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Carboxyhaemoglobin in women exposed to different cooking fuels

D Behera, S Dash, S P Yadav

Abstract

Blood carboxyhaemoglobin levels were estimated by double wavelength spectrophotometry in non-smoking women living in Chandigarh and its environs and related to the cooking fuel they used. Twenty nine used kerosene, 28 biomass fuel, and 30 liquified petroleum gas; the 27 control subjects had not done any cooking for seven days. The carboxyhaemoglobin concentrations were significantly higher in the women using the three types of fuel (mean (SEM) concentration 7·52% (0·67%) for kerosene, 15·74% (0·83%) for biomass fuel, and 17·16% (0·62%) for liquified petroleum gas, compared with 3·52% (0·33%) in the control subjects. It is concluded that cooking with any of the three fuels causes indoor air pollution. It is important to have better designed houses with adequate ventilation and stove vents that are cleaned regularly if pollution is to be reduced.

Smoke emission from domestic fuels is a major source of indoor air pollution, especially in the rural communities of developing countries. The emissions contain pollutants that adversely affect health.[1–3]

Common fuels used for cooking and other domestic purposes in India include biomass fuel (cowdung cake and other manures, agricultural wastes, firewood, etc), kerosene oil, liquified petroleum gas, and coal lighted Angithi. The biomass fuel is used on *chullas* made of earth and built inside the kitchen. The biomatter (cowdung and other manures) is dried in the sun and stored before use. Kerosene oil is used in pressure and wick stoves. Liquified petroleum gas is stored in cylinders and connected to a metal stove with burners. These cooking devices are in widespread use throughout India, where they produce significant morbidity and mortality,[4 5] as reported from other countries.[6–10] The pollutants include several known carcinogens, such as benzpyrene, and toxic substances such as carbon monoxide, sulphur dioxide, nitrogen dioxide, formaldehyde, asbestos fibres, microorganisms, and aeroallergens.[11–14] In an earlier study we found high blood carboxyhaemoglobin concentrations after acute exposure to smoke from biomass fuel.[15] The present study extends these observations, documenting the extent of indoor air pollution produced with various fuels, commonly used for cooking in India, including kerosene, liquified petroleum gas, and biomass fuel.

Department of Pulmonary Medicine
D Behera
S P Yadav

Department of Haematology
S Dash

Postgraduate Institute of Medical Education and Research, Chandigarh-160012, India

Reprint requests to:
Dr Behera

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Methods

The study was carried out on women exposed to different cooking fuels residing in Chandigarh and adjoining areas. Women using gas for cooking mostly belonged to the middle socioeconomic class and those using kerosene and biomass fuel belonged to the lower socioeconomic class. Women who smoked and those with any kind of respiratory disease were excluded from the study. Subjects were selected at random and after giving informed consent were asked for a detailed cooking history. The type of fuel used, average duration of cooking, and number of years of cooking were noted. The control group was selected from hospital attendants who had done no cooking for seven days. An exposure index (EI) was calculated by multiplying the number of years of cooking and the average hours of cooking per day. A single spot heparinised sample of venous blood was drawn within two hours of exposure and put into an airtight plastic phial for estimation of blood carboxyhaemoglobin concentration. The sample was also used to estimate packed cell volume.

ANALYTICAL PROCEDURE FOR ESTIMATION OF CARBOXYHAEMOGLOBIN

Blood carboxyhaemoglobin concentrations were measured by double wavelength spectrophotometry of absorbance difference.[16] The sensitivity and reproducibility of the method in our laboratory has been described.[15] Carbon monoxide was freshly prepared from formic acid and sulphuric acid for each estimation. To determine the wavelength pair, fresh blood was diluted with $Na_2S_2O_4$ as described.[15] The absorbance was read by spectrophotometer (Spectronic 106 Ambala Sarabhai Enterprises Ltd, Ahmedabad, India) every 5 nm from 500 nm up to 600 nm so that two wavelengths, on the extremes of the wavelength range, could be found at which the sample had minimum absorbance difference. For this study the two wavelengths were 530 and 585 nm.

LINEARITY AND REPRODUCIBILITY OF THE METHOD

Ten serially diluted samples of 0–100% carboxyhaemoglobin were measured and showed good linearity up to 90% carboxyhaemoglobin. Reproducibility for six measurements at every dilution had a coefficient of variation of less than 1% at 20–100% carboxyhaemoglobin and of 2–8% at 10% and below.

The normal control range for carboxy-

Table 1 Mean (SEM) age, time interval between exposure and sampling (TI), carboxyhaemoglobin (CoHb), exposure index (EI), and packed cell volume (PCV) in the subjects studied

Fuel	No of subjects	Age (y)	TI (min)	CoHb (%)	EI	PCV (%)
None (controls)	27	27·66 (1·31)	—	3·52 (0·33)	—	39·44 (0·77)
Kerosene	29	29·83 (1·39)	42·41 (7·31)	7·49 (0·67)	33·51 (3·82)	38·83 (0·64)
Biomass	28	26·25 (0·83)	49·82 (7·84)	15·74 (0·83)	36·21 (3·38)	38·11 (0·86)
Liquified petroleum gas	30	32·93 (1·69)	51·33 (7·82)	17·16 (0·62)	37·93 (4·52)	42·77 (0·76)
Analysis of variance:	F	4·667	0·39	102·494	1·147	7·55
	p	0·0041	0·6782	0·00001	0·3352	0·0001

haemoglobin was 0–5%. The mean value for the control subjects (10 samples) at the same time was 3·29% (SD 0·27%).

Analysis of variance was used to compare the values of carboxyhaemoglobin between the groups and Student's *t* test and the correlation coefficient as required. The data were analysed by means of a Statgraphics V 3·0 on a IBM PC XT computer.

Results

Of the 114 women studied, 29 had been exposed to kerosene, 28 to biomass fuel, and 30 to liquified petroleum gas, and 27 had done no cooking in the last seven days. The mean age, exposure index, carboxyhaemoglobin concentrations, and timing of blood sampling are shown in table 1. The mean age of the subjects was greater in the liquified petroleum gas users. The exposure index did not differ significantly between the three groups of fuel users, nor did the time interval between the last exposure and blood sampling (p = 0·67). The subjects exposed to the three different fuels had significantly higher carboxyhaemoglobin levels than the control subjects (p < 0·001). Liquified petroleum gas users had the highest values, followed by biomass and kerosene users. Packed cell volume was also higher in the liquified petroleum gas users, and lower in the other two groups of fuel users, than in the controls. There was a positive correlation between carboxyhaemoglobin concentration and packed cell volume in the three groups of fuel users but not in the control group (table 2). The carboxyhaemoglobin concentration and the time interval between the last exposure and blood sampling showed a negative correlation in all three groups, though this was significant only for the women using biomass fuel and liquified petroleum gas. Exposure index was not correlated with packed cell volume. Carboxyhaemoglobin was lower in women whose sample was taken 60 minutes or more after the last exposure. Although carboxyhaemoglobin tended to rise with exposure index in all three fuel groups, the trend was significant only in those using liquified petroleum gas (mean (SD) concentration 14·00% (5·29%) for exposure index 20–39 and 18·7% (2·985%) for 40 and over; p = 0·033).

Discussion

The blood carboxyhaemoglobin concentrations in non-smoking healthy subjects exposed to three different types of cooking fuel were two to five times higher than those in a non-smoking healthy control population; the difference was significant. The carboxyhaemoglobin values are similar to those observed in chronic bidi and cigarette smokers (unpublished data). The relatively high mean carboxyhaemoglobin concentration among healthy controls of 3·52% was possibly because of exposure to environmental smoke and pollution. Additionally, in the method used for carboxyhaemoglobin estimation the coefficient of variation was nearly 6·8% for carboxyhaemoglobin concentrations of 5·0% and below.

Biomass fuels are used largely in the developing countries and predominantly in the rural areas. They are composed of complex organic matter, vegetable proteins, and carbohydrates incorporating carbon, nitrogen, oxygen, hydrogen, and certain other elements in trace amounts. Chronic bronchitis and cor pulmonale are reported to be associated with the use of this fuel in non-smoking rural women in India and Nepal.[4-6] The high concentrations of carboxyhaemoglobin in biomass fuel users conform with our findings in a preliminary study.[15] Dary *et al*[17] in a study from rural Guatemala found raised blood carboxyhaemoglobin concentrations in women working in poorly ventilated kitchens with toxic concentrations of

Table 2 Correlation of different measurements

Fuel	No of subjects	CoHb v EI	CoHb v PCV	CoHb v TI	EI v PCV
None (controls): r	27	—	0·10	—	—
p			0·34		
Kerosene: r	29	0·12	0·403	−0·165	0·1099
p		0·52	0·03	0·39	0·57
Biomass: r	28	0·07	0·457	−0·528	−0·133
p		0·71	0·014	0·0039	0·50
Liquified petroleum gas: p	30	0·389	0·5089	−0·46	−0·05
p		0·033	0·004	0·0105	0·75

CoHb—carboxyhaemoglobin; EI—exposure index; PCV—packed cell volume; TI—time interval between last exposure and blood sampling.

environmental carbon monoxide (30–50 ppm).

In the case of low pressure petroleum gas stoves carboxyhaemoglobin concentrations were surprisingly high. The emission from this type of stove contains a small amount of carbon monoxide. This is normally converted rapidly into carbon dioxide, but if the burner of the gas chullah is not cleaned properly and the holes are blocked the emission of carbon monoxide will be high.

Melia *et al*[8,18] have reported a higher prevalence of respiratory symptoms and disease in children from homes where gas was used for cooking, which they thought was due to pollution of the indoor atmosphere by the products of gas combustion associated with gas cooking. Similarly, Comstock *et al*[19] and Ware *et al*[20] noted that gas cooking was related to an increased frequency of respiratory symptoms and impaired ventilatory function.

This study was concerned with acute effects and it has shown that cooking with three different cooking fuels produces unacceptable indoor air pollution as indicated indirectly by blood carboxyhaemoglobin concentrations. The encouragement of proper cleaning of stove vents and the provision of adequate ventilation in kitchens could prevent some respiratory illness in developing countries.

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