Original Article

Effect of Prenatal Exposure to Kitchen Fuel on Birth Weight

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ABSTRACT

Background: Maternal exposure to kitchen fuel smoke may lead to impaired fetal growth. **Objective:** To study the effect of exposure to various kitchen fuels on birth weight. **Methodology**: Study type: Retrospective analytical. Study setting: Hospital based. **Study Subjects:** Mothers and their newborns. **Inclusion Criteria:** Mothers registered in first trimester with minimum 3 visits, non-anemic, full-term, and singleton delivery. **Exclusion Criteria:** History of Pregnancy Induced Hypertension (PIH), Diabetes Mellitus (DM), tobacco chewers or mishri users. Sample size: 328 mothers and their new-borne. Study period: Six months. Study tools: Chi-square, *Z*-test, ANOVA, and binary logistic regression. **Results:** Effect of confounders on birth weight was tested and found to be non-significant. Mean ± SD of birth weight was 2.669 ± 0.442 in Liquid Petroleium Gas (LPG) users ($n = 178$), 2.465 ± 0.465 in wood users ($n = 94$), 2.557 ± 0.603 in LPG + wood users ($n = 27$) and 2.617 ± 0.470 in kerosene users ($n = 29$). Infants born to wood users had lowest birth weight and averagely 204 g lighter than LPG users ($F = 4.056$, $P < 0.01$). Percentage of newborns with low birth weight (LBW) in wood users was 44.68% which was significantly higher than in LPG users (24.16%), LPG + wood users (40.74%) and in kerosene users (34.48%) (Chi-square = 12.926, $P < 0.01$). As duration of exposure to wood fuel increases there is significant decline in birth weight ($F = 3.825$, $P < 0.05$). By using logistic regression type of fuel is only best predictor. **Conclusion:** Cooking with wood fuel is a significant risk-factor for LBW, which is modifiable.

Keywords: Kitchen fuel, low birth weight, solid biomass fuel

Introduction

In India prevalence of low birth weight (LBW) newborns is 28% of all live births and more than half of these are born at term.[1] LBW is one of the global indicators and the target was to reduce LBW births to less than 10%under "Health for All by 2000AD."[1] LBW is a multi-faceted problem; with some known and few unknown reasons. The etiology of LBW is also complex; with demographic, nutritional, reproductive, and socio-economic factors, each potentially playing a role. These causes can be enlisted as maternal Haemoglobin (Hb) level, hard manual work during antenatal period, maternal nutrition, economic condition, antenatal care, parents' education, tobacco use, maternal age, and parity.[2] It is observed that at birth, female newborns are lighter than male.[2] To improve the situation multi-pronged interventions are required. Women spend considerable time in kitchen, where they are exposed to fumes of various fuels used in kitchen stove. Half of world's population uses solid fuel for cooking.[3] Two-thirds of households in developing countries still rely on bio fuels and it is women of childbearing age who perform most cooking tasks.[4] Wood fuel is still widely used, especially in rural areas and semi urban areas. Maternal exposure to kitchen fuel smoke may lead to impaired fetal growth through hypoxia.[5] Thus, the inhaled particulate matter from smoke impairs fetal growth by damaging cells through oxidative stress.[6]

Access this article online

Quick Response Code:

Website: www.ijcm.org.in

DOI: 10.4103/0970-0218.120155

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Received: 07-04-11, **Accepted:** 19-02-13

The studies carried out previously, were mainly population based and have used birth weight records of previous few years where birth weight was recorded at different settings.[4-6]

To find out the effect of kitchen fuel on the birth weight, there is need to control the effect of other factors. For that purpose, it was planned to use a birth cohort from a hospital setting for the present study, so that it will be possible to take care of confounding factors and correct recording of birth weight would be carried out, e.g., taking care of observer and instrumental error.

Materials and Methods

Cross-sectional hospital based study was conducted from February 2010 to July 2010. Calculated sample size was 322 (P = 23%, a = 5%, d = 0.20).[5] Total 328 mothers were studied as all the eligible mothers who delivered in the last week of data collection were included. A preformed and pretested interview schedule was used to collect the information. Information was collected from the mother within 48 hours of delivery and birth weight of newborns was recorded. Data collection was carried out by one of the investigator who was trained appropriately including recording of birth weight for recording birth weight, pediatric weighing machine was used. Inclusion criteria for mothers were, those who have attended antenatal clinic from their first trimester and have paid minimum three visits, those who were non-anemic by the end of second trimester. For calculation of body mass index (BMI) weight is required for assessment of nutritional status. In clinical practice, it is difficult to calculate BMI as information on pre-pregnancy weight is usually unavailable at the first prenatal visit. In this regard, criteria of initial body weight have been proposed.[7] Initial weight recorded in early first trimester was obtained from records, which was available for only few mothers. Mothers having Pregnancy Induced hypertension (PIH) or any other illness such as diabetes, tuberculosis, malaria, Urinary Tract Infection (UTI), and having addictions (i.e., tobacco chewing or "tobacco mishri" i.e., burnt tobacco application to brush teeth) were excluded from the study. All mothers were communicated about the importance of diet, sleep and rest, iron prophylaxis etc., as a part of routine Ante Natal Checkup (ANC) check-up. Information about education, occupation, parity, type of cooking fuel, duration of exposure was collected. In the type of cooking fuel, wood fuel includes wood, crop residue, and cattle dung cake in open chulha. Data was analyzed with the help of SPSS-13, trial version.

Results

A total of 328 mothers aged between 19years and 35 years, participated in the study. Four mothers were over 30 years of age. Out of 328 mothers, 318 (96.95%) were housewives, 4 (1.21%) were in service, 3 (0.91%) were self-employed and 3 (0.91%) were farmers. Education wise, 2 (0.60%) were illiterate, 93 (28.35%) had primary education, 109 (33.23%) had education until high school, 80 (24.39%) until twelfth standard and 44 (13.41%) mothers were graduate.

Data was analyzed first to find out the effect of various confounding factors known to affect birth weight adversely. Out of 328 newborns 165 (50.30%) were males and 163 (49.69%) females. Males were heavier than females, however, the observed difference, i.e., 69 g, was not significant [Table 1].

To examine the effect of maternal age on birth weight, mean birth weight of different age groups was compared by using ANOVA. The highest mean birth weight was found in mothers having age ≥29 years and lowest in mothers of 24-28 years. The observed difference was not significant [Table 1].

Table 1: Effect of confounders on birth weight

Confounders	Number	Mean birth weight	SD	Significance
Sex of newborn				
Male	165	2.631	0.49	Z-value=1.3462, P>0.05
Female	163	2.562	0.45	
Age				
19-23 years	251	2.59	0.46	F-value=1.272, P>0.05
24-28 years	64	2.56	0.51	
≥29 years	13	2.8	0.39	
Education				
Upto primary	93	2.52	0.46	F-value=2.20, P>0.05
Upto H.Sec	189	2.64	0.48	
Upto graduate	44	2.58	0.41	
Occupation				
House wife	318	2.59	0.47	F-value=1.014, P>0.05
Service	4	2.93	0.67	
Self-employment	3	2.7	0.44	
Farmer	3	2.33	0.6	
Parity				
Primipara	206	2.6	0.45	F-value=0.129, P>0.05
Second para	100	2.58	0.49	
Multi-para (≥3)	22	2.62	0.6	
Breakfast				
Yes	312	2.61	0.47	Z-value=2.376, P<0.05
No	16	2.326	0.33	
Evening snacks				
Yes	272	2.627	0.46	Z-value=2.657, P<0.05
No	56	2.44	0.48	
Initial weight				
<45 kg	48	2.636	0.34	F-value=5.981, P<0.01
45-60 kg	82	2.772	0.38	
60 and above	3	3.333	0.47	
Weight gain				
5-10 kg	102	2.687	0.397	Z-value=2.727, P<0.05
10-16 kg	31	2.897	0.292	

*2 illiterate mothers excluded

Mean birth weight was low in primary educated and was highest in high school and higher secondary educated women. Newborns of graduate mothers were lighter than high school and higher secondary educated women. However, the observed difference was not significant [Table 1]. As there were only two mothers who were illiterate, they were excluded from this analysis.

Lowest mean birth weight was observed in mothers working in fields, as they do manual work, which requires more energy expenditure. Birth weight was best in mothers who were in service, which is predominantly sedentary work. However, the observed difference was not significant [Table 1].

Parity wise there were 206 (62.80%) primipara, 100 (30.49%) second para, 16 (4.88%) third para, 4 (1.22%) fourth para, and 2 (0.61%) were fifth para. For analysis mothers with third and above parity were combined together as "multi-para." Mean birth weight of multipara was better, followed by primi and then second para. However, the observed difference was not significant [Table 1].

Even though, mothers were advised on diet, out of 328, 16 mothers skipped breakfast while 56 skipped evening snacks. Mean birth weight was significantly less in mothers who skipped breakfast or evening snacks [Table 1].

For 133 women, initial weight recorded in early first trimester and last weight recorded at least within a week prior to delivery was available. The range of initial weight was 31 kg to 82 kg. Hence, they were divided into three groups: First group of mothers weighing up to 45 kg, second group of 45-60 kg and third group of more than 60 kg. Mean birth weight of newborns was higher in mothers with higher initial weight than mothers with lower initial weight. The mean birth weight of newborns increased as initial weight of mothers increased. The observed difference was significant (F = 5.981, P < 0.01) [Table 1]. However, there were only three mothers weighing more than 60 kg.

Weight gain in these 133 mothers was calculated (on the basis of initial weight) and was in the range of 5-16 kg. Average weight gain in mothers having initial weight <45 kg was 9.42 kg while those weighing more than 45 kg was 9.66 kg. The weight gain of these two groups was not significantly different (Z = 0.647, P > 0.05). On the basis of weight gain mothers were divided in to two groups. Mean birth weight of the newborns in mothers having less weight gain (5-10 kg) was significantly lower than those with better weight gain (10-16 kg).(Z = 2.727, P < 0.05) [Table 1].

Among all the above confounders presented in Table 1, confounders such as breakfast, evening snacks, initial weight, and weight gain were significantly associated. To know the distribution of significantly associated confounders in mothers using various fuels further analysis was carried out. Out of 178 LPG user mothers 7 (3.9%) mothers and out of 94 wood user 8 (8.5%) skipped breakfast and the observed difference between them was significant (Z = 10.312, P < 0.05). However, the number of mothers skipping breakfast was small. Distribution of mothers not having evening snacks according to fuel use was 33 out of 178 LPG users (18.53%) and 15 out of 94 wood user (15.95%). The observed difference was highly significant (Z = 3.184, P < 0.05).Distribution of 48 underweight mothers according to fuel use shows, 28 (15.73%) used LPG and 8 (8.5%) wood, the observed difference being highly significant (Z = 3.968, P < 0.05).

Out of 328 mothers, 178 (54.27%) used LPG, 94 (28.66%) used wood, 27 (8.23%) both wood and LPG while 29 (8.84%) were kerosene users. To find out the effect of various kitchen fuels on birth weight, newborns were classified according to birth weight, i.e., LBW and normal birth weight. Percentage of LBW newborns was highest in mothers using wood fuel alone (44.68%) and lowest in LPG users (24.16%). The proportion of LBW was high in wood users and close to those using wood along with LPG (40.74%). The observed difference is highly significant (Chi square = 12.926, P < 0.001) [Table 2].

To assess further the effect of kitchen fuel on birth weight, mean birth weight of newborns exposed to various kitchen fuels were compared. The highest mean birth weight was in LPG users (2.669 ± 0.44) and lowest in wood users (2.465 ± 0.46) preceded by wood + LPG users (2.557 ± 0.60). On an average, newborns of mothers using only wood was lighter by 204 g and wood + LPG users by 112 g than newborns of LPG users. Observed difference was highly significant (F = 4.056, P < 0.01) [Table 3].

Table 2: Distribution of newborns according to birth weight and fuel type

Type of fuel	No. of newborn		Total	Significance
	<2.5 kg	≥2.5 kg		
LPG	43	135	178	χ^2=12.926, P<0.001
(%)	24.16	75.84	100	
Wood	42	52	94	
(%)	44.68	55.32	100	
LPG+wood	11	16	27	
(%)	40.74	59.26	100	
Kerosene	10	19	29	
(%)	34.48	65.52	100	
Total	106	222	328	
(%)	32.32	67.68	100	

LPG: Liquid petroleum gas

Out of 96 mothers using wood fuel, exact duration of cooking was reported by 76 mothers. With increasing duration of exposure there was decline in mean birth weight. Newborns of mothers with more than 4 h exposure were lighter by 456 g than newborns of mothers with ≤2 h exposure. The observed difference was statistically significant (F = 3.825, P < 0.05). The correlation between duration of exposure and birth weight was inverse (r = −0.0828) [Table 3].

Factors, which were significant in univariate analysis, were considered in the multivariate analysis. Binary logistic regression with Wald's backward method was used to find out most significant predicted factors. Weight gain, type of fuel, breakfast, and evening snacks were the variables entered in step 1, which had significance <0.05. The least significant factor was removed from each step. It was found that, among the various factors considered, type of fuel was the only best significant predictor of birth weight [Table 4].

Discussion

Birth weight is affected by various factors. For assessing the effect of fuel used for cooking by expecting mothers on birth weight, there is need to take care of other factors, which might have similar effect on birth weight. For that purpose, care of known co-founders for LBW was taken at various levels of study. As a first step, care of few confounding factors was taken while selecting study subjects by deciding inclusion and exclusion criteria. As these mothers were provided with health education that also had taken care of some factors affecting birth weight like rest. In the second step, for some confounding factors such as sex of child, maternal age, education, occupation, and parity, analysis was carried out to know their effect on birth weight.

In this study, sex of the child had no significant effect on birth weight however, according to other studies male new borne were heavier than female.[8]

It has been stated by Samiran Bisai *et al.*, that the rate of LBW was high in mothers aged less than 19 years and older than 30 years.[2] In the present study, none of the mothers was below 19 years and only four mothers were above 30 years of age. This may be the reason, why the effect of maternal age on birth weight was not significant. Another study by Amita Bardham states that the relationship between birth weight and maternal age is weaker than parity.[9] This further explains why we did not observe significant effect.

Parity is another factor that affects birth weight.[10] The average birth weight tends to increase with parity.[9] In this study, significant effect was not observed.

Along with sex of child, age of mother and parity, other confounders like education and occupation had no significant effect on birth weight.

Pregnancy is a nutritionally highly demanding period. Mothers who had breakfast and/or snacks showed significantly better birth weight of their newborns than those who failed to do so.

Pre-pregnancy weight is a crude reflection of nutritional status of mother. Epidemiologically, pre-pregnancy weight may be considered a risk indicator of poor reproductive outcome. To assess nutritional status of mother, pre-pregnancy weight is important, which is very difficult to get in clinical practice[7] and hence, initial weight recorded during early pregnancy at the time of

Table 3: Effect of type of fuel and duration of cooking on birth-weight

Study factors		Number	Mean birth-weight	SD	Significance
Type of fuel	LPG	178	2.669	0.44	F-value = 4.056, P<0.01
	Wood	94	2.465	0.46	
	LPG+wood	27	2.557	0.6	
	Kerosene	29	2.617	0.44	
	Total	328	2.597	0.47	
Duration of cooking (h)	≤2	16	2.631	0.39	F-value = 3.826, P<0.05
	2.1-4	56	2.324	0.43	
	>4	4	2.175	0.27	
	Total	76	2.381	0.44	

LPG: Liquid petroleum gas

Table 4: Binary logistic regression

Study factors	*B*	SE	Wald	*df*	Significance	Exp (B)	95% CI for EXP (B)	
							Lower	Upper
Fuel type	–0.495	0.215	5.275	1	0.022	0.61	0.408	0.978
Evening snacks (yes)	–0.806	0.581	1.923	1	0.166	0.447	0.061	0.730
Constant	2.571	0.555	21.485	1	0	13.079		

B: Co-efficient of regression, SE: Standard error of mean, Wald: Wald statistic, *df*: Degree of freedom, Exp (B): Odds ratio, CI: Confidence interval diagnosis of pregnancy was considered.[7] In this study, it was observed that birth weight of underweight mothers was significantly low.

Weight gain during pregnancy was one more factor, which was found to be affecting birth weight significantly in this study.

In this study, frequency of LBW was significantly high in wood users and similar findings were noted in other studies.[4,5,11] Mothers using both LPG and wood had frequency of LBW higher than only LPG users but less than only wood user. This means even partial exposure to wood fuel smoke affects birth weight adversely and the observed difference is highly significant.

In the present study, birth weight of newborns was significantly low in wood users. Boy *et al*., found infants born to wood users averaged 63 g lighter than the infants born to natural gas users.[4] Similar findings are noted by Siddiqui and *et al.* (0.82 g lighter).[5] However, the difference was high in present study. Reason for this may be the recording of birth weight was carried out by investigator herself within 48 h of delivery and chances of having recall bias for history of exposure might be less. While Boy *et al*., has collected data within 72 h of delivery and includes hospital births as well as home births also. Study by Siddiqui *et al*., was a historical cohort study and had obtained infants birth weight from records.

From above analysis it is evident that wood fuel affects birth weight adversely. To establish causal association additional criteria for judging causality are used. One of these criteria is strength of association and one of the criteria for assessing it is dose-response (effect) relationship. The likelihood of a causal relationship is strengthened, if there is a biological gradient or dose response relationship.[1] To see the dose response relationship, effect of duration of cooking on birth weight was studied in mothers using only wood fuel. With increasing duration of exposure there is significant reduction in birth weight. This finding further strengthens cause-effect relationship.

Binary logistic regression concluded that type of fuel was the best predictor of birth weight among all confounders. More evidence was available in the form of dose-response relationship. In spite of the risk-factors such as poor initial maternal weight, evening snacks were less frequent in wood users; birth weight in them was low. It may further highlight the adverse effect of wood fuel on birth weight.

The present study clearly indicates that solid biomass fuel affects birth weight adversely. In rural or semi-urban area mainly wood, crop residue or cattle dung cakes are used for cooking as they are available as a byproduct of their farming activity, free of cost. Use of solid fuel is independent of socio-economic status especially in rural areas. Even today, use of LPG and biogas in villages is not much prevalent or it is used as an additional source of energy, where most of the cooking is carried out on an open chulha.

Conclusion

It can be stated that use of wood fuel affects birth weight adversely, although, there is still probability of potential residual confounding, despite care being taken for known confounding factors. Cooking with wood fuel is a significant risk-factor for LBW which is modifiable.

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How to cite this article: Kadam YR, Mimansa A, Chavan PV, Gore AD. Effect of prenatal exposure to kitchen fuel on birth weight. Indian J Community Med 2013;38:212-6.

Source of Support: Nil, **Conflict of Interest:** None declared.