Executive Summary

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According to the World Health Organization (WHO), annually, about 1-2 million people become blind and cataract accounts for more than 50% of this blindness. Global blindness statistics show that prevalence of cataract is higher in developing countries and more females than males are blind because of cataract. Cataract is a lens opacity associated with some degree of visual impairment. Understanding of risk factors for cataract formation is presently incomplete. Likely risk factors for cataract include active cigarette smoking, exposure to sunlight and severe diarrhea. Three epidemiological studies have provided evidence of an association between cooking with solid fuels (wood and dung) and cataract or blindness, presumably from the well established high air pollution exposures that result from household use of such fuels. However, these studies have had limitations, particularly in regard to possible confounding of the associations. The main purpose of this study was to confirm the previous findings by obtaining better measurement of exposure, high quality cataract diagnosis, and controlling for potential confounders.

I conducted a hospital-based case-control study among women visiting Lumbini Rana Ambika Eye Hospital, located in Nepal at the border with India. At the same time, I also measured the concentrations of formaldehyde (HCHO), naphthalene ($C_{10}H_8$) and particulate matter in the kitchens of few households, near hospital area that used different stoves and fuel types. In the indoor air quality monitoring study, concentration of formaldehyde (HCHO) and naphthalene ($C_{10}H_8$) were measured in 19 households and particulate matter (PM) in 9 households.

In the case-control study, cases (n=206) were women patients, aged 35-75 years, with confirmed cataract and age-matched controls (n=203) were selected from women patients attending the refractive error clinic at the same hospital from the same districts as the cases. Patients with a history of diabetes mellitus were excluded from both cases and controls. The cases and controls were residence of Maharajgunj and Gorakhpur districts in India, and Rupandehi, Nawalparasi and Kapilvastu districts in Nepal. All subjects were recruited and interviewed between July and October, 2002, at the hospital by a trained interviewer. A standardized questionnaire to collect detailed information on exposures of interest and potential confounders was administered to both groups.

For the case control study, statistical analyses were organized around three different sets of variables: the exposure of interest, other covariate exposures (potential confounders) and the outcome. The exposures (including covariates) were first analyzed using chi-square test, followed by univariate calculation of odds ratios for association with the outcome (cataract). The confounding effect of other variables on the relationship between the primary exposure of interest (exposure to solid-fuel indoor stove without a flue-SFUS) and risk of cataract were identified by using adjusted and unadjusted effect

estimates and the Mantel-Haenzel (M-H) odds ratios and Woolf confidence intervals. Based on the results of this test an unconditional logistic regression model was constructed that evaluated the simultaneous effect of multiple variables on the risk of cataract.
For the indoor air quality monitoring study, the variation of concentration of formaldehyde (HCHO), naphthalene ($C_{10}H_8$) and particulate matter by stove-fuel type were evaluated by Analysis of Variance test (ANOVA). And, the variation of concentration of formaldehyde (HCHO) by stove type was evaluated by regression analysis.

In the case control study, 76% of the cases and 79% of the controls were not smokers (p=<0.53) and almost all subjects' reported regular or intermittent exposure to some kind of cooking fuel and stove. After adjustment for age, education, area of residency, ventilation, and work in the sun, compared to liquid fuel stove (LFS), solid fuel improved stove (SFIS) use increased the risk of cataract by 26% (Odds ratio (OR): 1.26; 95%CI: 0.46-3.47), whereas use of a SFUS increased the risk by 111% (OR: 2.11; 95%CI: 1.19-3.77). Similarly, compared to a fully ventilated kitchen, lack of ventilation in the kitchen increased the risk of cataract by 105% (OR: 2.05; 95%CI: 1.33-3.15). I separately investigated whether ventilation in the kitchen modified the risk of cataract associated with stove-fuel type. For this a separate logistic regression models were constructed for subjects who cooked in ventilated kitchens and for subjects who cooked in unventilated kitchens. The results showed only a slight effect modification by ventilation of the risk associated with use of SFUS.

The results of indoor air quality monitoring suggested (ANOVA test) that the mean concentration of formaldehyde and particulate matter vary by stove and fuel type, where as concentration of naphthalene did not vary. The mean concentrations of formaldehyde (K-wallis chi-square p= <0.01) and particulate matter (K-wallis chi-square p= <0.01) were higher in the kitchens that used SFUS compared with LFS. The regression model suggested that compared to LFS, the SFUS generates about three and half times higher concentrations of formaldehyde (95%CI: 1.25-7.85).

The results of this case-control study supports the hypothesis that smoke from solid-fuel use in indoor stoves without flues increases the risk of cataract in women. The association is not likely to be due to bias, including confounding by other factors. This finding is consistent with and strengthens the findings of a previous cross-sectional study and two other case-control studies conducted in India. Similarly, the indoor air quality monitoring study suggest that concentration of particulate matter and formaldehyde vary by stove type and compared to SFUS, LFS generates much less pollutants in the kitchens.

Assuming that the association found in this study reflects a true causal relationship, it is still not clear which route of exposure, inhalation or direct eye contact, actively leads to the pathogenic process of cataract formation. This needs further research. Nevertheless, smoke from use of solid fuel in unimproved stoves should be considered an important risk factor for cataract and the appropriate action to reduce the risk of cataract could be

through promoting use of stoves with clear burning fuels or solid fuel stoves with flues to the outside of the house, and improvement of the ventilation of the kitchens.