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HEALTH RISK ASSESSMENT IN RURAL WOMEN ON EXPOSURE TO DOMESTIC INDOOR AIR POLLUTION BY COMBUSTION OF BIOMASS FUELS

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Abstract
Biomass fuels, derived from plants and animals, are intentionally burned by humans for various purposes, including cooking. However, the combustion of biomass fuels, such as wood, animal dung, and crop residues, often occurs in open fires, resulting in high indoor and outdoor air pollution. This poses significant health risks, particularly for women and young children. In this study conducted in villages around Meerut city in Western Uttar Pradesh, India, the focus was on rural integrated women's health, specifically those using biomass fuel for cooking.
The research included three age groups of women exposed to biomass fuel and a control group using cleaner alternatives like LPG and biogas. Hematological parameters, including hemoglobin, red blood cell count, total leukocyte count, and platelet count, were analyzed to assess the impact of biomass fuel exposure on health. The study involved 180 women from 15 villages, and blood samples were collected to evaluate immunological, hematological, and biochemical parameters.
Results indicated that women exposed to biomass fuel exhibited significant alterations in hematological parameters, including lower hemoglobin levels, reduced red blood cell counts, and changes in platelet counts. These findings suggest a potential association between biomass fuel exposure and health issues such as tuberculosis infection, decreased immunity, respiratory disorders, cataracts, liver dysfunction, kidney disorders, and anemia.
The study emphasizes the detrimental effects of indoor air pollution from biomass fuel smoke on the health of rural women. The observed alterations in hematological parameters highlight the urgent need for interventions to reduce biomass fuel usage and mitigate health risks in these communities. This research contributes valuable insights into the complex relationship between indoor air pollution and its adverse health effects, particularly among women in rural settings.

Introduction

Biomass fuels are those materials, which are obtained from plants and animals, which are intentionally burnt by human being. For example, wood, animal dung and crop residues are also example of biomass fuel. These biomass fuels are usually burnt as open fire which results high indoor and outdoor air pollution and harmful for women and young children. Indoor air pollution is a major public health problem in developing countries. Present study refers to rural integrated women health in villages. Coal is abundantly used for domestic purpose in countries like China and South Africa. About three billion people worldwide use biomass fuel (e.g. wood, agricultural residues, dung) for cooking and household energy. The common biomass fuels for cooking and heating are dry dung cake, wood, and crop residues such as jute sticks, paddy husk, dried leaves of plants, coconut, palm, sugarcane and dry cotton plants, kerosene and coal. These biomass fuels are usually burnt as open fire which results high indoor and outdoor air pollution and harmful for women and young children.

Methods:

This study has been conducted in different villages around Meerut city of Western Uttar Pradesh. The study included rural women which used biomass fuel forcooking every day taken as exposed women. These rural women used wood, crop residues and cattle dung cake to cook food. Some rural women used LPG and biogas for cooking taken as control. This investigationincludedrural women of 15 to 65 years age and divided into three groups.The groups are as follows:

Group A:

i. Control
ii. Women exposed to biomass fuel of 15 to 35 years age.

Group B:

i. Control
ii. Women exposed to biomass fuel of 36 to 50 years age.

Group C:

i. Control
ii. Women exposed to biomass fuel of 51 to 65 years age

Each group contained60 women, 10as control LPG gas users and 50 biomass fuel users. This study is based on comprehensive survey on health and environmental conditions by systematic epidemiological study, conducted in rural areas of districtMeerut.Present study included 180 women from 15 villages, about 10 to 15 rural women from each village.

Hematological parameters: Haemoglobin, RBCs, WBCs(TLC), preparation,hematological, biochemical and immunological studies followed as:

BLOOD SAMPLE COLLECTION AND SERUM PREPARATION:

Blood samples were collected from smoke exposed and control rural women for the study of variation inimmunological, haematological and biochemical parameters. Samples were collected according to the experimental design. Approximately 6 ml blood was taken as per requirement by veinpuncture with minimum manipulation and stresses to avoid haemolysis. Approximately 3.5 ml blood was collected in a plain vial for serum preparation for biochemical/immunological studies and rest in EDTA vial for haematological studies. The samples were collected with the help of technician by using disposable syringe. The blood in plain vial was allowed to clot at 37°C for half an hour and then centrifuged to get the serum. The separated serum was used for the
biochemical and immunological analysis. Haematological studies and enzymesassays were performed on fresh sample.

HAEMATOLOGICAL METHODS:

1. **Haemoglobin by cyanmethaemoglobin method (Dacie and Lewis, 1968):*Principle:*** In alkaline medium haemoglobin and its derivatives are oxidized in presence of potassium ferricyanide and get converted to methaemoglobin which then reacts with potassium cyanide to form purple red colouredcyanmethaemoglobin complex the intensity of which is measured at 546 nm or green filter.
2. **Total RBC Count by haemocytometer (Henry *et al.* 1989):**0.02 ml bloodhas been drawn in the pipette from the EDTA sample vial and blood has been delivered to clean glass vial. 4 ml RBC diluted fluid has been taken and pumped into the vial with 0.02ml blood. The diluted fluid and blood have been mixed thoroughly by covering the mouth ofglass vial with thumb. A drop of diluted bloodhas

been put in the Neubauer's Chamber very carefully. To count the RBC a cover slip has been kept over the Neubauer's RBC counting chamber. The counting chamber has been placed undera light microscope to count the RBC. The counting has been done in 80 small squares of Neubauer's RBC counting chamber. This method has been modified slightly in comparison to the previous documented method.A fresh clean glass vial has been used for mixing the blood thoroughly andaccurately in place of RBC tube to mix and dilute blood. Calculations of RBC has been done by following formula after counting the number of red blood cells per cubic millimeter.

$$\text{No. of RBC per mm}^3 = \frac{\text{No. of RBC counted x Dilution}}{\text{No. of small squares counted}} \text{ x } 4000$$

The length of each small square has been 1/20 mm and it had an area of 1/20x 1/20 or 1/400 square millimeters. The depth of the counting chamber has been 1/10 mm, hence the actual volume of the diluted blood in a small square has been 1/400 x 1/10 or 1/4000 cubic millimeter when the dilution has been 1:200.

$$\text{No. of RBC per mm}^3 = \frac{\text{No. of RBC counted x 200}}{\text{No. of small squares counted}} \text{ x } 4000$$

No. of RBC in per mm^3 = Number of RBC counted in 80 small square x4000

3. Total Leucocyte Count (TLC) by haemocytometer (Henry *et al.* 1989):

0.02 ml blood has been drawn into the pipette from the EDTA sample vial and blood has been delivered into clean glass vial. 0.38 ml WBC diluting fluid hasbeen taken and pumped into the vial having 0.02 ml of blood. The diluted fluid and
blood have been completely mixingby covering themouth of glass vial with thumb.A drop of diluted blood has beenplaced in the Neubauer's chamber. The filling has been done very conscientiously. A cover slip has been placedcovering the Neubauer's WBC counting chamber has been placed under a light microscope and counting chamber. Each of these 4 WBC counting chamber having 16 small squarehad sides of 1 mm i.e. has an area =1x1 = 1 square mm. The depth of the counting chamber has been 1/10 mm. Therefore, the actual volume of the diluted blood in each of the 4 WBC square was 1 cubic mm. Calculation of WBC were analyzed bycoming formula after counting the number of WBC in four WBC counting chambers.

$$\text{TLC per mm}^3 = \frac{\text{WBC counted x Dilution x Depth factor}}{\text{Area of 1 WBC Chamber x4}}$$

$$\text{TLC per mm}^3 = \frac{\text{WBC counted x 20 x10}}{4}$$

$$\text{TLC per mm}^3 = \text{WBC counted x 50}$$

4. Platelets Count by haemocytometer, Henry (1989):

A clean glass vial has been taken 0.02 ml blood has beendrawnin the pipette from the glass vial and blood

has been pumped into the clean glass vial. 1.98ml plateletsdiluted fluid has been taken with pipette and pumped into the clean glass tube
having 0.02ml of blood. The diluting fluid has been completely blended by covering out of glass tube with the thumb. A drop of diluted blood has been put in the Neubaur's chamber. The filling has been done very consciously. A coverslip has beenplaced over the Neubaur's chamber and allow for 30 minutes for the cells to settle. The counting chamber has been kept under a light microscope andcounting was done in the central square of the chamber (1x1mm). Calculation of platelets was done after counting of cells in central chamber per cubic millimeter (/mm^3) by coming formula:

$$\text{Platelets per mm}^3 = \frac{\text{Platelets counted x 100}}{0.1} \frac{\text{Platelets counted x Dilution}}{\text{Volume counted}}$$

$$\text{Platelets per mm}^3 = \text{Platelets counted in central square x1000}$$

HAEMATOLOGICALPARAMETERS:

Hematological observations were made in all the three groups of control andbiomass fuel smoke exposed women.

Group A: 15-35 years age women

Hemoglobin (Hb): The average value of hemoglobin of control women wasobserved to be 14.20 gm/dl. The average value of Hb level was observed tobe
13.50 gm/dl in the biomass fuel using women. It was lower than the value of
control women. However, it was not significantly decrease as control.

Red blood cells (RBC) count: The mean value of RBC count of controlwomen was observed to be 6.5million/mm3 blood. The mean value of RBC countin exposed women of this group was found to be 5.4 million/mm3 blood. It wasfound lower than the control group women. No significant alteration was observed.

Total leucocyte count (TLC): The mean value of TLC of control women was observed to be 7000/mm3 blood. The mean value of TLC in exposed women of this group was observed slightly increased as 7400/mm3 blood. It was found higher than the control group women. No significant alteration was observed.

Platelets counts (PC): The mean value of platelets count of control women was observed to be 2.75 Lac/mm3. The mean value of platelets count was observedin exposed women of this group was observed decreased as 2.2lac/mm3 blood. It was lower than the control women.

Group B: 36-50 years age women

Haemoglobin (Hb): The average value of Haemoglobin of control womenwas observed to be 13.20 gm/dl. The average value of Hb level was observed to be
12.40 gm/dl in the biomass fuel using women. It was lower than the value ofcontrol women. However, it was not significantly decrease as control.

Red blood cells (RBC) count: The mean value of RBC count of controlwomen was observed to be 5.0 million/mm3 blood. The mean value of RBC count
in exposed women of this group was observed to be 4.5 million/mm3 blood. It was lower than the control group women. No significant alteration was observed.

Total leucocyte count (TLC): The mean vale of TLC of control women was observed to be 7200/mm3 blood. The mean value of TLC in exposed women of this group was observed slightly increased

as 7500/mm3 blood. It was higher than the control group women. No significant alteration was observed.

Platelets counts (PC): The mean value of platelets count of control women was observed to be 2.40 Lac/ mm3. The mean value of platelets count was observed in exposed women of this group was observed decreased as 1.90 lac/mm3blood. It was lower than the control women.

Group C: 51-65 years age women

Haemoglobin (Hb): The mean value of Hb of control group women was observed to be 12.80 gm/dl. The mean value of Hb of biomass fuel smoke exposed women of this group was observed to be 11.40 gm/dl. It was lower than the controlgroup women. The statistical analysis revealed the significant ($p<0.05$) decrease of Hb level in comparison to control group women.

Red blood cells (RBC) count: The average value of RBC count of control group women has been noticed to be 4.4 million/mm3 and the average value of RBC count of exposed women found to be 3.2 million/mm3. It was lower than the control group. The statistical analysis revealed the significant ($p<0.05$) decrease of RBC level in the above group.

Total leucocyte count (TLC): The mean value of TLC was observed to be 7400/ mm3. The mean value of TLC level of exposed women found to be 8000/mm3. The value was higher than the control. Statistically no significant alteration was observed.

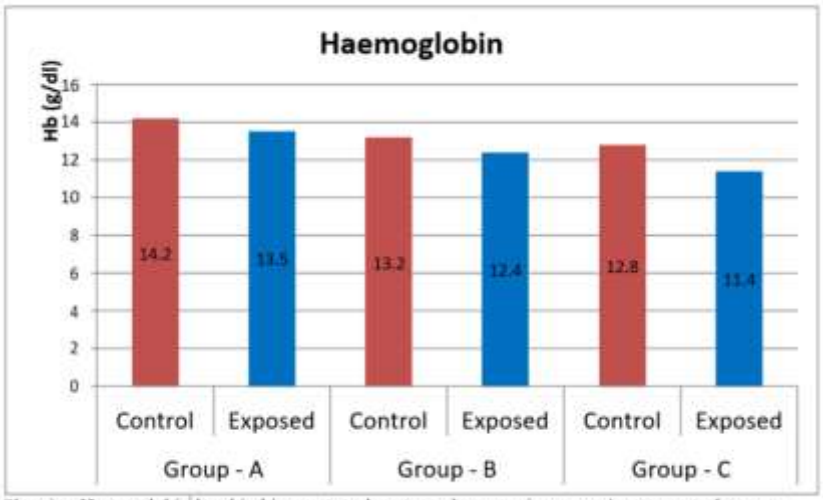
Platelets counts (PC): The mean value of platelets count of control women was observed to be 2.0 Lac/mm3. The mean value of platelets count of exposed women found to be 1.90 Lac/mm3. It was approximately similar to the control group. No significant alteration was observed.

Table 1. Showing alterations in Haematological parameters in biomass fuel exposed rural women and compared with control women.

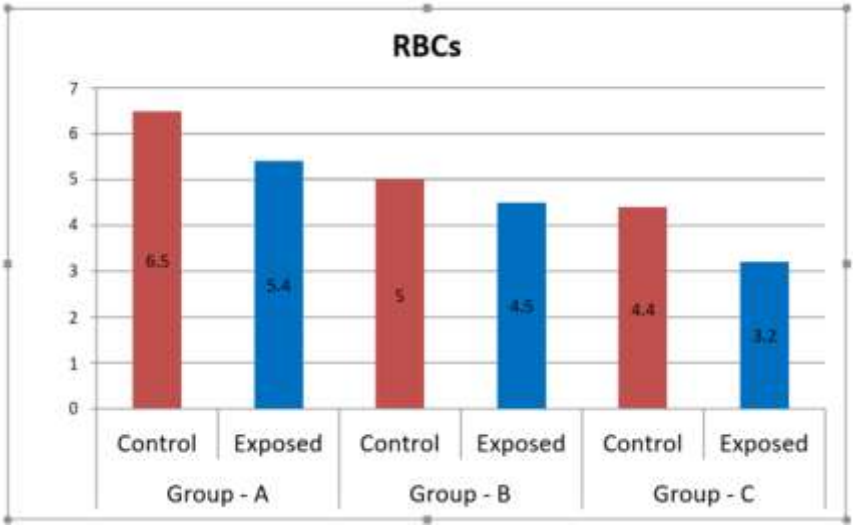
Parameters	Group A (15-35 years)		Group B (36-50 years)		Group C (51-65 years)	
	Control	Exposed	Control	Exposed	Control	Exposed
Haemoglobin (gm/dl)	14.20± 1.215	13.50 ±1.325	13.20 ±0.339	12.40 ±2.362*	12.80± 1.563	11.40± 1.328*
RBC (million/mm^3)	6.5 ±0.135	5.4± 1.159*	5.0 ±0.47	4.5 ±1.856	4.4 ±1.235	3.20 ±1.633*
TLC (/ mm^3)	7000 ±17.658	7400 ±12. 116	7200 ±23.571	7500 ±13.228*	7400 ±30. 105	8000 ±18.656
Platelets counts (Lac/ mm^3)	2.75 ± 0.366	2.2 ±0.169*	2.40 ±0.072	1.90 ±0.058	2.00 ±0.087	1.90±0. 013*

Results are expressed as mean, ± S.E.

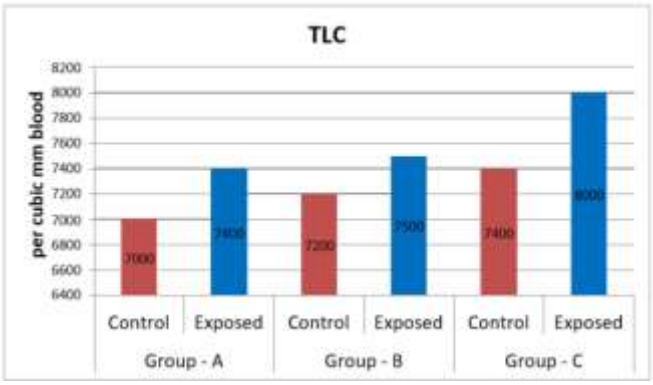
* values are significantly different from control ($p < 0.05$)

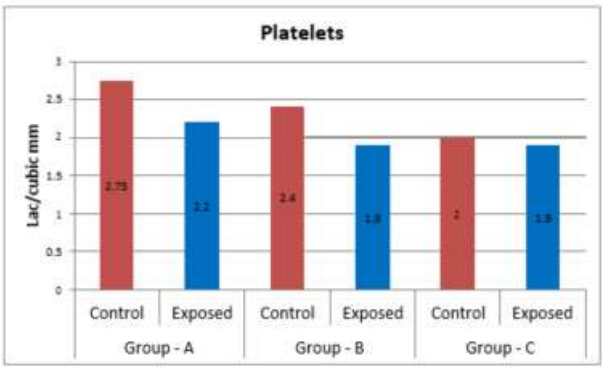


Showing Haemoglobin level in biomass smoke exposed women in comparison tocontrol women.



Showing Total RBC count in smoke exposed women in comparison to controlwomen.





Result and discussion

Indoor air pollution is a major public health problem in developing countries. Present study refers to rural integrated women health in villages. Theaim of this study was to find out association with pollution and health and between social factors viz. age, sex, rural area and income etc. Indoor air pollution from biomass fuels have been implicated as for tuberculosis infection, anemia, cataract, cancer and other diseases and death. Persistent indoor air pollution exposures in these regions cause tuberculosis as a major health risk. We under took a systematicstudy to assess the association between these exposures and the risk of infection, disease and death.

The findings of present investigation showed that biomass fuel smoke is associated with an increased risk of tuberculosis infection, decrease immunity of the body, cough disease, cataract, liver dis-function, kidney disorder and anemia. In the present study we found much more alterations in haematological parameters in rural women which use biomass fuel for cooking and other domestic works in comparison to LPG using women (control) for cooking.

Haemoglobin, total RBC, Platelets count and packed cell volume values decrease significantly in exposed women resulting, hypoxic secondary polycythaemia i.e. mild secondary types associated with erythrocytosis which is a compensatory mechanism in this case as seen in poor oxygenation and pulmonary arteriosclerosis. Present manuscript is an evaluation of the harmful impact of smoke on the health of rural women; it's about indoor air pollution and the harmful effect of smoke exposure which generate from cooking. In the present work the toxic effect of smoke on the health of rural women around Meerut is highlighted. This investigation has shown that certain haematological, biochemical and immunological parameters presented high exposure to biomass fuel smoke particularly during the august 2016 to august 2019 and 180 women, who were in extensive use. During this period, the mal effects of smoke levels in the affected women were probably observed accompanied by extensive lung disease and by respiratory tract disorder. According to Fullerton & Gordon et al. (2008) the respirable dust levels were high in Malawian homes which use biomass fuels. Findings are also suggestive of that indoor air pollution from biomass fuel smoke in Africa is a significant cause of mortality and morbidity both in children and adults.In the villages, it is possible to cure 80% women who are suffering with chronic bronchitis i.e. inflammation of the lining of bronchial tube and emphysema (over inflammation of the air sac in the lung) and chronic pulmonary disease and because of partially reversible and increasing air flow obstacles. This disease takes birth in places where use of biomass smoke is common. The spectrums of this disease have been reported in those women, which were extensively depended on biomass fuel for cooking. Adult women over 40 year age had a high occurrence of respiratory symptoms. A major problem of asthma was found in the women of 36- 51 years of age. The complex effect of indoor pollution was the developing of asthma. Biomass smoke is the cause of sensitizing susceptible allergies in people in early age. According to Bjarksten (1999) asthma and throat allergy also occurs in children due to indoor pollution. These studies revealed mixed findings and found asthma in children and adult women in relation to biomass smoke. In our survey women of age 15 to 65 of different villages Rithani, Putha,Kunda, Mohkampur, Arnawali, Dugrawali, Dabathua, Lakhvaya, Murlipur Gula,Rori, Narangpur, Kaithwadi etc. diagnosed by spirometryexplore that biomass fuel users have more cough and respiratory problems in comparison to LPG using women. Several studies however have reported in favour of above observations. In our study, women were selected so as to include those working in kitchen. The health effects can be seen in developing countries due to indoor pollutionshown by research of Smith, K.R. (1987) and Chen, B.H. et al. (1990) and provides further evidence of association with a range of serious and common health problems. Few studies measuring indoor air pollution or biomass subjection present the possibility of significant manifestation of exposure and imply

that very little information is available to measure, the co-relation between risk and exposure level. values decrease significantly in exposed women resulting, hypoxic secondary polycythaemia i.e. mild secondary types associated with erythrocytosis which is a compensatory mechanism in this case as seen in poor oxygenation and pulmonary arteriosclerosis. The total leucocyte counts increase slightly in biomass user women. The increase in TLC count is due to acute and chronic infection of lungs and kidneys which cause pulmonary mechanism and leads to increase of white blood cells. The red cell indices MCV and MCHC increase and decrease significantly in biomass user women. A variation in these values of red cell indices is directly co-related with decrease and increase in total RBC, haemoglobin concentration and PCV values causing secondary hypoxic polycythaemia in women. Significant elevations are found in the neutrophils, eosinophils and monocytes in biomass fuel using women. A large survey on this problem would strengthen our observations and provide good basis for devising a population awareness campaign. Our study focused with the view of health of rural women as they primarily have responsibility for cooking within the household.

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