Ocular morbidity and fuel use: an experience from India
A Saha, P K Kulkarni, A Shah, M Patel, H N Saiyed

The association of fuel use and ocular morbidity in a village in western India was investigated in a cross sectional prevalence survey involving 469 randomly selected subjects. All subjects were interviewed and underwent medical and ophthalmological examination. Wood use was found to be an important factor in the aetiology of age dependent cataract (OR 2.12, 95% CI 1.03–4.34). When comparing wood only and LPG only users, the odds ratio was 3.47 (95% CI 1.05–11.50). In cases of eye irritation, coal use (OR 2.04, 95% CI 1.13–3.68) and cattle dung use (OR 1.83, 95% CI 1.35–2.47) were shown to be important factors, while male sex posed a lesser risk.

Exposure to indoor air pollution from the combustion of traditional biomass fuels (wood, charcoal, animal dung, and crop wastes) and coal is a significant public health hazard, predominantly affecting poor rural and urban communities in developing countries. Large numbers of people are exposed on a daily basis to harmful emissions and other health risks from biomass and coal burning. It is estimated that globally 2.5–3 billion people rely on these fuels for everyday household energy needs. The majority of those exposed are women, who are normally responsible for food preparation and cooking, and infants/young children who are usually with their mothers near the cooking area. Although the fraction of global energy from biofuels has fallen from 50% in 1900 to around 13% currently, this trend has levelled off and there is evidence that biofuel use is increasing among the poor in some parts of the world.1

There is consistent evidence that exposure to biomass smoke increases the risk of a range of common and serious diseases of both children and adults. Chief among these are acute lower respiratory infections in childhood, particularly pneumonia.3 Association of exposure with chronic bronchitis (assessed by symptoms) and chronic obstructive pulmonary disease (progressive and incompletely reversible airways obstruction; assessed by spirometry and clinical assessment) is also quite well established, particularly among women.4 In addition there is evidence (mainly from China) that exposure to coal smoke in the home markedly increases the risk of lung cancer, particularly in women.5 In recent years, new evidence has emerged which suggests that indoor air pollution in developing countries may also increase the risk of other important child and adult health problems, although this evidence is more tentative, being based on fewer studies. It includes conditions such as low birth weight, perinatal mortality (stillbirths and deaths in the first week of life), asthma, and middle ear infection for children, and tuberculosis, nasopharyngeal and laryngeal cancer, and cataract in adults.6,7,8

With regard to ocular morbidity, there is increasing evidence that biofuel pollution causes eye irritation.9 There is also evidence that it may cause cataract.10 However, there is a need for more studies to address this issue of ocular morbidity in relation to fuel use. This study was therefore initiated to understand the effect of fuel use on ocular morbidity.

METHODS
This cross sectional prevalence survey was conducted in a small village of western India situated 20 kilometres away from the nearest city. This small village had a total adult population of 1509. The prevalence of cataract in India is 4% in the adult population; we calculated the sample size for prevalence study using an acceptable range of 2–6%. Thus, the minimum sample size for a 1% level of significance was calculated as 448. We set our target as 500 persons. Selection of subjects was done from the electoral list (voters’ list) of that village by using random numbers generated by Microsoft Excel software. This list, which is the most frequently updated and most complete list of its kind available in India was thought to be most suitable for this purpose.

Of the 500 people who were approached for study, 476 subjects participated. Of these 476, data for seven persons were not included in the analysis because of incomplete information. Ultimately, information in relation to 469 subjects was considered for analysis. These subjects were interviewed with a questionnaire to obtain information about their medical history and personal characteristics, including fuel use. All underwent a medical as well as an ophthalmological examination. Ophthalmological examination included ophthalmoscopy and slit lamp examination. Initially, a descriptive analysis was done to observe the personal characteristics of the study subjects as well as to investigate the prevalence of different ocular morbidities.

The subjects with and without ocular morbidity were compared with reference to their fuel use, taking care of the possible confounders. Analysis was done using SPSS release 6.1.4 software. The logistic regression technique was applied to obtain the contribution of individual fuel use to ocular morbidity, irrespective of the effect of the possible confounders. In our study we found that our subjects were users of wood, cattle dung, coal, kerosene, and liquefied petroleum gas (LPG), either alone or in combination. While categorising we initially classified wood and cattle dung users as biomass fuel users. Coal, kerosene, and LPG users were treated as separate groups. Subsequently, in order to evaluate the effects of individual fuels within the biomass fuel group, we treated wood and cattle dung as separate groups.

Four stage analysis was performed in relation to cataract while doing logistic regression: biomass versus no biomass analysis; individual fuel group analysis; only biomass versus only LPG (the most modern fuel of those used) analysis; and only wood (the most important fuel factor according to our study in relation to cataract) versus only LPG analysis. Though individual fuel analysis gave us the contribution of all the fuel factors in cataract occurrence, we performed different sub-analyses to show the one to one comparison of different fuel groups (biomass versus no biomass) or individual fuels (wood versus LPG).
As cataract is a pathological entity, more detailed analysis was performed for this. As eye irritation is a subjective symptom, analysis was restricted to individual fuel types only. Variables such as different fuels (yes, no), sex (male, female), smoking (ever smoker, never smoker), diabetes (yes, no), hypertension (yes, no), and house type (mud made, cement and brick made) were taken as categorical variables. Other variables such as age (years) and per capita income (Indian rupees) were taken as continuous variables. In our analysis we accommodated all fuel types together with possible confounding variables in the logistic regression model in order to estimate the effect of fuel variables, adjusting for the effects of other variables.

**RESULTS**

Mean age of the study subjects was 36.8 (16.5) years for females (n = 276) and 36.2 (16.2) years for males (n = 193).

Almost 18% of subjects were less than 20 years old, 193 (41.2%) were in the 20–39 year age group, 122 (26%) were in the 40–59 year age group, and 15.1% were more than 59 years old. Mean family income of the subjects was 1931 Indian rupees. Fifty two per cent of male subjects were farmers, while 26.1% were students. Among the females, the majority were housewives (47.1%); 40.6% were engaged in miscellaneous activities in relation to farming. A total of 152 (33%) study subjects were illiterate, whereas 22 (4.8%) had university level education. Among the participants of the study, 53 (27.5%) male and 2 (0.7%) female subjects were smokers.

Among the study subjects, 5 (1.1%) persons had diabetes, while 58 (12.4%) subjects had hypertension. With regard to ocular morbidities, 142 (30.5%) subjects complained of eye irritation during cooking hours, 120 (26%) subjects had cataracts, and 22 (4.8%) subjects had pterygium in their eyes. Among the subjects with cataract, 51 (78%) were more than 59 years old, 63 (51.6%) were 40–59 years old, and 6 (3.9%) were less than 40 years old. All the subjects with pterygium were engaged in farming activities.

So far as fuel use is concerned, 428 (91%) subjects were using biomass (wood, cattle dung) fuel either alone or in combination with other fuels. LPG, kerosene (a petroleum product widely used in India as a cooking fuel; it is not as purified as LPG), coal, wood, and cattle dung were being used by 129 (27.5%), 174 (37.1%), 16 (3.4%), 428 (91%), and 71 (15.1%) subjects respectively, either alone or in combination.

Only LPG was used by 29 (6%) subjects, while only wood and only biomass fuel were used by 173 (36.9%) and 206 (44.2%) subjects respectively. All subjects had been using these fuels for more than 10 years.

Cataract was present in 27.1% of wood users (either alone or in combination), while 27.2%, 28.9%, and 10.3% of only biomass (wood, cattle dung), only wood, and only gas users respectively had cataract in their eyes (table 1).

Among the biomass fuel users (alone or in combination), irritation of eyes during cooking hours was significantly higher (OR 2.39, 95% CI 1.49–3.85) in females (38.1%) than in males (20.5%). This eye irritation was significantly higher (OR 2.84, 95% CI 1.19–7.05) in the female subjects who were more than 20 years old (41.5%) in comparison to the female subjects aged 20 years or less (20%). Eye irritation was present in 30.4% biomass users (alone or in combination), while 62.5%, 53.5%, and 21.7% of coal, cattle dung, and LPG users (alone or in combination) respectively reported eye irritation. The percentages were 31.6% and 24.1% when only biomass users were compared with only LPG users (table 1).

Table 2 shows the results of logistic regression applied to the data with the aim of understanding the effect of fuel use on ocular morbidities. While deriving the effect of different fuel use on ocular morbidities, the effects of age, sex, per capita income, smoking, diabetes, hypertension, and house type were adjusted. Risk involved in the use of a particular fuel was calculated as odds ratio by comparing users of that fuel with the non-users. With respect to aetiology of cataract, wood users were found to have an increased risk in comparison to non-users (OR 2.12, 95% CI 1.03–4.34). When biomass fuel users (alone or in combination) were compared with non-biomass users, the odds ratio was 1.87 (95% CI 0.95–3.67). The odds ratio for the comparison between only biomass and only gas users was 2.40 (95% CI 0.95–3.67). The odds ratio for the comparison between only wood and only gas users was 3.47 (95% CI 1.05–11.50). Age had a significantly positive regression coefficient in logistic regression, indicating increasing trend in cataract occurrence with increasing age.

With respect to the aetiology of eye irritation, coal users (OR 2.94, 95% CI 1.13–3.68) and cattle dung users (OR 1.83, 95% CI 1.35–2.47) were found to have increased risk in comparison to the respective non-users. Male sex was found to have a lesser risk (OR 0.59, 95% CI 0.44–0.79).

Other variables such as smoking, diabetes, hypertension, per capita income, and house type did not show any

### Table 1: Distribution of fuel use and ocular morbidity among the study subjects

<table>
<thead>
<tr>
<th>Fuel use</th>
<th>No. of subjects</th>
<th>Cataract</th>
<th>Eye irritation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Either alone or combination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass (wood, cattle dung)</td>
<td>428 (91)</td>
<td>116 (27.1)</td>
<td>130 (30.4)</td>
</tr>
<tr>
<td>Liquefied petroleum gas</td>
<td>129 (27.5)</td>
<td>33 (25.6)</td>
<td>28 (21.7)</td>
</tr>
<tr>
<td>Kerosene</td>
<td>174 (37.1)</td>
<td>49 (28.2)</td>
<td>54 (31)</td>
</tr>
<tr>
<td>Coal</td>
<td>16 (3.4)</td>
<td>3 (18.7)</td>
<td>10 (62.5)</td>
</tr>
<tr>
<td>Wood</td>
<td>428 (91)</td>
<td>116 (27.1)</td>
<td>130 (30.4)</td>
</tr>
<tr>
<td>Cattle dung</td>
<td>71 (15.1)</td>
<td>17 (23.9)</td>
<td>38 (53.5)</td>
</tr>
<tr>
<td>Only biomass</td>
<td>206 (44.2)</td>
<td>56 (27.2)</td>
<td>65 (31.6)</td>
</tr>
<tr>
<td>Only LPG</td>
<td>29 (6)</td>
<td>3 (10.3)</td>
<td>7 (24.1)</td>
</tr>
<tr>
<td>Only wood</td>
<td>173 (36.9)</td>
<td>50 (28.9)</td>
<td>45 (26)</td>
</tr>
</tbody>
</table>

Figures in parenthesis indicate percentages.
significant contribution to the aetiology of cataract or eye irritation.

On analysis, no significant impact of fuel use on the aetiology of pterygium was observed.

**DISCUSSION**

A hospital based case control study conducted in Delhi showed that use of LPG was associated with an adjusted OR of 0.62 (95% CI 0.4–0.98), when compared to those using cow dung and wood. Another hospital based case-control study conducted in another city of India also concluded that cheap cooking fuels were a risk factor for cataract. A rural population based case-control study of senile cataract also showed a similar effect of cheap cooking fuels on cataract aetiology (OR 1.8). Though very few epidemiological studies have been undertaken to explore the effect of traditional fuels on the aetiology of cataract, some animal studies have shown that wood smoke condensates do, like cigarette smoke, damage the lens of rats, causing discoulouration, opacities, and particulate debris—the mechanism is thought to involve absorption and accumulation of toxins which then lead to oxidation. They concluded that cigarette smoke condensate and firewood smoke condensate permeate the lens capsule, impart colour, and opacify the lens in a light and dose dependent manner. Antioxidants offer partial inhibition against this damage. The condensates contain polycyclic aromatics, which generate reactive oxygen species photodynamically, and ppb levels of Fenton metal ions, which induce oxidative reactions through –OH.

This study has shown that wood use is an important factor in the aetiology of age dependent cataract (OR 2.12, 95% CI 1.03–4.34). When comparing only wood and only LPG users, the odds ratio was 3.47 (95% CI 1.05–11.50). In the case of eye irritation, coal use (OR 2.04, 95% CI 1.13–3.68) and cattle dung use (OR 1.83, 95% CI 1.35–2.47) have emerged as important factors. In eye irritation, male sex is a lesser risk, possibly because men are not actively involved in the act of cooking. Significantly higher eye irritation in women who are >20 years old in comparison to those who are ≤20 years old also supports this (older women are more frequently involved in cooking). However, for cataract, sex did not show any significant impact. Most of the families are farmers, and cooking is usually done in the early morning or evening to enable both male and female members to work in the fields. Furthermore, cooking at such times was found to be the custom of this village; both the male and female members of the families were therefore exposed to the effects of cooking fuels because of their presence during cooking hours. However, direct involvement in the act of cooking may have been the reason for more exposure in females, which may have caused more eye irritation in females.

Analysis of ocular morbidity according to duration of fuel use may have provided more information on the contribution of fuel use to ocular morbidities. This was a limitation of this study. Classification and analysis of cataract cases, taking into account factors such as UV light exposure and antioxidant intake could have made the study more valid. Inclusion of a large number of variables during analysis in the logistic regression model may have been another limitation of our study in view of its sample size (calculated sample size was for a prevalence study only). With a larger sample size, in addition to the effects of individual fuels, effects of all possible fuel combinations could have been studied. The cross sectional design also prevents analysis of the temporal relation of fuel use and ocular morbidity. Furthermore, selection of subjects from more villages could have made the findings of this study more generalisable.

This study showed the adverse effects of wood use in the aetiology of age dependent cataract, and the positive role of coal and cattle dung use in the aetiology of eye irritation. The findings of this study point towards an important environmental health problem involving mostly the poor women and children, and indicate that the health consequences of exposure from biomass and other solid fuels in developing countries should not be ignored, not only because the health burden is high, but also because of the fact that such fuels will continue to be used throughout the world by a large number of households in the foreseeable future for economic reasons.

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**Authors’ affiliations**


Correspondence to: Dr A Saha, Research Officer (Medical), Occupational Medicine Division, National Institute of Occupational Health, Meghani Nagar, Ahmedabad-380 016, Gujarat, India; asimsaha2311@yahoo.co.in

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**REFERENCES**


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