

Prenatal exposure to indoor air pollution and the risk of Low Birth Weight: A case-control study in a rural maternity hospital in Ramanagara district, Karnataka

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ABSTRACT

Background: In India, according to National Family Health Survey 4, the incidence of low birth weight was 18%. One of the factors that has emerged as a risk factor for low birth weight (LBW) is indoor air pollution. **Objectives:** To estimate the risk of low birth weight with prenatal exposure to indoor air pollution, in a rural area of south Karnataka. **Study design:** Case-control study. **Study setting:** The study was conducted in a Maternity hospital in a rural area of Ramnagara District in south Karnataka for two months. **Participants:** Women who delivered live singleton infants with LBW (birth weight < 2500g irrespective of gestational age) were considered "Cases". "Controls" included women who delivered single live infants weighing ≥ 2500g. **Methods:** Subjects were administered a pre-tested, face-validated structured questionnaire, with socio-demographic and obstetric information, exposure to various sources of indoor air pollution as well as environmental factors contributing to indoor air pollution. **Main outcome measures:** Odds ratio and adjusted odds ratio for various sociodemographic and environmental factors contributing to LBW. **Results:** Absence of exhaust ventilation in the kitchen, OR=3.76 (1.09-13.03), regular use of incense, OR=4.94 (1.12-21.73) and lack of cross ventilation in the house, OR=4.65 (1.60-13.51) were identified to be the main risk factors associated with LBW. **Conclusions:** Prenatal exposure to indoor air pollution carried a higher risk of LBW. Pregnant women need to be educated regarding the harmful effects of burning incense at home and the dangers of poor ventilation, and their effect on the birth weight of newborns.

Key Words: Incense, smoke, ventilation, low birth weight, indoor air pollution.

INTRODUCTION

Low birth weight (LBW) is defined as a weight of less than 2500 grams irrespective of gestational age [1]. Globally, in 2013, the incidence of low birth weight was 16% [2]. In India, according to National Family Health Survey 4 (NFHS-4), the incidence of low birth weight was 18% [3].

There are multiple established risk factors contributing to low birth weight such as extremes of maternal age, anaemia during pregnancy, maternal diet, previous miscarriages, gestational hypertension, antenatal infections and psychosocial stress [4]. Even though studies have been able to identify many causes of low birth weight, the incidence of LBW babies is still disturbingly high in developing nations like India, especially since the chances of survival of LBW children are lower compared to normal birth weight children.

One of the factors that has emerged as a risk factor for LBW is indoor air pollution. Indoor air pollution can be described as the decrease in air quality indoors due to harmful chemicals [5]. The main contributors are

combustion of biomass fuel, environmental tobacco smoke, bioaerosols and building materials [6]. Globally, 41% of households, mainly in developing countries in Asia and sub-Saharan Africa rely on solid fuels (coal and biomass) as their primary cooking fuel [7]. These emit a variety of pollutants including fine particles, CO, and nitrogen oxides as well as phenols, cresols, acrolein, and acetaldehyde; carcinogenic organic compounds such as benzene, formaldehyde, and 1,3 butadiene; and carcinogenic cyclic compounds such as polyaromatic hydrocarbons which are very harmful for health [8].

Tobacco smoke from people smoking inside the house is also an indoor air pollutant. Environmental tobacco smoke (ETS) is a combination of side-stream smoke that is emitted from the burning end of a cigarette and the mainstream smoke exhaled by the smoker. Side-stream smoke constitutes about 85% of the smoke present in a room and is considered more toxic than the mainstream smoke [9]. A meta-analysis shows that pregnant women who reported exposure to ETS has a higher risk of

delivering LBW and/or small for gestational age babies [10]. Another important contributing factor to LBW is smoking during pregnancy. Nicotine and carbon monoxide are major constituents of tobacco smoke and smoking during pregnancy can lead to birth weights of 200 g less than the mean birth weight of children of non-smokers [10].

The various other sources of indoor air pollution include paints, adhesives, solvents, pressed wood, household pesticides including insect sprays, deodorizers and burning of incense and mosquito coils [11]. These are the sources of various Volatile Organic Compounds (VOCs) including aromatic and aliphatic hydrocarbons, halogenated hydrocarbons, acetone, 2 – butanone and freons [12] which if present in harmful amounts can adversely affect the growth of the foetus.

Antenatal women are at increased risk for adverse outcomes from indoor air pollution due to large amount of time they spend at home. There are very few studies connecting low birth weight with various types of indoor air pollution, especially in rural areas of India. Therefore, this study was conducted with the aim of estimating the risk of low birth weight with prenatal exposure to indoor air pollution, in a rural area of south Karnataka.

MATERIAL AND METHODS

An unmatched case control study was conducted in a maternity hospital in a rural area of Ramnagara District in south Karnataka among women who delivered there during the period of September to October 2017, after receiving Institutional Ethics Committee approval and permission from the hospital authorities. Eligible participants were women who: (1) delivered a live singleton foetus; (2) delivered in the hospital (3) were residents of the mentioned study area for at least one year before delivery.

Women who delivered live singleton infants with low birth weight (birth weight less than 2500g irrespective of gestational age) were considered “Cases”. “Controls” included women who delivered single live infants weighing \geq 2500g. Data on the newborn was collected from the hospital records. After identifying the cases and controls, written informed consent was obtained and the subjects were administered a pre-tested, face-validated structured questionnaire, translated into the local language Kannada, which comprised socio-demographic and obstetric information, exposure to various sources of indoor air pollution as well as environmental factors contributing to indoor air pollution.

Sample size was calculated to be 28 cases based on a previous study [13]. It was decided to include two controls for every case.

Statistical analysis: The data obtained was entered into Microsoft excel and analysed using SPSS v20. Frequencies, proportions, mean with standard deviation

and median with interquartile range were used for descriptive statistics. To compare various variables between cases and controls, independent T test, Mann-Whitney U test and Kruskal Wallis test were used. Odds ratios with 95% confidence intervals were used to associate LBW with various sources of indoor air pollution. Significantly associated variables were entered into a multivariate logistic regression model to derive adjusted odds ratio.

RESULTS

Table 1: Sociodemographic details of cases and controls

Variable	Category	Cases (30)	Controls (60)	p value
Age (in years)	Mean (SD)	22.57 (2.89)	23.52 (3.56)	0.245\$
	Up-to high School and above	20(66.7)	17(28.3)	
Educational status	Housewife	10(33.3)	43(71.7)	0.000*
	Employed	27(90.0)	53(88.3)	
Occupation	Housewife	3(10.0)	7(11.7)	1.000#
	Employed	27(90.0)	53(88.3)	
Monthly per capita income (INR)	Median (IQR)	2366 (1000-3333)	2583 (1525 – 3333)	0.380\$
	Type of family	Nuclear	13(43.3)	
	Others	17(56.7)	45(75.0)	

*p value <0.05; statistically significant, # Fisher's exact test, \$ Mann-Whitney U test

Table 2: Obstetric details of cases and controls

Variable	Category	Cases (30)	Controls (60)	p value
Gestational age at delivery (weeks)	Mean (SD)	38.2 (1.7)	38.7 (1.0)	0.387\$
	1	26(86.7)	40(66.7)	
Parity	2	3(10.0)	14(23.3)	0.127#
	3 or more	1(3.3)	6(10.0)	
Haemoglobin (g/dL)	Mean (SD)	11.07 (2.19)	11.38 (1.39)	0.938\$
	Number of antenatal ultrasound scans	Median (IQR)	4 (3-4)	
Mode of delivery		Normal	28(93.4)	51(85.0)
	LSCS	1(3.3)	4(6.7)	
Gender of newborn	Assisted	1(3.3)	5(8.3)	0.551
	Male	17(56.7)	30(50.0)	
	Female	13(43.3)	30(50.0)	

*p value <0.05; statistically significant, # Fisher's exact test, \$ Mann-Whitney U test

A total of 30 cases and 60 controls in the ratio of 1:2 were included in the study. There was no significant difference between the cases and controls with regards to possible confounding socio-demographic variables like age, education, occupation, per capita monthly income, age at marriage, or type of family. *see table 1.* There was no significant difference between the cases and controls with regards to obstetric variables like gestational age at

Table 3: Indoor air pollutants and the risk of low birth weight.

Variable	Category	Cases (30)	Controls (60)	Odds Ratio	95% Confidence Interval	p value
Exposure to second hand smoke at home	Yes	7(23.3)	11(18.3)	1.35	0.46	3.95
	No	23(76.7)	49(81.7)			
Exposure to smoke producing cooking fuel	Yes	5(16.7)	15(25.0)	0.6	0.19	1.84
	No	25(83.3)	45(75.0)			
Regular use of mosquito coils	Yes	11(36.7)	13(21.7)	2.09	0.79	5.48
	No	19(63.3)	47(78.3)			
Regular use of Incense	Yes	27(90.0)	40(66.7)	4.5	1.21	16.64
	No	3(10.0)	20(33.3)			
Regular use of insect spray	Yes	7(23.3)	9(15.0)	1.72	0.57	5.2
	No	23(76.7)	51(85.0)			
Regular use of air freshener	Yes	3(10.0)	6(10.0)	1	0.23	4.31
	No	27(90.0)	54(90.0)			

*p value <0.05; statistically significant, # Fisher's exact test

Table 4: Environmental factors contributing to indoor air pollution and the risk of low birth weight

Variable	Category	Cases (30)	Controls (60)	Odds Ratio	95% Confidence Interval	p value
Separate kitchen	Absent	3(10.0)	5(8.3)	1.22	0.27	5.49
	Present	27(90.0)	55(91.7)			
Exhaust Ventilation in the kitchen	Absent	25(83.3)	34(56.7)	3.82	1.28	11.34
	Present	5(16.7)	26(43.3)			
Presence of soot on kitchen wall	Present	4(13.3)	4(6.7)	2.15	0.49	9.29
	Absent	26(86.7)	56(93.3)			
Cross Ventilation	Absent	22(73.3)	22(36.7)	4.75	1.81	12.46
	Present	8(26.7)	38(63.3)			
Windows (most of the day)	Closed	14(46.7)	13(21.7)	3.16	1.23	8.13
	Open	16(53.3)	47(78.3)			
Overcrowding	Present	5(16.7)	9(15.0)	1.13	0.34	3.73
	Absent	25(83.3)	51(85.0)			

*p value <0.05; statistically significant, # Fisher's exact test

Table 5: Adjusted factors for LBW: Multivariate logistic regression

Variable	Category	Adjusted Odds ratio	95% CI for Odds Ratio	p value	
Exhaust ventilation	Absent	3.76	1.09	13.03	0.037*
Regular use of Incense	Present	4.94	1.12	21.73	0.034*
Cross ventilation	Absent	4.65	1.6	13.51	0.005*

*p value <0.05; statistically significant

delivery, parity, mean haemoglobin level (latest third trimester value), number of antenatal ultrasound scans, mode of delivery and gender of the newborn. *See table 2.* The mean (SD) birthweight among neonates born to women in the case group was 2.16 (0.26) kgs, while that in controls was 2.86 (0.28) kgs.

Among various sources of indoor air pollution, regular use (on most days of the week) of incense (like

agarbhatti, dhoop, sambrani) was found to be of significant risk for LBW. Regular use (on most days of the week) of mosquito coils, insect sprays and air fresheners as well as exposure to second hand smoke were found to have no significant risk for LBW. *See table 3.* Among environmental factors contributing to indoor air pollution, presence of exhaust ventilation in the kitchen, lack of cross ventilation and keeping windows closed for most of the day carried significant risk for LBW. The absence of a separate kitchen, use of smoke-producing cooking fuel (like firewood, biomass, kerosene), presence of soot on the kitchen wall and overcrowding in the house were found to have no significant risk of LBW. In the present study none of the mothers were smokers. *See table 4.*

When variables that were associated with significant risk of LBW were entered into a multivariate logistic regression model, factors which continued to be of significant risk for LBW were absence of exhaust ventilation in the kitchen, OR=3.76 (1.09-13.03), regular

use of incense, OR=4.94 (1.12-21.73) and lack of cross ventilation in the house, OR=4.65 (1.60-13.51). See table 5.

DISCUSSION

Exposure to air pollution during pregnancy may affect maternal respiratory or general health, which can result in impairment of uteroplacental and umbilical blood flow, transplacental glucose, and total insulin which are identified as the major determinants of foetal growth [14]. Particulate matter can reduce the maternal lung function and can also cause oxidative stress causing cell damage in the foetus. Carbon monoxide can combine with haemoglobin and cross the placenta. This can result in decreased oxygen and nutrient supply to foetal tissues [15]. The results from our study shows that LBW among newborns is associated with exposure to indoor air pollution during antenatal period. Socio-demographic factors like maternal age, education, occupation, per capita monthly income which have been linked to LBW [16] [17], and are therefore potential confounders, were not significantly different between the cases and controls in the present study. Known confounding obstetric factors like gestational age, parity, haemoglobin, gender of the baby [18] too were not significantly different between the cases and controls.

In the present study we found nearly five times greater risk of LBW with the regular burning of incense at home. The products from burning incense include harmful gases like carbon monoxide, sulphur dioxide and volatile organic compounds, such as benzene, toluene, and xylenes, as well as polycyclic aromatic hydrocarbons [19]. Previous studies have shown association between ambient air pollutants including sulphur dioxide, PM10, carbon monoxide, total suspended particles and low birth weight [20][21][22].

Our study also found nearly four times greater chance of LBW in the absence of exhaust ventilation and nearly five times greater chance of LBW with lack of cross ventilation. The lack of exhaust ventilation and cross ventilation leads to decreased air circulation and stagnation of air pollutants, which might have contributed to longer exposure of the mothers to indoor air pollution. A study in the US found that ventilation from keeping windows open at least half the day had decreased risk of low birth weight [23].

Studies have shown that wood-fuel smoke exposure during prenatal period has a negative effect on birthweight of newborns [13][24][25][26]. Prenatal exposure to biomass fuel has also been associated with increased risk of low birth weight in India as well as in Ethiopia and Peru [18][27][28][29]. But no such association was found in our study probably because of the decreased use of biofuels in rural areas of south Karnataka, and the more widespread use of gas (LPG), as

similarly seen in a study conducted in central East India [30].

Exposure to environmental tobacco smoke (ETS) is a known risk factor for LBW. (28)(31)No such association was found in our study probably because of the low number of cigarette smokers in the home. This could be a result of increased awareness among the population with regards to hazards of smoking and exposure to second hand smoke. Studies have also shown that reduction of smoking in public places and work places also leads to a reduction of smoking in the home [32].

A study in the US found that women who reported regular or frequent usage of personal and household products such as, hairspray and insect spray had higher odds of term LBW [23]. In the present study however, there was no significantly greater risk of LBW among women who were regularly exposed to insect spray, or air fresheners. This was possibly due to the very small numbers of women reporting the use of insect sprays and air-fresheners in a rural setting.

Based on the findings in our study, it is recommended that pregnant women be educated during their antenatal visits regarding the harmful effects of burning incense at home and the dangers of poor ventilation, and their effect on the birth weight of newborns. These points can be reinforced by the ASHA worker during her home visits to pregnant women, where such practices can be observed and corrected.

Conclusion: This case-control study in a rural area of south Karnataka found that prenatal exposure to indoor air pollution carried a higher risk of low birth weight. Women who were exposed to regular burning of incense during pregnancy were nearly five times more likely to have a LBW baby. Absence of exhaust ventilation in the kitchen and lack of cross ventilation in the house, were also found to carry higher risk of LBW. It is recommended that pregnant women be educated regarding the harmful effects of burning incense at home and the dangers of poor ventilation, and their effect on the birth weight of newborns.

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