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International Journal of Current Research
Vol. 7, Issue, 04, pp.15249-15253, April, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EFFECT OF MATERNAL EXPOSURE TO KITCHEN FUEL ON BIRTH WEIGHT OF NEWBORN; A COMMUNITY BASED STUDY IN A RURAL BLOCK OF WEST BENGAL

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ARTICLE INFO

Article History:
Received 26th January, 2015
Received in revised form
06th February, 2015
Accepted 23rd March, 2015
Published online 30th April, 2015

Key words:

Wood smoke,
LPG,
Low birth weight,
Mean birth weight.

ABSTRACT

Background: Maternal exposure to wood fuel smoke may lead to impaired fetal growth due to hypoxia and oxidative stress from smoke constituents.
Objectives: Risk of low birth weight (LBW) and reduced mean birth weight in relation to use of high pollution fuel for cooking during the antenatal period, compared with low pollution fuel.
Methods: The study was done among women with singleton live birth. Duration of cooking and type of fuel used during the pregnancies periods were ascertained by a survey. Effect of common confounders leading to LBW was adjusted with appropriate statistical methods.
Results: Mean ± SD of birth weight (Kg) was 3.033±.25 in low-pollution fuel users, 2.688±.26 in medium-pollution and 2.668±.45 in high-pollution fuel users. Proportion of low birth weight among high-pollution fuel users was 78.3%, in medium-pollution fuel users it was 21.7% while there was no LBW among low-pollution fuel users. These differences were found to be significant. As duration of exposure to wood fuel increases there is significant decline in birth weight ($F = 9.28$, $P = 0.00$).
Conclusion: Cooking with wood fuel during pregnancy is modifiable risk factor associated with LBW as compared to use of LPG.

INTRODUCTION

Low birth weight (LBW), defined as birth weight < 2,500 g, is well established as an important risk factor for infant mortality and morbidity. Well over 90% of all LBW Babies are born in developing countries, where approximately 18% of newborns weigh less than 2,500 g (Boy *et al.*, 2002). LBW results from a wide range of factors both direct and contextual that determine premature birth, intrauterine growth retardation, or combinations of both of these outcomes (Martin *et al*, 1986).Any condition that interferes with trans placental delivery of nutrients and oxygen included, may cause varying degrees and types of intrauterine growth retardation (IUGR) (Smith *et al*, 1987). Incomplete combustion of any biomass which includes biofuels (wood, dung, and fiber residues) as well as fossil fuels such as coal and gas, which are used for cooking and heating purposes and combustion of tobacco produce carbon monoxide much more stable compound that does not readily give up O2 to peripheral tissues and organs, including the fetus (Dary *et al.*, 1981).

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Moreover in terms of emissions of suspended particulates and pollutant gases, the combustion of wood and other biomass is qualitatively similar to the burning of tobacco, although without the nicotine. The carbon monoxide produced by such combustion combined with hemoglobin after inhalation and forms carboxy-hemoglobin (CoHb). Studies have shown that exposure to biofuels is associated with COHb levels of 2.5–13% (Behera *et al*., 1988, WHO, 1997). So exposure to CO has been associated with fetal development and adverse pregnancy outcomes including reduced birth weight Astrup *et al.* (1972) Longo *et al.* (1977), Garvey *et al.* (1978). Women especially in rural areas 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. Around two-thirds of households in developing countries still rely on biofuels as their primary fuel (Chen *et al*., 1990). It is therefore not unreasonable to expect that the effect of passive smoking on birth weight would also apply to pregnant women habitually exposed to high levels of biofuel smoke, as is the case in developing countries (Bruce *et al.*, 2000). It is therefore essential to examine the association, if any between indoor smoke exposure and birth weight in developing countries. From this point of view we conduct this study to quantify the influence of biofuels use on birth weight.

Objective

1. To study the socio-economic and demographic characteristics of the study population.
2. To determine the effect of exposure to various kitchen fuels on birth weight.
3. To find out the association of birth weight with socio-demographic and other risk factors.

MATERIAL AND METHODS

Study Settings

The study was conducted in Nasibpur health center under Singur block which is the rural field practice area of All India Institute of Hygiene and Public Health, Kolkata.

Study subjects

Mothers having at least one under-five child were interviewed during the survey.

Inclusion criteria

Mothers those who had attended antenatal clinic from their first trimester and have paid minimum three visits, those who were non-anemic by the end of second trimester and taken at least 100 iron and folic acid tablets in their entire pregnancy period. BMI more than 18.5 during first trimester visit is considered as pre-pregnancy weight.

Exclusion criteria

Mothers having Pregnancy Induced hypertension (PIH) or any other illness such as diabetes, tuberculosis, malaria, Urinary Tract Infection (UTI), chronic illness and having addictions (i.e., smoking, tobacco chewing or "tobacco mishri" i.e., burnt tobacco application to brush teeth) were excluded from the study.

Sample size: 125
A study of (Kadam *et al.,* 2013) found that prevalence of low birth weight among wood user is 45% . Now considering this prevalence with 10% absolute error sample size was calculated to be 99 after applying the formula-
Sample size= 4pq/L2
(p=prevalence, q=1-p and L=absolute error).

Sampling design

All the mothers who had at least one under five child in the service area of Nasibpur urban health center were line listed and 125 households were selected by simple random sampling. Total number of mothers included in the study following the above criteria was 125. The birth weight of the children of the selected mothers were taken from the available health cards. If the mother had more than one child, youngest child were taken for study purpose. The survey also asked about the main cooking fuel and duration of cooking pre day – wood, dung, straw, charcoal, kerosene, electricity, and liquid petroleum gas (LPG)/natural gas, and a residual category of other fuels. Information on fuel types was used to group households into three categories representing the extent of exposure to cooking smoke-high pollution fuels (straw, wood or dung), medium pollution fuels (those use straw, wood or cow dung one time and gas another time), and low pollution fuels (LPG/natural gas or electricity).

Instrument and techniques

1. A predesigned and pretested schedule whose face and content validity was ensured by the experts of All India Institute of Hygiene and Public Health. All efforts were made to make the questionnaire simple, unambiguous and conformed to the objectives of the study. Since the study population was Bengali the questionnaire was prepared in the Bengali language only.
2. Weight of the mother and their children was taken from the health card and measuring tape was used to measure the height of each mother using standard operation procedure [13]. BMI was calculated as [weight in kg/ (Height in m.)2].

Study variables

For Objective No:-1
1) Socio-economic factors (Education, occupation and income).
2) Demographic factors (Age in birth certificate), gender, religion and type of the family nuclear/ joint).
For Objective No :-2
1) Type of fuel, duration, indoor or outdoor.
2) Anthropometric measurements.

Statistical analysis and plan

Data was analyzed using appropriate statistical methods by SPSS (version 20).

Definition of low birth weight

Low birth weight (LBW), defined as birth weight < 2,500 g.

Ethical Issues

A protocol was prepared and it was approved by the institution Ethics Committee. This research study was cross sectional and non-interventional in nature. Informed consent of the mothers under study was taken and they were also made aware about the nature and purpose of the research study. The mothers were also assured that all data would be kept confidential and would be used only for research and academic purpose. At the end of the data collection the mothers were given health education on the correct child feeding and rearing practices kitchen hygiene which would ensure good health of the child.

RESULTS

Table-I shows Total 125 mothers aged between 18 to 35 years participated in our study. Among the 125 mothers, 7(5.6%) were illiterate, 88(70.4%) were up to secondary, 22(17.6%) were up to higher secondary and 8(6.4%) were graduate or

Table-I: Effect of confounders on birth weight (n=125).

Co-variates	Number	Mean Birth WEIGHT±SD	Significance
SEX OF NEWBORN			
MALE	60	2.787±0.36	F-value=4.26
FEMALE	65	2.633±0.46	P = .041
AGE OF MOTHERS			
<19 YRS	*15*	2.750±0.49	
20-24 YRS	48	2.703±0.40	F-Value=.067
25-28 YRS	46	2.706±0.47	P= 0.97
≥29 YRS	16	2.684±0.24	
EDUCATION			
ILLITERATE			
PRIMARY &	07	2.700±0.30	
SECONDARY	88	2.684±0.44	F-Value=.468
HIGHER	22	2.746±0.39	P=0.70
SECONDARY	08	2.855±0.37	
GRADUATE			
OCCUPATION			
HOUSE WIFE	120	2.714±0.41	F-Value=.819
SERVICE	05	2.540±0.59	P=0.36
PARITY			
PRIMI PARA	81	2.721±0.42	
SECOND PARA	37	2.711±0.38	F-Value=.703
MULTIPARA	07	2.524±0.66	P=0.49

above. In occupation wise 120 (96%) were housewives and 5 (4%) were in service. Data was analyzed first to find out the effect of various co-factors known to affect birth weight adversely. Out of 125 children's 60 (48%) were males and 65 (52%) were females. Males were heavier than females; the observed difference was 154 grams and it was significance statistically. To examine the effect of maternal age on birth weight of the baby, mean birth weight of the baby of difference age group was compared by using ANOVA. The highest mean birth weight of the baby(2750g) were found among those mothers whose age was <19 years and lowest mean birth weight of the baby(2684g) was found among those mothers whose age was ≥29 years. However this difference was not significance. Mean birth of weight of the baby of graduate or above mothers is higher (2855g) and lower (2684g) in primary and secondary education mother. Mean birth weight of illiterate mothers was higher than mean birth weight of primary and secondary education mothers and lower than higher secondary and graduate or above education mothers. However the observed difference was not significance. By occupation, mean birth weight of the baby of housewives mothers was higher than the service mothers.

Table II. Distribution of newborn according to birth weight of children and maternal exposure to type of fuel(n=125).

BIRTH WEIGHT	TYPE OF FUEL USE: HIGH POLLUTION FUEL*	MEDIUM POLLUTION FUEL**	LOW POLLUTION FUEL***	TOTAL (%)	SIGNIFICANCE
LBW	36(78.3)	10(27.7)	00(00)	46(100)	
NORMAL WEIGHT	54(68.4)	13(16.5)	12(15.2)	79(100)	Chi squire=7.825 df=2 *P*=0.020
Total	90(72)	23(18.4)	12(9.6)	125(100)	

*Straw, wood and cow dung ** straw, wood, cow dung and gas *** gas and electricity #No one use charcoal or kerosene

Table III. Effect of type of fuel and duration of cooking on birth –weight (n=125).

STUDY FACTOR		NUMBER	MEAN BIRTH WEIGHT±SD	SIGNIFICANCE
TYPE OF FUEL	HIGH POLLUTION FUEL*	90	2.668 ± 0.45	
	MEDIUM POLLUTION FUEL**	23	2.688 ± 0.26	F-Value= 4.19 P= 0.017
	LOW POLLUTION FUEL***	12	3.033 ± 0.25	
	TOTAL	125	2.707 ± 0.42	
DURATION OF COOKING (H#)				
	<2	2	3.000 ± 0.28	
	2-4	29	2.920 ±0.35	F-Value= 9.28 P= 0.00
	4-6	60	2.749 ± 0.43	
	>6	34	2.434 ± 0.33	
	TOTAL	125	2.707 ± 0.42	

*Straw, wood and cow dung ** straw, wood, cow dung and gas *** gas and electricity # H=Hours

The difference of mean birth weight was 174g. However, this difference was not significance. Depending on the parity, mean birth weight of the baby of primipara (2721g) was higher than the multi para (2524g). However, this finding was not significance. Table-II shows out of 125 fuel users, 90(72%) mothers used straw, wood and cow dung for all time cooking(high pollution fuel), 23 (18.4%) mothers used one time straw, wood, cow dung and others time gas(medium pollution fuel) and 12 (9.6%) mothers uses gas and electricity(low pollution fuel) all time for their cooking. 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 in mothers using high pollution fuel for cooking was78.3% and 21.7% LBW newborn was in mothers who were used medium pollution fuel. There is no LBW in mothers who uses low pollution fuel for their cooking. The observed difference is significant (Chi square = 7.825, $P < 0.020$). Table-III to assess further the effect of kitchen fuel on birth weight, mean birth weight of newborns exposed to various kitchen fuels was compared. The highest mean birth weight was low pollution fuel users (3.033± 0.25) and lowest in high pollution fuel users (2.668 ± 0.45) followed by medium pollution fuel users (2.688 ± 0.26). On an average, newborns of mothers using only high pollution fuel was lighter by 365 g and medium pollution fuel users by 345 g than newborns of low pollution fuel users. Observed difference was significant (F-Value= 4.19 P= 0.017). Exact duration of cooking was reported by all mothers. With increasing duration of exposure there was decline in mean birth weight. Newborns of mothers with more than 6 hours exposure to smoke were lighter by 566 g and 4-6 hours exposure were 251 g and 2-4 hours exposure were 80 g than newborns of mothers with ≤2 hours exposure. The observed difference was statistically significant ($F = 9.28$, $P = 0.00$).

DISCUSSION

Birth weight is affected by various factors. The results from our analysis suggest that the use of biomass cooking fuels is associated with child's birth weight. The children of the mother who use high pollution fuels had significantly lower birth weight than those children born in mothers using low pollution fuels. For that purpose, care of known co-factors 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. 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, gender of the child has significantly associated with birth weight and male children were heavier than the female, which was similarly supported to the study of M.S. Kramer *et al* (1986). In our study it is stated that birth weight is decreasing with increasing maternal age but Martin *et al.* (1987) stated that the birth weight was increase with increasing maternal age. Parity is another factor that affects birth weight. The average birth weight tends to increase with parity, which is described by A. Bardhan *et al.* (1966). In this study, birth weight decrease with increasing parity. Here 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. Which is supported the study of Vega *et al.* (1993). In this study, frequency of LBW was significantly and gradually high in medium-pollution fuel and high-pollution fuel, that is10 (21.7%) and 36 (78.3%) respectively. On the other hand Eric Boy *et al.* (2002) in their study birth weight of the baby of mothers exposed to medium pollution fuel and high pollution fuel was 16.8% and 19.9% and *Kadam YR et al* (2013) in their study it was found 40.74% and 44.68% respectively. Mothers using medium-pollution fuel had frequency of LBW higher than low-pollution fuel users but less than high-pollution fuel user. This means even partial exposure to wood fuel smoke affects birth weight adversely and the observed difference is significant. In this study it is stated that increasing duration of exposure to wood fuel adversely affected the birth weight of the baby. In this study increasing duration of cooking from less than 2 hours to more than 6 hours, birth weight is decrease 566 g and this finding significantly supported other study of Kadam YR.*et al* (2013).

Conclusion and recommendation

It has been stated that cooking with wood fuel adversely affected birth weight of baby. Some preventive measure and awareness should be implemented like- Conducting public campaigns and social marketing initiatives to inform mothers and family members about knowledge and adverse effects of smoke in cooking environment during pregnancy. Preventive measures should be designed to minimize or remove this exposure like use of chimney and proper ventilation system in the kitchen. People must be encouraged to use alternative fuels for cooking like LPG or electricity during pregnancy. This would dramatically reduce the occurrence of LBW and its impact on children.

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