SHORT REPORT

Ocular morbidity and fuel use: an experience from India

A Saha, P K Kulkarni, A Shah, M Patel, H N Saiyed

Occup Environ Med 2005;**62**:66–69. doi: 10.1136/oem.2004.015636

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.¹ 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.^{1,2} 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.^{5,6} 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.^{4,7,8}

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).

Main message

- Traditional fuels such wood, cattle dung, and coal have adverse effects on the human eye.

Policy implication

- Substitution of traditional fuel use can minimise ocular morbidity.

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 (75%) 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 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 0.90–6.37). 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 2.04, 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

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

Figures in parenthesis indicate percentages.

Table 2 Effect of fuel use on ocular morbidity

Outcome variables	Covariates	Significance (p value)	Odds ratio*	95% CI
Cataract	Gas	0.5154	1.13	(0.78–1.65)
	Kerosene	0.1788	1.25	(0.90–1.73)
	Coal	0.3227	0.59	(0.20–1.68)
	Wood	0.0398	2.12	(1.03–4.34)
	Cattle dung	0.1789	0.72	(0.45–1.16)
Eye Irritation	Gas	0.1288	0.79	(0.58–1.07)
	Kerosene	0.7166	0.96	(0.75–1.21)
	Coal	0.0173	2.04	(1.13–3.68)
	Wood	0.082	0.68	(0.43–1.05)
	Cattle dung	0.0001	1.83	(1.35–2.47)

*Adjusted for age, sex, per capita income, smoking, diabetes, hypertension, and house type.

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.¹⁰ Another hospital based case-control study conducted in another city of India also concluded that cheap cooking fuels were a risk factor for cataract.¹¹ 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).¹² 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 discolouration, opacities, and particulate debris—the mechanism is thought to involve absorption and accumulation of toxins which then lead to oxidation.^{13–14} 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 $-OH$.¹⁴

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.

ACKNOWLEDGEMENTS

We acknowledge the help of the Ophthalmology Department of B J Medical College for their contribution to the ophthalmological examinations. We also acknowledge Dr D J Parikh, Dr L M Dave, Mr H Patel, Ms M Mankad, Ms S Sheikh, and Ms N Pathak for their help with this study.

Authors' affiliations

A Saha, P K Kulkarni, A Shah, M Patel, H N Saiyed, National Institute of Occupational Health, Ahmedabad, India

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

Accepted 27 September 2004

REFERENCES

- 1 **World Resources Institute.** *UNEP, UNDP, World Bank. 1998–99 world resources: a guide to the global environment.* Oxford: Oxford University Press, 1999.
- 2 **World Health Organisation.** *Health and environment in sustainable development, WHO/EHG/97.8.* Geneva: World Health Organisation, 1997.
- 3 **Smith K, Samet J, Romieu I, et al.** Indoor air pollution in developing countries and acute respiratory infections in children. *Thorax* 2000;**55**:518–32.
- 4 **Bruce N, Perez-Padilla R, Alablak R.** Indoor air pollution in developing countries: a major environmental and public health challenge. *WHO Bulletin* 2000;**78**:1078–92.

- 5 Mumford JL, He XZ, Chapman RS, *et al.* Lung cancer and indoor air pollution in Xuan Wei, China. *Science* 1987;**235**:217–20.
- 6 Smith KR, Liu Y. Indoor air pollution in developing countries. In: Samet J, eds. *Epidemiology of lung cancer. Lung biology in health and disease*. New York: Marcel Dekker, 1993.
- 7 Mishra V. Effect of indoor air pollution from biomass combustion on prevalence of asthma in the elderly. *Environ Health Perspect* 2003;**111**:71–8.
- 8 Mishra VK, Retherford RD, Smith KR. Cooking with biomass fuels increases the risk of tuberculosis. *Natl Fam Health Surv Bull* 1999;**13**:1–4.
- 9 Ellegard A. Tears while cooking: an indicator of indoor air pollution and related health effects in developing countries. *Environ Res* 1997;**75**:12–22.
- 10 Mohan M, Sperduto R, Angra S, *et al.* India-US case control study of age-related cataracts. *Arch Ophthalmol* 1989;**107**:670–6.
- 11 Ughade SN, Zodepy SP, Khanolkar VA. Risk factors for cataract: a case control study. *Indian J Ophthalmol* 1998;**46**:221–7.
- 12 Sreenivas V, Prabhakar AK, Badrinath SS, *et al.* A rural population based case-control study of senile cataract in India. *J Epidemiol* 1999;**9**:327–36.
- 13 Shalini VK, Luthra M, Srinivas L, *et al.* Oxidative damage to the eye lens caused by cigarette smoke and fuel smoke condensates. *Indian J Biochem Biophys* 1994;**31**:261–6.
- 14 Rao CM, Qin C, Robison WG Jr, *et al.* Effect of smoke condensate on the physiological integrity and morphology of organ cultured rat lenses. *Curr Eye Res* 1995;**14**:295–301.

Clinical Evidence—Call for contributors

Clinical Evidence is a regularly updated evidence-based journal available worldwide both as a paper version and on the internet. *Clinical Evidence* needs to recruit a number of new contributors. Contributors are healthcare professionals or epidemiologists with experience in evidence-based medicine and the ability to write in a concise and structured way.

Areas for which we are currently seeking authors:

- Child health: nocturnal enuresis
- Eye disorders: bacterial conjunctivitis
- Male health: prostate cancer (metastatic)
- Women's health: pre-menstrual syndrome; pyelonephritis in non-pregnant women

However, we are always looking for others, so do not let this list discourage you.

Being a contributor involves:

- Selecting from a validated, screened search (performed by in-house Information Specialists) epidemiologically sound studies for inclusion.
- Documenting your decisions about which studies to include on an inclusion and exclusion form, which we keep on file.
- Writing the text to a highly structured template (about 1500–3000 words), using evidence from the final studies chosen, within 8–10 weeks of receiving the literature search.
- Working with *Clinical Evidence* editors to ensure that the final text meets epidemiological and style standards.
- Updating the text every six months using any new, sound evidence that becomes available. The *Clinical Evidence* in-house team will conduct the searches for contributors; your task is simply to filter out high quality studies and incorporate them in the existing text.
- To expand the topic to include a new question about once every 12–18 months.

If you would like to become a contributor for *Clinical Evidence* or require more information about what this involves please send your contact details and a copy of your CV, clearly stating the clinical area you are interested in, to Klara Brunnhuber (kbrunnhuber@bmjgroup.com).

Call for peer reviewers

Clinical Evidence also needs to recruit a number of new peer reviewers specifically with an interest in the clinical areas stated above, and also others related to general practice. Peer reviewers are healthcare professionals or epidemiologists with experience in evidence-based medicine. As a peer reviewer you would be asked for your views on the clinical relevance, validity, and accessibility of specific topics within the journal, and their usefulness to the intended audience (international generalists and healthcare professionals, possibly with limited statistical knowledge). Topics are usually 1500–3000 words in length and we would ask you to review between 2–5 topics per year. The peer review process takes place throughout the year, and our turnaround time for each review is ideally 10–14 days.

If you are interested in becoming a peer reviewer for *Clinical Evidence*, please complete the peer review questionnaire at www.clinicalevidence.com or contact Klara Brunnhuber (kbrunnhuber@bmjgroup.com).