

Does Exposure to Indoor Cooking Smoke Increases the Risk of Cataracts? Can We Prevent Cataracts by Introducing Improved Cooking Stove?

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Introduction

According to the World Health Organization, at present there are 45 million people blind, worldwide, and 135 million are visually disabled, and depend on family support or care on a daily basis. Annually about 1-2 million people become blind and cataract is a major cause of blindness accounting for more than 50 percent of blindness burden. Prevalence of cataract is higher in developing countries, and in those countries more women than men are blind. In Nepal alone, every year about 60,000 people get cataracts. Although cataract prevalence is higher among women, cataract surgical coverage rate is 1.2-1.7 times lower for them. For example in Nepal, men aged 65-67 years have been found receiving 40 percent more cataract-related services than women in the same age group. In the 75+ age group, men have been found receiving 70 percent more surgery than women[2].

What is a cataract?

Cataract includes any opacity of the lens, from minor opacities not interfering with vision to total opacity causing blindness. Cataracts are also classified as congenital, infantile, or age-related (“senile”). In terms of cataract burden, age-related (senile) cataract is a major public health concern and challenge. There are no drugs available to treat cataracts. Only solution to get sight back is through surgery, which unfortunately is prohibitive to many poor people. Thus to reduce burden of cataracts in developing countries, preventive approach makes public health sense.

What are the risk factors?

Epidemiological studies have established certain risk factors for cataract formation. Particularly, age, exposure to UV-B radiation (sunlight), cigarette smoking, diabetes, severe diarrhea, malnutrition, lower socioeconomic status, lower education, and certain occupations have been found associated with cataract. Unfortunately, understanding of risk factors and biochemical and structural events leading to the formation of cataract is not complete yet. Three epidemiological studies have provided some evidence of an association between cataract or blindness and exposure to indoor smoke from household use of solid biomass fuels, such as animal dung, wood, and crop residues[3-5]. However, these studies have had limitations that have precluded establishment of a definitive causal relationship. To further investigate the possible relationship of cataract formation with indoor smoke exposure, I conducted a cataract case-control study in the area of the Nepal-India border where cooking with solid fuels in unvented indoor stoves is a common practice. The main objectives of this study were to confirm results of earlier

¹ This essay is based on the findings of study by Pokhrel et. al.: ‘ Case-control study of indoor cooking smoke exposure and cataract in Nepal and India, *International Journal of Epidemiology*; 2005; 34: (702-708).’

studies using clinically confirmed cataract cases, to investigate possible confounding of the relationship, and to examine whether the risk of cataract is modified by stove type or ventilation[1].

Study Method

A case-control study design was used to test the hypothesis, 'cooking/exposure with solid fuel unimproved stove (SFUS) increases the risk of cataract'. For the statistical analysis, exposure variables were constructed in three categories combining stove and fuel type. Stoves that used non-solid fuels – kerosene, liquefied petroleum gas (LPG), biogas, or electricity – were designated as 'clean-fuel stoves (CFS)' and used as the reference category for most analyses. Solid-fuel-burning (wood, dung) stoves without flues were designated as 'solid-fuel-unimproved stoves (SFUS),' and solid-fuel-burning stoves with flues were designated as 'solid-fuel-improved stoves (SFIS).' For some analyses (exposure response), the CFS and SFIS categories were combined as the reference category.

To evaluate if ventilation in the kitchen modifies the risk of cataracts, information on kitchen location and windows in the kitchen was combined to create a composite dichotomous variable. 'Fully and partially ventilated kitchens' included open-air kitchens, separate kitchens outside the house, and partitioned kitchens with windows inside the house. This was used as the reference category for ventilation. 'Unventilated kitchens' included partitioned and non-partitioned kitchens without windows inside the house.

Epidemiological studies are susceptible to bias including confounding. A confounding bias is a situation in which a measure of the effect of an exposure (SFUS in this study) is distorted because of the association of exposure with other factors (rural residency, socio-economic condition, education, etc.) that influence the outcome (cataracts) under study. Thus, potential confounders of the relationship between cataracts and exposure were evaluated by comparing adjusted and unadjusted relative risk estimates for the association between stove fuel type (using the combined CFS and SFIS as the reference category) and cataracts. A variable was considered a potential confounder if the difference between adjusted and unadjusted (without stove fuel variable in the association analysis) odds ratios² was more than 10 percent of the unadjusted value.

We also evaluated whether cataracts risk is modified by duration of cooking (exposure-response relationship). Duration of cooking on SFUS by cases and controls was categorized into 20-year bands and was compared with cooking in CFS. We created 20-year bands considering that after age 20, women actively engage in cooking, whereas before that time period they generally help in the kitchen and after age 40, other family members start helping them. For this analysis, SFIS and CFS were combined as the reference category.

Cases in this study were women (35-75 years) with slit lamp confirmed cataracts, diagnosed at Shree Rana Ambika Shah Eye Hospital in Lumbini. Controls were women

² Ratio of the odds in favor of exposure among the cases to the odds in favor of exposure among controls.

frequency matched with cases on age, who had a diagnosis of refractive error and no eye disorder and no cataracts. The term refractive error encompasses myopia (nearsightedness), hyperopia (farsightedness), astigmatism (presence of a cornea that is not perfectly round) and presbyopia (problem to focus near). The study was limited to women because only women do cooking in this area and our major hypothesis involved smoke from cooking. Cases and controls in this study all resided in Maharajgunj and Gorakhpur districts of India, and Rupandehi, Nawalparasi, and Kapilvastu districts of Nepal.

Results:

In the study, 206 cataract cases and 203 controls without cataract were recruited. Out of total participants, 80 percent of cases as well as 57 percent of the controls reported cooking with unvented biomass stoves, whereas 22 percent reported being past or current smokers. The univariate analysis (unadjusted odds ratio) showed statistically significant associations of cataracts with literacy, urban/rural residency, lack of ventilation in the kitchen, source of light (wick lamp) in the house, incense use, regular intake of vegetables and a glass of milk, house type, age at which cooking started, and working outside in the sun. We investigated whether all these variables were potential confounders of the relationship between exposure and disease. Analysis revealed illiteracy, rural residency, and light in the house, use of incense, and lack of ventilation as potential confounders, according to our criteria of 10 percent change from the unadjusted value. To evaluate an individual's probability of having cataracts as a function of risk factors, a logistic regression model was used. The risk of cataract was evaluated by three exposure variables by including potential risk factors and confounders in the model. The three exposure variables were: use of clean fuel stove (CFS), solid fuel improved stove (SFIS) and solid fuel unimproved stove (SFUS), where CFS was the reference category. In addition to the identified confounding variables, age and work outside in the sun were also included in the logistic regression model. Age was included as it was a matching variable, and 'work outside in the sun' was included because exposure to sunlight is a known independent risk factor for cataracts. The results showed that compared with CFS, SFIS use was associated with 23 percent increased risk of cataract, whereas the use of SFUS increased the risk by 90 percent. In other words, women who cook with unimproved stoves using solid fuels have 1.90 times the rate of cataracts than those who cook with clean burning fuels and stoves, after even controlling for other potential risk factors and confounders.

The analysis, whether ventilation in the kitchen modifies the risk of cataracts associated with stove-fuel type, revealed only a slight effect modification by ventilation on the risk. Similarly an investigation, whether the risk of cataract varied with the duration of cooking with SFUS, indicated some evidence of an exposure-related trend in the risk of having cataracts with increasing duration of cooking with SFUS. However, the trend was not statistically significant.

Discussion:

A causal relationship between exposure to indoor smoke and cataract is biologically plausible. Compromises of function of the lens and retina are exacerbated by depleted or

diminished primary antioxidant reserves, antioxidant enzyme capabilities, and diminished secondary defenses, such as proteases. There is evidence that smoke can induce oxidative stress and deplete plasma ascorbate, carotenoids and glutathione, which provide antioxidant protection against cataract formation[6-8]. Studies show that tobacco smoke consumption not only increases the risk of cataract but it also leads to an earlier onset of cataract formation. Studies have shown that stopping smoking correspondingly reduces the risk of cataract formation. Studies conducted in developed countries have even found an increased risk of cataract (pure nuclear sclerosis) increasing with increasing cigarette consumption and a decreased risk of cataract if the subject had quit smoking.

Tobacco smoke and bio-fuel smoke have many similarities. In many economically underprivileged countries, including Nepal, smoke from unvented stoves is a far more prevalent problem than tobacco smoking. However, assuming that the association found in our study reflects a true causal relationship, it is unclear which route of exposure, inhalation or direct eye contact with smoke leads to the pathogenic process of cataract formation among women who cook in unvented stoves with solid fuel.

In conclusion, this study confirms that use of solid fuels in unimproved stoves and accompanying lack of kitchen ventilation are associated with an increased risk of cataract. Bias including potential confounding, is not likely to explain these associations, which are biologically plausible and consistent with the results of other epidemiological studies. Worldwide, hundreds of millions of people, particularly women, are exposed to high levels of indoor smoke from cooking with solid fuels on unvented stoves. In Nepal every year about 60,000 new cataract cases emerge and there are several people who at present are living with cataract blindness because of lack of resources for cataract surgery. Majority among these blind are women. Thus the most effective remedial measure of cataracts would be to replace unflued stoves with flued stoves, which vent cooking smoke directly to the exterior of the house. Ideally, stoves with cleaner burning fuels, such as gas (Bio gas, LPG) or kerosene should be used. However, economic realities may prevent this from becoming widespread. Secondly, by ensuring that kitchens have some form of ventilation, particularly a window, there would be some degree of risk reduction, particularly if unflued stoves are retained. However, our study shows that simply increasing ventilation in the absence of improving stove type would not reduce the relative risk associated with unflued stoves. The public health benefits of widespread stove improvement, particularly addition of flues, are likely to be immense. Improved stoves dissemination programs will not only prevent blindness but also will help to eliminate other public health burden such as problem of low birth weight among children in rural areas as well as lung diseases among children and adults in Nepal.

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