Residential Environmental Tobacco Smoke Exposure During Pregnancy and Low Birth Weight of Neonates: Case Control Study in a Public Hospital in Lucknow, India

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Objective: To determine whether residential environmental tobacco smoke (ETS) exposure during pregnancy is associated with low birth weight (LBW) neonates and establish a dose response relationship.

Design: Case control study.

Setting: Tertiary care hospital.

Methodology: Mothers giving birth to LBW neonate (<2.5 kg) were cases and those whose neonates weighed ≥2.5 kg at birth were controls. Excluded were women smokers and tobacco chewers, high parity (>3), multiple pregnancy and still births. Included were 100 cases and 200 controls, aged 20 to 30 years. Information was collected on ETS exposure and other risk factors of LBW within 24 hours of delivery. Clinical information like maternal haemoglobin levels, birth weight and gestational age of the neonate was extracted from hospital records.

Results: On univariate analysis, preterm pregnancy, low socioeconomic status, previous LBW neonate, no utilization of antenatal care (ANC), severe anemia and ETS exposure were statistically significantly associated with LBW neonate and controlling for these in logistic regression analysis, adjusted Odds ratio for ETS exposure association with LBW neonate was 3.16 (95% CI=1.88-5.28). A dose response relationship was also found which was statistically significant (10-20 cigarettes smoked/day: OR = 4.06, 95% CI=1.78-9.26 and >20 cigarettes smoked/day, OR = 17.62, 95% CI= 3.76-82.43).

Conclusion: Exposure to ETS during pregnancy is associated with LBW of neonates. Hence, there is an urgent need to increase awareness about health hazards of ETS during pregnancy and bring about behavioural changes accordingly as a one of the strategies to reduce LBW deliveries in India.

Key words: *Environmental tobacco smoke, Etiology, India, Low birth weight, Neonate, Passive smoking.*

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Low Birth Weight (LBW) is a major public health issue in developing countries like India, where its prevalence is as high as 30% [1]. LBW leads to an impaired growth of the infant resulting in a higher mortality rate, increased morbidity, predisposition for infectious diseases, lowered cognitive abilities and chronic adult diseases [2,3]. Etiology of LBW is multifactorial and is related to maternal, fetal, placental and environmental risk factors including antenatal care (ANC) status and socio economic status of the mother [4]. Maternal smoking is an established cause of LBW [5]. Passive smoking containing the same toxic substances can be expected to have a similar effect on the fetus.

In India, although women smokers are scarce, they are exposed to the ill effects of tobacco smoke due to passive smoking at their home during their pregnancy [6]. Tobacco use in the form of smoking among males in India is around 33.3% [7] and environmental conditions like overcrowding and poor ventilation at home make the health effects of environmental tobacco smoke (ETS) more pronounced in such settings. Residential ETS exposure in India was reported to be 52.5% [8]. Studies investigating the association between maternal ETS exposure during pregnancy and birth outcomes had reported varied findings in developed countries [9,10]. Such studies are lacking in developing and under developed countries [11]. The current study was undertaken to examine the association of ETS exposure with LBW babies.

METHODS

This was a hospital-based case control study conducted from May 2011 to July 2011 at Queen Mary Hospital, attached to Department of Obstetrics and Gynecology, KGMU, Lucknow, a tertiary care government hospital in Northern India. Approval was obtained from the Institutional Ethics Committee (IEC). Before enrollment, written informed consent was obtained from all the participants.

Cases were mothers, in the age group 20 to 30 years, who had delivered a singleton live neonate with birth weight < 2.5 kg (LBW). Controls were mothers in the age group 20 to 30 years, who had delivered a singleton live neonate with birth weight ≥ 2.5 kg. As teen (<20 years) and high age group (>30 year) pregnancies are at an increased risk for LBW babies [12], mothers of age group 20 to 30 years have been included in the study. Only mothers delivering singleton neonates have been enrolled as multiple pregnancy is also associated with higher risk for LBW. Excluded from cases and controls were (*a*) women smokers and tobacco chewers (as they are at an increased risk for delivering LBW neonate); (*b*) high parity (>3) as such pregnancies have been associated with a decrease in birth weight of the neonate [13]; (*c*) birth weight not documented; and (*d*) still births.

The sample size was calculated using OpenEpi statistical tool. According to Global Adult Tobacco Survey, Fact Sheet India: 2009-2010, residential ETS exposure was found to be 51.3% in non-smoker females. So, to assess odd's ratio of 2.25 for LBW babies with an alpha (α) of 0.05 and power of 0.8, the total sample size calculated is 257. This study was conducted with a sample size of 300.

During the study period, the birth register maintained at QMH was reviewed every day. For every case (LBW) selected, two consecutive controls (birth weight ≥ 2.5 kg) were enrolled. This ratio of 1:2 for case: control resulted in participation of 100 cases and 200 controls. Higher number of controls were taken to maximize the statistical power of detection.

Data collection tool: Data were abstracted from hospital records for maternal hemoglobin levels, birth weight and gestational age of neonate. Preterm birth was defined as gestation age <37 weeks. A pre designed Questionnaire was used for recording ETS exposure and other significant risk

TABLE I PROFILE OF MOTHERS GIVING BIRTH TO NORMAL BIRTH WEIGHT (CONTROLS) AND LOW BIRTH WEIGHT(CASES) NEONATES

Characteristics	*Cases (n=100)*	*Controls (n=200)*	*P value*	
Age (mean± SD)	24.40±2.85	24.95±2.85	0.11	
Parity (mean± SD)		1.54±0.742	0.08	
Preterm* gestation	49 (49.0)	16 (8.0)	11.05 (5.80-21.4)	0.001
Cesarean delivery	48 (48.0)	80 (40.0)	1.38 (0.85-2.25)	0.217
Joint family	82 (82.0)	156 (78.0)	1.28 (0.70-2.36)	0.45
Socio-economic status				
Lower	33 (33.0)	43 (21.5)	3.36 (1.00-10.61)	0.05
Middle	63 (63.0)	140 (70.5)	1.91 (0.62-5.9)	0.26
Upper	04 (4.0)	17 (8.5)	Reference	
Obstetric history				
Abortion	15 (15.0)	27 (13.5)	1.13 (0.57-2.24)	0.73
Still birth/neonatal death	11 (11.0)	11 (5.5)	2.12 (0.89-5.09)	0.10
Previous LBW	7 (7.0)	3 (1.5)	4.94 (1.25-19.54)	0.02
Previous LSCS	15 (15.0)	33 (16.5)	0.89 (0.46-1.73)	0.87
Maternal illness				
Severe anemia#	31 (31.0)	38 (19.0)	1.92 (1.10-3.30)	0.02
Acute infection	19 (19.0)	28 (14.0)	1.48 (0.76-2.73)	0.31
Chronic infection	10 (10.0)	17 (8.5)	1.20 (0.53-2.72)	0.67
Pregnancy complications				
Pre-eclampsia/eclampsia	26 (13.0)	16 (16.0)	1.27 (0.65-2.50)	0.48
Antepartum hemorrhage	2 (2.0)	2.02 (0.28-4.56)	0.60	2 (1.0)
Gestational diabetes	1 (1.0)	3 (1.5)	0.66 (0.07-6.46)	1.00
ANC Utilization				
Any visit	89 (89)	193 (96.5)	0.29 (0.11-0.78)	0.02
1-2 visits	27 (27)	40 (20.0)		
≥3 visits	62 (62)	153 (76.5)	0.60 (0.34-1.06)	0.01

*Abbreviations: LBW- Low birth weight, OR-Odds ratio, CI-Confidence interval, SD –Standard Deviation, LSCS-Lower segment Caesarean section, ANC – Ante natal care *Preterm -<37 weeks , #Severe anemia<7g/dL.*

factors like (*a*) past obstetric history (previous LBW delivery, previous LSCS, abortion/miscarriage, still birth, neonatal death); (*b*) maternal illness (acute and chronic infections, severe anaemia (Hemoglobin <7 g/dL), cardiovascular disorders, diabetes mellitus); (*c*) maternal complications of current pregnancy (eclampsia/pre-eclampsia, Ante partum haemorrhage); (*d*) antenatal care (ANC) status ; and **(***e*) socio economic status (three categories based on score calculated by Kuppuswamy's Scale, 2007 [14].

Measurement of ETS: For measurement of residential ETS exposure, women were requested to answer a pre designed questionnaire regarding "active smokers" in their home who smoked in their presence during their pregnancy. While conducting the pilot study, we found out that women were more confident reporting a range of the number of cigarettes smoked. Hence categories were defined for easy recall for range of average number of cigarettes/*bidis* smoked per day per person. The median value of the range was multiplied by the number of smokers to give the 'Exposure Index'(EI). EI was calculated assuming that all the women were exposed to passive smoke over the entire duration of pregnancy. These women were then categorized into three groups for severity of ETS exposure during pregnancy. This was used to analyze a dose– response relationship between ETS and LBW babies.

Statistical analysis: Data were analyzed using software SPSS (Version 15). Univariate analysis was performed to study the frequency distribution of the variables. Chi-square and Students t-test were used to test the association between categorical and continuous variables, respectively. To assess association between LBW babies and various risk factors, crude odd's ratios were calculated with 95% confidence interval. A *P*<0.05 was considered significant. A dose response relationship between the amount of ETS exposure (Exposure Index) and risk of LBW babies was calculated using logistic regression. Unconditional Logistic Regression analysis was performed to assess the association of ETS exposure to LBW, after including all variables found to have significant association (*P*<0.05) on univariate analysis.

RESULTS

The present study included 300 (128 females) neonates. The mean (SB) birth weight calculated for cases (55% males) and controls (58.5% males) was 2.003±0.343 and 2.946±0.339, respectively. There was no statistically significant difference in the gender distribution of cases and controls.

Demographic and clinical profile of mothers of LBW (Cases) and Controls was compared as shown in ***Table* I**. Preterm pregnancy (<37weeks gestation), and mothers belonging to a lower socioeconomic status resulted in an increased risk for a LBW neonate. Previous LBW neonate and severe anemia were associated with LBW, whereas utilization of ANC was a protective factor. ETS exposure was reported by 135 (45%) of the 300 subjects enrolled in this study (***Table* II)**. Women exposed to ETS had 3.45 times the odds of delivering a LBW neonate as compared to unexposed women (*P*<0.001). Exposure with EI greater than 20 had increased odds of delivering a LBW neonate as compared to when EI was between 10 and 20. Controlling for variables having significant univariate association like preterm pregnancy, lower socioeconomic status, previous LBW neonate, severe anaemia, no utilization of ANC and ETS exposure, unconditional multiple logistic regression analyses was done (***Table* III**). Adjusted OR for ETS exposure association with LBW neonate was calculated to be 3.16 (95% CI=1.886-5.285) (*P*=<0.001).

DISCUSSION

This study has highlighted the detrimental impact of ETS exposure during pregnancy on the birth outcome in a tertiary care hospital in Northern India. Even after adjusting for other confounding factors like preterm pregnancy, lower socioeconomic status, previous LBW neonate, severe anemia and no utilization of ANC, there was an increased risk for LBW neonate with exposure to ETS. A dose response relationship was seen between ETS exposure and LBW, with significantly increased risk of LBW at higher Exposure Index.

Environmental Tobacco Smoke (ETS), also known as secondhand smoke or passive smoke is a combination of side-stream (SS) smoke that is emitted from the burning end of a cigarette and the mainstream (MS) smoke exhaled by the smoker. SS smoke contains toxins in higher

TABLE II ASSOCIATION OF ETS EXPOSURE WITH CASES (LBW NEONATES) AND CONTROLS (NORMAL BIRTH WEIGHT)

Variable	*Cases (100) N (%)*	*Controls (200) N (%)*	*OR (95% CI)*	*P-value*
ETS Exposure	65(65)	70(35.0)	3.45(2.08-5.7)	0.001
Exposure Index (EI)				
<10 E.I.	25(25)	55(27.5)	Reference	
11-20 E.I.	24(24)	13(6.5)	4.06(1.78-9.2)	0.001
>20 E.I.	16(16)	2(1.0)	17.62 (3.7-82.4)	<0.001

Abbreviations: ETS-Environmental Tobacco Smoke, EI-Exposure Index (median of range of No. of bidis and cigarettes smoked per person per day No. of family members smoking).*

TABLE III UNCONDITIONAL LOGISTIC REGRESSION TO ASSESS ASSOCIATION OF ETS EXPOSURE TO LBW

Parameters	*Adjusted OR (95%CI)*	*P value*
Preterm pregnancy	11.58 (5.9-22.77)	<0.001
Lower Socioeconomic status	1.71 (0.99-2.93)	0.054
Previous LBW baby	4.72 (1.19-18.69)	0.027
Severe Anaemia*	1.82 (1.04-3.18)	0.035
Utilisation of ANC	0.34 (0.13-0.93)	0.035
ETS Exposure	3.16 (1.89-5.28)	<0.001

*Abbreviations: LBW-Low Birth Weight, ANC-Ante natal care, ETS-Environmental Tobacco Smoke, *Severe anemia <7gm/dL.*

concentrations than in the mainstream smoke [15]. It has been classified as a class A (known human) carcinogen [16] and its constituents include toxic substances like tar, nicotine, benzene, radioactive compounds etc [17]. ETS exposure has been recognized to be one of the most ubiquitous and hazardous of environmental exposures and has a detrimental impact on adult and child health [18].

Low birth weight in ETS exposed women may be attributed to many factors, including the vasoconstriction properties of nicotine, elevated fetal carboxyhaemo-globin levels, fetal tissue hypoxia, reduced delivery of nutritional elements, and elevation of heart rate and blood pressure. The dose–response relationship between ETS exposure and LBW might be explained by the cumulative effect of inhaling nicotine and carbon monoxide, which reach the neonate through the placenta and prevent the fetus from getting nutrients and oxygen needed to grow [19].

Maternal smoking is an established risk factor for LBW babies [20]. Studies carried out in developed countries [19, 21] have reported that an ETS exposed women has an increased odds of delivering a LBW, with odds ratios in the range of 1.0 to 2.2. Most of the studies from India are on the pulmonary effects of passive smoking. Studies carried out in Vellore [22], Nagpur [23] and Chandigarh [24] have stated a decrease in birth weight of babies of ETS exposed mother. This study helps to establish that a stronger association exists between ETS exposure during pregnancy and LBW neonates in a developing country like India.

In India, besides cigarettes, *bidi* is also used for smoking. Bidis are made of crude sun-dried tobacco wrapped in a dried Tendu (*Dyospyros melanoxylon*) leaf. Being inexpensive and easily available, it is widely used by lower economic strata of the society. A higher content of nicotine and minor tobacco alkaloids in tobacco from bidi (37.7 mg/g) have been demonstrated, as compared to Indian or American cigarettes (14-16 mg/g) [25]. Majority of the patients admitted to our hospital belong to rural villages and towns of Uttar Pradesh, where tobacco smoking is in the form of *bidis*. Overcrowding and poorly ventilated homes, particularly in the lower socio-economic strata of the society are also likely to enhance the effects of the ETS exposure. These factors may possibly explain our finding of higher association of ETS with LBWas compared to other studies in developed countries. Further, the calculated odds ratio could be an overestimation of Relative risk (RR) in the population because of the nature of the case control design.

Most of these studies including this study used non-validated, self-reported measures to ascertain maternal ETS exposure, which could result in an underestimation of ETS exposure due to either a lack of awareness of maternal exposure or an unwillingness to declare exposure, and thus could result in biase towards null reports. In addition, dose response relationship was calculated on basis of approximate and average number of *bidis*/cigarettes smoked. Since, this too depends on recall, it could also be a subject of bias. Further, a more precise method of measuring ETS exposure would be by measuring biomarkers (nicotine and cotinine levels) in body fluids/samples like urine, saliva, hair sample [26]. Further, being a case control study, there are inherent chances of bias due to selection of controls. We tried to minimize this by selecting two consecutive controls after each case recruited. To minimize inter-observer variation, one person collected all the data using a pre designed questionnaire. The duration of interview was same for each case and control. Also, this study only highlighted residential ETS exposure, as during pregnancy home is the major source of ETS exposure for non working women belonging to rural part of India. Another limitation of this study is the non inclusion of certain factors such as periodontal diseases that could have had a significant influence on the outcome. Since residential maternal ETS exposure is a potentially entirely avoidable entity unlike some other risk factors, it further emphasizes the need to curb tobacco smoke exposure to pregnant women. Interventions should be carried out to ensure smoke-free living conditions and a healthy environment for all family members. There must be increased awareness and evaluation of ETS exposure and steps to avoid it during pregnancy should be an important part of antenatal care (ANC) counseling.

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