of non-exposed women (3.2 (0.53)). The average birth weight of children born to exposed and non-exposed women according to maternal age is shown in Fig. 1. For all age groups, the birth weight was significantly lower for the exposed group compared to the non-exposed group. The rate of preterm delivery among the exposed group was significantly higher than that among the non-exposed group (17.2 vs. 10.6%). The average (SD) gestational age in weeks for exposed women (36.9 (7.8)) was significantly lower (*P*-value < 0.005) than that for non-exposed women (37.7 (6.7)).

The relative frequency distribution of low birth weight delivery and preterm delivery according to socio-demographic, anthropometric and relevant characteristics of the participants are shown in Table 2.

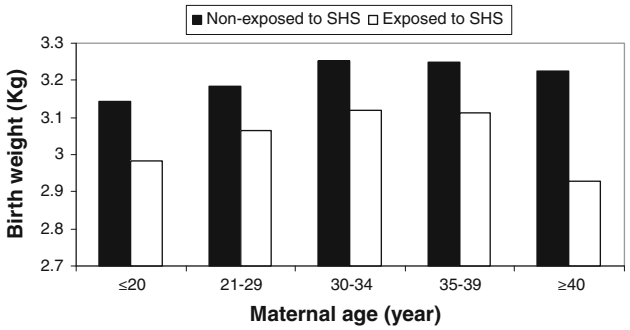

Fig. 1 The average birth weight for second-hand smoke (SHS) exposed and non-exposed women according to maternal age

Multivariate Analysis

In the multivariate analysis (Table 3), exposed women were almost one and half times (OR = 1.56 (95% CI: 1.31, 1.89) more likely to deliver a low birth weight baby compared to non-exposed women after adjusting for age, level of education, employment, family income, height, blood type, parity, history of preterm delivery. When preterm delivery was added to the multivariate analysis as a predictor, the odds ratio changed very little (OR = 1.52 (95% CI: 1.30, 1.79). After adjusting for the same variables, exposure to SHS was significantly associated with increased odds of preterm delivery (OR = 1.61 (95% CI: 1.30, 1.99).

Discussion

This study showed that exposure to SHS during pregnancy was significantly associated with increased odds of low birth weight (OR = 1.56 (95% CI 1.31, 1.89)) and preterm delivery (OR = 1.61 (95% CI: 1.30, 1.99)). Some studies have shown similar effects. Leonardi-Bee et al. [17] in their meta-analysis showed that SHS was associated with a reduction in mean birth weight of at least 33 g (95% CI 16–51) and increased risk of low birth weight (OR = 1.32 (95% CI 1.07, 1.63)) in prospective studies. In another meta-analysis [13] of studies conducted before mid-1995, the findings of pooled studies were inconsistent. It showed that the risk of low birth weight was not increased in infants of SHS-exposed women, but there was a somewhat increased risk for low birth weight at term (OR = 1.8 (95% CI 0.6, 4.8)). Ward et al. [18] found that SHS exposure was associated with decreased birth weights by 36 g (95% CI 5–67 g) among 18,297 UK infants. In Denmark, Hegaard et al. [19] found that newborns of mothers who exposed to SHS both at home and outside the home had a birth weight 78.9 g (95% CI −143.7 to −14.1) lower than the weight of newborns born to mothers unexposed to SHS. In India, Goel et al. [6] found that among 576 Indian pregnant women, mothers who exposed to SHS at home were more likely to have babies with a lower birth weight than babies in the unexposed group ($P = 0.014$).

The results of the current study showed that the exposure to SHS in pregnant women was significantly associated with higher odds of preterm delivery. The results of previous studies on the possible effects of exposure to SHS on the incidence of premature births were inconsistent. However, the possible association between exposure to SHS and premature delivery has been less studied [20]. Windham et al. [13] indicated that the estimation of exposure during a pertinent time period and the control of confounding variables are the most serious issues of legitimacy in studies of the effects of SHS on pregnancy outcomes. Ward et al. [18] showed that SHS produced a smaller increase in prematurity, which was non-significant after adjustment for potential confounding. In a meta-analysis study of Leonardi-Bee et al. [17], the authors found that SHS exposure was associated with prematurity (<10th percentile) only in retrospective studies (OR = 1.21, 95% CI 1.06–1.37). In a cohort study of 4,687 Swedish pregnant women by Ahlborg et al. [21], the adjusted risk ratio for preterm delivery was 0.49 (95% CI 0.23, 1.06) in women exposed in the home, and 1.27 (95% CI 0.70, 2.31) for those exposed in the workplace.

In the present study, self-reported exposure was used to define the exposure to SHS. Estimation of the length of exposure to SHS is very difficult task. DeLorenze et al. [22] has acknowledged that self-reporting could be underestimating the low levels of exposure. Eliopoulos et al. [23] recommended measuring cotinine concentrations in newborn' hair as an effective method for determining the intensity of effects of SHS on the individual.

In conclusion, exposure of women to SHS during pregnancy is associated with higher odds of giving birth to a low birth weight baby and giving birth to a preterm baby. Second hand smoke exposure is a major public health concern, which calls on decisions makers and legislation for strong preventive measures in the workplace and public places. Health care professionals should carry out educational programs to increase awareness and understanding of pregnant women and their husbands about the harmful effects of second hand smoke on birth outcomes. There is a need to implement laws prohibiting smoking in the workplace in developing countries such as Jordan. However, to prevent SHS-related adverse reproductive effects, the key priorities must include eradication of SHS exposure in both public places and the home. Future research on the effect of SHS during pregnancy on a set of pregnancy outcomes (perinatal parameters) other than low birth weight and preterm such as spontaneous abortion, sudden infant death syndrome and perinatal mortality and morbidity are needed.

Table 2 The relative frequency distribution of low birth weight delivery and preterm delivery according to socio-demographic, anthropometric and relevant characteristics of the participants

Variable	Giving birth to a preterm baby			Giving birth to a low birth weight baby		
	Yes *n* (%)	No *n* (%)	*P*-value	Yes *n* (%)	No *n* (%)	*P*-value
Age (years)			<0.005			0.011
≤20	155 (18.8)	668 (81.2)		71 (9.5)	677 (90.5)	
21–29	582 (11.7)	4,385 (88.3)		454 (9.7)	4,222 (90.3)	
30–34	182 (11.9)	1,345 (88.1)		162 (11.2)	1,288 (88.8)	
35–39	135 (17.2)	649 (82.8)		59 (8.3)	653 (91.7)	
≥40	119 (30.6)	270 (69.4)		47 (14.7)	272 (85.3)	
Level of education			<0.005			<0.005
<High school	363 (13.5)	2,328 (86.5)		209 (8.3)	2,296 (91.7)	
High school	240 (10.0)	2,151 (90.0)		209 (9.2)	2,071 (90.8)	
>High school	570 (16.7)	2,838 (83.3)		375 (12.0)	2,745 (88.0)	
Residence area			0.718			<0.005
City	655 (13.7)	4,127 (86.3)		497 (11.1)	3,979 (88.9)	
Village	518 (14.0)	3,190 (86.0)		296 (8.6)	3,133 (91.4)	
Occupation			<0.005			0.893
Employed	279 (21.7)	1,008 (78.3)		114 (9.9)	1,035 (90.1)	
Unemployed	894 (12.4)	6,309 (87.6)		679 (10.1)	6,077 (89.9)	
Family income (JD)			0.103			<0.005
<200	532 (13.2)	3,506 (86.8)		289 (7.8)	3,419 (92.2)	
≥200	641 (14.4)	3,811 (85.6)		504 (12.0)	3,693 (88.0)	
Height (cm)			<0.005			<0.005
<156	283 (13.1)	1,872 (86.9)		267 (12.9)	1,798 (87.1)	
156–160	303 (12.7)	2,083 (87.3)		209 (9.3	2,027 (90.7)	
161–165	348 (16.8)	1,728 (83.2)		145 (7.7)	1,745 (92.3)	
>165	239 (12.8)	1,634 (87.2)		172 (10.0)	1,542 (90.0)	
Blood type			<0.005			<0.005
A	324 (15.3)	1,793 (84.7)		152 (8.0)	1,737 (92.0)	
AB	114 (9.3)	1,110 (90.7)		101 (8.7)	1,054 (91.3)	
B	168 (9.9)	1,526 (90.1)		217 (13.4)	1,408 (86.6)	
O	567 (16.4)	2,888 (83.6)		323 (10.0)	2,913 (90.0)	
Parity			0.010			<0.005
Primiparous	371 (15.6)	2,011 (84.4)		270 (12.0)	1,971 (88.0)	
1 or 2	414 (13.5)	2,655 (86.5)		235 (8.3)	2,600 (91.7)	
>2	388 (12.8)	2,651 (87.2)		288 (10.2)	2,541 (89.8)	
History of abortion			<0.005			0.003
No	5,288 (88.3)	700 (11.7)		5,159 (89.5)	607 (10.5)	
Yes	2,029 (81.1)	473 (18.9)		1,953 (91.3)	186 (8.7)	
History of giving birth to preterm baby			<0.005			<0.005
Yes	293 (37.6)	486 (62.4)		510 (74.7)	173 (25.3)	
No	737 (11.2)	5,862 (88.8)		5,626 (91.0)	556 (9.0)	
History of giving birth to low birth weight baby			<0.005			<0.005
Yes	293 (37.6)	486 (62.4)		260 (32.7)	534 (67.3)	
No	5,862 (88.8)	737 (11.2)		487 (8.0)	5,569 (92.0)	
Exposure to second hand smoke			<0.005			<0.005
Yes	711 (17.2)	3,414 (82.8)		478 (12.6)	3,320 (87.4)	
No	462 (10.6)	3,903 (89.4)		315 (7.7)	3,792 (92.3)	

Table 3 Multivariate analysis of the association between exposure to second hand smoke during pregnancy and preterm/low birth weight delivery

Variables[a]	Giving birth to a preterm baby		Giving birth to a low birth weight baby	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Age (years)				
≤20	1		1	
21–29	0.73 (0.52, 1.02)	0.067	1.11 (0.81, 1.51)	0.525
30–34	0.71 (0.47, 1.09)	0.121	1.10 (0.76, 1.60)	0.603
35–39	1.20 (0.73, 1.95)	0.474	0.77 (0.49, 1.21)	0.252
≥40	1.95 (1.15, 3.32)	0.013	1.61 (1.001, 2.58)	0.049
Level of education				
<High school	1		1	
High school	1.29 (0.97, 1.72)	0.076	1.28 (1.02, 1.60)	0.034
>High school	1.39 (1.07, 1.80)	0.013	1.65 (1.33, 2.04)	<0.005
Occupation				
Employed	1.87 (1.43, 2.45)	<0.005	0.77 (0.54, 1.11)	0.104
Unemployed	1		1	
Family income (JD)				
<200	1.53 (1.21,1.93)	<0.005	1.70 (1.41, 2.06)	<0.005
≥200	1		1	
Height (cm)				
<156	1		1	
156–160	0.65 (0.49, 0.85)	0.002	0.89 (0.72, 1.11)	0.317
161–165	0.81 (0.62, 1.05)	0.109	0.48 (0.37, 0.61)	<0.005
>165	0.32 (0.23, 0.44)	<0.005	0.75 (0.60, 0.95)	0.016
Blood type				
A	1		1	
AB	0.85 (0.56, 1.31)	0.467	1.12 (0.82, 1.50)	0.510
B	1.16 (0.82, 1.63)	0.400	2.25 (1.76, 2.87)	<0.005
O	2.64 (1.98, 3.52)	<0.005	1.30 (1.03, 1.64)	0.026
Parity				
Primiparous	2.99 (2.20, 4.04)	<0.005	1.87 (1.48, 2.37)	<0.005
1 or 2	1.22 (0.92, 1.62)	0.163	0.66 (0.53, 0.83)	<0.005
>2	1		1	
History of preterm/low birth delivery				
Yes	5.15 (3.62, 7.32)	<0.005	2.51 (1.83, 3.45)	<0.005
No	1		1	
Exposure to second hand smoke				
Yes	1.61 (1.30, 1.99)	<0.005	1.56 (1.31, 1.89)	<0.005
No	1		1	

[a] Other studied variables were tested in the regression model and were found to be non significant

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