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Original Research Article

A hospital-based case-control study to find out the association between prenatal exposure of household air pollutants and low birth weight among postnatal mothers attending a tertiary care centre in Chennai

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ABSTRACT

Background: Indoor air quality is the air quality within and around buildings and structures. It is vital in determining the health status of a person. Indoor air pollution can predispose to development of several non-communicable diseases, especially among women and children. This study was undertaken to determine the patterns of indoor air quality in the houses of selected mothers and investigate the association between exposure to indoor air pollution and birth weight.
Methods: A case control study was conducted among 117 postnatal women, admitted in a tertiary hospital using a semi structured questionnaire. The participants were divided into groups of cases and controls in the ratio of 1:2, resulting in 39 cases and 78 controls. The study period spanned from July 2023 to December 2023.
Results: Among the cases, 48.71% were found to have been exposed to at least one household air pollutant against 38.46% among the controls. Factors which were found to have significant causative association towards birth of low-birth-weight babies included exposure to fungal moulds in consumed food items (8.33% among cases against 0% among controls with a p value of 0.009) and presence of water leakage in houses (8.33% among cases against 0% among controls with a p value of 0.016).
Conclusions: Antenatal exposure to fungal mold and water leakage were identified as major risk factors for low-birth-weight infants. Education and awareness regarding air pollutants and their management should be created among the general public.

Keywords: Indoor air pollution, Low birth weight, Moulds, Stains, Ventilation

INTRODUCTION

Low birth weight infants, as defined by the World Health Organization, are infants weighing less than 2500 grams at the time of their birth.[1] According to the statistical reports, in 2020, a total of 19.8 million new-borns, an estimated 14.7 per cent of all babies born globally that year, suffered from low birthweight.[2] According to the National Family Health Survey 5 conducted in India, the incidence of low birth weight was found to be 18%.[3]

Several well-known risk factors are associated with low birth weight, including maternal age at the extremes, anemia during pregnancy, inadequate maternal nutrition, a history of previous miscarriages, gestational hypertension, antenatal infections, and psychosocial stress.[4]

Indoor air pollution has recently been identified as a risk factor for low birth weight (LBW).[5] It refers to the deterioration of indoor air quality caused by harmful chemicals.[6] Common sources of indoor air pollution include stains and soot deposits inside homes, cigarette smoke, absence of kitchen exhaust fans, lead-based paints, indoor storage and use of pesticides or herbicides, home furnishing activities, pet dander, indoor fungal molds, and water leakage or stagnation in and around the household environment.[7]

Well into the 21st century, around 2.8 billion people worldwide still depend on solid fuels such as wood, dung, crop waste, charcoal, and coal, along with basic stoves for cooking and heating. Additionally, 1.2 billion people use simple kerosene lamps for lighting. This reliance is predominantly observed in low- and middle-income countries (LMICs) across Asia, Africa, and Latin America. In many nations, particularly in sub-Saharan Africa, over 95% of the population uses solid fuels for cooking. Rapid population growth has outpaced the availability of clean cooking solutions, leaving 923 million people without access to clean cooking methods, according to 2022 studies.[8] Women and children, who are often responsible for household tasks like cooking and collecting firewood, bear the brunt of the health impacts caused by the use of polluting fuels and technologies in homes. Antenatal women are at increased risk for adverse outcomes from indoor air pollution due to large amount of time they spend at home. The chemical constituents of biomass and coal smoke may be in the form of individual chemical compounds (such as carbon monoxide, benzene, formaldehyde), groups of compounds (such as total non-methane hydrocarbon, total organic carbon), elements (such as carbon, arsenic) or ions (such as fluoride, sulfate) all of which are very harmful for health.[9]

Environmental tobacco smoke (ETS) is produced from two main sources: side stream smoke (SS), which comes from the smoldering end of a tobacco product between puffs, and the smoker's exhaled smoke. The smoke directly inhaled by the smoker is referred to as mainstream smoke (MS).[10] Side stream smoke is the primary component of environmental tobacco smoke (ETS) from cigarettes. In enclosed indoor spaces with typical smoking and ventilation conditions, cigars can significantly elevate concentrations of certain regulated ambient air pollutants, such as carbon monoxide, respirable suspended particles (RSP), and polycyclic aromatic hydrocarbons (PAH). These pollutants may exceed air quality standards, further contributing to the levels of these harmful compounds already present in the ambient air from other combustion sources.[11] In a study by Misra et al pregnant women reporting increased exposure to ETS had a higher risk of delivering a LBW baby.[12]

Additional sources of indoor air pollution include paints, adhesives, solvents, pressed wood products, household pesticides (such as insect sprays), deodorizers, and the burning of incense and mosquito coils. These sources release various volatile organic compounds (VOCs), including aromatic and aliphatic hydrocarbons, halogenated hydrocarbons, acetone, 2-butanone, and freons. When present in harmful concentrations, these compounds can negatively impact fetal growth and development.[13]

METHODS

A matched case-control study was carried out at a tertiary care hospital in Chennai among women who delivered at the hospital between July 2023 and December 2023. The study was conducted after obtaining approval from the institutional ethics committee and permission from the hospital authorities. Eligible participants were postpartum women over the age of 18, without any known chronic conditions, who voluntarily agreed to take part in the study and have given birth within the last 42 days in the hospital, where the study is being conducted during the specified study period.

Women who had delivered a live baby weighing less than 2.5 kg at birth were considered as "case". Women who had delivered a live baby weighing more than 2.5 kg at birth were considered as "control". Controls were matched to cases for age, locality and parity.

Data on the newborns was gathered from hospital records. After identifying the cases and controls, written informed consent was obtained from the participants. A pre-tested, semi-structured questionnaire was designed in English and translated into Tamil. The questionnaire included questions about socio-demographic information, obstetric and trimester history, personal and family history, past medical history, birth history, socio-economic status, and details about the household and external environment, to gather the necessary information for the study.

Exposure to poor indoor air quality in the home environment was considered to be present among the study participants if exposure to any one of the following was found to exist: lack of exhaust fan in kitchen, presence of soot deposition inside the house, presence of stains inside the house, exposure to cigarette smoke, exposure to lead based paints in their house, indoor storage and usage of pesticides or herbicides, furnishing working done in their house during the period of pregnancy, exposure to pet dander, exposure to fungal moulds in consumed food items, presence of water leakage or stagnation in and around home environment.

Sample size

Based on a previous study, the sample size (n) was calculated based on the following formula:[14]

$$n = \frac{2(P)(100-P)(Z_\alpha + Z_\beta)^2}{(P_1 - P_2)^2}$$

where,

Z_α =1.96 for a confidence level (α) of 5%,

$Z_ß$ = 1.28 for a power (ß) of 10%,

P = Average of P_1 and P_2 [$(P_1 + P_2)/2$]

P_1 =43.3%; percentage of control with optimal indoor air quality from previous study,

P_2 = 6.7%; percentage of cases with optimal indoor air quality from previous study.

According to the calculations based on the above formula, the number of cases included under study was 39. It was decided to include two controls for every case (case to control ratio is taken as 1:2). Hence the number of controls to be included under the study was 78.

Sampling

Convenient sampling will be done to obtain the required cases and controls satisfying the inclusion criteria.

Statistical analysis

Data obtained was entered in the worksheets of Epicollect5 Data Collection application and Microsoft Excel, which would subsequently be analysed using SPSS software v.29. The exposure factors were collected for both cases and controls and reported as percentage and also assessed by calculating odd's ratio for each factor. Descriptive statistics were calculated using frequencies, proportions, mean, and median with interquartile range. To compare variables between cases and controls, the Pearson Chi-Square test and Fisher's exact test were applied. Odds ratios with 95% confidence intervals were used to examine the association between low birth weight (LBW) and various sources of indoor air pollution. Variables that showed significant associations were included in a multivariate logistic regression model to calculate the adjusted odds ratios.

RESULTS

A total of 117 participants were included in the study, with a 1:2 ratio of cases to controls, resulting in 39 cases and 78 controls. No significant differences were found between the cases and controls regarding potential confounding socio-demographic factors such as age, per capita monthly income, age at marriage, or family type.

Table 1: Sociodemographic details of cases and controls.

Variables	Category	Cases (39)	Controls (78)	P value
Age (in years)	Mean	24.74	24.25	
Locality	Urban	34	68	1.000
	Rural	5	10	
Monthly per capita income (INR)	Median (IQR)	3750	3266	
		(2800-5000)	(2500-4166)	
Type of family	Nuclear	8	11	0.37
	Others	31	67	

*P value <0.05 is statistically significant; a Fisher's exact test

Table 2: Obstetric details of cases and controls.

Variables	Category	Cases (39)	Controls (78)	P value
Gestational age at delivery	More than 36 weeks	39	78	NA
	Less than 36 weeks	0	0	
Parity	1	17	32	
	More than 1	22	46	0.791
Number of antenatal ultrasound scans	4	39	78	NA
	Less than 4	0	0	
Mode of delivery	Normal	39	78	NA
	LSCS	0	0	

*P value <0.05 is statistically significant; a Fisher's exact test

There was no significant difference between the cases and controls with regards to obstetric variables like gestational age at delivery, parity, number of antenatal ultrasound scans and mode of delivery of the newborn. In the present study, none of the mothers were found to have delivered a pre-term baby nor had any previous abortion/miscarriage. None of the mothers were known cases of any chronic disease affliction nor were they known smokers, alcoholics or known to have had history of any other substance abuse. All of the participants had fulfilled the minimum required antenatal visits to the hospital (a minimum of 4 antenatal visits). The mean birthweight of neonates born to women belonging to the 'case' group was calculated to be 2.33 kg, while that among 'controls' was 3.21 kg.

None of the various sources of indoor air pollution were found to be carrying significant risk for LBW.

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

Variables	Category	Cases (39)	Controls (78)	Odds ratio	95% CI		P value
Exposure to second-hand smoke at home	Yes	10	11	2.1	0.8	5.49	0.125
	No	29	67				
Exposure to smoke producing cooking fuel	Yes	2	1	4.16	0.36	47.38	0.257[a]
	No	37	77				
Regular use of insect spray	Yes	4	4	2.11	0.49	8.95	0.438[a]
	No	35	74				
Furnishing work done during pregnancy	Yes	0	1	NA			1.000[a]
	No	39	77				
Presence of pet animals	Yes	2	5	0.78	0.14	4.26	1.000[a]
	No	37	73				

*P value <0.05 is statistically significant; [a] Fisher's exact test

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

Variable	Category	Cases (39)	Controls (78)	Odds ratio	95% CI		P value
House type	Kucha	11	20	1.13	0.48	2.7	0.402
	Pucca	28	58				
Separate kitchen	Absent	7	26	0.43	0.17	1.12	0.081
	Present	32	52				
Separate fridge	Absent	11	30	0.63	0.27	1.44	0.273
	Present	28	48				
Exhaust Ventilation in the kitchen	Absent	20	23	2.52	1.13	5.57	0.022*
	Present	19	55				
Presence of soot on kitchen wall	Present	3	1	6.42	0.364	63.84	0.107[a]
	Absent	36	77				
Stains on walls	Present	8	6	3.10	0.99	9.67	0.051
	Absent	31	72				
Cracks and crevices on walls	Present	7	14	1	0.36	2.72	1.000
	Absent	32	64				
Water Leakage	Present	3	0		NA		0.009*
	Absent	36	78				
Water Stagnation	Present	12	22	1.13	0.48	2.62	0.773
	Absent	27	56				
Fungal mould growth	Present	3	0		NA		0.009*
	Absent	36	78				
Cross Ventilation	Absent	24	54	0.71	0.31	1.59	0.405
	Present	15	24				
Overcrowding	Present	12	22	1.13	0.48	2.62	0.773
	Absent	27	56				

*P value <0.05 is statistically significant; [a] Fisher's exact test

Among the environmental factors contributing to indoor air pollution, the presence of exhaust ventilation in the kitchen, fungal mold growth on food items, and sources of water leakage in the household were significantly associated with an increased risk of low birth weight (LBW). However, factors such as the absence of a separate kitchen, use of smoke-producing cooking fuels (like firewood, biomass, or kerosene), presence of soot on the kitchen walls, stains inside the house, and overcrowding were not found to have a significant impact on the risk of LBW.

Table 5: Adjusted factors for LBW: multivariate logistic regression.

Variables	Category	P value
Fungal mold growth	Present	0.009*
Water Leakage	Present	0.016*

*P value <0.05 is statistically significant; [a] Fisher's exact test

When the variables associated with a significant risk of low birth weight (LBW) were entered into a multivariate logistic regression model, the factors that remained significantly associated with LBW were the presence of fungal mold growth and sources of water leakage inside the house.

DISCUSSION

Exposure to air pollution during pregnancy can negatively impact maternal respiratory or overall health, potentially leading to impaired uteroplacental and umbilical blood flow. This, in turn, may affect the transfer of glucose and insulin across the placenta, which are key factors influencing fetal growth.[15] Particulate matter can impair maternal lung function and induce oxidative stress, leading to cellular damage in the fetus. Carbon monoxide, due to its higher affinity for hemoglobin compared to oxygen, binds more readily with hemoglobin, causing increased levels of carboxyhemoglobin crossing the placenta. This reduces the supply of oxygen and nutrients to fetal tissues, hence impairing fetal development.[16] Based on the analysis of this study, it can be concluded that low birth weight (LBW) among newborns is associated with exposure to indoor air pollution during the antenatal period. Known confounding socio-demographic factors, such as maternal age, locality, per capita monthly income, and family type, as well as obstetric factors like gestational age, parity, and mode of delivery, were not significantly different between the cases and controls.[17-19]

In this study, we found that the incidence of low birth weight (LBW) was significantly higher among women exposed to fungal molds and water leakage within their homes. In studies conducted by Lu et al the authors have reported that mold and dampness are linked to the development and worsening of allergic diseases, as well as respiratory infections. It has been suggested that hyphal fragments of common mold species, which have strong pro-inflammatory properties, may play a key role in respiratory diseases associated with damp or mold-contaminated indoor air.[20-22]

There has been increasing evidence of increase in risk of low-birth-weight deliveries among women living in homes with poor ventilation. The lack of proper ventilation leads to poor air circulation and stagnation of air pollutants, potentially resulting in prolonged exposure to indoor air pollution for the mothers. In a study in the US, conducted by Ghosh et al, it was found that keeping windows open for at least half the day was associated with a reduced risk of low birth weight.[23] This study also found that women who reported regular or frequent use of personal and household products, such as hairspray and insect spray, had higher odds of delivering a term low birth weight baby. In the present study, however, there was no significantly greater risk of low birth weight among women who were regularly exposed to insect spray or other aerosol products. This may have been due to the very small number of women reporting the use of aerosols.

Studies conducted in different countries, such as those by Abusalah et al in Palestine, Epstein et al in India, Pathirathna et al in Sri Lanka and Amegah et al in Ghana, have demonstrated that exposure to wood-fuel smoke and indoor soot deposition during the antenatal period have detrimental effects on the birth weight of newborns.[24-27] According to the studies conducted by Tielsch et al in India, Yucra et al in Peru and Demelash in Ethiopia, it has been observed that prenatal exposure to biomass fuel increases risk of low birth weight.[28-30] However, no such association was found in our study, likely due to the reduced use of biofuels in households in Chennai and the more widespread use of cleaner cooking fuels such as liquefied petroleum gas, etc. This trend is similar to what was observed in a study conducted by Wylie et al in central east India.[31]

In their study Niu et al observe that exposure to environmental tobacco smoke (ETS) contributes to increased risk of low birth weight.[32] No such association was found in our study, likely due to the low number of cigarette smokers in the household. This could be attributed to increased awareness about the hazards of smoking and second-hand smoke exposure. In another study, Lee et al have shown that reducing smoking in public places and workplaces leads to a decrease in smoking within homes.[33]

Other factors known to influence indoor air quality, such as the type of house, presence of cross ventilation, overcrowding, the presence of pet animals in the home, and possession of commodities like a separate kitchen or a refrigerator for food storage, were not found to significantly contribute to an increased risk of LBW in our study.[7] This may be attributed to heightened awareness and education among the general public, as well as widespread improvements in the overall quality of living.

Due to lack of extensive resources, our study includes only those participants availing proper treatment and care from a tertiary hospital. Household conditions and indoor air quality will certainly differ in people belonging to extremely poor socioeconomic classes. It might be difficult to assess this population due to lack of awareness and difficulties in outreach.

Lack of a proper scoring system and facilities hinders qualitative assessment of levels of air pollution among households of participants.

CONCLUSION

This case-control study conducted in an urban area in Chennai found that prenatal exposure to indoor air pollution significantly increased the risk of low birth weight (LBW). Specifically, antenatal exposure to fungal mold growth and water leakage in the home were identified as major risk factors for LBW. It is recommended that pregnant women be educated during their antenatal visits about the harmful effects of these pollutants, their potential adverse impact on newborns, and the necessary safety measures that should be taken to mitigate such risks.

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