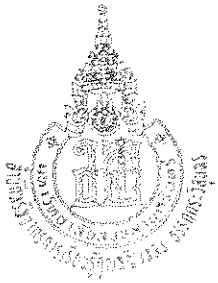

Use of Traditional Cooking Fuels and Risk of Young Adult Cataract in Rural Bangladesh: A Hospital-Based Case-Control Study

Joydhan Tanchangya

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Thesis Title	Use of Traditional Cooking Fuels and the Risk of Young Adult Cataract in Rural Bangladesh: A Hospital-Based Case-Control Study
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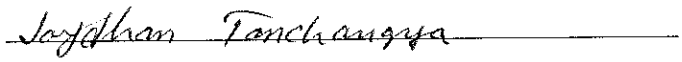

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Abstract

Background: A population-based survey in Bangladesh 2000 indicated that around 80 percent of blindness was due to cataract. Although the prevalence of cataract increases with age, the proportion of young adult cataract in this country was higher than in many other settings, particularly among women. The use of cheaper cooking fuels, such as wood, leaves, straw and animal dung, had been previously reported to increase the risk of cataract in India and Nepal. Such fuels are traditionally and commonly used in rural areas of Bangladesh. Multiparity had also been reported to be associated with increased risk of cataract in females in India. Multipariaty is common among rural women in Bangladesh. The average household size in Bangladesh was 4.8 (2005) and tends to be higher among families of lower socioeconomic status, the illiterate and the rural population. These exposures might account in part for the high incidence of cataract in rural Bangladesh.

Objectives: 1. To compare the background characteristics of young adult cataract patients and those without cataract in the study.

2. To determine the independent associations between the uses of cheaper cooking fuels such as wood/dry leaves, cow dung and rice straw and young adult cataract in rural Bangladesh.

3. To determine if high parity is independently associated with young adult cataract among females after controlling for exposures to other previously identified risk factors.

Methodology: A hospital-based matched case-control study in a rural area of Bangladesh incorporating two controls groups was conducted. Cases were cataract patients aged 18-49 years diagnosed by an ophthalmologist under slit-lamp examination showing any opacity of the crystalline lens or its capsule and having decreased visual acuity poorer than 6/18 on the Log Mar Visual Acuity Chart, or having had a cataract removed by a qualified ophthalmologist within the previous 5 years. Non-eye-disease controls (NE) were selected from patients without eye problems attending the ENT or Orthopaedics departments in the study hospital. Non-cataract eye-disease controls (NC) were selected from those patients attending in the hospital with eye problems other than cataract. Both controls groups were matched on age and sex with cases. The distributions of variables were explored and summarized within each outcome group using mean and standard deviation or frequency. Data were analyzed using tabulation and conditional logistic regression modelling. To examine the associations with use of cooking fuels, matched pairs of case vs

NE control and of case vs NE control were analyzed. For examining the role of parity among females, the NE and NC controls were combined to give 80 cases and 160 controls in a matching ratio of 1:2.

Results: Among the study subjects, ever use of wood/dry leaves and of rice straw as cooking fuel were reported by a slightly higher proportion, and ever use of cow-dung by a slightly lower proportion, of cases than of either control group. However, after adjustment for other previously reported risk factors for cataract, ever use of wood/dry leaves and ever use of rice straw as cooking fuel were significantly positively associated with case status in comparison with NE controls, and ever use of cow-dung significantly negatively related with case status in comparison with both control groups. Case status also showed a significant trend association (shown as odds ratio and 95% confidence interval) with lifetime hours of exposure when fitting exposure classified as never, ≤ median, > median: wood/dry leaves 2.15 (1.09-4.23), rice straw 1.83 (1.06-3.16), cow-dung compared with NE controls 0.54 (0.33, 0.88) and compared with NC controls 0.61 (0.39-0.97).

Other factors identified as being positively associated with case status were family history of cataract in both control comparisons, current or past smoking in comparison with NC controls and lower educational attainment in comparison with NE controls.

There was no statistically significant relationship between parity and case status in this study. Nevertheless, the analysis among females did identify a family history of cataract, as well as a

lower level of formal education, and possibly also long occupational exposure to sunlight, as independent predictors of young adult female cataract.

Conclusion: In conclusion, the results of the current study are in agreement with those of earlier studies that the use of cheaper cooking fuels may increase the risk of cataract, in our case cataract in young adults. The study also provides evidence that use of cow-dung as a cooking fuel does not increase the risk of developing cataract in young adult life, and may actually be protective.

Recommendations: In view of the lack of plausible explanation for the protective effect of using cow-dung as a cooking fuel, further studies of the relationship between use of cow-dung and cataract in other settings, as well as comparative analysis of the constituents of the smoke from wood/dry leaves/rice straw and that of cow-dung, are needed. From the public health aspect for Bangladeshi villagers, a change to the use of alternative fuels such as biogas or liquefied petroleum gas, the adoption of stoves that can reduce the free emission of smoke from wood/dry leaves and rice straw fuel, or improved ventilation of cooking areas of the house, are recommended.

Key words: Young adult cataract, risk factor, traditional cooking fuels, cow-dung, multiparity, rural Bangladesh.

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Joydhan Tanchangya

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ABBREVIATION LIST

PSC = Posterior subcapsular cataract

BIM = Body Mass Index

Cd = Cadmium

Fe = Ferrous

SES = Socio-economic status

NC = Non-cataract eye-disease control

NE = Non-eye-disease control

CS = Cataract case

ENT = Ear, Nose and Throat

Tk. = Taka, Bangladesh currency

vs = Versus

N = Number

SD = Standard deviation

OR = Odds Ratio

CI = Confidence Interval

hr = Hour

yr = Year

wk = Week

ref = Reference

Hx = History of

DOB = Date of birth

Chapter 1: Introduction

1.1 Background

1.1.1 Study background

Blindness is a global problem nowadays and cataract is the leading cause of blindness in both developed and developing countries. The numbers of blind in the world in 1975 was estimated to be 28 million. The number increased in 2002 to around 45 million with 16-20 million due to cataract and is projected, if present trends continue, to reach 75 million by 2020.[1;2]

Increasing age is associated with an increased prevalence of cataract. People aged 50 years and older and females are at greater risk of developing cataract.[1] Data from Australia showed that the prevalence doubles with each decade of age after 40 years, so that almost everyone in their nineties is affected by cataract.[3;4] The prevalence of cataract also increases with age in developing countries, although it often occurs earlier in life.[3] In an Indian study, significant cataract occurred 14 years earlier than in a comparable study in the United States.[3;5] The age-adjusted prevalence of cataract in India was three times that of the U.S.A.[3;6] A major challenge in developing countries is to reduce the magnitude of cataract in the population by delaying the development of cataract and by providing ready access to cataract surgery for all those who need it. Thus total numbers of blind in developed countries was estimated to be 3.5 million in 1990 and

3.8 million in 2002. By contrast, in developing countries the numbers were 18.8 million in 1990 and 19.4 million in 2002.[2]

A recent population-based survey in Bangladesh estimated 650,000 people were blind aged 30 years and older and 79.63 percent were due to cataract. Around 130,000 new cases developed annually.[7;8] The prevalence of bilateral blindness was 2.9%, that of severe visual impairment 1.2%-2.0%, and that of all visual impairment 8.4%. Seventy nine percent of (79%) bilateral blindness was due to cataract and the cataract surgical coverage was moderate in quality as judged by the improvement in visual acuity.[9] The age-standardized prevalence of bilateral blindness was 1.52% aged 30 years and older, of which 79.6% was caused by cataract; and the prevalence of low-vision was 13.8%, of which 74.2% was due to cataract. The age-specific blindness prevalence was found to increase with increasing age, and to be higher in women and the illiterate and disadvantaged people.[7]

In the neighbouring region, blindness prevalence surveys in Nepal and Pakistan found all age and gender standardized blindness prevalence of 0.8%[10] and 2.7%[11] respectively. The overall prevalence of blindness was 0.9% in Myanmar with 64% due to cataract, 0.7% in India with 77% due to cataract and 0.8% in Nepal with 72% due to cataract.[12]

Another study in Nepal identified a blindness prevalence of 3.0% in people 45 years and older. In China and India the estimated numbers of blind people in 1990 were 6.7 and 8.9 million respectively, and in 2002 there were an estimated 6.9 million blind people in China and 6.7 million in India.[2] While these

numbers represent an increase of 3% in China, they also mark a decrease of 25% in India.

1.1.2 Study setting background

The study was conducted in the rural disadvantaged area of Bangladesh. Total land area of the country around 147,570 km^2. Bangladesh has a population of about 140 million,[13] making it one of the most densely populated countries of the world. The country is covered with a network of rivers and canals.

The Indian states of West Bengal, Meghalaya, Assam and Tripura border on the west, the north and the east respectively. Bangladesh also shares its border with Myanmar on the southeast corner. In the south, the country has a long coast along the Bay of Bengal. The only hilly parts are in the northeast and southeast of the country. The population, vital statistic and health system profile of Bangladesh are given Tables 1 and 2.

Table 1. Population and Vital Statistics of Bangladesh

Indicators	Available data	Year
Total population (millions)	140	2005
Population density (persons per sq km)	948	2005
Sex ratio (males per 100 females)	106	2003
Population under 15 years (%)	38	2004
Population 60 years and above (%)	7	2004
Crude birth rate (per 1000 population per year)	20.9	2003
Crude death rate (per 1000 population per year)	5.9	2003
Natural (population Growth rate(%)	1.54	2001
Total fertility rate (per woman)	3.0	2004
Urban population (%)	31	2003
Socioeconomic Situation:		
Gross national product per capita (US $)	444	2003-04
Population living with per capita income below US$ 1 a day (%)	36	2004
Adult literacy rate (%)		
Total	49.6	2002
Male	55.5	2002
Female	43.4	2002
Prevalence of low birth weight (weight <2500 grams at birth) (%)	40	2005

Table 1. Population and Vital Statistics of Bangladesh (cont.)

Indicators	Available data	Year
Prevalence of underweight (weight- for-age) in children <5 years of age (%)	47.7	1994-99
Total population (millions)	140	2005
Population density (persons per sq km)	948	2005
Sex ratio (males per 100 females)	106	2003
Population under 15 years (%)	38	2004
Population 60 years and above (%)	7	2004

Source: Bangladesh Bureau of Statistics, Statistics Bangladesh, 2006.[13]

Table 2. Health System Profile of Bangladesh

Indicators	Available data	Year
Facilities:		
Number of hospital beds	51,648	2005
Hospital beds per 10,000 population	3.43	2005
Number of health centres	1385	2004
Human resources:		
Number of physicians	42,881	2005
Population per physician	3169	2005
Physicians per 10,000 population	3	2005

Table 2. Health System Profile of Bangladesh (cont.)

Indicators	Available data	Year
Population per nurses	6442	2005
Functions:		
Pregnant women attended by trained personnel during pregnancy (%)	27.2	2004
Deliveries attended by trained personnel (%)	13.4	2004
Women of childbearing age using family planning(%)	58.1	2004
One year olds immunized against Measles (%)	77	2005
Immunization coverage among one year old children (fully immunized)	52.8	1999
Women that have been immunized with tetanus toxoid (TT) during pregnancy (%)	29	2003
Outcomes:		
Life expectancy at birth (years):		
Total	64.9	2002
Male	64.5	2002
Female	65.4	2002
Infant mortality rate (per 1000 live births)	53	2003
Under- five mortality rate (per 1000 live births)	88	2003
Maternal mortality ratio (per 100,000 live births)	380	2002

Source: Bangladesh Bureau of Statistics, Statistics Bangladesh, 2006.[13]

Households

Bangladesh has about 25.3 million households, while 98.2% are dwelling households. Average household size is 4.8. Male-headed household account for 89.6% and female-headed households 10.4%.[14]

The constitutional commitment of the Government of Bangladesh is to provide basic health and medical requirements to all people in the society. The Constitution of the People's Republic of Bangladesh ensured that "Health is the basic right of every citizen of the Republic," as health is fundamental to human development.

Lifestyle and Risk Factors

The percentage of the male population aged 15 years and above who are regular smokers increased over the last decade. Data for 1995 showed that the proportions of adult males and females who were regular smokers was 41 percent and 4.6 percent, respectively.[14] The prevalence of current tobacco smoking for more than 15 years among young adults in 2005 was 47.0 percent and 3.8 percent in males and females respectively.[15]

The majority of people in rural areas in Bangladesh are very poor. For cooking, solid fuels such as wood, leaves and cow-dung etc are main sources. In 1990, it was found that total energy consumed in the household sector 91.5% supplied by biomass fuels and 8.5% by commercial fuels. In 2002 about 83% people used solid cooking fuel in Bangladesh, and around 77% (54% in urban and 99% in rural) in the year 2003.[15]

Blindness and cataract in Bangladesh:

- Avoidable blindness is one of the major public health problems in Bangladesh.[16]
- Presently about 650,000 people are blind age 30 years and above with around 80% due to cataract and around 130,000 new cases developed annually.[16]
- Estimated childhood blindness prevalence of 0.75/1,000 children, there are about 40,000 blind children in Bangladesh.[16;17]
- It is feared the number of blind population will be double by the year 2020 if no intervention is initiated immediately.[16]
- The prevalence of blind women as compared with men 1.72% v 1.06%.[7]
- Cataract was identified as the major cause of bilateral blindness (79.6%) and low vision (74.2%) amongst adults.[17]
- Un-operated cataract as the main cause of blindness and low vision was more prevalent among elderly persons, women, illiterate individuals and disadvantaged people.
- The National Eye Care Plan, which was formally adopted and launched by the Ministry of Health and Family welfare, Bangladesh has prioritized three major areas of disease control, namely cataract, childhood blindness, and refraction and low vision.[16]
- To control the cataract blindness in Bangladesh, there is need for nearly 380,000 cataract operations annually but currently about 140,000 cataract operations are being done, which represents around 45 percent of the need.[18] To control the avoidable

blindness due to cataract, surgery is not enough. Besides increasing the cataract surgical rate it is necessary to identify the risk factors which are responsible for development of cataract in early life that may be preventable.

1.1.3 Background of study site

The study was conducted in Impact "Jibon Tari" Floating Hospital, Bangladesh. The hospital is on the river and moves to a different remote and disadvantaged area of the country at 5- to 6-month intervals. Impact "Jibon Tari" Floating Hospital is the one of the innovative projects of Impact Foundation Bangladesh. Impact Foundation Bangladesh is a Charitable and Non-Government Organization started in 1993, with the mission to prevent disability by improving the living conditions of disadvantaged people and communities, as an effective means for achieving the goal of Alleviation of Poverty. Impact "Jibon Tari" Floating Hospital, the first and unique project of its kind in Bangladesh, started its journey in April 1999. The aim of this floating hospital is to provide health services in general, and specialized curative services, both clinical and surgical, and to address the problems of disability in the remote and disadvantaged areas of the country for the benefit of the poorer section of the society.

Health care services:

The available services in the "Jibon Tari" Floating Hospital are:

- Surgical services for correction of disability
- Pathology, X-ray facilities

- Supply of assistive devices
- Physiotherapy treatment
- Awareness raising on health, nutrition and sanitation and their relationship with disability
- Immunisation program
- Training for Traditional Birth Attendants (TBA)
- Training on early detection of disability for school teachers
- Training on early detection of disability for community leaders and health workers

Up to December 2007, 25,162 patients received surgical treatment through Eye, Orthopaedic, ENT, and Plastic and General Surgeries.

Eye	17,438
ENT	2,117
Orthopaedic	4,291
Plastic	653
General	663

Among the eye surgical patients 90 percent were cataract operation and almost 14 percent were young adult (age between 15-49 years) cataract patients (Source: Impact Annual Report 2007).

Table 3 depicts the data on cataract operation done in Impact "Jibon Tari" Floating Hospital in 2007 and 2008. Although this table shows that the proportion of young adults (15-49 years) among patients with mature cataract patients and having an

operation was not so high (approximately 14% of cases), the percentage of young adult (15-49 years) patients among all cataract patients, including those with non-mature cataract and those who did not want to have an operation, would be much higher.

Table 3. Cataract operation done in Impact "Jibon Tari" Floating Hospital during 2007 and 2008

Age group	2007(Jan-Dec)	2008(Jan-Sept)
0-14 years	Total=4 (M=1, F=3)	Total=7 (M=2, F=5)
15-29 years	Total=19 (M=12, F=7)	Total=5 (M=5, F=0)
	=0.96%	=0.29%
30-49 years	Total=220(M=109,F=111)	Total=235(M=122,F=113)
	=11.15%	=13.58%
≥ 50 years	Total=1730(M=1041,F=689)	Total=1448(M=801,F=682)
	=87.68%	=83.70%
	Sub-total=1973	**Sub-total= 1730**

1.2 Literature review

A review of the literature reveals numerous risk factors for cataract. Most risk factors were reported from a variety of study settings, and included both non-modifiable and modifiable exposures. Some risk factors had been identified for specific types of cataracts. According to the International Classification of Diseases Revision 10, cataract is opacity of the crystalline lens or its capsule. As people age cataracts grow progressively darker and dense, preventing light from easily passing through the lens. This results in vision loss. Anatomically there are three main types of cataract; **cortical cataract,** a cataract in which the opacity lies in the cortex of the crystalline lens and the opaque areas are usually oriented radially. **Nuclear cataract** is opacity of the central nucleus of the crystalline lens. **Posterior subcapsular cataract (PSC)** is an opacity involving the posterior segment of the lens, especially the area beneath the posterior lens capsule.

1.2.1 Non-modifiable risk factors

1.2.1.1 Age

Aging is a well established risk factor for development of cataract. Increasing age is associated with an increasing prevalence of cataract.[3] The most common cause of cataract is the deterioration of the normal structure within the lens of the eye with age. Increasing age causes progressive loss of lens protein. One study indicated that posterior sub-capsular cataract is the most common type in people under 70 years old, while nuclear and

mixed cataracts are most common in people over the age of 80.[2] The Beaver Dam Eye Study reported the cumulative incidence of nuclear cataract increased from 2.9% in persons aged 43 to 54 years at baseline to 40.0% in those aged 75 years or older.[19]

1.2.1.2 Sex

A number of epidemiological studies using cross-sectional data had shown an increased prevalence of cataract in women compared with men. Although some had shown an increased prevalence of cataract in general, most had demonstrated an increased prevalence of cortical cataract, with only one study showing an increased prevalence of nuclear cataract.[20] The cause of the sex differences in cataract occurrence is not clear but could be related to the hormonal differences between women and men. Postmenopausal estrogen deficiency may be a factor. Recent epidemiologic data provide some evidence that estrogen and hormone replacement therapy (HRT) may play a protective role in reducing the incidence of age-related cataract and cataract surgery.[21] Data from the Beaver Dam Eye Study, an observational, longitudinal and population-based study of age-related eye disease in Beaver Dam in 1998-2000, had shown that early age of menarche, current and longer duration of estrogen therapy, as well as ever use of the oral contraceptive pill, are protective against nuclear cataract. However, women were more likely than men to have nuclear cataract even after adjusting for age.[19] The Blue Mountains Eye Study found that the risk of cortical and nuclear cataract were greater for female sex.[22]

1.2.1.3 Family history of cataract

Family history of cataract had been found to pose a significantly increased risk in most studies. A population-based study of age-related eye diseases conducted in 1988-1990 in Beaver Dam reported that there was a strong relationship between family history of sibling and age-related cataract even adjusting for age especially nuclear and cortical types.[23] Among the cohort in the Salisbury Eye Evaluation study the probability of development of nuclear cataract was significantly increased among individuals with a sibling with nuclear cataract after adjusting for personal and environmental risk factors for cataract.[24] Another study from Switzerland during 1995-1998 found a positive association between family history of hereditary hyperferritinaemia cataract syndrome and cataract in both mother and sister and mother and brother. Hereditary hyperferritinaemia cataract syndrome is an autosomal dominant hereditary disease characterised by congenital bilateral nuclear cataract.[25] Nevertheless, despite these findings, a case-control study from India failed to identify any association between cataract and family history.[26]

1.2.1.4 Myopia

High myopia is known to be associated with age-related cataracts.[27;28] Only a few population-based studies,[29;30] had attempted to assess the association between high myopia and age-related cataract. Cross-sectional data from the Blue Mountains Eye Study had provided evidence suggestive of an association between high myopia and both nuclear and PSC cataracts. The association between high myopia and nuclear cataract was also supported by

data from the Beaver Dam Eye Study.[30] Nuclear cataract was strongly associated with high axial myopia. The density of the cataract was higher in the high myopia group. No association was observed between PSC or cortical cataract and high axial myopia.[31] Another study found there were associations between myopia and both nuclear and posterior subcapsular opacities. However, no association was found between myopia and cortical opacity. There was strong association between posterior subcapsular opacity and myopia for those wearing glasses by age 21 years and for those without glasses. One study from India reported that myopia in early life is a risk factor for cataract because a myopic shift occurs at an early stage in the development of cataract. Moreover, myopia is expected to play a significant additive role in the ultimate outcome of cataract in combination with other significant risk factors.[24]

1.2.2 Modifiable risk factors

1.2.2.1 Low socioeconomic status and illiteracy

Low socioeconomic condition is always strongly associated with development of cataract. However, the low socioeconomic people in the society generally smoke and use cheaper cooking fuels and suffer from malnutrition, which were identified risk factors for cataract.[26] Another study found, in multivariate analyses after adjusting for all demographic factors and for history of smoking, that females, illiterate persons and those belonging to the extreme lower socioeconomic status group had a significantly higher prevalence of any cataract.[32;33] A population-based survey

from Bangladesh found that age-specific blindness prevalence was greater among illiterate and disadvantaged people.[7]

1.2.2.2 Smoking

Cigarette smoking is an established risk factor for nuclear cataract, and there is growing epidemiologic evidence that smoking is also a risk factor for PSC cataract.[32] Evidence exists that cigarette smokers are more at risk of development of cataract at an earlier age than are non-smokers.[34;35] A study from Australia found strong association between nuclear cataracts and cortical cataracts and heavy cigarette smoking, and also between nuclear cataract and cigar smoking.[36] Another study from Singapore reported that current smoking and low education are associated with nuclear cataract.[37] The same results were found in the Melbourne Visual Impairment Project and the Blue Mountains Eye Study, Australia.[22] Studies from India found that cataracts were significantly associated with smokeless tobacco, after adjusting for age and sex[38] and cigarette and cigar smokers had a significantly higher prevalence of any cataract.[33] Another case-control study among women from India and Nepal found the use of solid fuel, unimproved stoves and unventilated kitchen to be independent risk factors for cataract.[39]

1.2.2.3 Direct sunlight exposure

Working in direct sunlight is another established risk factor for development of cataract. Throughout the world, cataracts are most prevalent in areas where the amount of annual and daily sunlight is high,[40] ambient temperatures are high,[41] and the latitude is

low.[40] These areas receive more solar radiation, which includes ultraviolet and infrared radiation and visible light. The Melbourne Visual Impairment Project, Australia, found there was significantly increased risk of cortical cataract with increased UV-B exposure.[22] However, a study from USA found a history of outdoor work which may involve higher sunlight exposure was not related to an increased risk of lens disease.[42]

1.2.2.4 Anthropometric status

Variation of body mass index (BMI) has also been shown to influence cataract risk, although there is no consensus on direction or nature of the association. Both higher[43] and lower[44;45] BMIs have been associated with increased risk of cataract. A study in Maryland's Eastern Shore, US, found the risk of nuclear opacification was greater in participants with lower BMI (with a BMI of 22.5 compared with 28.0) and of taller stature (with a stature of 170.5 cm compared with 164 cm). After adjusting for age, race, sex, stature, education, smoking and hypertension, risks were reduced but nuclear opacification was still associated with lower BMIs. On the other hand, after adjustment for age, race, sex, alcohol consumption and UV-B, the risk of cortical opacities was greater in those with higher BMI.[29]

1.2.2.5 Size at Birth

It is well established that adverse influences during foetal life including viral infections,[45] metabolic disturbance,[43] and premature birth[46] may lead to congenital cataract. A recent report showed that slow growth in early life with reduced weight at the

age of 1 year was associated with a twofold risk of nuclear cataract.[47] Another study from England found no consistent association between size at birth and age-related cataract. However, men and women born before 37 weeks of gestation were at increased risk of cortical cataract.[30]

1.2.2.6 Dietary salt and antioxidants

The Blue Mountains Eye Study, Australia, found that higher dietary sodium intake was associated with greater risk of PSC cataract.[27;27] It may be that the higher level of extra-cellular sodium might make it more difficult for sodium pumps to maintain the low levels of intracellular sodium required for lens transparency. A prospective cohort study in USA found 10-15% reduction of cataract among women with higher intakes of fruit and vegetable when compared to women with modest intake.[28] The Beaver Dam Eye Study found an association between carotenoid and nuclear cataracts. However, nuclear cataracts were not significantly related to intake of vitamin C or vitamin E.[48] Another randomized clinical trial from USA found no statistically significant effect of the antioxidant formulation on the development or progression of age-related lens opacities.[49] On the other hand, the Blue Mountains Eye Study, Australia, found that higher vitamin E intake was associated with increased risk of PSC and having ever used vitamin A supplements was protective for PSC.[22]

1.2.2.7 Use of cheaper cooking fuel

A case-control study from India has reported that age-related cataract was more common among persons having exposure with less

expensive cooking fuels.[24] However, users of cheaper cooking fuel tended also to be of lower socioeconomic status and this was itself found had an independent association with cataract. Another similar study among women in India and Nepal border areas confirmed that the use of solid fuels in unimproved stoves and a lack of kitchen ventilation were associated with an increasing risk of cataract even after adjusting for outdoor working.[39] A weakness of this study was that they did not adjust for socioeconomic status.

Biological plausibility

Smoking may damage the lens. Damage appears not to be related to the nicotine in tobacco, but more generally and commonly from tobacco, coal, wood, cooking fuel or automobile fuel. The damaging mechanism is claimed to be oxidative stress by reactive oxygen species either among the smoke constituents or generated endogenously by photodynamic action in response to smoke constituents. These smoke constituents might be absorbed directly or, more likely, absorbed systemically.[39] Free radicals, such as Cd and Fe, produced by smoke may also damage the lens protein and fibrous cell membrane of lens by its direct action.

1.2.2.8 Parity

Having more than three births had been reported to double the risk of cataract. After adjustment for effects of age, outdoor work and BMI, the risk increased by an estimated 20% for each additional birth, according to a study among young adult women in India.[50] Multiple child bearing is common among those people of low

socioeconomic condition, which is individual risk factor for cataract.

Biological plausibility

The birth effect seems to be mediated through the potentially adverse local practice of fluid abstention after birth, which is likely to result in severe dehydration, a factor shown to be strongly associated with cataract. Other possible explanations for the relationship with higher parity are the increasing exposure to episodes of acute nutritional deficiencies with increasing number of births; the higher exposure to episodic increase in blood urea levels leading to cyanate-induced carbamylation of lens proteins, and the exposure to episodes of hyperglycemia during pregnancy leading to glycation of lens proteins. Furthermore, there may be a complex of other adverse factors related to the stress of many pregnancies and the care of many babies.[50]

1.2.2.9 Diabetes mellitus

A 5-year follow-up study conducted in Australia from 1997 to 1999 reported diabetes mellitus and having taken calcium channel blockers for longer than 5 years to be independent risk factors for PSC cataract[36] Another similar study from Boston, USA, a part of the Nurses' Health Study cohort, reported women with diabetes were significantly more likely to have posterior subcapsular opacities than were women with fasting plasma glucose concentrations <6.1 mmol/L. Diabetes and measures of adiposity were unrelated to the prevalence of cortical and nuclear opacities.[51] The Beaver Dam Eye Study reported that statin use in

a general population appeared to be associated with lower risk of nuclear cataract, the most common type of age-related cataract.[52]

1.2.2.10 Severe dehydration

A series of case-control studies from India reported that there were strong marked, consistent and dose-dependent associations between exposure to dehydration, history of episodes of severe life threatening diarrhoea and/or heatstroke and the risk of cataract. The study suggested that severe diarrhoea is a major risk factor in early development of cataract.[53;54] Another group-matched hospital-based case-control study of 463 cases and equal number of controls, carried out at the Government Medical College and Hospital, Nagpur, also identified significant association between dehydrational crisis from severe diarrhoea and age-related cataract.[55] However, a case-control study carried out in the state of Tamil Nadu, southern India, did not support an increased risk of cataract in persons with a positive history of severe diarrhoea.[56]

1.3 Rationale

The percentage of blindness due to cataract is still high in Bangladesh comparing with many other countries. According to a recent population-based survey in Bangladesh, about 130,000 new cataract cases develop annually[7] and the proportion of young adult cases is significantly high. Previous data from Impact "Jibon Tari" Floating Hospital also indicated that among all eye surgical patients around 90% were cataract operation and 14% were young adult (age between 18-45 years) cataract patients. The

proportion of young adults is higher in Bangladesh than in many other countries, suggesting that there might be some specific risk factors for early onset of cataract in this population or that known risky exposures are occurring earlier or at a more intense level that in other settings where the prevalence is lower and the onset generally at a later age.

Despite the availability of modern high-quality operative procedures and approximately 500 trained ophthalmologists in Bangladesh, the service is not sufficient for the large population (around 140 million in 2005) of the country. Efforts should therefore be taken in attempts to reduce the incidence of cataract in Bangladesh, and to do this a reliable identification of the major risk factors operating in this setting is required.

It is clear that several of the known risk factors are prevalent among the rural Bangladeshi population, such as low socioeconomic status and illiteracy, working in sunlight, use of cheaper biomass cooking fuel, and high parity among females. Among these, the most readily modifiable factor is the use of biomass cooking fuel, followed, perhaps, by high parity of females. Both of these variables have been identified to be risk factors for cataract in India and Nepal.[26;50]

Most rural households in Bangladesh are of low socioeconomic status and commonly use wood, leaves, cow-dung or rice straw for household cooking. Most cooking stoves are of open type, which does not control the smoke or vent the smoke to the outside. Rural people in general, and the women in particular, are therefore exposed to the smoke from these biomass fuels from an early age.

High parity among Bangladeshi females is reflected in the average household size in Bangladesh of 4.8 (2005)[14] and this tends to be higher in families of lower socioeconomic status.

This research, therefore, aimed primarily to identify the role of these two variables, use of biomass fuels and high parity, as factors related to the development of early adult cataract in rural Bangladesh. Biomass fuels themselves comprise a number of different types, and this study aimed to identify the separate effects of these different types. Few previous studies have addressed this issue. It is expected that the findings of this study may indicate possible approaches for future policy-making to prevent cataract.

1.4 Objectives

1.4.1 *General objective*

To identify the potential modifiable risk factors for young adult cataract.

1.4.2 Specific objectives

1. To compare the background characteristics of young adult cataract patients and those without cataract in the study.

2. To find the independent associations between the use of cheaper cooking fuel such as wood/dry leaves, cow dung and rice straw and young adult cataract in rural Bangladesh after adjustment for exposures to other previously identified risk factors.

3. To determine if high parity is independently associated with young adult cataract among females after controlling for exposures to other previously identified risk factors.

1.5 Research questions

1. Is a history of using cheaper cooking fuel such as wood or leaves, cow dung and rice straw associated with the development of cataract in young adults in rural Bangladesh?

2. Is high parity associated with the development of cataract in young adult females in rural Bangladesh?

1.6 Research hypotheses

1. The proportion of young adult patients with cataract having a history of exposure to smoke from wood or leaves, cow-dung and rice straw used in cooking is higher than that in patients of similar age and same sex with other eye diseases or in patients with non-eye disease.

2. The proportion of young adult female patients with cataract having high parity is higher that among similarly aged patients with other eye diseases or in patients with non-eye disease.

Chapter 2: Methodology

Overview

This case-control study was carried out at Impact "Jibon Tari" Floating Hospital in Bangladesh between April and October 2009. Cases of cataract coming to visit the eye specialist at this hospital were recruited as study cases if they satisfied predetermined inclusion and exclusion criteria. For each case, two age- and sex-matched controls were selected, one from the Eye Department patients with eye problem other than cataract and the other from ENT or Orthopedics Department in the same hospital. One hundred and fifty three subjects were included in the case group and in each of the control groups.

Information regarding history of cooking and exposure to different types of cooking fuel and socio-demographic and other characteristics were obtained using an interviewer-administered questionnaire. The association between history of exposure to various cooking fuel types and case status was determined using univariate and multivariate conditional logistic regression techniques.

2.1 Conceptual framework

Aging is the most common risk factor for development of cataract. Usually people age over 50 years are at greater risk of developing cataract. From previous literature review female gender, family

history of cataract and myopia are established known risk factors and are non-modifiable. Nutritional deficiency, exposure to cheaper cooking fuels, sunlight exposure, multi-parity and illiteracy have been linked with an increased risk of cataract, are themselves all associated with low socioeconomic condition.

Figure 1: The conceptual framework of the study

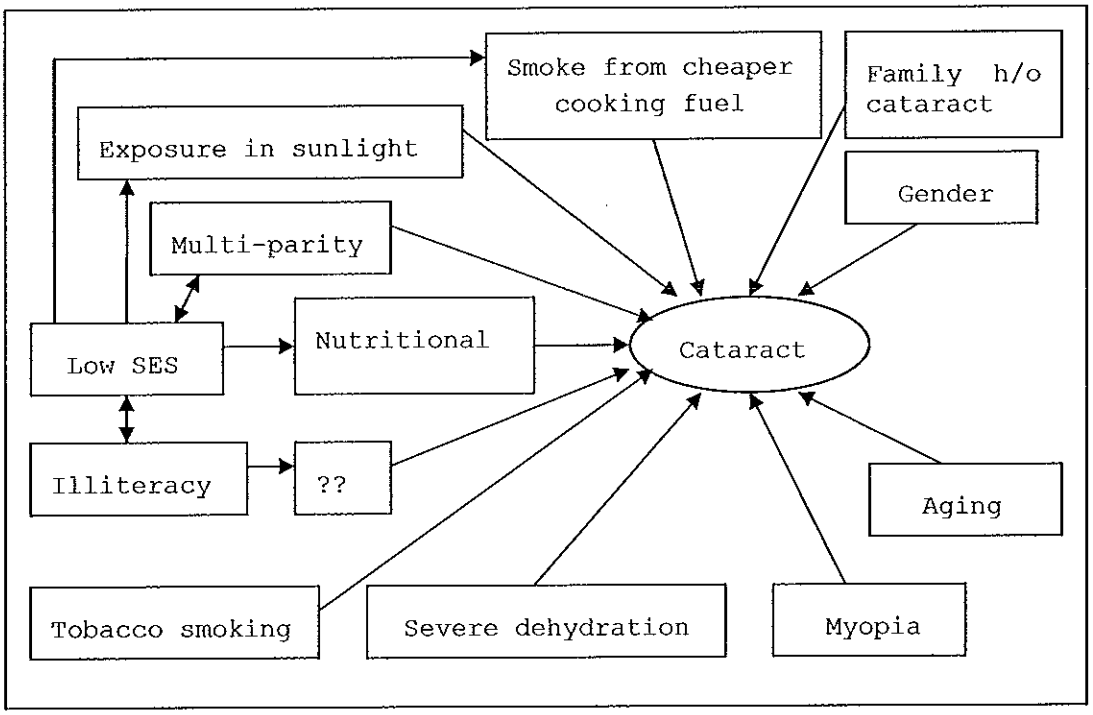

Figure 1: Conceptual framework

From previous studies nutritional deficiency, exposure to cheaper cooking fuels, sunlight exposure, multi-parity and illiteracy are risk factors for cataract that may be modifiable. Tobacco smoking and severe dehydration had also been identified as potentially modifiable risk factors for cataract in many previous studies. Some literature has reported that illiteracy is a risk factor for cataract but the relationship between illiteracy and cataract is not clear.

2.2 Study design

This study was designed as a hospital-based matched case-control study with two age- and sex-matched control groups.

2.2.1 Rationale for the choice of case-control design

Case-control studies can evaluate a range of exposures related to a rare disease. Young adult cataract is a relatively rare disease. The evaluation of effects on rare diseases is problematic in cohort studies, but rare diseases are well suited to case-control studies. On the other hand, case-control studies are inefficient for the evaluation of the effects of exposures that are rare in the source population for the cases. In fact, history of using cheaper cooking fuels such as wood, leaves, straw and animal dung are very common exposures in the source population.

Case-control studies are relatively simple and economical to carry out and are increasingly used to investigate risk factors for disease. Thus this design is suitable for a study undertaken in developing countries, especially a poor country like Bangladesh, where the budget is very limited.

Cohort studies require a long time for follow-up (depending on the latent period between the exposures to the outcome). But in this study of the association between young adult cataract and exposure to cheaper cooking fuels, the latent period between exposure to cooking fuels and the outcome young adult cataract is not known exactly. Therefore, case-control design is a good choice. Case-control studies can reduce the time consumed even in studying a disease with long latent period between exposure and outcome. A

case-control study introduces few ethical problems compared to cohort study.

2.2.2 Explanation for the design of two control groups

By selecting all young adult (18-49 years of age) cataract cases that came to visit an ophthalmologist in the study hospital we could obtain a case group including subjects who represented all the cases from a specific population. The more difficult task was to select controls in this study. The most appropriate controls should be subjects drawn from the same source population but not having developed cataract. However, as this was a hospital-based study - which has the potential advantage of reducing information bias - the controls would be subjects with some health problem other than cataract. On one hand, if only patients with eye disease other than cataract were used as controls, there may have too much similarity in exposure history with the cases and we may fail to identify important exposures. On the other hand, the provision of health services for eye-disease is a major component of the overall health services of this hospital, thus a large proportion of patients attending the hospital are those with eye-problems. The way chosen to solve this problem was to choose two types of control subjects: one from patients with non-eye disease (NE) and the other from patients with non-cataract eye disease (NC). The NE controls patients were selected from the ENT and Orthopedics Departments. Each control was matched with the case on sex and age group, and comparisons of exposures between cases and each control group were made separately for the case-control

comparisons using matched tabulation and conditional logistic regression modeling.

2.3 Study setting

The study was conducted in Impact "Jibon Tari" Floating Hospital, Bangladesh.

2.4 Study population

Males and females aged between 18-49 years old who came to visit Impact "Jibon Tari" Floating Hospital, Bangladesh, during the study period from May to October 2009. As a mobile floating hospital, during the studied period it was located in Barisal district, in the south-west of Bangladesh, a region criss-crossed by many rivers.

2.5 Study sample and sample selection

Case recruitment: All patients who came to visit the eye specialist in Impact "Jibon Tari" Floating Hospital during the study period and diagnosed as cataract were recruited as cases in this study.

2.5.1 Cases (CS)

Definition of cataract:

Cataract case was an ophthalmologic patient age between 18-49 years diagnosed by an ophthalmologist under clinical and slit-lamp examination showing any opacity of the crystalline lens or its capsule and having decreased visual acuity poorer than 6/18 on the Log Mar Visual Acuity Chart.

Or, his/her cataract had been already removed by a qualified ophthalmologist within the previous 5 years.

Inclusion criteria:

1. Patients diagnosed as cataract by an eye specialist according to pre-defined cataract criteria.

2. Age between 18-49 years.

Exclusion criteria:

1. Unable to speak.

2. Congenital cataract.

3. Severe mental disorders.

4. Cataract secondary to serious eye disease such as glaucoma, diabetes retinopathy and severe injury.

2.5.2 Non-cataract eye-disease (NC) controls

Non-cataract eye-disease controls: Non-cataract eye-disease controls were selected from among patients attending in the same hospital with an eye problem other than cataract and matched 1:1 with cases on age (within same 5-year age range) and sex.

Inclusion criteria:

1. Age between 18-49 years.

2. Had eye problem other than cataract.

3. Had no diagnostic criteria for cataract.

Exclusion criteria:

1. Severe mental disorders.

2. Unable to speak.

2.5.3 Non-eye disease (NE) controls

Non-eye-disease controls: Non-eye-disease control subjects were selected from patients without any eye problem but attending other departments available in the same hospital and 1:1 matched to cases on age (within same 5-year age range) and sex. Potential subjects were recruited alternately from among out-patients fulfilling the inclusion criteria in the ENT and Orthopedics departments on the same or following working day as the case to which they were matched.

Inclusion criteria:

1. Age between 18-49 years.
2. No history of prior cataract/eye surgery.
3. No eye problem within last 3 months.

Exclusion criteria:

1. Known case of myopia.
2. Severe mental disorders.
3. Unable to speak.

2.5 Sample size calculation

Sample size calculation was based on the theory developed by Dupont (1988) for matched case-control studies.[57]

For the 1st hypothesis, we assumed the proportion of exposures among the control population to be 40%, one control per case, correlation coefficient between cases and controls to be 0.14,

odds ratio to be detected as significant at an alpha of 0.05 equal to 2.0, and power required 80%.

Then the required number of cases and of controls is 153.

The total required number of subjects therefore would be 153 cases, 153 NE controls and 153 NC controls, or a total number of enrolled subjects of 153*3 = 459.

For the 2nd research hypothesis:

Slightly more than half of the subjects were expected to female (say about 77). Because of this small number, it was decides to combine the two types of control into a single control group, so that the matching ratio would 1 case : 2 controls.

We assumed the proportion of exposures among the control population to be 40%, 2 controls per case, and correlation coefficient between cases and controls to be 0.14. This would provide a power of 80% to detect an odds ratio of 2.3 as significant at an alpha of 0.05, and was considered adequate for this second objective.

2.6 Variables

Table 4. Independent variables

Variable	Method of data collection	Scale of measurement
Age	Questionnaire	Continuous
Sex	Questionnaire	Categorical
Literacy	Questionnaire	Categorical
Socioeconomic status	Questionnaire	Ordinal
Smoking history	Questionnaire	Ordinal
Myopia in early life	Questionnaire	Dichotomous
Family history of cataract	Questionnaire	Dichotomous
Exposure to sunlight	Questionnaire	Ordinal
BMI (ht. and wt.)	Measurement	Continuous
Use of cheaper cooking fuel	Questionnaire	Categorical/ordinal/ continuous
Parity	Questionnaire	Ordinal

Table 5. Dependent/outcome variable

Variable	Data collection	Scale of measurement
Cataract in young age	Ophthalmic examination	Dichotomous

2.7 Operational definitions

Young adult cataract: was defined as cataract in a patient aged between 18 and 49 years.

Low SES: was based on the lower and upper-lower categories of modified Kuppuswamy's classification for socio-economic status.

The **modification of Kuppuswami scale** meant to determine the socioeconomic status of family based on education and occupation of head of the family and per capita income per month.

Kuppuswami's classification: It is based on education, occupation and income of **family head:**

Table 6. A. Education

Educational level	Score
Professional Degree, PG and above	7
Graduate	6
Intermediate or Past High School Diploma	5
High School Certificate	4
Junior High School Completion	3
Primary School or Literate	2
Illiterate	1

Table 7. B. Occupation

Occupation	Score
Professional(Teacher, Physician, Engineer etc.)	12
Semi Professional (who change the profession on time)	10
Clerk, Shop Owner, Farm Owner	6
Skilled Worker	4
Semi Skilled Worker	3
Unskilled Worker	2
Unemployed	1

Table 8. C. Per capita income (Taka per month) is adjusted with Bangladesh currency, Taka (Tk)

Per capita income (Taka/month)	Score
30001 and more	12
15001-30000	10
10001-15000	6
7001-10000	4
5001-7000	3
2001-5000	2
Below 2000	1

Table 9. The total score is graded as follows

Socio-economic status	Score
Upper	26-29
Upper Middle	16-25
Lower Middle	11-15
Upper Lower	5-10
Lower	<5

Cheaper cooking fuels:

Parameters of use of wood or dry leaves, cow dung and rice straw for cooking were recorded as follows:

- Ever use; {Recorded in yes/no}
- Age of first cooking; {Recorded in years}
- How many times cooked per day? {Recorded times/day}
- How many days cooked per week? {Recorded as days/week}
- How long cooked for each time? {Recorded hours/time}
- First started use of fuel of each type {Recorded}
- Last stopped use of fuel of each type {Recorded}
- If used more than one type of fuel together then;

Percentage of using of each specific types of cooking fuels in the previous 5 years and 1 year.

Finally;

- Duration (years) = age of stopping - age of starting

- Frequency (times/week) = times/day * days/week
- Intensity (hours/week) = hours/time * times/day * days/week
- Lifetime exposure (hours) = intensity * 52 * duration

Parity: number of pregnancies of married women. (Additional questions were asked about mode and place of delivery and number of children.)

Smoking status: number of cigarettes or biri/day and duration of smoking were recorded.

Early myopia: was specified by history or clinical examination.

Sunlight exposure: average hours/day direct occupational exposure to sunlight and lifetime duration of exposure in years.

Outcome variable (young adult cataract): was determined by questionnaire and ophthalmic examination. Either the patient had cataract or not. It was determined by:

1. Any opacity of the crystalline lens or its capsule found under slit-lamp examination by an ophthalmologist.

2. Or, his/her cataract had been already removed by a qualified ophthalmologist within the previous 5 years.

3. Age between 18-49 years.

4. Might be one or both eyes.

2.8 Data processing and management

2.8.2 Data collection

Data were collected by semi-structured questionnaire through personal face-to-face interview and clinical examination. The questionnaire covered general socio-demographic characteristics, details of cooking history and exposure to various cooking fuels, and other previously documented risk factors for cataract.

History of exposure to cooking fuels was recorded on a matrix table comprising fuel types in rows and age (years 11 to 49) in columns. Information was also obtained regarding the number of cooking sessions per day, hours spent cooking per session and number of days when cooking was done per week. These data were used to derive parameters of frequency, intensity, duration and cumulative lifetime exposure to each cooking fuel type.

Written informed consent was requested from all respondents before their participation. For participants who were willing but could not sign, a fingerprint was taken after explaining the research process.

2.8.3 Preparatory phase

Tools and technique for the study were finalized after consultation with assigned advisors in PSU and Bangladesh. After finalization of the questionnaire, readability of the instrument was tested in Bangladesh at a hospital in a similar setting to that of the main study.

As patient recruitment and data collection involved a number of staff of the hospital, an explanation and training session was held among the supporting staff, nurses and doctors in the hospital, to ensure consistency of patient recruitment and data collection methods and adherence to the study protocol. Setting-up of the study procedures was undertaken in collaboration with the research supervisor from PSU during an on-site visit.

2.8.4 Collecting phase

Participants were included from the Eye, ENT and Orthopedic Departments of the hospital. Each patient who came to visit for eye consultation going through an ophthalmic examination and diagnosed as cataract was enrolled as a case. Following acceptance of each cataract patient the next patient with diagnosed eye disease other then cataract and matched to the case on age (in same 5-year age range) and sex was enrolled as the non-cataract eye-disease (NC) control subject.

For non-eye disease (NE) control, after enrolling each case into the study the researcher waited in the ENT and Orthopaedic Departments and the 2nd patient matched to the case on age (in same 5-year age range) and sex was selected as the NE subject. If possible, non-eye disease control subjects were selected alternately from ENT and Orthopaedic Departments. The case and control ascertainment algorithm is shown in Figure 2.

Figure 2: The recruitment of the subjects in the study

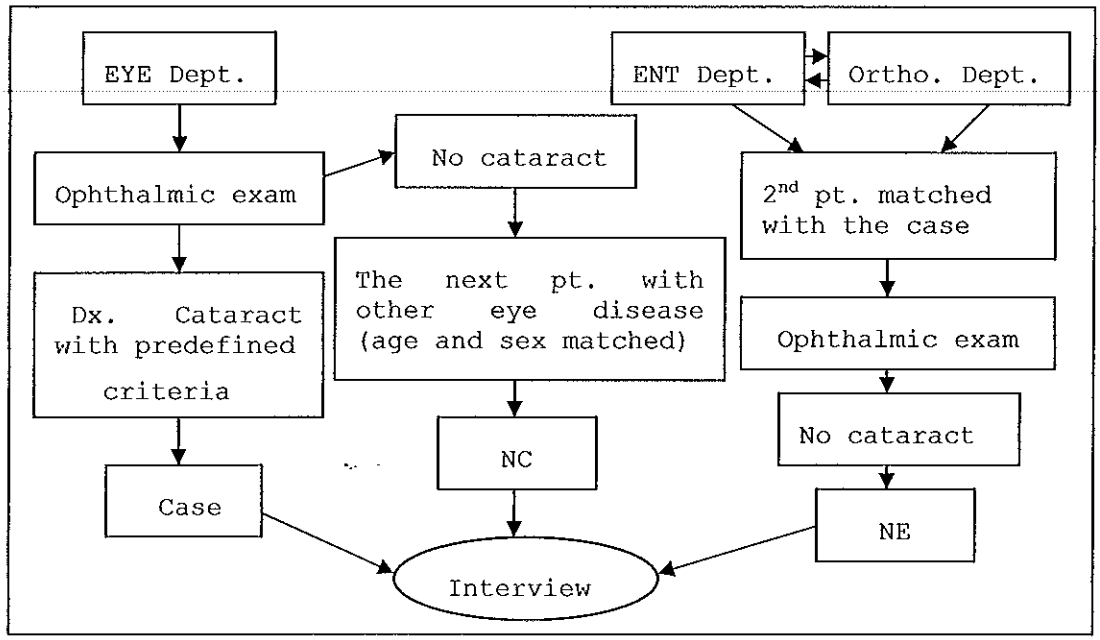

Figure 2: Data collection procedure

2.8.5 Data management and statistical analysis

Quality control of data was done concurrently, daily or on a day-after basis. All interview questionnaires were checked for completeness, correctness and internal consistency to find out missing or inconsistent data.

The results in the questionnaire and ophthalmic examination record data were entered into the computer using EpiData version 3.1[58] and transferred into R version 2.10.0[59] for cleaning, exploration and analysis. The distributions of variables were explored and summarized within each outcome group using mean and standard deviation or frequency. Tabulation of independent variables was performed for matched pairs of case vs non-eye-disease control and for case vs eye-disease control. Those variables showing any

indication of differing within the matched pairs in either comparison ($p \leq 0.3$), in addition to selected parameters of cooking fuel use, were included in initial conditional logistic regression models for matched pairs of case vs NE control and of case vs NC control, and the models refined by successive removal of variables showing no statistically significant contribution to the fit of either model, other than the selected cooking fuel variables, which were retained in the models irrespective of their statistical significance. Likelihood ratio test p-values ≤ 0.05 were considered as indicating statistical significance.

After initially fitting categorical cooking-fuel-exposure variables in the models, associations between case status and alternative, ordinal, parameters of cooking fuel use were then explored among these fuels to identify any dose-response relationships. These ordinal exposure variables comprised frequency (times per week during the years used), intensity (hours per week during the years used), duration (years) and lifetime exposure (lifetime hours of use). Each variable was cut into three levels: never used, used for less than or equal to the median among all users, and greater than the median for all users. These variables were fitted first in categorical form and subsequently in trend-across-category form.

To evaluate the effect of matching, additional analyses were performed using multinomial logistic regression modeling.

2.9 Ethical considerations

Ethical approval was sought and received from the Ethics Committee of the Faculty of Medicine, Prince of Songkla University, Thailand, and an oral approval was granted after a detailed presentation of the research proposal within the management of Impact Foundation Bangladesh, the authority of the study hospital, before conducting the study. Written informed consent was taken from all respondents before their participation. For participants who could not sign, a fingerprint was taken after explaining the research process. All potential participants in the study were informed that the study was aimed at identifying certain behaviours that might increase the risk of their developing ailments common in rural Bangladesh. Only after the patient gave signed consent was the interview conducted. Computerized data did not indicate the identity of any patient.

Chapter 3: Results - Use of cheaper biomass cooking fuels

3.1 General characteristics of cases and controls

3.1.1 Distribution of socio-demographic characteristics of study sample

A total of 459 subjects, including 153 cataract cases aged between 18-49 years with an equal number of each control group matched on age and sex, were recruited and interviewed. The distributions of the socio-demographic characteristics among the cases and controls are given Table 10.

There were slightly more females than males. The mean age of the all participants was 41.8 (SD. 6.3) years and 30 percent were aged 40 or less. In all groups, most of the females were housewives, the commonest occupation among males was farmer, and about 80 percent were classified as having low socioeconomic status as measured on the modified Kuppuswami scale using education, occupation and income of the family head. Around 70 to 75 percent of subjects were classified as being underweight. Very few subjects reported a history of diagnosis of hypertension or diabetes mellitus (Table 10).

Cases had less commonly received secondary or tertiary education than controls, particularly NE controls, and more commonly

reported a history of current or past smoking and a greater occupational exposure to sunlight. Cases also more frequently reported a family history of cataract.

Table 10. Distribution of socio-demographic characteristics among cases and controls

Variable	Case (CS) N (%)	NE control N (%)	NC control N (%)
Age in years (mean ± SD)	42.0 ± 6.1	41.8 ± 6.6	41.5 ± 6.1
Age group			
18 - 20	1 (0.7)	5 (3.3)	2 (2.0)
21 - 30	10 (6.5)	5 (3.3)	7 (4.6)
31 - 40	36 (23.5)	36 (23.5)	36 (23.5)
41 - 49	106 (69.3)	107 (69.9)	107 (69.9)
Sex			
Male	73 (47.7)	73 (47.7)	73 (47.7)
Female	80 (52.3)	80 (52.3)	80 (52.3)
Religion			
Muslim	91 (59.5)	83 (54.2)	75 (49.0)
Others	62 (40.5)	70 (45.8)	78 (51.0)
Marital status			
Single	7 (4.6)	6 (3.9)	5 (5.3)
Married	139 (90.8)	137 (89.5)	144 (94.1)
Education			
No education	61 (39.9)	54 (35.3)	55 (35.9)
Primary	73 (47.7)	54 (35.3)	65 (42.5)
Secondary	19 (12.4)	45 (29.4)	33 (21.6)
Occupation			
Farmer	26 (17.0)	30 (19.6)	26 (17.0)
Housewife	76 (49.7)	69 (45.1)	72 (47.1)
Labour	11 (7.2)	10 (6.5)	9 (5.9)
Business	12 (7.8)	14 (9.2)	13 (8.5)
Teacher	3 (2.0)	3 (2.0)	7 (4.6)
Others	25 (16.3)	27 (17.6)	26 (17.0)

Table 10. Distribution of socio-demographic characteristics among cases and controls (cont.)

Variable	Case (CS) N (%)	NE control N (%)	NC control N (%)
Household members			
≤4	39 (25.5)	40 (26.1)	41 (26.6)
5-7	93 (60.8)	94 (61.4)	86 (56.2)
>7	21 (13.7)	19 (12.4)	26 (17.0)
Household income (in previous year) Taka/month			
≤3000	50 (32.7)	50 (32.7)	31 (20.3)
3001-7500	66 (43.1)	65 (42.5)	84 (54.9)
>7500	37 (24.2)	38 (24.8)	38 (24.8)
Socioeconomic status			
Lower	127 (83.0)	120 (78.4)	124 (81.0)
Middle	26 (17.0)	33 (21.6)	29 (19.0)
Body Mass Index (BMI)			
Underweight	116 (75.8)	111 (72.5)	106 (69.3)
Normal	27 (17.6)	34 (22.2)	40 (26.1)
Overweight	8 (5.2)	8 (5.2)	7 (4.6)
Hypertension			
Yes	5 (3.3)	5 (3.3)	1 (0.7)
No	148 (96.7)	148 (96.7)	152 (99.3)
Diabetic mellitus			
Yes	0 (0.0)	2 (1.3)	2 (1.3)
No	153 (100.0)	151 (98.7)	151 (98.7)
Myopia			
Yes	5 (3.3)	0 (0.0)	14 (9.2)
No	148 (96.7)	153 (100.0)	139 (90.8)
Family history of cataract			
Yes	54 (35.3)	26 (17.0)	29 (19.0)
No	99 (64.7)	127 (83.0)	124 (81.0)
Hx of working in sunlight			
Yes	125 (81.7)	110 (71.9)	121 (79.1)
No	28 (18.3)	43 (28.1)	32 (20.9)

Table 10. Distribution of socio-demographic characteristics among cases and controls (cont.)

Variable	Case (CS) N (%)	NE control N (%)	NC control N (%)
Years of sunlight exposure			
>18yr	70 (45.8)	51 (33.3)	54 (35.3)
≤18yr	55 (35.9)	59 (38.6)	67 (43.8)
Not exposed	28 (18.3)	43 (28.1)	32 (20.9)
Smoking status			
Current or past	55 (35.9)	45 (29.4)	36 (23.5)
Never smoked	98 (64.1)	108 (70.6)	117 (76.5)
Current no. cigarettes /day			
>10	25 (16.3)	22 (14.4)	12 (7.8)
≤10	17 (11.1)	15 (9.8)	17 (11.1)
None	111 (72.5)	116 (75.8)	124 (81.0)

Over half of the NE controls (56.2%) were diagnosed with various ear diseases, followed by nasal, throat, and orthopedic diseases. Among NC controls, refractive error, corneal diseases and conjunctival diseases were most common (Table 11).

Table 11. Distribution of diagnosed diseases among case and controls status

NE control		NC controls	
Diseases	**N (%)**	**Diseases**	**N (%)**
Ear diseases	86 (56.2)	Refractive error	47 (30.7)
Nasal diseases	15 (9.8)	Corneal diseases	42 (27.5)
Throat diseases	13 (8.5)	Conjunctival diseases	30 (19.6)
Orthopedics diseases	11 (7.2)	Lacrimal tract disease	8 (5.2)
Others	28 (18.3)	Others	26 (17.0)

3.1.2 Univariate analysis of factors related to socio-demographic characteristics by case status.

Crude matched odds ratios and 95% confidence intervals (95% CI) of variables related to socio-demographic characteristics using univariate conditional logistic regression analysis of case vs NE control and of case vs NC control groups are shown in Table 12.

Table 12. Univariate analysis of socio-demographic status among cases and controls

Variables	Case vs NE controls		Case vs NC controls	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Religion		0.352		0.073
Muslim	1.24 (0.79,1.96)		1.50 (0.96,2.35)	
Others	1(ref)		1(ref)	
Marital status		0.713		0.400
Single	1(ref)		1(ref)	
Married	0.83 (0.22,3.13)		0.60 (0.14,2.51)	
Divorce/widow	0.56 (0.11,2.82)		1.50 (0.17,13.23)	
Education		< 0.001		0.082
No education	2.89 (1.45,5.76)		2.07 (1.01,4.21)	
Primary	3.49 (1.73,7.03)		2.09 (1.04,4.18)	
Secondary	1(ref)		1(ref)	
Household members		0.931		0.637
≤4	1(ref)		1(ref)	
5-7	1.02 (0.579,1.736)		1.14 (0.67,1.93)	
>7	1.16 (0.52,2.57)		0.83 (0.39,1.76)	
Occupation		0.556		0.754
Farmer	0.80 (0.14,4.48)		1.87 (0.41,8.46)	
Housewife	2.50 (0.36,17.19)		3.44 (0.66,18.04)	
Labour	1.09 (0.18,6.68)		2.31 (0.5,10.61)	
Business	0.74 (0.13,4.18)		1.67 (0.32,8.69)	
Teacher	1(ref)		1(ref)	
Others	0.89 (0.16,4.97)		1.89 (0.41,8.74)	
Household income (in previous year) taka/month		0.990		0.039
≤3000	1.03 (0.55,1.93)		1.65 (0.85,3.21)	
3001-7500	1.04 (0.6,1.8)		0.81 (0.45,1.46)	
>7500	1(ref)		1(ref)	

* P value from likelihood ratio test of univariate conditional logistic model

Table 12. Univariate analysis of socio-demographic status (cont.)

Variables	Case vs NE controls		Case vs NC controls	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Socioeconomic status		0.326		0.639
Lower	1.32 (0.76,2.29)		1.16 (0.63,2.14)	
Middle	1(ref)		1(ref)	
Body Mass Index (BMI)		0.596		0.181
Underweight	1.29 (0.73,2.29)		1.60 (0.92,2.76)	
Normal	1(ref)		1(ref)	
Overweight	1.49 (0.52,4.22)		2.11 (0.72,6.16)	
Hypertension		1		0.088
Yes	1.00 (0.30,3.45)		5.00 (0.58,42.8)	
No	1(ref)		1(ref)	
Family history of cataract		< 0.001		< 0.001
Yes	2.40 (1.42,4.04)		2.79 (1.51,5.13)	
No	1(ref)		1(ref)	
Hx of working in sunlight		0.054		0.579
Yes	1.65 (0.98,2.77)		1.17 (0.68,2.01)	
No	1(ref)		1(ref)	
Years of sunlight ex.		0.03		0.083
Ex.>18yr	1.30 (0.73,2.32)		0.78 (0.4,1.52)	
Ex.≤18yr	2.24 (1.2,4.2)		1.57 (0.85,2.92)	
Not expose	1(ref)		1(ref)	
Smoking status		0.084		< 0.001
Current or past	1.83 (0.91,3.7)		3.37 (1.53,7.43)	
Never smoked	1(ref)		1(ref)	

* P value from likelihood ratio test of univariate conditional logistic regression model

3.2 Distribution of cooking history and exposure to cooking fuels types by case/control status

3.2.1 Distribution of cooking history

Cooking history and exposure to various types of cooking fuels among subjects in each group are shown in Table 13.

About two thirds of subjects in each group reported a history of cooking, either regularly or occasionally. The commonest fuel used for cooking in all groups was wood and/or dry leaves, followed respectively by cow-dung and rice straw. Further analysis of cooking fuel exposure was confined to these three groups of cooking fuels. Gas or kerosene was used by only a small number of subjects in any group. The proportion of cases using rice straw was higher than that of either of the controls, whereas the proportion of cases using cow-dung was lower than that in each control group. The lifetime duration of cooking activities was somewhat higher among cases than either of the control groups. Exposure parameters explored included duration from first to most recent exposure in years (irrespective of the intensity or frequency of exposure), intensity of exposure, frequency of exposure (times per week), and total lifetime exposure (in hours of actual exposure). However, none of these differentials was statistically significant.

Table 13. Distribution of parameters of cooking history and cooking fuel use among cases and controls

Variable	Case (CS) N (%)	NE control N (%)	NC control N (%)
Cooking history:			
Ever cooked			
Yes	108 (70.6)	100 (65.4)	105 (68.6)
No	45 (29.4)	53 (34.6)	48 (31.4)
Frequency			
Regular	87 (80.6)	84 (84.0)	83 (79.0)
Occasionally	21 (19.4)	16 (16.0)	22 (21.0)
Cooking place			
Living house	33 (30.6)	21 (21.0)	20 (19.0)
Separate house	75 (69.4)	79 (79.0)	85 (81.0)
Duration of cooking			
≤26 yr	53 (49.1)	48 (48.0)	65 (61.9)
>26 yr	55 (50.9)	52 (52.0)	40 (38.1)
Times/cook/day			
≤2/day	100 (92.6)	91 (91.0)	93 (88.6)
>2/day	8 (7.4)	9 (9.0)	12 (11.4)
Hour/cook			
≤2hr/time	90 (83.3)	81 (81.0)	94 (89.5)
>2hr/time	18 (16.7)	19 (19.0)	11 (10.5)
Gas:			
Ever used			
Used	0 (0.0)	3 (2.0)	4 (2.6)
Never used	153 (100.0)	150 (98.0)	149 (97.4)
Kerosene:			
Ever used			
Used	4 (2.6)	4 (2.6)	3 (2.0)
Never used	149 (97.4)	149 (97.4)	150 (98.0)

Table 13. Distribution of parameters of cooking history and cooking fuel use among cases and controls (cont.)

Variable	Case (CS) N (%)	NE control N (%)	NC control N (%)
Wood /dry leaves:			
Ever used			
Used	106 (69.3)	95 (62.1)	102 (66.7)
Never used	47 (30.7)	58 (37.9)	51 (33.3)
Frequency of use			
Never used	47 (30.7)	58 (37.9)	51 (33.3)
Used ≤14times/wk	98 (64.1)	85 (55.6)	90 (58.8)
Used >14times/wk	8 (5.2)	10 (6.5)	12 (7.8)
Intensity of use			
Never used	47 (30.7)	58 (37.9)	51 (33.3)
Used ≤20hr/week	64 (41.8)	50 (32.7)	56 (36.6)
Used >20hr/week	42 (27.5)	45 (29.4)	46 (30.1)
Duration of use			
Never used	47 (30.7)	58 (37.9)	51 (33.3)
Used ≤26yr	52 (34.0)	43 (28.1)	61 (39.9)
Used >26yr	54 (35.3)	52 (34.0)	41 (26.8)
Life time exposure			
Never used	47 (30.7)	58 (37.9)	51 (33.3)
Used ≤25000 hr	55 (35.9)	44 (28.8)	52 (34.0)
Used >25000 hr	51 (33.3)	51 (33.3)	50 (32.7)
Rice straw:			
Ever used			
Used	29 (19.0)	18 (11.8)	22 (14.4)
Never used	124 (81.0)	135 (88.2)	131 (85.6)
Frequency of use			
Never used	124 (81.0)	135 (88.2)	131 (85.6)
Used ≤14times/wk	25 (16.3)	18 (11.8)	21 (13.7)
Used >14times/wk	4 (2.6)	0 (0.0)	1 (0.7)
Intensity of use			
Never used	124 (81.0)	135 (88.2)	131 (85.6)
Used ≤20hr/week	16 (10.5)	10 (6.5)	12 (7.8)
Used >20hr/week	13 (8.5)	8 (5.2)	10 (6.5)

Table 13. Distribution of parameters of cooking history and cooking fuel use among cases and controls (cont.)

Variable	Case (CS) N (%)	NE control N (%)	NC control N (%)
Duration of use			
Never used	124 (81.0)	135 (88.2)	131 (85.6)
Used ≤26yr	12 (7.8)	10 (6.5)	11 (7.2)
Used >26yr	17 (11.1)	8 (5.2)	11 (7.2)
Life time exposure			
Never used	124 (81.0)	135 (88.2)	131 (85.6)
Used ≤24000 hr	12 (7.8)	7 (4.6)	9 (5.9)
Used >24000 hr	17 (11.1)	11 (7.2)	13 (8.5)
Cow dung:			
Ever used			
Used	26 (17.0)	34 (22.2)	37 (24.2)
Never used	127 (83.0)	119 (77.8)	116 (75.8)
Frequency of use			
Never used	127 (83.0)	119 (77.8)	116 (75.8)
Used ≤14times/wk	24 (15.7)	34 (22.2)	34 (22.2)
Used >14times/wk	2 (1.3)	0 (0.0)	3 (2.0)
Intensity of use			
Never used	127 (83.0)	119 (77.8)	116 (75.8)
Used ≤20hr/week	11 (7.2)	16 (10.5)	15 (9.8)
Used >20hr/week	15 (9.8)	18 (11.8)	22 (14.4)
Duration of use			
Never used	127 (83.0)	119 (77.8)	116 (75.8)
Used ≤26yr	10 (6.5)	14 (9.2)	19 (12.4)
Used >26yr	16 (10.5)	20 (13.1)	18 (11.8)
Life time exposure			
Never used	127 (83.0)	119 (77.8)	116 (75.8)
Used ≤31500 hr	12 (7.8)	16 (10.5)	20 (13.1)
Used >31500 hr	14 (9.2)	18 (11.8)	17 (11.1)

3.2.2 Univariate analysis of factors related to cooking history

Crude matched odds ratios and 95% confidence intervals (95% CI) of factors related to cooking history using univariate conditional logistic regression analysis of case vs NE control and of case vs NC control groups are shown in Table 14.

Table 14. Univariate analysis of variables related to cooking history

Variables	Case vs NE controls		Case vs NC controls	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Cooking history		0.181		0.590
Yes	1.57 (0.8,3.07)		1.21 (0.6,2.46)	
No	1(ref)		1(ref)	
Frequency of cooking		0.406		0.351
Regular	1.64 (0.57,4.68)		3.00 (0.6,15.03)	
Occasionally	1.54 (0.71,3.36)		1.00 (0.46,2.15)	
Never cook	1(ref)		1(ref)	
Smoke accumulation		0.563		0.086
Yes	1.40 (0.44,4.41)		3.50 (0.73,16.85)	
No	1(ref)		1(ref)	
Types of cooking place		0.151		0.147
Never cook	1(ref)		1(ref)	
Living house	2.03 (0.94,4.39)		1.74 (0.77,3.93)	
Separate house	1.23 (0.58,2.62)		0.94 (0.44,2.02)	
Age of 1st cooked		0.328		0.355
Never cook	1(ref)		1(ref)	
From ≤15yr	1.35 (0.61,3.02)		1.67 (0.71,3.91)	
From >15yr	1.67 (0.83,3.33)		1.14 (0.56,2.34)	

* P value from likelihood ratio test of univariate conditional logistic regression model

Table 14. Univariate analysis of variables related to cooking history (cont.)

Variables	Case vs NE controls		Case vs NC controls	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Years of cooking		0.370		0.007
Never cook	1(ref)		1(ref)	
For ≤26yr	1.53 (0.77,3.02)		1.17 (0.57,2.38)	
For >26yr	1.88 (0.66,5.38)		4.65 (1.41,15.39)	
Times/cook/day		0.380		0.566
Never cook	1(ref)		1(ref)	
≤2times/day	1.59 (0.81,3.11)		1.23 (0.61,2.5)	
>2times/day	1.31 (0.4,4.22)		0.81 (0.27,2.49)	
Hour/cook		0.370		0.336
Never cook	1(ref)		1(ref)	
≤2hr/time	1.62 (0.82,3.2)		1.17 (0.58,2.39)	
>2hr/time	1.37 (0.55,3.4)		2.06 (0.72,5.87)	

* P value from likelihood ratio test of univariate conditional logistic regression model

3.2.3 Selection of parameters to represent of each main exposure to cooking fuel type

For each of the main exposures of interest, the various parameters of cooking fuel exposure comprised frequency (times per week during the years used), intensity (hours per week during the years used), duration (years) and lifetime exposure (lifetime hours of use) were entered into separate univariate conditional logistic regression models and the log likelihood recorded. The log likelihood models for wood or dry leaves, rice straw and cow-dung used variables are shown in Tables 15-17.

3.2.3.1 Wood or dry leaves

The crude odds ratios and 95% confidence intervals (95% CI) from univariate analyses are shown in Table 15.

Table 15. Univariate analyses of parameters of wood or dry leaves use among cases and controls

Variable	Case vs NE control		Case vs NC control	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Ever used		0.053		0.449
Never used	1(ref)		1(ref)	
Used	2.00 (0.97,4.12)		1.33 (0.63,2.82)	
Frequency of use		0.123		0.502
Never used	1(ref)		1(ref)	
Used ≤14times/week	2.04 (0.99,4.23)		1.33 (0.63,2.82)	
Used >14times/week	1.45 (0.45,4.73)		0.89 (0.28,2.85)	
Intensity of use		0.107		0.596
Never used	1(ref)		1(ref)	
Used ≤20hr/week	2.13 (1.02,4.47)		1.35 (0.64,2.87)	
Used >20hr/week	1.65 (0.71,3.85)		1.09 (0.42,2.81)	
Duration of use		0.154		0.024
Never used	1(ref)		1(ref)	
Used ≤26yr	1.99 (0.95,4.16)		1.24 (0.58,2.65)	
Used >26yr	2.07 (0.7,6.15)		3.87 (1.22,12.3)	
Life time exposure		0.154		0.741
Never used	1(ref)		1(ref)	
Used ≤25000 hr	2 (0.97,4.13)		1.33 (0.63,2.81)	
Used >25000 hr	1.95 (0.69,5.52)		1.41 (0.51,3.94)	

* P value from likelihood ratio test of univariate conditional logistic regression model

3.2.3.2 Rice straw

The crude odds ratios and 95% confidence intervals (95% CI) from univariate analyses are shown in Table 16.

Table 16. Univariate analyses of parameters of rice straw use among cases and controls

Variable	Case vs NE control		Case vs NC control	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Ever used		0.053		0.273
Never used	1(ref)		1(ref)	
Used	2.00 (0.97,4.12)		1.41 (0.76,2.63)	
Frequency of use		0.017		0.288
Never used	1(ref)		1(ref)	
Used ≤14times/week	1.82 (0.87,3.79)		1.28 (0.67,2.44)	
Used >14times/week	-		4.21 (0.47,37.95)	
Intensity of use		0.153		0.547
Never used	1(ref)		1(ref)	
Used ≤20hr/week	1.95 (0.8,4.73)		1.44 (0.64,3.25)	
Used >20hr/week	2.08 (0.75,5.75)		1.38 (0.58,3.29)	
Duration of use		0.072		0.420
Never used	1(ref)		1(ref)	
Used ≤26yr	1.29 (0.48,3.45)		1.13 (0.48,2.67)	
Used >26yr	3.25 (1.06,9.97)		1.76 (0.74,4.2)	
Life time exposure		0.154		0.548
Never used	1(ref)		1(ref)	
Used ≤24000 hr	2.00 (0.73,5.48)		1.40 (0.56,3.49)	
Used >24000 hr	2.00 (0.79,5.07)		1.42 (0.63,3.2)	

* P value from likelihood ratio test of univariate conditional logistic regression model

3.2.3.3 Cow dung

The crude odds ratios and 95% confidence intervals (95% CI) from univariate analyses are shown in Table 17.

Table 17. Univariate analyses of parameters of cow dung use among cases and controls

Variable	Case vs NE control		Case vs NC control	
	OR (95% CI)	P-value*	OR (95% CI)	P-value*
Ever used		0.204		0.112
Used	0.67 (0.35,1.25)		0.60 (0.32,1.14)	
Never used	1(ref)		1(ref)	
Frequency of use		0.088		0.219
Never used	1(ref)		1(ref)	
Used ≤14times/week	0.62 (0.33,1.19)		0.58 (0.31,1.11)	
Used >14 times/week	-		0.48 (0.08,3.04)	
Intensity of use		0.424		0.224
Never used	1(ref)		1(ref)	
Used ≤20hr/week	0.61 (0.26,1.42)		0.59 (0.24,1.43)	
Used >20hr/week	0.72 (0.32,1.62)		0.57 (0.27,1.2)	
Duration of use		0.444		0.115
Never used	1(ref)		1(ref)	
Used ≤26yr	0.64 (0.26,1.58)		0.39 (0.15,1.01)	
Used >26yr	0.69 (0.3,1.56)		0.78 (0.35,1.77)	
Life time exposure		0.447		0.185
Never used	1(ref)		1(ref)	
Used ≤31500 hr	0.67 (0.3,1.49)		0.49 (0.21,1.12)	
Used >31500 hr	0.67 (0.3,1.49)		0.68 (0.3,1.54)	

* P value from likelihood ratio test of univariate conditional logistic regression model

3.3 Selected variables for initial multivariate conditional logistic regression models

In addition to the selected parameters of exposure to various cooking fuels, variables initially included in the two multivariate conditional logistic regression models (one each for the comparison with each control group) comprised education level, income of family, socioeconomic status, treatment of diagnosis of hypertension, family history of cataract, exposure to sunlight exposure in workplace and smoking status.

Of the parameters of exposure to various types of cooking fuel, ever use of wood/dry leaves, rice straw and cow dung was first selected to create conditional logistic regression models for the comparison with each control group and for their refinement by sequential removal of non-cooking-fuel variables if the p-value obtained by the likelihood ratio test was >0.05 in both comparison models.

The remaining non-cooking-fuel variables in these models were then retained in a series of models designed to examine the dose-response relationships between the magnitude of use of the various types of cooking fuel and case status. These models fitted cooking fuel use successively using duration of use (years), frequency of use (times per week during the years used), intensity of use hours per week during the years used), and lifetime exposure (lifetime hours of use), respectively. The first three of these models are presented together, whereas the last is presented separately as lifetime exposure represents the overall combination of the first three parameters.

3.4 Multivariate analyses – "ever use" models

After refinement of the two models in which cooking fuel use was fitted as ever used/never used, the variables remaining were education level of the subject, family history of cataract, and smoking status of the subject (Table 18).

Family history of cataract was strongly associated with case status in both models (OR=2.55; 95%CI 1.43-4.54 and 2.53; 95%CI 1.33-4.80). Lower education was associated with case status in the comparison with NE controls (compared to secondary education or higher, OR=4.18 (95% CI 1.94-9.03) for primary education and OR=3.79 (95% CI 1.71-8.41) for less than primary) and history of smoking in comparison with NC controls (OR=3.13 (95%CI 1.38-7.10) (Table 18).

In comparisons with NE controls, ever use of wood/dry leaves (OR= 2.68; 95%CI 1.14-6.33) and of rice straw (OR=2.56; 95%CI 1.07-6.10) showed significant associations with case status, whereas ever use of cow dung showed a significant inverse association with case status (OR=0.42; 95%CI 0.15-0.90). In comparison with NC controls, only use of cow dung among cooking fuels was significantly associated with a reduced risk of being a case (OR=0.45; 95%CI 0.22-0.93) (Table 18).

Table 18. Multivariate conditional logistic models of common variables and ever use of cooking fuel types

Variable	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude OR	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Family h/o cataract						
No	1(ref)	1(ref)	<0.001	1(ref)	1(ref)	0.003
Yes	2.40 (1.42, 4.04)	2.55 (1.43, 4.54)		2.79 (1.51, 5.13)	2.53 (1.33, 4.80)	
Smoking status						
Never smoked	1(ref)	1(ref)	0.216	1(ref)	1(ref)	0.003
Current or past	1.83 (0.91, 3.70)	1.67 (0.73, 3.77)		3.38 (1.53, 7.43)	3.13 (1.38, 7.10)	
Formal education						
At least secondary	1(ref)	1(ref)	<0.001	1(ref)	1(ref)	0.188
Primary	3.49 (1.73, 7.03)	4.18 (1.94, 9.03)		2.09 (1.04, 4.18)	1.92 (0.89, 4.15)	
None	2.89 (1.45, 5.76)	3.79 (1.71, 8.41)		2.07 (1.01, 4.21)	1.99 (0.90, 4.43)	
Use of cooking fuels:						
Wood or dry leaves						
Never used	1(ref)	1(ref)	0.020	1(ref)	1(ref)	0.336
Used	2.0 (0.97, 4.12)	2.68 (1.14, 6.33)		1.33 (0.63, 2.82)	1.54 (0.63, 3.78)	
Rice straw						
Never used	1(ref)	1(ref)	0.025	1(ref)	1(ref)	0.219
Used	2.00 (0.97, 4.12)	2.56 (1.07, 6.10)		1.41 (0.76, 2.63)	1.54 (0.77, 3.10)	
Cow-dung						
Never used	1(ref)	1(ref)	0.020	1(ref)	1(ref)	0.025
Used	0.67 (0.35, 1.25)	0.42 (0.15, 0.90)		0.58 (0.31, 1.09)	0.45 (0.22, 0.93)	

Parameters reflecting the magnitude of exposure to cooking fuel were then fitted to models containing family history of cataract, smoking status and education. These parameters, each fitted to separate models were duration (years), frequency (times per week during the years used), intensity (hours per week during the years used) and lifetime exposure (lifetime hours of use). The patterns of association were similar for each parameter.

3.5 Multivariate analyses - "duration", "frequency" and "intensity" models

After adjustment for family history of cataract, smoking status and level of formal education, in comparison with NE controls, all three parameters of all fuels provided evidence of association with case status, but a dose-response relationship was only evident for rice straw (increasing risk) and cow dung (decreasing risk), and then only for duration (Table 19), frequency (Table 20) and intensity (Table 21). By contrast, in comparison with NC controls after similar adjustment, duration of using wood/dry leaves showed a positive dose-response association with case status (Table 19), whereas frequency and intensity of use of cow dung showed a decreasing dose-response relationship with case status (Tables 20 and 21).

Thus only intensity of cow dung use showed a consistent relationship with case status in the comparisons with both controls.

Table 19. Duration of using cooking fuels - conditional logistic regression models

Cooking fuel	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Wood or dry leaves						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤26 years	1.99 (0.95,4.16)	2.88 (1.17,7.14)	0.055	1.24 (0.58,2.65)	1.41 (0.56,3.54)	0.048
Used >26 years	2.07 (0.7,6.15)	2.22 (0.62,7.90)		3.87 (1.22,12.3)	4.88 (1.21,19.70)	
Trend		1.76 (0.97,3.19)	0.059		2.29 (1.20,4.39)	0.008
Rice straw						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤26 years	1.29 (0.48,3.45)	1.36 (0.4,4.6)	0.056	1.13 (0.48,2.67)	1.82 (0.59,5.58)	0.328
Used >26 years	3.25 (1.06,9.97)	5.34 (1.26,22.61)		1.76 (0.74,4.2)	1.70 (0.63,4.61)	
Trend		2.03 (1.12,3.7)	0.012		1.38 (0.88,2.17)	0.157
Cow-dung						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤26 years	0.64 (0.26,1.58)	0.51 (0.15,1.72)	0.056	0.39 (0.15,1.01)	0.35 (0.11,1.09)	0.101
Used >26 years	0.69 (0.3,1.56)	0.33 (0.11,0.99)		0.78 (0.35,1.77)	0.58 (0.22,1.54)	
Trend		0.59 (0.36,0.96)	0.026		0.68 (0.43,1.06)	0.079

Table 20. Frequency of using cooking fuels - conditional logistic regression models

Cooking fuel	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Wood or dry leaves						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤14 times/wk	2.04 (0.99,4.23)	2.90 (1.21,6.97)	0.011	1.33 (0.63,2.82)	1.56 (0.64,3.82)	0.268
Used >14 times/wk	1.45 (0.45,4.73)	0.78 (0.16,3.82)		0.89 (0.28,2.85)	0.64 (0.12,3.35)	
Trend		1.55 (0.81,2.95)	0.182		1.10 (0.57,2.15)	0.774
Rice straw						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤14 times/wk	1.82 (0.87,3.79)	2.57 (1.01,6.53)	0.037	1.28 (0.67,2.44)	1.23 (0.58,2.62)	0.174
Used >14 times/wk	-	-		4.21 (0.47,37.95)	8.65 (0.59,126.6)	
Trend		2.91 (1.22,6.95)	0.008		1.58 (0.84,2.95)	0.144
Cow-dung						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤14 times/wk	0.62 (0.33,1.19)	0.33 (0.15,0.76)	0.024	0.58 (0.31,1.11)	0.46 (0.22,0.95)	0.082
Used >14 times/wk	-	8.97 (0,Inf)		0.48 (0.08,3.04)	0.33 (0.02,5.59)	
Trend		0.48 (0.23,1)	0.043		0.47 (0.24,0.92)	0.021

Table 21. Intensity of using cooking fuels - conditional logistic regression models

Cooking fuel	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Wood or dry leaves						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤20 hours/wk	2.13 (1.02,4.47)	2.91 (1.19,7.11)	0.051	1.35 (0.64,2.87)	1.57 (0.64,3.86)	0.601
Used >20 hours/wk	1.65 (0.71,3.85)	2.35 (0.82,6.76)		1.09 (0.42,2.81)	1.66 (0.49,5.6)	
Trend		1.50 (0.91,2.48)	0.110		1.31 (0.75,2.28)	0.335
Rice straw						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤20 hours/wk	1.95 (0.8,4.73)	1.75 (0.61,5.06)	0.045	1.44 (0.64,3.25)	1.23 (0.45,3.36)	0.362
Used >20 hours/wk	2.08 (0.75,5.75)	4.74 (1.15,19.57)		1.38 (0.58,3.29)	2.07 (0.69,6.17)	
Trend		2.10 (1.14,3.88)	0.011		1.40 (0.88,2.22)	0.150
Cow-dung						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤20 hours/wk	0.61 (0.26,1.42)	0.41 (0.14,1.20)	0.048	0.59 (0.24,1.43)	0.53 (0.19,1.44)	0.065
Used >20 hours/wk	0.72 (0.32,1.62)	0.35 (0.11,1.14)		0.57 (0.27,1.20)	0.36 (0.13,1.00)	
Trend		0.52 (0.32,0.86)	0.008		0.57 (0.37,0.90)	0.013

3.6 Multivariate analyses - lifetime exposure models

After adjustment for family history of cataract, smoking status and level of formal education, in comparison with NE controls, lifetime exposure to wood or dry leaves as cooking fuel increased the odds of being a case by 2.77 (95% CI 1.16, 6.58) for exposures of no more than 25000 hours and by 4.01 (95% CI 0.98, 16.31) for longer exposures compared with no exposure (P for trend 0.023). For lifetime exposure to rice straw as cooking fuel the corresponding odds ratios were 2.24 (95% CI 0.69, 7.27) for exposures of no more than 24000 hours and 3.01 (95% CI 0.96, 9.45) for longer exposures (P for trend 0.022). By contrast the odds ratios for case status associated with use of cow dung were 0.42 (95% CI 0.16, 1.13) for exposures of no more than 31500 hours and 0.34 (95% CI 0.13, 0.98) for longer exposures compared with no exposure (P for trend 0.010) (Table 22).

In comparison with non-cataract eye-disease controls, after similar adjustment, among lifetime exposures to cooking fuels, only that to cow dung was weakly significant, although the trend was not clear (trend OR= 0.61, 95%CI 0.39-0.97) (Table 22).

Using multinomial logistic regression modeling, essentially the same relationships between predictors and case status as in the conditional models were obtained in comparison with each control group.

Table 22. Lifetime exposure to cooking fuels – conditional logistic regression models

Cooking fuel	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Wood or dry leaves						
Never used	1(ref)	1(ref)	0.048	1(ref)	1(ref)	0.467
Used ≤25000 hours	2.00 (0.97, 4.13)	2.77 (1.16, 6.58)		1.33 (0.63, 2.81)	1.54 (0.63, 3.81)	
Used >25000 hours	1.95 (0.69, 5.52)	4.01 (0.98, 16.31)		1.41 (0.51, 3.94)	2.15 (0.62, 7.44)	
Trend		2.15 (1.09, 4.23)	0.023		1.51 (0.83, 2.77)	0.175
Rice straw						
Never used	1(ref)	1(ref)	0.071	1(ref)	1(ref)	0.404
Used ≤24000 hours	2.00 (0.73, 5.48)	2.24 (0.69, 7.27)		1.40 (0.56, 3.49)	1.42 (0.47, 4.28)	
Used >24000 hours	2.00 (0.79, 5.07)	3.01 (0.96, 9.45)		1.42 (0.63, 3.20)	1.74 (0.68, 4.47)	
Trend		1.83 (1.06, 3.16)	0.022		1.31 (0.86, 2.01)	0.204
Cow-dung						
Never used	1(ref)	1(ref)	0.050	1(ref)	1(ref)	0.053
Used ≤31500 hours	0.67 (0.30, 1.49)	0.42 (0.16, 1.13)		0.49 (0.21, 1.12)	0.37 (0.15, 0.95)	
Used >31500 hours	0.67 (0.30, 1.49)	0.34 (0.13, 0.98)		0.68 (0.30, 1.54)	0.46 (0.17, 1.23)	
Trend		0.54 (0.33, 0.88)	0.010		0.61 (0.39, 0.97)	0.032

Chapter 4: Results – Multiparity and other personal characteristics among young adult females in rural Bangladesh

4.1 Distribution of socio-demographic characteristics of female participants

A total of 80 female cases, 80 NE controls and 80 NC controls were included in the study. However, the two controls were considered as a single control group so that the matching ratio of case: control was 1:2. The distributions of the socio-demographic characteristics among female subjects are given Table 23.

The mean age of the female participants was 41.4 (SD. 6.0) years and 35 percent were aged 40 or less. More than 90 percent of the females were housewives and about 43 percent had not received any formal education. Around 80 percent were classified as having low socioeconomic status and 80 to 85 percent of subjects were classified as being underweight. Small numbers reported a history of hypertension, though more among cases ((6.2%) than among controls (0.6 %). Few reported having myopia in both groups (2.5% and 3.1%, respectively). Cases were more commonly reported a family history of cataract (Table 23).

Controls were more than twice as likely (18.8%) to have received at least secondary or higher education than cases (7.5%). Around 81 percent of cases and 76 percent of controls had more than 2

children and more than 80 percent in both groups had parity over 2. Mode and place of delivery were very similar in the two groups.

Table 23. Distribution of female for parity among cases and controls

Variables	Cases	Controls	OR (95% CI) Case vs control	P-value*
	N (%)	N (%)		
Age in years (mean ± SD)	41.6±6.1	41.2±6.0		
Age groups				
18-30	6 (7.5)	10 (6.2)		
31-40	22 (27.5)	44 (27.5)		
41-49	52 (65.0)	106 (66.2)		
Religion				0.289
Muslim	50 (62.5)	89 (55.6)	1.36 (0.77,2.41)	
Others	30 (37.5)	71 (44.4)	1(ref)	
Education				0.046
No education	35 (43.8)	69 (43.1)	2.40 (0.94,6.15)	
Primary	39 (48.8)	61 (38.1)	3.02 (1.17,7.79)	
Secondary	6 (7.5)	30 (18.8)	1(ref)	
Occupation				0.080
Housewife	76 (95.0)	141 (88.1)	2.46 (0.82,7.35)	
Others	4 (5.0)	19 (11.9)	1(ref)	
Household member				0.723
≤4	25 (31.2)	42 (26.2)	1(ref)	
5-7	44 (55.0)	95 (59.4)	0.78 (0.43,1.43)	
>7	11 (13.8)	23 (14.4)	0.80 (0.33,1.97)	
Household income (last year) taka/month				0.872
≤3000	16 (20.0)	29 (18.1)	1.21 (0.56,2.60)	
3001-5700	39 (48.8)	76 (47.5)	1.13 (0.61,2.11)	
>7500	25 (31.2)	55 (34.4)	1(ref)	

Table 23. Distribution of female for parity among cases and controls (cont.)

Variables	Cases N (%)	Controls N (%)	OR (95% CI) Case vs control	P-value*
Household income (last year) taka/month				0.872
≤3000	16 (20.0)	29 (18.1)	1.21 (0.56,2.60)	
3001-5700	39 (48.8)	76 (47.5)	1.13 (0.61,2.11)	
>7500	25 (31.2)	55 (34.4)	1(ref)	
Socioeconomic status				0.578
Lower	64 (80.0)	123 (76.9)	1.21 (0.62,2.34)	
Middle	16 (20.0)	37 (23.1)	1(ref)	
Body Mass Index (BMI)				0.701
Underweight	68 (85.0)	131 (81.9)	1.39 (0.61,3.18)	
Normal	9 (11.2)	24 (15.0)	1(ref)	
Overweight	3 (3.8)	5 (3.1)	1.64 (0.32,8.38)	
Myopia				0.771
Yes	2 (2.5)	5 (3.1)	0.77 (0.13,4.48)	
No	78 (97.5)	155 (96.9)	1(ref)	
Family history of cataract				0.007
Yes	27 (33.8)	27 (16.9)	2.27 (1.26,4.1)	
No	53 (66.2)	133 (83.1)	1(ref)	
Hx of working in sunlight				0.914
Yes	60 (75.0)	121 (75.6)	0.97 (0.51,1.82)	
No	20 (25.0)	39 (24.4)	1(ref)	
Years of sunlight ex.				0.107
Ex.>18yr	20 (25.0)	39 (24.4)	0.69 (0.34,1.40)	
Ex.≤18yr	26 (32.5)	71 (44.4)	1.42 (0.69,2.94)	
Not expose	34 (42.5)	50 (31.2)	1(ref)	
Second hand smoking				0.545
Yes	46 (57.5)	98 (61.3)	0.83 (0.46,1.51)	
No	34 (42.5)	62 (38.8)	1(ref)	

* P value from likelihood ratio test of univariate conditional logistic model

Table 23. Distribution of female for parity among cases and controls (cont.)

Variables	Cases	Controls	OR (95% CI)	P-value*
	N (%)	N (%)	Case vs control	
Marital status				0.416
Yes	78 (97.5)	158 (98.8)	0.37 (0.03,4.42)	
No	2 (2.5)	2 (1.2)	1(ref)	
Age of married				0.519
Married ≤15 yr	2 (2.5)	2 (1.2)	0.4 (0.03,4.81)	
Married >15 yr	44 (55.0)	81 (50.6)	0.32 (0.03,3.87)	
Unmarried	34 (42.5)	77 (48.1)	1(ref)	
Number of children				0.334
Children ≤2	15 (18.8)	38 (23.8)	1.43 (0.69,2.96)	
Children >2	65 (81.2)	122 (76.2)	1(ref)	
Number of parity				0.687
≤2	13 (16.2)	29 (18.1)	1.18 (0.53,2.61)	
>2	67 (83.8)	131 (81.9)	1(ref)	
Place of delivery				0.851
Hospital	2 (2.5)	4 (2.5)	0.62 (0.06,7.01)	
Home	72 (90.0)	143 (89.4)	0.69 (0.16,2.94)	
Both	2 (2.5)	7 (4.4)	0.39 (0.05,3.35)	
No/unmarried	4 (5.0)	6 (3.8)	1(ref)	
Mode of delivery				0.884
Normal vaginal	75 (93.8)	152 (95.0)	0.69 (0.16,2.94)	
Caesarean	1 (1.2)	2 (1.2)	0.69(0.04,11.41)	
No/unmarried	4 (5.0)	6 (3.8)	1(ref)	

* P value from likelihood ratio test of univariate conditional logistic regression mode

4.2 The final conditional logistic regression model for female subjects

An initial multivariate model was constructed containing the variables educational status, occupation, family history of cataract, years of occupational sunlight exposure, and parity.

After successively removing variables, with the exception of parity, not contributing significantly to the fit of the model, the final model retained, in addition to parity, family history of cataract, level of formal education, and years of sunlight exposure. Family history of cataract was strongly associated with case status (adjusted OR = 2.48 (95%CI 1.33, 4.62). Compared to at least secondary or higher education, lower education was found associated with case status, (OR = 3.06, 95%CI 1.11, 8.46 for primary education and OR = 3.17, 95%CI 1.14, 8.82 for less than primary education). Long-term occupational sunlight exposure (>15 years) was significantly associated with case status when compared to shorter-term exposure, but was not significantly different from no occupational sunlight exposure (Table 24).

Parity was not significantly associated with case status. The adjusted OR for >2 vs ≤2 was 0.73 (95% CI 0.29, 1.85).

Table 24. Final multivariate conditional logistic regression model for female subjects

Variables	OR (95% CI)		p-value
	Crude	Adjusted	
Family history of cataract			
No	1(ref)	1(ref)	0.004
Yes	2.27 (1.26,4.1)	2.48 (1.33,4.62)	
Education			
At least secondary	1(ref)	1(ref)	0.021
Primary	3.02 (1.17,7.79)	3.06 (1.11,8.46)	
Non-educated	2.40 (0.94,6.15)	3.17 (1.14,8.82)	
Year of sunlight exposure			
Not exposed	1(ref)	1(ref)	
Ex.<=15 years	0.69 (0.34,1.4)	0.57 (0.26,1.22)	0.035
Ex.>15 years	1.42 (0.69,2.94)	1.51 (0.71,3.18)	
Number of parity			
≤2	1(ref)	1(ref)	0.506
>2	1.18 (0.53,2.61)	0.73 (0.29,1.85)	

*P value from likelihood ratio test

Chapter 5: Discussion

This chapter is presented five main parts. The first part discusses the first main objective of the study: the relationship between the use of cheaper cooking fuels such as wood/dry leaves, rice straw and cow-dung and young adult cataract. The second part discusses the second main objective: the relationship of parity and young adult cataract in females. The third part refers to other risk factors for cataract. The fourth part consists of strengths and limitation of the study and the fifth part presents the overall conclusion and recommendations.

5.1 The relationship between the use of cheaper cooking fuels and early development of cataract.

This study aimed to test the hypothesis that exposure to cheaper cooking fuels, such as wood or dry leaves, cow-dung and rice straw, is significantly associated with the development of cataract among adults less than 50 years of age in rural Bangladesh. After adjusting for family history of cataract, smoking status and level of formal education, use of wood or dry leaves and use of rice straw were identified as risk factors in comparison with non-eye-disease controls and exhibited a dose-response trend in risk with increasing lifetime exposure. No such relationships were seen in comparison with non-cataract eye-disease control patients.

5.1.1 Explanation for the difference of results between non-eye disease control and non-cataract eye-disease control groups.

A possible, though unsupported, explanation for this difference depending on the type of controls employed is that the other eye diseases share these risk factors with cataract patients, or that patients with diseases included among the non-eye-disease control group are less exposed to these particular cooking fuels. Inter-comparison of the two types of control, however, revealed no significant associations with the use of these cooking fuels.

An elevated risk of cataract associated with the use of wood/dry leaves and rice straw is consistent with the findings of several previous studies in which a link was detected between the use of cheaper, biomass or solid fuels and the risk of cataract. The use of less expensive cooking fuels was more common among patients with age-related cataract than non-cataract patients in India,[26] and use of solid fuel unvented stoves more common among female cataract patients of any age than among non-cataract eye-disease patients in the Nepal-India border area.[39;39] In both instances the associations remained significant after adjustment for other risk factors, including low educational achievement.[7;32-34;60-62]

5.1.2 Possible mechanism underlying the association between the use of wood/dry leaves and rice straw and development of cataract

A plausible mechanism underlying the association between the use of wood/dry leaves and rice straw and development of cataract may

be related to the constituents of the large amounts of smoke produced from these fuels damaging the tissues of the eye following either systemic absorption or even local diffusion through the cornea. It has been suggested that such damage may be a result of the endogenous generation of reactive oxygen species by photodynamic action, similar to the purported mechanism by which smoking tobacco may raise the risk of cataract.[63;64]

5.1.3 Comparison of current findings with the results from previous studies.

Despite the relationship between risk of cataract and use of cooking fuel being reported in a number of studies, few have attempted to document the risk for different types of biomass fuel. The component materials have either not been specified or have been specified but combined in the analysis. Thus, Mohan (1989) and Mishra (1999) reported elevated risks of, respectively, cataract and blindness among an Indian population with exposure to the smoke of biomass cooking fuel, specified as wood, crop residuals and/or cow dung, but separate analyses of each of these materials were not described.[44;65]

In view of these reports, the independent inverse association between the use of cow dung as a cooking fuel and case status in the current study was unexpected. The relationship held true in comparisons with each type of control, although the evidence for a dose-response relationship was somewhat stronger in the comparison with non-eye-disease controls. While copious amounts of smoke are known to emanate from burning cow dung, the opposite direction of relationship in our study between wood, dry leaves and rice straw

on the one hand and cow dung on the other, might be related to the different complement of smoke constituents. Although cow diet consists largely of fresh grass, bacterial and enzymatic actions of the bovine gastrointestinal tract result in considerable transformations of the plant material.

Constituents of smoke from biomass fuels has been reported to vary considerable with the type of stove employed and with various other differences in the way it is prepared. Comparative information on the constituents of smoke from different biomass fuels, or from dung fuel separate from other biofuels, is scarcely available in the scientific literature, despite several studies of smoke constituents of biomass fuels combined.[66-70] Mudway (2005), however, demonstrated that particles derived from the burning of cow-dung cake burned in a traditional Indian cooking stove and deposited in the human respiratory tract lining fluid had considerable oxidative activity, which was mostly due to their transitional metal content.[71] If the postulated mechanism whereby smoke from biomass fuels induces cataract formation through the activity of reactive oxygen species is true, then it is difficult to understand why smoke from cow-dung does not have a similar risk-enhancing effect to that of wood/dry leaves and rice straw. Further comparative analyses are required to identify differences in the smoke constituents and elucidate possible differences in the mechanisms of action.

Consideration, however, must also be given to the possibility that the apparent protective effect against the development of young adult cataract of using cow dung as a cooking fuel could be due to

uncontrolled confounding. Exposure to cow-dung as cooking fuel is more common among middle class family in rural areas in Bangladesh. Cows are usually used for cultivation and dairy products, so more frequently kept by land and firm owners, whereas poor families can rarely afford to buy or keep cattle. Use of cow-dung as a fuel thus may be acting as a proxy for higher socioeconomic status, which itself has been identified in some previous studies to be associated with a lower prevalence of cataract (of any type).[7;26;32;33;72] Nevertheless, adjusting the models for family income level or for the composite socioeconomic status indicator based on the Kuppuswami scale, had no discernable effect on the relationship between case status and use of cow dung as a cooking fuel, so that confounding, if it is to be invoked as the explanation for the relationship, must involve an as yet unidentified variable.

It is of interest, however, that an Indian study of the relationship between fuel use and ocular morbidity in which separate independent associations between different types of cooking fuel and cataract were examined demonstrated a significantly increased risk for wood but not for cattle dung or for gas, kerosene or coal.[73] On the other hand, eye irritation was significantly associated with the use of coal and cattle dung but not the other fuels.

5.2 Role of parity

The second objective of this study was to determine if an association existed between multiparity and the development of cataract among young adult females in the study population.

The study failed to identify a relationship between parity and case status, but this may be owing to the small sample size providing insufficient power to detect a weak association. Minassian (2002), showed the evidence of being cataract and dose-response relationship with child bearing and pregnancy.[50] The birth effect was possibly mediated through the potentially adverse local practice of fluid abstention after birth and may be causing severe dehydration, which was a identified risk factor cataract.[53-56]

Nevertheless, the analysis along females did identify a family history of cataract, as well as a lower level of formal education, and possibly also long occupational exposure to sunlight, as independent predictors of young adult female cataract.

5.3 Other identified risk factors for cataract found in the current study

Other variables related to case status in our study have each been recognized as risk factors in previous studies.

5.3.1 Family history of cataract

A genetic predisposition to cataract has been indicated by the finding of a strong independent association with family history of cataract in most studies of cataract in general[23-25;62;74] as in the current study of young adult cataract. Nevertheless an Indian case-control study failed to identity such as association.[74]

5.3.2 Smoking

Various studies have identified an association, in some cases in a dose-related manner, between cataract and cigarette smoking. These studies have included those with case-control,[75] cross-sectional,[37;76] and prospective designs.[34-36;77;78] Most of these studies found smoking to be related with nuclear cataract, although an increased risk among smokers of posterior subcapsular cataract was also reported in two of the prospective studies.[34;35] Our study revealed an association between smoking status and young adult cataract when compared with NC controls, but not in comparison with NE controls. The discrepancy appears to be linked with the finding of a higher frequency of smokers among NE than among NC controls. More than half of the NE controls had ear diseases, with otitis media accounting for 35% of all NE controls. It is known to be common practice among this population to smoke cigarettes to help relieve the irritation and itching associated with ear disease.

5.3.3 Level of formal education

Educational attainment lower than secondary level was identified as a risk factor for case status in comparison with NE controls in this study, as well as in the subset analysis of females, and is in agreement with this findings of many previous studies of cataract in general[7;32;33;37;60-62;76;79] The explanation may lie in the generally poorer nutritional status of less educated people. Poor nutritional status has itself been identified as an independent risk factor for cataract.[29;61;72;80] The educational level of NC controls in our study was higher than that in NE controls, and may

explain the failure to identify a significant association with case status in this comparison. Low educational attainment in this group of controls was particularly related to controls with conjunctivitis or pterygium and those with refractive errors. These diseases together accounted for 60% of NC controls.

5.3.4 Occupational exposure to direct sunlight

In the full study, working in the sunlight was slightly rather less frequent among NE controls but did not retain its significance after adjustment for other factors. Nevertheless, there appeared to be some indication that long-term exposure among females might be related to the development of young adult female cataract. Previous studies have yielded conflicting findings regarding this exposure. Some have reported a relationship between sunlight exposure in the workplace and cataract,[22;40;42;81] whereas others have failed to identify outdoor work involving higher sunlight exposure as a risk factor for lens disease.[61;79;82]

5.4 The strength and limitations of the study

5.4.1 The limitations of the study

A limitation of this study stems from difficulties in recalling lifetime use of various cooking fuels, although recall was stimulated during the interview by referring to significant life events of each patient. However, it is unlikely that recall misinformation was biased as all patients, both cases and controls, were visiting the hospital for treatment of some ailment, and the specific hypothesis under study was not known to

the subjects. Such random errors that may have occurred would therefore tend to reduce the observed strength of association between exposures and outcome.

As the relationship between use of wood or dry leaves and rice straw as cooking fuels and development of young adult cataract was not consistently significant in comparisons with both controls, the role of these exposures in increasing the risk of young adult cataract should be interpreted with caution. However, the consistent relationship between the use of cow-dung and lowered risk of cataract is more convincing, although at present a clear plausible explanation is lacking.

The study did not classify the cases with respect to type of cataract. Unless all types share the same risk factors, any heterogeneity of cataract types would have the effect of diluting the true relationships with exposure.

Finally, since this study was conducted in a charitable non-government organization hospital, catering for disadvantaged villagers in remote parts of the country, the range of socio-economic status among subjects was not very wide. Such restricted variability may have prevented the identification of certain risk factors that may be seen in studies with a wider variety of patient backgrounds.

Particularly in the female-only analytical part of the study, the sample size was relatively small. Weak associations with parity would not have achieved statistical significance. Thus interpretation of the role of parity in this study remains inconclusive.

5.4.2 The strength of the study

The strength of this study lies in its separation of different types of traditional cooking fuel, which allowed the identification of contrasting directions of association among these fuel types.

5.5 Conclusions and recommendations

5.5.1 Conclusions

In conclusion, the results of the current study are in agreement with those of earlier studies that the use of cheaper cooking fuels may increase the risk of cataract, in our case cataract in young adults. The study also provides evidence that use of cow-dung as a cooking fuel does not increase the risk of developing cataract in young adult life, and may actually be protective.

5.5.2 Recommendations

In view of the lack of plausible explanation for the protective effect of using cow-dung as a cooking fuel, further studies of the relationship between use of cow-dung and cataract in other settings, as well as comparative analysis of the constituents of the smoke from wood/dry leaves/rice straw and that of cow-dung, are needed. From the public health aspect for Bangladeshi villagers, a change to the use of alternative fuels such as biogas or liquefied petroleum gas, the adoption of stoves that can reduce the free emission of smoke from wood/dry leaves and rice straw fuel, or improved ventilation of cooking areas of the house, are recommended.

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Appendices

Appendix I: Invitation to participate form

Project: "Risk Factors of Young Adult Cataract, Bangladesh"

Dear Sir/Madam,

We want to tell you about our project and invite you to join in the study.

Blindness is a global problem nowadays and cataract is one of the leading causes of blindness in both developed and developing countries. The numbers of blind in the world in 1998 was estimated to be 45 million, with 20 million due to cataract. The number of blind increased in 2001 to around 50 million and is projected, if present trends continue, to reach 75 million by 2020.

A recent population-based survey in Bangladesh estimated 650,000 people were blind due to cataract aged 30 years and older and 13,000 new cases developed annually. It is estimated that a third of the world's 45 million blind in Bangladesh. It has been observed recently that prevalence of cataract under 50 yrs age has increased and it is speculated that there might be some specific risk factors for this new trend. The research team is undertaking this project to find out those risk factors of cataract among young adults in Bangladesh.

If you agree to participate in this study it will help answer our research question, and with the information we could plan further

preventative measures that would eventually help this group of people who are developing cataract at their early age.

Your information will be kept confidential and used only for this research purpose. If you do not want to join in this project, we will appreciate your decision and it will not affect your treatment in any way.

If you have any question before making decision to join in the project, please ask to the research team at hospital at any time.

Thank you very much.

Research Team

Appendix II: Consent form (English and Bangla version)

Project: "Risk Factors of Young Adult Cataract, Bangladesh"

I am (Miss, Mr, Mrs) _____ surname_____ agree to join in the project about which the researcher, Joydhan Tanchangya position Medical officer, has already explained the details to me as in the invitation to participation form.

If I have any queries with respect to questions or procedures in the research project, I can ask the research team at any time. If I am not satisfied with the performance of the research team, I have the right to notify the Administrator, "Jibon Tari" floating hospital, telephone number.....or the president of the Ethics Committee (Dean of Faculty of Medicine, PSU, Thailand telephone no. +66 74 451100). If I am still not satisfied with the project, I have the right to discontinue participation in this project at any time without any consequences.

I have read and understood all details of the project provided by the researcher, and that I can change the consent at any time if I wish. I voluntarily participate in the study.

....

Signature/fingerprint Date:

of participant

....

Signature of researcher Date:

Appendix III: The Ethical Approval Letter

EC 52-210-18-5-3

Documentary Proof of Ethical Clearance

The Ethics Committee, Faculty of Medicine, Prince of Songkla University

The Project Entitled : Risk Factors of Young Adult Cataract, Bangladesh

Principal Investigator : Mr. Joydhan Tanchangya

Name of Department : Epidemiology Unit, Faculty of Medicine, Prince of Songkla University.

has been reviewed and approved by The Ethics Committee, Faculty of Medicine, Prince of Songkla University.

Date of Approval : May 6, 2009

(Assoc.Prof. Verapol Chandeying, M.D.)

Associate Dean for Research Affairs

Appendix IV: Questionnaire for Risk Factors of Young Adult Cataract in Rural Bangladesh.

Part1: General Information

ID ☐☐☐

1. Status of participant: set ☐☐☐

ptstatus ☐

☐0. Case

☐1. Control-I (Non-cataract eye-disease)

☐2. Control-II (Non-eye-disease)

Tel 01☐-☐☐☐☐-☐☐☐☐

Date ☐☐-☐☐-☐☐☐☐ idate ☐☐-☐☐-☐☐☐☐

Address:

☐1. Village:

☐2. Union:

☐3. Sub-district:

☐4. District:

2. Age ☐☐ y age ☐☐

(DOB ☐☐-☐☐-☐☐☐☐) dob ☐☐-☐☐-☐☐☐☐

3. Sex ☐1.M ☐2. F sex ☐

4. Religion ☐1.Muslim ☐2.Hindu religion ☐

☐3.Buddhist ☐4.Christian

☐5.Other.....

5. Marital Status ☐1.Single mstatus ☐

☐2.Married /Cohabitate

☐3.Divorce/Separate

. ☐4.Widow/widower

6. Education level ☐1.No education ☐2.Primary school ☐3.Secondary school ☐4.Higher secondary/college ☐5.Vocational school ☐6.Bachelor or higher ☐7.Other.....	edu ☐
7. Occupation ☐1. Farmer ☐2. Housewife ☐3. Labor ☐4. Rickshaw polar ☐5. Business ☐6. Teacher ☐7. Government officer ☐8. Engineer ☐9. Physician ☐10. Other.....	occ ☐☐
8. Household member ☐☐ person(s)/ household	hhmem ☐☐
9. Household income (average of last year) taka/month ☐☐☐☐☐ taka/ month	income ☐☐☐☐☐
Part2: Parity (only for female)	
10. Are you married? ☐1. Y ☐2. N (jump to qust. 17)	mgd ☐
11. At what age did you get married? ☐☐ years	mgdage ☐☐

12. Do you have any child? ☐1. Y ☐2. N (jump to qust. 14)	chid ☐
13. How many children do you have? ☐☐	nchid ☐☐
14. How many times have you given birth? ☐☐	ngbrt ☐☐
15. Where was the delivery?	pdv ☐
☐1. Hospital Number: ☐☐	pdvn1 ☐☐
☐2. Home Number: ☐☐	pdvn2 ☐☐
☐3. Both	
16. What was the mode of delivery?	mdv ☐
☐1. Normal delivery Number: ☐☐	mdvn1 ☐☐
☐2. Caesarean delivery Number: ☐☐	mdvn2 ☐☐
☐3. Both	
Part 3: Cooking fuels use	
17. Have you ever cooked for your family?	cokf ☐
☐1. Y ☐1. Regularly ☐2. Occasionally	freqcok ☐
☐2. N (jump to qust. 26)	
18. What types of fuels do you use for household cooking?	
☐1. Gas ☐1. Yes ☐2. No	tcokf1 ☐
☐2. Kerosene ☐1. Yes ☐2. No	tcokf2 ☐
☐3. Coal ☐1. Yes ☐2. No	tcokf3 ☐

☐4. Charcoal ☐1. Yes ☐2. No	tcokf4 ☐
☐5. Wood ☐1. Yes ☐2. No	tcokf5 ☐
☐6. Cow-dung ☐1. Yes ☐2. No	tcokf6 ☐
☐7. Dry leaves ☐1. Yes ☐2. No	tcokf7 ☐
☐8. Others ☐1. Yes ☐2. No	tcokf8 ☐
☐9. Rice straw ☐1. Yes ☐2. No	tcokf9 ☐
19. What types of cooking stove do you use in your house?	tcoksv ☐
☐1. Open fire/stove without chimney/hood	
☐2. Open fire/stove with chimney/hood	
☐3. Closed stove with chimney	
☐4. Others.....	
20. Does smoke during cooking accumulate inside the kitchen?	acomsm ☐
☐1. Yes ☐2. No ☐3. Not sure	
21. Where is cooking usually done?	
☐1. In a room used for living/sleeping	cokpl ☐
☐2. In a separate room used as kitchen	
☐3. In a separate house used as kitchen	
☐4. Outdoor	
☐5. Others.....	
22. What was the age you 1st cooked?	ageftcok ☐☐
☐☐ years	

23. How many years have you been cooking? ☐☐ years	yrcok ☐☐
24. How many times do you cook in a day? ☐ time(s)	tmcokpd ☐
25. How many hours do you cook at a time? ☐.☐☐ hour(s)	tmpcok ☐.☐☐
Part 4: Socioeconomic status Based on the modification of Kuppuswami scale on the basis of Education, Occupation and Income of the family head	
26. What is the maximum educational level of the head of family? ☐1. Professional Degree, PG and above (26) ☐2. Graduate (12) ☐3. Intermediate or diploma (9) ☐4. High school certificate (8) ☐5. Junior high school completion (7) ☐6. Primary school or Literate (2) ☐7. Illiterate (1)	Mxedhf ☐
27. What is the occupation of the head of family? ☐1. Professional (58)	occhf ☐

☐2. Semi-professional (12)	
☐3. Clerk, Shop owner, Farm owner (9)	
☐4. Skilled worker (8)	
☐5. Semi-skilled worker (7)	
☐6. Unskilled worker (2)	
☐7. Unemployed (1)	
28. What is the per capita income (Tk. Per Month) of the head of family?	inpmthf ☐
☐1. 30,001 or above (32)	
☐2. 15,001-30,000 (58)	
☐3. 10,001-15,000 (12)	
☐4. 7,001-10,000 (8)	
☐5. 5,001-7,000 (7)	
☐6. 2,001-5,000 (2)	
☐7. Below 2,000 (1)	
Part5: Medical history	
Q 29 - 32 Have you been checked of these within 1(one) year?	
29. Blood pressure ☐1. Y ☐2.N ☐3.Not sure	ckbp ☐
30. Blood sugar ☐1. Y ☐2.N ☐3.Not sure	ckbs ☐
31. Serum lipid ☐1. Y ☐2.N ☐3.Not sure	cksl ☐

32. Eye check up ☐1. Y ☐2.N ☐3.Not sure	eckup ☐
Q33 - 36 Have you ever had a diagnosis of or been treated for the following diseases?	
33. HT ☐1. Y ☐2.N ☐3.Not sure	rxht ☐
34. DM ☐1. Y ☐2.N ☐3.Not sure	rxdm ☐
35. Hyperlipidemia ☐1. Y ☐2.N ☐3.Not sure	rxdlp ☐
36. Night blindness ☐1. Y ☐2.N ☐3.Not sure	hxnb ☐
Myopia:	
37. Have you ever been faced problem to see short/distance object or to read paper/book? ☐1. Y ☐2.N (jump to qust. 39)	ptsee ☐
38. If so at which age? at ☐☐ year(s)	ageptsee ☐☐
39. Have you ever been diagnosed as myopia (short sightedness) or hypermetropia (long sightedness)? ☐1. Y ☐2.N (jump to qust. 42)	dxmp ☐
40. At what age were you diagnosed as myopia/hypermetropia? at ☐☐ year(s)	agemp ☐☐
41. Do you use prescribed glasses? ☐1. Y ☐2.N	usegl ☐
***** Myopia or hypermetropia was explained by interviewer*****	

Part 6: Family history of cataract	
42. Do you have any member of your family	fhcat ☐
diagnosed as cataract?	
☐1. Y ☐2.N (jump to qust. 46)	
If yes what is the relation with him/her?	
43. 1st degree relation (father, mother, brother	drl1 ☐
and sister) ☐1. Y ☐2. N	
44. 2nd degree relation (grand father, grand	drl2 ☐
mother, uncle and aunt) ☐1. Y ☐2. N	
45. 3rd degree relation (cousin by paternal and	drl3 ☐
maternal uncle and aunt) ☐1. Y ☐2. N	
Part 7: Exposure in sunlight	
46. Have you been exposed to sunlight in you	
work? ☐1. Y ☐2.N (jump to qust. 50)	exsunlt ☐
47. How long (average) you have to work in	exsunltpd ☐☐
sunlight per day? ☐☐ hours/day	
48. Which part of the day have you worked in	
sunlight?	
☐1. 6:00 am-9:00 am ☐1. Y ☐2. N	ptdexsun1 ☐
☐2. 9:00 am-12:00 pm ☐1. Y ☐2. N	ptdexsun2 ☐
☐3. 12:00 pm-3:00 pm ☐1. Y ☐2. N	ptdexsun3 ☐
☐4. 3:00 pm-6:00 pm ☐1. Y ☐2. N	ptdexsun4 ☐

49. How many years have you worked in sunlight? ☐☐ years	yrexsun ☐☐
Part 8: Smoking	
50. Do you smoke? (smoking status) ☐1. Current smoking (continue the next qust.) ☐2. Never (jump to qust. 57) ☐3. Used to (have quitted) (jump to qust. 54)	smst ☐
51. Manufacturing types of smoke ☐1. biri ☐2. cigarettes ☐3. both	smtype ☐
52. How many cigarettes/biri do you smoke per day? ☐☐ cigarettes a day	nocigd ☐☐
53. At what age did you begin smoking? at ☐☐ year of age (jump to qust. 57)	agebsm ☐☐
**** Only for quitted smoker (54-56)****	
54. How many years have you quitted? ☐☐ year(s)	dissmoke ☐☐
55. How long had you been smoking? ☐☐ year(s)	yrsmoke ☐☐
56. How many cigarettes/biri did you smoke per day? ☐☐ cigarettes a day	cigd ☐☐
57. Do any of your family member(s) currently smoke? ☐1. Y Number: ☐ person(s) ☐2.N	fhsm ☐ fhsm1 ☐☐

Part 9: Weight Height

wth □□□.□

hth □□□.□

58. Weight □□□.□ kg.

59. Height □□□.□ cm.

Interviewer.....

Double Check.....

Data Entry 1.....

Data Entry 2.....

Appendix V: Life table for cooking history exploration

Table 8: Life table for explore of cooking history with age and specific fuel types use

Fuels types	Age in years																																			% of fuel used			Frequency of cooking fuel used		
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	5th last yrs	1st yrs	last	days/ week	time/ day	hours/ time
Gas																																											
Kerosene																																											
Coal																																											
Charcoal																																											
Wood																																											
Cow-dung																																											
Dry leaves																																											
Others																																											
Rice straw																																											

Coding from life table

Table: Duration and frequency of cooking fuel used with age

1. gasu (gas used) ☐ 1. Y 2. N (jump to 9)

2. gasst ☐☐ 3. gassp ☐☐ 4. gas5y ☐☐☐

5. gas1y ☐☐☐ 6. gasd ☐ 7. gast ☐

8. gash ☐.☐☐

9. ksineu (kerosene used) ☐ 1. Y 2. N (jump to 17)

10. ksinest ☐☐ 11. ksinesp ☐☐ 12. ksine5y ☐☐☐

13. ksine1y ☐☐☐ 14. ksined ☐ 15. ksinet ☐

16. ksineh ☐.☐☐

17. coalu (coal used) ☐ 1. Y 2. N (jump to 25)

18. coalst ☐☐ 19. coalsp ☐☐ 20. coal5y ☐☐☐

21. coal1y ☐☐☐ 22. coald ☐ 23. coalt ☐

24. coalh ☐

25. charcoalu (charcoal used) ☐ 1. Y 2. N (jump to 33)

26. ccoalst ☐☐ 27. ccoalsp ☐☐ 28. ccoal5y ☐☐☐

29. ccoal1y ☐☐☐ 30. ccoald ☐ 31. ccoalt ☐

32. ccoalh ☐.☐☐

33. woodu (wood used) ☐ 1. Y 2. N (jump to 41)

34. woodst ☐☐ 35. woodsp ☐☐ 36. wood5y ☐☐☐

37. wood1y ☐☐☐ 38. woodd ☐ 39. woodt ☐

40. woodh ☐.☐☐

41. cdungu (cow-dung used) ☐ 1. Y 2. N (jump to 49)

42. cdungst ☐☐ 43. cdungsp ☐☐ 44. cdung5y ☐☐☐

45. cdung1y ☐☐☐ 46. cdungd ☐ 47. cdungt ☐

48. cdungh ☐.☐☐

49. dleaveu (dry leaves used) ☐ 1. Y 2. N (jump to 57)

50. dleave ☐☐ 51. dleavesp ☐☐ 52. dleave5y ☐☐☐

53. dleave1y ☐☐☐ 54. dleaved ☐ 55. dleavet ☐

56. dleaveh ☐.☐☐

57. otheru (other used) ☐ 1. Y 2. N (jump to 65)

58. otherst ☐☐ 59. othersp ☐☐ 60. other5y ☐☐☐

61. other1y ☐☐☐ 62. otherd ☐ 63. othert ☐

64. otherh ☐.☐☐

65. rstarwu(rice straw used) ☐ 1. Y 2. N (new id start)

66. rstarwst ☐☐ 67. rstarwsp ☐☐ 68. rstarw5y ☐☐☐

69. rstarw1y ☐☐☐ 71. rstarwd ☐ 72. rstarwt ☐

73. rstarwh ☐.☐☐

Appendix VI: The Submitted Manuscript

Use of traditional cooking fuels and the risk of young adult cataract in rural Bangladesh: a hospital-based case-control study

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Abstract

This study aimed to investigate the independent relationship between the use of various traditional cooking fuels and the occurrence of cataract in young adults in rural Bangladesh.

Methods

A hospital-based case-control study incorporating two controls groups was conducted. Cases were cataract patients aged 18-49 years diagnosed as any opacity of the crystalline lens or its capsule visual acuity poorer than 6/18 on the Log Mar Visual Acuity Chart, or cataract removed by a qualified ophthalmologist within the previous 5 years. Non-eye-disease (NE) controls were selected from patients from the ENT or Orthopaedics departments in the study hospital. Non-cataract eye-disease (NC) controls were selected from those patients with eye problems other than cataract. Both controls groups were matched on age and sex with cases. Detailed history of exposure to various cooking fuels as well as data pertaining to established risk factors for cataract were obtained by face-to-face interview. Data were analyzed using conditional logistic regression.

Results

Ever use of wood/dry leaves and ever use of rice straw as cooking fuel were significantly positively associated with case status in comparison with NE controls, and ever use of cow-dung significantly negatively related with case status in comparison with both control groups. Case status also showed a significant trend association (shown as OR and 95% CI) with lifetime hours of

exposure fitted as never, ≤median, >median: wood/dry leaves 2.15 (1.09-4.23), rice straw 1.83 (1.06-3.16), cow-dung compared with NE controls 0.54 (0.33, 0.88) and compared with NC controls 0.61 (0.39-0.97).

Conclusions

The increased risk of young adult cataract associated with the use of wood/dry leaves or rice straw as cooking fuel is supported in this study. Of particular interest is the demonstration of a negative association between of young adult cataract and the use of cow-dung as cooking fuel. The precise nature of this apparent protective effect should be investigated further.

Keywords

Young adult cataract, risk factor, traditional cooking fuels, Bangladesh.

Background

Blindness is a global problem nowadays and cataract is the leading cause of blindness in both developed and developing countries. The numbers of blind in the world in 1975 was estimated to be 28 million. The number of blind increased in 2002 to around 45 million with 16-20 million due to cataract and is projected, if present trends continue, to reach 75 million by 2020 [1,2].

Increasing age is associated with an increased prevalence of cataract. People aged 50 years and older and females are at greater risk of developing cataract [1]. The prevalence of cataract also increases with age in developing countries, although it often occurs earlier in life [3]. A major challenge in developing countries is to reduce the magnitude of cataract in the population by delaying the development of cataract and by providing ready access to cataract surgery for all those who need it [2].

A recent population-based survey in Bangladesh estimated 650,000 people were blind aged 30 years and older, around 80% due to cataract, and 130,000 new cases developed annually [4,5]. The prevalence of bilateral blindness was 2.9%, severe visual impairment 1.2%-2.0% and that of visual impairment 8.4%. Seventy nine percent of bilateral blindness was due to cataract and the cataract surgical coverage was moderate in quality [6]. The age-standardized prevalence of bilateral blindness was 1.52% aged 30 years and older, of which 79.6% was caused by cataract; and the

prevalence of low-vision was 13.8%, among whom 74.2% was due to cataract. Among neighboring countries, the overall prevalence of blindness was 0.9% in Myanmar with 64% due to cataract, 0.7% in India with 77% due to cataract and 0.8% in Nepal with 72% due to cataract [7].

The age-specific blindness prevalence in Bangladesh was found to increase with increasing age, and to be higher in women and the illiterate and disadvantaged people [4]. Most of those women and of low socioeconomic status are commonly used wood, leaves, cow-dung and rice straw for household cooking and from early life. Previous data from Impact "Jibon Tari" Floating Hospital also indicated that among all eye surgical patients around 90% were cataract operation and 14% were young adult (age between 18-45 years) cataract patients. The proportion of young adults is higher in Bangladesh than in many other countries, suggesting that there might be some specific risk factors for early onset of cataract in this population. This research, therefore, aimed to identify those risk factors which are particularly prevalent in the Bangladesh population and may be preventable, and thereby indicate possible approaches for future policy-making to prevent blindness. Exposure to cheaper cooking fuels has been identified to be a risk factor in India and Nepal [8,9] and is very common in rural Bangladesh. Therefore, these exposures might be related to the high incidence of young adult cataract in Bangladesh. Moreover, most previous studies have been conducted based on age-related cataract. We therefore conducted this study among a younger age group to determine if exposure to cheaper cooking fuels are actually risk factors in this Bangladesh setting.

Methods

Study setting

The study was designed as a hospital-based matched case-control study with two types of control and conducted from May to October 2009 in Impact "Jibon Tari" Floating Hospital, Bangladesh. The hospital is located on a river and moves to disadvantaged areas of the country at 5- to 6-month intervals. It aims to provide health services, both clinical and surgical, to address the problems of disability in the remote areas of the country. At the time of the study, the hospital was located in Barisal district, in the south-west of Bangladesh, a region criss-crossed by many rivers.

Study population

Subjects were recruited from males and females aged between 18-49 years who came to visit Impact "Jibon Tari" Floating Hospital, Bangladesh, during the study period. The required sample size was 153 subjects in each of the case, non-eye-disease control and non-cataract eye-disease control groups, based on having a power of 80% to detect an odds ratio of at least 2 when the prevalence of exposure among control groups was 30%.

Sample selection

Case recruitment: Ophthalmologic patients age between 18-49 years who came to visit the eye specialist in Impact "Jibon Tari" Floating Hospital and diagnosed as cataract by clinical and slit-lamp examination results showing opacity of the crystalline lens or its capsule and visual acuity poorer than 6/18 on the Log Mar

Visual Acuity Chart and or whose cataract had already been removed by a qualified ophthalmologist not more than 5 years previously were recruited as cases in this study. Patients not willing to participate, having congenital cataract, severe mental disorder or cataract secondary to serious eye disease, such as glaucoma, diabetes retinopathy and severe injury, were excluded.

Non-eye-disease (NE) controls: Non-eye-disease control subjects were selected from patients without any eye problem but attending other departments available in the same hospital and 1:1 matched to cases on age (within same 5-year age range) and sex. Inclusion criteria were: aged between 18 and 49 years, having no history of prior cataract/eye surgery and no eye problem within last 3 months. Known cases of myopia were excluded. Potential subjects were recruited from among out-patients fulfilling the inclusion criteria in the ENT and Orthopedics departments on the same or following working day as the case to which they were matched.

Non-cataract eye-disease (NC) controls: Non-cataract eye-disease controls were selected from among patients attending in the same hospital with an eye problem other than cataract and matched 1:1 with cases on age (within same 5-year age range) and sex. Inclusion criteria were: aged between 18 and 49 years, having no history of prior cataract/eye surgery. Recruitment of potential subjects was made from the first patient subsequent to case attainment who fulfilled the inclusion criteria.

Potential controls of either type who were not willing to participate or had severe mental disorder were excluded.

Matching was done to reduce to control the potential confounding effect arising from age and sex (both documented risk factors for cataract and likely to be associated with exposure to different types of cooking fuel). The case and control ascertainment algorithm is shown in Figure 1.

Data collection

Data were collected by semi-structured questionnaire through personal face-to-face interview and clinical examination. The questionnaire covered general socio-demographic characteristics, details of cooking history and exposure to various cooking fuels, and other previously documented risk factors for cataract.

History of exposure to cooking fuels was recorded on a matrix table comprising fuel types in rows and age (years 11 to 49) in columns. Information was also obtained regarding the number of cooking sessions per day, hours spent cooking per session and number of days when cooking was done per week. These data were used to derive parameters of frequency, intensity, duration and cumulative lifetime exposure to each cooking fuel type.

Written informed consent was requested from all respondents before their participation. For participants who were willing but could not sign, a finger print was taken after explaining the research process.

Statistical analysis

Data were entered using EpiData version 3.1 [10] and transferred into R version 2.10.0 [11] for cleaning, exploration and analysis. The distributions of variables were explored and summarized within

each outcome group using mean and standard deviation or frequency. Tabulation of independent variables was performed for matched pairs of case vs non-eye-disease control and for case vs eye-disease control. Those variables showing any indication of differing within the matched pairs in either comparison ($p<0.2$), in addition to selected parameters of cooking fuel use, were included in initial conditional logistic regression models for matched pairs of case vs non-eye-disease control and of case vs non-cataract eye-disease control, and the models refined by successive removal of variables showing no statistically significant contribution to the fit of either model, other than the selected cooking fuel variables, which were retained in the models irrespective of their statistical significance. Likelihood ratio test p-values $<=0.05$ were considered as indicating statistical significance.

Associations between case status and alternative, ordinal, parameters of cooking fuel use were then explored among these fuels to identify any dose-response relationships. These ordinal exposure variables comprised age at first exposure, frequency (times per week during the years used), intensity (hours per week during the years used), duration (years) and lifetime exposure (lifetime hours of use). Each variable except age at first exposure was cut into three levels: never used, used for less than the median among all users, and equal to or greater than the median for all users. Age at fist exposure was cut into never exposed, older than median age, and less than of equal to the median age. These variables were fitted first in categorical form and subsequently in trend-across-category form.

To evaluate the effect of matching, additional analyses were performed using multinomial logistic regression modeling.

Ethical considerations

The study was approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla University, Thailand, and an oral approval was granted after a detailed presentation of the research proposal within the management of Impact Foundation Bangladesh, the authority of the study hospital, before conducting the study. All potential participants in the study were informed that the study was aimed at identifying certain behaviours that might increase the risk of their developing ailments common in rural Bangladesh. Only after the patient gave signed consent was the interview conducted. Computerized data did not indicate the identity of any patient.

Results

A total of 459 subjects, including 153 cataract cases aged between 18-49 years with an equal number of each control group matched on age and sex, were recruited and interviewed. There were slightly more females than males. The mean age of all participants was 41.8 (SD 6.3) years and 30 percent were aged 40 or less. In all groups, most of the females were housewives, the commonest occupation among males was farmer, and about 80 percent were classified as having low socioeconomic status as measured on the modified Kuppuswami scale using education, occupation and income of the family head. Around 70 to 75 percent of subjects were classified

as being underweight. Very few subjects reported a history of diagnosis of hypertension or diabetes mellitus (Table1).

Over half of the NE controls (56.2%) were diagnosed as various ear diseases followed by nasal, throat, and orthopedic diseases. Among NC controls, refractive error, corneal diseases and conjunctival diseases were most common (Table 2).

Cases had less commonly received secondary or tertiary education than controls, particularly non-eye-disease controls and more commonly reported a history of current or past smoking and a greater occupational exposure to sunlight. Cases also more frequently reported a family history of cataract.

Cooking history and exposure to various cooking fuels among subjects in each group are shown in Table 3. About two thirds of subjects in each group reported a history of cooking, either regularly or occasionally. The commonest fuel used for cooking in all groups was wood and/or dry leaves, followed respectively by cow-dung and rice straw. Further analysis of cooking fuel exposure was confined to these three groups of cooking fuels. Gas or kerosene was used by only a small number of subjects in any group. The proportion of cases using rice straw was higher than that of either of the controls, whereas the proportion of cases using cow-dung was lower than that in each control group. The lifetime duration of cooking activities was somewhat higher among cases than either of the control groups. Exposure parameters explored included age at fist exposure, frequency of exposure (times per week), intensity of exposure (hours per week during the years used), duration from first to most recent exposure in years

(irrespective of the frequency of intensity of exposure), and total lifetime exposure (hours of actual exposure). However, these differentials was not statistically significant.

Educational level, income of family, socioeconomic status, treatment of diagnosis of hypertension, family history of cataract, exposure to sunlight exposure in workplace and smoking status were included in the initial multivariate model as the p-value for their univariate association with case status was ≤3 in comparison with at least one of the control groups. Exposures to the main cooking fuel types (as binary variables: ever /never exposed) were included irrespective of their statistical significance.

After refinement of the two models, the variables remaining were education level of the subject, family history of cataract, smoking status of the subject, and ever use of wood or dry leaves, of cow dung and of rice straw (Table 4).

Family history of cataract was strongly associated with case status in both models (OR=2.55; 95%CI 1.43-4.54 and 2.53; 95%CI 1.33-4.80). Lower education was associated with case status in the comparison with non-eye-disease controls (compared to secondary education or higher, OR=4.18 (95% CI 1.94-9.03) for primary education and OR=3.79 (95% CI 1.71-8.41) for less than primary) and history of smoking in comparison with eye-disease controls (OR=3.13, 95%CI 1.38-7.10).

In comparisons with non-eye-disease controls, ever use of wood/dry leaves (OR= 2.68; 95%CI 1.14-6.33) and of rice straw (OR=2.56; 95%CI 1.07-6.10) showed significant associations with case status,

whereas ever use of cow dung showed a significant inverse association with case status (OR=0.42; 95%CI 0.15-0.90). In comparison with non-cataract eye-disease controls, only use of cow dung among cooking fuels was significantly associated with a reduced risk of being a case (OR=0.45; 95%CI 0.22-0.93).

Parameters reflecting the magnitude of exposure to cooking fuel were then fitted to models containing family history of cataract, smoking status and education. These parameters, each fitted to separate models were age at first exposure, frequency, intensity, duration and lifetime exposure. The patterns of association were similar for each parameter. The models for lifetime exposure are shown in Table 5. Significant dose-response relationships with case status were revealed in comparison with non-eye-disease controls after controlling for family history of cataract, education level and smoking status. Lifetime exposure to wood or dry leaves as cooking fuel increased the odds of being a case by 2.77 (95% CI 1.16-6.58) times for exposures of no more than 25000 hours and by 4.01 (95% CI 0.98-16.31) times for longer exposures compared with no exposure. For lifetime exposure to rice straw as cooking fuel the corresponding odds ratios were 2.24 (95% CI 0.69-7.27) for exposures of no more than 24000 hours and 3.01 (95% CI 0.96-9.45) for longer exposures. By contrast the odds ratios for case status associated with use of cow dung were 0.42 (95% CI 0.16-1.13) for exposures of no more than 31500 hours and 0.34 (95% CI 0.13-0.98) for longer exposures compared with no exposure (Table 5).

In comparison with non-cataract eye-disease controls, among lifetime exposures to cooking fuels, only that to cow dung was weakly significant, although the trend was not marked (trend OR= 0.61, 95%CI 0.39-0.97).

Using multinomial logistic regression modeling, essentially the same relationships between predictors and case status as in the conditional models were obtained in comparison with each control group.

Discussion

This study aimed to test the hypothesis that exposure to cheaper cooking fuels, such as wood or dry leaves, cow-dung and rice straw, is significantly associated with the development of cataract among adults less than 50 years of age in rural Bangladesh. After adjusting for family history of cataract, smoking status and level of formal education, use of wood or dry leaves and use of rice straw were identified as risk factors in comparison with non-eye-disease controls and exhibited a dose-response trend in risk with increasing lifetime exposure. No such relationships were seen in comparison with non-cataract eye-disease control patients.

A possible, though unsupported, explanation for this difference depending on the type of controls employed is that the other eye diseases share these risk factors with cataract patients, or that patients with diseases included among the non-eye-disease control group are less exposed to these particular cooking fuels. Inter-

comparison of the two types of control, however, revealed no significant associations with the use of these cooking fuels.

An elevated risk of cataract associated with the use of wood/dry leaves and rice straw is consistent with the findings of several previous studies in which a link was detected between the use of cheaper, biomass or solid fuels and the risk of cataract. The use of less expensive cooking fuels was more common among patients with age-related cataract than non-cataract patients in India [8], and use of solid fuel unvented stoves more common among female cataract patients of any age than among non-cataract eye-disease patients in the Nepal-India border area [9]. In both instances the associations remained significant after adjustment for other risk factors, including low educational achievement.

A plausible mechanism underlying the association between the use of wood/dry leaves and rice straw and development of cataract may be related to the constituents of the large amounts of smoke produced from these fuels damaging the tissues of the eye following either systemic absorption or even local diffusion through the cornea. It has been suggested that such damage may be a result of the endogenous generation of reactive oxygen species by photodynamic action, similar to the purported mechanism by which smoking tobacco may raise the risk of cataract [12,13].

Despite the relationship between risk of cataract and use of cooking fuel being reported in a number of studies, few have attempted to document the risk for different types of biomass fuel. The component materials have either not been specified or have been specified but combined in the analysis. Thus, Mohan

(1989) and Mishra (1999) reported elevated risks of both cataract and blindness among an Indian population with exposure to the smoke of biomass cooking fuel, specified as wood, crop residuals and/or cow dung, but separate analyses of each of these materials were not described [14,15].

In view of these reports, the independent inverse association between the use of cow dung as a cooking fuel and case status in our study was unexpected. The relationship held true in comparisons with each type of control, although the evidence for a dose-response relationship was somewhat stronger in the comparison with non-eye-disease controls. While copious amounts of smoke are known to emanate from burning cow dung, the opposite direction of relationship in our study between wood, dry leaves and rice straw on the one hand and cow dung on the other, might be related to the different complement of smoke constituents. Although cow diet consists largely of fresh grass, bacterial and enzymatic actions of the bovine gastrointestinal tract result in considerable transformations of the plant material.

Constituents of smoke from biomass fuels has been reported to vary considerable with the type of stove employed and with various other differences in the way it is prepared. Comparative information on the constituents of smoke from different biomass fuels, or from dung fuel separate from other biofuels, is scarcely available in the scientific literature, despite several studies of smoke constituents of biomass fuels combined [16-20]. Mudway (2005), however, demonstrated that particles derived from the burning of cow-dung cake burned in a traditional Indian cooking

stove and deposited in the human respiratory tract lining fluid had considerable oxidative activity, which was mostly due to their transitional metal content [21]. If the postulated mechanism whereby smoke from biomass fuels induces cataract formation through the activity of reactive oxygen species is true, then it is difficult to understand why smoke form cow-dung does not have a similar risk-enhancing effect to that of wood/dry leaves and rice straw. Further comparative analyses are required to identify differences in the smoke constituents and elucidate possible differences in the mechanisms of action.

Consideration, however, must also be given to the possibility that the apparent protective effect against the development of young adult cataract of using cow dung as a cooking fuel could be due to uncontrolled confounding. Exposure to cow-dung as cooking fuel is more common among middle class family in rural areas in Bangladesh. Cows are usually used for cultivation and dairy products, so more frequently kept by land and farm owners, whereas poor families can rarely afford to buy or keep cattle. Use of cow-dung as a fuel thus may be acting as a proxy for higher socioeconomic status, which itself has been identified in some previous studies to be associated with a lower prevalence of cataract (of any type) [4,8,22-24]. Nevertheless, adjusting our models for family income level or for the composite socioeconomic status indicator based on the Kuppuswami scale, had no discernable effect on the relationship between case status and use of cow dung as a cooking fuel, so that confounding, if it is to be invoked as the explanation for the relationship, must involve an as yet unidentified variable.

It is of interest, however, that an Indian study of the relationship between fuel use and ocular morbidity in which separate independent associations between different types of cooking fuel and cataract were examined demonstrated a significantly increased risk for wood but not for cattle dung or for gas, kerosene or coal [25]. On the other hand, eye irritation was significantly associated with the use of coal and cattle dung but not the other fuels.

Other variables related to case status in our study have each been recognized as risk factors in previous studies. A genetic predisposition to cataract has been indicated by the finding of a strong independent association with family history of cataract in most studies of cataract in general [26-30] as in the current study of young adult cataract. Nevertheless an Indian case-control study failed to identity such as association [8].

Various studies have identified an association, in some cases in a dose-related manner, between cataract and cigarette smoking. These studies have included those with case-control [31], cross-sectional [32,33], and prospective designs [34-38]. Most of these studies found smoking to be related with nuclear cataract, although an increased risk among smokers of posterior subcapsular cataract was also reported in two of the prospective studies [34,35]. Our study revealed an association between smoking status and young adult cataract when compared with NC controls, but not in comparison with NE controls. The discrepancy appears to be linked with the finding of a higher frequency of smokers among NE than among NC controls. More than half of the NE controls had ear

diseases, with otitis media accounting for 35% of all NE controls. It is known to be common practice among this population to smoke cigarettes to help relieve the irritation and itching associated with ear disease.

Educational attainment lower than secondary level was identified as a risk factor for case status in comparison with NE controls in this study, and is in agreement with this findings of many previous studies of cataract in general [4,22,23,26,32,33,39-42]. The explanation may lie in the generally poorer nutritional status of less educated people. Poor nutritional status has itself been identified as an independent risk factor for cataract [24,41,43,44]. The educational level of NC controls in our study was higher than that in NE controls, and may explain the failure to identify a significant association with case status in this comparison. Low educational attainment in this group of controls was particularly related to controls with conjunctivitis or pterygium and those with refractive errors. These diseases together accounted for 60% of NC controls.

Working in the sunlight was slightly rather less frequent among NE controls but did not retain its significance after adjustment for other factors. Previous studies have yielded conflicting findings regarding this exposure. Some have reported a relationship between sunlight exposure in the workplace and cataract [45-48], whereas others have failed to identify outdoor work involving higher sunlight exposure as a risk factor for lens disease [41,42,49].

A limitation of this study stems from difficulties in recalling lifetime use of various cooking fuels, although recall was

stimulated during the interview by referring to significant life events of each patient. However, it is unlikely that recall misinformation was biased as all patients, both cases and controls, were visiting the hospital for treatment of some ailment, and the specific hypothesis under study was not known to the subjects. Such random errors that may have occurred would therefore tend to reduce the observed strength of association between exposures and outcome.

As the relationship between use of wood or dry leaves and rice straw as cooking fuels and development of young adult cataract was not consistently significant in comparisons with both controls, the role of these exposures in increasing the risk of young adult cataract should be interpreted with caution. However, the consistent relationship between the use of cow-dung and lowered risk of cataract is more convincing, although at present a clear plausible explanation is lacking.

The study did not classify the cases with respect to type of cataract. Unless all types share the same risk factors, any heterogeneity of cataract types would have the effect of diluting the true relationships with exposure.

Finally, since this study was conducted in a charitable non-government organization hospital, catering for disadvantaged villagers in remote parts of the country, the range of socio-economic status among subjects was not very wide. Such restricted variability may have prevented the identification of certain risk factors that may be seen in studies with a wider variety of patient backgrounds.

The strength of this study lies in its separation of different types of traditional cooking fuel, which allowed the identification of contrasting directions of association among these fuel types.

In conclusion, our results are in agreement with those of earlier studies that the use of cheaper cooking fuels may increase the risk of cataract, in our case cataract in young adults. The study also provides evidence that use of cow-dung as a cooking fuel does not increase the risk of developing cataract in young adult life, and may actually be protective. In view of the lack of plausible explanation for this protective effect, further studies of the relationship between use of cow-dung and cataract in other settings, as well as comparative analysis of the constituents of the smoke from wood/dry leaves/rice straw and that of cow-dung, are needed. From the public health aspect for Bangladeshi villagers, a change to the use of alternative fuels such as biogas or liquefied petroleum gas, the adoption of stoves that can reduce the free emission of smoke from wood/dry leaves and rice straw fuel, or improved ventilation of cooking areas of the house, are recommended.

Competing interests

The authors declare they have no competing interests.

Authors' contributions

Joydhan Tanchangya, MBBS, Medical Officer, Impact "Jibon Tari" Floating Hospital, Bangladesh, designed the study, carried out the entire data collection, conducted data analysis and interpretation

of the data. Alan F. Geater, PhD, Senior Lecturer, Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Thailand, supervised the entire study and was involved equally during design, data analysis and interpretation of the data.

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Figure 1: The case and control ascertainment algorithm

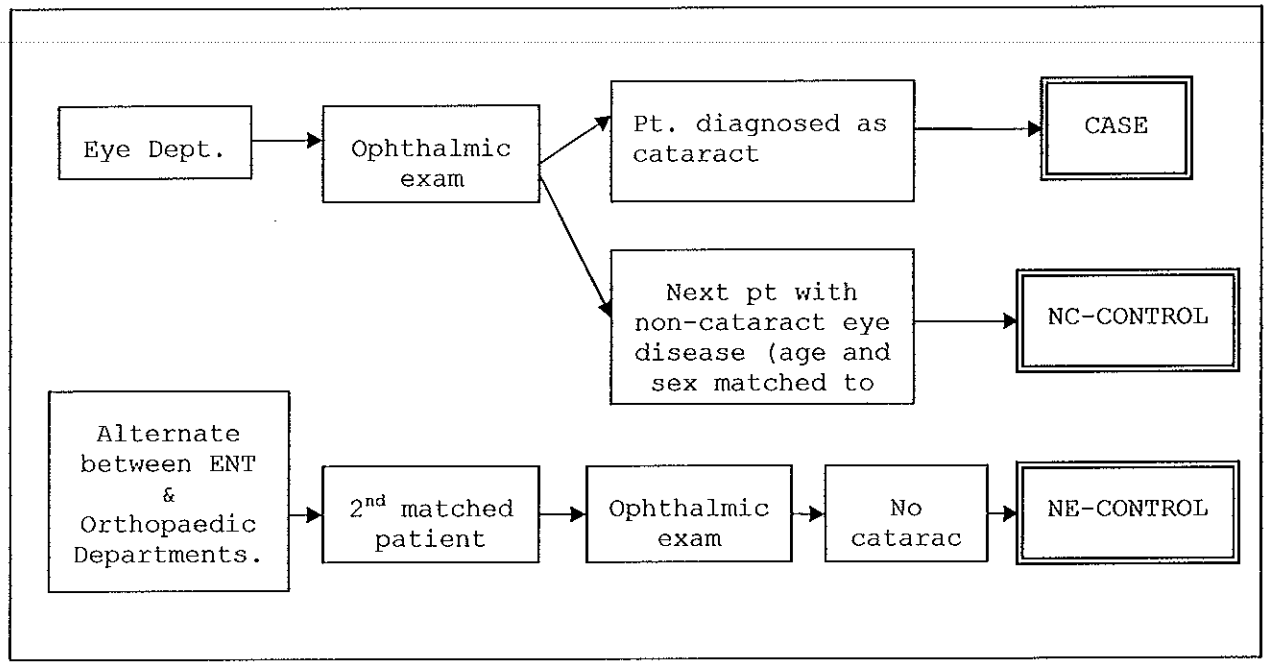

Figure 1. Case and control enrolment scheme

Table 1. Distribution of socio-demographic characteristics distribution among cases and controls

Variables	Cases N (%)	Non-eye-disease controls		Non-cataract eye-disease controls	
		N (%)	P-value*	N (%)	P-value*
Age in years (mean ± SD)	42.0 ± 6.1	41.8 ± 6.6		41.5 ± 6.1	
Age groups					
18 - 20	1 (0.7)	5 (3.3)		2 (2.0)	
21 - 30	10 (6.5)	5 (3.3)		7 (4.6)	
31 - 40	36 (23.5)	36 (23.5)		36 (23.5)	
41 - 49	106 (69.3)	107 (69.9)		107 (69.9)	
Sex					
Male	73 (47.7)	73 (47.7)		73 (47.7)	
Female	80 (52.3)	80 (52.3)		80 (52.3)	
Religion			0.352		0.073
Muslim	91 (59.5)	83 (54.2)		75 (49.0)	
Others	62 (40.5)	70 (45.8)		78 (51.0)	
Marital status			0.713		0.400
Single	7 (4.6)	6 (3.9)		5 (5.3)	
Married	139 (90.8)	137 (89.5)		144 (94.1)	
Education			<0.001		0.082
No education	61 (39.9)	54 (35.3)		55 (35.9)	
Primary	73 (47.7)	54 (35.3)		65 (42.5)	
Secondary	19 (12.4)	45 (29.4)		33 (21.6)	
Occupation			0.556		0.754
Farmer	26 (17.0)	30 (19.6)		26 (17.0)	
Housewife	76 (49.7)	69 (45.1)		72 (47.1)	
Labour	11 (7.2)	10 (6.5)		9 (5.9)	
Business	12 (7.8)	14 (9.2)		13 (8.5)	
Teacher	3 (2.0)	3 (2.0)		7 (4.6)	
Others	25 (16.3)	27 (17.6)		26 (17.0)	
Household members			0.931		0.638
≤4	39 (25.5)	40 (26.1)		41 (26.6)	
5-7	93 (60.8)	94 (61.4)		86 (56.2)	
>7	21 (13.7)	19 (12.4)		26 (17.0)	

Table 1. Distribution of socio-demographic characteristics distribution among cases and controls (cont.)

Variables	Cases N (%)	Non-eye-disease controls		Non-cataract eye-disease controls	
		N (%)	P-value*	N (%)	P-value*
Household income (in previous year) taka/month			0.990		0.039
≤3000	50 (32.7)	50 (32.7)		31 (20.3)	
3001-7500	66 (43.1)	65 (42.5)		84 (54.9)	
>7500	37 (24.2)	38 (24.8)		38 (24.8)	
Socioeconomic status			0.326		0.639
Lower	127 (83.0)	120 (78.4)		124 (81.0)	
Middle	26 (17.0)	33 (21.6)		29 (19.0)	
Body Mass Index (BMI)			0.856		0.481
Underweight	116 (75.8)	111 (72.5)		106 (69.3)	
Normal	27 (17.6)	34 (22.2)		40 (26.1)	
Overweight	8 (5.2)	8 (5.2)		7 (4.6)	
Hypertension			1.000		0.088
Yes	5 (3.3)	5 (3.3)		1 (0.7)	
No	148 (96.7)	148 (96.7)		152 (99.3)	
Diabetic mellitus			0.096		0.096
Yes	0 (0.0)	2 (1.3)		2 (1.3)	
No	153 (100)	151 (98.7)		151 (98.7)	
Myopia			0.009		0.016
Yes	5 (3.3)	0 (0.0)		14 (9.2)	
No	148 (96.7)	153 (100.0)		139 (90.8)	
Family history of cataract			<0.001		<0.001
Yes	54 (35.3)	26 (17.0)		29 (19.0)	
No	99 (64.7)	127 (83.0)		124 (81.0)	
Hx of working in sunlight			0.054		0.579
Yes	125 (81.7)	110 (71.9)		121 (79.1)	
No	28 (18.3)	43 (28.1)		32 (20.9)	

* P value from likelihood ratio test of univariate conditional logistic model

Table 1. Distribution of socio-demographic characteristics distribution among cases and controls (cont.)

Variables	Cases N (%)	Non-eye-disease controls		Non-cataract eye-disease controls	
		N (%)	P-value*	N (%)	P-value*
Years of sunlight ex.			0.030		0.083
Ex.>18yr	70 (45.8)	51 (33.3)		54 (35.3)	
Ex. ≤18yr	55 (35.9)	59 (38.6)		67 (43.8)	
Not expose	28 (18.3)	43 (28.1)		32 (20.9)	
Smoking status			0.084		0.001
Current or past	55 (35.9)	45 (29.4)		36 (23.5)	
Never smoked	98 (64.1)	108 (70.6)		117 (76.5)	
Current.no.cigsarettes /day			0.724		0.028
>10/day	25 (16.3)	22 (14.4)		12 (7.8)	
≤10/day	17 (11.1)	15 (9.8)		17 (11.1)	
None	111 (72.5)	116 (75.8)		124 (81.0)	

* P value from likelihood ratio test of univariate conditional logistic model

Table 2. Distribution of diagnosed diseases among case and controls status

Non-eye-disease controls		Non-cataract-eye-disease controls	
Diseases	**N (%)**	**Diseases**	**N (%)**
Ear diseases	86(56.2)	Refractive error	47(30.7)
Nasal diseases	15(9.8)	Corneal diseases	42(27.5)
Throat diseases	13(8.5)	Conjunctival diseases	30(19.6)
Orthopedics diseases	11(7.2)	Lacrimal tract disease	8(5.2)
Others	28(18.3)	Others	26(17.0)

Table 3. Distribution of parameters of cooking history and cooking fuel use among cases and controls

Variables	Cases N (%)	Non-eye-disease controls		Non-cataract eye-disease controls	
		N (%)	P-value*	N (%)	P-value*
Cooking history					
Ever cooked			0.181		0.590
Yes	108 (70.6)	100 (65.4)		105 (68.6)	
No	45 (29.4)	53 (34.6)		48 (31.4)	
Frequency			0.560		1.000
Regular	87 (80.6)	84 (84.0)		83 (79.0)	
Occasionally	21 (19.4)	16 (16.0)		22 (21.0)	
Place			0.218		0.155
Living house	33 (30.6)	21 (21.0)		20 (19.0)	
Separate house	75 (69.4)	79 (79.0)		85 (81.0)	
Gas					
Ever used			0.041		0.019
Used	0 (0.0)	3 (2.0)		4 (2.6)	
Never used	153 (100)	150 (98.0)		149 (97.4)	
Kerosene					
Ever used			1.000		0.705
Used	4 (2.6)	4 (2.6)		3 (2.0)	
Never used	149 (97.4)	149 (97.4)		150 (98.0)	
Wood /dry leaves					
Ever used			0.053		0.449
Used	106 (69.3)	95 (62.1)		102 (66.7)	
Never used	47 (30.7)	58 (37.9)		51 (33.3)	
Age at 1st exposure			0.151		0.421
Never exposed	47 (30.7)	58 (37.9)		51 (33.3)	
Exposed at ≥15 yr	56 (36.6)	45 (29.4)		60 (39.2)	
Exposed at <15 yr	50 (32.7)	50 (32.7)		42 (27.5)	
Frequency of use			0.124		0.632
Never used	47 (30.7)	58 (37.9)		51 (33.3)	
Used≤14 times/week	98 (64.1)	85 (55.6)		90 (58.8)	
Used>14 times/week	8 (5.2)	10 (6.5)		12 (7.8)	

Table 3. Distribution of parameters of cooking history and cooking fuel use among cases and controls (cont.)

Variables	Cases N (%)	Non-eye-disease controls		Non-cataract eye-disease controls	
		N (%)	P-value*	N (%)	P-value*
Intensity of use			0.093		0.435
Never used	47 (30.7)	58 (37.9)		51 (33.3)	
Used≤20 hr/week	64 (41.8)	50 (32.7)		56 (36.6)	
Used>20 hr/week	42 (27.5)	45 (29.4)		46 (30.1)	
Duration of use			0.154		0.024
Never used	47 (30.7)	58 (37.9)		51 (33.3)	
Used≤26yr	52 (34.0)	43 (28.1)		61 (39.9)	
Used >26yr	54 (35.3)	52 (34.0)		41 (26.8)	
Life time exposure			0.154		0.741
Never used	47 (30.7)	58 (37.9)		51 (33.3)	
Used≤25000 hr	55 (35.9)	44 (28.8)		52 (34.0)	
Used>25000 hr	51 (33.3)	51 (33.3)		50 (32.7)	
Rice straw					
Ever used			0.053		0.273
Used	29 (19.0)	18 (11.8)		22 (14.4)	
Never used	124 (81.0)	135 (88.2)		131 (85.6)	
Age at 1st exposure			0.031		0.215
Never exposed	124 (81.0)	135 (88.2)		131 (85.6)	
Exposed at ≥15 yr	11 (7.2)	11 (7.2)		13 (6.5)	
Exposed at <15 yr	18 (11.8)	7 (4.6)		9 (7.8)	
Frequency of use			0.140		0.194
Never used	124 (81.0)	135 (88.2)		131 (85.6)	
Used≤14 times/week	25 (16.3)	18 (11.8)		21 (13.7)	
Used>14 times/week	4 (2.6)	0 (0.0)		1 (0.7)	
Intensity of use			0.153		0.280
Never used	124 (81.0)	135 (88.2)		131 (85.6)	
Used≤20 hr/week	16 (10.5)	10 (6.5)		12 (7.8)	
Used>20 hr/week	13 (8.5)	8 (5.2)		10 (6.5)	
Duration of use			0.072		0.420
Never used	124 (81.0)	135 (88.2)		131 (85.6)	
Used ≤26yr	12 (7.8)	10 (6.5)		11 (7.2)	
Used >26yr	17 (11.1)	8 (5.2)		11 (7.2)	

Table 3. Distribution of parameters of cooking history and cooking fuel use among cases and controls (cont.)

Variables	Cases N (%)	Non-eye-disease controls		Non-cataract eye-disease controls	
		N (%)	P-value*	N (%)	P-value*
Life time exposure			0.154		0.548
Never used	124 (81.0)	135 (88.2)		131 (85.6)	
Used≤24000 hr	12 (7.8)	7 (4.6)		9 (5.9)	
Used>24000 hr	17 (11.1)	11 (7.2)		13 (8.5)	
Cow dung					
Ever used			0.204		0.084
Used	26 (17.0)	34 (22.2)		36 (23.5)	
Never used	127 (83.0)	119 (77.8)		117 (76.5)	
Age at 1st exposure			0.447		0.131
Never exposed	127 (83.0)	119 (77.8)		116 (75.8)	
Exposed at ≥14 yr	14 (9.2)	18 (11.8)		25 (16.3)	
Exposed at <14 yr	12 (7.8)	16 (10.5)		12 (7.8)	
Frequency of use			0.281		0.158
Never used	127 (83.0)	119 (77.8)		116 (75.8)	
Used≤14 times/week	24 (15.7)	34 (22.2)		34 (22.2)	
Used>14 times/week	2 (1.3)	0 (0.0)		3 (2.0)	
Intensity of use			0.424		0.223
Never used	127 (83.0)	119 (77.8)		116 (75.8)	
Used≤20 hr/week	11 (7.2)	16 (10.5)		15 (9.8)	
Used>20 hr/week	15 (9.8)	18 (11.8)		22 (14.4)	
Duration of use			0.444		0.115
Never used	127 (83.0)	119 (77.8)		116 (75.8)	
Used ≤26yr	10 (6.5)	14 (9.2)		19 (12.4)	
Used >26yr	16 (10.5)	20 (13.1)		18 (11.8)	
Life time exposure			0.447		0.185
Never used	127 (83.0)	119 (77.8)		116 (75.8)	
Used≤31500 hr	12 (7.8)	16 (10.5)		20 (13.1)	
Used>31500 hr	14 (9.2)	18 (11.8)		17 (11.1)	

* P value from likelihood ratio test of univariate conditional logistic model

Table 4. Conditional logistic regression model of variables related to case status

Variable	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude OR	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Family h/o cataract						
No	1(ref)	1(ref)	<0.001	1(ref)	1(ref)	0.003
Yes	2.40 (1.42, 4.04)	2.55 (1.43, 4.54)		2.79 (1.51, 5.13)	2.53 (1.33, 4.80)	
Smoking status						
Never smoked	1(ref)	1(ref)	0.216	1(ref)	1(ref)	0.003
Current or past	1.83 (0.91, 3.70)	1.67 (0.73, 3.77)		3.38 (1.53, 7.43)	3.13 (1.38, 7.10)	
Formal education						
At least secondary	1(ref)	1(ref)	<0.001	1(ref)	1(ref)	0.188
Primary	3.49 (1.73, 7.03)	4.18 (1.94, 9.03)		2.09 (1.04, 4.18)	1.92 (0.89, 4.15)	
None	2.89 (1.45, 5.76)	3.79 (1.71, 8.41)		2.07 (1.01, 4.21)	1.99 (0.90, 4.43)	
Use of cooking fuels:						
Wood or dry leaves						
Never used	1(ref)	1(ref)	0.020	1(ref)	1(ref)	0.336
Used	2.0 (0.97, 4.12)	2.68 (1.14, 6.33)		1.33 (0.63, 2.82)	1.54 (0.63, 3.78)	
Rice straw						
Never used	1(ref)	1(ref)	0.025	1(ref)	1(ref)	0.219
Used	2.00 (0.97, 4.12)	2.56 (1.07, 6.10)		1.41 (0.76, 2.63)	1.54 (0.77, 3.10)	
Cow-dung						
Never used	1(ref)	1(ref)	0.020	1(ref)	1(ref)	0.025
Used	0.67 (0.35, 1.25)	0.42 (0.15, 0.90)		0.58 (0.31, 1.09)	0.45 (0.22, 0.93)	

Table 5. Lifetime exposure to cooking fuels- conditional logistic regression models

Cooking fuel	Cases vs non-eye-disease controls			Case vs non-cataract eye-disease patients		
	Crude	Adjusted		Crude	Adjusted	
	OR (95% CI)	OR (95% CI)	P-value	OR (95% CI)	OR (95% CI)	P-value
Wood or dry leaves						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤25000 hours	2.00 (0.97, 4.13)	2.77 (1.16, 6.58)	0.048	1.33 (0.63, 2.81)	1.54 (0.63, 3.81)	0.467
Used >25000 hours	1.95 (0.69, 5.52)	4.01 (0.98, 16.31)		1.41 (0.51, 3.94)	2.15 (0.62, 7.44)	
Trend		2.15 (1.09, 4.23)	0.023		1.51 (0.83, 2.77)	0.175
Rice straw						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤24000 hours	2.00 (0.73, 5.48)	2.24 (0.69, 7.27)	0.071	1.40 (0.56, 3.49)	1.42 (0.47, 4.28)	0.404
Used >24000 hours	2.00 (0.79, 5.07)	3.01 (0.96, 9.45)		1.42 (0.63, 3.20)	1.74 (0.68, 4.47)	
Trend		1.83 (1.06, 3.16)	0.022		1.31 (0.86, 2.01)	0.204
Cow-dung						
Never used	1(ref)	1(ref)		1(ref)	1(ref)	
Used ≤31500 hours	0.67 (0.30, 1.49)	0.42 (0.16, 1.13)	0.050	0.49 (0.21, 1.12)	0.37 (0.15, 0.95)	0.053
Used >31500 hours	0.67 (0.30, 1.49)	0.34 (0.13, 0.98)		0.68 (0.30, 1.54)	0.46 (0.17, 1.23)	
Trend		0.54 (0.33, 0.88)	0.010		0.61 (0.39, 0.97)	0.032