

The Bangladesh National Blindness and Low Vision Survey

Identification of Prevalence, Causes and the Need for Eye Care Services

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Table of Contents

Declaration.....	i
Acknowledgements.....	i
List of Tables	i
List of Figures.....	v
List of Abbreviations / Acronyms.....	viii
Dedications.....	xiii
1.0 Introduction	1
1.1 Background to the Bangladesh National Blindness and Low Vision Survey....	1
1.2 Rationale for the Bangladesh National Blindness and Low Vision Survey	7
2.0 Aim	10
3.0 Objectives.....	11
4.0 Literature Review	12
4.1 Literature Search	12
4.2 Bangladesh Country Profile	13
4.2.1 Geography of Bangladesh	13
4.2.2 Population and Demographic Trends in Bangladesh	13
4.2.3 Millennium Development Goals (MDGs) in Bangladesh.....	18
4.2.4 Human Development Index (HDI) rankings for Bangladesh	20
4.2.5 Implications of Poverty and Health in Bangladesh.....	23
4.2.6 Health economics issues within the Bangladeshi context.....	24
4.3 Epidemiological profile of blindness and visual impairment	27
4.3.1 Global prevalence for blindness and visual impairment.....	27
4.3.2 <i>Vision 2020 – The Right to Sight</i>	29
4.3.3 Blindness and visual impairment epidemiology	30
4.3.4 ‘Global Burden of Disease’ for blindness and visual impairment	36
4.3.5 Eye care service delivery models in India and Bangladesh	38
5.0 Methods.....	46

Table of Contents

5.1 Overview of the Methods Chapter	46
5.2 Subjects	46
5.3 Sample size.....	48
5.4 Sampling Strategy	49
5.5 Household enumeration and subject identification	51
5.6 Ethical approval	52
5.7 Training of survey personnel	52
5.8 Training for visual acuity testing with RLM chart.....	53
5.8.1 Inter-examiner agreement assessment.....	54
5.8.2 Intra-examiner agreement assessment.....	55
5.9 Inter-examiner agreement analysis	56
5.10 Intra-examiner agreement analysis	57
5.11 Survey data collection process	58
5.11.1 Measurement of visual acuity	58
5.11.2 Refractive Error.....	59
5.12 Operational definitions used in the ophthalmic examination.....	59
5.13 Statistical analysis	61
5.13.1 Prevalence and causes	61
5.13.2 Outcomes of cataract surgery.....	63
5.13.3 Cataract surgical coverage for eyes and for persons.....	63
5.13.4 Barriers to uptake of cataract surgery	68
5.13.5 Refractive errors and spectacle coverage.....	69
5.13.6 Low vision and the need for rehabilitation	70
6.0 Results	71
6.1 Overview of the Results Chapter	71
6.2 Prevalence and causes of blindness and visual impairment.....	72
6.3 Cataract surgical outcomes in Bangladeshi adults	92
6.4 Cataract surgical coverage for eyes and persons in Bangladeshi adults	95
6.5 Barriers to up-take of cataract surgical service	108
6.6 Prevalence of refractive errors and spectacle coverage in adults.....	129
6.7 Prevalence of low vision and the need for rehabilitation services.....	148
7.0 Discussion.....	159

Table of Contents

7.1 Overview of the Discussion Chapter.....	159
7.2 Prevalence and causes of blindness and visual impairment.....	160
7.3 Cataract surgical outcomes	183
7.4 Cataract surgical coverage (CSC) and cataract surgical rate (CSR)	196
7.5 Barriers to up-take of cataract surgical services	207
7.6 Prevalence of refractive error and spectacle coverage.....	219
7.7 Prevalence of low vision and need for rehabilitation services.....	222
7.8 Eye care services development in the context of Bangladesh.....	230
8.0 Conclusion.....	248
9.0 References	250
10. Appendices	309
Appendix 1. PhD Research Proposal	310
Figure 1. Map of Bangladesh with rural and urban sample cluster sites	317
Figure 2. Examination protocol - Bangladesh National Blindness and Low Vision Prevalence Survey	318
Figure 3. Bangladesh National Blindness and Low Vision Prevalence Survey Proforma.....	319
Appendix 2. List of Survey Clusters – Administrative Strata (Division, District, Thana / Upazila, Union / Parashad, Village / Block) by Rural / Urban setting ...	321
Appendix 3. Personal publications related to the epidemiology of blindness and eye care service provision	335

Declaration

Declaration

I declare that the content of this dissertation is my own original work and has been prepared by me. This has not been presented and will not be presented to any other University for a similar or any other degree award.

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List of Tables

Table 4.2.1. Human Development Index (HDI) indicators for 2000 and 2015.

Table 4.2.2. Comparison of key government and family-level health expenditure indicators for 2000 and 2015.

Table 4.3.1. Trend of the estimated magnitude and prevalence of blindness and visual impairment, from 1972 to 2010, according to WHO analysis.

Table 5.4.1. Distribution of administrative strata / levels in Bangladesh

Table 5.4.2. Distribution of the survey sample clusters (rural and urban), by Division.

Table 5.10.1. Intra-examiner agreement (right eyes only).

Table 5.13.1. The Mehra – Minassian Lens Opacification Grading System

Table 6.2.1. Distribution of examined subjects, by 10-year age groups, according to presenting visual acuity status, \geq or $<$ 6/12 in the better eye.

Table 6.2.2. Distribution of subjects according to presenting and corrected visual acuities in the better eye with age-sex standardised prevalences based on presenting visual acuity.

Table 6.2.3. Binary logistic regression model results for socio-demographic predictor variables for blindness.

Table 6.2.4. Distribution of all lens opacities in eyes with $<$ 6/12 visual acuity.

Table 6.2.5. Distribution of all ocular disorders in eyes with $<$ 6/12 visual acuity.

Table 6.2.6. Distribution of the main cause of visual impairment in persons with $<$ 6/12 presenting VA in the better eye.

Table 6.2.7. Principal combinations of ocular disorders in eyes with visual acuity $<$ 6/12.

List of Tables

Table 6.2.8. Distribution of cases of glaucoma in subjects with $<6/12$ visual acuity.

Table 6.3.1. Cataract surgical outcomes in eyes, by surgical technique.

Table 6.4.1. Distribution of the total number of eyes examined and those with operable cataract, by Division.

Table 6.4.2. Distribution of eyes with 2B or 3 lens opacity, by gender, Division, rural/urban location, literacy status and type of work.

Table 6.4.3. Cataract surgical coverage (%) for eyes, according to visual acuity levels $<3/60$, $<6/60$ and $<6/18$, by Division.

Table 6.4.4. Cataract surgical coverage (%) for eyes, according to visual acuity levels $<3/60$, $<6/60$ and $<6/18$, by 10-year age groups, and by gender for $<3/60$.

Table 6.4.5. Cataract surgical coverage (%) for eyes, according to visual acuity levels $<3/60$, $<6/60$ and $<6/18$, by residence and by gender for $<3/60$.

Table 6.4.6. Cataract surgical coverage (%) for eyes, according to visual acuity levels $<3/60$, $<6/60$ and $<6/18$ by literacy status, and by gender for $<3/60$.

Table 6.4.7. Distribution of cataract surgical coverage for persons $<3/60$, $<6/60$ and $<6/18$ by Division, and by gender for $<3/60$.

Table 6.4.8. Distribution of cataract surgical coverage for persons $<3/60$, $<6/60$ and $<6/18$ by 10-year age groups, and by gender for $<3/60$.

Table 6.4.9. Distribution of cataract surgical coverage for persons $<3/60$, $<6/60$ and $<6/18$ by residence, and by gender for $<3/60$.

Table 6.4.10. Distribution of cataract surgical coverage for persons $<3/60$, $<6/60$ and $<6/18$ by literacy status, and by gender for $<3/60$.

Table 6.5.1. Distribution of all subjects concerning lens opacity status.

List of Tables

Table 6.5.2. Barriers to up-take of cataract surgery amongst Bangladeshi adults.

Table 6.5.3. Logistic regression results comparing those who had undergone cataract surgery versus those who had not accessed medical care for a 2B or 3 lens opacity.

Table 6.5.4. Multi-variable logistic regression model analysis results for up-take of cataract surgery.

Table 6.5.5. Univariate logistic regression results comparing those with a 2B or 3 lens opacity who had been assessed medically versus those who had not accessed medical care.

Table 6.5.6. Multi-variable logistic regression model results of factors associated with having been assessed medically for cataract compared with not having sought medical assistance.

Table 6.6.1. Prevalence of emmetropia, myopia and hypermetropia, by level of refractive error, by gender.

Table 6.6.2. Age- and sex-specific prevalence of myopia in Bangladeshi adults.

Table 6.6.3. Age- and sex-specific prevalence of hypermetropia in Bangladeshi adults.

Table 6.6.4. Uni-variate analysis of socio-demographic and ocular variables associated with myopia and hypermetropia.

Table 6.6.5. Binary logistic regression model results for myopia.

Table 6.6.6. Binary logistic regression model results for hypermetropia.

Table 6.6.7. Association of socio-demographic variables with 'met' and 'unmet' need for spectacles.

Table 6.6.8. Association of socio-demographic variables with visual acuity ($\geq 6/12$ v $< 6/12$) amongst spectacle users.

List of Tables

Table 6.7.1. Causes of functional low vision in the Bangladeshi adults.

Table 6.7.2. Uni-variate cross-tabulation results for low vision cases, by selected categorical explanatory variables.

Table 6.7.3. *Post hoc* comparative analysis of mean age, by low vision category.

Table 6.7.4. Results of the multi-variable logistic regression model for predicting low vision cases.

Table 7.2.1. Blindness prevalence, cataract blindness prevalence and cataract as cause of blindness (%) – presenting (PVA) and best corrected visual acuity (BCVA).

Table 7.3.1. Presenting visual acuity (PVA) and best corrected visual acuity (BCVA) for cataract surgical outcomes and percentage of IOL use.

Table 7.5.1. Model of barriers to cataract surgery – consumer and service provider.

Table 7.7.1. Prevalence of functional low vision amongst persons aged 50 years and older in Bangladesh RAAB studies.

Table 7.8.1. Assessment of the strengths and limitations of eye care service-related issues in Bangladesh.

List of Figures

Figure 4.2.1. Five-year age group population pyramids of Bangladesh for the years 2000 and 2015.

Figure 4.2.2. Population pyramids of Bangladesh for the years 2030 and 2050.

Figure 4.3.1. Distribution of the prevalence of blindness by WHO region.

Figure 4.3.2. Distribution of the number of practising ophthalmologists worldwide, by country.

Figure 4.3.3. Trend of the estimated magnitude blind persons globally, from 1972 to 2010, by presenting and best corrected visual acuity.

Figure 4.3.4. Cycle of Aravind eye care delivery – goal, strategies and service components.

Figure 4.3.5. Pyramidal organisation of LV Prasad Eye Institute service delivery model.

Figure 4.3.6. Operational diagram of the Sight Savers International (SSI) Modular Eye Care (MEC) programme in Bangladesh.

Figure 4.3.7. Total number of cataract surgeries and number of surgeries with IOL implantation in SSI MEC programme, 1994 – 2002.

Figure 5.9.1. Bland-Altman chart indicating the difference between measured VA and mean VA for each of the three examiners.

Figure 6.2.1. Distribution of presenting visual acuity categories across ten-year age groups

Figure 6.2.2. Linear and exponential trends of blindness prevalence according to 10-year age groups.

Figure 6.2.3. Main cause of blindness for persons with visual acuity $<3/60$ in the better eye.

List of Figures

- Figure 6.2.4. Distribution of normative intra-ocular pressure measurements.
- Figure 6.4.1. Percentage of eyes with vision <6/12 having lens opacities grades 2B or 3.
- Figure 6.5.1. Barriers to up-take of cataract surgery, by gender.
- Figure 6.5.2. Barriers to up-take of cataract surgery, by rural versus urban residence.
- Figure 6.5.3. Barriers to up-take of cataract surgery by literacy level.
- Figure 6.5.4. Barriers to up-take of cataract surgery, by school attendance.
- Figure 6.5.5. Barriers to up-take of cataract surgery by employment status.
- Figure 6.6.1. Age group-specific prevalence of emmetropia, myopia and hypermetropia in females by 10-year age groups.
- Figure 6.6.2. Age group-specific prevalence of emmetropia, myopia and hypermetropia in males by 10-year age groups.
- Figure 6.7.1. Age group-specific low vision prevalence.
- Figure 6.7.2. Age-sex standardised low vision prevalence.
- Figure 6.7.3. Mean age of low vision subjects, by cause.
- Figure 6.7.4. Mean age of subjects with low vision, by category.
- Figure 7.2.1. Results of blindness prevalence (%) and blindness due to cataract (%) from RAAB studies conducted in Bangladesh, by District and year of survey.
- Figure 7.4.1. Cataract surgical coverage (persons) from RAAB studies conducted in Bangladesh, by year of survey.
- Figure 7.5.1. Barriers to uptake of cataract surgery in twelve RAAB surveys in Bangladesh

List of Figures

Figure 7.5.2. Barriers to uptake of cataract surgery in twelve RAAB surveys in Bangladesh, by gender.

Figure 7.8.1. Distribution of eye care service delivery level in Bangladesh in 2018.

Figure 7.8.2. Distribution of healthcare facilities providing eye care services, by type.

List of Abbreviations / Acronyms

AC-IOL – Anterior chamber intra-ocular lens

APEDS – Andhra Pradesh Eye Disease Study

ANOVA – Analysis of variance

ARM – Age-related maculopathy

ARMD – Age-related macular degeneration

BBS – Bangladesh Bureau of Statistics

BBSCO – Bangladesh Bureau of Statistics Classification of Occupations

BCVA – Best-corrected visual acuity

BECS – Bangladesh Eye Care Society

BED – Basic eye doctor

BMRC – Bangladesh Medical Research Council

BNBLVS – Bangladesh National Blindness and Low Vision Survey

BNCB – Bangladesh National Council for the Blind

BNSB – Bangladesh National Society for the Blind

BSc – Bachelor of Science

CBR – Crude birth rate

CDR – Cup:Disc ratio

CEITC – Chittagong Eye Infirmary and Training Complex

CI – Confidence interval

CIEMS – Central India Eye and Medical Study

CMR – Crude mortality rate

CSC – Cataract surgical coverage

CSR – Cataract surgical rate

D – Dioptre

List of Abbreviations / Acronyms

DM – Diabetes mellitus

DO – Diploma in Ophthalmology

DR – Diabetic retinopathy

ECCE – Extra-capsular cataract extraction

ETDRS – Early Treatment Diabetic Retinopathy Study

FCPS – Fellow of the College of Physicians and Surgeons

FHF – Fred Hollows Foundation

FLV – Functional low vision

FRCS – Fellow of the Royal College of Surgeons

FRCP – Fellow of the Royal College of Physicians

FRCOphth – Fellow of the Royal College of Ophthalmologists

GAP – Global Action Plan

GBD – Global Burden of Disease

GDP – Gross domestic product

GNI – Gross national income

GoB – Government of Bangladesh

HDI – Human Development Index

HDR – Human Development Report

HIES – Household Income and Expenditure Survey

HKI – Helen Keller International

HPI – Human Poverty Index

HPNSDP – Health, Population, Nutrition Sector Development Programme

IAPB – International Agency for the Prevention of Blindness

ICARE – International Centre for the Advancement of Rural Eyecare

ICCE – Intra-capsular cataract extraction

List of Abbreviations / Acronyms

- ICD – International Classification of Diseases
- ICEH – International Centre for Eye Health
- IHDI – Inequality-adjusted Human Development Index
- INGO – International non-governmental organisation
- IOL – Intra-ocular lens
- IOP – Intra-ocular pressure
- LMIC – Low and Middle Income Countries
- logMAR – log of the minimum angle of resolution
- LR – Logistic regression
- LVPEI – LV Prasad Eye Institute
- MDG – Millennium Development Goal
- MDP – Multi-dimensional poverty
- MEC – Modular eye care
- MeSH – Medical subject headings
- MHFW – Ministry of Health and Family Welfare
- MLOP – Mid-level ophthalmic personnel
- MVI – Moderate visual impairment
- MSICS – Manual small incision cataract surgery
- MSVI – Moderate and severe visual impairment
- NECP – National Eye Care Programme
- NGO – Non-governmental organisation
- NIO – National Institute of Ophthalmology
- NPCB – National Programme for the Control of Blindness
- NRG – Natural rate of growth
- NRI – Natural rate of increase

List of Abbreviations / Acronyms

OOPP – Out-of-pocket payment

OR – Odds ratio

OSB – Ophthalmological Society of Bangladesh

PC-IOL – Posterior chamber intra-ocular lens

PEC – Primary eye care

PHC – Primary health care

PL – Perception of light

PNBVIS – Pakistan National Blindness and Visual Impairment Survey

PPP – Purchasing power parity

PPS – Probability-proportional-to-size

PRB – Population Reference Bureau

PRECOG – Prospective Review of Early Cataract Outcomes and Grading

PSD – Posterior segment disease

PVA – Presenting visual acuity

RAAB – Rapid assessment of avoidable blindness

RACSS – Rapid assessment of cataract surgical services

RLM – Reduced logMAR

RPCOS – Rajendra Prasad Centre for Ophthalmic Sciences

RPE – Retinal pigment epithelium

SD – Standard deviation

SE – Spherical equivalent

SEARO – South-East Asia Regional Office

SPSS – Statistical Package for the Social Sciences

SSI – Sight Savers International

SVI – Severe visual impairment

List of Abbreviations / Acronyms

TAR – Tibet Autonomous Region

TFR – Total fertility rate

UEH – Universal eye health

UN-DESA – United Nations Department of Economic and Social Affairs

UNDP – United Nations Development Programme

VA – Visual acuity

VLEG – Vision Loss Expert Group

WHA – World Health Assembly

WHO – World Health Organization

WHO-PBD – WHO Prevention of Blindness and Deafness

WHO-PBL – WHO Prevention of Blindness

Dedications

Dedications

To the people of Bangladesh – amongst and with whom this national study was conducted – may your kindness and humanity always be your strength against all adversity.

From a personal perspective my parents, Mary Rita and Lawrence Dineen, deserve more than being merely acknowledged. In spite of the travails they had endured, their encouragement, understanding and love over the years have been key sources of inspiration and belief in the work chosen by their son to pursue.

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1.0 Introduction

1.1 Background to the Bangladesh National Blindness and Low Vision Survey

In the autumn of 1998, discussions took place between Sight Savers International (SSI), a prominent international non-governmental organisation, based in England and dedicated to blindness prevention, treatment and rehabilitation, and the International Centre for Eye Health (ICEH), Department of Preventive Ophthalmology, University College London. These negotiations focused on establishing a Research Fellow academic post within ICEH to carry out epidemiological research on behalf of SSI in support of the latter's priority international eye care programmes.

Upon the establishment of the post, the dissertation author was appointed as Senior Research Fellow and was requested to develop an evidence base – by means of a national prevalence survey – for furthering the work of SSI in Bangladesh, in the first instance. Subsequent population-based ophthalmic epidemiological research was conducted over the ensuing seven years, also in the form of very large national blindness prevalence surveys which the author co-ordinated, led to similar research being conducted in Pakistan, Nigeria and Belize, amongst other countries.

In early 1999, the dissertation author and Professor Gordon Johnson, Roth's Professor in Epidemiology and Preventive Ophthalmology, Department of Preventive Ophthalmology, University College London travelled to Bangladesh. The main purpose of the visit was to liaise and confer with the principal stakeholders – both individuals and institutions within governmental and non-governmental sectors – in the field of ophthalmology and eye care service provision in Bangladesh regarding the prospect of carrying out a national prevalence survey.

Over the course of that initial two-week visit, a series of key meetings were held in order to:

Introduction

- * gather details about any previous research dealing with ocular conditions and/or eye care service provision, especially study results focusing on blindness prevalence;
- * appraise the perceived levels of need and interest amongst major stakeholders for carrying out population-based ophthalmic research in the country;
- * discuss comprehensively the relative merits (advantages / disadvantages) of the different types of ophthalmic epidemiological studies that potentially could have been conducted (all-age prevalence versus one focussing on a specific age group, eg in adults only);
- * to explore the views of the key agents about carrying out a nation-wide population-based blindness prevalence survey;
- * to identify the major logistical issues (e.g. climate, transport, financial) associated with the proposed population-based survey, and
- * to identify the existing human resource capacity available in Bangladesh for conducting this type of research.

During the course of this study visit, a scientific meeting was held with the four key Professors of Ophthalmology in Bangladesh at that time, namely:

- * Professor MA Matin, FCPS, FRCS, FRCP. Chairman of the Bangladesh National Council for the Blind (BNCB), Member of the Bangladeshi Parliament, former Deputy Prime Minister and former Minister of Health.
- * Professor Syed Modasser Ali, FRCS, FCPS. Director of the National Institute of Ophthalmology (NIO) and Bangladesh Country Representative to the World Health Organisation (WHO).
- * Professor Mohammed Mustafizur Rahman, DO. Director of Islamia Eye Hospital and MA Ispahani Institute of Ophthalmology and Founder Director of the Bangladesh Eye Care Society (BECS).

Introduction

* Professor Rabiul Hussain, FRCS, FCPS. Director of Chittagong Eye Infirmary and Training Complex (CEITC), President of the Bangladesh National Society for the Blind (BNSB).

The meeting, held with the aforementioned leading Bangladeshi ophthalmologists, was convened by Mr Jalaluddin Khan, Country Director, Sight Savers International. At this meeting presentations were made by Professor Johnson and the dissertation author regarding the scientific rationale and epidemiological study design options regarding blindness prevention research, especially in relation to a population-based survey versus a hospital-based, audit-oriented research approach.

Following a number of further, in-depth meetings, involving a series of presentations, questions and clarifications, a consensus was reached concerning the nature of the epidemiological research study that would be conducted, namely, a blindness and low vision prevalence survey in persons aged 30 years and older based on a nationally representative sample.

During the ensuing first semester of 1999, several actions were engendered by the author, appointed as Research Project Co-ordinator, in order to progress on the planning, organisation and carrying out of this national blindness and low vision prevalence survey. Principal amongst these were:

* conferring with key ophthalmologists and ophthalmic epidemiologists in preparation for developing the research study proposal; these include the aforementioned Professor Johnson and Dr Darwin Minassian, FRCOphth, Reader in Ophthalmic Epidemiology, Institute of Ophthalmology, University College London and Moorfields Eye Hospital

* submission of the research protocol for ethical approval by the Bangladesh Medical Research Council (BMRC), that which was granted in June 1999;

* identification and selection of the National Institute of Ophthalmology as the collaborating partner hospital for the purpose of recruiting staff to conduct the data collection field work throughout both rural and urban areas of Bangladesh;

Introduction

- * drawing up a detailed budget for the survey consisting of equipment, personnel, travel and running costs, both within Bangladesh and internationally;

- * recruitment of survey personnel and carrying out the standardised ophthalmic examination training required by each specific cadre of staff prior to commencing the survey field work; this training was conducted in conjunction with Dr Rupert Bourne, FRCOphth, Clinical Research Fellow, Department of Preventive Ophthalmology, University College London and Specialist Registrar in Ophthalmology in Moorfields Eye Hospital, London (now Professor of Ophthalmology and Associate Director of the Vision and Eye Research Unit, Anglia Ruskin University, Cambridge);

- * designing the sampling strategy for the nationally representative sample of 12,900 subjects aged 30 years and older; this was undertaken collaboratively with technical input from Mitra and Associates, a survey research organisation with experience of more than 125 population-based studies on varied health-related topics in Bangladesh and the Bangladesh Bureau of Statistics (BBS), Ministry of Planning, Government of Bangladesh;

- * direct supervision by the dissertation author of the survey field work over a period of 11 months, inclusive of three pilot studies, in over 150 rural and urban survey cluster sites in 62 of the 64 administrative Districts of Bangladesh;

- * database development, double entry data processing supervision and extensive statistical analyses were carried out by the author over the next several months.

Details about each of the above facets of the national survey will be further elucidated in the course of this dissertation.

The justification for conducting this challenging and ambitious research study was in order to obtain much-needed scientific evidence regarding the magnitude and causes of blindness in Bangladesh. Such information was recognised by Sight Savers International and within the Bangladeshi eye care

Introduction

services community as being indispensable for the rational planning and implementation of eye care services by government and non-government eye care providers. Such a study of this nature – nationally representative, population-based survey – had never been undertaken in Bangladesh, thus in large measure explaining the dearth of epidemiological evidence concerning the vision status of adults prior to the survey. In fact, national blindness prevalence studies had only ever been undertaken in two countries prior to the Bangladesh study, namely, in Nepal in the early 1980s and in Pakistan approximately ten years later.²⁻³

Though all three studies differ in terms of specific details (e.g. number of subjects examined; eye examination protocol that was employed), the aftermath of the Bangladesh survey was similar to that which transpired in both of the South Asian neighbours previously mentioned in terms of improving eye care service delivery. Essentially, the key epidemiological findings generated by the blindness and low vision prevalence study, which is the focus of this dissertation, led to a series of transformations in the provision of essential eye care services in Bangladesh. Notable amongst these changes are the following: development of a government eye care policy for the first time in the country; increased resource provision for eye care both within the government and the non-governmental sectors; increased cataract surgical coverage and, additional international non-government organisations establishing operations within the country in large measure due to the availability of epidemiological evidence concerning blindness prevalence and causes against which the planning, implementing and evaluating of eye care services could be established.

Advances such as those just mentioned, and others, will be further discussed in the course of this dissertation. Prior to doing so, details concerning the cross-sectional cluster study design, the sampling strategy (e.g. the sample size calculation of 12,900 subjects), and the complex sample statistical analysis techniques employed for analysing the data will be presented in the detailed Methods (Chapter 5) .

Introduction

The data collected for this study was extensive as regards both the number of adult subjects examined (11,624) as well as in terms of the breadth of socio-demographic, ocular and eye care service utilisation variables involved. Specific sections of results on these inter-related elements will be included in this dissertation with a view to highlighting the salient findings of this study. Principal amongst the results to be presented and discussed include:

- * the prevalence of visual impairment / blindness and the associated causes among adults aged 30 years and older, both nationally and by the six administrative Divisions of the country.
- * distribution of visual impairment / blindness by gender, age, area of residence (rural / urban), level of education, literacy status and occupational category
- * visual outcomes of cataract surgery in those having undergone treatment
- * cataract surgical coverage by Division, gender, age, and visual acuity level
- * barriers to the up-take of eye care services in persons in need of treatment
- * prevalence of refractive error in the adult population, and
- * the level of need for low vision rehabilitation services in the country

Dissemination of the results according to the rubrics listed above formed a core activity following completion of the prevalence survey. Presentation of the results took place between 2001 and 2004 at numerous scientific symposia both within Bangladesh and internationally as well as at key eye care planning workshops. In the latter, several international non-governmental organisations (INGOs), national non-governmental bodies and representatives of Bangladesh government ministries gathered to formulate a national eye care policy and a model of eye care service implementation programme.

Details about the actions taken based on the survey results will be discussed in this dissertation in light of *Vision 2020 – The Right to Sight*.⁴⁻⁶ This

Introduction

initiative, established in 1999 by the World Health Organisation (WHO) and the International Agency for the Prevention of Blindness (IAPB), advocates for collaboration amongst governments, INGOs, NGOs and individuals for taking action towards the elimination of avoidable blindness.⁷⁻¹⁰ A comprehensive discussion will be presented concerning the results of the national blindness survey in relation to *Vision 2020*, both conceptually and in practical terms, outlining the strategies involved and the successes achieved in eye care service provision for this populous, resource-poor country.

1.2 Rationale for the Bangladesh National Blindness and Low Vision Survey

A number of factors influenced the decision to conduct a population-based survey in Bangladesh concerning the epidemiological profile of blindness and visual impairment. Principal amongst these were a) the absence of reliable data as to the prevalence and principal causes of vision loss, and b) the need to obtain evidenced-based data for the purposes of effective eye care planning and adequate resourcing of the blindness prevention control programmes carried out in the country.

As of 1999, no nation-wide study had ever been conducted concerning the extent of blindness in Bangladesh or regarding the main causes of vision loss or impairment. Rather, only four blindness-related research activities had ever been carried out in the country prior to the BNBLVS. These include one WHO situational analysis conducted in 1978 on the status of blindness prevention and treatment in the country,¹¹ and three population-based studies, each with distinctive methodological and results-based limitations (ie self-reported visual impairment combined with a limited clinical examination;¹²⁻¹³ study on nutritional blindness in children;¹⁴⁻¹⁵ blindness prevalence study based on a small sample size).¹⁶ Despite their shortcomings, the three latter studies represented what was known about blindness and visual impairment prior to the BNBLVS, on which this dissertation is based.

The first research study on blindness in Bangladesh was a 1976 population-based survey that was carried out in rural areas only, amongst 183,000 subjects. In this study, which involved a quite simplified ocular examination

Introduction

as part of the national population census, the definition of blindness corresponded to a visual acuity of less than 1/60 – more restrictive than the WHO definition of best corrected vision of less than 3/60 in the better eye. According to this definition, the study identified a prevalence of blindness of 0.56% for all ages. Cataract accounted for the majority of the cases of blindness (46.8%), followed by corneal opacities, including trachoma (31.4%), trauma (11.9%), glaucoma (5.2%), and choroidal / retinal conditions (4.6%).¹²⁻¹³

Latterly, in 1982 and 1983, a further study was conducted dealing with nutritional blindness, due to deficiency of Vitamin A. The main result from this nationwide, representative survey in children aged 3 to 71 months was the very high prevalence of night blindness, keratomalacia and advanced corneal scarring, combined. The main finding was that 5.5% of the 11,618 households (23,335 children) surveyed had at least one child visually affected due to complications of Vitamin A deficiency. Bilateral blindness prevalence due to xerophthalmia alone was 6.4 per 10,000 (0.064%).¹⁴⁻¹⁵

A decade later, in 1993, a small-scale study (2,663 subjects) was undertaken in a delimited area within one of the 64 administrative districts (Kishoreganj) that comprise Bangladesh. In this survey, an all-age prevalence of 1.49% for blindness (best corrected visual acuity less than 3/60 in the better eye) was reported. It merits pointing out, however, that the research design, small sample size, unclear operational definitions and limited data analysis of this study were not scientifically rigorous. As such it was thought imprudent to consider the findings of this study as a veritable indication of blindness for the whole of Bangladesh.¹⁶

Thus, in order to re-dress the dearth of blindness and low vision data amongst adults for this populous country, a nation-wide survey was proposed, designed and organised. This present document outlines this study, which aimed to identify the prevalence and specific causes of blindness and visual impairment throughout Bangladesh, as well as providing information on the relative needs of the urban and rural areas of the six main regional administrative divisions of the country. Issues relating to quality of life, visual

Introduction

functioning and population projections for visual disability in Bangladesh were also investigated. Likewise, the surgical outcomes of persons operated for cataract and the refractive error status of the study sample were assessed, with extrapolations of the magnitude of blindness and visual impairment amongst the adult population of the country.

In related manner to conducting the national survey, attempts were made in the final quarter of 2000 and early 2001 to carry out a situational analysis of eye care services in Bangladesh, through the co-ordination of the BNCB.¹⁷ Data that was prioritised for collection included the available human resources (eg ophthalmologists, ophthalmic nurses), active surgical facilities (government, NGO-affiliated and private) and details concerning the number of cataract surgeries performed in the previous calendar year. However, as this was the first attempt at collecting this type of detailed information, the level of response to the questionnaire that was circulated was very low, thereby effectively calling in to question the representativeness and completeness of the partial findings that were obtained. As such, it was not until early 2003 – in preparation for the first national eye care services planning meeting – that a follow-up, more fructiferous situation analysis was achieved, through the co-ordination of the recently established Bangladesh Vision 2020 office.¹⁸

The findings from that assessment are presented in the Discussion (Chapter 7) of this dissertation, in light of the findings of the national survey and contextually, with regard to the two national eye care services plans that have been developed in the past number of years.

Aim

2.0 Aim

The aim of this study was:

To determine the prevalence and causes of blindness and low vision amongst persons aged 30 years and older in Bangladesh, based on a nationally representative, randomly selected sample.

Objectives

3.0 Objectives

The objectives of this research study were:

To establish the age- and sex-specific prevalence rates of blindness and low vision in adults 30 years of age and older in Bangladesh.

To identify the causes of blindness and low vision within the study sample.

To evaluate cataract service delivery by measuring the cataract surgical coverage (CSC) levels (for eyes and for persons) as well as to identify visual functioning outcomes of surgery amongst all aphakes and pseudophakes, as per analysis of cataract surgical outcomes amongst the study cohort.

To identify the socio-economic and cultural barriers to up-take of eye care service provision, especially concerning cataract surgery, amongst severely visually impaired and blind subjects.

To determine the prevalence and types of refractive errors and to estimate the level of unmet need for spectacle correction within Bangladeshi adults.

To review the scientific literature concerning the epidemiology of blindness and eye care service provision within Bangladesh and on a global level as well as that related to the most pertinent social, economic and health service-related factors associated with blindness in adults within Bangladesh.

4.0 Literature Review

This section of the dissertation will provide essential information regarding the following topics:

- * a description of the literature search strategy, including the key search terms, used in the course of writing this dissertation.

- * a country profile for Bangladesh, encompassing the period from pre-2000 through 2016 – the year(s) for which the most up-to-date information is available. This description will include geographical, socio-economic, demographic, human development and health-related indicators for the country.

- * an epidemiological outline, based on a comprehensive research review of the scientific literature concerning blindness and visual impairment in Bangladesh, in the South Asian region as well as within a global context.

- * a description and analysis of a) the Bangladeshi government eye care service model and b) two comprehensive eye care service provision models from India. These three service-based models and their implementation strategies are discussed in relation to the global initiative for eliminating and preventing avoidable blindness, *Vision 2020 – The Right to Sight*, which was co-developed by the International Agency for the Prevention of Blindness (IAPB) and the WHO.

4.1 Literature Search

Extensive literature searches were undertaken for the purposes of preparing the research protocol (eg study design considerations; reviewing the results from similar previous studies) and during the data analysis and reporting phases of this population-based blindness and visual impairment research study. Similarly, comprehensive literature searches were conducted in the course of writing this dissertation. Notably, the latter search strategy encompassed a vast array of epidemiological, socio-economic and health service provision-related topics, both specific to Bangladesh and global in scope, dating from 1980s to the present.

Literature Review

The principal MeSH (Medical Subject Headings) search terms, shown below, were: a) utilised for developing, initially, the research protocol and preparing peer-reviewed publications about this study, and b) subsequently while writing this document are: ophthalmic epidemiology; survey research methods; epidemiological study design; sampling methodology; blindness; visual impairment, low vision; cataract; cataract surgery; cataract surgical coverage (CSC); cataract surgical rate (CSR); refractive error; spectacles; poverty; Millennium Development Goals (MDGs); health economics; eye care service provision; barriers to eye care services; amongst other key MeSH terms.

The main on-line databases searched include: Pubmed; MEDLINE; Cochrane Library / Cochrane Database of Systematic Reviews, BioMed Central; Science Direct and, specifically the archives of past issues of the (previously) non-indexed specialist journals, *Community Eye Health* and the *Indian Journal of Ophthalmology* (IJO). In Britain, the ATHENS platform was for obtaining on-line access to the articles and journals identified through reference searches, whilst the Irish Research eLibrary (IReL) was utilised for the same purpose in-country.

4.2 Bangladesh Country Profile

4.2.1 Geography of Bangladesh

According to the United Nations Development Programme (UNDP), Bangladesh is a member of the 'South Asia' group of nations, along with Bhutan, India, Nepal, Afghanistan, Pakistan, Maldives and Sri Lanka.¹⁹⁻²⁰ A relatively small country in terms of area, particularly for its large population, Bangladesh has a land mass of 147,570 square kilometres, approximately twice the size of Ireland.

4.2.2 Population and Demographic Trends in Bangladesh

The national population of Bangladesh in 2001 was officially cited by the Bangladesh Bureau of Statistics (BBS) as being 124.3 million inhabitants, in the national census that was conducted that year.²¹ Population estimates that were reported by other organisations near the beginning of the century vary

Literature Review

in the number of inhabitants and in the year of data reporting, ie 124.8 million (UNDP based on data from 1998),¹⁹ 130 million (International Database of Populations in 1999)²² and 131.6 million (Population Division of the United Nations Department of Economic and Social Affairs [UN-DESA] in 2000).²³

With the most recent national population census having taken place in 2011, the population of Bangladesh in 2015 was officially cited as being 158.9 million, based on up-dated demographic national estimates.²⁴ Similarly, the Population Division of UN-DESA estimated the population to be 160.9 million in 2015²⁵ while the Population Reference Bureau (PRB) reported 162.9 million inhabitants lived in Bangladesh in 2016.²⁶

By comparison with other nations, the demographic profile of Bangladesh is quite distinctive, due mainly to its high population density. As the eighth most populous country globally,²⁷ it accounts for 2.2% of the world's total population, though its land mass is only 0.1% of the world's total. As of the year 2000, the population density (persons per square kilometre) was 919 whereas as of 2015 it had increased to 1114. Said figures compare unfavourably with the more populated, albeit geographically larger countries of India (317 in 2000, 390 in 2015) and China (133, 146), respectively, as with those of the 'global' mean values for the years 2000 and 2015 (45, 54).²⁷ Accordingly, the population density of Bangladesh is one of the highest in the world and, due to a projected increase in its population to approximately 185 million inhabitants by 2030, the population density will inevitably continue to rise.²⁸

Since the late 1970s, the fertility rate of Bangladesh has undergone a significant reduction, from an official rate of 6.6 in the period 1975 to 1980, to the present 2.2 births per woman in 2015.²⁹ In terms of the demographic transition that has been taking place in Bangladesh over the past several years, the population pyramids for the years 2000 and 2015 (Figure 4.2.1) demonstrate a pattern of evolving fertility reduction and an increased life expectancy; the latter has been occurring in conjunction with a reduced crude mortality rate over time.³⁰

Literature Review

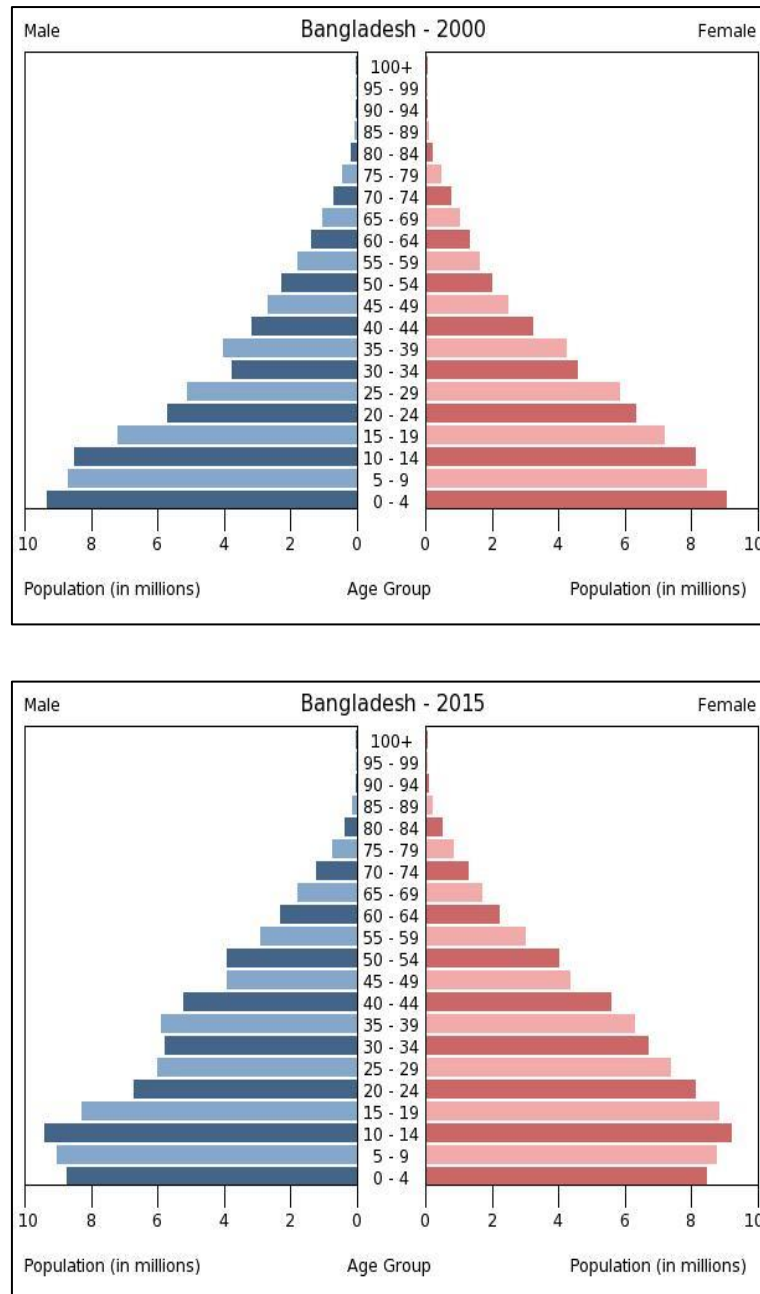


Figure 4.2.1. Five-year age group population pyramids of Bangladesh for the years 2000 and 2015.

Nonetheless, despite the success of the national family planning programmes – recognised internationally as a model example of fertility reduction practices – the national population continues to rise, having undergone an increase from 70 million in 1974 (three years on from Bangladesh independence)³¹⁻³⁴ to the aforementioned present 160 million.³⁵ This represents an increase of more than 125% in the national population in just over 40 years. Reductions in infant and under-five mortality rates have also been critically important in the growth of the Bangladeshi population. For

Literature Review

example, as reported by the UN Inter-agency Group for Child Mortality Reduction, under-five mortality has decreased by 72%, from 144 per 1000 live births in 1990 to 41 by 2012.³⁶

Despite substantial on-going fertility reduction,³⁷⁻³⁸ due to a stagnated decline in the total fertility rate (TFR) from 1993-2002, the optimal ‘replacement level’ of fertility (2.2 children per woman) was delayed for several years. Rather than replacement fertility level having been achieved, as officially reported, Bangladesh appears to have reached and maintained an ‘intermediate fertility rate’ – defined as a TFR ranging from 2.1 to less than 5 children per woman – which is associated with likely substantial on-going population growth over the next several ensuing decades.³⁹⁻⁴⁰

As a result, from early 2000s to 2015, it is estimated that in excess of 35 million persons have been added to the national population. Similarly, gradual increases in life expectancy at birth have impacted on population growth, from 48 years in 1974 to 64 years in 2000 to the presently estimated 72.2 years as of 2015.⁴¹

Overall, the demographic transitions of reduced fertility and increased life expectancy have combined to produce a larger and relatively older population. Such factors have direct consequences and pose certain challenges regarding eye care service delivery. Most notable of these is the increase in the percentage – and absolute numbers of persons – aged 65 years and older, due to its relevance for public health programmes (chronic disease management) and eye care services (especially age-related cataract incidence). The increasing number of persons with visually impairing / blinding cataract that would accrue as a result of a growing and ageing population will likely place further demands of the already under-resourced cataract surgical services, as discussed later in this dissertation.

The UNDP Human Development Reports for the years 2000⁴² and 2015⁴³ provide information on the proportion of the Bangladeshi population aged 65 years and older for those years, respectively. In the year 2000, 3.2% of the total national population of 125 million was amongst the ‘elderly’ group; this

Literature Review

percentage corresponded to approximately 4.0 million persons aged 65 years and older. By the year 2015, the percentage had risen to 4.8%, equivalent to 7.5 million elderly individuals. This higher number of persons aged 65 years of age and older is attributable to a) an overall increase in the national population to over 160 million persons and b) increased longevity of the population.⁴²⁻⁴³

Based on present demographic data, it is projected that by 2030, 8.0% of the population of 185 million will be at least 65 years of age, ie approximately 15 million persons (Figure 4.2.2).⁴⁴

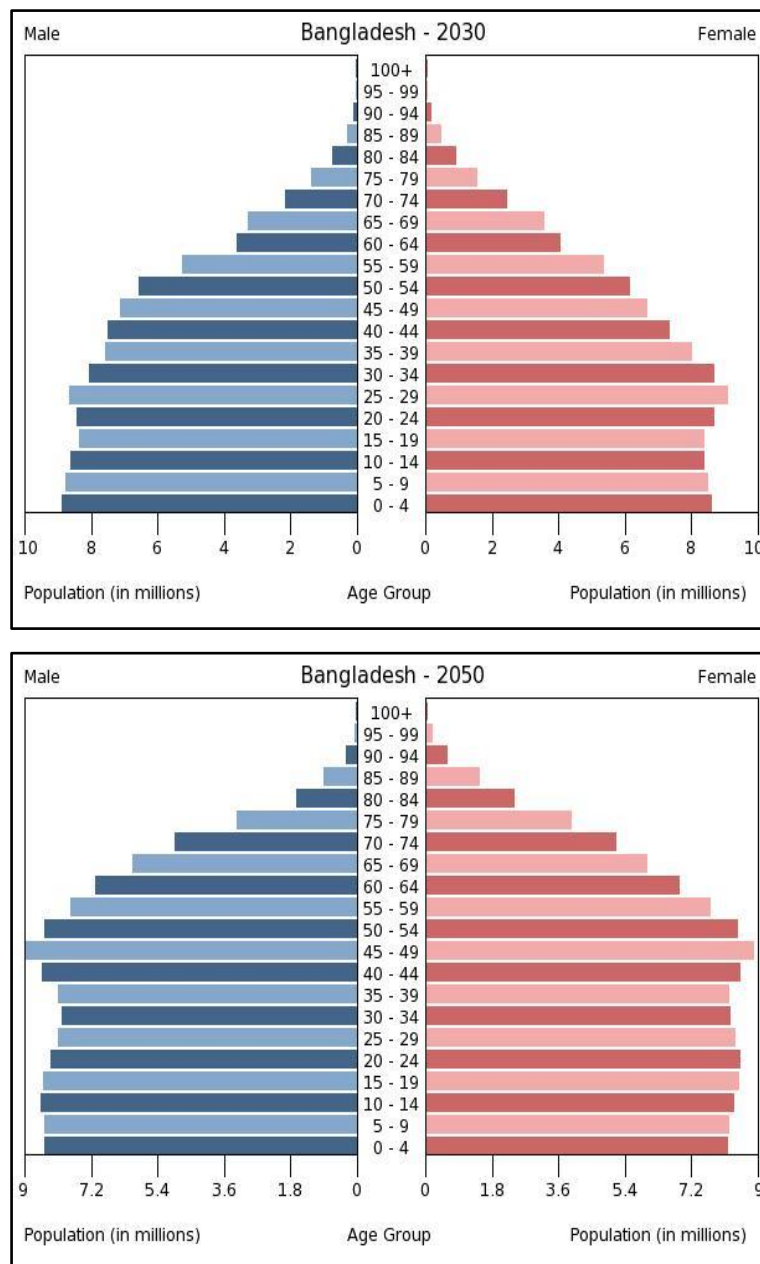


Figure 4.2.2. Population pyramids of Bangladesh for the years 2030 and 2050.

Literature Review

The crude birth rate (CBR) per 1000 population was assessed as being 18.9, based on a survey conducted in over 160,000 households nationally in 2014.⁴⁵ Conversely, the crude mortality rate (CMR) was 5.2 per 1000 population. For both the CBR and CMR, the rural areas yielded higher rates of births and deaths, as compared with urban areas (CBR 19.4 v 17.2; CMR 5.6 v 4.1).³⁸ Overall the natural rate of increase (NRI), ie the population natural growth rate (NGR) was 1.37% in 2014.⁴⁷ By area of residence, the NRI for the rural population was 1.38% whereas the urban NRI was 1.31%.⁴⁶⁻⁴⁷

Thus, combined with a decreased crude death rate and a relatively stable crude birth rate, population growth will continue, likely resulting in more than 200 million by 2050. It is estimated that the peak population of Bangladesh by the end of this century will be in the order of 250 million inhabitants despite the 'considerable success' in fertility rate reduction terms.³⁸

Finally, it is critical to point out that the number of 'elderly' persons will substantially increase, to as many as 65 million individuals aged 60 years and older, thereby constituting over one quarter (26%) of the total future population.³⁸

4.2.3 Millennium Development Goals (MDGs) in Bangladesh

The Millennium Development Goals, instituted in 2000 within the UN Millennium Declaration, are a set of eight comprehensive goals concerning sustainable human development priorities. These include aspects of economic growth / poverty reduction, access to schooling, gender equity, health status, environmental conditions and global development partnerships amongst the 182 signatory UN member countries. The MDGs, comprised of 21 targets and 60 specific indicators, utilised 1990 baseline data against which year-to-year developments were compared in view of defined 2015 target levels for each indicator.

In the course of the fifteen year period (2000 to 2015), Bangladesh demonstrated substantial progress on a number of the MDGs, with the established 2015 targets having been achieved for many though not all of the specific indicators.⁴⁸

Literature Review

Viewed retrospectively, the first Bangladesh country report concerning MDG progress, based on data from 2002-2003, was published in 2005.⁴⁹ Notably, favourable developments had occurred in certain key areas (eg increases in immunisation coverage and primary school attendance, especially amongst girls). However, the lack of a substantial reduction in the level of poverty – compared with MDGs baseline data – from 58.8% to 49.6% of the population living on less than \$1 per day (PPP) pre-2005, was identified at that stage as a key reason for the relatively overall slower-than-needed progress of many of the remaining MDGs.

Over the ensuing decade, Bangladesh experienced an unprecedented level of economic growth – in excess of 6% annually – that contributed to further important advances being made vis-à-vis the 2015 MDG targets. Major achievements were particularly made in a) reduced infant and child mortality rates, b) lowered prevalence of underweight children aged less than five years and c) increased levels of primary and secondary school attendance for both girls and boys. However, notwithstanding the unprecedented level of economic growth, the reduction of poverty within the population – as measured by the percentage of the population living on less than \$1.25 per person per day according to the revised indicator definition – remained higher, at 43.3%, than the targeted level of 35.1%.⁵⁰ This level was substantially higher than that of neighbouring Nepal (23.7%), India (23.6%) and Pakistan (12.6%).⁴⁸

As of 2011 – the most recent year of reporting for this specific indicator – more than 75 million persons (47.8% of the country's population) were living in 'multi-dimensional poverty' (MDP), a composite index comprised of ten inter-related social and economic indicators, placing Bangladesh third highest globally behind only Ethiopia and Nigeria.⁵¹

In related manner, 31.5% of the Bangladeshi population were living below the *nationally defined poverty line* in 2010. By 2016, it was estimated that this figure had reduced to 26.2%, ie more than 40 million persons living on approximately US\$21 per person per month.⁵²⁻⁵³ However, among the rural population, more than one-third (36%) of the more than 100 million

inhabitants, lived below the national poverty line, thus highlighting a major disparity between the national and the rural population percentages in terms of poverty eradication progress within Bangladesh in recent years.⁵⁴⁻⁵⁵

4.2.4 Human Development Index (HDI) rankings for Bangladesh

The HDI is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. As in the 2011 Human Development Report (HDR),⁵¹ a long and healthy life is measured by life expectancy. Access to knowledge is measured by: a) mean years of schooling for the adult population, which is the average number of years of education received in a life-time by people aged 25 years and older; and b) expected years of schooling for children of school-entrance age, which is the total number of years of schooling a child of school-entrance age can expect to receive if prevailing patterns of age-specific enrolment rates stay the same throughout the child's life. Standard of living is measured by Gross National Income (GNI) per capita expressed in constant 2005 international dollars converted using purchasing power parity (PPP) rates.

In 2000, Bangladesh was categorised as being of 'Low Development', with a ranking of 146 out of 174 countries. The classification of 'Low Development' corresponds to the lowest ranking of nations in terms of human development indicators.⁴⁹

In fact, Bangladesh was grouped with the other 'Low Development' countries until 2014, at which time it was re-categorised as being of 'Medium Development', albeit having been ranked as third lowest amongst the 43 countries of this classification. This re-grouping corresponded to a positive trend in the HDI over the previous five years with an average of 1.1% annual increase in the HDI. Much of the progress achieved in human development terms corresponded to increases in life expectancy at birth, improving to 70.7 years by 2014.⁴⁸

In Table 4.2.1, the data for the 2000 and 2015 HDI indicators are presented, reflecting an overall favourable development for each of the four

Literature Review

development indicators, thus leading to an improvement by four places on the global rankings – from 146th to 142nd – over time.⁴²⁻⁴³

Literature Review

Table 4.2.1. Human Development Index (HDI) indicators for 2000 and 2015.

Human Development Index Indicators	2000 ⁴²	2015 ⁴³
Life expectancy at birth (years)	58.6	70.7
Adult literacy rate (% aged 15 years and older)	40.1	-
Expected years of schooling	-	10.0
Combined enrolment ratio (%)	36	-
Mean years of schooling	-	5.1
Gross national income (GNI) per capita (Current US \$)	420	1,060
Gross national income (GNI) per capita (PPP \$)	1,361	3,191
Human Development Index ranking	146	142
Human Development Index (HDI) value	0.461	0.570

* Note: The indicators used for calculating the HDI were revised in 2010 and again in 2014. As such, those indicators used in 2000 and 2015 were not identical though the information is comparable.

It merits pointing out that the advances in the level of development exemplified in the HDI were not equitably experienced throughout the whole of Bangladeshi society. According to the inequality-adjusted human development index (IHDI) – a related metric that accounts for socio-economic and gender inequalities – it was noted that amongst the poorer groups of the population, inequalities existed in terms of life expectancy at birth, school achievement and participation in addition to that of GNI per person. Overall, when accounting for the presence of such inequalities – referred to as ‘the human development cost of inequality’ – the level of development as evidenced in the 2014 HDI (0.570) was reduced to 0.403, reflecting a decrease of 29.4% due to inequality in the distribution of the parameters comprising the HDI within the Bangladeshi population.⁴³ Principal amongst the indicators that were indicative of the presence of unequal development was that of educational opportunities within society.

4.2.5 Implications of Poverty and Health in Bangladesh

Based on data from the United Nations Development Programme, the chronic poverty situation in Bangladesh is one of particular concern due to the persistence of income-related inequalities within the society.⁵⁶⁻⁵⁷ As thus far mentioned, this has been the case for the ‘rural versus urban divide’ within the country, with the urban settings being generally more favourable in terms of income, access to schooling, health services and employment opportunities.⁵⁸ With growing urbanisation and the relocation of as many as 400,000 persons annually from rural to urban settings, it has been postulated that increased numbers of urban poor will be added to the already existent *basti* (slum) population in Bangladeshi cities.⁵⁹ Notably as much as 40% of the urban dwellers of Dhaka, the capital city, presently live in slums.⁴³

In quantitative terms, the UN Development Programme Human Poverty Index (HPI-1, relating to developing countries) is a multi-dimensional measure of poverty, incorporating three essential dimensions of human deprivation, as follows:

* deprivation as regards having a long and healthy life (percentage of those born today who are not expected to live to age 40);

* deficit in knowledge (adult illiteracy rate);

* limitations in economic provisioning (percentage of persons lacking access to health services, percentage of the population without safe, clean water and, the percentage of children aged less than five years who are moderately or severely malnourished).⁵⁶

It merits pointing out that an unacceptably high proportion of those who are employed in Bangladesh continue to live on less than \$1 per day. Thus, while being involved in so-called ‘gainful employment’, these several million workers would be affected by a significantly inadequate purchasing power.⁵⁷

Over the past few decades, there has been an increasing interest in population health inequalities in relation to socio-economic status. In the case of Bangladesh, key issues concerning health inequalities include: a) the complex issue of poverty,⁶⁰ b) lack of access to required health services (eg limited availability of primary and advanced eye care services within the country, especially within the populous rural areas), c) systematic inefficiencies in health service provision – especially within the government sector,⁶¹ and d) the inordinately high level of out-of-pocket (OOP) payments for healthcare costs made by tens of millions of Bangladeshis, as the country has one of the world’s highest levels of out-of-pocket payments (OOPPs)for healthcare.⁶²

As regards socio-economic position and health status, Bangladesh is characterised by ‘wealthier population groups [having] a higher probability of obtaining health care when they need it’.⁶³ This assertion is evidenced by the gradient in accessing health services according to the socio-economic quintile for a given Bangladeshi individual and/or family.

4.2.6 Health economics issues within the Bangladeshi context

Research concerning the level of out-of-pocket health expenditure amongst the Bangladeshi public has identified that a substantial proportion of total health expenditure (63.0%) is associated with individual / familial OOP expenditure for healthcare,⁶⁴ mostly for purchasing medications rather than for in-patient (8.9%) or ambulatory care (6.5%). OOP payments include the

Literature Review

following health services: fees, clinic / hospital charges, medicines, tests / investigations, transport, other health-related service charges.

It is worth noting that the level of public health expenditure in Bangladesh, expressed as ‘percentage of gross domestic product (GDP), is one of the world’s lowest, at 3.7% as of 2015.⁴³ This level is indeed lower than the average value for public health expenditure for the Low Human Development countries (4.5%), that for the Middle Human Development group of countries (4.6%) to which Bangladesh belongs as of 2014, and to that of the other seven South Asian countries (5.5%), as grouped by the UNDP. While the government allocated a mere 3.7% of the national GDP for the health budget in 2014, OOP payments constituted 61.3% of total health expenditure (Table 4.2.2).⁶⁴

As such, serious financial challenges arise for the majority of Bangladeshis in terms of accessing essential healthcare services. Thus, whilst most primary health care (PHC) services are ostensibly free, the availability and quality of government PHC is less than ideal, due in large measure to inadequately supported government health services.⁶⁵ This is most especially the case in rural areas where the majority of the impoverished population resides.

Results from the 2010 national Household Income and Expenditure Survey (HIES)⁶⁶ highlighted that the percentage of expenditure allocated to food items was more than half (54.8%) of all purchases nationally, with those living in rural areas actually spending more on food – in percentage terms – than those residing in urban areas (58.7% v 48.2%). Moreover, the average consumption expenditure level was 98.2% of the average monthly income for both the rural and urban sub-populations. Effectively, such consumption expenditure levels leave little or no additional monies for payment of other essential services, eg when needed for a medical emergency (ie a ‘health catastrophe’)^{62,67-68} or for any advanced procedure such as sight-saving / sight-restoring cataract surgery. As commented this ‘suggests that the small percentage spent on health may well be all that is affordable’.⁶⁶

Literature Review

Table 4.2.2. Comparison of key government and family-level health expenditure indicators for 2000 and 2015.

Government and family health expenditure indicators	2000 ⁶⁶	2015 ⁶⁹
Health expenditure, public (% of GDP)	1.1	1.3
Health expenditure, total (% of GDP)	2.6	3.7 ⁷⁰
Health expenditure, public (% of government expenditure)	7.4	7.8
Health expenditure, public (% of total health expenditure)	40.7	35.2
Health expenditure per capita (current US\$)	9.1 ⁷¹	31.6
Health expenditure per capita, PPP (constant 2011 international \$)	28.9 ⁷¹	95.3
Out-of-pocket health expenditure (% of total expenditure on health)	57.8 ⁷¹	60.2 ⁷²
Out-of-pocket health expenditure (% of private expenditure on health)	97.4 ⁷¹	93.0 ⁷²
Health expenditure, private (% of GDP)	1.6	2.4

The percentage of GDP attributed to total health expenditure has marginally increased from 2000 (2.6%) to 2015 (3.7%).^{66,69} However, the actual percentage of public health expenditure proportional to total health expenditure has decreased over that period (from 40.7% to 35.2%). As a consequence, this has resulted in a notably minimal increase (0.2%) in the percentage of GDP allocated for public health services (1.3% in 2015) despite the unprecedented growth of the Bangladeshi economy in recent years. Thus, the government is funding approximately only one-third of the country's total health expenditure (35.2%), with OOP payments covering more than 60% of all health-related costs. This situation has been commented upon in a World Bank report on poverty reduction programmes in the country, noting that 'the incidence of spending on adult curative care favours the non-poor'.⁴³

4.3 Epidemiological profile of blindness and visual impairment

The following sub-sections provide detailed information on the epidemiological profile of vision loss on a global scale, highlighting the major causes responsible for blindness and visual impairment and the public health strategies and measures developed to reduce the impact of loss of vision. Evidence is presented from the Global Burden of Disease (GBD) research group dealing with visual impairment and blindness, by cause, throughout various world regions, especially that of South Asia. Finally, examples of eye care service models from India and Bangladesh are discussed.

4.3.1 Global prevalence for blindness and visual impairment

A seminal report concerning the prevalence and major causes of blindness throughout the world was published by the WHO in 1994.⁷³ In that paper, Thylefors *et al* estimated that 38 million persons were blind while an additional 110 million had low vision, ie having moderate or severe visual impairment. The global burden of vision loss was derived from population-based prevalence surveys that had been conducted at national and sub-national levels in more than 30 countries. The major causes of blindness and low vision identified in this systematic literature review were, as follows: cataract, trachoma, glaucoma, onchocerciasis and xerophthalmia, amongst other causes.

Literature Review

In the report, the global, all-age prevalence of blindness was 0.7%, ranging from 0.3% in the so-called 'established market economies' (eg North America, Europe) to 1.4% in Sub-Saharan Africa. One per cent of the Indian population was estimated to be blind, ie 8.5 million persons. Due to its large population, it was estimated that India alone contributed 23.5% of the overall global burden of blindness, which the WHO stated was in need of 'urgent consideration'⁷³ for being resolved.

Two further key findings were highlighted in this important WHO publication. Firstly, it was estimated that cataract was the cause of blindness in approximately 16 million persons (41.8% of global blindness cases) followed by trachoma (15.5%) and glaucoma (13.5%), amongst others. Notably, in India, more than half (51.2%) of the cases of blindness were attributable to cataract. Secondly, blindness prevalence was significantly age-related, as 90% of global blindness was in persons aged 45 years or older, with 58% of those blind being aged 60 years or older.⁷³

This key ophthalmic epidemiology report highlighted that blindness would 'experience an accelerated growth unless sufficient resources for its prevention'⁷³ were to be mobilised. Based on: a) demographic projections of global population growth (mainly in developing countries of Asia and Africa), b) increased life expectancy globally⁷⁴ and c) ocular disease-specific incidence, especially for cataract, the WHO estimated that as many as 54 million persons aged 60 years or older would be blind by 2020.⁷⁵

As of the mid-1990s, a heightened awareness and increased emphasis on the part of world health authorities (WHO, governmental Ministries of Health, international NGOs [INGOs]) was placed on developing strategies and implementing comprehensive actions needed for up-scaling blindness control programmes. The level of advocacy needed for strengthening blindness prevention, treatment and control programmes⁷⁶ was increased substantially as a result of this 1994 WHO paper by Thylefors *et al*,⁷³ both within certain countries (eg India)⁷⁷ as well as on a global scale.⁷⁸

4.3.2 Vision 2020 – The Right to Sight

Cognisant of the then present and future impending challenges associated with such a large and growing blindness magnitude – mainly due to avoidable / preventable causes – the WHO Programme for the Prevention of Blindness and Deafness (PBD) convened a series of high-level co-ordination meetings in 1997 and 1998. These were held with the *Task Force of the Partnership Committee of Non-governmental Organisations dedicated to the Prevention of Blindness and the Education and Rehabilitation of the Blind*.⁷⁹ This so-called ‘Task Force’ was a consortium of global INGOs involved in blindness prevention / treatment, rehabilitation and social service programmes.

Jointly, these bodies produced the initial strategic plan for reducing the global burden of blindness, entitled the ‘*Global initiative for the elimination of avoidable blindness*’.^{9,80} Upon being officially launched by the WHO in February 1999, this initiative became known as ‘Vision 2020 – the Right to Sight’.⁸¹⁻⁸² In 2000, the Task Force was integrated into the International Agency for the Prevention of Blindness (IAPB), a similar global entity that had been founded in 1975 to advocate for prevention of blindness actions by governments, NGOs, academic institutions, eye care professionals and researchers worldwide. Through establishing partnerships with and amongst relevant bodies a collaborative approach towards improving eye care services was outlined.

From its inception, the principal aim of the Vision 2020 initiative was: ‘. . . to eliminate the main causes of avoidable blindness by the year 2020 by facilitating the planning, development and implementation of sustainable national eye-care programmes’.⁷⁹ The three principal components of the Vision 2020 initiative are:

- * Investment in infrastructure and appropriate technology
- * Effective control of the major causes of blindness and visual impairment
- * Human resource development including increased training of eye care personnel at all levels (ophthalmologists, mid-level ophthalmic personnel and administrators)

The importance of an effective and functional nexus between primary healthcare structures of a health system and those of primary eye care services have been highlighted as being essential to strengthening blindness prevention programmes.⁸³⁻⁸⁶ In this way, Vision 2020 follows ‘the health system approach, which encompasses the integration of eye care programmes into the wider health care system at all levels (primary, secondary, and tertiary)’ as a key strategy for reducing avoidable blindness through prevention and treatment services.⁸⁷

4.3.3 Blindness and visual impairment epidemiology

At the outset of the Global Initiative in 2000, the four main priority ocular diseases were cataract, onchocerciasis, trachoma and xerophthalmia due to Vitamin A deficiency.⁷⁹ Presently, the principal ocular conditions meriting attention on a global scale have changed due to a number of reasons. Major advances in the control and prevention of onchocerciasis, trachoma and xerophthalmia have been achieved, thus substantially reducing the numbers of persons whose sight is threatened by infectious ocular diseases, or in the case of xerophthalmia, as a complication of measles infection. However, the situation concerning cataract has not been as straightforward, in spite of major successes in increasing cataract surgical coverage (CSC) in countries with a high burden of blinding / visually impairing cataract, eg in India and Pakistan,⁸⁸⁻⁹⁴ as well as outlined in this dissertation in neighbouring Bangladesh.

Indeed the prevalence of blindness due to cataract has decreased in India (the country with the highest number of blind persons).⁹⁵ However, due to an overall increase in population and increased longevity, the actual number of blind persons due to cataract has increased despite a tripling of cataract surgeries over the past twenty-five years.⁹⁶ The situation globally, especially in developing countries such as Bangladesh, is similar, *viz*, an increase in the number of blind persons due to cataract even though the CSC has actually increased over time.⁹⁷

The key indicator for determining the adequacy of the level or number of cataract surgeries, per million population per year, is the cataract surgical rate

Literature Review

(CSR). The higher the number of blinding / visually impairing cataracts within a population, the higher the CSR should be in order to a) treat those presently impaired due to cataract and b) to prevent an increase in the backlog of such cases.⁹⁸

Eight years following the aforementioned WHO report on blindness prevalence and causes, a follow-up systematic review of the global estimates for visual impairment and blindness was undertaken by the WHO.⁹⁹ As such, based on 2002 data, a re-estimation of the global burden of ocular disease was published, indicating that the number of blind persons was of the order of 37 million, with an additional 124 million being visually impaired. These revised, updated values represented an improvement in the overall number of blind persons – a decrease of one million globally – mainly due to an increase in the cataract surgical rate in India through a revamped National Programme for the Control of Blindness (NPCB) in the mid-to-late 1990s.¹⁰⁰

Nevertheless, notably, an additional 14 million individuals were visually impaired globally, according to the more recent WHO analysis. Cataract continued to be the major cause of blindness, with more than 90% of blinding cataract cases having been reported from developing countries in which access to and affordability of sight-restoring cataract surgery was limited.

In 2012, the WHO published a further up-dated review on global blindness and visual impairment, based on prevalence surveys conducted from 2000 to mid-year 2010.¹⁰¹ In total, 53 studies from 39 countries met the inclusion criteria for the review, which estimated as many as 39 million persons were blind with a further 246 million visually impaired, corresponding to 0.58% and 3.65% of the global population, respectively. These all-age prevalence figures were based on the WHO definition of ‘best corrected vision’, ie the visual acuity achieved when the subject’s vision would be re-tested following having had her/his ‘presenting’, unaided vision initially examined.¹⁰²⁻¹⁰³

As had been previously reported,¹⁰¹ the vast majority of those either blind or visually impaired were from developing countries. India and China, combined, constituted over 40% of the world’s blind. The vast majority of

Literature Review

those who were blind (82%) or visually impaired (65%) were aged 50 years and above. Cataract was identified as the principal cause of blindness, being responsible for 51% all cases whereas uncorrected refractive error – reflecting an unmet need for access to and use of spectacles by millions worldwide – was the major cause of visual impairment (43%). Notably, the prominence of other blinding ocular conditions had undergone a transition from being caused by infectious diseases (eg reduced to only 3% due to trachoma) to more chronic non-communicable eye diseases (eg 8% due to glaucoma and 5% to age-related macular degeneration).

Bastawrous and Hennig have pictorially represented the 2010 WHO report data as a density-equalised cartogram (Figure 4.3.1) in which the larger areas – especially India and China and the African continent – represent the areas of highest blindness prevalence.¹⁰⁴ By contrast, the authors highlight the disproportionate availability of ‘practising ophthalmologists’ globally given the distribution of blind persons, as shown in Figure 4.3.2. As such, taken together, these two cartograms highlighted the existent ‘inverse care law’ concerning blindness prevalence, ophthalmologists and the inadequate distribution of the two entities, ie the gap between the patient requiring attention and the eye specialist to provide the required care, eg cataract surgery.

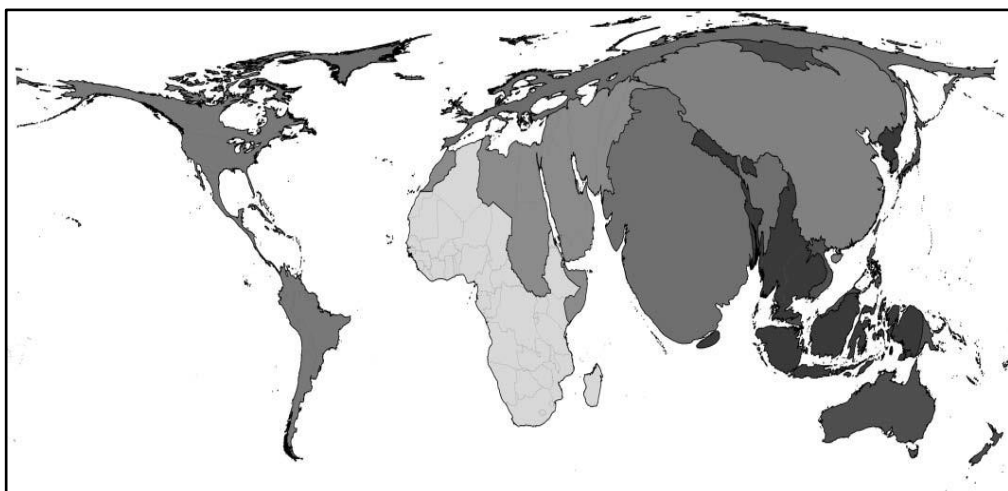


Figure 4.3.1. Distribution of the prevalence of blindness by WHO region.¹⁰⁴

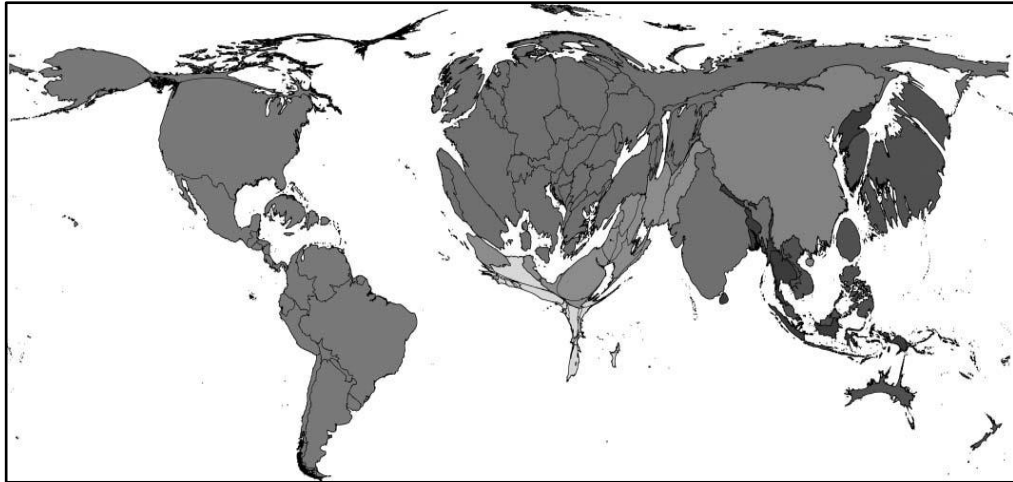


Figure 4.3.2. Distribution of the number of practising ophthalmologists worldwide, by country.¹⁰⁴

As previously discussed, the blindness and visual impairment prevalence results reported in the individual studies and, *ergo*, in the WHO systematic review were based on best-corrected visual acuity (BCVA) testing. Increasingly, over a series of years, concern was raised as to the underestimation effect that BCVA testing – as compared to presenting visual acuity (PVA) – had vis-à-vis prevalence results for visual impairment and blindness. Essentially, as the official WHO definitions were based on BCVA when surveys were being conducted,^{75,102} the actual prevalence levels for blindness and visual impairment were being underestimated. Given that the visual acuity testing results followed the WHO protocol standards,¹⁰² ie reporting BCVA rather than PVA data obtained from population-based research studies, the prevalence data for BCVA was lower than PVA.¹⁰⁵

While theoretically best-corrected visual acuity results indicated the optimal vision a person could obtain should s/he wear glasses, in reality many millions of individuals would not have been wearing spectacles other than during the course of the research study itself, in the form of a temporary ‘pinhole’.¹⁰² This measurement phenomenon was commonplace during the course of surveys especially in resource poor settings where obtaining spectacles to correct refractive errors would not have been feasible financially (not affordable) or logistically (ophthalmic services not available or accessible).¹⁰⁶⁻¹⁰⁷ The consequence, artifactually, of reporting BCVA instead

Literature Review

of PVA results for blindness and visual impairment prevalence was to disregard the major role that refractive errors have had in vision loss.

Having recognised this conundrum concerning the reporting of blindness and visual impairment prevalence data, the WHO proposed a change in the actual International Classification of Diseases (ICD-10) definition for blindness and visual impairment. Following the WHO recommendation, PVA would be the basis on which prevalence results would be reported, stating, '*Many recent studies have shown that the use of best-corrected vision overlooks a large proportion of persons with visual impairment, including blindness, due to uncorrected refractive error, a common occurrence in many parts of the world.*'¹⁰⁸

In line with this proposed modification in the definition of blindness and visual impairment – pending World Health Assembly ratification of ICD-11 in 2017 – the WHO indicated in the '*Action Plan for the Prevention of Avoidable Blindness and Visual Impairment 2009-2013*' that based on PVA, there were 45 million persons blind and as many as 269 million persons visually impaired.¹⁰⁹ Over 90% of those who were blind were from developing countries, as had been previously reported. The fact that the number of blind persons was seen to increase from 39 million to an estimated 45 million and that those visually impaired increased by 23 million highlights: a) the importance as to which definition (PVA v BCVA) is used for reporting blindness prevalence; b) the impact that having access to and wearing spectacles potentially would have for those who are blind or visually impaired due to uncorrected refractive error and c) the need for strengthened comprehensive implementation of the Vision 2020 strategic plan on a global scale in order to prevent avoidable blindness.

Literature Review

Table 4.3.1. Trend of the estimated magnitude and prevalence of blindness and visual impairment, from 1972 to 2010, according to WHO analysis.

Year	Millions of blind persons n (Prevalence %)	Millions of visually impaired n (Prevalence %)
1972 ⁷³	15.0 (0.39) [⊗]	Not available
1978 ⁷³	28.0 (0.65) [⊗]	Not available
1984 ⁷³	31.2 (0.66) [⊗]	Not available
1990 ⁷³	38.0 (0.72) [⊗]	110.0 (2.07) [⊗]
2002 ⁹⁹	36.9 (0.59) [⊗]	124.3 (1.98) [⊗]
2002 ¹¹⁰	42.0 (0.67) [§]	217.2 (3.46) [§]
2004 ¹¹¹	45.1 (0.70) [§]	269.2 (4.19) [§]
2010 ¹¹²	39.4 (0.57) [§]	246.0 (3.57) [§]

Note: Prevalence data based on: [⊗] best corrected visual acuity, [§] presenting visual acuity

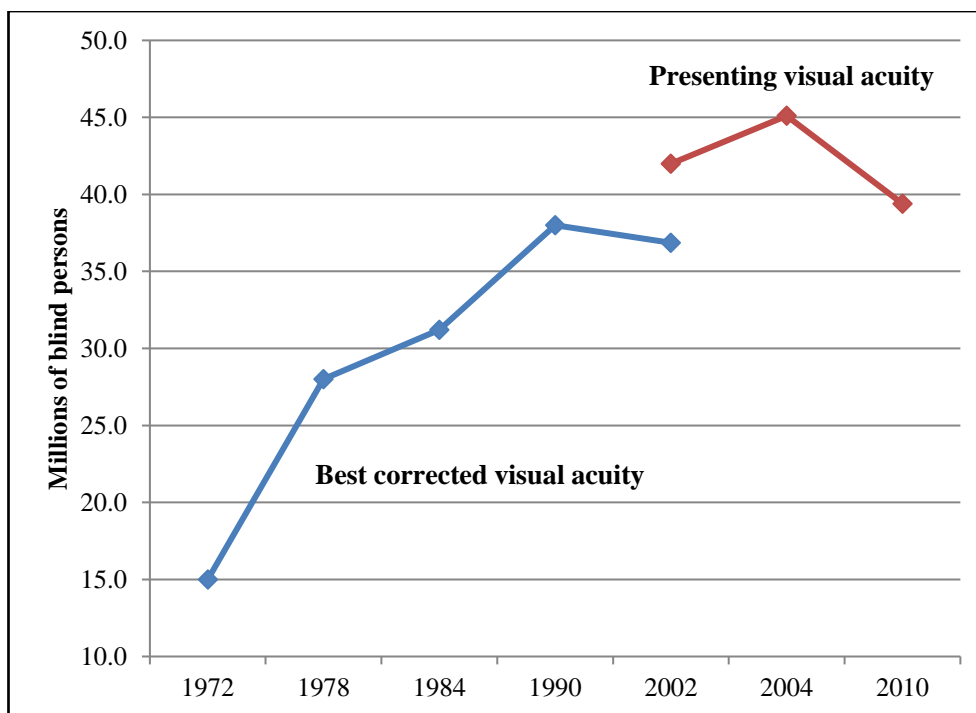


Figure 4.3.3. Trend of the estimated magnitude of blind persons globally, from 1972 to 2010, by presenting and best corrected visual acuity.^{73,99,110-112}

It merits emphasising the increasingly recognised importance of uncorrected refractive error that has occurred in recent years.¹¹³⁻¹¹⁸ As elucidated in Table 4.3.1, according to 2010 WHO estimates, nearly 250 million persons were visually impaired, when taking into account their presenting VA. However, based on BCVA data for the same systematic review conducted by the WHO, there were estimated to have been as few as 142.7 million persons visually impaired.¹⁰¹ In other words, as many as 100 million persons would not have been considered visually impaired if the reporting of survey data would have continued to refer to BCVA results rather than being based on presenting VA findings (Figure 4.3.3).

4.3.4 'Global Burden of Disease' for blindness and visual impairment

In 2013, a series of systematic reviews were published by the 'Global Burden of Disease – Vision Loss Expert Group' (GBD – VLEG) concerning the prevalence of blindness and visual impairment. These reviews dealt with a) the global situation and, separately, b) each of the major geographical regions of the world.¹¹⁹⁻¹²³ Presenting visual acuity results were used for the definitions of both blindness and visual impairment, on which the prevalence data were calculated.

Literature Review

Basing the reviews on indexed scientific literature over a twenty year period, there was a decrease in the trend in global age-standardised prevalence of blindness from 1990 (3.0%) to 2010 (1.9%).¹¹⁹ Similarly, the prevalence of MSVI underwent a reduction, from 14.3% to 10.4%. However, as previously pointed out, due to a substantial increase in the world's population – from 5.3 billion in 1990 to 6.9 billion in 2010 – and the relative increase in older adults linked with increased life expectancy, the actual number of blind and visually impaired persons had increased. As such, according to the GBD – VLEG analyses, there were an estimated 32.4 million (95% CI: 29.4 – 36.5 million) blind and 191 million (95% CI: 174 – 230 million) visually impaired individuals globally as of 2010.

As commented by the authors regarding the favourable decrease in blindness and visual impairment prevalence, ‘. . . around half was a result of decline in vision impairment caused by cataracts. A further 20% and 45% of the reductions in the prevalence of blindness and MSVI, respectively, resulted from declines in uncorrected refractive error.’¹²⁰ Despite the significant reduction in the global burden of avoidable blindness and visual impairment due to cataract and uncorrected refractive error, it merits highlighting that cataract remained the leading cause of blindness in 2010 – as also had been the case in 1990. Likewise, uncorrected refractive error was identified as the major cause of visual impairment, followed by cataract.

In all, nearly two-thirds (65%) of blindness and three-quarters (76%) of MSVI was either preventable or treatable, ie due to ‘avoidable’ causes, in accordance with Vision 2020 definitions.⁹

One of the regions for which a GBD – VLEG systematic review of the prevalence and causes of blindness and visual impairment was undertaken was that of South Asia.¹²² Vision loss estimates for the region indicated an improvement in the age-standardised blindness prevalence from 1.7% to 1.1% and MSVI reduced from 8.9% to 6.4%. Extrapolating these prevalence figures to the South Asian country-specific populations, it is estimated that as many as 10.6 million (95% CI: 8.4 – 12.5 million) were blind and 71.6 million (57.6 – 92.6 million) were visually impaired. As was shown to be the case

globally, cataract and uncorrected refractive errors were the major causes of blindness and visual impairment, respectively.

From a ‘burden of disease’ perspective, although said prevalences had undergone significant reductions, the number of persons blind and visually impaired had actually increased due to population growth, particularly amongst older adults.

4.3.5 Eye care service delivery models in India and Bangladesh

The Indian National Programme for the Control of Blindness (NPCB)¹²⁴ was established in 1975 in order to improve the delivery of eye care services countrywide, especially regarding management of the growing backlog of un-operated blinding cataract cases. In the mid-1970s – as is still the case today – cataract was the principal cause of blindness. Two major challenges existed for dealing with cataract as a public health issue within the vast mainly impoverished population of India, namely a) increasing the cataract surgical rate within the population and b) ensuring optimal quality of the surgeries as concerns sight restoration for the patient post-operatively.

As part of a comprehensive effort to deal with blindness, it was decided that a national blindness survey would be conducted in India (1986–1989).¹²⁵⁻¹²⁶ This study identified that there were 12 million blind persons in the country, with 80.1% due to cataract. In 1990, the annual incidence of blinding cataract was estimated to be 3.8 million persons whereas only 1.7 million cataract surgeries had been performed that year.¹²⁷ Faced with an increasing backlog, the World Bank decided to support a nationwide cataract surgery programme, the first of its kind, with involvement of government, non-government and private and/or charitable organisations as cataract surgery service providers. The cost of this World Bank project was US\$ 135 million with a target of 11 million cataract surgeries. Over the course of the 89 months of the project, through targeting underserved groups across seven states in India, especially women and tribal populations, a total of 15.3 million cataract surgeries were performed.

Literature Review

It was estimated that approximately 5 million cataract surgeries had been conducted globally in 1988; by 2008 that number had increased to as many as 15 million operations. Nonetheless, an additional 17 million persons were still in need of undergoing sight-restoring cataract surgery.¹²⁸⁻¹²⁹

By the end of the decade, as reported in 1999 at the Sixth General Assembly of the IAPB, as many as 10 million cataract surgeries were being performed annually. However, despite such a high level of surgical output for cataract blindness, it was estimated that the required annual number of sight-restoring procedures was three times (ie 30 million surgeries) that which was being carried out at that time.⁹⁸

One of the most prominent entities involved in developing a successful model for, initially, delivery of cataract surgeries and, progressively, for comprehensive eye care is the Aravind Eye Institute in Madurai, in southern India, established in 1976.¹³⁰ This model of eye care provision has evolved in response to an increasingly complex set of eye care needs within the Indian population. Aravind is recognised globally for its notable achievements in providing high volume, high quality cataract surgery – for both those able to pay for the operation as well as for a vast indigent population in the southern region of the country. In 2011, over 200,000 cataract surgeries were conducted – the highest number of such operations by any hospital worldwide.¹³¹ The vast majority of those surgeries were provided at no or minimal cost, in line with the cost-recovery model – through cost-subsidising surgeries for those unable to pay – with the profits made on full-cost operations from fee-paying patients.

Key features of the Aravind eye care model (Figure 4.3.4) include community outreach and vision screening activities, followed by referral to hospital settings for those requiring surgery – all within a working ethos of service based on teamwork and commitment to the patient.¹³²

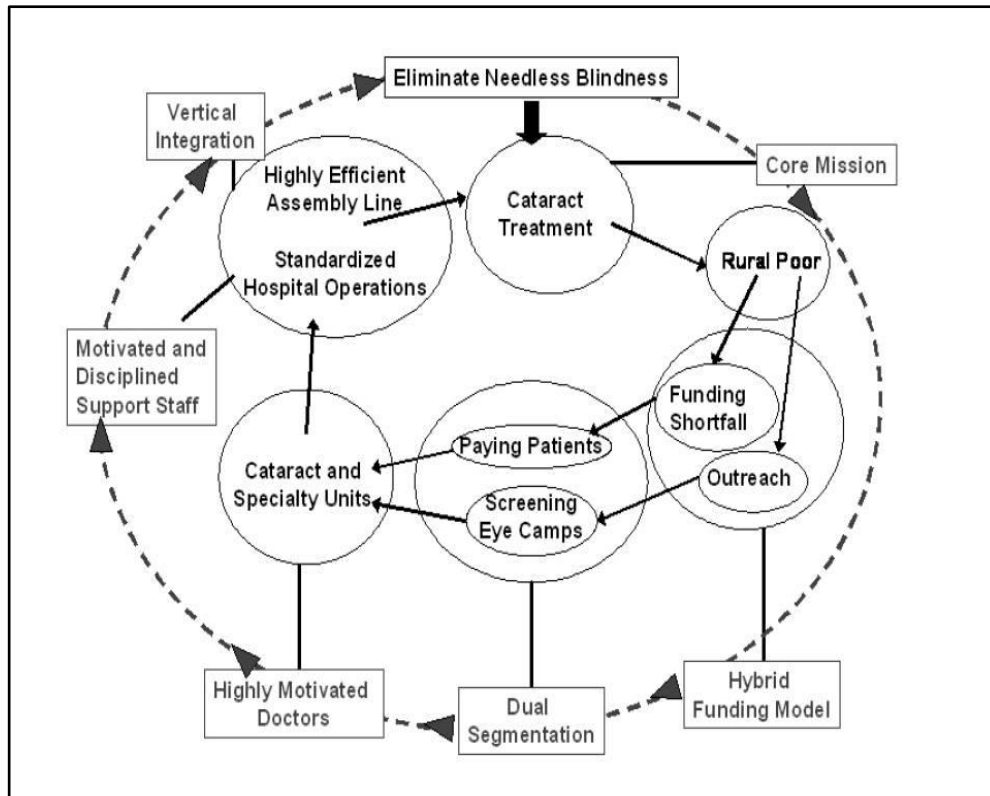


Figure 4.3.4. Cycle of Aravind eye care delivery – goal, strategies and service components.¹³²

The Aravind eye care service delivery model consists of the following components:

- * eye care facilities in Madurai and surrounding catchment area for the delivery of affordable, high-quality services, especially sight-restoring cataract surgery
- * community outreach primary eye care programmes¹³³
- * telemedicine technology to facilitate screening, diagnosis and referrals
- * production facility of low cost, high quality intra-ocular lenses (Aurolab)
- * Aravind Post-graduate Institute of Ophthalmology
- * Aravind Medical Research Foundation
- * Lions Aravind Institute of Community Ophthalmology
- * Rotary Aravind International Eye Bank

Literature Review

The Aravind model of payment cross-subsidisation for eye care, especially cataract surgery, has been adopted and replicated in diverse settings around the world, including various countries in Africa and Latin America.¹³⁴

Another prominent eye care service in India is that provided by the LV Prasad Eye Institute (LVPEI), based in Andhra Pradesh State. Similar to Aravind, LVPEI has developed an integrated primary eye care service delivery model, known as ICARE (International Centre for the Advancement of Rural Eyecare).¹³⁵ Comprised of a comprehensive set of eye care personnel cadres – including volunteer ‘vision guardians’ at village level,¹³⁶ vision technicians and other mid-level ophthalmic staff through to specialist ophthalmic services at the tertiary centre in Hyderabad, sustainable – low cost ophthalmic services (especially cataract surgery and correction of refractive errors) are provided across a network of inter-related facilities¹³⁷ throughout Andhra Pradesh, as below (Figure 4.3.5).

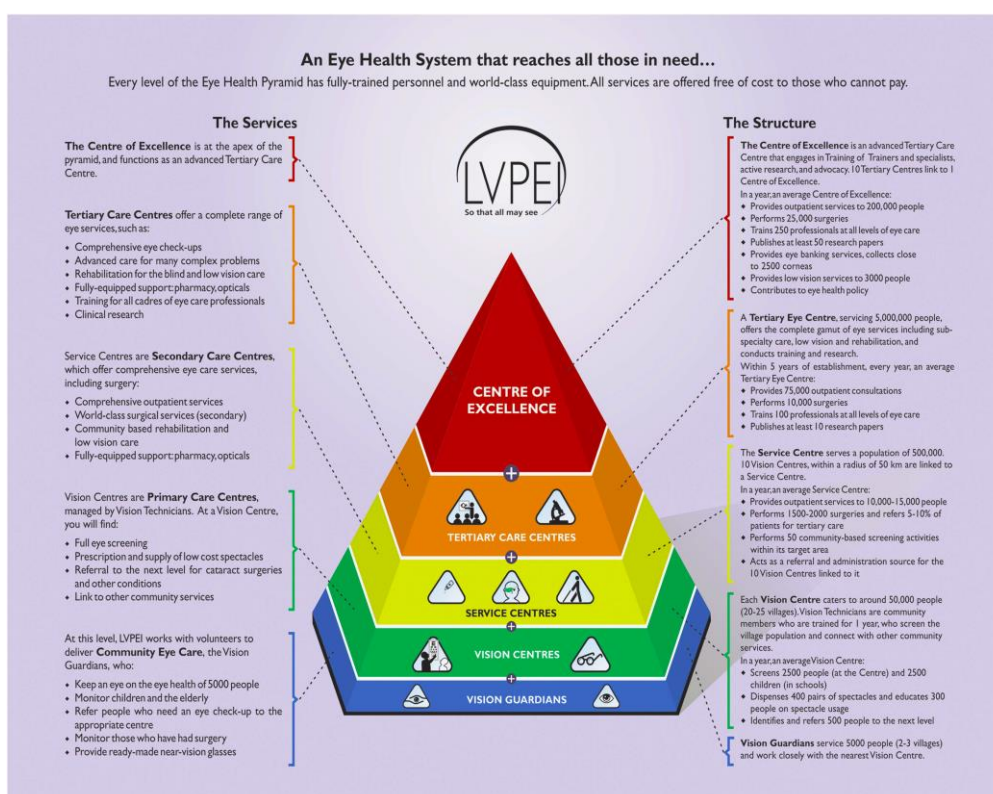


Figure 4.3.5. Pyramidal organisation of LV Prasad Eye Institute service delivery model.¹³⁷

One further example of an effective eye care model is that implemented by the Rajendra Prasad Centre for Ophthalmic Sciences (RPCOS) servicing a

Literature Review

large urban slum population of New Delhi through ten primary eye care clinics. Basic eye care (eg treatment of common eye conditions, refraction correction through prescription of spectacles) and referral to the RPCOS of any patient in need of more advanced treatment (eg cataract surgery) are two of the key activities implemented through this joint community-based – ophthalmic centre model.¹³⁸

The aforementioned eye care service models are three examples of successful, sustainable programmes that, in line with the tenets and objectives of Vision 2020, have contributed significantly to blindness prevention and control activities in India.

Key attributes of these programmes include:

- * involvement of para-medical and mid-level ophthalmic personnel in PEC, (eg undertaking vision screening at community level);
- * referral to the appropriate healthcare delivery level required according to the eye condition identified;
- * maintaining eye care affordable for those unable to pay while ensuring delivery of a high quality, high volume service.

Notably, the impressive sight-preserving / restoring achievements have been made possible due to the organisational efficiencies and financial expertise demonstrated by these three institutes. These programmes have, in turn, influenced the development of other, similar initiatives elsewhere in Africa and South Asia, including Bangladesh.

As with the Indian eye care service models thus far discussed, through the auspices and financial support of Sight Savers International (SSI) in Bangladesh, a so-called ‘modular eye care’ (MEC) programme was developed in that country in the mid-1990s.¹³⁹ Whereas previously primary eye care services were ‘vertical’ in their implementation (ie not integrated into the country’s overall PHC structure), the MEC approach emphasised the importance of linking eye care services into PHC, both within the government

and NGO sectors (Figure 4.3.6). Moreover, in terms of cataract surgical service delivery, the MEC was designed to replace the traditional ‘eye camp’ modality, which had increasingly been under scrutiny due, especially, to the poor post-surgical outcomes in patients who had been operated upon in eye camps.¹⁴⁰

The MEC programme focussed its services within each of the seven districts in which it was initially implemented, consisting of a centrally-located 50-bed eye hospital with an additional four satellite centres with a 50 to 80 kilometre radius from the hospital.

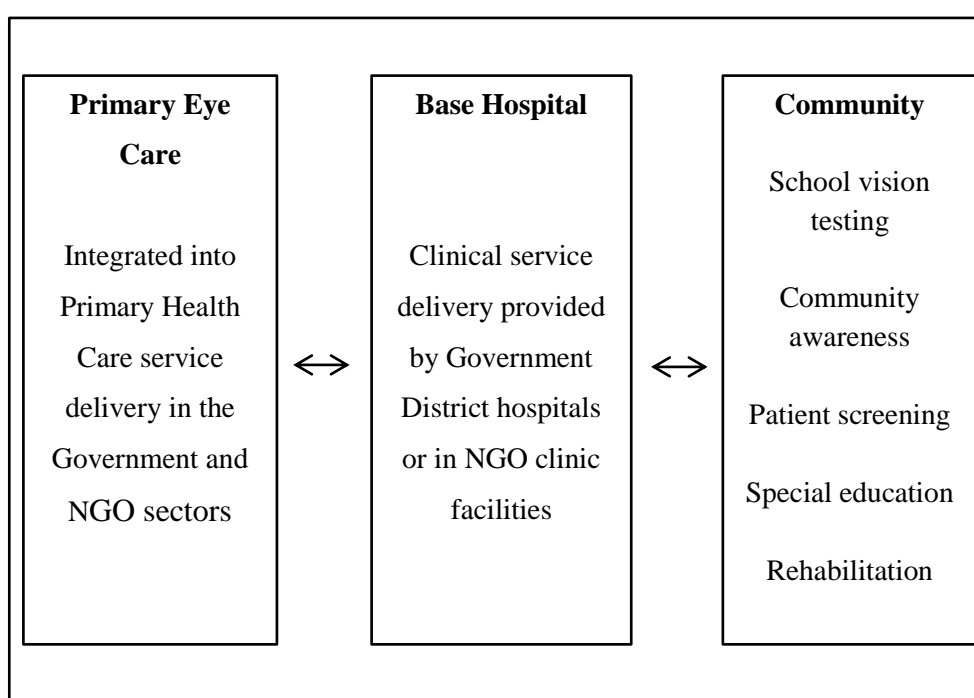


Figure 4.3.6. Operational diagram of the Sight Savers International (SSI) Modular Eye Care (MEC) programme in Bangladesh.

By means of the MEC, therefore, integration of screening (eg for lens opacities and refractive errors), referral and counter-referral from primary to more advanced levels of eye care provision was developed; effectively support of eye care services delivery from within a single, comprehensive programme was initiated. Implementation of the MEC model was carried out through partnerships with national NGOs (eg Bangladesh National Society for the Blind (BNSB), amongst others) for delivery of preventive, curative

and community-based rehabilitation services within the seven district-based programmes.¹⁴¹⁻¹⁴³

Furthermore, starting in 1997, Sight Savers International provided financial support and technical capacity building – in collaboration with qualified surgical trainers from Aravind Eye Hospital – concerning intra-ocular lens microsurgery. Moreover, through supporting cataract surgeries with IOL, rather than providing +10 diopter aphakic spectacles for correction of refractive error following lens extraction, the post-surgical vision quality was improved.

The SSI MEC model was shown to be successful following its introduction, most notably in terms of the increased number of cataract surgeries performed and in the proportion of patients who had an intra-ocular lens (IOL) implanted (Figure 4.3.7).

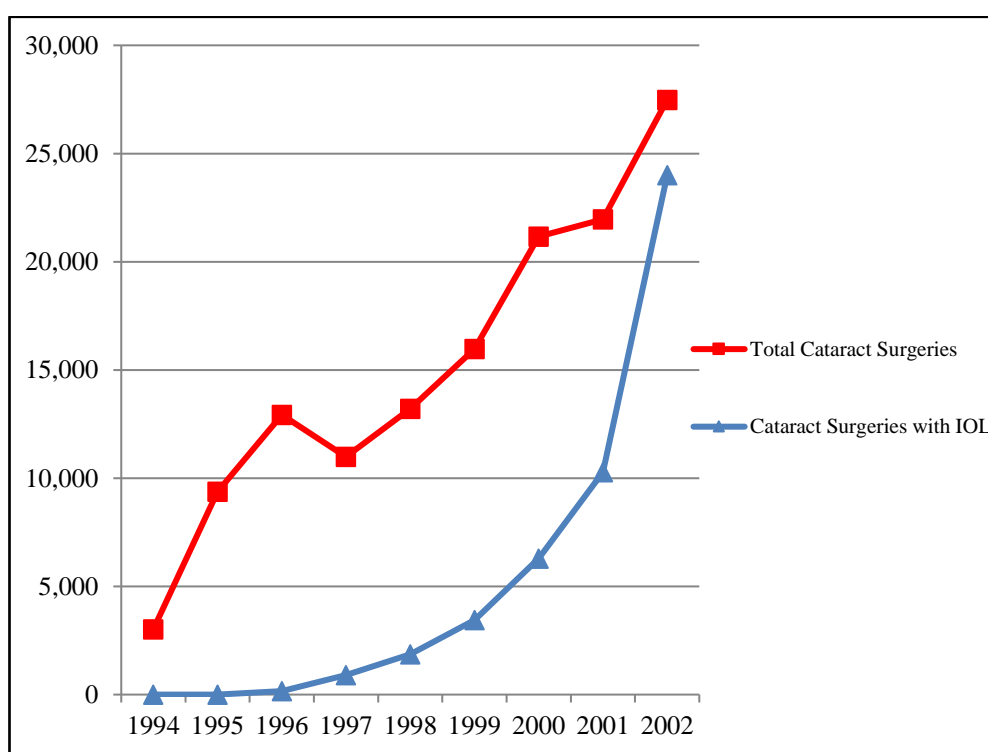


Figure 4.3.7. Total number of cataract surgeries and number of surgeries with IOL implantation in SSI MEC programme, 1994 – 2002.

The increase in the number of cataract surgeries through the MEC programme, as above following its inception, came largely as a result of a)

Literature Review

organisational change in the delivery of eye care services, b) increased technical surgical capacity following training c) essential financial support for eye care programme implementation, and d) integration of primary eye care into the existent primary health care structures – both the government district hospitals and the NGO healthcare facilities.¹⁴⁴⁻¹⁴⁵

5.0 Methods

5.1 Overview of the Methods Chapter

The following Methods section delineates, in detail, the principal elements of the research study design (eg field-based enumeration procedures, subject selection); the ophthalmic examination procedures undertaken (visual acuity testing, lens opacity grading, dilated retinal assessment) and the key epidemiological aspects of the survey (training and standardisation of examination team members, operational definitions for ocular diseases, data analysis, statistical procedures utilised).

It merits pointing out that as per the examination protocol – described herein – clinical data were collected on the study participants, depending upon their eye health status. Accordingly, the findings from this survey (visual status, cause(s) of impaired vision, if any; the need for surgery and/or spectacles) as well as the reasons for not having accessed eye care services are presented in separate sections in the Results chapter. Thus, while this Methods chapter outlines the procedures for the overall survey, the results from the clinical examinations amongst this very large sample are presented in a total of six Results sub-sections.

5.2 Subjects

The principal inclusion criterion for this national survey was the age of the study subject, ie that the enumerated individual who was to undergo an eye examination was aged 30 years or older. The major reasons for having limited the scope of this blindness and low vision survey to the adult population aged 30 years or older were in line with the epidemiological profile of visual impairment globally, as described below.¹⁴⁶⁻¹⁴⁷

It has been widely reported that the prevalence of blindness is known to be age-related whereby an increase in visual impairment is associated with increasing age of an individual.^{98,148} In ‘life course’ terms, visual problems occur with ageing, as in the case of the structural and protein metabolism changes that lead to development of lens opacities (ie cataract); such alterations of the lens can severely affect one’s visual acuity if not surgically

Methods

treated. The majority of persons that are blind or visually impaired (moderately or severely) are adults, most especially due to age-related cataract, which is the leading cause of blindness worldwide.

Conversely, the prevalence of visual impairment (blindness and/or low vision) in young individuals – children and young adults - is known to be very low globally, ranging from 0.1% to 1.0% of children aged less than 5 years of age, specifically, depending on the reigning pathologies and level of eye care service provision of the specific country.¹⁴⁹⁻¹⁵¹

The decision to include only adults aged 30 years and older in the survey - thereby to excluding the cohort of children and young adults from this particular study - was collectively taken during the course of the initial consultation meetings with the Bangladeshi ophthalmic experts, Sight Savers International and colleagues in the ICEH. The following explanations further outline the reasons for targeting adult subjects, as below:

* if the study would have included persons of all ages, a very large sample size would have been required, when acceptable levels of precision of the prevalence estimate were factored in to the sample size calculation.¹⁵²⁻¹⁵³

* given the substantially large population of children and young adults in Bangladesh when the study was undertaken, two-thirds of the overall sample would have been aged less than 30 years, in whom the prevalence of visual impairment was considered to be very low.

In light of the aforementioned, it was decided to focus upon the Bangladeshi adult population for this national survey.²¹⁻²² In doing so vital information on this age cohort would be obtained in line with the programmatic objective of developing an evidence-base of population estimates for blindness and low vision that would serve as essential inputs for eye care service provision, planning, resourcing and implementation. In this way, the required focus of this unprecedented survey would appropriately focus on the major burden of vision impairing disease within the Bangladeshi population by targeting adult subjects.

Methods

Furthermore, from a logistically practical perspective, selecting the age of 30 years as the youngest age of prospective subjects coincided closely with the age of the country of Bangladesh, as the national independence of Bangladesh occurred in 1971.⁶⁵ Thus for the purposes of enumerating individuals to be included in the study this event served as a useful age verification marker for those persons unsure of their exact age (compulsory birth registration would commence in Bangladesh in 2004 with the enactment of the Birth and Death Registration Act). If individuals were uncertain of their age, s/he would have been asked whether their birth took place prior to independence and, if so, approximately how old s/he was at that time in 1971.¹⁵⁴⁻¹⁵⁵

According to the official 1991 Bangladesh census data, officially up-dated with estimates of the national population in 1996,¹⁵⁶ there were an estimated 44 million persons within the target age group (33.6% of the total population). Demographic data indicated that the majority of the population resided in rural areas (79.9%) while a lesser proportion was located in urban zones (20.1%). As stated, 30 years was chosen as the threshold age for potentially being included in the survey. In view of the 57.5-year life expectancy in Bangladesh in 1999,¹⁵⁶ due consideration was undertaken to determine that those aged 30 years and older would best represent the period of adulthood in Bangladesh.

5.3 Sample size

The calculation of the sample size was based upon an estimation of the prevalence of blindness among adults 30 years and older. Several population-based studies concerning blindness prevalence were reviewed with regard to the minimum age of subjects examined as well as concerning the geographical region in which the surveys took place. An example of such a study was that conducted in urban Hyderabad, Andhra Pradesh, India in which the age-adjusted blindness prevalence for persons 30 years and older was 2.53% according to presenting visual acuity and 2.23% as per best corrected acuity (the WHO definition for blindness).¹⁴⁷ Age-specific prevalence for blindness and low vision derived from other studies indicated

Methods

similar levels to that found in Hyderabad, with increased age-specific prevalence being identified amongst older individuals.¹⁵⁷⁻¹⁵⁸

Based upon the target age population of Bangladesh National Blindness and Low Vision Prevalence Survey of 30 years and older (44 million adults),¹⁵⁶ a blindness prevalence estimate of 2.5% for Bangladesh adults was considered. Utilising a random sampling error of 0.35% and a design effect of 1.5 due to the cluster sampling strategy,¹⁵⁹⁻¹⁶⁰ a sample size of 11,463 subjects was calculated. This figure was increased by an approximate further 10% in order to increase the likelihood of attaining the minimal sample size in case of lower than expected participation by enumerated subjects. The adjusted, final calculated sample size for this national survey was therefore set at 12,900 subjects. The 95% confidence interval projection for adult blindness prevalence was 2.23% – 2.77%.¹⁶¹

5.4 Sampling Strategy

Multi-stage stratified cluster random sampling, with probability proportional-to-size (PPS) procedures,¹⁶² was adopted as the strategy for the selection of a cross-sectional, nationally representative sample of the population. Administratively, the country of Bangladesh is comprised of a number of levels or strata. These are, as follows:

Methods

Table 5.4.1. Distribution of administrative strata / levels in Bangladesh¹⁵⁶

Administrative Strata	Frequency
Divisions	6
Districts	64
Sub-Districts (<i>Thanas / Upazilas</i>)	488
Unions (<i>Parashads</i>)	4,491
Villages	59,900
Urban Wards	603

For the purposes of this survey, a rural cluster consisted of a village while an urban cluster comprised a street block within an urban ward. Stratification of the sample by rural and urban residence – corresponding to official municipality ordinance status in the latter case – was incorporated in the sample selection process.

Proportional allocation of the cluster sites across each of the six major administrative Divisions in Bangladesh was factored in to the study design in order to ensure a nationally representative sample. The number of clusters surveyed, by Division, was proportional to the population of each of the six Divisions in relation to the overall national population, based upon official census data.¹⁵⁶ The relative numbers of rural and urban clusters within each Division was, likewise, proportional to census data regarding residence of inhabitants in the six Divisions, eg Dhaka Division having a higher percentage of urban residents led to proportionally more urban subjects being selected than in the other Divisions, which were principally rural. In total, 154 cluster sample sites were therefore selected by PPS, of which 104 were rural villages while the remaining 50 were urban block areas. The rural cluster areas consisted of 100 subjects, while the urban study areas consisted of 50 subjects each (Table 5.4.2).

The logistical advantages of this sampling strategy included efficiency in terms of time, transport and subject enumeration and subsequent examination

Methods

per cluster. Moreover, the decision to limit the sample size per urban cluster to 50 individuals was done in order to increase the precision of the prevalence estimates for blindness and low vision in the urban settings.¹⁶⁰ With the sub-total of urban adult residents calculated to be 2,500 based on PPS methodology, by reducing the number of subjects per cluster from 100 to 50, the number of clusters increased from 25 to 50, thereby achieving greater precision of the prevalence estimates due to having more urban clusters.

Table 5.4.2. Distribution of the survey sample clusters (rural and urban), by Division.

Division	Percentage of National Population	Rural Clusters	Urban Clusters	Total Clusters
Barisal	6.8	8	2	10
Chittagong	19.6	19	9	28
Dhaka	31.0	31	23	54
Khulna	11.8	12	7	19
Rajshahi	24.5	27	8	35
Sylhet	6.3	7	1	8
Total	100	104	50	154

5.5 Household enumeration and subject identification

The actual field work for the survey consisted of two sets of staff – the advance enumeration team and the eye examination team – travelling to the respective cluster sites. In total a period of 10 months was required to complete the field work, during which time 62 of the 64 Districts of the country had been accessed in order to carry out the study in at least one cluster per district, as per the PPS methods for identifying the survey sites.

As above, prior to the three eye examination teams accessing their respective cluster sites, enumeration of eligible subjects in each cluster site was undertaken, i.e. 100 adults for each rural site and 50 for each urban cluster. A

Methods

dedicated team from Mitra and Associates^{37,45} of six experienced survey enumerators, supervised by one Enumeration Co-ordinator, carried out the enumeration for all the clusters, both the rural villages and urban street blocks. Households were identified in a systematic manner by proceeding round in a clock-wise direction from a randomly identified reference point within the cluster, after having counted all of the households in that particular setting.¹⁶²

Subject identification involved the two-person enumeration teams serially assigning a number to each household. The enumeration teams proceeded to record the names and ages of all habitual residents in a given household until the requisite target number of persons aged 30 years and older was achieved, ie 100 in the rural clusters and 50 in the urban clusters (Appendix 2). Therefore, the total population corresponding to the households in which the required number of persons 30 years of age and older was obtained. Following the listing of all the family members in the households, a summary, abridged list of those who were 30 years and older was prepared, that which was used for identifying the eligible persons to be examined by the survey research team. As well, a site map of the location of the cluster and the individual households was drawn by the enumeration teams for use by the survey examination team enumerators. In doing so, this facilitated the location of the eligible subjects that had been listed by the advance enumeration team. All eligible subjects were informed that they would be asked to attend for an examination in their community in the near future.

5.6 Ethical approval

The Bangladesh Medical Research Council (BMRC) provided written ethical approval for this survey in March 1999.

5.7 Training of survey personnel

Two UK-based personnel – the author of this dissertation and a Specialist Registrar ophthalmologist were responsible for providing training to the Bangladeshi survey team members concerning the subject interview process, the enumeration methodology and the ophthalmic examination process. Three ophthalmologists, three ophthalmic nurses and six medical technicians comprised the three Bangladeshi ophthalmic sub-teams. Other, non-medical

Methods

staff included six enumerators, one enumeration quality control supervisor, three interviewers, three post-enumeration logisticians, two data processors and three drivers. All participants of the survey team underwent specialised training during a six week-long period, which was followed by pilot studies in three rural villages.

The survey interviewers were trained on the content and protocol for completing the demographic information interview schedule questionnaire (a modified WHO/PBL Version III).¹⁰² .

5.8 Training for visual acuity testing with RLM chart

As above, prior to the actual survey, specialised training concerning the ocular examination techniques - including visual acuity testing - was conducted. The three ophthalmologists, three senior ophthalmic nurses and six medical technicians underwent extensive training sessions in the National Institute of Ophthalmology (NIO), Dhaka¹⁶³ in visual acuity assessment, interpretation of vision testing results and of findings derived from the other eye examination procedures, eg lens opacity assessment, cup:disc ratio measurement.

In the course of this survey the nurses and ophthalmic technicians were directly responsible for distance visual acuity (VA) testing, the auto-refraction procedures and the VA re-testing, as required.¹⁶⁴ The ophthalmologists were in-charged with carrying out all the other ocular examinations – assessment of the optic disc, lens opacity grading, intra-ocular pressure measurement¹⁶⁵ and a complete eye fundus assessment in those with visual impairment.

Distance visual acuity was measured with a reduced logMAR-based (logarithm of minimum angle of resolution) tumbling ‘E’ chart, with three letters (optotypes) per line, fewer than other similar logMAR visual acuity charts which routinely have five optotypes per chart line. Per line, the three ‘E’ optotypes are oriented in a different direction, ie facing to the right, to the left, upwards or downwards. This specific chart had been extensively validated in clinic-based¹⁶⁶ and population-based studies,¹⁶⁷⁻¹⁶⁸ and evaluated

Methods

for inter- and intra- examiner agreement, in advance of its selection for use in VA testing in the Bangladesh National Survey. An additional advantage of the RLM 'E' chart is that it can be used to test vision even in those who are illiterate (53% of Bangladeshi adult population)¹⁵⁶ especially in those unfamiliar with the Roman alphabet on which most validated vision charts are based.

During the training period, the RLM 'E' chart was further validated as a tool for assessment visual acuity by comparing it against a Lighthouse logMAR ETDRS chart. The presenting vision was measured with the subject's current distance refractive correction, if worn, from a distance of 4 metres. VA testing was performed first for the right and then for the left eye. VA measurement was performed, as follows. With the medical technician standing to the left side of the RLM chart, he would point to each successive 'E' optotype with a red-tipped pointer of medium-sized length. Testing would begin from the top line of letters on the chart and would progress from left to right. The subject would indicate with non-ambiguous hand signals to the nurse - standing aside the seated subject - the directional orientation of each 'E' letter that was being pointed to by the technician. The number of letters reported correctly by the subject was recorded by the ophthalmic nurse using a hand-held tally counter.

If the subject was unable to see any one of the three letters of the top line of the RLM chart at 4 metres distance ($\log\text{MAR} = 1.0$), s/he was moved forward to a distance of 1 metre from the chart, and then re-tested.¹⁶⁷⁻¹⁶⁸ If s/he was still unable to see any of the top letters at 1 metre, the ophthalmologist then tested the subject's ability to count fingers, see hand movements, or perceive light.

5.8.1 Inter-examiner agreement assessment

Following training in the use of the RLM chart, inter-observer agreement analysis was conducted, based upon binocular visual acuity. Thirty patients were selected from the Out-Patients Department of the National Institute of Ophthalmology, Dhaka¹⁶³ to act as subjects in the inter-observer assessment process. Testing of visual acuity took place in the controlled environmental lighting conditions of the Refraction Room in the NIO. The visual acuity

Methods

(VA) testing procedure was explained to each subject prior to starting. Two different versions of the RLM chart, with different sequences of the orientations of the 'E' optotypes, were alternately used so as to avoid any potential recall bias on the part of the subject, as each subject had her/his vision tested three times, once each by one of the three different nurses.

Each subject was placed inside a VA testing cubicle along with one senior ophthalmic nurse and a medical technician at a time. Meanwhile the other two nurses remained outside the cubicle and were not able to observe the examination taking place. The binocular VA of each subject was measured by one of the nurses, (e.g. Nurse 'A') and the number of 'E' optotypes seen was written down by the principal investigator – the author of this dissertation – onto a special recording form. Next, the binocular VA of the same subject was examined by Nurse 'B' while Nurse 'A' waited outside the cubicle in a different area from where Nurse 'C' was waiting. This was done so that information could not be passed between the two nurses not presently engaged in VA testing as regards the outcome of the VA testing conducted by Nurse 'A' of the previous subject. Upon finishing, Nurse 'B' provided the VA result to the investigator and was asked to join Nurse 'A'. Finally, the subject had his/her VA tested by Nurse 'C' and the result was likewise recorded. This process was repeated for each of the 30 subjects. This sequence of testing was followed for the first ten patients, wherein Nurse 'A' preceded Nurse 'B' who was followed by Nurse 'C'. For subjects 11 through 20, the order was altered such that Nurse 'B' was first, followed by Nurse 'A' who was then followed by Nurse 'C'. Finally for subjects 21 to 30, Nurse 'C' was the first to test the vision of these subjects, followed by Nurses 'A' and 'B', accordingly.

5.8.2 Intra-examiner agreement assessment

Intra-observer agreement evaluation was formally conducted during the course of the national survey, following training, when the three survey teams were in different rural villages. According to the sampling strategy for the study, a total of 100 subjects were enumerated in each rural cluster site. On average, 60 subjects were examined on the first of two days that the

Methods

examination teams were conducting the survey in each cluster. As such, for the purposes of carrying out intra-observer agreement testing for the RLM chart, it was decided that a total of thirty randomly selected subjects would have their VA tested twice, on consecutive days. Accordingly a list of random numbers ranging from 1 to 60, without replacement, was developed, using Epi Info (Version 6.04a)¹⁶⁹ corresponding to 'subject serial numbers' on the examination record form. The 30 randomly chosen subjects underwent monocular and binocular VA testing on the first day as part of the survey and were requested to return the following day to have their VA re-tested by the same nurse. Results for each subject were recorded on a special recording form.

5.9 Inter-examiner agreement analysis

Agreement between the measurements taken by the three nurses was assessed by calculating the standard deviation of the repeated measurements on each subject. This value is known as the 'estimated within-subject standard deviation',¹⁷¹⁻¹⁷² from which 95% confidence limits of agreement are calculated. This method was applicable if the differences between the measurements taken by the three nurses were independent of the true underlying acuity. Plotting the mean of the three measurements taken on each subject (the best available estimate of the true underlying acuity) against the difference between each isolated acuity measurement and the mean of the three measurements conducted by the three nurses suggested that these two variables were independent (Figure 5.9.1).

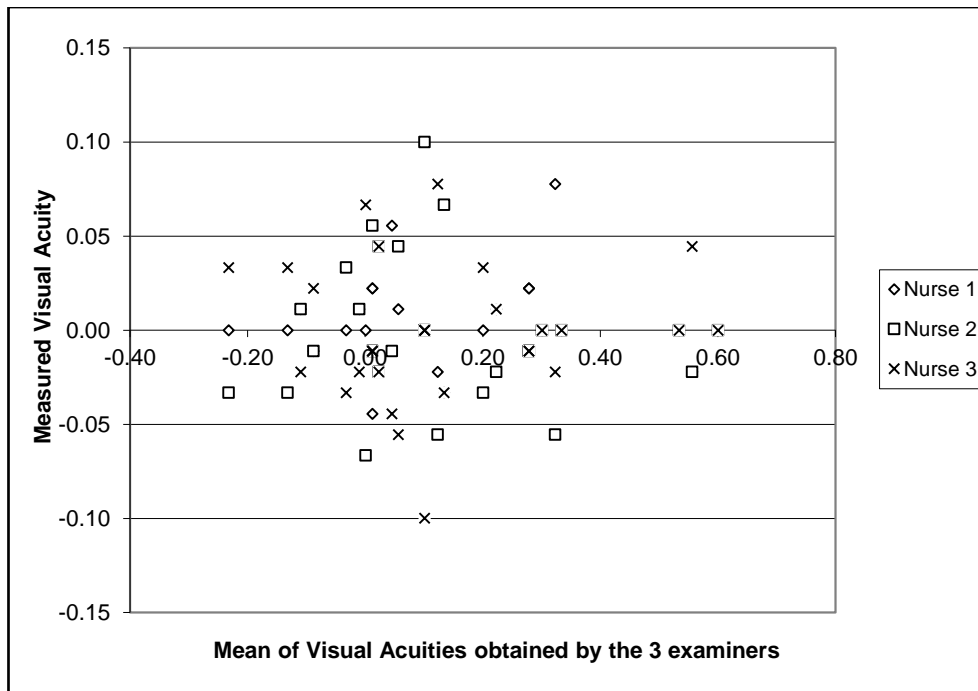


Figure 5.9.1. Bland-Altman plot indicating the difference between measured VA and mean VA for each of the three examiners.

The mean of the variances of the 3 measurements on each subject was 0.002 logMAR whereas the ‘within subject standard deviation’ was 0.04 logMAR.

The 95% confidence limits of agreement were:

$$\pm 1.96 \times 0.04 \times \sqrt{2} = \pm 0.11 \text{ logMAR}$$

Thus, on average, the measurements carried out by different examiners on the same subject were within ± 4 letters of each other 95% of the time.

5.10 Intra-examiner agreement analysis

The agreement between consecutive measurements taken by a given examiner was calculated from the distribution of the differences between the two measurements. The mean difference showed a slight bias towards improvement on the second test (Table 5.10.1) which indicated that the mean difference exceeded the confidence intervals of this mean for each nurse (range: ± 0.01 to ± 0.015). This can be explained by the ordering effect. However the 95% confidence limits showed a spread of -0.055 to $+0.105$.

Methods

Table 5.10.1. Intra-examiner agreement (right eyes only).

Examiner	Mean difference	Standard Deviation * 1.96	Mean difference 95% Confidence Interval
Nurse A	+0.029	+/- 0.053	-0.024 to 0.082
Nurse B	+0.019	+/- 0.069	-0.050 to 0.088
Nurse C	+0.025	+/- 0.080	-0.055 to 0.105

For all 90 measurements, the change in visual acuity of the better eye on retesting, ranged from a worsening of vision of 0.03 to an improvement of – 0.1 logMAR (mean –0.018; 95% CI: -0.024 to –0.012). There was a significant correlation between initial visual acuity in the better eye and the change in visual acuity on retesting. There was a trend (Pearson’s correlation coefficient $r=-0.129$, $P=0.226$) for subjects with worse initial visual acuity to have a greater improvement in visual acuity on retesting.

5.11 Survey data collection process

Prior to the ophthalmic examination, personal and demographic data (age, sex, literacy status, previous school attendance, occupation, land tenure status, religious affiliation) were obtained by the interviewer for each of the enumerated subjects that attended the eye examinations. If the subject was unable or had difficulty in responding to questions at any time, a relative was subsequently asked for clarification. Oral informed consent was sought from each subject by the senior ophthalmic nurse, following explanation of the procedures to be conducted in the course of the eye examination procedures.

5.11.1 Measurement of visual acuity

The ophthalmic nurse recorded whether the subject arrived with distance spectacles, usually wore distance spectacles but had forgotten to bring them, had been prescribed distance spectacles but did not habitually wear them, or did not possess them. Visual acuity was measured with no refractive correction, for the right and then the left eye. The number of letters seen at 4 metres was recorded by the ophthalmic nurse using a hand-held tally counter. If the subject was unable to see any of the three letters of the top line of the

Methods

RLME chart at 4m distance (logMAR = 1.0), s/he was moved to 1m, and then re-tested. If s/he was still unable to see any of the top letters at 1m, the ophthalmologist was called to test the ability to count fingers, see hand movements, or perceive light. Rather than select acuity cut-offs, this method of counting the total letters seen at a certain distance allowed measurement of the exact logMAR (and Snellen equivalent) acuity.¹⁶⁶ In this manner, data could be grouped at any logMAR acuity for analysis purposes.

Based on presenting visual acuity, subjects were assigned either a red card (acuity was worse than 6/12 in either eye) or a green card (equal or better than 6/12 in both eyes tested separately). This categorisation – according to visual acuity – defined the subsequent sequence of examinations that each individual subject would undergo (Appendix 1 Figure 2). If the subject was assigned a red card, the binocular unaided visual acuity was also measured. In addition, if the subject was wearing their habitual distance correction, the spectacle-corrected visual acuity was re-measured for each eye. The nurse also asked the subject if they wore reading spectacles.

5.11.2 Refractive Error

All patients underwent automated refraction with use of a Nikon Retinomax K-Plus II refract-keratometer;¹⁷² this procedure was performed by the trained ophthalmic technicians. Measurements obtained included average refractive error (based on three consecutive readings), spherical equivalent, vertex distance, and keratometry. If the auto-refractor did not yield a measurement – due especially to a media opacity such as a hyper-mature cataract or corneal opacity – in a subject with less than 6/12 visual acuity (ie 'red card' subjects), the ophthalmologist attempted a manual objective and subjective refraction. Subjects with less than 6/12 visual acuity were then re-tested for visual acuity in each eye with their auto-refraction result placed in a trial frame using trial lenses.¹⁰² This was performed to estimate the contribution of refractive error to these subjects' visual disability.

5.12 Operational definitions used in the ophthalmic examination

The WHO categories of visual impairment were used for this study.¹⁷³ Blindness was defined as a corrected visual acuity of less than 3/60 (Snellen

Methods

system of visual acuity) in the better eye. Low vision was defined as corrected visual acuity of less than 6/18 but equal to or better than 3/60 in the better eye (comprising categories 1 and 2 in ICD-10). Category 1 is visual impairment, less than 6/18 to 6/60, and category 2, severe visual impairment, corresponds to visual acuity less than 6/60 to 3/60. Subjects whose presenting visual acuity was worse than 6/12 in either eye were targeted in this study for further examination, as these subjects represented those with 'near normal' vision, possibly related to uncorrected refractive error. Visual fields were not tested due to logistic and technical difficulties in a primarily rural population. Therefore, potential findings from visual field assessment were not used in the definition of blindness, nor of glaucoma.

Below are found condition-specific definitions for the main diseases causing visual impairment:

* Cataract was defined as any opacity visualised with a direct ophthalmoscope through an un-dilated pupil. The grading system used was that of Mehra and Minassian.¹⁷⁴

* Myopia was defined as a spherical equivalent refractive error of ≤ -0.50 diopters. Myopia was further categorised as myopia (≤ -0.50 dioptries to -5.00 diopters), high myopia (-5.25 dioptries to -10 dioptries) and extreme myopia (> -10 dioptries).

* Hypermetropia was defined as a spherical equivalent refractive error of more than $+0.50$ diopters. Hypermetropia was further categorised as low hypermetropia ($+0.50$ dioptries to $+5.00$ diopters), high hypermetropia ($+5.25$ dioptries to $+10$ dioptries) and extreme hypermetropia ($> +10$ dioptries).

* From a population-based distribution of intraocular pressure (IOP) measured by Schiottz tonometry¹⁷⁵ techniques on a sub-sample during the main survey, the 95%, 97.5%, and 99.5% percentiles for IOP were calculated. A subject was recorded as a glaucoma case if the optic cup : disc ratio (CDR) was ≥ 0.7 in either eye in the presence of an IOP of $\geq 97.5\%$ ile. Glaucoma suspects included those with a CDR of ≥ 0.7 and IOP $< 97.5\%$ ile ('normotensive glaucoma'), and those where the optic discs were obscured

Methods

but the IOP was >99.5%ile. Ocular hypertensives were defined as those subjects with a CDR (in either eye) of <0.7 and an IOP \geq 97.5%ile.¹⁷⁶⁻¹⁷⁸

* Age-related maculopathy (ARM) was defined as the presence of any one of the following: soft drusen or reticular drusen, hyper- or hypo-pigmentation of the retinal pigment epithelium (RPE).¹⁷⁹

* Late ARM or age-related macular degeneration (ARMD) was subdivided into non-exudative geographic atrophy of the RPE in the absence of sub-retinal neovascular changes and exudative changes where neovascular ARM with RPE detachment, haemorrhages, and/or fibrous scars were evident.¹⁷⁹

* Diabetic retinopathy (DR) was subdivided into three types: non-proliferative, proliferative and maculopathy. These were not mutually exclusive, as the latter two types, for example, may co-exist. Cases of suspected diabetic retinopathy, in the absence of a history of diabetes mellitus, underwent a random blood glucose test to detect hyperglycaemia (defined as >11.0mmol/l).¹⁸⁰

5.13 Statistical analysis

5.13.1 Prevalence and causes

A systematic, decision-making approach was implemented concerning the identification of the cause(s) of low vision and/or blindness for each subject, based on the ocular examination findings. Accordingly, one singular cause of low vision or blindness was identified for each subject with presenting visual acuity less than 6/12. The decision-making process as to which possible condition was causing the subject to be visually impaired was based on the WHO recommendation that the cause should be the pathology ‘most amenable to treatment or prevention’.¹⁰²

In accordance with the Coding Instructions for the WHO/PBL Prevention of Blindness Proforma, (Version III),¹⁰² the survey ophthalmologist would record all ocular disorders - for each eye separately - that were identified in the course of examining all subjects with <6/12 VA in either one or both eyes. After listing ‘all causes of blindness or low vision for each eye’, the ophthalmologist identified which of these disorders was the main cause of

Methods

low vision or blindness for each eye separately. Next, the ophthalmologist decided which the principal disorder responsible for low vision or blindness for the subject was, taking into account the main cause for each individual eye. When more than one singular ocular disorder was present, one of which was secondary to the other, the 'primary' cause to be selected as the principal visual disorder was that which was 'most readily curable' or, if not curable, that which was 'most easily preventable'. The final decision concerning the major cause of visual impairment for a particular subject was determined after considering the disorder in either eye that was 'most amenable to treatment or prevention'.

Based on the criteria of 'most readily curable or most easily preventable',¹⁰² the following ranking system for determination of the cause of low vision or blindness was utilised:

- * Uncorrected aphakia
- * Refractive errors / amblyopia (in the presence of a lens opacity graded 0 or 1 with SE ≥ 0.5 or ≤ -0.5)
- * Cataract (when lens opacity grading was adjudged to be '2A', '2B' or '3')
- * Corneal opacities and phthisis
- * Glaucoma
- * Anterior uveitis
- * Posterior segment disorders

All information from the personal data records and the visual examinations data was processed in a specially designed database in Epi Info (Version 6.04b).¹⁶⁹ In order to ensure optimal data quality control, all questionnaire data was sequentially entered into the database twice by two experienced data processors specially trained to work with this database. Validation of the doubly-entered data was then performed and any corrections needed were

Methods

made prior to proceeding on the data analysis in Epi Info and SPSS (Statistical Package for the Social Sciences).^{169,181-183}

The prevalences for blindness and low vision were estimated, while accounting for design effects caused by the cluster sampling strategy according to the Taylor Linearised Deviation variance estimate approach.^{169,184-185} Multi-variable logistic regression modelling was carried out in order to investigate the associations of gender, age, area of residence, literacy status and employment status with visual impairment and blindness.¹⁸⁶⁻¹⁸⁷ The 95% confidence intervals for the prevalence estimates and logistic regression odds ratios (OR) were also determined.¹⁸⁸ Finally, p-values less than 0.05 were taken to be statistically significant for χ^2 and logistic regression analysis ($\alpha = 0.05$).¹⁸⁹

A flow chart which outlines the full examination procedure is presented in Appendix 1 Figure 2. Also attached is a copy of the two-page data collection proforma instrument used in this study, which was a specially modified version of the WHO Prevention of Blindness standardised proforma Appendix 1 Figure 3.

5.13.2 Outcomes of cataract surgery

The visual acuity of the eyes that had undergone cataract surgery were categorised into the following outcome categories: 'Good' ($\geq 6/18$ or better), 'Borderline' ($\leq 6/18$ to $6/60$) and 'Poor' ($< 6/60$), as per WHO classification for cataract surgical outcomes.¹⁹⁰⁻¹⁹¹ Statistical analysis involved logistical regression of key explanatory variables with cataract surgical outcome such as the type of surgery, visual acuity post-operatively and the socio-demographic variables (age group, sex, rural or urban residence).

5.13.3 Cataract surgical coverage for eyes and for persons

A thorough clinical ophthalmic examination was performed on all 11,624 subjects that participated in the survey (90.9% response rate). Assessment of the orbital crystalline lenses of both eyes in each individual was carried out by direct ophthalmoscopy. Grading of the extent of the obscuration of the lens due to the protein changes involved in cataract formation was undertaken.

Methods

For the purposes of this study, the classification system used for assessing central lens opacification was the Mehra–Minassian cataract grading scheme.¹⁷⁴ This system is based on recording the extent of the area of lens opacity that obscures the red reflex – in response to light being shone through the pupil by the ophthalmoscope – relative to the area of the clear red reflex. The selection of this examination / classification scheme was due to both its documented validity and reliability as assessment method for cataract within similar field conditions to that of Bangladesh.

Grading of the lenticular opacities according to the Mehra–Minassian system was as follows (Table 5.13.1):

Methods

Table 5.13.1. The Mehra – Minassian Lens Opacification Grading System¹⁷⁴

Central lens opacity grading	Criteria
0	Clear red reflex; no opacities.
1	Few small dot opacities in the lens appearing as tiny scattered dark spots in the red reflex. Maximum area occupied by the dots 1 mm ² .
2A	Lens opacity obscuring part of the red reflex. Area obscured is smaller than area of clear red reflex.
2B	Lens opacity obscuring part of the red reflex. Area obscured is equal to or larger than area of clear red reflex.
3	Lens opacity totally obscuring the red reflex.
4	Aphakia or displaced lens.
5	Unable to assess red reflex owing to corneal opacity.

Methods

For the purposes of this study, visually impairing, operable cataracts were defined as those graded '2B' and '3.' As commented, within the context of community eye health service provision, the acuity status of the visually impaired individual is also a key factor when determining the prioritised need and eligibility for cataract surgery.¹⁹²

Estimation of the cataract surgical coverage within a population is derived from community-based blindness prevalence survey data, which in itself is determined by visual acuity status of the subjects examined.¹⁹³⁻¹⁹⁴ The information required for calculating the CSC in this study included the number of persons with operable cataract, in either one or both eyes, and the number of persons who have been operated in either one or both eyes. More specifically, the CSC for persons is determined by the following formula:

Cataract surgical coverage is defined for both individual eyes as well as for persons.¹⁹² Both of these indicators serve to indicate the level to which cataract surgical services have covered the need for cataract surgery within the population.

In the context of this present study, information on the grading of lens opacities was available for all persons who were unable to achieve $\geq 6/12$ in both eyes. In other words, all persons who had $< 6/12$ visual acuity in either or both eyes were assessed for cataract status, as per the Mehra-Minassian lens opacity grading scheme. In total there were 2,518 subjects who were identified as having $< 6/12$ visual acuity uni-ocularly or bilaterally. Additionally, those persons who had undergone cataract surgery in either or both eyes and whose vision was $\geq 6/12$ bilaterally were also taken into account for the purposes of calculating the cataract surgical coverage. Presence of aphakia (absence of ocular lens as a result of cataract surgery) was noted. Likewise, pseudophakia (presence of a synthetic intra-ocular lens following extraction of the natural crystalline lens) was also recorded.

Methods

Formulae for calculating cataract surgical coverage for eyes and for persons

The cataract surgical coverage (CSC) for eyes is defined¹⁹² as follows:

$$\text{CSC for eyes} = \frac{(A)}{(A + B)} * 100\%$$

A = (Pseudo)aphakic eyes
B = Eyes with operable cataract

In related manner the cataract surgical coverage (CSC) for persons is defined¹⁹² as:

$$\text{CSC for persons} = \frac{(X + Y)}{(X + Y + Z)} * 100\%$$

X = Persons with unilateral (pseudo)aphakia and operable cataract in the other eye
Y = Persons with bilateral (pseudo)aphakia
Z = Persons with bilateral operable cataract

For the purposes of determining the cataract surgical coverage, operable cataract is defined as a lens opacity of grade 2B or 3, according to the Mehra-Minassian classification scheme. Given that the study subjects who were (pseudo)aphakic had already undergone surgery it was not possible to determine what had been their pre-surgical visual acuity. In practice, cataract surgery can be performed on persons although the person may not be totally blind, i.e. <3/60. As such cataract surgical coverage indices need to be calculated at the levels of visual acuity corresponding to blindness (<3/60), severe visual impairment (<6/60) and moderate visual impairment (<6/18). It merits pointing out that visual acuity <6/60 contains those eyes <3/60 as well as eyes $\geq 3/60$ to <6/60. Similarly, the <6/18 VA category comprises visual acuity categories <3/60 and <6/60 in addition to eyes with VA $\geq 6/60$ to <6/18.

5.13.4 Barriers to uptake of cataract surgery

As described in Section 5.13.4, each subject with <6/12 vision in either (or both) eyes underwent a lens opacity assessment, according to the Mehra - Minassian central lens opacity grading system.¹⁷⁴ This cataract classification system consists of six categories based on obscuration of the red reflex of an un-dilated normal pupil due to the presence of a lens opacity, as assessed using direct ophthalmoscopy. Those subjects who had an advanced, potentially visually-impairing lens opacity corresponding to grades 2B or 3, were interviewed by the ophthalmologist in order to ascertain why the subject had not sought medical care for her/his visual condition. The principal reason provided by the subject was thus recorded on the survey proforma. The responses were then reviewed by the project epidemiologist (the author of this dissertation) and subsequently grouped accordingly.

For the purposes of analysis, three subject sub-groups were developed concerning cataract surgical up-take, as follows: a) those who had a 2B or 3 lens opacity but, prior to this survey, had never been assessed by any medical or ophthalmic personnel for their visual impairment; these subjects reported a barrier to up-take of cataract surgery; b) those individuals who indicated that they had already undergone a medical consultation with either a general practitioner or ophthalmologist for their ocular condition but had not yet undergone cataract surgery; c) those who had been operated upon for cataract in either or both eyes.

The statistical analyses undertaken consisted of:

- * the socio-demographic characteristics of all three sub-groups.
- * univariate analysis of the barriers to cataract surgery in subjects who had not been assessed medically for their visual impairment.
- * univariate logistic regression analysis comparing subjects who had not been operated upon for cataract with those who had already undergone surgery. The explanatory variables assessed via cross-tabulations (χ^2 and t-test analyses) were: sex, rural / urban residence, literacy status, school attendance,

Methods

level of education achieved, type of employment, if any, and age of the subject.

* a multi-variable logistic regression model, based on the explanatory variables that were statistically significant as per univariate analyses, in order to determine those factors associated with surgery up-take when controlling for the other variables in the model.¹⁸²⁻¹⁸³

5.13.5 Refractive errors and spectacle coverage

Spherical refractive error is defined as the spherical equivalent, which equals the sphere power plus half the cylinder power.¹⁶⁴ Direct standardisation¹⁹⁵⁻¹⁹⁶ of the prevalence results by age and gender against a reference population involved national census data from the Bangladesh Bureau of Statistics (BBS).¹⁵⁶ Statistical analysis was performed using right eyes only,¹⁹⁷ in keeping with methodology used in similar refractive error studies. For the analysis of right eyes, data from those that had no refractive error recorded or who had undergone cataract surgery were excluded. Univariate analysis was performed with logistical regression of key variables with refractive errors (myopia, hypermetropia), such as age, gender, literacy, education, occupation, and residence (urban or rural). Multi-variable logistic regression was undertaken to analyse those variables associated with refractive errors when controlling for other variables in the model.

Spectacle coverage¹⁹⁸ was calculated, as below:

$$\text{Spectacle coverage (\%)} = \frac{\text{Met need for spectacles}}{\text{Total need for spectacles}} * 100\%$$

where Total need = Met need + Unmet need.

‘Met need’ corresponds to the number of subjects who wore distance spectacles and had visual acuity less than 6/12 in the better eye without correction, but who achieved 6/12 or better in the better eye with their present distance spectacles. ‘Unmet need’ was defined as the number of subjects who did not wear spectacles and who had acuity less than 6/12 in the better eye

without correction, but who could achieve 6/12 or better in the better eye with correction.

5.13.6 Low vision and the need for rehabilitation

Descriptive statistics (frequencies, percentages) and uni-variate analysis (χ^2 and t-test) as well as a binary logistic regression model analysis were undertaken on this sub-set of cases who had functional low vision.

6.0 Results

6.1 Overview of the Results Chapter

In this section of the dissertation, a comprehensive set of population-based findings dealing with the visual status, including the level of blindness and low vision in Bangladeshi adults, will be presented. These results are based directly on the ophthalmic examinations that were conducted on the study subjects. Likewise, the demographic profile of the participants (eg age, gender, literacy and socio-economic status) are presented and analysed in relation to the clinical findings. Further analysis identifies the barriers to up-take of cataract surgical services as perceived by the study subjects themselves, amongst other vision-related factors and outcomes.

Each sub-section within this chapter relates to one of the specific objectives of the dissertation, as outlined previously. This structured approach to this chapter is intended to elucidate particular survey findings as well as develop a comprehensive epidemiological profile for blindness and low vision amongst Bangladeshi adults. The topics of said profile to be presented are:

- * prevalence and causes of blindness and visual impairment
- * cataract surgical outcomes amongst those subjects who had undergone surgery prior to the survey
- * cataract surgical coverage and cataract surgical rate results
- * barriers to up-take of cataract surgical services
- * prevalence of refractive error and the level of unmet need for refractive error services (ie spectacle coverage rate)
- * level of need for low vision rehabilitation services

6.2 Prevalence and causes of blindness and visual impairment

The seminal, peer-reviewed scientific paper relating to this nationwide research study is the article cited below. In this sub-section of the dissertation, the major findings – prevalence of blindness and low vision as well as the causes responsible for visual impairment in Bangladeshi adults – are presented.

Dineen BP, Bourne RR, Ali SM, Huq DM, Johnson GJ. Prevalence and causes of blindness and visual impairment in Bangladeshi adults: results of the National Blindness and Low Vision Survey of Bangladesh. *Br J Ophthalmol.* 2003;87(7):820-8.

Results

Demographics

A total of 12,782 eligible adults 30 years of age and older were enumerated, of which 11,624 subjects were examined (90.9% response rate). There were 9,371 (90.9%) and 2,253 (91.0%) subjects examined within the rural and urban clusters, respectively. In gender terms, the overall response rate for being examined was higher for women (94.65%) than that for men (87.37%) in the study. Stratified analysis according to 10-year age groups identified that there were substantially more males ($P < 0.001$) that did not participate in the survey as compared with females, especially amongst individuals of ages ranging from 30 to 59 years. Upon analysing the reasons identified for non-participation in the survey – as provided by family members or neighbours of the non-respondents – it was found that ‘working at the time of the examination’ was the principal reason reported for males not being examined. This was most especially the case amongst males of ages 30 to 59 years, which corresponds to being economically active in Bangladesh. There was no difference however in the proportions of male and female non-responders amongst older subjects, i.e. aged 60 and above, which typically relates to a status of economical dependency rather than being in active employment in Bangladesh. No statistically significant difference was found in the proportion of responders and non-responders across the six administrative Divisions of Bangladesh or according to rural versus urban residence of the subject.

Results

Table 6.2.1. Distribution of examined subjects, by 10-year age groups, according to presenting visual acuity status, \geq or $<$ 6/12 in the better eye (n = 11,624).

Age	Number of subjects examined (%)			
	Females		Males	
	$\geq 6/12$	$< 6/12$	$\geq 6/12$	$< 6/12$
30 – 39 years	2,563 (95.7)	115 (4.3)	2,080 (95.6)	95 (4.4)
40 – 49 years	1,260 (86.3)	200 (13.7)	1,374 (90.5)	144 (9.5)
50 – 59 years	511 (60.0)	340 (40.0)	628 (73.5)	226 (26.5)
60 – 69 years	212 (35.1)	392 (64.9)	338 (49.6)	343 (50.4)
70 + years	51 (14.7)	295 (85.3)	89 (19.5)	368 (80.5)
Total	4,597 (77.4)	1,342 (22.6)	4,509 (79.3)	1,176 (20.7)

Distribution of examined subjects into two broad visual acuity groups ($\geq 6/12$ and $< 6/12$), according to gender and by 10-year age groups is presented in Table 6.2.1. Analysis of the relative proportions of females and males having $\geq 6/12$ or $< 6/12$ VA in the better eye according to the age bands indicates that there was a significant difference ($\chi^2 = 105.6$; $P < 0.0001$) between genders. This difference demonstrates that with increasing age, there is a higher proportion of females that are visually impaired (VA $< 6/12$) when compared with males in the same 10-year age groups.

Presenting and Corrected Visual Acuity

A large majority of the examined subjects (9,854 persons / 84.77%) had a presenting visual acuity of $\geq 6/12$ (logMAR < 0.3) in the better eye. Of these, however, there were 748 subjects who had $< 6/12$ vision in the fellow eye. A further 1,770 (15.23%) persons had $< 6/12$ vision bilaterally. In total, therefore, there were 2,518 subjects (21.66%, 95% CI 20.9%–22.4%) who had a presenting visual acuity of less than 6/12 in either one or both eyes. As described above, these individuals underwent a more comprehensive ocular examination that involved cataract grading and a dilated posterior segment

Results

examination, in order to identify the cause of low vision or blindness for these subjects. The distribution of all examined subjects by presenting and corrected visual acuity categories in the better eye is shown below (Table 6.2.2).

Results

Table 6.2.2. Distribution of subjects according to presenting and corrected visual acuities in the better eye with age-sex standardised prevalences based on presenting visual acuity (n = 11,624).

Visual Acuity	Snellen Equivalent (logMAR)	Presenting Vision n (%) (95% CI)	Corrected Vision n (%) (95% CI)	Age-sex standardised prevalence* (95% CI)
Normal	≥6/12 (<0.30)	9,854 (84.77) (83.80% – 85.75%)	10,759 (92.56) (91.88% – 93.23%)	83.57 (82.89% – 84.25%)
‘Near Normal’	<6/12 to ≥6/18 (≥0.30 to <0.50)	704 (6.06) (5.52% – 6.60%)	329 (2.83) (2.47% – 3.20%)	6.46 (6.02% – 6.91%)
Moderate Visual Impairment	<6/18 to ≥6/60 (≥0.50 to <1.00)	849 (7.30) (6.72% – 7.89%)	385 (3.31) (2.89% – 3.74%)	7.92 (7.43% – 8.41%)
Severe Visual Impairment	<6/60 to ≥3/60 (≥1.00 to <1.30)	55 (0.47) (0.33% – 0.61%)	26 (0.22) (0.14% – 0.31%)	0.52 (0.39% – 0.65%)
Blind	<3/60 (≥1.30)	162 (1.39) (1.17% – 1.62%)	125 (1.08) (0.86% – 1.29%)	1.53 (1.31% – 1.75%)
Total	-	11,624 / 100.0	11,624 / 100.0	11,624 / 100.0

Note: * Age-sex standardised prevalence based on presenting vision results.

Results

A total of 162 subjects were found to be bilaterally blind on presentation ($<3/60$; >1.3 logMAR) in the study sample. This corresponds to a crude blindness prevalence of 1.39% (95% CI 1.17% – 1.62%, design effect = 2.2), while the age-sex standardised blindness prevalence was determined to be 1.53% (95% CI 1.31% – 1.75%) in persons over the age of 30 years, based on the most recent official population estimates available for Bangladesh¹⁴. In those aged 50 years and older the prevalence of blindness was 3.95%.

In relation to other grades of visual loss within the sample, 55 persons (0.47%, 95% CI 0.33% – 0.61%) had severe visual impairment upon presentation ($<6/60$ to $\geq 3/60$) in the better eye, and 849 subjects (7.30%, 95% CI 6.72% – 7.89%) who had moderate visual impairment ($<6/18$ to $\geq 6/60$). Finally a total of 704 persons (6.06%, 95% CI 5.52% – 6.60%) had ‘near normal’ presenting visual acuity ($<6/12$ to $\geq 6/18$) in the better eye.

Following trial lens correction based on the objective, auto-refractometer result, these values for blindness, severe visual impairment, moderate visual impairment and near normal vision changed, indicating a notable shift towards improvement in visual acuity status. These new figures became 125 (1.08%, 95% CI 0.86% – 1.29%), 26 (0.22%, 95% CI 0.14% – 0.31%), 385 (3.31%, 2.89% – 3.74%), 329 (2.83%, 95% CI 2.47% – 3.20%), respectively. The sub-total of 9,854 subjects (84.77%, 95% CI 83.80% – 85.75%) with a presenting visual acuity of $\geq 6/12$ in either one or both eyes, became 10,759 (92.56%, 95% CI 91.88% – 93.23%) with correction. The crude and age-sex standardised prevalence results for presenting and corrected visual acuities are presented in Table 6.2.2, as are age-sex standardised prevalence values based on presenting VA. By combining the blindness and severe visual impairment categories, the age-sex standardised prevalence for having a presenting visual acuity $<6/60$ in the better eye was 2.05% (95% CI 1.79% – 2.31%), while the age-sex standardised prevalence for vision $<6/12$ in the better eye was 16.43% (95% CI 15.76% – 17.10%).

Unilateral blindness

In addition to the 162 binocularly blind persons, there were a further 313 subjects who were found to be unilaterally blind; this corresponds to a

Results

unilateral blindness prevalence of 2.69% (95% CI 2.39% – 2.98%). The majority of those subjects found to be uni-ocularly blind (61.0%) had less than 6/12 vision in the other eye. The major causes of blindness in the affected eye was cataract (62.24%), central corneal opacity (9.18%) and phthisical/disorganised or absent globe (6.12%).

Visual Acuity and Age

Figure 6.2.1 illustrates the distribution of presenting visual acuity status according to age of the subject, in 10-year age groups. The proportion of subjects with normal vision ($\geq 6/12$) reduced significantly with increasing age. Overall this chi-square for trend analysis across the five visual acuity categories, by age, was found to be statistically significant ($\chi^2 = 3883.9$; $P < 0.00001$). Moreover, there was a marked exponential increase in blindness prevalence according to increased age of the subject (Figure 6.2.2), culminating with a prevalence of 11.46% in persons 70 years of age and older. Subjects who were bilaterally blind were statistically significantly older than those not blind, 69.1 versus 44.8 years (t-value = 23.4; 95% CI of the mean difference 22.3 – 26.3 years).

Results

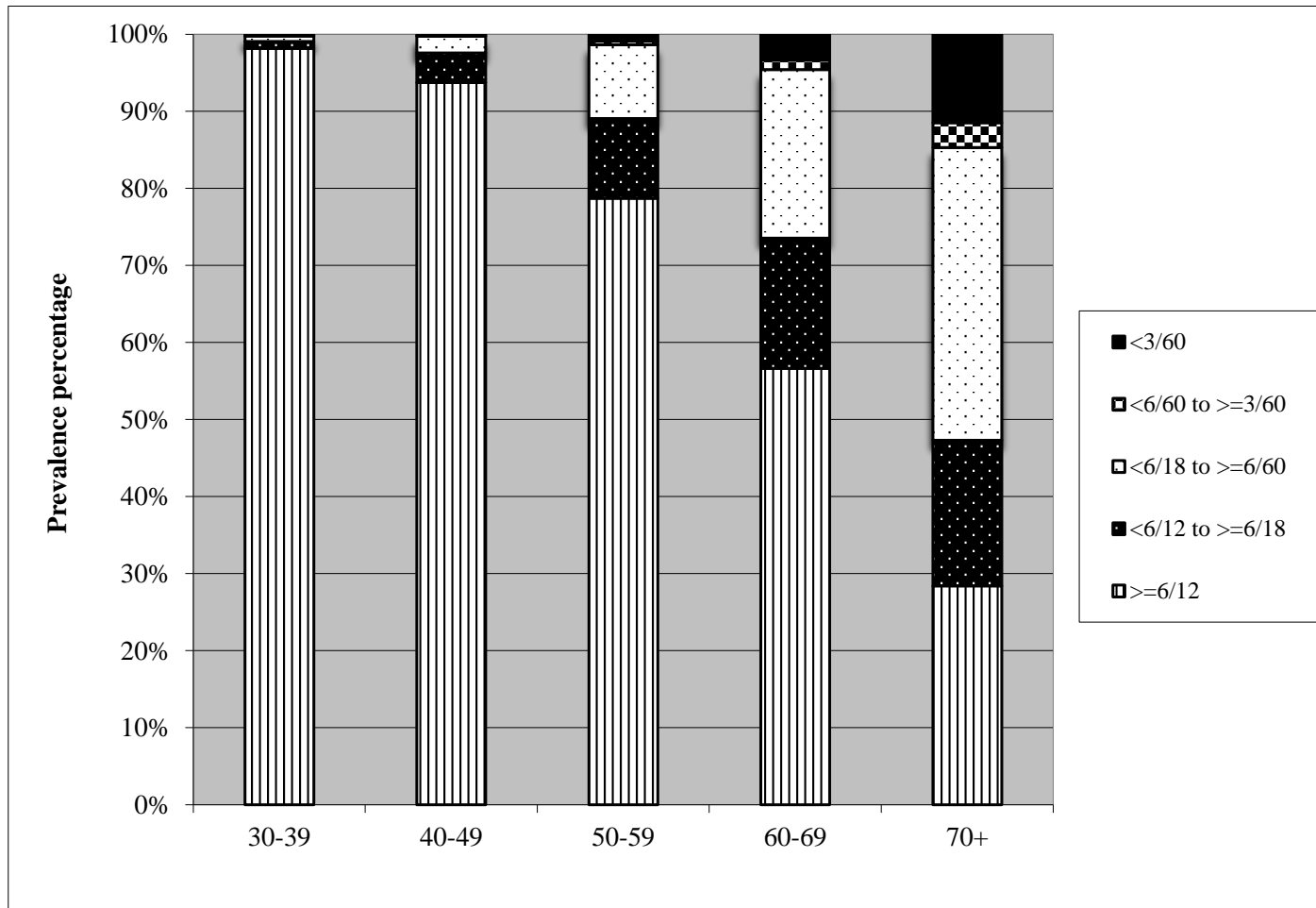


Figure 6.2.1. Distribution of presenting visual acuity categories across ten-year age groups (n= 11,624).

Results

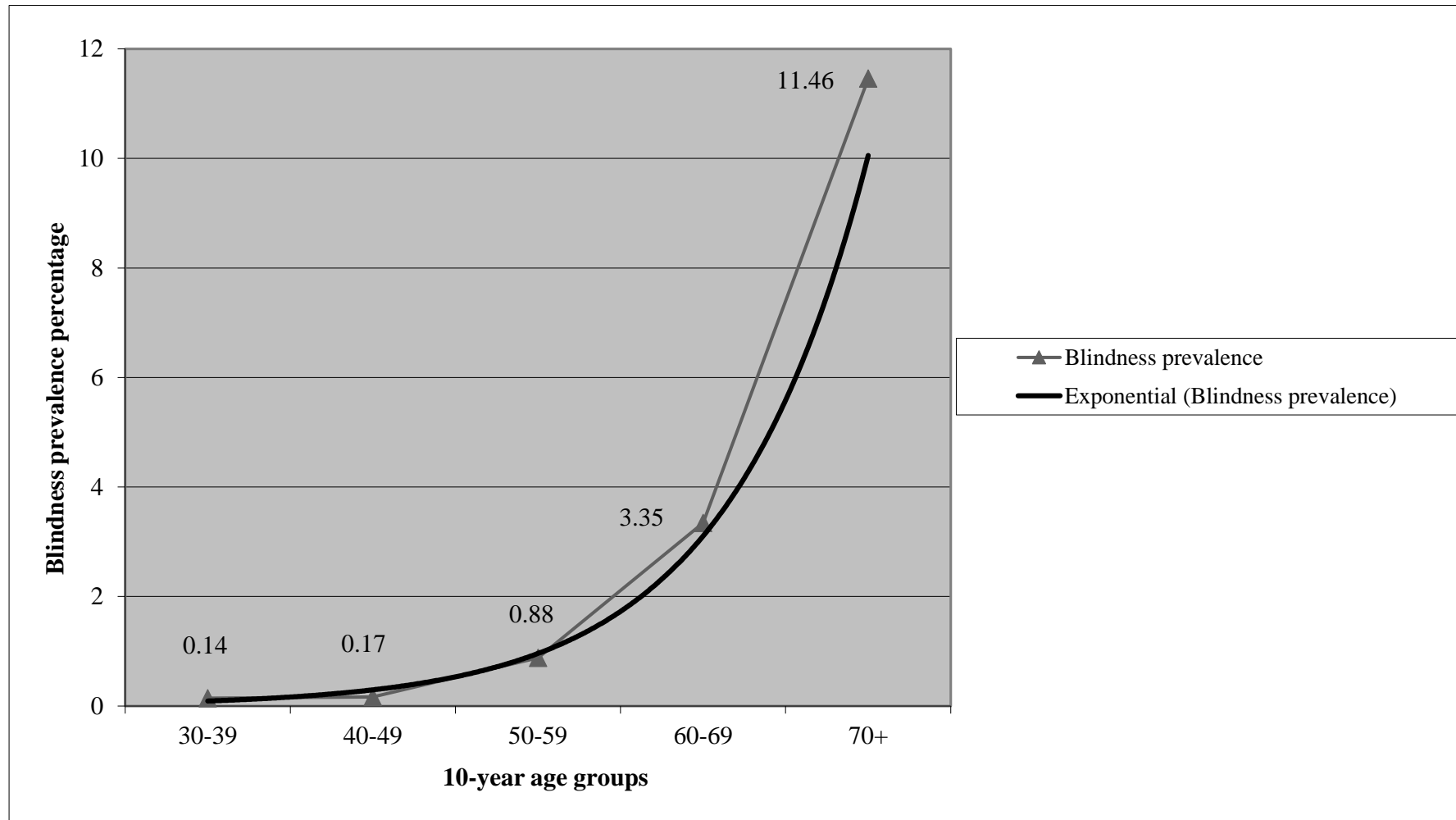


Figure 6.2.2. Linear and exponential trends of blindness prevalence according to 10-year age groups.

Results

Visual Acuity and Rural / Urban residence

There was a significant difference in terms of rural versus urban residence regarding presenting visual acuity, with a higher proportion of rural dwellers being less than 6/12 when compared with urban residents. ($\chi^2=37.2$; $P<0.0001$; OR=1.55; 95% CI OR 1.38–1.79). However, there was no statistically significant difference ($\chi^2=0.78$; $P=0.38$; OR=1.21; 95% CI OR 0.79–1.83) among those of rural or urban residence in relation to the proportion of blind subjects living in each area.

Visual Acuity and Gender

There was a marked difference between women and men as regards presenting visual acuity in that there was a higher prevalence of blindness for women (1.72%) in comparison with men (1.06%). This difference was statistically highly significant ($\chi^2=9.3$; $P=0.002$; OR=1.64; 95% CI OR 1.19–2.26) as was the difference in the proportion of women with <6/18 vision in the better eye when compared to males ($\chi^2=6.1$; $P=0.014$; OR=1.17; 95% CI OR 1.03–1.33).

Visual Acuity and Administrative Division

In terms of the geographic and administrative regions within Bangladesh, higher blindness prevalences were found to exist in the Divisions of Barisal (2.28%; 95% CI 1.24 – 3.32%) and Khulna (1.97%; 95% CI 1.28% – 2.69%) located in the south and western areas of the country when compared with the remaining four Divisions. Most notable was the relatively low blindness prevalence in Dhaka Division (1.13%; 95% CI 0.80% – 1.46%), the largest and most urbanised of the six Divisions of Bangladesh.

Visual Acuity, Literacy and Occupation

Occupational status was classified into three major categories: manual, non-manual and inactive/unemployed. The prevalence of visual impairment (36.5%; 95% CI 32.5% – 40.6%) among those who were occupationally inactive, i.e. either unemployed or retired, was significantly higher ($\chi^2=673.4$; $P<0.0001$; OR=8.54; 95% CI OR 7.01–10.2) when compared with manual and non-manual employees combined (6.4%; 95% CI 5.9% – 6.8%). Likewise, the prevalence of blindness (18.4%; 95% CI 14.9% – 22.6%) in

Results

those who were unemployed or retired was significantly higher ($\chi^2=1839.1$; $P<0.00001$; OR=1148.5; 95% CI OR 281.3–4689.6) than that of manual and non-manual employees combined (0.02%; 95% CI 0.002% – 0.07%).

Similarly, there was a higher proportion of manual workers (8.6%, 95% CI 7.8% – 9.4%) whose VA was $<6/12$ in the better eye when compared with non-manual workers (3.2%, 95% CI 1.6% – 5.8%). As such, the type of work undertaken by employed male subjects was associated with a statistically significant difference in visual impairment status ($\chi^2=11.1$; $P<0.001$; OR=2.83; 95% CI OR 1.49–5.35).

Literacy status was found to be statistically significantly associated with visual acuity in the BNBLVS. The odds of being visually impaired (ie VA $<6/12$) were nearly three times greater among illiterate subjects when compared with those able to read, both in terms of low vision ($\chi^2=322.2$; $P<0.0001$; OR=3.49; 95% CI OR 3.02–4.03) and approximately six times higher in terms of being blind ($\chi^2=84.4$; $P<0.0001$; OR=5.88; 95% CI OR 3.83–9.02).

A backward, stepwise binary logistic regression model with blindness status as the dependent variable was developed, using age, sex, administrative Division, literacy and employment status as predictors. The results (Table 6.2.3) indicate that sex, literacy status and age were independent risk factors for being blind, while holding constant the other variables in the model, as follows:

- * females had 1.5 times greater odds of being blind compared to males,
- * being illiterate trebled the odds of being blind compared to those who could read and write, and
- * the odds of being blind increased by 7% with each additional year of age.

Results

Table 6.2.3. Binary logistic regression model results for socio-demographic predictor variables for blindness.

Variable	β	Wald χ^2	P-value	Odds Ratio	OR (95% CI)
Age	0.07	116.649	<0.0001	1.07	1.06 – 1.09
Sex – Female*	0.458	6.137	0.013	1.58	1.10 – 2.27
Literacy status – illiterate*	1.158	17.476	0.000029	3.18	1.85 – 5.48

Note: * Female sex was coded as '1' whilst illiteracy was coded as '2' in the model.

Results

Causes of Low Vision and Blindness

As described previously, the ophthalmologists recorded each ocular disorder that was diagnosed in eyes with $<6/12$ visual acuity. In total there were 4,288 visually impaired eyes; this figure represents 18.44% of all the eyes examined, corresponding to 21.88% of the 11,624 examined subjects. Table 6.2.4 provides a breakdown of the lens opacity grading for all $<6/12$ eyes, indicating that more than two-thirds (68.59%) of eyes were graded '2A', '2B' or '3', while only approximately one quarter (25.28%) either had no cataract (Grade '0') or minimal lens opacity present (Grade '1').

Table 6.2.4. Distribution of all lens opacities in eyes with $<6/12$ visual acuity.

Lens opacities	n	%
* Grades '0' or '1'	1,084	25.28
* Grades '2A', '2B' or '3'	2,941	68.59
* Grades '4', '5' and Other (e.g. phthisical globe)	263	6.13

Table 6.2.5 outlines in further detail the diverse mix of *all* ocular disorders, including lens opacities, that were diagnosed in eyes with $<6/12$ vision. The percentages for this table are calculated on the basis of the 4,288 total eyes. Principal among the disorders is that of refractive error for which approximately 80% of all subjects examined with $<6/12$ VA were found to have a spherical equivalent ≥ 0.5 SE or, alternatively, ≤ -0.5 SE.

A sub-analysis of those subjects with refractive error was conducted in which the lens opacity grading was taken into account in order to determine the level of refractive error in eyes with non-existent (Grade '0') or minimal cataract (Grade '1'). Overall 13.46% of visually impaired eyes, without significant lens opacity, were slightly hypermetropic (SE $\geq +0.5$ to $< +5.0$) whereas mild myopia (SE ≤ -0.5 to > -5.0) was less common (7.53%) in visually impaired eyes. Infrequently reported as well were high hypermetropia (0.46%) and high (0.40%) and extreme myopia (0.21%) in eyes with minimal or non-existent lens opacity. The remainder of Table 6.2.5 indicates the extent to which other disorders were diagnosed in $<6/12$ eyes.

Results

Table 6.2.5. Distribution of all ocular disorders in eyes with <6/12 visual acuity.

Disorder	n	%
Refractive error [⊗] (irrespective of lens opacity grading status)	3,429	79.97
Refractive Error in subjects with lens opacity grading of '0' or '1'	597	13.92
* Low hyper-metropia (SE ≥+0.5 to <+5.0)	577	13.46
* High hyper-metropia (SE ≥+5.00 to <+10.0)	20	0.46
* Extreme hyper-metropia (SE ≥+10.0)	0	0.00
Refractive Error in subjects with lens opacity grading of '0' or '1'	349	8.14
* Low myopia (SE ≤-0.5 to >-5.0)	323	7.53
* High myopia (SE ≤-5.00 to >-10.0)	17	0.40
* Extreme myopia (SE ≤-10.0)	9	0.21
Lens opacities (grades '2A', '2B', '3', '4' and '5')	3,204	74.72
Age-related macular degeneration (ARMD)	516	12.03
Others / miscellaneous, eg Stargardt's disease	177	4.13
Corneal opacity	96	2.24
Glaucoma	70	1.63
Uncorrected aphakia	56	1.31
Pterygium	38	0.89
Optic atrophy	36	0.84
Phthisis	33	0.77
Squint	32	0.75
Chorioretinitis	29	0.68
Diabetic retinopathy	27	0.63
Vitreous opacity	26	0.61
Total	8,789	100.0

Note: [⊗] Spherical equivalent ≥0.5 or ≤-0.5.

Note: [∞] Refraction was not possible in 11 subjects with Grades '0' or '1' lens opacities.

Results

As shown in Table 6.2.6, the main cause of <6/12 presenting visual acuity for subjects was cataract (73.39%), followed by refractive error (18.87%) and uncorrected aphakia (1.19%). In relation to the causes of bilateral blindness, cataract was also the principal disorder, having been identified for 129 of the 162 blind subjects (79.63%) followed by uncorrected aphakia in 10 subjects (6.17%), as shown in Figure 6.2.3. The lens opacity grading in 127 of 129 (98.45%) subjects blind due to cataract were either of grades '2B' or '3', indicating a tendency towards the development of untreated, hypermature opacities. The remaining two bilaterally blind cases had lens opacities that were graded '2A'. The average age of those blind due to cataract was 71.02 years (SD = 12.74) while the mean age in the other 33 bilaterally blind persons was 61.76 years (SD = 15.64); this difference was statistically significant ($P < 0.0005$; $t = 3.55$; 95% CI of the mean difference 4.1 – 14.4 years). Macular degeneration was the third most common cause of blindness, with the mean age for the five subjects with blinding macular disease of 72.60 years (SD = 7.99).

Results

Table 6.2.6. Distribution of the main cause of visual impairment in persons with <math><6/12</math> presenting VA in the better eye (n=1,770).

Disorder	n	%
Cataract	1,299	73.39
Refractive error	334	18.87
Macular degeneration	33	1.86
Uncorrected aphakia	21	1.19
Central Corneal Opacity	15	0.85
Other posterior segment disease	15	0.85
Glaucoma	13	0.73
Other (including 'Incomplete examination')	11	0.62
Optic atrophy	9	0.51
Phthisical eye	8	0.45
Chorioretinitis	6	0.34
Diabetic retinopathy	3	0.17
Pterygium	3	0.17
Total	1,770	100.00

Combined pathologies in eyes with <math><6/12</math> visual acuity was a common finding, as indicated in Table 6.2.7. The most frequently identified combinations were those of refractive error with cataract, refractive error with ARMD and cataract with ARMD.

Results

Table 6.2.7. Principal combinations of ocular disorders in eyes with visual acuity <6/12 (n = 3,167).

Disorder	Cataract	Refractive Error	ARMD	Corneal opacity	Glaucoma	Cataract and Glaucoma
	Cataract	2,243 [⊗]	369	32	48	NA
		Refractive Error	385	23	24	21
			ARMD	1	4	3
				Corneal opacity	10	4
					Glaucoma	NA
						Cataract and Glaucoma

Note: [⊗] denotes a refractive error as defined by a spherical equivalent ≥ 0.5 or ≤ -0.5 , in the presence of a lens opacity of grades 2A, 2B or 3.

Results

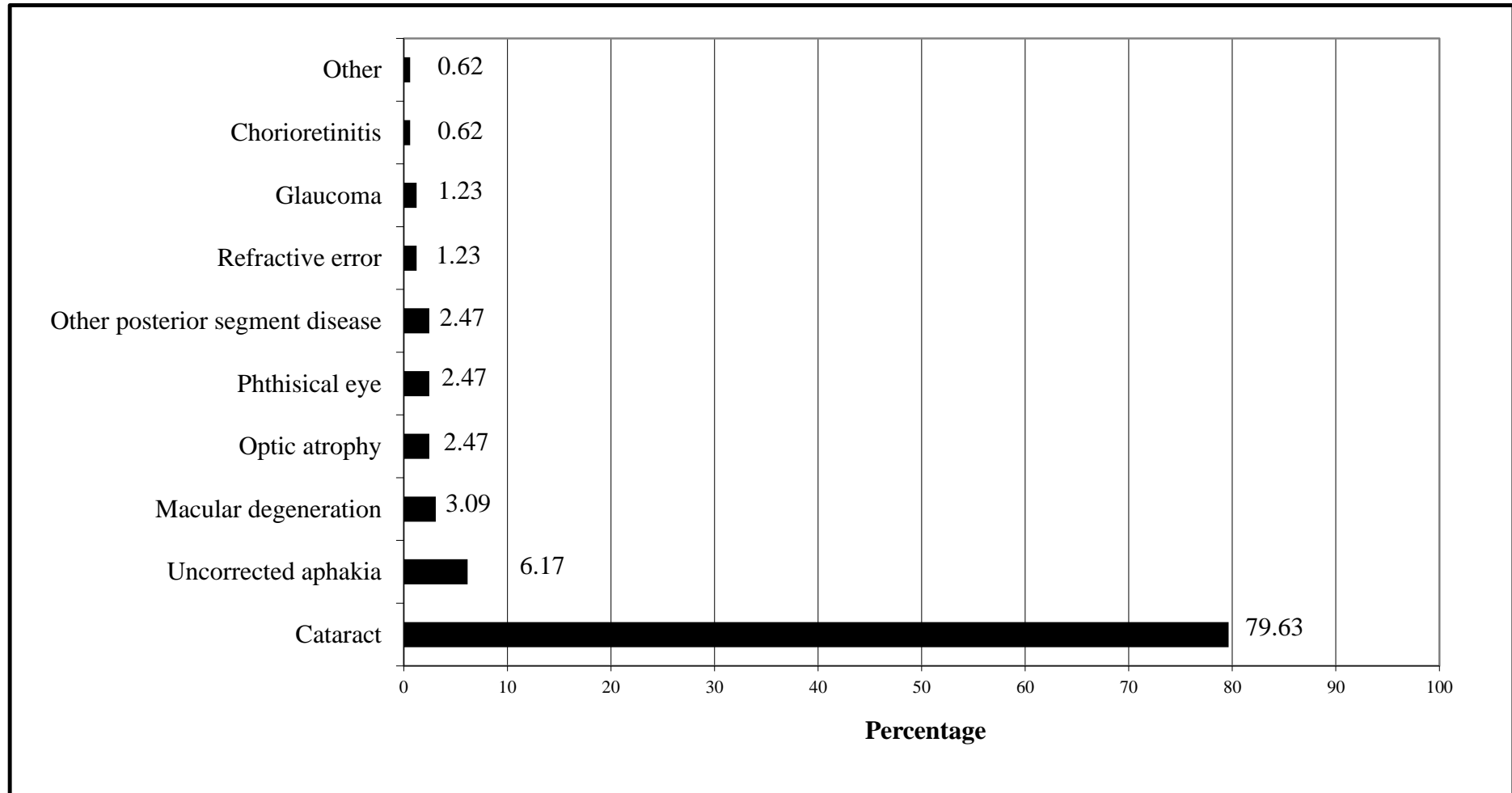


Figure 6.2.3. Main cause of blindness for persons with visual acuity <3/60 in the better eye.

Results

In relation to glaucoma, CDR and IOP were measured on specific individuals according to the examination process.

During the course of the survey normative IOP data were collected on 242 randomly selected subjects, as measured with the Schiotz tonometer. Based on this population-based distribution of intraocular pressure, the 95%, 97.5%, 99% and 99.5% percentile cut-offs were: 18.9 mmHg, 20.6, 29.3, and 31.9 mmHg respectively (Figure 6.2.4).

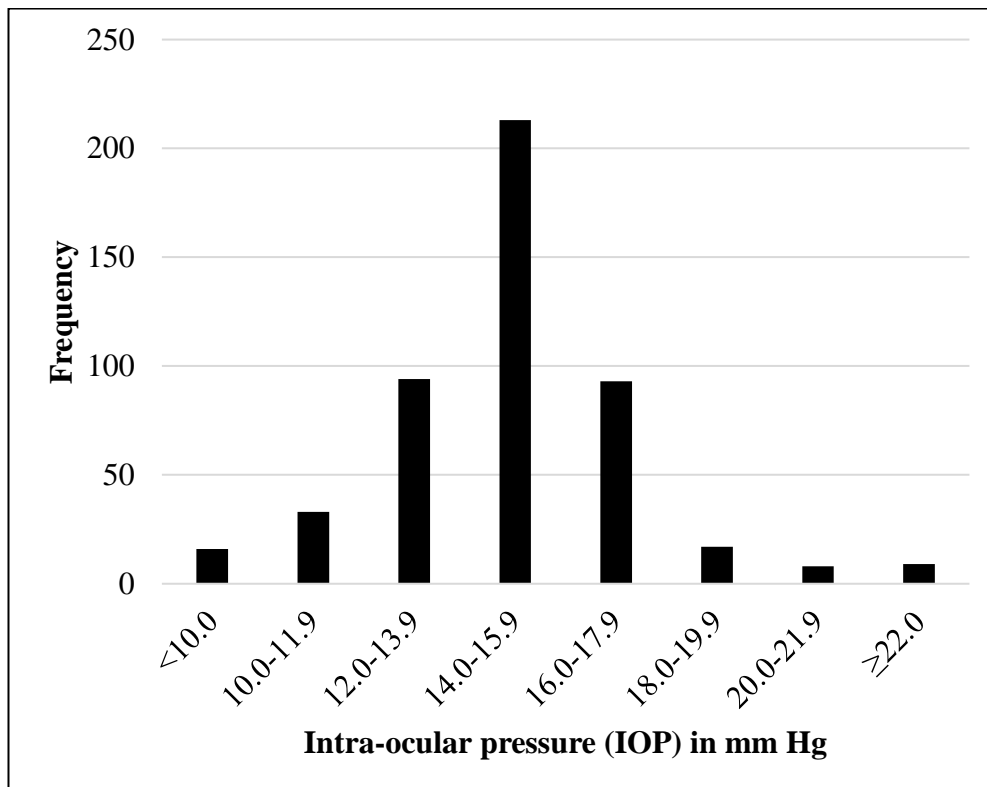


Figure 6.2.4. Distribution of normative intra-ocular pressure measurements (n = 483).

Of the 13 persons identified with glaucoma as the main cause of <6/12 presenting vision in the better eye, the findings in each eye were recorded according to the defined categories of ‘glaucoma’, as shown below (Table 6.2.8). The more ‘glaucomatous’ category of each of the eyes is chosen as that for the individual.

Results

Table 6.2.8. Distribution of cases of glaucoma in subjects with <6/12 visual acuity.

Category	Definition	Number of subjects
1	$CDR \geq 0.7$ & $IOP \geq 97.5\%ile$	5
2	$CDR \geq 0.7$; $IOP < 97.5\%ile$	1
3	Disc obscured; $IOP > 99.5\%ile$	5
4	$CDR < 0.7$; $IOP \geq 97.5\%ile$	0
5	Disc obscured; $IOP \geq 97.5\%ile$	2
Total	-	13

6.3 Cataract surgical outcomes in Bangladeshi adults

Despite relatively very few study subjects having undergone cataract surgery prior to the BNBLVS, assessment of the visual outcomes in those who had been operated upon formed an important element of this survey. In this subsection of the dissertation, the essential details presented concerning the visual outcomes of cataract surgery were published in the peer-reviewed scientific article cited below.

Bourne RR, Dineen BP, Ali SM, Huq DM, Johnson GJ. Outcomes of cataract surgery in Bangladesh: results from a population based nationwide survey. *Br J Ophthalmol.* 2003;87(7):813-9.

Results

Cataract surgical outcomes

During the course of the visual examinations of each study subject, 162 were identified as having undergone cataract surgery in one or both eyes. Assessment of the visual acuity indicated that those who had undergone an intra-capsular cataract extraction (ICCE) had worse visual outcomes than those who had been operated on with the extra-capsular cataract extraction with placement of an intra-ocular lens (ECCE with IOL). The presenting and best corrected visual acuity results for the two groups are shown in Table 6.3.1. Notably, nearly one-third (31.2%) of post-ICCE eyes had presenting visual acuity $<6/60$ whereas three-quarters (77.3%) of the ECCE with IOL group had vision $\geq 6/18$. With refractive correction, the ICCE-operated eyes improved favourably whereby the proportion of 'Poor' outcomes was reduced significantly, to 14.6%. Refractive correction was also beneficial to the ECCE with IOL group in that the best corrected visual acuity proportion increased to over 90% when re-tested. Loss of aphakic spectacles amongst the ICCE group, lack of having an IOL implanted, poor surgical technique, post-surgical infection (endophthalmitis),¹⁹⁹⁻²⁰⁰ and development of concomitant posterior segment disease over time since the surgery occurred are potential reasons for the less than optimal cataract surgical outcomes in this survey.

Results

Table 6.3.1. Cataract surgical outcomes in eyes, by surgical technique (n = 221)

	Presenting Visual Acuity			Best corrected Visual Acuity		
	Good ($\geq 6/18$) n (%)	Borderline ($<6/18 - \geq 6/60$) n (%)	Poor ($<6/60$) n (%)	Good ($\geq 6/18$) n (%)	Borderline ($<6/18 - \geq 6/60$) n (%)	Poor ($<6/60$) n (%)
ICCE	81 (40.7)	56 (28.1)	62 (31.2)	122 (61.3)	48 (24.1)	29 (14.6)
ECCE with IOL	17 (77.3)	5 (22.7)	0 (0.0)	20 (90.9)	2 (9.1)	0 (0.0)

6.4 Cataract surgical coverage for eyes and persons in Bangladeshi adults

The purpose of this Results section is to quantify the cataract surgical coverage for both eyes and persons in Bangladesh, according to: place of residence (by administrative Division and by rural or urban setting), gender, age group and literacy status.

In Table 6.4.1, results are presented for the total number of eyes examined (23,248), by administrative Division. In total, 2518 subjects were visually impaired (presenting vision $<6/12$) in either one or both eyes (ie the ‘Red cards’). All of these subjects were assessed for lens opacity and/or evidence of having undergone cataract surgery, i.e. aphakia or pseudophakia. Amongst this group of visually impaired subjects, 1,283 right eyes and 1,303 left eyes had visually impairing cataract of grades 2B or 3, thus yielding 2,586 eyes with advanced cataract.

In total, 1,146 subjects were found to have bilateral operable cataract while a further 294 subjects had unilateral lens opacity of grades 2B or 3. Therefore, 1,440 subjects (57.2%) of those with vision $<6/12$ in either or both eyes had advanced, operable cataract. The results are shown for the total number of eyes examined and for those with lens opacity 2B / 3, across the six administrative Divisions of Bangladesh (Table 6.4.1). Approximately one in ten eyes (ranging from 9.62% to 11.98%) was found to have an operable cataract, both nationally and across the six Divisions of the country.

Results

Table 6.4.1. Distribution of the total number of eyes examined and those with operable cataract, by Division (n = 23,248).

Division	Number of eyes examined	Eyes with lens opacity 2B or 3	
	N	n (%)	95% CI
Barisal	1,580	152 (9.62)	8.44 – 11.21
Chittagong	4,172	444 (10.64)	9.87 – 11.63
Dhaka	7,804	842 (10.79)	10.22 – 11.50
Khulna	2,846	331 (11.67)	10.69 – 12.92
Rajshahi	5,476	656 (11.98)	11.27 – 12.88
Sylhet	1,370	161 (11.75)	10.36 – 13.60
Total	23,248	2,586 (11.13)	10.79 – 11.54

The total number of eyes examined in the study were 23,428 of which 2,586 (11.1%; 95% CI 10.79% – 11.54%) were found to have a lens opacity of grade 2B or 3. The number of eyes and those with 2B or 3 lens opacities are presented according to Division, gender and age groups.

By gender, no significant difference existed between the percentages of all females (11.2%) and all males (11.1%) in terms of having operable cataract eyes. Likewise, amongst those persons with vision <6/12 in the better eye there was no difference in the proportions of females (44.4%) and males (46.8%) that had bilateral operable cataract ($\chi^2=1.32$; $P=0.25$; OR = 0.91, 95% CI 0.78 – 1.07). However, it was noted that proportionally more males (13.4%) than females (10.1%) had unilateral operable cataract ($\chi^2=6.55$; $P=0.01$; OR = 1.37, 95% CI 1.08 – 1.75).

An increasing trend in the percentage of eyes with a 2B or 3 lens opacity was noted, as follows: 0.6% (30 – 39 years old); 2.4% (40 – 49 years old); 13.5% (50 – 59 years old); 36.7% (60 – 69 years old) and 61.5% of eyes in those aged 70 years and older.

Results

In related manner, an increasing trend was identified for the percentage of eyes with operable cataract who were visually impaired, ie those with presenting visual acuity $<6/12$ (Figure 6.4.1). Lens opacities of grades 2B or 3 existed in nearly two-thirds (64.2%) of the 4,176 eyes in persons aged 60 years and older whereas in the eyes of persons aged 70 years and older, this value increased to 74.4%.

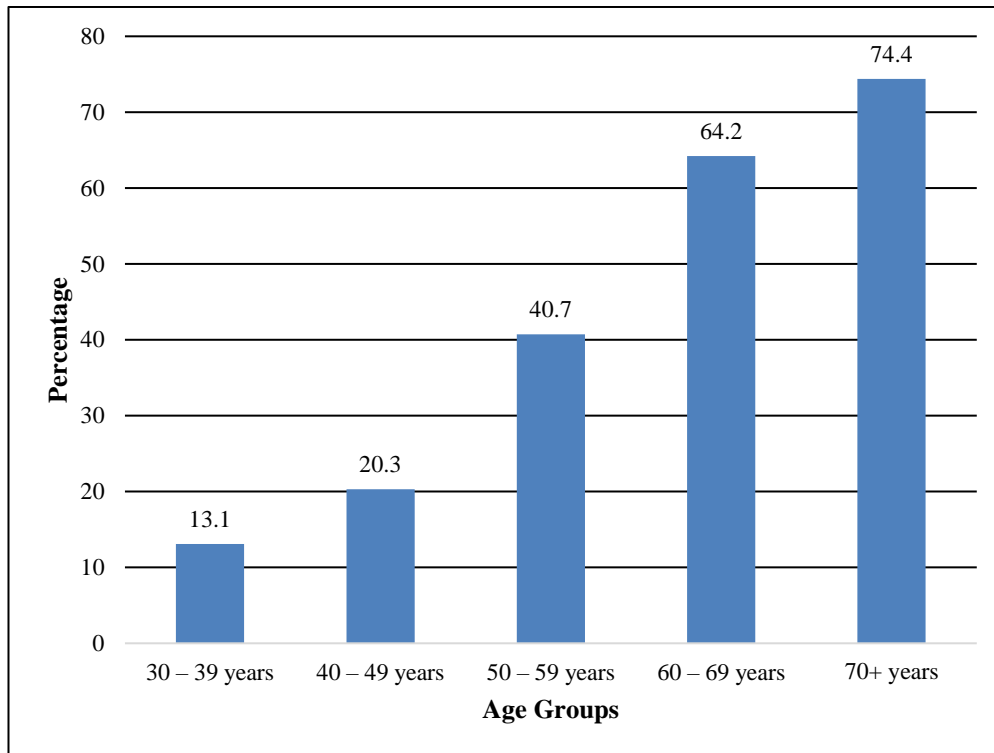


Figure 6.4.1. Percentage of eyes with vision $<6/12$ having lens opacities grades 2B or 3 (n=2,444).

Within the 2,518 persons with visual impairment 146 subjects were found to have undergone cataract surgery in either one or both eyes, as follows: 55 right eye only surgeries, 39 left eye only surgeries and 52 bilateral cataract surgeries. All of these 146 subjects had presenting visual acuity $<6/12$ bilaterally. An additional 28 (pseudo)aphakic eyes in 16 subjects had been operated on for cataract though these subjects were not visually impaired as their presenting vision was $\geq 6/12$ bilaterally. Therefore, a total of 162 survey subjects had undergone cataract surgery prior to the study. Overall there were 226 (pseudo)aphakic eyes in these 162 persons. Of the 98 unilaterally (pseudo)aphakic subjects, 75 were found to be visually impaired (i.e. presenting vision $<6/12$ in the better eye). Furthermore, 79 of the 98

Results

unilaterally operated subjects had an operable, visually impairing cataract of grades 2B or 3 in the other eye.

The percentage of surgeries (28.3%) performed on the second eye of persons who had already undergone surgery in the other eye was relatively low, whereas the majority of the surgeries were carried out in the so-called ‘first eyes’ (71.6%). Given the high prevalence of cataract blindness, from a public health ophthalmology perspective, cataract surgical services should emphasise carrying out sight restoring surgeries for as many visually impaired persons as can be treated. Thus, operating on one cataract blind eye in as many individuals as possible is prioritised above that of operating on second eyes within a given population, assuming that the first cataract surgery did indeed lead to restoration of sight.

Analysis of the presenting visual acuity status of the 226 cataract operated eyes identified that 158 (69.9%) were $<6/12$ while only 68 (30.1%) had vision $\geq 6/12$. A relatively low percentage of intra-ocular lens (IOL) implantation was noted as only twenty (8.8%) of the 226 operated eyes had received an IOL. The majority of those eyes with an IOL had adequate vision, with three-quarters achieving $\geq 6/18$ visual acuity.

As noted in Table 6.4.2, certain socio-demographic variables were significantly associated with having a visually impairing lens opacity. These include: being illiterate or semi-literate; being inactive / unemployed or being manually employed; living in a rural area and, in terms of geographic location, residing in Rajshahi or Khulna Divisions – both which are regions in the western part of Bangladesh. No gender difference was identified in terms of having an advanced lens opacity. Together, with the increased prevalence being associated with older ages (as per Figure 6.4.1), the profile of those at higher risk of visual impairment / blindness due to cataract were identified.

Results

Table 6.4.2. Distribution of eyes with 2B or 3 lens opacity, by gender, Division, rural/urban location, literacy status and work type (n=23,248).

Socio-demographic Variable	Number of eyes examined	Eyes with 2B or 3 lens opacity	Percentage (95% CI)	Odds ratio (OR 95% CI)
Division				
Barisal	1,580	152	9.6 (8.2 – 11.2)	Reference
Chittagong	4,172	444	10.6 (9.7 – 11.6)	1.12 (0.92 – 1.37)
Dhaka	7,804	842	10.8 (10.1 – 11.5)	1.14 (0.94 – 1.37)
Khulna	2,846	331	11.6 (10.5 – 12.9)	1.24 (1.01 – 1.52)
Rajshahi	4,756	656	13.8 (12.8 – 14.8)	1.50 (1.24 – 1.82)
Sylhet	1,370	161	11.8 (10.1 – 13.6)	1.25 (0.98 – 1.59)
Sex				
Female	11,878	1,328	11.2 (10.6 – 11.8)	1.01 (0.93 – 1.1)
Male	11,370	1,258	11.1 (10.5 – 11.7)	Reference
Location				
Rural	18,742	2,228	11.9 (11.4 – 12.4)	1.56 (1.39 – 1.76)
Urban	4,506	358	7.9 (7.2 – 8.8)	Reference

(continued)

Results

Socio-demographic Variable	Number of eyes examined	Eyes with 2B or 3 lens opacity	Percentage (95% CI)	Odds ratio (OR 95% CI)
Literacy				
Easily reads	9,446	529	5.6 (5.1 – 6.1)	Reference
With difficulty	2,434	221	9.1 (8.0 – 10.3)	1.68 (1.42 – 1.99)
Illiterate	11,300	1,836	16.3 (15.6 – 17.0)	3.27 (2.95 – 3.62)
Type of Work				
Inactive/Unemployed	1,288	663	51.5 (48.7 – 54.2)	41.50 (28.52 – 60.69)
Manual	20,582	1,888	9.2 (8.8 – 9.6)	3.95 (2.76 – 5.69)
Non-manual	1,324	33	2.5 (1.7 – 3.5)	Reference

Results

Cataract surgical coverage for eyes

In Table 6.4.3, the distribution of (pseudo)aphakia cases by administrative Division is presented. The numbers of eyes with a lens opacity of either grade 2B or 3 are also shown according to three visual acuity levels, namely <math><3/60</math>, <math><6/60</math> and <math><6/18</math>.

Nationally the cataract surgical coverage for eyes with visual acuity <math><3/60</math> was shown to be less than one-third (31.8%) of the existent need for cataract surgery. In total there were 492 eyes with VA <math><3/60</math> (i.e. blind) that had an operable cataract. Across the Divisions, the CSC for eyes <math><3/60</math> with cataract was highest for Dhaka (34.7%) and Chittagong (34.6%) while the lowest level of surgical coverage for eyes was that of Barisal (25.7%). The other three, mainly rural Divisions, Khulna, Rajshahi and Sylhet, each had coverage levels less than 30% for eyes <math><3/60</math>. Lower CSC percentages were identified for severely visually impaired eyes (28.4%) and for moderately visually impaired eyes 10.6% nationally. More eye care delivery facilities – government, private and those supported by non-governmental agencies – providing cataract surgical services are located in Dhaka and Chittagong than in the other Divisions.

Table 6.4.3. Cataract surgical coverage (%) for eyes, according to visual acuity levels <math><3/60</math>, <math><6/60</math> and <math><6/18</math>, by Division.

Division	CSC <math><3/60</math> %	CSC <math><6/60</math> %	CSC <math><6/18</math> %
Barisal	25.7	22.5	13.4
Chittagong	34.6	33.6	11.9
Dhaka	34.7	29.2	11.0
Khulna	29.9	26.6	10.0
Rajshahi	29.9	26.7	8.8
Sylhet	29.4	29.4	10.9
Total	31.8	28.4	10.6

Results

By gender, the cataract surgical coverage was higher for men compared to that for women in eyes with vision <3/60 (33.2% v 30.6%) and for <6/60 eyes (29.0% v 27.9%), though the reverse was the case for <6/18 (10.3% v 11.0%) vision.

In terms of age, cataract surgical coverage was higher in persons less than 50 years of age for eyes <3/60, <6/60 and <6/18 when compared to persons of older ages (Table 6.4.4). This is most evident in the case of younger women, aged 30 to 39 years, as the CSC for this sub-group was higher for all three visual acuity levels, e.g. 53.3% for female CSC for eyes <3/60 compared to 11.1% for young males. Similarly, the CSC for females aged 40 to 49 years was higher than the level noted for males of the same ages for all three acuities.

However, when considering all of the age groups, the CSC for eyes at thresholds <3/60 and <6/60 was higher in males than for females, despite the somewhat higher level in younger women. This gender difference, as evidenced by a substantially higher level of cataract surgery in males (35.0%) aged 70 years and older when compared with that for women (25.4%) at <3/60 visual acuity.

Table 6.4.4. Cataract surgical coverage (%) for eyes, according to visual acuity levels <3/60, <6/60 and <6/18, by 10-year age groups, and by gender for <3/60.

Age groups	CSC <3/60 %	Female CSC <3/60 %	Male CSC <3/60 %	CSC <6/60 %	CSC <6/18 %
30-39 years	37.5	53.3	11.1	36.0	19.6
40-49 years	37.8	42.1	33.3	37.8	13.7
50-59 years	30.9	25.6	35.7	26.9	7.8
60-69 years	33.7	35.7	30.3	29.3	9.0
70+ years	30.0	25.4	35.0	27.0	12.2
Total	31.8	30.6	33.2	28.4	10.6

Results

Differences in cataract surgical coverage were also identified according to rural and urban residence of the examined subjects. Across all three visual acuity levels, the CSC was higher for persons living in urban settings when compared to rural dwellers (Table 6.4.5). Amongst those with <math><3/60</math> eyes, the CSC was only 29.0% for rural residents whereas for persons living in cities throughout Bangladesh, it was notably higher at 41.7%. Furthermore, when taking gender also into account, one notes that rural males have a higher cataract surgical rate for <math><3/60</math> eyes than females (31.1% v 27.2%) whereas amongst urban residents this gender difference is less marked (42.6% v 41.1%). Similar patterns of lower cataract surgical coverage in rural areas also exists for <math><6/60</math> and <math><6/18</math> eyes. Effectively, women were found to have lower CSC at all three visual acuity levels in rural areas compared with urban females, urban males and rural males.

Table 6.4.5. Cataract surgical coverage (%) for eyes, according to visual acuity levels <math><3/60</math>, <math><6/60</math> and <math><6/18</math>, by residence and by gender for <math><3/60</math>.

Rural/Urban	CSC <math><3/60</math> %	Female CSC <math><3/60</math> %	Male CSC <math><3/60</math> %	CSC <math><6/60</math> %	CSC <math><6/18</math> %
Rural	29.0	27.2	31.1	25.5	9.0
Urban	41.7	41.1	42.6	39.6	20.2
Total	31.8	30.6	33.2	28.4	10.6

Higher CSC percentages were identified amongst literate persons and semi-literate subjects when compared with persons who were unable to read and write. For example, amongst blind eyes (i.e. <math><3/60</math>), the CSC for literate persons (49.6%) was approximately twice that of illiterate persons (25.8%). A similar pattern of higher CSC was identified for <math><6/60</math> and $6/18$ eyes according to literacy status. In terms of gender, women were shown to have overall lower levels of CSC for all three visual acuity levels.

It would appear that lower CSC was related to the predominance of illiteracy in females with respect to males. In order to elucidate this point, for eyes <math><3/60</math>, women contributed 275 of the 492 eyes with operable cataract with this VA level. Of those 275 blind eyes, 254 (92.4%) were in illiterate women

Results

whereas for men with blind eyes due to cataract, only 139 out of 217 subjects (64.1%) were illiterate. A similar pattern of a disproportionately high level of illiteracy was noted for women in comparison with men concerning the cataract surgical coverage indices for <math><6/60</math> and <math><6/18</math> visual acuities (Table 6.4.6). However, it merits highlighting that whilst the overall CSC by literacy status was lower for women, this was not the case amongst literate and semi-literate persons.

Table 6.4.6. Cataract surgical coverage (%) for eyes, according to visual acuity levels <math><3/60</math>, <math><6/60</math> and <math><6/18</math> by literacy status, and by gender for <math><3/60</math>.

Literacy	CSC <math><3/60</math> %	Female	Male	CSC <math><6/60</math> %	CSC <math><6/18</math> %
		CSC <math><3/60</math> %	CSC <math><3/60</math> %		
Literate	49.6	57.9	46.6	44.9	17.4
Semi-literate	44.0	64.3	36.1	37.3	11.7
Illiterate	25.8	26.2	25.3	23.2	8.8
Total	31.8	30.6	33.2	28.4	10.6

Cataract surgical coverage for persons

The cataract surgical coverage for persons was also calculated based on the data for (pseudo)aphakia and the presence of operable cataract of grades 2B or 3 in eyes with vision <math><3/60</math>, <math><6/60</math> and <math><6/18</math>. As with the CSC for eyes in these subjects, a descending gradient exists regarding the cataract surgical coverage for persons across the visual acuity levels. The CSC for persons is highest for the visual acuity of <math><3/60</math>, intermediate for <math><6/60</math> and lowest for <math><6/18</math>.

Nationally the CSC for persons <math><3/60</math> within Bangladesh was 39.7% while the indices at VA <math><6/60</math> was 33.3% and for VA <math><6/18</math> was 13.5% (Table 6.4.7). By administrative Division the highest level of cataract surgical coverage for persons <math><3/60</math> was found to be Chittagong (45.7%) followed by Barisal (40.9%).

Results

Table 6.4.7. Distribution of cataract surgical coverage (%) for persons <3/60, <6/60 and <6/18 by Division, and by gender for <3/60.

Division	CSC <3/60 %	CSC <6/60 %	CSC <6/18 %
Barisal	40.9	34.5	20.8
Chittagong	45.7	43.2	15.1
Dhaka	39.6	29.2	13.6
Khulna	38.7	36.4	11.4
Rajshahi	36.6	31.3	11.9
Sylhet	33.3	26.7	12.7
Total	39.7	33.3	13.5

As with the cataract surgical coverage for eyes, the CSC for persons <3/60 was lower for females than for males (38.5% v 41.6%). Conversely, at the less visually impairing categories of <6/60 (34.1% v 32.3%) and <6/18 (14.9% v 11.9%), the CSC was somewhat higher for women, as was observed in the ‘CSC for eyes’ at these visual acuity thresholds (Table 6.4.8).

As regards the CSC for persons by subject age groups, a higher degree of coverage was observed in the two youngest age groups, namely those 30 to 39 years and 40 to 49 years of age. This pattern was found at all three visual acuity levels. Notably the cataract surgery coverage amongst persons aged 50 years and older declined for each successive age decade such that the CSC for persons aged 70 years and older with VA <3/60 was only approximately one-third of the existent need. By gender, males had a higher degree of coverage at the <3/60 VA threshold (41.6%) compared with females (38.5%). This gender difference was most marked for the oldest age group (70 years and older) in which the largest number of persons in need of cataract surgery is found. Though women had a higher level of CSC overall for <6/60 and <6/18 visual acuities, as distinct from that for <3/60 VA, the differential favouring a higher CSC for 70 year and older men was still identified (Table 6.4.8).

Results

Table 6.4.8. Distribution of cataract surgical coverage (%) for persons <3/60, <6/60 and <6/18 by 10-year age groups, and by gender for <3/60.

Age groups	CSC <3/60 %	Females CSC <3/60 %	Males CSC <3/60 %	CSC <6/60 %	CSC <6/18 %
30-39 years	66.7	80.0	0.0	66.7	31.3
40-49 years	80.0	75.0	100.0	80.0	25.0
50-59 years	42.1	50.0	36.4	33.3	8.2
60-69 years	40.7	45.7	31.6	32.4	11.2
70+ years	35.5	27.7	46.7	30.5	15.1
Total	39.7	38.5	41.6	33.3	13.5

Cataract surgical coverage <3/60 for persons was found to be higher in persons resident in urban areas compared with those who live in rural locations in Bangladesh (Table 6.4.9). This differential was identified for all three visual acuity thresholds. Amongst persons with VA <3/60, 50% of those living in urban areas had their need for cataract surgery met while in rural settings the CSC was only approximately one-third (36.7%) of the existent need. In addition to the difference between rural and urban settings, males were found to have a higher CSC for persons compared with women at <3/60 VA level. Additionally, rural women were shown to have the lowest CSC (34.1%) compared with rural males (40.3%), urban males (46.7%) and urban females (51.7%).

Results

Table 6.4.9. Distribution of cataract surgical coverage (%) for persons <3/60, <6/60 and <6/18 by residence, and by gender for <3/60.

Residence	CSC <3/60 %	Females	Males	CSC <6/60 %	CSC <6/18 %
		CSC <3/60 %	CSC <3/60 %		
Rural	36.7	34.1	40.3	29.7	11.4
Urban	50.0	51.7	46.7	46.9	26.3
Total	39.7	38.5	41.6	33.3	13.5

Literacy status was found to be associated with cataract surgical coverage for persons, as the level of coverage in persons with VA <3/60 was twice as high for literate (65.7%) and semi-literate persons (63.6%) compared with those who were illiterate (31.8%) (Table 6.4.10). This gradient difference across visual acuity levels was identified for both females and males. A similar profile of CSC for persons was identified for VA <6/60 and VA <6/18.

Table 6.4.10. Distribution of cataract surgical coverage (%) for persons <3/60, <6/60 and <6/18 by literacy status, and by gender for <3/60.

Literacy	CSC <3/60 %	Females	Males	CSC <6/60 %	CSC <6/18 %
		CSC <3/60 %	CSC <3/60 %		
Literate	65.7	75.0	60.9	57.5	21.9
Semi-literate	63.6	75.0	57.1	50.0	17.1
Illiterate	31.8	32.7	29.8	26.7	11.4
Total	39.7	38.5	41.6	33.3	13.5

6.5 Barriers to up-take of cataract surgical service

As per Table 6.5.1, 1,263 subjects were identified as having a visually-impairing lens opacity in either one or both eyes. These opacities correspond to the 2B and 3 gradings of the Mehra-Minassian lens opacity classification system outlined previously (Table 5.13.1). These persons had never sought medical assistance for their impaired vision due to the advanced lens opacity. A further 86 persons reported having undergone a medical consultation for their visual impairment due to cataract, though they had not undergone surgery for that condition at the time of the survey. A further 162 persons had been operated upon for cataract, as has described in Section 6.2 and Section 6.3. Of these 162 subjects, of the 98 persons that were operated upon in one eye only, 78 had a lens opacity of grade 2B or 3 in the other eye. Finally, the remaining 10,113 who did not have lens opacities 2B or 3 were mainly subjects with $>6/12$ bilateral vision (9,106, inclusive of 16 cataract surgical cases) as well as a further 1,023 subjects with $<6/12$ vision unilaterally (or bilaterally) that did not have a 2B or 3 lens opacity. This latter sub-group were not asked whether they had undergone a medical consultation for their visual impairment as in those cases the visual impairment was not related to advanced lens opacity (Table 6.5.1).

Results

Table 6.5.1. Distribution of all subjects concerning lens opacity status (n = 11,624).

Lens opacity categories per subject	Frequency	Percentage
Sought medical care for 2B or 3 lens opacity; no surgery performed	86	0.7
Underwent cataract surgery in either or both eyes	162	1.4
Has a lens opacity of grade 2B or 3 unilaterally or bilaterally	1,263	10.9
Does not have a lens opacity of grade 2B or 3 in either eye	10,113	87.0
Total	11,624	100.0

Results

The respective numbers of women and men with visually-impairing lens opacities were 647 and 616, respectively. In terms of prevalence (10.9 % for females v 10.8% for males), there was no statistically significant difference between the genders for having these grades of cataract ($\chi^2 = 0.35$; $P=0.53$).

The barriers to up-take of cataract surgery in those who had never been assessed medically whilst having a cataract are presented in Table 6.5.2. Most prominent among the reported reasons for not seeking medical attention for the visual impairment was that of 'poverty', with nearly half of respondents (47.0%) indicating being too poor to afford treatment for their visual impairment due to the lens opacity.

Results

Table 6.5.2. Barriers to up-take of cataract surgery amongst Bangladeshi adults (n = 1,263).

Barriers to up-take of cataract surgery	Frequency	Percentage
Poverty / not having enough money to be treated for cataract	593	47.0
Subject did not know about having cataract	164	13.0
Adequate vision according to subject, surgery not needed	90	7.1
Carelessness; casualness / lack of interest in being treated for vision problem	84	6.7
No person available to accompanying the subject to seek medical care	73	5.8
Fear of undergoing surgery	58	4.6
No particular or specific reason identified	52	4.1
Lack of time available to seek medical care	39	3.1
Subject perceived as being too old to seek treatment	30	2.4
Other reasons identified (no local medical services; not knowing any doctor)	25	2.0
Subject was ill due to other medical problem(s)	25	2.0

(continued)

Results

Barriers to up-take of cataract surgery	Frequency	Percentage
Waiting for maturation of cataract prior to being operated upon	19	1.5
Vision decreased due to being old; part of a natural process	9	0.7
Having a vision problem as a matter of God's will	2	0.2
Total	1,263	100.0

Results

The second most prominent constraint to seeking medical care was reported as not knowing about having cataract (13.0%). The other barriers that were reported are listed in Table 6.5.2.

As shown in Figure 6.5.1, whilst poverty was cited as the most important reason for not having sought medical care for visually-impairing cataract amongst both females and males (49.1% and 44.6%), certain gender-related differences were observed concerning other reported barriers. More than one-in-ten females (10.4%) indicated that the lack of an accompanying person able to assist the female to consult a doctor or attend a hospital was a constraint as regards at least initiating the process for undergoing treatment.

Conversely, proportionally more males than females highlighted not knowing about having cataract as well as not having enough time to seek medical care, likely linked to being actively involved in essential remunerative work.

Results

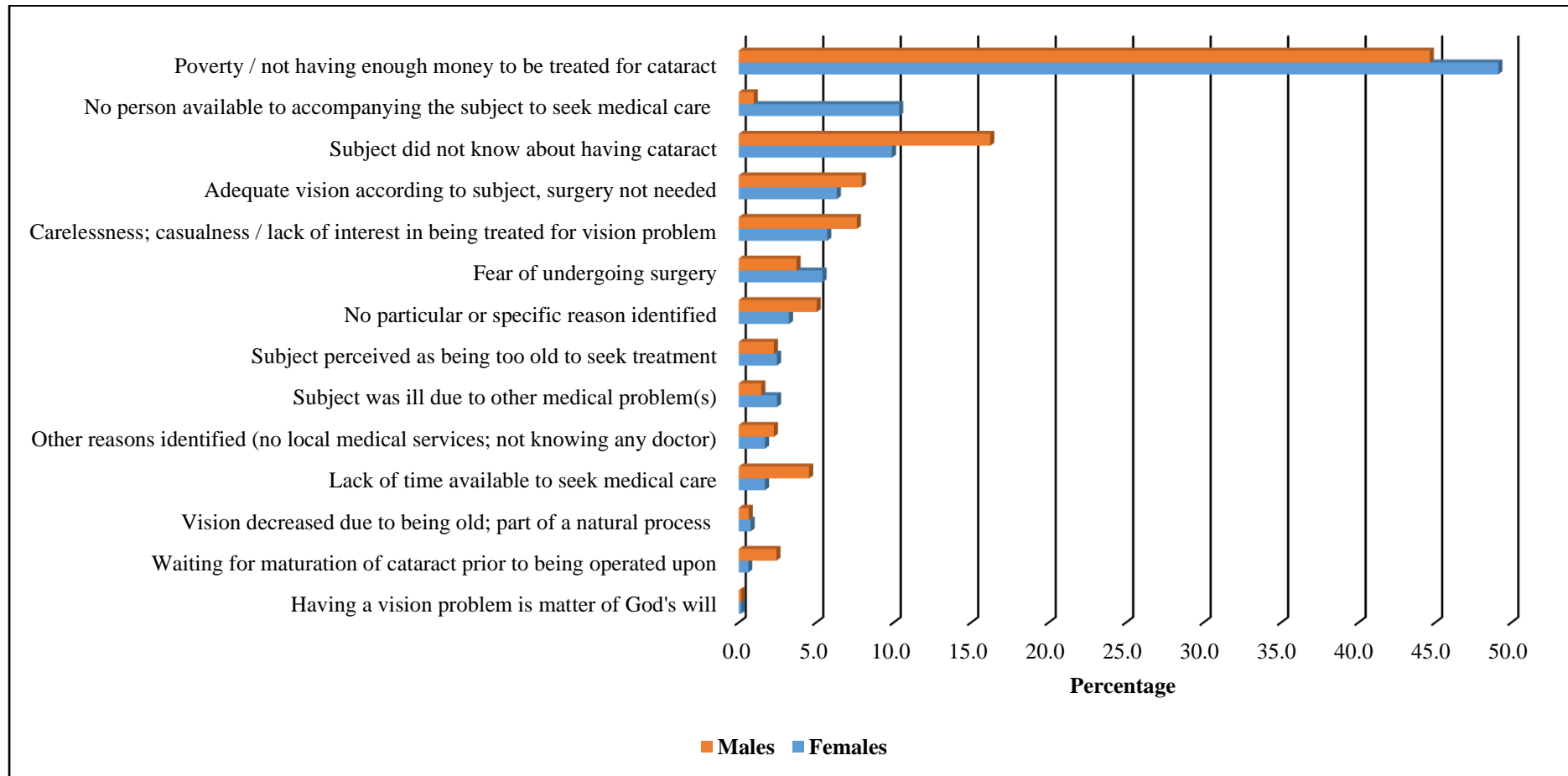


Figure 6.5.1. Barriers to up-take of cataract surgery, by gender (n = 1,263)

Results

As has been already reported in Section 6.2, blindness prevalence in rural areas was statistically significantly higher than in urban locations, although cataract blindness was identified as being the major cause of blindness in both settings. Similarly, the prevalence of visually-impairing lens opacities in rural dwellers (11.7%) was substantially higher than for those living in urban areas (7.3%); this difference was statistically significant ($\chi^2=37.1$; p-value=0.0001) (Figure 6.5.2).

In terms of barriers to up-take of cataract surgery, poverty was the main constraint in rural areas (48.0%) followed by not knowing about having a cataract (12.1%). As for the urban areas, poverty (40.2%) and the lack of knowledge about cataract as the cause of one's visual impairment (18.9%) were the main barriers, though relative proportions for these reasons in each setting differed.

Results

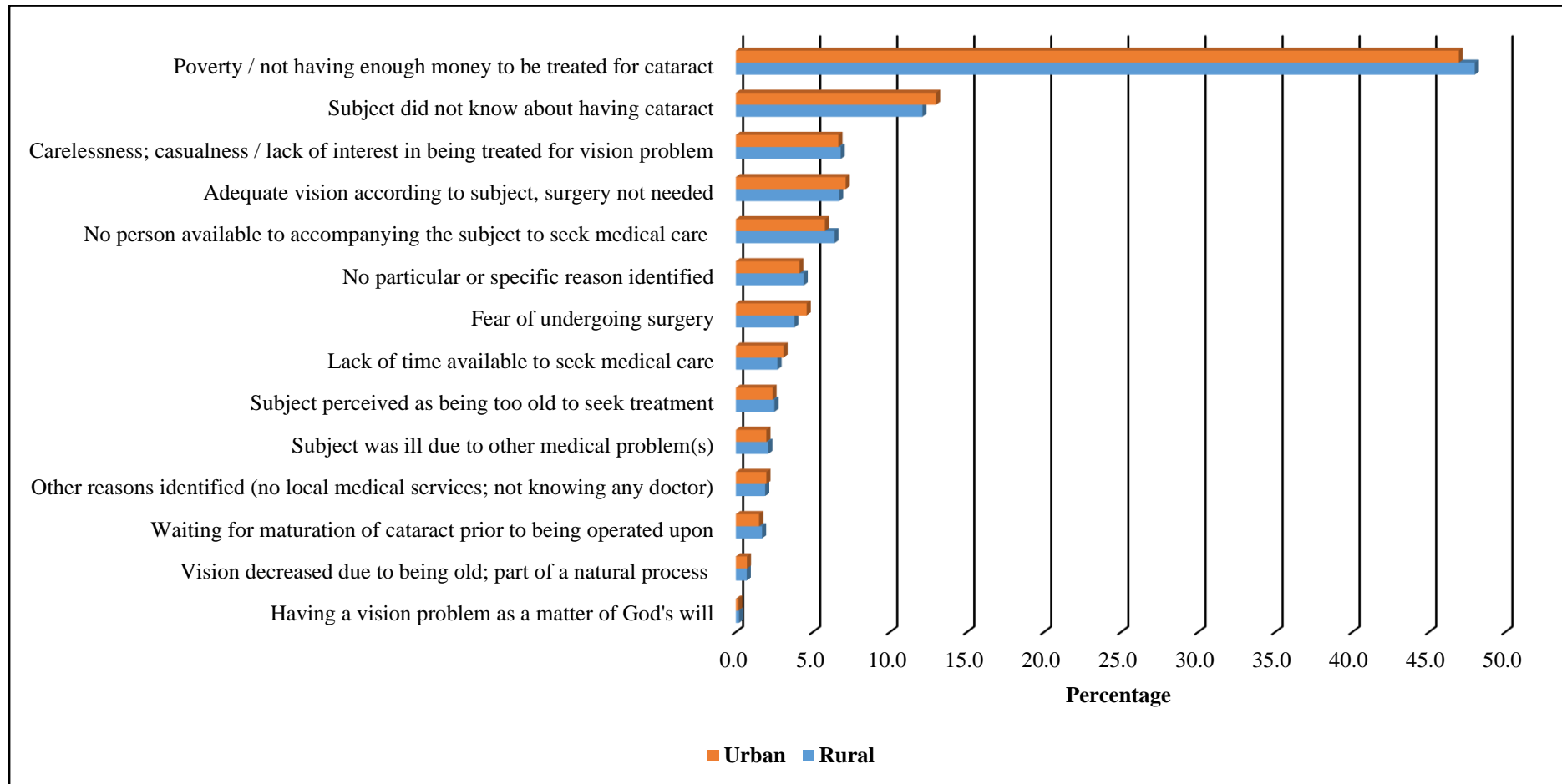


Figure 6.5.2. Barriers to up-take of cataract surgery, by rural versus urban residence (n = 1,263).

Results

Amongst those subjects with grades 2B or 3 lens opacities, the majority were found to be illiterate (71.6%); approximately only one-fifth of this sub-group (19.4%) were able to 'easily' read whilst a further 9.0% could read with some degree of 'difficulty', ie were semi-literate. For the purposes of further analysis concerning barriers to cataract surgery, the two latter groups of subjects were combined in to a 'literate' category against which those who self-reported as being illiterate were compared. Though the main constraint to cataract treatment for both was poverty, this was most notably the case amongst the illiterate cohort (51.5%) as compared to 35.4% of those who were 'literate'. Both groups indicated not knowing about having cataract as the second major barrier to seeking treatment (Figure 6.5.3).

In those who could read, perceiving that one's vision was adequate, not being interested or possibly 'careless' towards seeking treatment followed by a reported lack of time were also key constraints. For the group who were illiterate, not having a person to accompany the subject to obtain medical attention as well as being of the opinion that one's vision was adequate were identified as key barriers.

Results

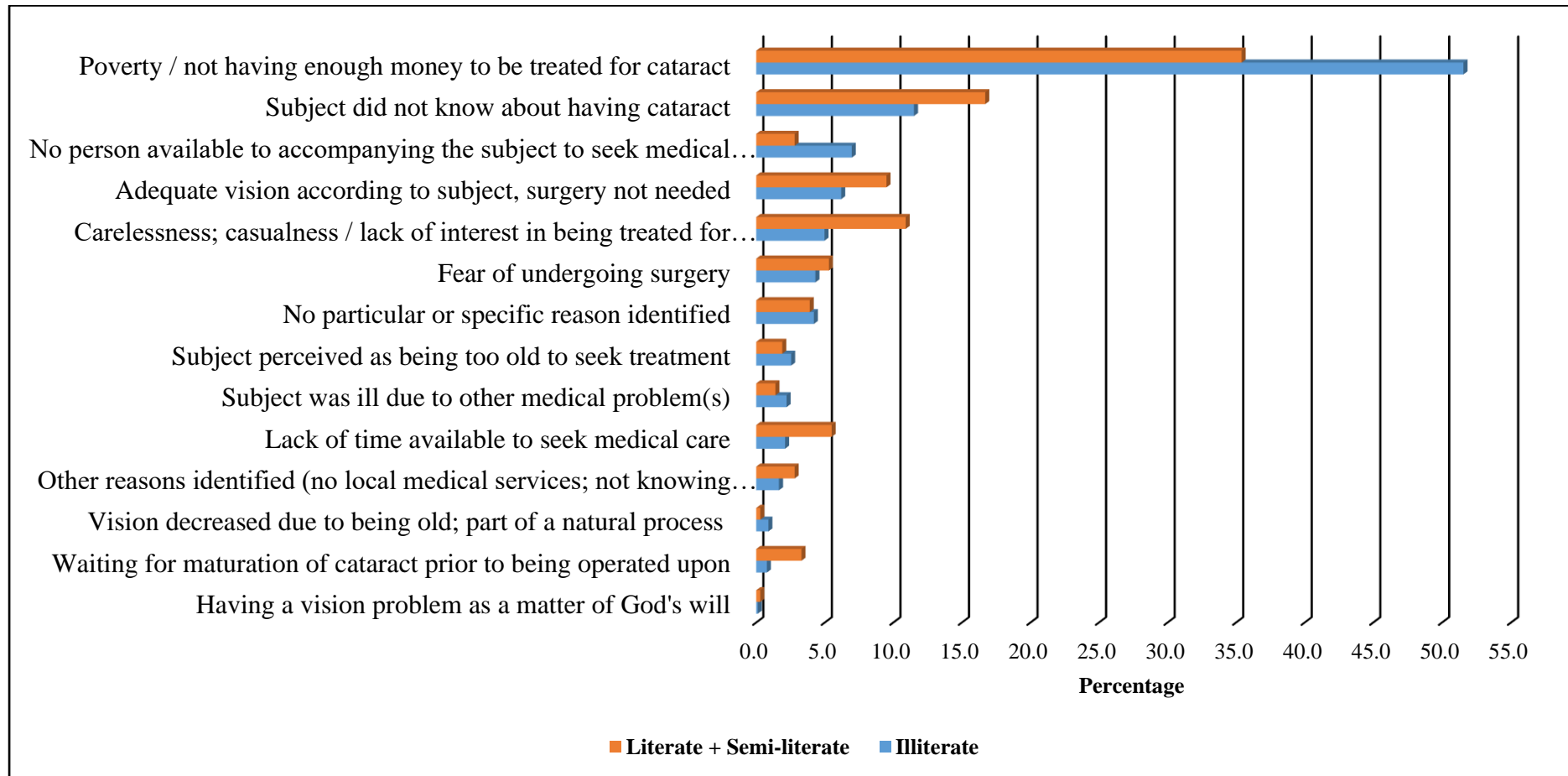


Figure 6.5.3. Barriers to up-take of cataract surgery by literacy level (n=1,263)

Results

In terms of educational status, those subjects who had never attended school were found to have a statistically significantly higher prevalence of visually-impairing lens opacities in comparison with those subjects who had ever been a student, irrespective of the level of school achievement (Figure 6.5.4). In line with previous results, poverty was the most frequently reported constraint when educational status was considered, though this was more pronounced amongst the non-school attenders (51.6%) than for those who had been in school (33.8%). Additional barriers amongst the former group were: not knowing about having cataract (11.2%) and, the visually impaired person not having a person to accompany her / him to seek treatment (7.1%).

For those subjects who had attended school at a given point – in addition to having prioritised poverty as the main barrier – these persons further indicated not knowing about having cataract (18.%) as well as having expressed a lack of interest in being treated for their ocular condition (11.9%). This response was considered by the survey ophthalmologists to be indicative of a certain level of ‘carelessness’ or ‘casualness’ on the part of the subjects who appeared to be disinterested in seeking treatment for their eye disorder.

Results

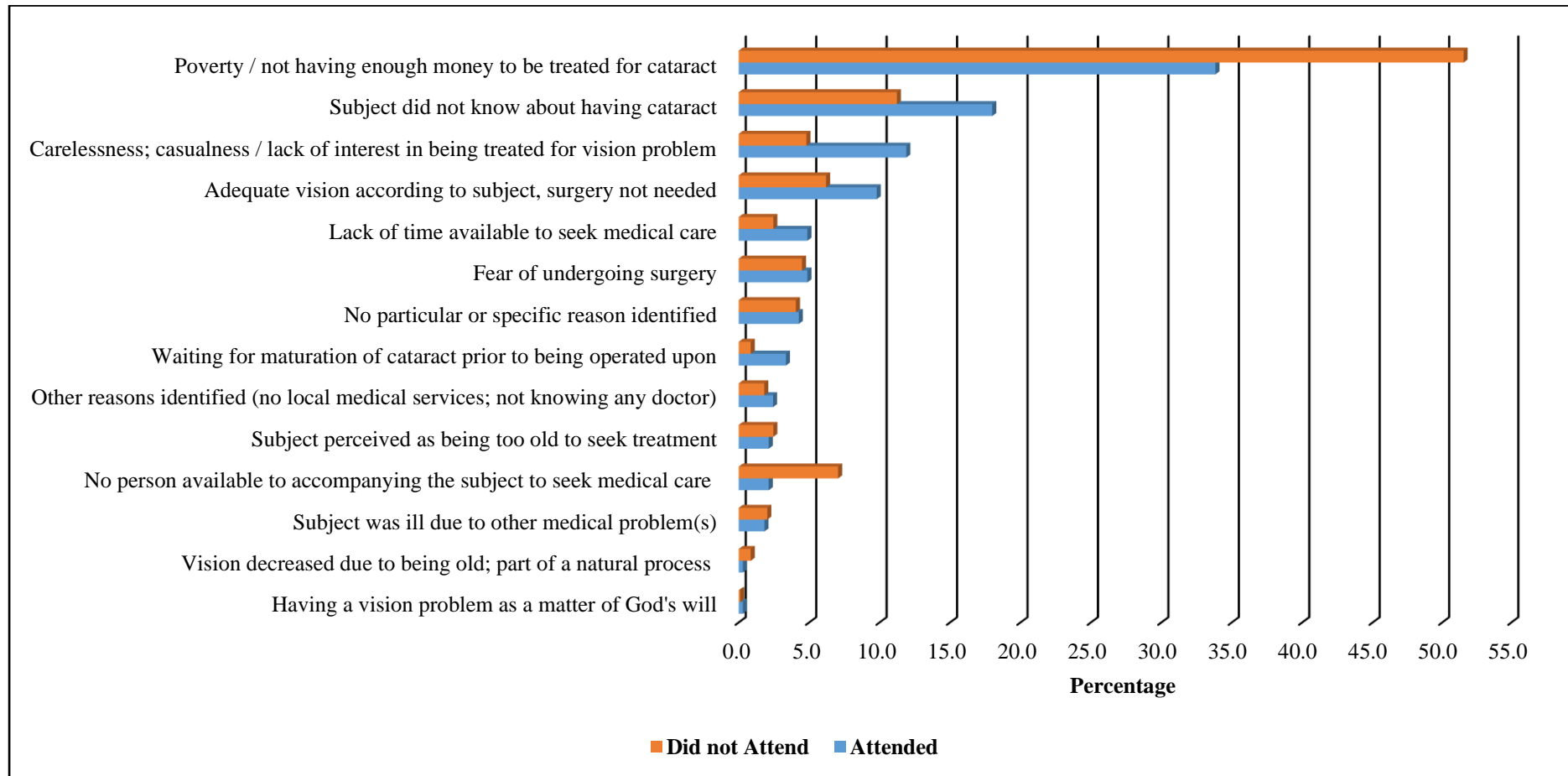


Figure 6.5.4. Barriers to up-take of cataract surgery, by school attendance (n = 1,263)

Results

Based on the Bangladesh Bureau of Statistics Classification of Occupations (BBSCO), the type of work, if any, reported by subjects was grouped in to one of three categories, namely: a) manual, b) non-manual and c) inactive / retired.²⁰¹

Notably, poverty was the main reason for not having sought treatment for cataract in all three groups, though, proportionally, this was less the case for non-manual staff (29.4%) as compared to the other two cohorts (48.9% for manual workers and 41.8% amongst the inactive / retired). Additional key barriers identified across all three employment categories were: a) fear of undergoing surgery, b) perceiving one's vision to be 'adequate' thus being of the opinion that seeking medical attention was not warranted at the time of the survey and c) the subject not knowing about having cataract (Figure 6.5.5).

It is important to point out that confounding by the age of the subject would likely have been present when analysing the association between having undergone cataract surgery and the type of work of the individual. This is due to those who were either inactive or retired having been, on average, older (75.1 years), than those employed at the time of the survey who reported being actively employed – in either manual (62.1 years) or non-manual work (55.3 years). As such, the age of the subject being a risk factor for cataract surgery would also have been associated with an individual being retired or not actively employed. Thus, further comparative analysis of occupational classification vis-à-vis cataract surgery up-take included only the manual and non-manual worker groups.

Results

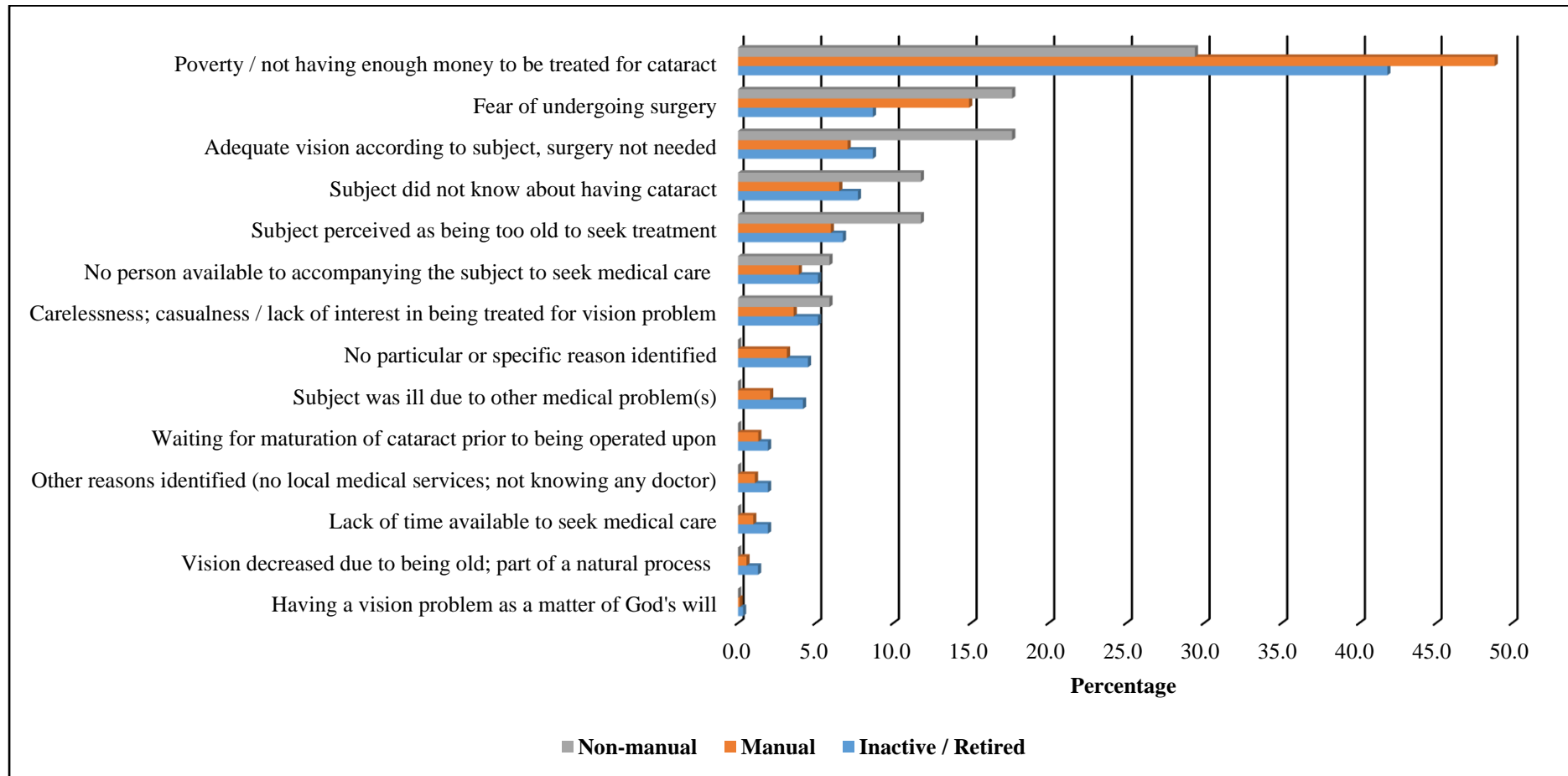


Figure 6.5.5. Barriers to up-take of cataract surgery by employment status (n = 1,249).

Results

The results thus far presented focused on identifying barriers to up-take of cataract surgery amongst those with a visually-impairing lens opacity of grades 2B or 3 in either or both eyes. Associations of specific socio-demographic variables with the reported constraints to accessing surgery have thus been presented. In order to further elucidate the nature of the barriers to treatment for operable cataract, logistical regression analyses were also conducted.

Towards this end, comparisons were made between those 1,263 subjects with a 2B or 3 lens opacity and the 162 subjects who had already undergone cataract surgery regarding socio-demographic explanatory variables, the results of which are presented below (Table 6.5.3). Urban residence, having attended school and amongst this sub-group, those who had achieved post-primary education, being literate or semi-literate all were significantly statistically associated with having undergone cataract surgery compared with those who had not been operated upon despite having a visually impairing lens opacity. However, no associations existed between cataract surgical up-take and gender nor with employment type, when taking into account manual and non-manual workers only.

Results

Table 6.5.3. Logistic regression results comparing those who had undergone cataract surgery versus those who had not accessed medical care for a 2B or 3 lens opacity (n=1,425).

Variable	χ^2	P-value	Odds Ratio	OR 95% CI
Urban v Rural residence	25.11	<0.00001	2.58	1.73 – 3.84
Post-primary v Primary education only *	12.91	0.0003	2.77	1.57 – 4.89
Attended v Did not attend school	8.88	0.0028	1.68	1.19 – 2.36
Literate and Semi-literate v Illiterate	7.54	0.006	1.60	1.14 – 2.25
Female v Male	0.35	0.55	0.91	0.65 – 1.23
Manual and Non-manual v Inactive / Retired	0.76	0.38	1.73	0.49 – 6.01

Note: * In those who attended school, comparing primary school attendees versus a combined group consisting of secondary, higher secondary and college / university attendees.

Results

A multi-variable logistic regression model for up-take of cataract surgery (Table 6.5.4) was developed utilising as predictor co-variates the socio-demographic variables that were shown to be statistically significantly associated with surgery up-take by means of univariate analysis. The explanatory variables selected for the multi-variable logistic regression model were:

* area of residence (urban versus rural)

* literacy (able to read easily or with some degree of difficulty versus being illiterate)

* school attendance (attended versus never having attended school)

The results from this logistic regression model (Table 6.5.4) identified urban residence and having attended school as being statistically significant predictors of the up-take of cataract surgery, when controlling for the other variables in the model.

Table 6.5.4. Multi-variable logistic regression model analysis results for up-take of cataract surgery.

Variable	β	Wald χ^2	P-value	Odds Ratio	OR 95% CI
Urban residence	0.916	21.71	<0.0001	2.49	1.70 – 3.65
Having attended school	0.466	6.93	0.008	1.59	1.13 – 2.25

Similarly, further analysis was undertaken whereby those subjects with a 2B or 3 lens opacity were compared with the 86 subjects who had already sought medical attention for their visually-impairing lens opacity though had not yet undergone cataract surgery.

Based on univariate logistic regression analyses, key statistically significant differences were identified when comparing those subjects who had consulted with a medical professional for her/his visual impairment due to lens opacity – though did not undergo cataract surgery – compared with those who had never been assessed for their visual impairment (Table 6.5.5).

Results

Table 6.5.5. Univariate logistic regression results comparing those with a 2B or 3 lens opacity who had been assessed medically versus those who had not accessed medical care (n=1,349).

Variable	χ^2	P-value	Odds Ratio	OR 95% CI
Urban v Rural residence	25.27	<0.00001	3.23	2.00 – 5.23
Attended v Did not attend school	25.59	<0.00001	2.99	1.92 – 4.64
Literate and Semi-literate v Illiterate	21.92	<0.00001	2.76	1.78 – 4.29
Females v Males	1.59	0.21	1.33	0.86 – 2.06
Post-primary v Primary education only *	1.76	0.18	1.53	0.81 – 2.89
Manual and Non-manual v Inactive / Retired	1.59	0.21	1.43	0.82 – 2.50

Note: * In those who attended school, comparing a combined group consisting of secondary, higher secondary and college / university attendees versus primary school only attendees.

Results

As above, living in an urban setting, having attended school and being literate or semi-literate were statistically significantly associated with having sought medical care for one's visual impairment due to cataract. However, there were no statistically significant associations identified for gender, school attendance or employment status in terms of having sought medical attention.

Finally, based on multi-variable logistic regression analysis using the three aforementioned variables as explanatory predictors, only urban residence and having attended school were identified as being associated with seeking care for one's visual impairment, whilst controlling for the other two variables in the model.

Results

Table 6.5.6. Multi-variable logistic regression model results of factors associated with having been assessed medically for cataract compared with not having sought medical assistance (n=1,349).

Variable	β	Wald χ^2	P-value	Odds Ratio	OR 95% CI
Urban residence	1.081	18.88	0.000014	2.95	1.81 – 4.80
Having attended school	1.023	20.18	0.000007	2.78	1.78 – 4.35

6.6 Prevalence of refractive errors and spectacle coverage in adults

In this sub-section, the principal results of the epidemiological profile of refractive major are presented, including the prevalence of refractive errors within the sample studied as well as the associated risk factors for visual impairment due to refractive errors within Bangladeshi adults.

Bourne RR, Dineen BP, Ali SM, Noorul Huq DM, Johnson GJ. Prevalence of refractive error in Bangladeshi adults: results of the National Blindness and Low Vision Survey of Bangladesh. *Ophthalmology*. 2004 Jun;111(6):1150-60.

Bourne RR, Dineen BP, Huq DM, Ali SM, Johnson GJ. Correction of refractive error in the adult population of Bangladesh: meeting the unmet need. *Invest Ophthalmol Vis Sci*. 2004 Feb;45(2):410-7.

Results

Refractive errors

The prevalence of refractive errors within the survey are defined according to spherical equivalent results, measured in dioptres (Section 5.13.5). As shown in Table 6.6.1, approximately one-half (51.6%) of all subjects were emmetropic whilst one-quarter (24.7%) were myopic (≤ -0.5 D SE) with the remaining subjects (23.7%) being hypermetropic (≥ 0.5). However, certain differences were identified in the distribution of refractive status according to gender. Specifically, males were shown to have a higher prevalence (53.8%) of emmetropia, compared to females (49.4%). However, myopia – at all three defined levels (≤ -0.5 , ≤ -1.0 and ≤ -5.0 D SE) – was substantially higher in males. Conversely, hypermetropia prevalence was higher in females, at both ≥ 0.5 and ≥ 1.0 D SE thresholds, compared to males.

Further detailed analysis of the distribution of myopia by age and gender (Table 6.6.2) identified a progressive increase in the prevalence of the condition – at all three degrees of myopia – for both females and males. For instance, myopia (≤ -0.5 D SE) affected 23.4% of males aged 30 to 39 years, rising to 46.7% in those 60 to 69 years and in nearly three-quarters of those aged 70 years and older (71.4%). A similar trend by age also was identified for women, though with a lower prevalence than that of males. This age-related trend for myopia likewise existed for more advanced myopia, ie (≤ -1.0 and ≤ -5.0 D SE).

The age-related profile of both female and male subjects with hypermetropia was characterised by a progressive increase in the first three 10-year age groups (30 to 39 years through 50 to 59 years) with a subsequent reduced prevalence from 60 years onwards (Table 6.6.3). This trend occurred at both levels of hypermetropia (≥ 0.5 and ≥ 1.0 D SE) for both females and males. Notably, hypermetropia was more common in women (Figure 6.6.1) across the age spectrum compared with men (Figure 6.6.2).

Based on Bangladesh national population data for persons aged 30 years and older, the age-sex standardised prevalence for myopia (26.3%) and hypermetropia (24.4%) were also determined. For both conditions, these age-sex standardised results were slightly higher than the crude prevalence figures

Results

(24.7% and 23.7%) cited above. Myopia in males was more common than females (crude prevalence: 27.9% v 21.7%; age-sex standardised prevalence: 28.8% v 23.6%). Through extrapolation to the national population, 11.1 million adults aged 30 years and older were estimated to be myopic. Conversely, hypermetropia was more prevalent in females than males (crude prevalence: 29.0% v 18.3%; age-sex standardised prevalence: 30.2% v 18.6%). with the overall age-sex standardised prevalence of 24.4%. By extrapolation, approximately 10.3 million persons were estimated to be hypermetropic.

Results

Table 6.6.1. Prevalence of emmetropia, myopia and hypermetropia, by level of refractive error, by gender (n = 11,221).

Refractive Status	Women (n = 5,720)		Males (n = 5,501)		All (total = 11,221)	
	n	Prevalence (%) 95% CI	n	Prevalence (%) 95% CI	n	Prevalence (%) 95% CI
Emmetropia (>-0.5 to $<+0.5$ D SE)	2,824	49.4 48.1 - 50.7	2,962	53.8 52.5 - 55.2	5,786	51.6 50.6 - 52.5
Myopia						
Myopia (≤-0.5 D SE)	1,240	21.7 20.6 - 22.7	1,534	27.9 26.7 - 29.1	2,774	24.7 23.9 - 25.5
Myopia (≤-1.0 D SE)	663	11.6 10.8 - 12.4	852	15.5 14.5 - 16.4	1,515	13.5 12.9 - 14.1
High myopia (≤-5.0 D SE)	115	2.0 1.6 - 2.4	130	2.4 2.0 - 2.8	245	2.2 1.9 - 2.5
Hypermetropia						
Hypermetropia ($\geq+0.5$ D SE)	1,656	29.0 27.8 - 30.1	1,005	18.3 17.2 - 19.3	2,661	23.7 22.9 - 24.5
Hypermetropia ($\geq+1.0$ D SE)	868	15.2 14.2 - 16.1	414	7.5 6.8 - 8.2	1,282	11.4 10.8 - 12.0

Results

Table 6.6.2. Age- and sex-specific prevalence of myopia in Bangladeshi adults (n = 11,221).

Gender	Age	Subjects	Myopia (≤ -0.5 D SE)		Myopia (≤ -1.0 D SE)		High Myopia (≤ -5.0 D SE)	
			n (%)	95% CI	n (%)	95% CI	n (%)	95% CI
Women	30–39	2,664	521 (19.6)	18.1 – 21.1	165 (6.2)	5.3 – 7.2	10 (0.4)	0.2 – 0.7
	40–49	1,449	173 (11.9)	10.3 – 13.7	71 (4.9)	3.8 – 6.1	4 (0.3)	0.1 – 0.7
	50–59	829	171 (20.6)	17.9 – 23.5	115 (13.9)	11.6 – 16.4	20 (2.4)	1.4 – 3.7
	60–69	533	224 (42.0)	37.8 – 46.3	183 (34.3)	30.3 – 38.5	47 (8.8)	6.6 – 11.6
	70+	245	151 (61.6)	55.2 – 67.8	129 (52.7)	46.2 – 59.0	34 (13.9)	9.8 – 18.8
	Total	5,720	1,240 (21.7)	20.6 – 22.8	663 (11.6)	10.8 – 12.4	115 (2.0)	1.7 – 2.4
Men	30–39	2,167	508 (23.4)	21.7 – 25.3	129 (6.0)	5.0 – 7.0	7 (0.3)	0.1 – 0.6
	40–49	1,501	253 (16.9)	15.0 – 18.8	105 (7.0)	5.7 – 8.4	5 (0.3)	0.01 – 0.6
	50–59	833	218 (26.2)	23.2 – 29.3	141 (16.9)	14.4 – 19.6	19 (2.3)	1.3 – 3.5
	60–69	643	300 (46.7)	42.7 – 50.6	248 (38.6)	34.8 – 42.4	46 (7.2)	5.3 – 9.4
	70+	357	255 (71.4)	66.4 – 76.1	229 (64.1)	58.9 – 69.1	53 (14.8)	11.3 – 19.0
	Total	5,501	1,534 (27.9)	26.7 – 29.1	852 (15.5)	14.5 – 16.5	130 (2.4)	2.0 – 2.8

Results

Table 6.6.3. Age- and sex-specific prevalence of hypermetropia in Bangladeshi adults (n = 11,221).

Gender	Age	Subjects	Hypermetropia (≥ 0.5 D SE)		Hypermetropia (≥ 1.0 D SE)	
			n (%)	95% CI	n (%)	95% CI
Women	30–39	2,664	377 (14.2)	12.8 – 15.5	79 (3.0)	2.4 – 3.7
	40–49	1,449	537 (37.1)	34.6 – 39.6	276 (19.0)	17.1 – 21.2
	50–59	829	448 (54.0)	50.6 – 57.5	301 (36.3)	33.0 – 39.7
	60–69	533	231 (43.3)	39.1 – 47.7	170 (31.9)	30.0 – 36.0
	70+	245	63 (25.7)	20.4 – 31.7	42 (17.1)	12.6 – 22.5
	Total	5,720	1,656 (29.0)	27.8 – 30.1	868 (15.2)	14.3 – 16.1
Men	30–39	2,167	173 (8.0)	6.9 – 9.2	33 (1.5)	0.1 - 0.2
	40–49	1,501	334 (22.2)	20.2 – 24.4	122 (8.1)	6.8 – 9.6
	50–59	833	279 (33.5)	30.3 – 36.8	134 (16.1)	13.7 – 18.8
	60–69	643	166 (25.8)	22.5 – 39.4	91 (14.1)	11.6 – 17.1
	70+	357	53 (14.8)	11.3 – 19.0	34 (9.5)	6.7 – 13.1
	Total	5,501	1,005 (18.3)	17.3 – 19.3	414 (7.5)	6.8 – 8.3

Results

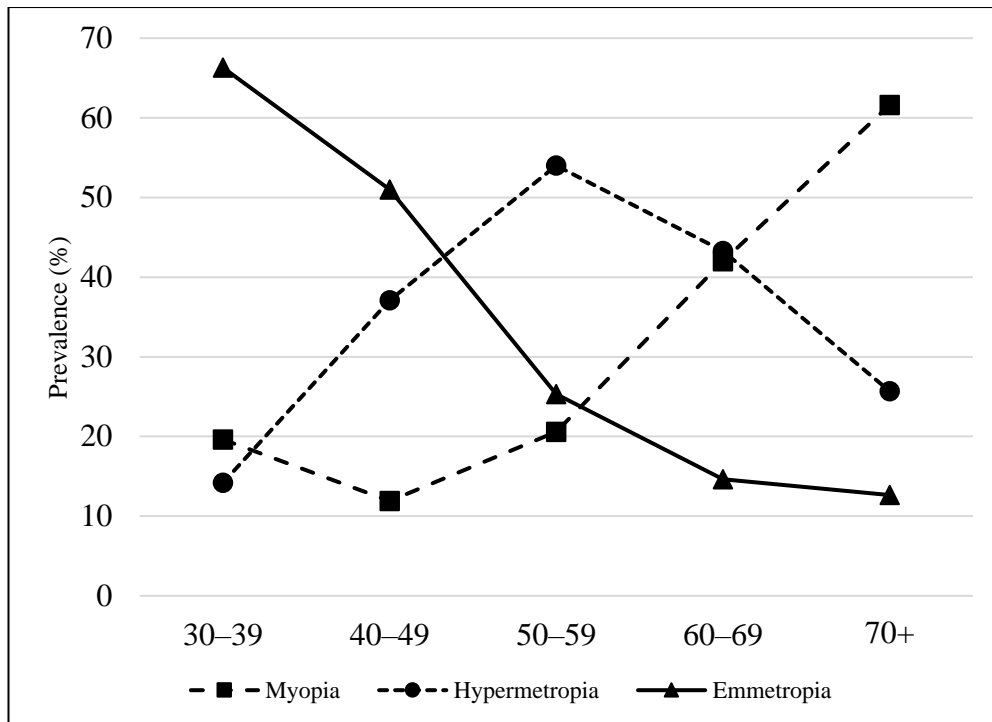


Figure 6.6.1. Age group-specific prevalence of emmetropia, myopia and hypermetropia in females by 10-year age groups (n = 5,720).

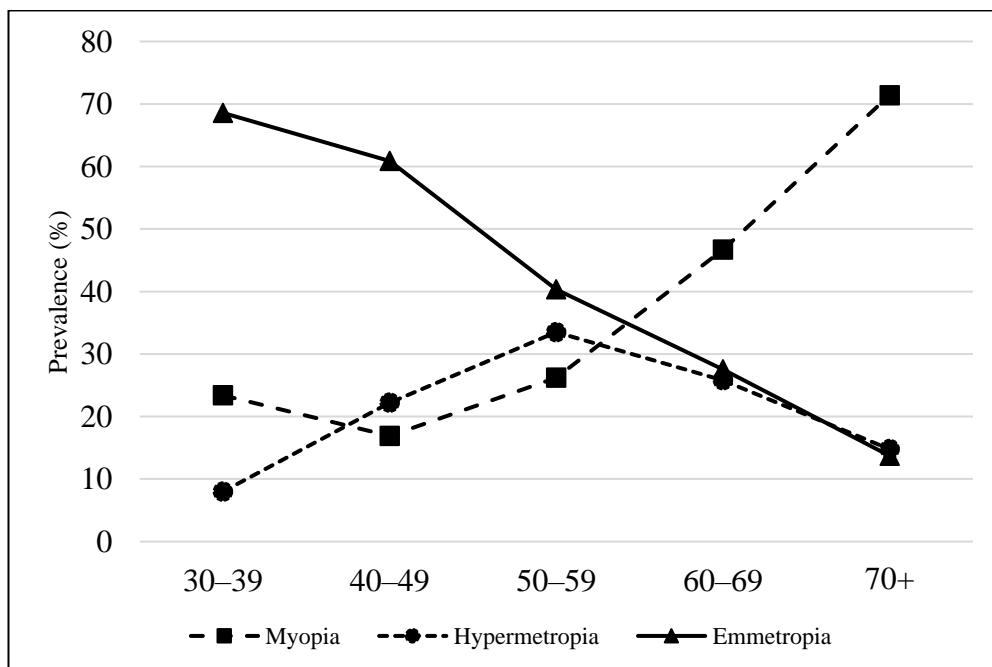


Figure 6.6.2. Age group-specific prevalence of emmetropia, myopia and hypermetropia in males by 10-year age groups (n = 5,501).

Further analyses (Table 6.6.4), undertaken to elucidate the socio-demographic and ocular variables that were associated with myopia and, separately, hypermetropia were performed. In comparison with emmetropic

Results

subjects, the odds of myopia were lower in females (OR 0.85; OR 95% CI 0.77 – 0.93) compared to males whilst being higher in subjects who were illiterate (OR 1.51; OR 95% CI 1.36 – 1.66) or semi-literate (OR 1.24; OR 95% CI 1.06 – 1.45) compared to those who could read / write. Subjects who were inactive / unemployed had more than six-fold increased odds of myopia compared to non-manual workers (OR 6.69; OR 95% CI 4.92 – 9.10), whereas those who wore spectacles (OR 3.24; OR 95% CI 2.37 – 4.45) and in those with grade 2A, 2B or 3 lens opacity (OR 5.66; OR 95% CI 4.22 – 7.58), the odds of having myopia were likewise substantially increased.

The odds of being hypermetropic were increased by 73% amongst females compared to males (OR 1.73; OR 95% CI 1.57 – 1.90) whilst being more than doubled in inactive / unemployed subjects compared to non-manual workers (OR 2.34; OR 95% CI 1.66 – 3.32), whilst those who wore spectacles had a five-fold increase of hypermetropia compared with those not using glasses (OR 5.50; OR 95% CI 4.11 – 7.38). In comparison with those subjects who were literate, persons who could not read / write had increased odds of hypermetropia (OR 1.32; OR 95% CI 1.19 – 1.46) whereas those who were semi-literate were less likely to be hypermetropic (OR 0.82; OR 95% CI 0.69 – 0.97). Similarly, persons who lived in rural areas had reduced odds of hypermetropia (OR 0.87; OR 95% CI 0.77 – 0.97) compared to those from urban settings.

Results

Table 6.6.4. Uni-variate analysis of socio-demographic and ocular variables associated with myopia and hypermetropia (n=11,221).

Risk Factor	Emmetropic subjects >-0.5 to <0.5 D SE n	Myopia subjects ≤-0.5 D SE n	Myopia Odds Ratio (OR 95% CI)	Hypermetropic subjects ≥+0.5 D SE n	Hypermetropia Odds Ratio (OR 95% CI)
Gender					
Female	2,824	1,240	0.85 (0.77 – 0.93)	1,656	1.73 (1.57 – 1.90)
Male	2,962	1,534	1.00	1,005	1.00
Age groups					
30 – 39 years	3,252	1029	1.00	550	1.00
40 – 49 years	1,653	426	0.814 (0.718 – 0.93)	871	3.12 (2.76 – 3.52)
50 – 59 years	546	389	2.25 (1.94 – 2.61)	727	7.87 (6.82 – 9.08)
60 – 69 years	255	524	6.49 (5.51 – 7.66)	397	9.21 (7.68 – 11.04)
70 years and older	80	406	16.04 (12.49 – 20.59)	116	8.57 (6.36 – 11.56)
Residence					
Rural	4,683	2,280	1.09 (0.97 – 1.23)	2,093	0.87 (0.77 – 0.97)
Urban	1,103	494	1.00	568	1.00

(continued)

Results

Table 6.6.4. Uni-variate analysis of explanatory socio-demographic and ocular variables for myopia and hypermetropia (n=11,221).

Risk Factor	Emmetropic subjects >-0.5 to <0.5 D SE n	Myopia subjects ≤-0.5 D SE n	Myopia Odds Ratio (OR 95% CI)	Hypermetropic subjects ≥+0.5 D SE n	Hypermetropia Odds Ratio (OR 95% CI)
Literacy					
Illiterate	2,526	992	1.5 (1.36 – 1.66)	1,366	1.32 (1.19 – 1.46)
Semi-literate	658	313	1.24 (1.06 – 1.45)	221	0.82 (0.69 – 0.97)
Literate	2,582	1,460	1.00	1,059	1.00
Occupation					
Inactive / Unemployed	100	280	6.69 (4.92 – 9.10)	102	2.34 (1.66 – 3.32)
Manual	5,315	2,339	1.05 (0.86 – 1.28)	2,398	1.04 (0.85 – 1.26)
Non-manual	363	152	1.00	158	1.00
Spectacles					
Yes	70	106	3.24 (2.37 – 4.45)	168	5.5 (4.11 – 7.38)
No	5,716	2,668	1.00	2,493	1.00
Cataract					
Grade 2A, 2B or 3	117	971	5.66 (4.22 – 7.58)	268	0.89 (0.66 – 1.20)
Grade 0 or 1	150	220	1.00	385	1.00

Results

Finally, binary logistic regression analyses were carried out with myopia and hypermetropia as the dependent variables in the respective models. The explanatory predictor variables in the analyses were those factors shown to be statistically significantly related to myopia and hypermetropia in the univariate analyses already discussed.

When controlling for other explanatory variables in the myopia model, older persons (especially amongst those 60 years and older), difficulty with reading / writing or being illiterate and being a spectacle wearer were statistically significantly associated with myopia (Table 6.6.5). Similarly, hypermetropia was associated with several predictor variables, including female gender, urban residence, older age groups and wearing spectacles, when controlling for other variables in the regression model. However, when compared with literate subjects, those with difficulty reading / writing had reduced odds of being hypermetropic (Table 6.6.6).

Results

Table 6.6.5. Binary logistic regression model results for myopia.

Variable	β	Wald χ^2	P-value	Odds ratio (OR)	OR 95% CI
Age groups					
40-49 years	-0.230	12.3	<0.001	0.79	0.69 – 0.90
50-59 years	0.754	95.9	<0.0001	2.13	1.83 – 2.47
60-69 years	1.786	409.5	<0.0001	5.96	5.02 – 7.09
70 years and older	2.621	351.8	<0.0001	13.75	10.45 – 18.08
Difficulty reading / writing	0.211	6.0	0.014	1.24	1.04 – 1.46
Illiteracy	0.219	13.8	<0.001	1.25	1.11 – 1.40
Wearing spectacles	0.973	30.9	<0.0001	2.65	1.88 – 3.73

Results

Table 6.6.6. Binary logistic regression model results for hypermetropia.

Variable	β	Wald χ^2	P-value	Odds ratio (OR)	OR 95% CI
Urban residence	0.267	16.2	<0.0001	1.31	1.15 – 1.49
Female gender	0.801	201.7	<0.00001	2.23	1.99 – 2.49
Age groups					
40-49 years	1.19	342.0	<0.0001	3.29	2.90 – 3.73
50-59 years	2.16	792.1	<0.0001	8.63	7.42 – 10.02
60-69 years	2.35	558.7	<0.0001	10.49	8.63 – 12.75
70 years and older	2.35	190.8	<0.0001	10.50	7.50 – 14.60
Difficulty reading / writing	-0.352	13.4	<0.001	0.70	0.58 – 0.85
Wearing spectacles	1.174	54.7	<0.0001	3.23	2.37 – 4.41

Results

Spectacle coverage

Due to the high levels of myopia and hypermetropia identified in the BNBLVS, as reported above, further analysis concerning the presence of spectacles – or lack thereof – amongst survey subjects was undertaken. Use of spectacles for distance vision was reported by 461 persons (4.0% of all examined subjects). Of these, 262 (56.8%) had presenting bilateral visual acuity $\geq 6/12$, 70 (15.2%) had $\geq 6/12$ in the better eye whilst 129 subjects (28.0%), despite wearing glasses, had vision $< 6/12$ bilaterally. Thus, in total, 332 of the spectacle wearers (72.0%) achieved vision $\geq 6/12$ in the better eye. However, more than one-quarter of those wearing glasses were bilaterally visually impaired, due to inadequate refractive correction and/or presence of concomitant ocular disease, eg cataract, age-related macular degeneration, diabetic retinopathy – conditions which may have developed (or worsened) after having been issued the spectacles being worn at the time of the survey. To determine the extent to which the need for spectacles was fulfilled, the levels of ‘met’ and ‘unmet’ need were determined. Compositely, spectacle coverage within the sample was therefore determined. As above, 332 persons of the spectacle wearers had presenting visual acuity in the better eye $\geq 6/12$. This sub-group corresponds to those having had their need for refractive correction adequately met (‘met need’). A further sub-group, comprised of 1,048 subjects with $< 6/12$ presenting visual acuity, improved to $\geq 6/12$ in the better eye upon having their visual acuity re-tested with trial lenses. This sub-group corresponded to those with ‘unmet need’. Accordingly, spectacle coverage was calculated as being 19.9% (95% CI: 17.1% – 23.0%) overall. By gender, it was noted that spectacle coverage was higher for males (28.8%; 95% CI: 25.3% - 32.5%) than females (19.9%; 95% CI: 17.1% - 23.0%); this difference in proportions was statistically significant at $P < 0.001$.

Table 6.6.7 indicates the socio-demographic variables associated with ‘met’ and ‘unmet’ needs for spectacles within the sample. Specifically, the results presented highlight disproportionately higher levels of unmet need for spectacles among females, older persons (from 50 years onwards), those living in rural areas, persons who were semi-literate or illiterate as well as inactive / unemployed individuals and those in manual occupations. These

Results

sub-groups within the Bangladeshi population were shown to have high levels of need for spectacles given that more than 80% of such subjects achieved $\geq 6/12$ vision in the better eye upon being re-tested with trial lenses. In all but one of the aforementioned higher risk sub-groups (inactive / unemployed subjects), unmet need exceeded 80%, eg amongst the rural population 84.3% of the need for spectacles was unmet due to a lack of spectacle use.

Finally, in relation to the visual acuity of those persons wearing spectacles (Table 6.6.8), it merits pointing out that many subjects who wore glasses were not achieving $\geq 6/12$ vision in the better eye. The inadequacy of the spectacles being used was most notable amongst older persons (aged 60 years and older), those from rural areas, semi-literate and illiterate subjects, inactive / unemployed persons as well as manual workers.

Results

Table 6.6.7. Association of socio-demographic variables with ‘met’ and ‘unmet’ need for spectacles (n = 1,380).

Risk Factor	Wears spectacles ≥6/12 in the better eye <i>‘Met need’</i> n (%)	Does not wear spectacles With re-testing, ≥6/12 in the better eye <i>‘Unmet need’</i> n (%)	Odds Ratio (OR 95% Confidence Interval) of <i>‘Unmet Need’</i> for Spectacles
Gender			
Female	146 (19.9)	588 (80.1)	1.63 (1.26 – 2.11)
Male	186 (28.8)	460 (71.2)	1.00
Age groups			
30 – 39 years	54 (44.3)	68 (55.7)	1.00
40 – 49 years	96 (34.5)	182 (65.5)	1.51 (0.98 – 2.33)
50 – 59 years	76 (19.5)	314 (80.5)	3.28 (2.12 – 5.08)
60 – 69 years	77 (19.7)	314 (80.3)	3.24 (2.09 – 5.01)
70 years and older	29 (14.6)	170 (85.4)	4.66 (2.74 – 7.92)
Residence			
Rural	169 (15.7)	906 (84.3)	6.15 (4.66 – 8.13)
Urban	163 (53.4)	142 (46.6)	1.00
Literacy			
Literate	261 (49.7)	264 (50.3)	1.00
Semi-literate	23 (18.4)	102 (81.6)	4.38 (2.70 – 7.11)
Illiterate	48 (6.6)	680 (93.4)	14.01 (9.98 – 19.66)

(continued)

Results

Risk Factor	Wears spectacles ≥6/12 in the better eye <i>'Met need'</i> n (%)	Does not wear spectacles With re-testing, ≥6/12 in the better eye <i>'Unmet need'</i> n (%)	Odds Ratio (OR 95% Confidence Interval) of <i>'Unmet Need'</i> for Spectacles
Occupation			
Inactive / Unemployed	47 (30.5)	107 (69.5)	7.10 (4.03 – 12.51)
Manual	207 (18.4)	915 (81.6)	13.79 (8.58 – 22.18)
Non-manual	78 (75.7)	25 (24.3)	1.00

Results

Table 6.6.8. Association of socio-demographic variables with visual acuity ($\geq 6/12$ v $< 6/12$) amongst spectacle users (n = 461).

Risk Factor	Wears spectacles $\geq 6/12$ in the better eye n (%)	Wears spectacles $< 6/12$ in the better eye n (%)	Odds Ratio (OR 95% Confidence Interval) Spectacle wearer having $\geq 6/12$ VA in better eye
Gender			
Female	146 (70.5)	61 (29.5)	1.00
Male	186 (73.2)	68 (26.8)	1.14 (0.76 – 1.72)
Age groups			
30 – 39 years	54 (87.1)	8 (12.9)	1.00
40 – 49 years	96 (92.3)	8 (7.7)	1.78 (0.63 – 5.00)
50 – 59 years	76 (88.4)	10 (11.6)	1.13 (0.42 – 3.04)
60 – 69 years	77 (62.6)	46 (37.4)	0.25 (0.11 – 0.57)
70 years and older	29 (33.7)	57 (66.3)	0.08 (0.03 – 0.18)
Residence			
Rural	169 (63.8)	96 (36.2)	1.00
Urban	163 (83.2)	33 (16.8)	2.81 (1.79 – 4.40)
Literacy			
Literate	261 (83.1)	53 (16.9)	1.00
Semi-literate	23 (63.9)	13 (36.1)	0.36 (0.17 – 0.75)
Illiterate	48 (43.2)	63 (56.8)	0.16 (0.09 – 0.25)

(continued)

Results

Risk Factor	Wears spectacles ≥6/12 in the better eye n (%)	Wears spectacles <6/12 in the better eye n (%)	Odds Ratio (OR 95% Confidence Interval) Spectacle wearer having ≥6/12 VA in better eye
Occupation			
Inactive / Unemployed	47 (51.6)	44 (48.4)	0.04 (0.01 – 0.14)
Manual	207 (71.9)	81 (28.1)	0.97 (0.03 – 0.32)
Non-manual	78 (96.3)	3 (3.7)	1.00

Results

6.7 Prevalence of low vision and the need for rehabilitation services

In order to determine those subjects whose visual impairment in the better eye was due to low vision not remediable by means of surgery or refractive correction – as per the WHO definition for those with low vision – several related database queries were performed. Initially those subjects with vision $\geq 6/12$ in the better eye (ie the 9,104 ‘Green cards’) were identified and excluded from further analysis concerning low vision prevalence and causes. Next, the visual acuity and causes of those subjects with vision $< 6/12$ in the better eye (ie the 2,518 ‘red cards’) were determined. (Two additional subjects, both elderly individuals, had presenting vision $< 6/12$, though the causes of visual impairment in these subjects were not elucidated due to only partial ophthalmic examinations, without refractive correction, having been carried out at household level.)

A further 162 individuals who were blind bilaterally, based on presenting visual acuity testing results, were also excluded from further analysis dealing with low vision prevalence. Likewise, the 1,614 subjects with visually-impairing cataract (due to obscuration of more than half the red reflex, ie 2B and 3, according to the Mehra-Minassian cataract grading system)¹⁷⁴ in the better eye were disregarded from further analysis on account of not fulfilling the criteria for having low vision. This exclusion criterion for low vision is predicated on the assumption that the vision in those subjects would have improved to better than 6/18 following cataract surgery, when combined with implantation of an IOL and/or with the correct post-surgical refractive correction. Similarly, 608 subjects with refractive error were also excluded from the analysis of the prevalence and causes of low vision due to these subjects having achieved a $\geq 6/18$ corrected visual acuity upon re-testing with trial lenses.

Of the remaining 229 subjects with presenting vision in the better eye ranging from $< 6/18$ to perception of light (PL) not due to visually-impairing cataract and/or refractive error, the corrected VA in 164 of these improved to $\geq 6/18$ when re-tested. Therefore, following the aforementioned exclusions of subjects not fulfilling the criteria for low vision, a total of 67 subjects (35

Results

females, 32 males) were identified as having corrected visual acuity $<6/18$ to the perception of light (PL), ie low vision, due to causes other than advanced cataract and/or refractive error. This corresponds to a low vision prevalence of 0.58% (95% CI 0.46% – 0.74%) within the nationally representative survey sample, the causes of which are presented in Table 6.7.1.

The crude prevalence of low vision for females (0.59%; 95% CI 0.044% – 0.83%) was higher than that for males (0.54%; 95% CI 0.40% – 0.77%). Overall an increase in the age group-specific prevalence for low vision was noted, (similar to that observed for blindness prevalence, presented in Section 6.2) whereby an approximate exponential increase exists for those affected with low vision, most notably from age 60 years of age and older (Figure 6.7.1).

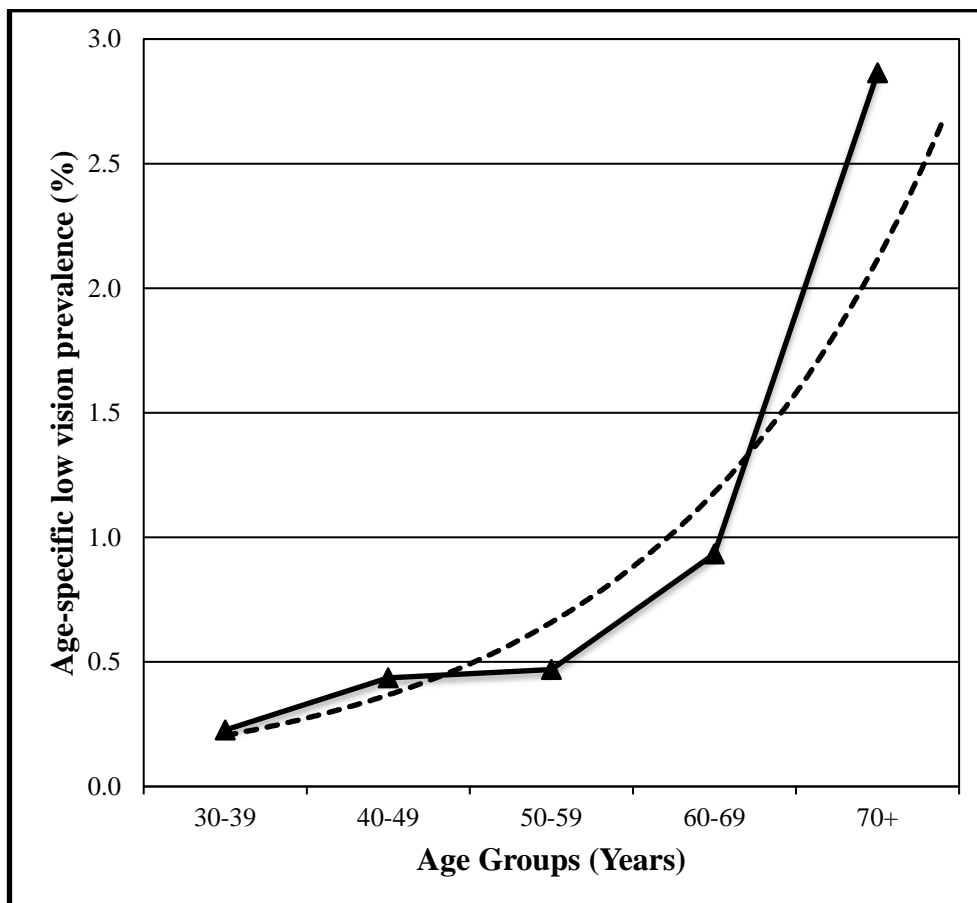


Figure 6.7.1. Age group-specific low vision prevalence (n = 67).

Further analysis identified that the age-sex standardised low vision prevalence was similar though somewhat higher than the aforementioned

Results

crude prevalence (0.61% v 0.58%), based on direct standardisation of the survey results to Bangladesh Bureau of Statistics national population data.¹⁵⁶ The minor increase in the age-sex standardised prevalence is likely due to a slightly older national population compared with that of the sample population as a result of minor sampling error. (Figure 6.7.2). Finally, age-sex standardisation for low vision prevalence was higher for females than males, based on the survey findings (0.61% v 0.51%).

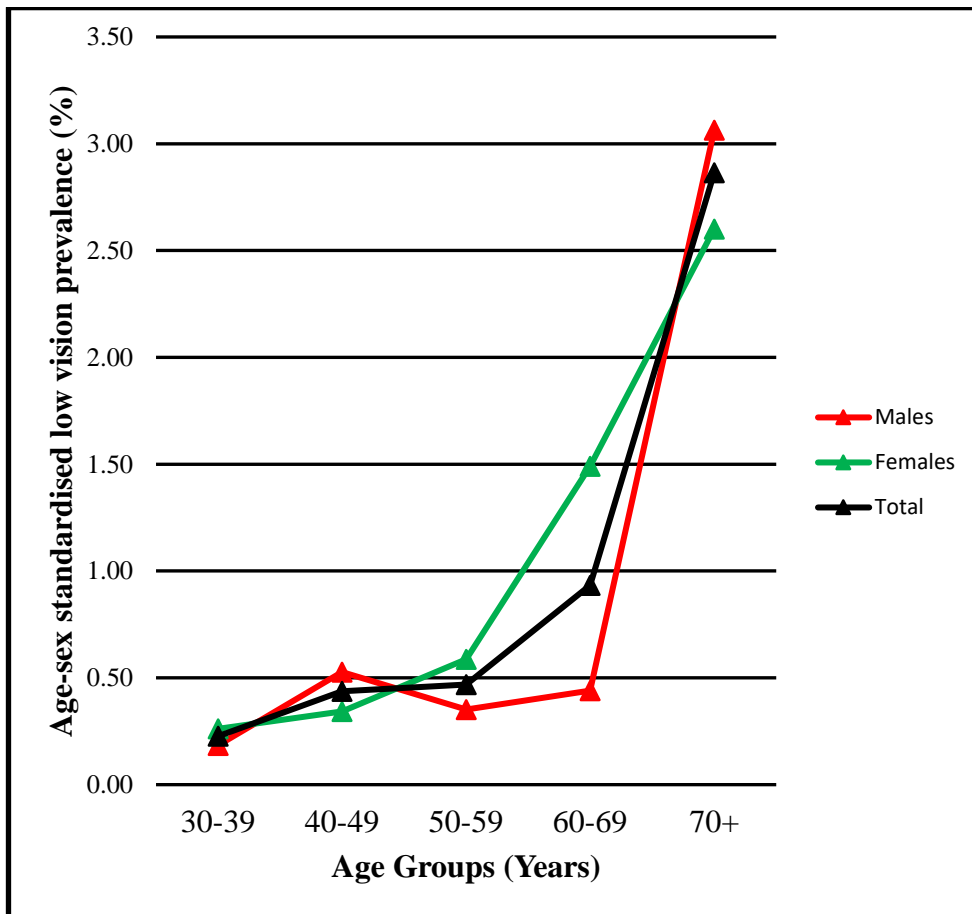


Figure 6.7.2. Age-sex standardised low vision prevalence (n = 67).

In terms of the causes of low vision, the most prominent was ‘severe refractive error’, corresponding to those subjects who did not achieve $\geq 6/18$ vision in the better eye upon being re-tested with the appropriate refractive correction trial lenses. This sub-group of low vision subjects was comprised of individuals with either no evidence of lens opacity (Grade 0) or a small opacity, assessed as covering less than half of the red reflex (Grades 1 and 2A). No other cause of low vision was identified in these subjects (9 females, 9 males).

Results

Table 6.7.1. Causes of low vision in the Bangladesh National Blindness and Low Vision Survey (n=67).

Cause	Frequency	Percentage
Severe refractive error	18	26.9
Macular degeneration	14	20.9
Retinal diseases	10	14.9
Optic nerve damage	9	13.4
Corneal diseases	7	10.4
Other ocular conditions	5	7.5
Amblyopia	4	6.0
Total	67	100.0

Based on the automated refraction results, the majority of the low vision cases with severe refractive error were myopic (mean spherical equivalent right eye $\bar{X} = -2.71$; spherical equivalent left eye $\bar{X} = -2.60$). Notably only one individual was hypermetropic amongst those with severe refractive error as the cause of low vision. Despite undergoing visual acuity re-testing with the appropriate refractive correction this individual did not attain $\geq 6/18$ vision, as was the case for all others in this sub-group of low vision subjects.

As presented in Table 6.7.1, macular degeneration, the second most common cause of low vision, accounted for one-fifth of the cases in the survey. Retinal conditions – including chorioretinitis (four cases), macular scars and retinitis pigmentosa (two cases each), amongst other retinal diseases – were responsible for approximately 15% of the low vision cases. A further nine cases of low vision (13.4%) were due to optic nerve conditions, including optic atrophy (six cases) as well as one each of glaucoma, optic nerve hypoplasia and retrobulbar neuritis.

Corneal conditions, mainly corneal opacities associated with previous history of corneal ulcers, were identified in seven low vision subjects followed by amblyopia, which was responsible for four cases. Five subjects with low vision were identified due to ‘Other causes’, including two due to vitreous opacities, one posterior capsule opacification following cataract surgery not remediable to refractive correction and two indeterminate cases of low vision.

Results

Uni-variate analysis was undertaken to determine those variables that were associated with having low vision. The variables included in the series of cross-tabulations were: sex; administrative Division; rural / urban residence; literacy status; type of work, if any; religion and age of the subject.

Following cross-tabulation of each one of these variables with the binomial variable for low vision cases (Yes / No), a number of those proposed explanatory predictor variables were shown not to be associated with low vision status compared to those without low vision. As such, there was no difference in the proportion of subjects in one (or more) categories of the predictor variables with low vision status compared to the proportion of persons without low vision for those same potential predictors (Table 6.7.2).

These variables shown not to be associated with low vision status were sex of the subject; rural / urban residence and religion. Alternatively, not being able to read and, separately, being labourally inactive / unemployed were both statistically significantly associated with having low vision. The odds of having low vision were increased among those who were illiterate (OR 2.7; 95% CI 1.5 – 4.9) compared to those who were literate. Likewise, the odds of having low vision were several times higher amongst those who were inactive / unemployed (OR 19.0; 95% CI 2.5 – 142.8) compared to those who were employed in a non-manual position. These results are summarised in Table 6.7.2. It merits pointing out that due to the cross-sectional nature of this epidemiological study, it is not possible to ascertain whether having low vision was a precursor or a consequence of not being able to read or, separately, not being employed at the time of the survey.

In terms of the cross-tabulation of low vision cases by administrative Division of residence, a borderline though non-significant chi-square result ($P= 0.072$) was obtained. Sylhet was shown to have the highest percentage of low vision cases (1.31%) compared to much lower levels in Rajshahi and Dhaka Divisions (both at 0.43%), Khulna and Barisal (0.56% and 0.63%, respectively) as well as for that of Chittagong (0.77%). Binary logistic regression analysis – with administrative Division as the single explanatory variable – indicated a three-fold increase (OR=3.0; 95% CI= 1.27 – 7.21) in

Results

the odds of low vision for a case being from Sylhet compared with Rajshahi. This latter location was selected as the reference category Division in the statistical model due to it having the lowest prevalence for low vision (jointly with Dhaka).

Table 6.7.2. Uni-variate cross-tabulation results for low vision cases, by selected categorical explanatory variables (n=11,624).

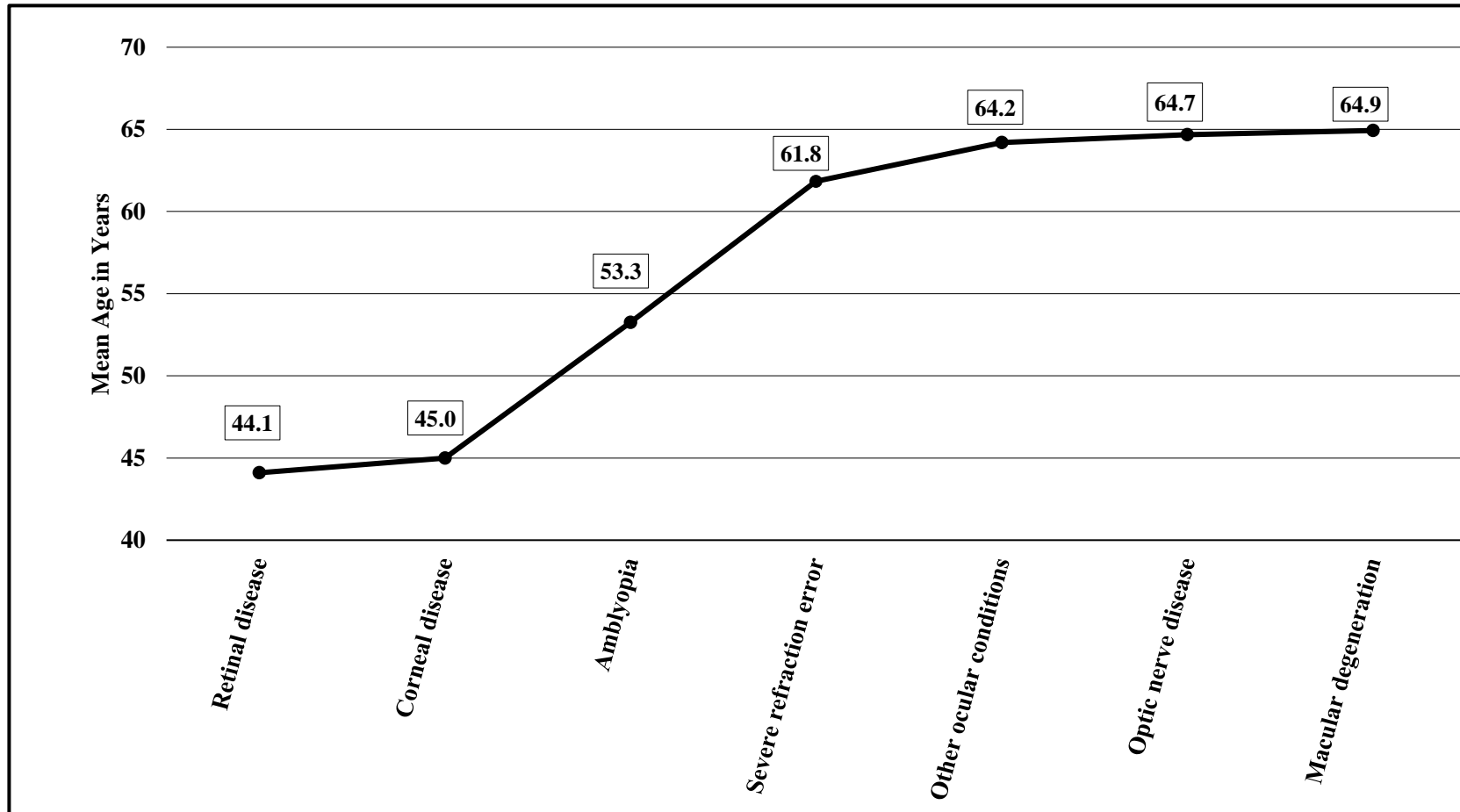
Variable	Low vision (%)	P-value	Odds Ratio (OR 95% CI)
Sex			
Female	0.59		1.00
Male	0.56	0.85	0.96 (0.59 – 1.54)
Residence			
Rural	0.60		1.00
Urban	0.48	0.54	0.82 (0.43 – 1.56)
Division			
Barisal	0.63		1.45 (0.51 – 4.12)
Chittagong	0.77		1.76 (0.83 – 3.72)
Dhaka	0.44		0.99 (0.47 – 2.09)
Khulna	0.56		1.28 (0.52 – 3.15)
Rajshahi	0.44		1.00
Sylhet	1.31	0.07	3.02 (1.27 – 7.21)*
Literacy status			
Easily reads	0.30		1.00
Reads with difficulty	0.66		2.2 (0.93 -5.32)
Illiterate	0.80	0.003	2.7 (1.48 – 4.93)*
Work status			
Inactive / Unemployed	2.80		19.01 (2.53 – 142.80)*
Manual	0.47		3.10 (0.43 – 22.48)
Non-manual	0.15	<0.0001	1.00

Note: * Sub-group of explanatory variable that is associated with low vision via uni-variate binary logistic regression.

The distribution of the low vision subjects by mean age, according to category of cause, is shown in Figure 6.7.3.

Results

Figure 6.7.3. Mean age of low vision subjects, by cause (n = 67).

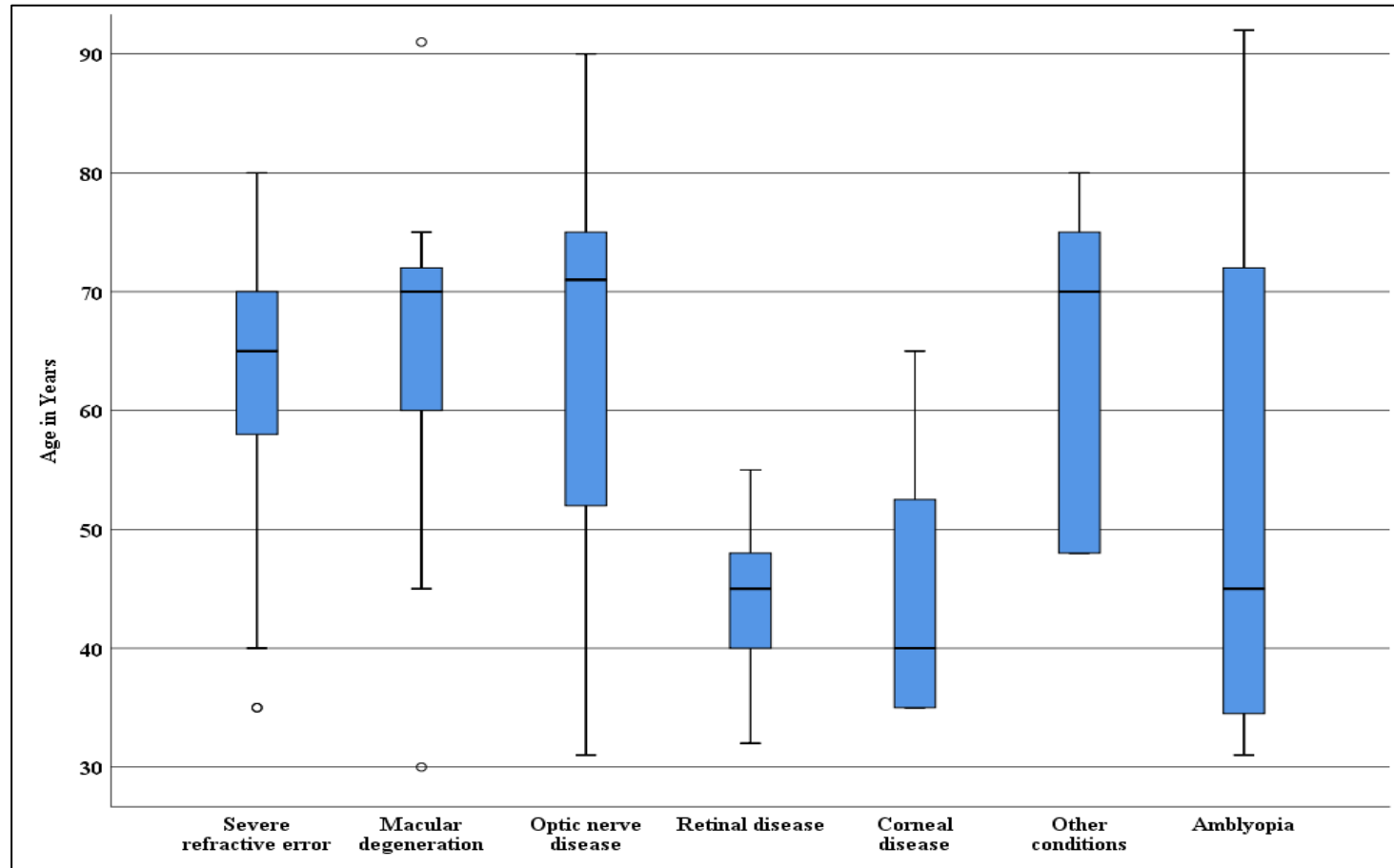


Results

Those subjects with low vision were substantially older ($\bar{X}=58.1$ years) compared with all other subjects in the survey ($\bar{X}=45.1$ years); this difference was statistically significant ($t = 7.94$, $P<0.0001$; mean difference 13.0 years; 95% CI 9.8 – 16.2 years). When comparing low vision subjects with those persons with presenting vision in the better eye $<6/12$ (ie the other so-called ‘Red Cards’), no statistically significant difference in age ($\bar{X}=58.1$ v $\bar{X}=59.7$ years) was identified ($t = 0.92$, $P=0.36$; -1.6 years; 95% CI -5.0 – 1.8 years). However, it was noted that low vision subjects were, on average, more than ten years younger than the group of subjects with corrected vision in the better eye $<6/18$ who were not low vision cases ($\bar{X}=58.1$ v $\bar{X}=68.8$ years). This difference was statistically significant ($t = 5.9$, $P<0.0001$; -10.6 years; 95% CI: -14.2 to -7.1 years).

Results

Figure 6.7.4. Mean age of subjects with low vision, by category (n = 67).



Results

As indicated in Figures 6.7.3 and 6.7.4 the mean ages of subjects varied according to the low vision cause categories, with those who had either retinal (\bar{X} =44.1 years) or corneal diseases (\bar{X} =45.0 years) being on average the youngest sub-groups. Alternatively, those with macular degeneration, optic nerve disease or ‘Other’ conditions were, on average, the eldest sub-groups, ie each greater than 64 years of age, followed by those with severe refractive error (\bar{X} =61.8 years). Univariate analysis, as per one-way ANOVA, identified a statistically significant association between age and category of low vision cause ($F = 3.4, P=0.006$). Furthermore, *post hoc* analysis identified significant differences in the mean ages for both retinal and corneal diseases from four of the other low vision categories, although not from amblyopia (Table 6.7.3).

Table 6.7.3. *Post hoc* comparative analysis of mean age, by low vision category.

Ocular Condition	Retinal diseases		Corneal diseases	
	Mean difference (Years)	P-value	Mean difference (Years)	P-value
Macular degeneration	20.8	0.002	19.9	0.006
Optic nerve disease	20.6	0.005	19.7	0.013
Other ocular conditions	20.1	0.019	19.2	0.035
Severe refractive error	17.7	0.004	16.8	0.016
Amblyopia	9.1	0.314	8.3	0.391

Note: LSD *post hoc* multiple comparison method utilised.

Results

Based on the aforementioned uni-variate analyses (binary logistic regression and t-test), a multi-variable logistic regression model was developed using the categorical explanatory variables (Division, work status and literacy level) in addition to ‘age in years’ as possible predictors for low vision (Table 6.7.4).

Whilst controlling for the other variables in the logistic regression model, age was confirmed as being associated with having low vision, ie for every additional year of age, the odds of having low vision increased by a factor of 3.8% (95% CI 1.020 – 1.057). The logistic regression analysis also indicated that the odds of having low vision were 2.7 times greater in Sylhet Division, when controlling for other variables in the model. Likewise, illiteracy was associated with an approximate doubling (OR=1.89) of the odds of having low vision compared to those who could read, either easily or with some degree of difficulty.

Table 6.7.4. Results of the multi-variable logistic regression model for predicting low vision cases.

Variable	β	Wald χ^2	P-value	Odds Ratio	OR 95% CI
Age	0.038	17.68	<0.0001	1.038	1.02 – 1.06
Sylhet Division	1.011	5.13	0.024	2.749	1.15 – 6.59
Illiterate	0.640	3.92	0.048	1.897	1.01 – 3.58

Finally, the estimated magnitude of low vision cases in Bangladesh was derived by extrapolating the age-sex standardised prevalence results to the national population of the country. Thus, approximately 256,000 persons aged 30 years and older were estimated to have low vision, and would potentially benefit from having access to low vision services and use of appropriate sight-enhancing devices.

7.0 Discussion

7.1 Overview of the Discussion Chapter

This section outlines the salient findings from the Results chapter, according to the focus of the analysis, eg prevalence of blindness. Discussion of the relevant implications of the epidemiological findings as well as comparisons with similar studies will be presented. Finally, a profile of the eye care services strategies – both globally and in Bangladesh – will be discussed in light of the need for further development of the eye care services in the country with increased emphasis of enhanced implementation of the Vision 2020 initiative.

7.2 Prevalence and causes of blindness and visual impairment

The Bangladesh National Blindness and Low Vision Survey (BNBLVS) was the first comprehensive, nationally representative study on the prevalence and causes of blindness and low vision in Bangladeshi adults. By conducting the BNBLVS, the dearth of vital epidemiological evidence concerning blindness prevalence and its causes in the country was redressed. The information obtained through this survey has been indispensable for the subsequent rational planning and implementation of organised eye care service delivery – particularly that focused on cataract surgical services – in Bangladesh.

Prevalence and causes of blindness and visual impairment

Prior to the national blindness and low vision survey undertaken in Bangladesh, no national data existed on the number of visually impaired persons in the country or at the level of any of the six administrative Divisions. Likewise, the relative contribution of specific causes of blindness within the adult population were unknown – a critical paucity of information concerning the epidemiological profile of blindness and low vision. Effectively, only three small studies had previously been conducted, dating between 1976 and 1993, with all-age blindness prevalence figures of 1.50%,¹⁶ 0.94%,¹² and 0.56%¹³ having been reported. With cataract identified as the principal cause of blindness in adults (eg 72.5% in rural Kishoreganj District in those 40 years and older),¹⁶ these surveys estimated the magnitude of blindness to range from 530,000 to 1.3 million adults. Notably the national population during those years was substantially smaller (eg 75.7 million in 1976) and life expectancy was approximately only 50 years of age.^{12-13,16,202}

The age-sex standardised prevalence of blindness in the BNBLVS was calculated at 1.53% (95% CI 1.29-1.77%) amongst the 11,624 persons aged 30 years and older that were examined. An exponentially increasing trend in age-specific blindness prevalence, according to 10-year age groups, was identified with blindness prevalence increasing most markedly from aged 50 years and older. Blindness was also found to be more prevalent amongst women, illiterate subjects, and in economically disadvantaged persons. These findings are similar to those reported elsewhere in southern Asia, in numerous

Discussion

studies from India,^{147,157-158,203-204} Myanmar,²⁰⁵ Nepal,^{2,206} Pakistan,^{3,92} Sri Lanka,²⁰⁷ Myanmar.²⁰⁸ Notably, the age-sex standardised blindness prevalence for females (2.11%; 95% CI 1.70% - 2.52%) was nearly double that of males (1.06%; 0.79% – 1.33%), a finding that has been reported upon elsewhere in South Asia.²⁰⁹⁻²¹³

Based upon the blindness prevalence estimate obtained in this survey, by extrapolation to the national target population of Bangladeshi adults aged 30 years and older, it is estimated that there were approximately 650,000 adults (95% CI 552,175 – 740,736) blind due to cataract in the country at the time of the survey. Assuming the annual incidence of blinding cataract cases to be one-fifth of the prevalent cases,^{75,88} a further 130,000 new cases were estimated to have developed within a year of completion of the survey. Similarly, by extrapolation, there were an estimated 6.65 million (95% CI 6.94 – 7.23 million) adults with moderate or severe visual impairment (<6/12 vision in either or both eyes).

Importantly, from a public health, community ophthalmology perspective, cataract was identified as the major cause (79.6%) of bilateral blindness; this figure was one of the highest ever reported from a nationally representative, population-based study. One key explanation for the preponderance of cataract as the primary cause of blindness was the very low cataract surgical output in Bangladesh, ie less than one-third of that required to meet the existent treatment need - both the prevalent and annually incident cases – as substantiated by cataract surgical coverage data (Section 6.4).

As with the BNBLVS, each of the twelve Bangladesh RAAB surveys, carried out between 2006 – 2013, identified cataract as the main cause of blindness, being responsible for at least half of all blindness cases across the various sub-District communities surveyed.²¹⁴⁻²¹⁹ Whereas the lowest proportion of blindness due to cataract was in Jamalpur District (52.6%), studies conducted in three other sub-Districts reported it to be greater than 80% (Figure 7.2.1).

In terms of blindness prevalence in those aged 50 years and older due to any ocular condition, variation in the age-sex standardised results also existed in

Discussion

the RAAB studies, ranging from 0.56% in Brahmanbaria District, which adjoins Dhaka, to as high as 4.88% in the remote area of Cox's Bazar. Overall, blindness prevalence in those 50 years and older in five of the RAAB studies (ranging from 3.10% – 4.88%) were similar to the 3.95% prevalence in persons 50 years and older in the BNBLVS, whilst the reported prevalence was notably lower in the remaining seven RAAB studies (Figure 7.2.1).

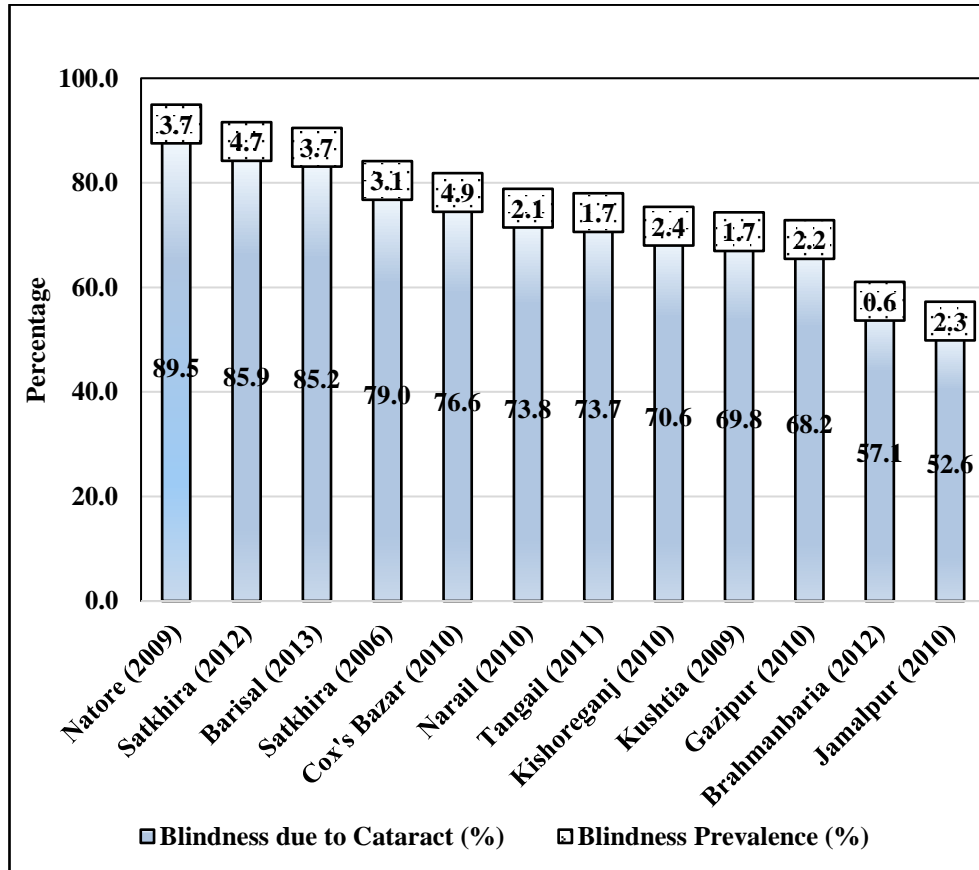


Figure 7.2.1. Results of blindness prevalence (%) and blindness due to cataract (%) from RAAB studies conducted in Bangladesh, by District and year of survey (n =12).

A systematic review on the global and regional causes of blindness and visual impairment, based on studies conducted from 1990 to 2010, reported that the principal ocular condition associated with blindness was cataract.¹²⁰ Whilst the proportion of blindness due to cataract as a cause of blindness did in fact reduce over this period, it nonetheless remained the major cause in all but the most developed world regions, eg. Australasia, North America. The predominance of blinding cataract was shown to vary across the 21 WHO-recognised geographical regions. For instance, in the countries of the South

Discussion

Asia region cataract was responsible for nearly half (47.7%) of all blindness in 1990; this level was substantially higher than in more developed regions such as Western Europe (19.2%) where cataract was less prevalent as a cause of blindness and visual impairment. By 2010, though cataract continued to be the main cause of blindness, the proportion of vision loss due to this age-related condition had decreased globally (38.6% to 33.4%), including within the South Asia region (41.7%). Reduction in cataract blindness had been brought about through eye care services programme initiatives (eg outreach screening), enhanced financial investments in staff, training and equipment leading to overall expansion of cataract surgical services in high prevalence countries such as India and Nepal.

Further systematic reviews of the epidemiology of global vision impairment and blindness have been conducted recently.^{122,220} As reported in 2015 by the Vision Loss Expert Group of the Global Burden of Disease Study, at least 32.4 million persons were bilaterally blind while 191 million were moderately or severely visually impaired, with women comprising the majority of both categories of impaired vision (60% and 57%, respectively).¹²⁹ Overall, 10.8 million blind persons and a further 35.2 million moderately or severely visually impaired individuals were affected by cataract. Compared with population-based data from 1990,⁷³ the number of cataract blind persons in 2010 had reduced by 11.4% (from 12.3 million) while visual impairment caused by cataract had undergone an even further diminution (20.2%) globally. Other reviews posit that as many as 45 million persons may be bilaterally blind with a further 250 – 300 million persons moderately (<6/18) or severely visually impaired (<6/60) in the better eye.²²¹⁻²²²

Despite the variation in estimates of the worldwide magnitude of blindness, a clear consensus exists concerning cataract as the principal cause of blindness, most especially in developing countries. In India alone, at least 9.9 million persons aged 50 years and older are estimated to be blind due to bilateral cataract.²²³ This situation persists despite a co-ordinated national blindness prevention and control programme that has over the past three decades

Discussion

developed to the extent that annually over six million sight-restoring surgeries are carried out within the country.^{124-125,224}

In 2017, a follow-up systematic review by the VLEG-GBD research collaboration included an additional 61 recent blindness prevalence studies. This up-dated report estimated there to be 36 million bilaterally blind persons with a further 217 million visually impaired individuals globally. The increase of 3.6 million persons blind from the estimate developed five years previously was attributable to on-going population growth and increased ageing,²²⁵ both of which are notably present within the South Asia region, including Bangladesh.

Overall, from 1990 to 2015, it is estimated that the number of blind persons globally had increased by approximately 18.0% (from 30.6 to 36.0 million), with the vast majority (86%) being aged 50 years and older. Notably, South Asia, along with eastern and western sub-Saharan Africa, were the world regions with the highest age-standardised blindness prevalence results, all being in excess of 4.0% in this age group.²²⁶ Based on the BNBLVS data, the age-sex standardised blindness prevalence was 3.95% at the time of the survey, similar to that reported by the VLEG-GBD group.

However, due to an indeed favourable increase in life expectancy in Bangladesh from 2000 (67 years) to 2015 (73 years), the population of those aged 50 years and older had increased by approximately 72%, from 15.2 to 22.2 million; similarly, the population aged 60 years and older underwent an 81% increase, from 7.5 to 13.6 million persons.²⁴ This being the case in terms of the increase in older persons in Bangladesh, combined with inadequate cataract surgical coverage for those affected by blinding cataract, it is reasonable to infer that a) the number of cataract blind persons may have increased and b) the age-sex standardised prevalence of blindness likely would have increased beyond that identified by the BNBLVS (ie 3.95%).

In order to elucidate the effects of population growth and increased life expectancy on the blindness burden and potential cataract surgical backlog in Bangladesh, modelling of the most recently available data, from 2015,²⁴ was

Discussion

undertaken to estimate the number of blind persons and, of those, how many were blind due to cataract. The derived model was based on an assumed 70% proportion of bilateral blindness being due to cataract – in line with the recent RAAB studies from Bangladesh - together with the official IAPB number of cataract surgeries performed in 2014,²²⁷ corresponding to a CSC of only 24.5%. The results of the model indicate a substantial increase in the cases of blindness – 1.1 million adults aged 30 years and older – of whom more than 750,000 were blind due to cataract. According to the model, the age-sex standardised prevalence of blindness was estimated to be 1.62%, greater than the 1.53% identified in the BNBLVS.

Uncorrected aphakia

Uncorrected aphakia as a cause of blindness typically had arisen due to the inadequate provision, maintenance and/or use of aphakic spectacles following cataract surgery in which an intra-ocular lens was not used for whichever reason. In the BNBLVS, uncorrected aphakia was responsible for blindness in ten subjects (6.2%) of all blindness as well as accounting for 44 (46.3%) of visually impaired post-surgical eyes. Not having and/or not using aphakic spectacles was associated with being female, having undergone surgery in an eye camp rather than a hospital, being illiterate and living in a rural area.

The reason(s) for not using aphakic spectacles amongst the BNBLVS surgical cohort was not elucidated as part of the survey. Post-surgically, at any given point ranging from a matter of months to potentially several years, the aphakic spectacles provided at the time of surgery may have subsequently been damaged, lost or simply not routinely worn. Use of the spectacles may have been voluntarily discontinued if the individual felt that her/his vision was not sufficiently aided by using the glasses,²²⁸⁻²²⁹ a phenomenon that can occur due to on-going ocular changes and/or the development of other pathologies in the operated eye.²³⁰ Secondly, a very low level of intra-ocular lens (IOL) implantation existed in Bangladesh in the years preceding the BNBLVS, as the most common surgical technique pre-survey was the intra-capsular cataract extraction (ICCE) without IOL.¹⁷

Discussion

Over time, a transition away from the ICCE without IOL²³¹ to extra-capsular cataract extraction (ECCE) with IOL surgery has occurred.^{232,233} Latterly manual small incision cataract surgery (MSICS) with IOL has been the principal technique in most developing countries, including India,²³⁴⁻²³⁵ Nepal²³⁶ and – by the early 2000s – in Bangladesh.¹³⁹ Thus, though uncorrected aphakia was the second most important cause of blindness in the BNBLVS, this was not found to be the case in the most of the RAAB studies carried out between 2006 and 2013 in the country due to the transition away from ICCE without IOL to surgeries (ECCE or MSICS) with IOL.²¹⁴⁻²¹⁹

Corneal opacities

Central corneal opacities were identified in 2.24% of visually impaired (<6/12) eyes, were the main cause of low vision in fifteen persons (0.85%) and were the second most common cause of unilaterally blind eyes (9.18%), following cataract. The prevalence of uni-ocular blindness due to a corneal opacity (0.12%) was lower than that reported in Heilongjiang Province, China²³⁷ (0.2%) and in two sites in India, namely Haryana²³⁸ (0.45%) and Hyderabad, India²³⁹ (0.56% at <6/60 level). Several studies have reported on the prevalence of bilateral blindness due to corneal opacities, eg from India (Tirunelveli,²⁰⁹ 1.6%; Aravind,²⁰⁴ 2.0%; Delhi,²⁴⁰ 4.45% and rural Rajasthan¹⁵⁷ 6.1%) and Nepal (Rautahat,²⁴¹ 2.3%; Lumbini / Chetwan,²⁴² 3.8%) and Malaysia²⁴³, (3.4%) – all higher than that in the BNBLVS.

Corneal opacities as a cause of visual impairment in Bangladesh have been reported upon previously, being responsible for 7.5% of bilateral blindness in rural Kishoreganj District¹⁶ and in Satkhira District²¹⁴ (3.5%). Such opacities are aetiologically associated with severe diarrhoeal disease (eg endemic cholera in Bangladesh,²⁴⁴ measles infection, Vitamin A deficiency and subsequent blinding corneal scarring (xerophthalmia).²⁴⁵

Traumatic eye injuries in both childhood and amongst adults²⁴⁶ leading to blinding bacterial and fungal infections of the cornea have also been reported in Bangladesh,²⁴⁷⁻²⁴⁹ and elsewhere in the South Asia region.²⁵⁰⁻²⁵² Ocular injuries in adults were mainly due to agricultural-related incidents, eg rice grain ocular penetrating accidents and industrial exposure.²⁵³⁻²⁵⁴

Discussion

One Bangladeshi study,²⁵⁵ published in 2013, indicated that as much as 2% of the more than 8,000 subjects examined reported having previously suffered an ocular injury, with the most affected parts of the eye being the eyelid, conjunctiva and cornea. Approximately 6% of traumatically injured eyes became blind, mainly due to scarring of the cornea. A notable delay, on average of 18 days, was reported for the time elapsed between when the injury occurred and when professional medical care was sought for the trauma and subsequent loss of vision and/or infection of the eye.

Relatedly, recent evidence from Mymensingh District²⁵⁶ indicated the high levels of antibiotic resistance posed by various bacterial corneal infections (eg 44.1% of *Pseudomonas spp* resistant to Azithromycin), reflecting the ongoing challenges associated with such infections and the increased potential risk for corneal opacification, ulceration and long-term visual impairment / blindness in the absence of adequate early antibiotic treatment and/or surgical repair via keratoplasty. As of 2017, it was estimated that as many as 500,000 persons are in need of transplant surgery for repair of opacification or ulceration of the cornea. Whilst the keratoplasty procedures have increased five-fold since 2009 compared to the amount performed over the previous two decades, still only approximately 500 corneal transplants occur annually despite the much greater need for treatment.²⁵⁷

Glaucoma

Based on a glaucoma prevalence study carried out in Dhaka in 1997–1998, the prevalence of glaucoma in Bangladeshi adults aged 40 years and older was identified as ranging between 2.1% (as defined by increased or asymmetric cup:disc ratio [CDR] readings in combination with ‘definite’ field defects) and 3.1% (based on the presence of CDR abnormalities with ‘definite’ or ‘probable’ field defects).¹⁷⁸ These prevalence figures were higher than that of the BNBLVS (1.2% in persons aged 30 years and older) and from that reported from Nepal (1.7%) in persons 45 years and older. The aforementioned glaucoma survey, on which the author of this dissertation was a co-author, approximately 586,000 Bangladeshi adults 40 years and older

Discussion

were estimated to have glaucoma, though glaucoma as a cause of blindness was estimated to be approximately only 0.60% in those aged 40 and older.

As per a two-decade review of population-based studies on glaucoma prevalence, the VLEG-GBD reported that blindness due to glaucoma had increased in South Asia over the period, 1990 – 2010, from 2.4% to 4.7%; this corresponded to an estimated 72% increase in the number of persons blind due to glaucoma in the region.²⁵⁸ With the observed increased life expectancy and population growth in South Asia,²⁵⁹ including Bangladesh, it would be reasonable to forecast that the prevalence of visually impairing / blinding glaucoma would likewise increase due to the association of progressive sight loss due to glaucoma – particularly when untreated – amongst older individuals.

Diabetic retinopathy

The very low level of diabetic retinopathy as the main cause of visual impairment, ie in only three individuals, is quite notable. Moreover, no subject was found to be blind due to diabetic retinopathy (DR), similar to that reported by the APEDS study in Hyderabad, India.²⁶⁰ However, in the Gazipur District RAAB study in 2010, one person was blind due to DR.²¹⁶

Despite the relatively favourable finding that the prevalence of DR was low within the BNBLVS sample, the situation both within the country and more generally within South Asia is not as optimistic presently. As reported by the GBD-VLEG in 2016, diabetic retinopathy as a cause of blindness (2.8%; 95% CI 1.7 – 4.8%) – representing a 46% increase – was highest in the South Asia region, contributing more than 35% of the global total of persons blind due to this treatable / manageable ocular condition.²⁶¹

Several studies have indicated a markedly increasing trend of Type II diabetes mellitus in the country,²⁶²⁻²⁶⁶ linked to the significant increases in the prevalence of overweight and obesity in recent years.²⁶⁷ Specifically, a systematic review of 17 population-based diabetes prevalence studies in Bangladesh estimated the pooled prevalence of Type II diabetes mellitus to be 6.7% (95% CI: 4.9%–8.6%), being higher in urban areas (10.2%; 95% CI:

Discussion

2.9%–7.3%) than rural communities (5.1%; 95% CI: 6.0%–14.4%).²⁶⁸ Further analyses estimate 7.1 million adults had diabetes as of 2017 with expected further increase to 13.6 million by 2040.²⁶⁹ Unfortunately, access to treatment and medical management of known diabetic is very low, especially in rural areas,²⁷⁰ eg less than half of known diabetics had never had blood sugar retested after being diagnosed.²⁷¹ Another study, amongst more than 850 persons with diabetes, reported that approximately one-third received anti-hyperglycaemic medications for their condition,²⁷² whilst furthermore only 13.0% used adequate medication for their condition.²⁷³ Finally, from an ophthalmological perspective, in a related study amongst Type 2 DM patients, though 81% of participants agreed that uncontrolled diabetes could cause certain complications, only 18.1% were aware of the risk of the retinopathic / ocular complications associated with diabetes over time.²⁷⁴

Finally, it merits pointing out that the increasing prevalence of diabetes mellitus amongst Bangladeshi adults presents additional ocular health consequences beyond that of diabetic retinopathy given that diabetes is a known risk factor for cataract development.²⁷⁵⁻²⁷⁶ As such, the already very high burden of age-related cataract – as previously discussed – may further increase over time by cataractogenic changes in persons with diabetes.²⁷⁶⁻²⁷⁷ Similarly, tobacco use – another known risk factor for development of cataract – is high with a reported prevalence of 39.0% in adult males smoking manufactured cigarettes or *bidis* (hand-rolled cigarettes) or consuming smokeless tobacco.²⁷⁸ Such a high level of tobacco use could itself contribute further to an increase in the incidence of visually impairing cataract.

Unilateral blindness

In addition to the 162 binocularly blind people, a further 313 subjects were found to be unilaterally blind; this corresponds to a unilateral blindness prevalence of 2.69% (95% CI 2.39 to 2.98). The majority of the unilaterally blind (61.0%) subjects had less than 6/12 vision in the other eye. The major causes of blindness in the affected eye were cataract (62.24%), central corneal opacity (9.18%), and phthisical/disorganised or absent globe (6.12%).

Discussion

Numerous surveys on blindness and visual impairment have been conducted over the past approximately 40 years, the majority of these in the South Asia region, especially in India^{147, 157-158, 204} and Nepal.^{241, 279} The impetus to carry out such studies has been to identify the prevalence and main causes of blindness and vision deficit. Additionally, based on the survey results, estimation of the magnitude of blindness within the reference population has been a key objective as a means to determine the level of need for eye care services, eg cataract surgery. Carrying out blindness prevalence surveys coincides with the main pillars of the Global Action Plans of the International Agency for the Prevention of Blindness (IAPB), namely that of establishing the evidence base for the rationale planning, development and implementation of eye care service provision.²⁸⁰⁻²⁸¹

Comparing the BNBLVS survey results with other population-based studies from the South Asia region, it is worth emphasising the similarity that the Bangladeshi results have with those obtained in other surveys several years before, ie with survey results obtained between the 1980s and early 2000s in other South Asia countries. In the case of Nepal, a very large national blindness survey was conducted in 1981 through the auspices of the Seva Foundation, an INGO dedicated to prevention of blindness in developing settings.² The three most pertinent findings from that study were: a) an age-sex standardised blindness prevalence in persons aged 60 years and older of 8.6% (compared to 6.4% in Bangladesh); b) cataract was the main cause (66.8% for all ages, 83% in those aged 45 years and older) and c) an estimated 92% of blind persons in Nepal were from rural areas, similar to that identified in the BNBLVS.

A follow-up regional study of blindness prevalence and cataract surgery was conducted in Nepal in 1995 in order to assess the impact of nearly 15 years of eye care services development following the previous national survey.²⁰⁶ Amongst the 4,602 examined subjects aged 45 years and older, the prevalence of bilateral blindness (VA<6/60) was 5.3% (95% CI 3.6 – 6.8%), with cataract being the principal cause (78.0%). Females, adults 60 years and older and

Discussion

illiterate individuals were the highest risk groups for cataract blindness, a finding that coincides with that of the BNBLVS.

In the form of an eye care services impact assessment, the authors of this study indicated that despite an increase in the level of cataract surgery in the preceding 15 years, ‘. . . *the blindness problem, and that due to cataract specifically, remains at challengingly high levels*’.²⁰⁶

Notably, over the ensuing three decades following the national blindness survey, eye care services in Nepal underwent significant development whereby, particularly, access to cataract surgery expanded. The overall impact of such changes has been: a) a substantial decrease in all-age blindness prevalence from 0.84% to 0.35%; b) a reduction in the 3.8% prevalence of blindness in those 45 years and older to only 2.4% (95% CI 2.2% – 2.6%) in persons 50 years and older; c) increased cataract surgical coverage from 35% to 84.6%, the majority of which occurred in persons aged 50 years and older, and d) a reduction in the proportion of blindness due to cataract from 83% to 52.9%. Similarly, although only in its nascent stages, improvements in eye care service provision in Bangladesh have taken place following the BNBLVS, eg the increase in surgical coverage for cataract as evidenced by the numerous RAAB survey results which reported, on average, 66.4% cataract surgical coverage.²¹⁴⁻²¹⁹

Subsequent research studies in Nepal carried out in the past decade have further elucidated the situation concerning the epidemiological profile of blindness prevalence and its causes in that country.^{241-242,279,282-283} Significant progress in blindness treatment and control, especially focused on cataract, has been achieved by means of substantial financial and technical support of international NGOs working effectively in collaboration with the coordinating national eye care programme.

When comparing the RAAB results from Bangladesh with those carried out in similarly recent years in Nepal (ie 2006 – 2013), one finds that the contribution of cataract as the cause of blindness is, on average, approximately 10% higher in Bangladesh compared with Nepal. In other

Discussion

words, despite quite similar levels of socio-economic development in these two countries,⁴³ the level of cataract surgical service delivery in the latter has progressed substantially more when compared to that of Bangladesh. More discussion of this issue will be provided in Section 7.4 when analysis of the cataract surgical coverage data for various countries will be presented.

As previously highlighted, several blindness research studies have been conducted in the countries of South Asia, including India, Nepal, Pakistan, Sri Lanka, Myanmar as well as further afield in China. The blindness prevalence results – presenting and best corrected (when available) – from those studies are shown in Table 7.2.1. Likewise, the percentage of blindness due to cataract, per study, is also provided. The main observation to be made regarding Table 7.2.1 is that the prevalence of blindness identified in the BNBLVS is higher than that reported in most of the cited population-based surveys from the various countries. With few exceptions, this comparison is recognised to be the case when considering the RAAB results from within Bangladesh wherein the age-sex standardised blindness prevalence results in persons aged 50 years and older were lower than was identified in the BNBLVS.

Discussion

Table 7.2.1. Blindness prevalence, cataract blindness prevalence and cataract as cause of blindness (%) – presenting (PVA) and best corrected visual acuity (BCVA).

Country	Year	Subjects (n)	Age (Years)	PVA Blindness Prevalence (%)	BCVA Blindness Prevalence (%)	Cataract Blindness Prevalence (%) [#]	Cataract as Cause of Blindness (%) [*]
Bangladesh⁺	2000	11,624	30+	1.53	1.39		79.63
RAAB Surveys							
Satkhira ²¹⁴	2006	4,868	50+	3.10 (2.60 – 3.60)	2.90 (2.40 – 3.40)	2.00 (1.60 – 2.4)	79.0
Kushtia ²¹⁷	2009	2,476	50+	1.67 (0.91 – 2.43)	1.63 (0.89 – 2.37)	1.02 (0.48 – 1.54)	69.8
Natore ²¹⁷	2009	2,486	50+	3.68 (2.84 – 4.52)	3.55 (2.70 – 4.40)	2.88 (2.10 – 3.66)	87.2
Narail ²¹⁵	2010	2,390	50+	2.1 (1.1 – 3.1) [§]	2.1 (1.1 – 3.1)	1.4 (0.5 – 2.2)	73.8
Jamalpur ²¹⁵	2010	2,978	50+	2.3 (1.6 – 3.0) [§]	2.0 (1.2 – 2.7)	1.1 (0.7 – 1.5)	52.6
Gazipur ²¹⁶	2010	2,318	50+	2.17 (1.38 – 2.96)	2.17 (1.38 – 2.96)	1.51 (0.87 – 2.15)	69.6
Cox's Bazar ²¹⁶	2010	2,485	50+	4.88 (3.93 – 5.83)	4.76 (3.83 – 5.69)	3.49 (2.59 – 4.39)	76.6
Kishoreganj ²¹⁶	2010	3,023	50+	2.35 (1.62 – 3.08)	2.35 (1.62 – 3.08)	1.35 (0.85 – 1.85)	70.6
Tangail ²¹⁷	2011	3,049	50+	1.86 (1.40 – 2.32)	1.71 (1.25 – 2.17)	1.30 (0.90 – 1.70)	73.7
Brahmanbaria ²¹⁸	2012	3,050	50+	0.56 (0.31 – 0.81)	0.49 (0.25 – 0.73)	0.30 (0.09 – 0.51)	57.1
Satkhira ²¹⁸	2012	2,485	50+	4.70 (3.10 – 6.30)	2.85 (2.11 – 3.59)	2.40 (1.68 – 3.12)	85.9
Barisal ²¹⁹	2013	2,498	50+	3.8 (2.7 – 4.8)	3.6 (2.6 – 4.6)	2.9 (1.9 – 3.8)	85.2

(continued)

Discussion

Country	Year	Subjects (n)	Age (Years)	PVA Blindness Prevalence (%)	BCVA Blindness Prevalence (%)	Cataract Blindness Prevalence (%) [#]	Cataract as Cause of Blindness (%) [‡]
Nepal - nationally			50+	2.4 (2.2 – 2.5)	2.0 (1.9 – 2.2)	1.28 (1.2 – 1.4)	62.2
Rautahat District ²⁴¹	2006	4,717	50+	6.9 (6.2 – 7.6) [§]	6.3 (5.6 – 7.0)	23.7 (22.5 – 24.9) I	85.9 [∞]
Gandaki ²⁸²	2006	5,002	45+	1.7 (1.3 – 2.0)	1.2 (0.9 – 1.6)	1.9 I E	64.5 [∞]
Bagmati ²⁷⁹	2008	1,908	50+	0.6 (0.2 – 1.1)	0.6 (0.2 – 1.1)	0.19 (0.1 – 0.4)	53.3
Janakpur ²⁷⁹	2008	1,705	50+	2.4 (1.5 – 3.2)	2.1 (1.4 – 2.8)	1.26 (0.7 – 1.8)	66.7
Kosi ²⁷⁹	2008	2,895	50+	2.1 (1.5 – 2.8)	2.1 (1.5 -2.7)	1.19 (0.8 – 1.6)	64.7
Makakali and Seti ²⁷⁹	2008	2,513	50+	2.7 (1.8 – 3.7)	2.5 (1.6 – 3.5)	1.44 (0.7 – 2.2)	62.5
Sagarmatha ²⁷⁹	2008	2,914	50+	1.3 (0.7 – 1.8)	1.2 (0.6 – 1.7)	0.84 (0.4 – 1.3)	66.7
Bheri ²⁷⁹	2009	2,993	50+	3.5 (2.6 – 4.4)	3.2 (2.3 – 4.0)	1.41 (0.8 – 2.0)	65.8
Mechi ²⁷⁹	2009	3,041	50+	2.4 (1.7 – 3.0)	1.9 (1.4 – 2.5)	1.31 (0.8 – 1.8)	77.5
Dhawalagiri ²⁷⁹	2010	2,990	50+	1.2 (0.7 – 1.6)	0.8 (0.4 – 1.1)	0.40 (0.2 – 0.6)	57.1
Lumbini and Chetwan ²⁴²	2010	5,141	50+	2.3 (1.8 – 2.8)	1.7 (1.3 – 2.1)	7.6 (6.9 – 8.3)	48.1 [∞]
Rapti ²⁷⁹	2010	2,921	50+	1.7 (1.0 – 2.3)	0.9 (0.5 – 1.4)	0.34 (0.0 – 0.7)	40.7
Narayani ²⁸³	2015	4,771	50+	1.2 (0.9 – 1.5)	1.1 (0.8 – 1.4)	0.6 (0.4 – 0.9)	61.8

(continued)

Discussion

Country	Year	Subjects (n)	Age (Years)	PVA Blindness Prevalence (%)	BCVA Blindness Prevalence (%)	Cataract Blindness Prevalence (%) [#]	Cataract as Cause of Blindness (%) [‡]
China							
Doumen County ²⁸⁴	1999	5,342	50+	2.67 (2.09 – 3.24)	2.34 (1.79 – 2.90)	1.9 (1.6 – 2.3)	42.2 (63.7% in 70+)
Bin County, Harbin ²⁸⁵	2010	4,956	40+	1.9 (1.5 – 2.3)	1.7 (1.3 – 2.1)	Not available	44.0
China Nine Province Study ²⁸⁶	2010	45,747	50+	2.29	1.93	Not available	NA
Hainan Province ²⁸⁷	2013	6,482	50+	3.5 (3.1 – 4.0) [§]	Not available	Not available	55.2
Yunnan Minority, Dali ²⁸⁸	2013	2,133	50+	3.59 (2.80 – 4.39)	2.88 (2.17 – 3.60)	Not available	70.5
Shuangcheng ²⁸⁹	2014	5,481	50+	1.90	1.72		52.7
Chaonan ²⁹⁰	2017	3,484	50+	2.4 (1.9 – 2.9)	Not available	Not available	67.1
Inner Mongolia ²⁹¹	2017	3,985	50+	1.2 (0.8 – 1.6) [¥]	Not available	Not available	34.9

Adjusted prevalence of bilateral cataract blindness, based on BCVA <3/60 in the better eye.

‡ Cause in bilaterally blind persons, based on BCVA <3/60 in the better eye.

∞ CSC corresponded to PVA <6/60 in the better eye

¥ Age-standardised prevalence

(continued)

Discussion

Country	Year	Subjects (n)	Age (Years)	PVA Blindness Prevalence (%)	BCVA Blindness Prevalence (%)	Cataract Blindness Prevalence (%) [#]	Cataract as Cause of Blindness (%) [‡]
India							
Andhra Pradesh – urban ¹⁴⁷	1998	1,399	30+	2.53 (1.38 – 3.68)	2.23 (1.17 – 3.29)	1.6	32.5
Andhra Pradesh – rural ^{147, 292}	1998	521	50+	10.9 (8.3 – 13.7) [∞]	Not available	Not available	61.1
Seven States Study ²⁹³	1999	24,818	50+	5.33 (5.05 – 5.61)	Not available	11.2 (10.9 – 11.6)	Not available
Rajasthan State ¹⁵⁷	2001	4,284	50+	11.9 (10.0 – 13.9) [∞]	6.1 (4.7 – 7.4)	8.1 (6.6 – 9.5)	67.5
Andhra Pradesh (AP) State ²⁹⁴	2001	10,293	All ages	1.84 (1.49 – 2.19)	Not available	Not available	44.0
Tirunelveli, Tamil Nadu ²⁰⁹	2002	5,411	50+	4.1 (3.3 – 5.0)	3.0 (2.3 – 3.7)	7.7 (6.1 – 9.3)	70.6
Sivaganga, Tamil Nadu ²¹⁰	2002	4,642	50+	4.0 (3.5 – 4.5)	2.0 (1.5 – 2.6)	4.2 (3.3 – 5.0)	69.4
Madurai, Tamil Nadu ²⁰⁴	2003	5,337	40+	4.3 (3.8 – 4.9)	1.0 (0.7 – 1.2)	Not available	77.5
Chennai ²⁹⁵	2005	3,924	40+	3.4 (2.8 – 3.9)	Not available	Not available	74.6
Rural Karnataka State ²⁰³	2007	1,505	50+	6.6% (5.3-7.8%)	Not available	12.1	78.7
Fifteen States Study (RAAB) ²⁹⁶	2008	40,447	50+	3.6 (3.4 – 3.8)	3.0 (2.8 – 3.2)	Not available	72.2
Gujarat State ²⁹⁷	2009	4,738	50+	6.9 (5.7 – 8.1)	3.11 (2.5 – 3.7)	5.7	68.3
CIEMS Study ²¹²	2011	4,706	30+	0.7 (0.5 – 1.0)	0.5 (0.3 – 0.7)	Not available	75.0

(continued)

Discussion

Country	Year	Subjects (n)	Age (Years)	PVA Blindness Prevalence (%)	BCVA Blindness Prevalence (%)	Cataract Blindness Prevalence (%)[#]	Cataract as Cause of Blindness (%)[‡]
Nandurbar, Maharashtra ¹⁵⁸	2011	2,005	50+	1.87 (1.32 – 2.42)	1.63 (1.11 – 2.15)	Not available	76.0
Surat District, Gujarat ²⁹⁸	2011	2,200	50+	2.3 (1.6 – 3.0) ASA	2.0 (1.4 – 2.7)	Not available	67.3
AP State Tribal Areas ²⁹⁹	2012	7,281	50+	2.3 (1.9 – 2.7)	2.1 (1.7 – 2.5)	Not available	70.3
Andhra Pradesh – rural ²⁹²	2012	2,160	50+	8.0 (6.9 – 9.1) [∞]	Not available	Not available	72.8
Kolar District, Karnataka ³⁰⁰	2013	2,907	50+	3.9 (2.7 – 5.1)	Not available	2.5 (1.6 – 3.4)	74.6
Delhi Region ²⁴⁰	2014	4,172	50+	4.0 (3.4 – 4.6)	Not available	Not available	60.9
Sindudurg, Maharashtra ³⁰¹	2014	2,737	50+	4.8 (1.1 – 8.5)		Not available	
Wardha, Maharashtra ³⁰²	2014	5,263	50+	3.81 (3.3 – 4.8)	Not available	2.09 (1.7 – 2.5)	62.5
Urban Delhi ³⁰³	2015	1,311	50+	2.0 (1.2 – 2.7)	Not available	Not available	65.5
Mahabubnagar, Telengana ²¹³	2017	665	50+	1.8 (0.9 – 3.5)	Not available	Not available	75.0
Bhutan ³⁰⁴	2013	4,046	50+	1.49 (1.09 – 1.89)	1.4 (1.0 – 1.8)	0.7 (0.5 – 1.0)	67.6
Takeo Province Cambodia ²⁰⁸	2015	4,650	50+	3.4 (2.8 – 4.0)	Not available	Not available	Not available
Meiktila Myanmar ²⁰⁵	2007	2,073	40+	8.1 (6.5 – 9.9)	5.3 (4.0 – 6.6)	Not available	64.0
The Maldives ³⁰⁵	2017	3,020	50+	2.0 (1.5 – 2.6) [§]	Not available	AS standardised E	51.4

Discussion

Similar comparisons with the results from Nepal and in the more recent studies of India indicate that blindness prevalence was lower in those settings. Notably, over the course of several years, a decreasing blindness prevalence trend was observed elsewhere, though not consistently so in the case of Bangladesh, as based on the evidence of the aforementioned twelve RAAB studies.²¹⁴⁻²¹⁹

A second main observation concerning Table 7.2.1 is the substantial percentage reduction of cataract as a cause of blindness across many settings. Whereas, for instance in Nepal, cataract was clearly the main cause of blindness in 1981 (83%)² and in 1995 (78%)²⁰⁶, the contribution of cataract to blindness reduced to approximately 63%, based on studies carried out between 2006 and 2015.^{241-242, 279, 282-283}

Similar transitions indicative of the reduced prevalence of blindness and decreased proportion of blindness due to cataract have been reported over time in numerous Indian surveys. Large, population-based studies dating from the 1980s and 1990s highlighted the prominence of blinding cataract, particularly in rural areas of the country, wherein more than 70% of blindness was due to cataract. Through the National Programme for the Control of Blindness (NPCB) of India,^{124-126,224} established following a three-year national blindness survey in which cataract was responsible for 80% of blindness, co-ordinated eye care service development progressively evolved, mainly focusing on increasing cataract surgical services. As a result, the proportion of cataract as a cause of blindness has reduced whilst other, mainly chronic ocular conditions have emerged as causes of visual impairment and blindness. These include glaucoma,²⁹⁵ macular degeneration,³⁰⁶ diabetic retinopathy,³⁰⁷ amongst others.

Prevalence and causes of vision loss in Central and South Asia – 1990 – 2010

A systematic review of blindness and visual impairment surveys conducted in South and Central Asia between 1990 and 2010 was carried out by the Vision Loss Expert Group (VLEG) of the Global Burden of Disease Study.¹²² This review forms an integral and relevant part of a series of related studies by the VLEG, the main findings of which will be discussed herein.

Discussion

Over the twenty-year period comprising the review, age-standardised blindness prevalence in persons aged 50 years and older decreased from 6.9% to 4.4% in South Asia, based on 39 total studies from India (16), Nepal (16), Pakistan (five) and two from Bangladesh (including the survey on which this dissertation is based). Despite the favourable progress in the reduction of blindness prevalence in South Asia, by comparison, the age-standardised blindness prevalence in this region was approximately 2.3 times higher than the global figure.

Two key findings meriting attention for this region were: a) the increased level of blindness as well as moderate and severe visual impairment amongst women – as was shown to be the case in the BNBLVS – and b) that cataract and uncorrected refractive error were the main causes of blindness and vision loss. Across the South Asian region, glaucoma, macular degeneration and diabetic retinopathy were the other main causes of blinding vision loss, findings which compare closely to those of the Bangladesh national survey, as well as the subsequent RAAB conducted in Satkhira District in 2006.²¹⁴ However, cataract as a cause of blindness throughout the region was less prominent (41.7%) than that shown in the BNBLVS (79.3%), a study that was conducted mid-way through the time period of this VLEG review. With higher levels of cataract surgical rate and cataract surgical coverage resultant from more developed eye care services targeting the cataract blind, India and Nepal have made progress in reducing cataract as a cause of blindness. This had not been the case to as great a degree in Bangladesh, a topic that will be further discussed in Section 7.8.

Concerning other key visually impairing ocular conditions in the South Asia region, the proportion of blindness attributable to glaucoma, macular degeneration (including age-related macular degeneration) and diabetic retinopathy have all increased substantially in the past two decades, by 85.7%, 95.8% and 47.4% respectively. Two main explanations for this phenomenon are a) the relative decrease of cataract as a cause of blindness in the region and globally and b) that the emergence of the three aforementioned posterior segment diseases are closely associated with increased life expectancy, that

Discussion

which has been observed throughout South Asia and Bangladesh. As such, when comparing the RAAB²¹⁴⁻²¹⁹ and BNBLVS cause-related results, it is worth pointing out that while cataract remained the major cause of blindness as per the RAAB studies, posterior segment disease had increased. For example, in Brahmanbaria District,²¹⁸ posterior segment diseases accounted for 21.4% of bilateral blindness, whilst cataract blindness (64.5%), though still unacceptably prominent, was lower than that identified in the national survey (79.6%).

This is also the case for the BNBLVS survey results given the age group examined, ie subjects aged 30 years and older. Several blindness prevalence studies have examined persons of all ages, eg the national eye survey in Malaysia²⁴³ whilst more recently, with the advent of the RACSS³⁰⁸ and latterly RAAB methodologies,³⁰⁹ the inclusion criteria for age has been persons aged 50 years and older only. One notably important blindness prevalence study, on which the BNBLVS survey was partially modelled, was that of APEDS which was carried out in both rural and urban settings of Andhra Pradesh State in India, with the main survey results reported in 1998.¹⁴⁷ The APEDS survey also examined persons aged 30 years and older, though the ocular examination protocol differed somewhat from that of the subsequent BNBLVS, eg use of fixed site, more technically advanced examination centres as with, for instance, use of visual field testing for detecting glaucoma. Moreover, the methods used in APEDS for determining the cause of visual impairment and/or blindness differed from that of the standard approach promulgated by the WHO Prevention of Blindness and Control Programme wherein the most '*preventable or avoidable cause*' would be identified as the '*main cause*' of visual impairment.¹⁰²

Contrary to this standard approach that which was utilised by the BNBLVS, APEDS attributed a certain percentage to each existing visually impairing ocular condition that was identified in each examined subject. The main effect of this modified analysis method was to decrease the relative contribution of cataract as a cause of vision loss when one (or more) ocular pathology was identified in an eye with visually impairing cataract. Thus, in APEDS, all

Discussion

diagnosed findings were taken into account as potentially contributing to one's visual impairment, eg age-related macular degeneration present in an eye with blinding cataract. Therefore, direct comparisons of the APEDS results with those of the BNBLVS would not be possible, nor has it been possible to compare the APEDS findings with any other large-scale blindness prevalence study. Despite this being the case, cataract was still the main cause of blindness in the four-site Andhra Pradesh study though cataract blindness prevalence was substantially lower (APEDS cataract blindness 44%) than in numerous other Indian surveys (Karnataka 78.7%,²⁰³ Madurai 77.5%,²⁰⁴ The Fifteen States Study 72.2%,²⁹⁶ Rajasthan 67.5%¹⁵⁷). Thus, the age-sex adjusted prevalence of blindness was 1.34% in persons aged 30 years and older in the APEDS study.

Furthermore, the APEDS results identified an increased risk of blindness was associated with increased age, female gender, living in rural communities as well as being of lower socio-economic status – all being findings in the BNBLVS. Poverty, socio-economic inequality, living in rural areas and, most notably, gender are four key factors associated with the epidemiological distribution of blindness and low vision in Bangladesh. Such findings highlight the central importance of equity³¹⁰⁻³¹² and access within the population to eye care services whereby taking into account the social determinants of eye health status, such as poverty,³¹³⁻³¹⁴ increased emphasis on practical interventions to improve access³¹⁵ and to achieve more equitable results in terms of blindness prevention within society can be prioritised and achieved.^{211,316}

As stated above, cataract was responsible as a contributing cause in 44% of the cases of blindness in the APEDS survey of representative rural and urban settings, whereas refractive error was the second most important cause (16%). Taken together, as has been shown in several other surveys, cataract and refractive error are responsible for the majority of cases of blindness as well as of non-blinding visual impairment whereas uncorrected refractive is the leading cause of cause of moderate visual impairment followed by cataract.

Discussion

There is a need to highlight the fact that despite a significant increase in the CSC over the past several years in such countries as Sri Lanka,²⁰⁷ Nepal²⁸³ and India,³⁰⁰ a very high burden of cataract blindness persists.³¹⁷ In the case of Bangladesh, the situation is even more pronounced given that the CSC as of 2014 had only reached approximately one-third of the level that has been estimated to deal with the annual incident cases, let alone to clear the backlog of several hundred thousand prevalent cases.²²⁷

In order to achieve the goal of significantly reducing the backlog a substantial increase in the number of cataract surgeries would need to be performed on a sustainable, cost-effective level.³¹⁸ Given that the backlog of cases is potentially growing – due to concomitant increases in life expectancy and in the size of the older adult population – those who do not undergo surgery have increased risks of falls, accidents, decreased quality of life and increased dependence on others in order to carry out activities of daily living and ultimately, increased risk of shortened life span compared with non-visually impaired persons.³¹⁹⁻³²¹

7.3 Cataract surgical outcomes

Starting in the 1990s, the initial studies concerning cataract surgical outcomes were based on data obtained in population-based surveys. Whilst this information was beneficial to highlight the disproportionately high proportion of surgeries with poor outcomes^{190,229,322} key methodological problems were associated with such findings. For instance, many of the surgeries would have taken place over a potentially long period prior to the survey, thus allowing for coincident disease(s) to develop (eg ARMD, glaucoma). As well, the use of different surgical techniques^{231,235} and locations of surgery (eye camp or hospital)^{228,323} posed challenges for elucidating the key factors associated with less than adequate surgical outcomes.

Nonetheless, such surveys were useful in the sense that study results highlighted the all-too pervasive situation of poor surgical visual outcomes.¹⁴⁰ Based on ever-increasing evidence as to the deficiencies identified, changes were brought about in the surgical techniques used. This involved a transition from the use of intra-capsular cataract extraction (ICCE) without intra-ocular lens (IOL) to extra-capsular cataract extraction (ECCE) with PC-IOL to, latterly, manual small incision cataract surgery (MSICS with PC-IOL). In addition, eye camp surgeries declined as hospital-based operations progressively occurred as a result of increased eye care services development. In this way, both the quality of surgical outcomes, eg through improved surgical techniques and the use of IOLs along with the quantity of patients undergoing surgery as a result of organising high volume hospital surgical delivery services became more common. Latterly, increased emphasis has been placed on monitoring the visual outcomes of surgeries through clinical audits and systematic follow-up / revision of post-surgical patients (eg upon discharge, at one week and at six weeks after the procedure).

Research has indicated that poor visual outcomes are associated with a number of patient- and surgical service-related factors. These include the age³²⁴⁻³²⁵ and gender of the patient³²⁶; pre-operative visual acuity;³²⁷⁻³²⁸ co-existent posterior segment disease prior to surgery (eg age-related macular degeneration) which were not identified pre-operatively;³²⁹ surgery type

Discussion

(ICCE without IOL compared to other procedures);²³⁰⁻²³² non-use of aphakic spectacles especially over time due to having lost or damaged the glasses;^{230,324} the operation having taken place in an eye camp rather than a hospital facility;^{228,233,323} level of experience of the surgeon and intra- and/or post-operative complications including vitreous loss and endophthalmitis,^{200,330} amongst others.

As regards the BNBLVS, the visual outcomes following cataract surgery in 162 subjects (226 eyes) have been presented in Section 6.3 of this dissertation. The most salient results regarding the identified outcomes are comprised of two main components: a) visual acuity status – both presenting (PVA) and best corrected vision (BCVA) in the operated eye – and its association to certain explanatory variables; b) causes of reduced vision, both for PVA and BCVA. These two points will be discussed in relation to findings from similar research studies on cataract outcomes that have been conducted in India, Nepal, China and other nearby countries.

In approximately 90% of the surgeries in the BNBLVS, the intra-capsular cataract extraction (ICCE) procedure, without implantation of an intra-ocular lens (IOL), was used. Only 22 eyes were fitted with a posterior chamber IOL (PC-IOL) in conjunction with the extra-capsular cataract extraction (ECCE) technique. The PVA and BCVA for ECCE with PC-IOL surgeries were significantly better than the ICCE outcomes. None of the PC-IOL visual outcomes (PVA or BCVA) were <6/60 whereas nearly one-third of the PVA (31.2%) and one-in-seven (14.6%) of the BCVA in ICCE subjects were <6/60. It would thus appear that having undergone an ECCE with implantation of an PC-IOL was a key factor in both the PVA and BCVA visual outcomes achieved.

Notably, the majority of the hospital procedures were ICCEs. However, in the three years prior to the survey, the proportion of ECCE with PC-IOL surgeries increased compared to that amongst subjects whose surgery had taken place four or more years earlier. This trend follows that observed elsewhere, especially in India, wherein the transition away from ICCE to ECCE with PC-IOL had started by the early 1990s.²²⁹⁻²³⁰ The ECCE with PC-

Discussion

IOL technique was shown in a two-site non-randomised comparative trial (one hospital, one eye camp setting) to be clinically and cost-effective, safe, fast and applicable for situations in which high volume output would be required whilst also endeavouring to ensure high quality visual outcomes.³³¹

Poor visual outcomes following cataract surgery in an eye camp setting are well documented.^{140,233} Whilst the advantage of increasing access to surgery amongst the cataract-blind was generally brought about by holding eye camps, especially in remote, rural areas of developing countries such as Bangladesh, the visual outcomes from such surgeries have been shown repeatedly to be less than ideal.²²⁸ This is the case also for the BNBLVS, as surgeries undertaken in eye camps were associated with double the odds of poor visual outcomes compared with operations performed in hospitals.

In addition to the type of surgery and where it was carried out, other key factors were associated with post-surgical visual impairment. Principal amongst these was the lack of refractive correction, particularly in those without aphakic spectacles. The majority of the 95 (60%) operated eyes with <6/12 vision were impaired due to uncorrected refractive error. Approximately half of these eyes 44 (46.3%) were associated with not wearing aphakic correction.

In those who had undergone ICCE and were without aphakic spectacles, 60% of the 199 eyes had PVA <6/18; visual impairment reduced by 20% through refractive correction. Being female, having been operated in an eye camp, living in a rural area and being illiterate were all significantly associated with not using aphakic spectacles.

Complications during and/or after cataract surgery and co-existent ocular conditions were associated with presenting visual outcomes <6/12, affecting 40% of visually impaired eyes. Having undergone an ICCE procedure in an eye camp was associated with a substantially increased risk of <6/12 vision post-operatively as well as increased level of post-operative complications in eye camp patients. In terms of co-existent diseases, macular degeneration was identified in nearly half (46%) of eyes with <6/12 BCVA. As described in

Discussion

similar studies, posterior segment disease is a key factor in less-than-optimal post-surgical visual outcomes. Having been operated upon in an eye camp compared with a hospital surgery was shown to be associated with more than twice the odds of having posterior segment disease.

In order to place the cataract surgical outcomes from the BNBLVS into a temporal and geographical context and for purposes of results comparison, an extensive systematic review of the literature on surgical outcomes was conducted. This review included published surveys and clinical research studies from Asian countries, dating from the late-1990s through to the present. An analysis of 37 peer-reviewed papers, undertaken for this dissertation, on visual outcomes following cataract surgery identified presenting and/or best corrected visual acuity results. As above, research studies on cataract outcomes have been of two main types: a) population-based surveys and b) clinical trials in which those who had undergone cataract surgery were examined at defined time(s) following surgery, eg six weeks.

As with the BNBLVS, results from population-based surveys typically identified visual outcomes from surgeries that may have taken place several months or even years prior to the reported survey. In many instances, as compared with the clinical trial studies, these cataract outcomes were of poorer quality due to a number of factors, such as inadequate pre-operative assessment of posterior segment disease that would likely have affected post-surgical vision.

The list of population-based and clinical trial studies concerning cataract outcomes, including details on the PVA, BCVA and proportion of surgeries that involved IOL implantation, is shown in Table 7.3.1.

The most salient findings from these numerous studies include:

* improvements in visual outcomes from PVA to BCVA with refractive correction. The advantage of correcting the PVA – either with use of trial lenses or simply via re-testing with pinhole – is manifested with a) a reduction in poor outcomes and b) an increase in the proportion of subjects who achieve good vision, and

Discussion

* a variable level of use of IOLs, with an increasing trend over time throughout the various studies.

The importance of refractive correction was identified in a study conducted in Rajasthan, India.³²⁴ Nearly half of the 723 subjects (44.1%) had presenting VA <6/60, though, notably, following refractive correction, this reduced substantially to just 14%. Similarly, the proportions of severe visual impairment and/or blindness reduced with refractive correction in several other settings in India (Tirunelveli,²⁰⁹ Sivaganga,³²⁷ Madurai,^{232,332-333} Andhra Pradesh State^{322,334-335}); in Nepal (Eastern Nepal,²³³ Bhaktapur³³⁶); China (The Nine Province Study,²⁸⁶ Heilongjiang,³³⁷), Takeo Province Cambodia²⁰⁸ and Pakistan.^{90,338}

Discussion

Table 7.3.1. Presenting visual acuity (PVA) and best corrected visual acuity (BCVA) for cataract surgical outcomes and percentage of IOL use

Study Location	Year	Post-surgical Follow-up	Vision testing PVA or BCVA	Operated eyes (n)	Good n (%)	Borderline n (%)	Poor n (%)	IOL implant (%)
Seven States in India ²²⁹	1999	Variable	PVA only	3,580	1,693 (47.3)	1,029 (28.7)	858 (24.0)	9.4
Hyderabad, India ³²²	1999	Variable	PVA only	131	63 (48.1)	40 (30.5)	28 (21.4)	42.0
Rural Punjab, India ³²⁵	2000	Variable	BCVA only	428	194 (45.3)	162 (37.9)	72 (16.8)	0.0
Rajasthan, India ³²⁴	2001	Variable	PVA	723	228 (31.5)	176 (24.3)	319 (44.1)	5.5
Rajasthan, India ³²⁴	2001	Variable	BCVA	723	425 (61.5)	169 (24.5)	97 (14.0)	5.5
Sivaganga, India ³²⁷	2002	Variable	PVA	938	566 (60.3)	122 (13.0)	250 (26.7)	35.8
Sivaganga, India ³²⁷	2002	Variable	BCVA	912	793 (87.0)	41 (4.5)	78 (8.6)	35.8
Tirunelveli District, India ³²⁸	2002	Variable	PVA	891	570 (64.0)	138 (15.5)	183 (20.5)	56.7
Tirunelveli District, India ³²⁸	2002	Variable	BCVA	891	740 (83.1)	64 (7.2)	87 (9.8)	56.7
Hong Kong ³³⁹	2002	Variable	PVA	473	282 (60.1)	138 (29.4)	49 (10.5)	87.4
Hong Kong ³³⁹	2002	Variable	BCVA	473	341 (72.7)	88 (18.8)	40 (8.5)	87.4

(continued)

Discussion

Study Location	Year	Post-surgical Follow-up	Vision testing PVA or BCVA	Operated eyes (n)	Good n (%)	Borderline n (%)	Poor n (%)	IOL implant (%)
Bangladesh (nationwide) ³⁴⁰	2003	Variable	PVA	226	99 (43.8)	63 (27.9)	64 (28.3)	8.0
Bangladesh (nationwide) ³⁴⁰	2003	Variable	BCVA	226	145 (64.1)	51 (22.6)	30 (13.3)	8.0
Satkhira District, Bangladesh ²¹⁴	2006	Variable	PVA	213	128 (60.1)	35 (16.4)	50 (23.5)	54.9
Satkhira District, Bangladesh ²¹⁴	2006	Variable	BCVA	213	144 (67.6)	26 (12.2)	43 (20.2)	54.9
Pakistan (nationwide) ³³⁸	2007	Variable	PVA	1,773	528 (29.8)	632 (35.6)	613 (34.6)	33.9
Pakistan (nationwide) ³³⁸	2007	Variable	BCVA	1,788	895 (50.2)	492 (27.6)	395 (22.2)	33.9
Gujarat, India ²⁹⁷	2009	Variable	PVA	1,299	658 (50.7)	407 (31.3)	234 (18.0)	84.1
Gujarat, India ²⁹⁷	2009	Variable	BCVA	1,299	968 (74.5)	189 (14.5)	142 (11.0)	84.1
The China Nine Province Study ²⁸⁶	2010	Variable	PVA	1,174	546 (46.5)	352 (30.0)	276 (23.5)	NA
The China Nine Province Study ²⁸⁶	2010	Variable	BCVA	1,174	749 (63.8)	217 (18.5)	208 (17.7)	NA
Bhakatpur District, Nepal ³³⁶	2011	Variable	PVA	226	123 (54.4)	78 (34.5)	25 (11.1)	93.8
Bhakatpur District, Nepal ³³⁶	2011	Variable	BCVA	226	164 (72.6)	43 (19.0)	19 (8.4)	93.8
Ha Tinh Province, Vietnam ³⁴³	2011	Variable	PVA only	412	182 (44.2)	148 (35.9)	82 (19.9)	91.5

(continued)

Discussion

Study Location	Year	Post-surgical Follow-up	Vision testing PVA or BCVA	Operated eyes (n)	Good n (%)	Borderline n (%)	Poor n (%)	IOL implant (%)
CIEMS Study, India ³⁴²	2011	Variable	PVA	318	117 (36.8)	165 (51.9)	36 (11.3)	78.0
CIEMS Study, India ³⁴²	2011	Variable	BCVA	318	201 (63.2)	84 (26.4)	33 (10.4)	78.0
Andhra Pradesh State Tribal Areas ²⁹⁹	2012	Variable	PVA	1,548	1056 (68.2)	273 (17.6)	219 (14.1)	85.0
Andhra Pradesh State Tribal Areas ²⁹⁹	2012	Variable	BCVA	1,548	1,292 (83.5)	109 (7.0)	147 (9.5)	85.0
Hainan Province, China ²⁸⁷	2013	Variable	PVA only	524	309 (59.0)	105 (20.0)	110 (21.0)	87.2
Yunnan Minority, Dali, China ²⁸⁸	2013	Variable	PVA	129	62 (48.0)	30 (23.3)	37 (28.7)	79.8
Yunnan Minority, Dali, China ²⁸⁸	2013	Variable	BCVA	129	85 (65.9)	14 (10.9)	30 (23.2)	79.8
Heilongjiang Province, China ³³⁷	2014	Variable	PVA only	21	12 (57.1)	4 (19.1)	5 (23.8)	71.4
Takeo Province, Cambodia ²⁰⁸	2015	Variable	PVA	372	260 (69.9)	63 (16.9)	49 (13.2)	92.7
Takeo Province, Cambodia ²⁰⁸	2015	Variable	BCVA	372	307 (82.5)	24 (6.5)	41 (11.0)	92.7
Andhra Pradesh (AP) State, India ³³⁴	2016	Variable	PVA only	1,228	897 (74.6)	150 (12.5)	156 (13.0)	87.9
Rural South, India ³⁴⁴	2016	Variable	PVA	1,112	590 (53.1)	424 (38.1)	98 (8.8)	90.0
Rural South, India ³⁴⁴	2016	Variable	BCVA	1,110	836 (75.2)	191 (17.2)	82 (7.4)	90.0

(continued)

Discussion

Study Location	Year	Post-surgical Follow-up	Vision testing PVA or BCVA	Operated eyes (n)	Good n (%)	Borderline n (%)	Poor n (%)	IOL implant (%)
Chaonan, China ²⁹⁰	2017	Variable	PVA	211	142 (67.2)	34 (16.1)	35 (16.6)	97.1
Chaonan, China ²⁹⁰	2017	Variable	BCVA	211	158 (74.9)	24 (11.4)	29 (13.8)	97.1
Madurai IOL Study ²³²	1998	2 months	PVA only	3,348	1,615 (48.2)	1,694 (50.6)	39 (1.2)	50.1
Eye camp in India ²²⁹	1999	6 weeks	BCVA only	3,908	3,122 (79.9)	619 (15.8)	167 (4.3)	3.7
South Asian Cataract Management Study ²³¹	2000	12 months	BCVA only	1,040	912 (87.7)	89 (8.6)	39 (3.8)	49.9
Eastern Nepal ²³³	2001	6 weeks	PVA	166	23 (13.9)	46 (27.7)	97 (58.4)	50.6
Eastern Nepal ²³³	2001	6 weeks	BCVA	166	78 (47.0)	56 (33.7)	32 (19.3)	50.6
Rural Andhra Pradesh, India ¹²⁸	2003	6 weeks	BCVA only	2,344	2,011 (85.8)	260 (11.1)	73 (3.1)	92.7
Aravind Hospital, Madurai, India ³⁴⁵	2005	6 weeks	PVA	520	228 (43.9)	265 (51.0)	27 (5.3)	1.5
Aravind Hospital, Madurai, India ³⁴⁵	2005	6 weeks	BCVA	520	491 (94.4)	21 (4.0)	8 (1.6)	1.5
Eight Centres Study ³⁴⁶	2005	1 – 7 weeks	PVA	3,478	1,635 (47.0)	1,356 (39.0)	487 (14.0)	76.7
Eight Centres Study ³⁴⁶	2005	1 – 7 weeks	BCVA	3,478	2,330 (67.0)	939 (27.0)	209 (6.0)	76.7

(continued)

Discussion

Study Location	Year	Post-surgical Follow-up	Vision testing PVA or BCVA	Operated eyes (n)	Good n (%)	Borderline n (%)	Poor n (%)	IOL implant (%)
Satkhira District, Bangladesh ³⁴⁷	2009	12 months	PVA	122	98 (80.3)	9 (7.4)	15 (12.3)	100.0
Satkhira District, Bangladesh ³⁴⁷	2009	12 months	BCVA	122	99 (81.1)	9 (7.4)	14 (11.5)	100.0
Chitrakoot, MP, India ³⁴⁸	2010	6 weeks	BCVA only	14,367	12,522 (87.2)	1,473 (10.3)	372 (2.6)	100.0
PRECOG Multicentre Study (11 countries) ³⁴⁹	2013	40+ days	PVA	3,430	2,198 (64.1)	897 (26.2)	335 (9.8)	100.0
PRECOG Multicentre Study (11 countries) ³⁴⁹	2013	40+ days	BCVA	3,339	2,847 (85.3)	321 (9.6)	171 (5.1)	100.0
Kashmir, India ³⁵⁰	2014	16 weeks	BCVA only	100	77 (77%)	21 (21.0)	2 (2.0)	100.0
Xianfeng County, China ³⁵¹	2014	6 weeks	PVA	82	50 (61.0)	22 (26.8)	10 (12.2)	100.0
Xianfeng County, China ³⁵¹	2014	6 weeks	BCVA	82	57 (69.5)	18 (22.0)	7 (8.5)	100.0
Secondary Care Centres, India ³³⁵	2016	4 – 11 weeks	PVA	1,441	891 (61.8)	508 (35.3)	42 (2.9)	70.3
Secondary Care Centres, India ³³⁵	2016	4 – 11 weeks	BCVA	1,441	1322 (91.7)	96 (6.7)	23 (1.6)	70.3
Takeo Hospital, Cambodia ³⁵²	2017	1 – 3 weeks	PVA	5,640	3,170 (56.2)	2,058 (36.5)	412 (7.3)	99.0
Takeo Hospital, Cambodia ³⁵²	2017	1 – 3 weeks	BCVA	5,640	3,993 (70.8)	1,331 (23.6)	316 (5.6)	99.0

Discussion

The cataract outcomes from three research studies conducted in Bangladesh are cited in Table 7.3.1. These correspond to the BNBLVS³⁴⁰ and two studies carried out in Satkhira District – one population-based survey²¹⁴ and one prospective clinical follow-up study.³⁴⁷ Following the BNBLVS, a rapid assessment of avoidable blindness (RAAB) survey of 4,686 subjects aged 50 years and older, was conducted in late 2005 in Satkhira District.²¹⁴ Of the 213 eyes that had been operated upon for cataract, both the PVA and BCVA results were shown to be better than those of the national survey. The PVA in 60.1% and the BCVA in two-thirds (67.6%) of subjects was better than or equal to 6/18. However, in terms of ‘poor’ outcomes, while the PVA was similar between the two surveys (23.5% in Satkhira and 28.3% nationally), poor BCVA in the former was higher (20.2%) than in the BNBLVS (13.3%). These comparisons of post-surgical VA results are noteworthy given the vast disparity between the percentages of eyes that had received an IOL at the time of surgery, ie only 9.7% nationally versus 54.9% in the Satkhira sample.

Upon further analysis, this finding is likely to be attributable to the type of refractive correction employed by the two surveys. In the BNBLVS, BCVA was assessed with trial set lenses based on subject-specific auto-refractometry results whereas in the RAAB study, correction involved re-testing with use only of a pinhole. Thus, despite the much higher use of IOL in the Satkhira cohort, in the absence of optimal refractive correction, nearly one-quarter of eyes were severely visually impaired or blind. As commented upon by the authors of the Satkhira survey, *‘The totality of evidence points to clear recommendations for improving visual results of cataract surgery. There is an urgent need to distribute spectacles routinely after surgery.’*³⁴⁷

Inadequate selection of potential patients for surgery and the need to improve the quality of surgery were also identified as reasons for poor outcomes. It merits pointing out that the cataract surgical coverage for blind eyes (<3/60) in Satkhira District was only 34.8%, which was similar to that of the BNBLVS (36.8%). Having undergone surgery for cataract and still being visually impaired or blind can be a major disincentive within communities as those in need of cataract surgery – or their family members – may not be

Discussion

convinced of the value of surgery if the visual outcomes for past patients are not positive.³⁵³⁻³⁵⁴

A follow-up prospective clinical outcomes study in Satkhira District³⁴⁷ was carried out amongst 99 subjects from the aforementioned RAAB who had been identified as needing cataract surgery (all eyes $<6/18$, with 65% $<3/60$). These subjects had been referred for free surgery at a designated hospital. One-year post-surgery, PVA and BCVA were assessed to identify the outcomes of the MSICS with PC-IOL procedures; biometry preceded surgery in order to determine the power of the IOL required by each patient. Notably, the post-surgical PVA (48% $\geq 6/9$; 81% $\geq 6/18$) and the BCVA (59% $\geq 6/9$; 81% $\geq 6/18$) were vastly improved from the pre-surgical visual status. Co-morbid ocular conditions (58%), especially posterior segment diseases, were the main cause of adverse surgical outcomes.

Poor and/or borderline outcomes were identified in 20% of cases, mainly due to pre-operative conditions and surgical complications which together accounted for 79% of all adverse outcomes. However, due to the use of pre-operative biometry and implantation of an IOL in each visually disabled eye, refractive error as a cause of adverse outcome was only identified in one subject of those with $<6/18$ vision. The findings of this prospective study serve to highlight the importance of providing a comprehensive high quality cataract surgical service – involving biometry, IOL implantation and refractive corrective with spectacles – for the purposes of ensuring sight restoration.

The main reasons for poor surgical outcome are varied but may be grouped into three main categories: a) other pre-existing eye conditions; b) inadequate refractive error correction and c) surgical complications.³⁵⁵

As regards surgical complications, these may be numerous and are potentially related to one or more of the following factors: the degree of maturity / hyper-maturity of the cataract, the type of surgical technique, the equipment available for use during the operation and the experience of the surgeon, amongst others. Vitreous loss, retinal detachment, infections (eg

Discussion

endophthalmitis), cystoid macular oedema, amongst others conditions, have been shown to occur during and/or following cataract surgery.

Based on the findings of the BNBLVS and similar cataract outcomes research, including the other two Bangladesh studies from Satkhira District, vision restoration following surgery is contingent on key inter-related factors. These include: a pre-surgical ocular examination to rule out any co-existent disease (eg retinal conditions), a safe, high quality surgery, preferably involving IOL implantation (eg MSICS with PC-IOL) followed by proper post-surgical follow-up to detect and treat any post-operative complications and, refraction correction in order to ensure optimal sight restoration of the operated eye(s).

Further analysis of the numerous challenges in the organisation and delivery of improved cataract surgical services within Bangladesh are further discussed in Section 7.8 of this dissertation.

7.4 Cataract surgical coverage (CSC) and cataract surgical rate (CSR)

A number of population-based blindness prevalence studies have been conducted over the past two decades. More recently, an especial emphasis has been placed on quantifying the degree to which operable cataract has been treated within a given population. Through a series of surveys, cataract surgical coverage levels have been identified. Many of these studies were based on the rapid assessment of cataract surgical services methodology. Other blindness surveys followed more generic 'all cause' blindness and low vision prevalence methodology. Commonly, both approaches have led to an evidence base concerning cataract surgical coverage levels and the distribution of CSC within communities by gender, age, residence and in socio-economic terms.

The BNBLVS has identified low levels of cataract surgical coverage (CSC), as assessed both for eyes and for persons. Nationally, the CSC for eyes that were visually impaired with operable cataract was only one-third of that required while that for persons was less than 40%. Minor differences across the administrative Divisions of the country reflect the ubiquitous nature of the deficit, especially within rural areas, of the provision and/or up-take of cataract surgical services. Furthermore, the BNBLVS determined that lower cataract surgical coverage levels existed for women, dwellers of rural areas, persons aged 60 years older as well as those who were illiterate.

Comparison of the CSC results with those obtained in surveys from South Asia, China and settings in Africa and Latin America serve to highlight the relatively lower level of cataract surgical coverage that was identified in Bangladesh. Regionally, within South Asia, the CSC within Bangladesh compares unfavourably with that reported for several sites in India, Nepal and more recently in Pakistan. Details of the findings from these blindness prevalence and RACSS studies are provided below, as are the CSC results from three studies conducted in China and, nationally in Oman.

Several blindness prevalence studies have been conducted in India over the past two decades. In 1995, a very large blindness survey was undertaken in Karnataka State, India amongst persons aged 50 years and older.³⁵⁶ In all,

Discussion

21,950 subjects were examined for visual acuity status and in order to determine if the subject had visually impairing cataract. This study served as the precursor to what has since been referred to as 'rapid assessment of cataract surgical services' (RACSS) methodology.³⁵⁷ Limburg and Kumar reported that the cataract blindness prevalence was 4.93% in persons ≥ 50 years, with females (6.51%) being nearly twice as likely to be blind compared to males (3.39%). The cataract surgical coverage for persons at VA $< 3/60$ was 53% overall, with a difference observed in the CSC for males (60%) compared with females (49%). Similarly, the CSC for eyes $< 3/60$ revealed a gender differential in that for males with eyes of VA $< 3/60$ the coverage level was 40% while that for females was only 32%.

In a 1999 report regarding the cataract surgical coverage in persons aged 50 years or older,²²⁹ cataract surgery in either one or both eyes had been performed in 9.5% of the 24,818 examined subjects. Overall the cataract surgical coverage for persons at VA $< 6/60$ was 47.6%. The level of surgery undertaken on male eyes was similar to that for female eyes (7.2% of eyes by gender for both groups) and the CSC for persons was likewise almost equal. Distinctly, the level of cataract surgery was greater in those subjects who were older, i.e. ≥ 70 years of age compared to persons of younger ages. Productive work involvement was also shown to be associated with higher cataract surgical coverage (47.7%) compared with lack of work by the study subjects (44.1%).

A similar study, published in 2002, reported on cataract surgical coverage amongst 1,505 subjects aged 50 years and older in Karnataka State, India.³⁵⁴ At VA $< 3/60$, the CSC for people was 63% while that for eyes was 51%. The percentage of first eye surgeries having been operated upon was 70% and that for second eyes was 30%. This finding for first or second eye cataract surgery contrasts markedly with the values for the BNBLVS as the majority of cataract surgeries had been performed on second eyes (55.9%).

One further study conducted in the State of Rajasthan, India identified cataract as the principal cause (65.7%) of bilateral blindness in persons aged 50 years and older.¹⁵⁷ The overall cataract surgical coverage level in this study

Discussion

of 4,728 subjects was 65.7%. Differences were noted amongst those with ≥ 1 year of schooling versus those without any formal schooling (79.6% v 63.7%) as well as for urban (75.3%) compared with rural (64.3%) residence. A slightly higher CSC was shown to exist for younger individuals (68%) in those 50–59 years compared with persons ≥ 70 years of age (64.9%). However, no such gender difference was found in this study.

The Sivaganga Eye Survey, carried out amongst 4,642 subjects aged ≥ 50 years in southern India in 1999, demonstrated that cataract was the major cause (56.5%) in bilaterally blind eyes.²¹⁰ An increased risk for blindness was shown to exist for older persons and those with no formal schooling. Cataract surgical coverage in this survey sample was 77.5% with non-significant differences in coverage levels being observed according to gender, age or residence (rural v urban). However, based on multiple logistic regression analysis, it was shown that any schooling (i.e. ≥ 1 year) was associated with a higher CSC (89.3%) as compared with the level (71.2%) for those with no schooling whatsoever.

Results from the initial rapid assessment of avoidable blindness (RAAB) study to have been conducted in Bangladesh indicated that cataract was the predominant cause (79%) of bilateral blindness. This finding was effectively the same as that identified by the BNBLVS (79.6% of bilateral blindness due to cataract). In the RAAB study²¹⁴ conducted in 2005 in Satkhira District, in the south-west part of the country, the cataract surgical coverage for persons at VA level $< 3/60$ was 60.9% while that for eyes $< 3/60$ was 34.8% overall. Coverage for males and females did not differ greatly for either persons or eyes with VA $< 3/60$.

Subsequent to the BNBLVS, a total of twelve RAAB studies have been conducted in the country, each of which has reported on blindness prevalence, the causes of blindness and low vision as well as cataract-specific indicators, eg cataract surgical coverage by District (Figure 7.4.1). It is notable that each of the RAAB surveys identified CSC levels greater than 50%, with five Districts having surgical coverage for bilaterally blinding cataract being greater than 70%. These results from studies carried out from 2006 through

Discussion

2013 demonstrate the increased development of cataract surgical delivery in the country following the national survey due, in large part, to increased mobilisation of financial and qualified human resources in blindness prevention aimed at reducing the cataract backlog.³⁵⁸⁻³⁶¹ Additional analysis and comment on the present state of eye care services in Bangladesh will be provided in Section 7.8 of this dissertation.

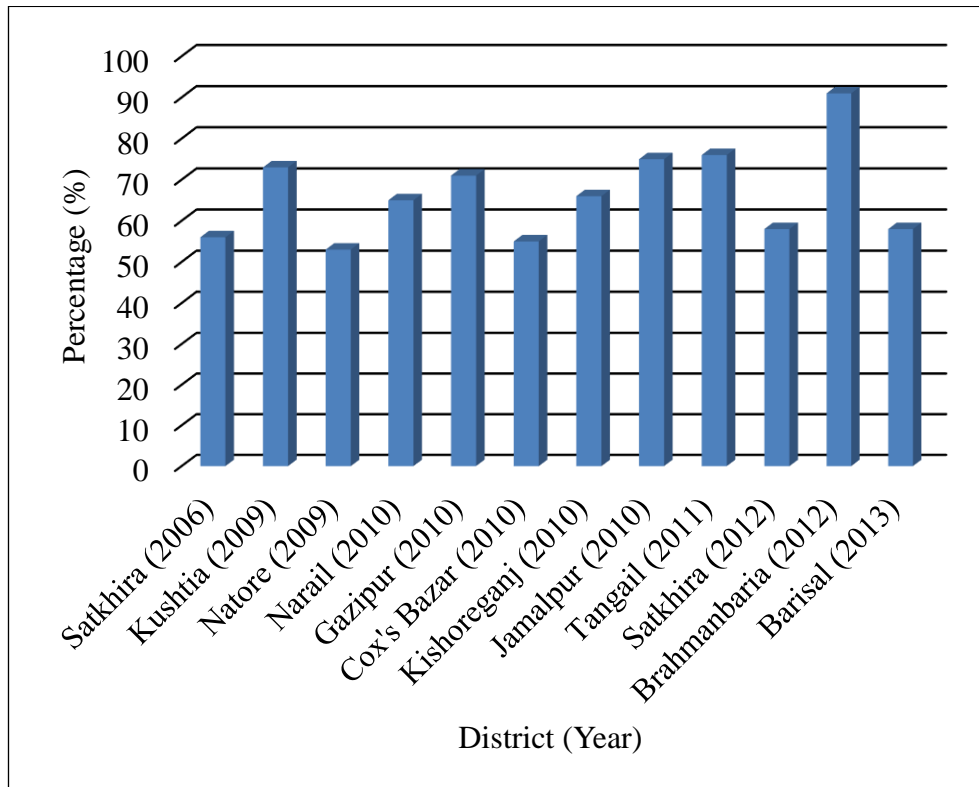


Figure 7.4.1. Cataract surgical coverage (persons) from RAAB studies conducted in Bangladesh, by year of survey

In a 2016 review of several population-based blindness surveys, including a number of RAABs, in South Asia, the cataract surgical coverage for persons, for eyes and by gender was analysed.³¹⁶ The levels of surgical coverage for persons ranged from 30.5% for a remote coastal area of India (Sindhudurg District in Maharashtra State) to in excess of 90% elsewhere in the country (in urban Surat, Gujarat State). This review highlighted that Bangladesh had a notably low CSC for persons compared with that from countries elsewhere in South Asia, including India which – with the exception of the Sindhudurg survey – reported CSC for persons greater than 80%. Despite the more favourable CSC levels from the other countries from the South Asia region

Discussion

compared to Bangladesh, this review noted the presence of socio-economic and gender inequities in terms of accessing surgery for blinding cataract across several countries, including Bhutan and Nepal. Females, those who were illiterate / less educated, those living in rural communities and in some instances, those who were older, were less likely to have been operated upon for cataract, factors reflective of 'gross inequity'.^{316,362-363}

Based on a series of RAAB studies carried out between 2006 and 2012 in Nepal, the cataract surgical coverage for bilaterally blind persons due to cataract was notably high (84.6%).²⁷⁹ It was estimated, according to the age-sex adjusted prevalence data from the fourteen zones of the country, that approximately 110,000 people were bilaterally blind due to cataract, with the majority being women (56.6%).

Three blindness prevalence studies conducted in China have reported on cataract blindness prevalence and cataract surgical coverage. The first of these surveys was carried out in Shunyi County by Zhao *et al* in 1996 amongst 5,084 persons ≥ 50 years of age.³⁶⁴ Cataract was the main cause of blindness in at least one eye in nearly half (48.2%) of all the blind persons. The observed CSC for persons at $<6/60$ level was 47.8%. Higher surgical coverage was identified in those 50-59 (71.4%) and 60-69 (72.4%) years of age compared with persons ≥ 70 years (36.4%). Male gender and having attended primary school were also associated with higher cataract surgical coverage.

In Doumen County in the southern part of China, another blindness prevalence study was undertaken in 1997.²⁸⁴ Cataract was identified as the major cause of blindness having been responsible for 61.5% of the examined subjects found to be blind. Surgical coverage for cataract was 40.3% overall. Higher levels of CSC were noted in gradient form for younger persons as for those 50-59 years coverage was 66.7%, those 60-69 years 51.4% while those 70 years and older was only 37.0%. Likewise, only one-half of males (49.1%) in need of cataract surgery had obtained it while approximately one-third of females had done so (36.9%). Finally, an increased level of schooling was associated with a higher CSC for those with >5 years of schooling (58.3%) compared with those who had never attended school (33.6%).

Discussion

In the Tibet Autonomous Region (TAR) of China, a large population-based blindness prevalence study was conducted in 1999-2000.³⁶⁵ The age-sex adjusted blindness prevalence (<3/60) in TAR was 0.89%. Blindness due to cataract was found to be responsible for more than half of all cases of blindness (50.7%). The great majority (>85%) of these cases were found in persons aged 50 years and older. The overall cataract surgical coverage for persons with VA <6/60 was 56% and that for VA <3/60 was 66%. The CSC for women was significantly lower than for males at <6/60 VA level. In persons aged 50–59 years, a level of 70% CSC at <6/60 was identified while for those aged 70 years and older the CSC was only 48%.

In another RACSS study, conducted in Chakwal District, Pakistan cataract was identified as the main cause of blindness in the 1,505 subjects who were examined.³⁶⁶ Extrapolating the data from this study to the population of the District, it was estimated that as many as 6659 persons aged ≥ 50 years were blind. The cataract surgical coverage obtained from this survey was relatively high at 83.8% for persons with VA <3/60 while that for eyes <3/60 was rather favourable at 70% overall. A higher surgical coverage for persons existed for males (92.8%) compared with females (73.9%). In a similar RACSS study performed in the Orakzai Agency, a tribal area of Pakistan, the cataract surgical coverage for persons at VA <3/60 was 60.9%.⁹⁰ Males were found to have a notably higher CSC (68.9%) compared with females ((51.6%) in this study. As noted both the overall level of CSC for persons was higher in this District of Pakistan than in Bangladesh nationally as well as being higher than for any of the six individual administrative Divisions.

In Oman, a national blindness survey reported on the cataract surgical coverage for both eyes and persons.³⁶⁷ At <3/60 visual acuity level due to blinding cataract, the CSC for persons was 61.1% while that for visually impaired eyes on account of cataract was 51.6%. Males and older subjects (i.e. those 60 years and older) were identified as having higher surgical coverage levels compared to females and those less than 60 years of age. The finding in Oman that older persons had a higher CSC than younger individuals contrasts from that in Bangladesh wherein surgical coverage was

Discussion

higher for persons less than 60 years of age. However, in terms of gender, males were shown in both national surveys to have a preferentially higher level of cataract surgery when compared with females.

Several inter-related factors are associated with the inadequate level of cataract surgical coverage in Bangladesh. These include aspects related to a low level of cataract surgical service provision; social,³⁶⁸ economic,³⁶⁹ cultural³⁷⁰ and geographic^{59,136} barriers to accessing available services; attitudes concerning the potential risks and benefits associated with undergoing surgery. In order to contextualise the findings on cataract surgical coverage in Bangladesh, a separate analysis on the barriers to cataract surgery will be presented in another sub-section of the Results within the dissertation. Studies concerning barriers to eye care service have focused on the dual aspects of service provision limitations and service up-take constraints.⁹⁴ Accessing eye care services in order to undergo cataract surgery is a complex entity that, as stated previously, is conditioned by several inter-related factors of a diverse nature.^{94,371}

Several complementary strategies are required in order to increase the cataract surgical coverage in Bangladesh. These include, amongst others, the following:

- * developing a model of eye care service delivery that leads to increased cataract case detection through outreach screening camps,³⁷²⁻³⁷⁴ followed by referral for treatment in accessible locations such as the 64 district hospitals within the country.³⁷⁵

- * target females, all persons aged 60 years and older and those who are illiterate for inclusion in cataract screening camps in order to increase their involvement in the process associated with being identified, referred and treated for cataract.

- * increase the level of service provision in rural areas and in those Divisions that have relatively lower cataract surgical coverage rates and/or are predominantly rural, such as Khulna and Barisal.

Discussion

* increase the level of awareness within communities concerning cataract as a treatable ocular condition so as to promote increased interest and uptake of surgical services, albeit that such services are very limited geographically – especially in rural areas – and in terms of cost to the patient.

* increase the proportion of cataract surgeries that include placement of intra-ocular lens (IOL) given that the visual outcome of such surgeries has been shown to be better than the visual status post-surgically of operated eyes without IOL. As has been reported, increasing the quality of cataract surgical outcomes over time has led to increased levels of surgical output. Improvements in the quality and quantity of cataract surgery potentially can serve or contribute to the process of overcoming the fear of surgery, which has been identified as one of the major barriers to undergoing cataract procedures.

Comparison of BNBLVS with RAAB studies

Over the past two decades, numerous rapid assessment studies concerning blindness and visual impairment have been conducted globally. Initially, these studies emphasised identifying the prevalence of blindness due to cataract as well as assessing the level of adequacy of cataract surgical services provided by area / regional health services.³⁰⁸ More recently, rapid assessment methods³⁰⁹ have been extended to investigate additional causes of blindness and visual impairment in addition to cataract, eg diabetic retinopathy, refractive error.³⁷⁶ Accordingly, such assessments of the prevalence and causes of avoidable blindness are referred to – as discussed previously in this dissertation – as rapid assessment of avoidable blindness (RAAB) studies.³⁷⁷

Such exercises obtain (sub-)district-level evidence concerning the prevalence and causes of blindness and visual impairment in a relatively rapid manner at reduced cost compared to larger population-based blindness prevalence surveys, eg the BNBLVS. However, certain caveats should be highlighted regarding the utility of the RAAB research methodology, particularly when contrasted with the methodological strengths and attributes of the BNBLVS. These include:

Discussion

* individuals less than 50 years of age are not examined as per the RAAB methodology.³⁷⁸ As such, the contribution of specific causes of blindness and visual impairment in adults aged less than 50 years, eg refractive error, is under-estimated. In the BNBLVS, 7.4% of blind subjects were aged less than 50 years whilst a further 14.1% were visually impaired, mainly due to refractive error. Accordingly, by having used a lower age threshold for subject inclusion in the BNBLVS, ie aged 30 years and older, the national survey more accurately profiled the prevalence and specific causes of blindness and visual impairment within the Bangladeshi adult population than that which has been obtained subsequently through the twelve sub-District level RAAB studies which were conducted between 2006 and 2012.²¹⁴⁻²¹⁹

* the sample size of the BNBLVS, namely 12,900 enumerated subjects of whom 11,624 were examined, was substantially larger than any of the twelve RAAB studies conducted in Bangladesh (mean number of subjects of 2,842). Importantly, therefore, the precision of the estimate of the number of blind and visually impaired adults – based on the prevalence and the 95% confidence interval of the prevalence for impaired vision and blindness – is greater than that which has been obtained by any of the RAAB studies due to the larger sample size of the BNBLVS. Thus the estimated magnitude of the number of persons affected by blindness and visual impairment in Bangladesh, based on the more narrow 95% confidence interval reported by the BNBLVS, is more accurate than the estimated magnitudes that accrued from the RAAB studies. However, importantly, it merits pointing out that the scope of RAAB studies is more directly focused on the district level rather than national population for which the burden of sight impairing disease would be estimated.

* according to the RAAB methodology, following the initial visual acuity examination, re-testing the vision of study subjects through the use of a pinhole occurs in order to determine if any improvement in vision accrues, whereby the presence of refractive error is detected.³⁷⁹ This technique of use of pinhole contrasts markedly from that of the BNBLVS wherein trial lenses for re-testing the visual acuity of subjects with detailed auto-refractometry

Discussion

results was undertaken for each subject with impaired vision. Thus, it was possible to specify for all subjects with vision in either / both eyes the degree of refractive error and to prescribe spectacles for those persons with the individualised refractive correction required. Moreover, it should be pointed out that the refractive error cut-off which elicited further refractive investigations and re-testing for the BNBLVS was <6/12 rather than the threshold of <6/18 as used in RAAB studies. As such, the BNBLVS methodology identified a greater proportion of the sample with potentially visually impairing refractive errors than would be the case as per the RAAB methodology.

* the thorough ophthalmic examination protocol of the BNBLVS involved assessment of the cup:disc ratio in all subjects – for the detection of potential glaucomatous ocular pathology – as well as pupillary dilation in all subjects with <6/12 vision for examining the posterior segment of the eye, inclusive of the retina and optic nerve. Assessment of the cup:disc ratio, in addition to the measurement of intra-ocular pressure (IOP) in glaucoma ‘suspects’ is not a routine component of the RAAB methodology, though pupillary dilation is performed. As such, the BNBLVS protocol allowed for enhanced detection and diagnosis of posterior segment / retinal pathologies, eg macular degeneration, diabetic retinopathy amongst other pathologies.

Although specific differences exist between the BNBLVS and RAAB methodologies, it merits highlighting the value in conducting RAAB studies, particularly in terms of contributing to the expansion of the evidence base concerning blindness and visual impairment.³⁸⁰ Specifically, it is recommended that the results from numerous, individual RAAB studies be reviewed systematically in order to develop a more representative estimate of the prevalence of blindness and its causes within a region or at national level.³⁸¹ Due to the limited sample size of RAAB studies, approximately subjects aged 50 years and older and inherent sampling variability across potential study sites, formulation of eye care service policy based on a single study for populations other than that in which the rapid assessment was conducted would not be justified. However, through systematically reviewing

Discussion

the existent RAAB study findings within a given country or region would provide a more rational evidence base on which to establish parameters for the magnitude of blindness within a population and to prioritise the relevant eye care service measures required,³⁸² eg increased cataract surgical services, enhanced delivery of refractive correction and, increasingly, access to diabetic retinopathy screening and laser photocoagulation treatment.

In conclusion, the level of cataract surgical coverage for both individual eyes and for persons in Bangladesh is inadequate to meet the existent need. Blindness due to cataract is unacceptable given that an effective, inexpensive treatment in the form of sight restoring surgery exists. Significant increase of the cataract surgical output within the country is required in order to meet the present need for cataract surgery. It has been estimated that as of 2001 there more than 550,000 adults bilaterally blind due to cataract in Bangladesh. Development and implementation of a set of effective public health and community ophthalmology-oriented strategies are required in order to confront the challenge of the existent backlog of blinding cataracts as well as those which inevitably occur due to population growth and increased life expectancy of the population.

7.5 Barriers to up-take of cataract surgical services

This sub-section discusses the self-reported reasons amongst those with advanced cataract for not having accessed treatment for this visually impairing / blinding condition. As well, comparisons of the survey results with other population-based research studies will be discussed, particularly with regard to barriers to cataract surgery uptake.

The main barrier reported by persons with advanced cataract associated with not having sought treatment was due to poverty. Nearly one-half (47.0%) of all such subjects indicated that they were incapable of affording the costs associated with undergoing surgery. It merits pointing out that no further questions were posed by the interviewing ophthalmologists concerning whether the subject was referring to direct (eg hospital and surgeon fees) or indirect (eg transport to the facility) costs of cataract surgery.³⁸³ That methodology has been utilised in studies that have focused specifically on barriers to eye care services³⁸⁴ and/or cataract surgical uptake.³⁸⁵⁻³⁸⁶ However, for the purposes of this survey, consisting principally of a comprehensive set of eye examinations, it was considered sufficient to identify the main barriers amongst the studied cohort. Nonetheless, despite the streamlined nature of the questioning, this survey was the first ever study in Bangladesh to document the barriers to cataract surgery.

Not being able to afford treatment for cataract surgery as the principal barrier was consistent with a number of factors, such as the very high level of impoverishment in the country – especially in rural areas – wherein eye care service provision was greatly lacking.³⁸⁷⁻³⁸⁸ As such due to a combination of limited economic resources and unavailable ophthalmic services and personnel, accessing cataract surgery was very limited.

It merits bearing in mind that the cost of cataract surgery involves both direct and indirect costs. Furthermore, it is crucial to recognise the additional financial and logistical constraints for the majority of those who are blind due to cataract given that the majority of these persons live in impoverished, rural areas. In such settings, physical access to a facility (eg government district hospital, non-government clinic) is both costly and logistically challenging.

Discussion

This is particularly the case for elderly persons who may be incapable of undertaking the journey to even the closest such facility where cataract surgery is provided. Furthermore, in the case of females, in addition to not being able to afford the varied costs associated with cataract surgery, the need to have someone to accompany her is cited as a major constraint (5.4%) more than double that for males (2.3%).

In addition to being too poor to afford surgery, thirteen other barriers were also mentioned; together these accounted for 53.0% of responses. Notably the lack of awareness on the part of subjects about having cataract was the second most commonly cited reason (13.0%) for not seeking treatment. Perceiving one's vision to be adequate despite the presence of visually impairing cataract either in one eye or bilaterally; a lack of interest in undergoing treatment, *viz*, being 'careless' according to the interviewing ophthalmologists; lack of someone to accompany the visually impaired subject (especially in the case of females) and fear of being operated upon were other prominent reasons.

The main gender differences concerning barriers to cataract surgery indicated that women were proportionally more likely to identify that poverty and the lack of someone to accompany the female to a health facility as the reasons for not accessing treatment. Males, for their part, had a lower level of awareness about having cataract as well as having expressed a lack of time, possibly due to work (eg farming, business) activities. Rural residents, persons who were illiterate and, relatedly, those who had never attended school were three sub-groups for whom poverty was identified proportionally more than amongst urban, literate / semi-literate and in persons who had ever been in school.

Finally, as regards employment status, manual workers were more inclined to cite poverty as the main barrier. This was also the case for those who were inactive / retired or who a non-manual job. However, the inactive / retired group also cited being too ill to undergo surgery, being too old to seek treatment, not knowing about having cataract and perceiving one's vision to be adequate.

Discussion

Logistic regression (LR) analyses were also performed, comparing those who had or had not undergone cataract surgery. The multi-variable LR model identified that urban residence and having attended school were associated with having been operated upon for cataract. Likewise, living in an urban setting and having undergone some level of schooling were shown to be associated with having sought eye care (ie consulted with a doctor for one's visual impairment due to cataract) as compared with those who had never attended such a consultation. The significance of urban setting to having accessed medical care and, possibly, surgery was associated with the availability of eye care services in the country. With the vast majority of ophthalmic personnel being based in cities in Bangladesh and the population being mainly rural and extremely poor, accessing eye care services was in many instances not feasible logistically or economically.

Comparison of the barriers to cataract surgery identified in the survey with findings from other research, particularly from Bangladesh^{387,389} and India,^{94,136} was undertaken. Findings from within Bangladesh were obtained from the twelve RAAB surveys conducted to-date, between 2006 and 2013.²¹⁴⁻²¹⁹ The results from those studies were systematically combined in order to obtain an overview concerning barriers to up-take of cataract surgery amongst those bilaterally blind due to cataract. In total, the responses from a total of 1,177 subjects were analysed and compared with that of the BNBLVS.

As in the national survey, the main reason identified by more than half those persons blinded by cataract was the inability to afford the treatment (50.3%).³⁹⁰ Two further prominent barriers were: a) not feeling the need to undergo surgery to restore one's vision due to being old and b) not being aware or knowing that a treatment existed for one's vision problem.³⁹¹ These three reported reasons were the key barriers for both males and females in the combined RAAB analysis (Figure 7.5.1).

Discussion

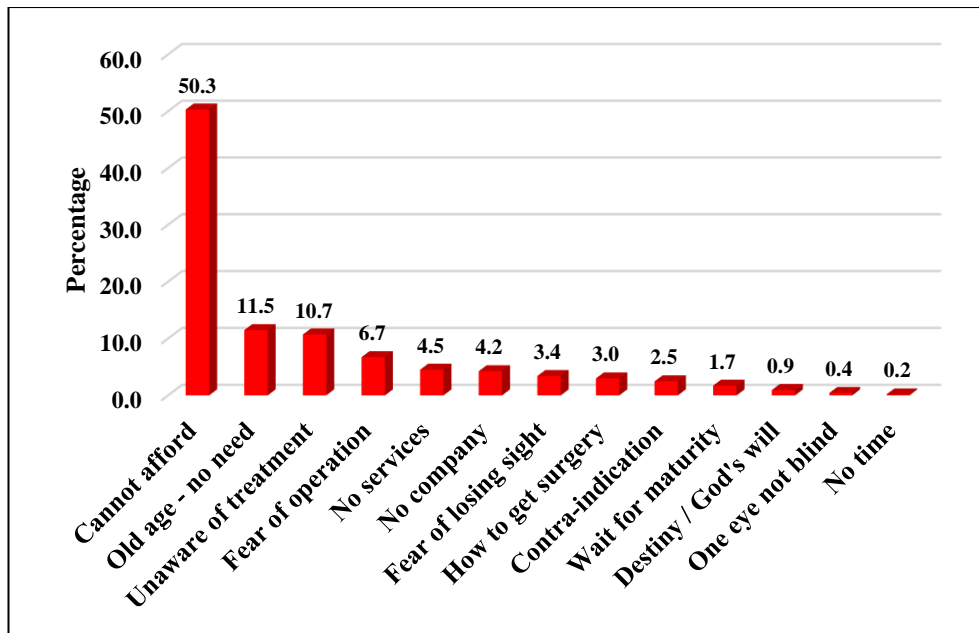


Figure 7.5.1. Barriers to uptake of cataract surgery in twelve RAAB surveys in Bangladesh (n = 1,177).

Lack of awareness about having cataract and/or its treatment was also identified by approximately 10% of the RAAB subjects (combined females and males) with visually impairing lens changes as compared to 13.0% of the BNBLVS subjects (Figure 7.5.2).²¹⁴⁻²¹⁹

The lack of accompaniment to hospital as a barrier to uptake was reported by females more than males, as in many other barrier-related studies that have been carried out in developing countries.^{363,392-393} However, different from that of the national survey, the RAAB studies indicated that fear of undergoing surgery was more common in males, a finding which differs from that of the BNBLVS and various other studies in India^{94,354,394} and Nepal.^{370,395}

Discussion

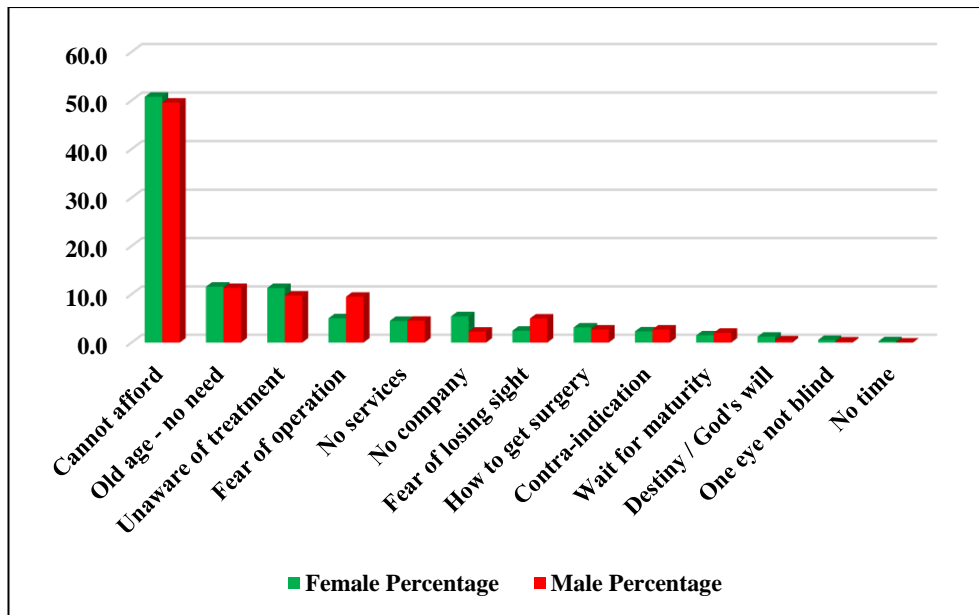


Figure 7.5.2. Barriers to uptake of cataract surgery in twelve RAAB surveys in Bangladesh, by gender (n = 1,177).

In a separate study in assessing eye care services access in rural Bangladesh, the main barriers identified were financial in nature, ie the inability to pay the direct (diagnosis and treatment) and indirect costs (travel, food, loss of income from regular work) associated with seeking care.³⁹⁶ Additionally, the perception that the quality of the eye care service and the reputation of its staff were inadequate / ‘not good enough’ as the third most important factor weighing against seeking care for one’s impaired vision was also reported elsewhere.^{303,353,394}

In a separate study, the barriers to uptake of cataract surgery amongst subjects in rural Satkhira District in Bangladesh who were screened and informed of their need for cataract surgery were identified over the course of a one-year follow-up study.³⁸⁷ Upon carrying out a rapid assessment of avoidable blindness survey in the district, inability to afford surgery (38%) and being unaware of having cataract (37%) were the main two barriers initially reported. Following being examined, reimbursement of transport costs and free cataract surgery were offered to all subjects with vision <6/24 due to visually impairing lens changes. However, despite the financial support provided – for both indirect and direct costs associated with the surgery – only 53.9% of the visually blind had undergone surgery.

Discussion

One year after the survey, the main barriers for not having accessed surgery despite having been informed about the condition and its treatment as well as having been offered financial support for surgery, were identified. These were: a) fear of being operated upon / losing one's sight as a result of surgery (58%) and being old and feeling that surgery was not needed at that point in one's life (30%).

In a similarly designed, one-year post-cataract screening activity in Nepal,³⁶⁸ the follow-up study on barriers to cataract surgery identified were principally economic (50.0%, eg fees for surgery, loss of income during hospitalisation) and logistical (44.8%, capability / willingness of a family member to accompany the visually impaired individual for treatment at the district hospital). Fear of surgery (33.3%) and lack of time (18.8%) due to farming activities were also reported as barriers to surgery uptake.

The effect of outreach cataract screening camps on the uptake of surgery was also investigated in rural communities of Andhra Pradesh State in India, wherein it was observed that only half of subjects in need of surgery utilised the service on offer.³⁷² The main barriers to the uptake of cataract surgery following screening were: lack of awareness about having cataract and a concomitant lack of information about accessing eye care services, including surgical treatment for the condition; personal factors of the visually impaired individual (ie subjectively perceiving no need of improving one's vision in order to carry out one's daily activities); lack of financial resources (ie not being able to afford the indirect costs of transport to the hospital, not being able to take off work or due to a lack of family support and expenditure for the surgery); fear of undergoing surgery in general, fear of having her/his eye(s) operated upon and more broadly, fear of leaving one's rural community when travelling to an unknown setting (a hospital) and location (a city).

As above, since the initial blindness prevalence and cataract surgical coverage studies in the late 1980s, several investigations on barriers to uptake of cataract surgery have been carried out, mainly in various locations in India and more recently, in China and adjoining Asian countries.

Discussion

Specific research studies on barriers to cataract surgery have included as previously indicated the following barrier-related issues: willingness to pay for treatment in Nepal,³⁹⁵ India,²⁹⁸ China³⁶⁹ and Tanzania;³⁹⁰ knowledge levels about cataract, its treatment and decision-making factors on undergoing surgery;³⁹⁷ lack of family support and lack of perceived need for cataract surgery;³⁹⁸⁻³⁹⁹ the impact of cataract outreach screening programmes as a public health strategy for increasing awareness and demand for cataract surgery^{372-373,400-402} and, the effect of different financial support modalities for prospective patients in terms of the subsequent uptake of surgery.⁴⁰³⁻⁴⁰⁵

The understandings and attitudes held by elderly patients concerning their own 'health-in-ageing' are known to be important to their own self-esteem, life satisfaction and health.⁴⁰⁶ Likewise, it is recognised that despite socio-cultural differences and paradigms regarding the impact that ageing may have in specific settings, it is indisputable that attitudes regarding ageing – those personally held and those of society – influence health-related decision-making.³⁷²

In the context of visually impaired elderly subjects in Bangladesh, the perception of being too old to seek having one's vision restored was a significant factor leading to a lower level of demand for cataract surgery than that which actually existed. When combined with not knowing that an effective and relatively inexpensive treatment exists – in the form of cataract surgery – a self-ageist attitude, one reinforced by family and community norms, contributed to the low uptake of cataract surgery within the country.

One investigation from 1998 in Karnataka State in India identified the main barriers as: patients being informed by medical personnel of the need to wait for the cataract to mature prior to being recommended for surgery (23.6%), despite being bilaterally blind at the time of the screening examination; not having anyone to accompany the visually impaired individual to the hospital for surgery (21.6%); fear of undergoing surgery (12.3%), particularly amongst females; and ill health / medical contraindications (9.2%).³⁵⁶

Discussion

However, in contrast to findings from other studies in India,^{301,354} as well as that of the BNBLVS, inability to afford cataract surgery payment was not perceived as important (7.2%). This finding from Karnataka also differed from that reported in a study conducted in the Kathmandu Valley in Nepal wherein respondents identified poverty as the main barrier (44.0%) to the uptake of surgery.³⁹⁵ Likewise, monetary constraints were the principal barrier to accessing surgery in rural India although cataract surgery in government hospitals was free, thus emphasising the importance of increasing awareness about available services and to recognise concerns over indirect costs for patients (eg transport to the facility). It merits being pointed out that the deciding whether to undergo surgery was shown to be taken not solely by the visually impaired individual but rather that such a decision was the prerogative of the family, especially the adult males (eg a son in employment).^{372,402}

The key role of indirect costs as a barrier to cataract surgery uptake, including transport to hospital, accommodation, lost income due to not working on the part of the patient and/or by an accompanying family member was discussed in a study carried out in Ethiopia.⁴⁰⁷ Whilst indirect costs formed the principal barrier (40%), reported by more than 800 subjects in need of surgical treatment for cataract or advanced trachoma amongst a rural population, approximately one-quarter (27.8%) indicated that direct costs associated with surgery were the main reason for not seeking care.

Other barriers to cataract surgery reported in the literature include a lack of knowledge about the nature of cataract and its treatment (57.8%),³⁷⁰ especially in those with lower levels of education in a large urban setting in India.³⁹⁷ As reported in a study from rural eastern China on awareness about cataract and its treatment, being able to still see well enough ('residual functional vision') and financial difficulties were cited as the major barriers to cataract surgery.⁴⁰³

Elsewhere, in a study conducted in three rural areas in the Indian State of Andhra Pradesh, the main barriers to eye care services amongst a cohort of 764 subjects with <20/60 vision were shown to be similar to those of the

Discussion

BNBLVS, as follows: a) not having money to pay for an eye examination (37.0%), b) not perceiving the vision loss to be a serious problem (21.1%) and c) having other commitments due to farming activities / family business matters which deterred the subject from having her/his eyes checked (14.9%).¹³⁶

Barriers to accessing cataract surgery were ascertained amongst a cohort of patients in a study conducted in Delhi, India.³⁹⁹ Similar to the BNBLVS, the main reasons for not having accessed eye care services for treatment despite being visually impaired due to cataract were dual in nature, namely financial and attitudinal on the part of the patient. Following methods of allowing for multiple responses, whilst insufficient family income was reported by 76% of respondents as the major financial barrier, it was also noted that there was less concern over the cost of the cataract surgery itself (27%). Rather, attitudinally, patients expressed the view that she/he could manage with one's daily routine without needing to be operated upon (71%) and that the cataract was not yet mature enough to require surgery (68%).

Reasons for low uptake of eye care delivered through outreach screening and referral camps in 48 rural villages in Tamil Nadu State in southern India were identified.³⁹⁸ As distinct from other research studies, the main barrier to accessing eye care, especially for cataract surgery, was fear on behalf of both the prospective patient (33.3%) and her/his family members (26.2%). In-depth elucidation of the role fear represented to these persons highlighted the perception that eye surgery would damage the eye ('pluck', 'peel' or 'spoil' the eye) or more generally, that undergoing surgery represented a risk of dying. Additional key barriers reported included: subject perceiving being able to manage their daily activities well enough without treatment (27.9%), despite 24 such subjects who provided this response being severely visually impaired or blind bilaterally; not having time due to work or family commitments / responsibilities (26.1%), treatment costs – both direct and indirect (24.2%) and that treatment in old age was not worthwhile (as reported by 20% of those aged 60 years and older), amongst other reasons. Finally, unlike the situation in Bangladesh, whilst the subjects generally were aware

Discussion

of the availability of eye services near their villages, a majority (73%) of those with cataract were not aware of their diagnosis prior to the screening camp being held. Rather, the visual impact of having cataract was perceived as blurred vision consistent with old age, for which, as above, it was felt that treatment was not necessary.³⁹⁸

In the case of Takeo Province in rural Cambodia, amongst 180 subjects who were screened locally and referred to follow-up eye care, the main barrier (47.8%) reported was that of not having sufficient time to attend the nearby hospital.³⁵³ This reason was shown to be linked to inter-related socio-economic issues, such as that of needing to work in order to earn sufficient money for food for other family members. Lack of someone to accompany the visually impaired person (21.7%), also possibly related to other family members needing to work rather than escort their family member to the hospital could have been due to chronically impoverished conditions in this rural area of Cambodia. Fear of losing one's eyesight due to complication of cataract surgery, not being able to afford transport to the hospital and being of the opinion / belief that one's eye problem was not serious enough to merit medical attention were also key barriers to uptake of eye care services amongst this Cambodian cohort.⁴⁰⁸

As discussed above as one of the findings from a study conducted in Bangladesh, perceptions that local eye care services were of poor quality, together with a lack of knowledge about cataract, were identified as key factors for not accessing cataract surgery amongst a group of severely visually impaired Chinese rural adults.⁴⁰⁹ The study elucidated the relationship between existent attitudes about the eye care services with the observation that more than one-quarter of post-intervention cataract patients continued to be blind following surgery. This being the case, the study's authors opined, would have deleteriously affected the level of surgical uptake in these communities. Similar findings concerning attitudes towards eye care delivery negatively influencing surgical uptake, effectively inadvertent 'negative social marketing'⁴⁰⁴ have been reported elsewhere.⁴¹⁰

Discussion

In summary, models for categorising barriers to accessing cataract surgery have been proposed by various researchers. In light of the findings of the survey, the framework below (Table 7.5.1) is proposed. Public health measures aimed at ameliorating the negative effects of barriers to treatment for cataract will be addressed later in this dissertation when discussing eye health care programme development within Bangladesh.

Discussion

Table 7.5.1. Model of barriers to cataract surgery – consumer and service provider

Consumer ³⁹⁸ / Person-related Barriers ⁴¹¹	Provider / Service-related Barriers ³⁸³
Costs of surgery – direct and indirect	Lack of ophthalmologists and facilities
Distance to health care facility	Lack of other ophthalmic personnel, resources
Gender-related issues, eg no accompaniment	Inadequate eye care services budget
Lack of awareness of eye care services	Lack of accessibility to facilities; no transport
Not knowing about having cataract	Poor reputation in terms of quality of care
Fear of undergoing cataract surgery	Lack of community-based outreach services
Lack of perceived need; vision adequate	Insufficient, ineffective social marketing
Being elderly; surgery not needed	Delay of cataract surgery; ‘need to mature’

7.6 Prevalence of refractive error and spectacle coverage

In accord with the WHO and IAPB joint strategic initiative, *Vision 2020 Initiative – A Right for Sight*,^{4,7,9} correction of refractive errors is a central priority in the quest towards reducing the burden of avoidable visual impairment and blindness globally. Reporting on the prevalence of refractive errors within the Bangladeshi population for the first time by means of the BNBLVS was an important achievement. In doing so, the overall burden of refractive errors was quantified as were the sub-groups identified within the population at increased risk of having uncorrected refractive error. Finally, as a significant extension of the refractive error data analysis, the indicator – spectacle coverage – was defined and calculated, thus elucidating the level of unmet need for refractive correction amongst the BNBLVS subjects.

Refractive errors were present in approximately half of all subjects (48.4%), contributing to presenting visual acuity <6/12 in the better eye. Whereas myopia was more prevalent in males (at all three dioptres of spherical equivalent thresholds), hypermetropia was more common in females. This finding has also been reported in certain studies particularly those which identify refractive errors and distinguish between the subjects who, with refractive error, have either myopia or hypermetropia. One such study was the APEDS survey which reported a prevalence of myopia of 19.5% and of hypermetropia of 8.4% in individuals aged 15 years and older.⁴¹²⁻⁴¹³ These figures differ from those of the BNBLVS (24.7% and 23.7%), likely due to the younger age threshold, ie 15 years, in the Indian study. As in the BNBLVS, myopia was more common in males, whereas hypermetropia was associated with females and living in urban settings. Both conditions were associated with increased age, in both surveys, though hypermetropia was shown to decrease in those 60 years and older.

Global estimates of uncorrected refractive errors indicate the very large burden of visual impairment and blindness due to the lack of spectacle use.⁴¹⁴⁻⁴¹⁵ These estimates differ according to the age groups under consideration and the level of refractive error (mild, moderate, severe) as well as by distance versus near vision capacity. Notwithstanding such methodological and

Discussion

clinical specifications, uncorrected refractive errors are the leading cause of visual impairment and a major cause of blindness worldwide. It is thought that as many as 2 billion persons would benefit from wearing spectacles.⁴¹⁶⁻

418

A 2017 systematic review, based on 63 studies, reported a myopia prevalence in adults of 26.5% (95% CI: 23.4% – 29.6%), that which compares closely to the BNBLVS finding (24.7%).⁴¹⁹ The global prevalence of hyperopia was 30.6% (95% CI: 26.1 – 35.2) in adults while that for the South East Asia region was 28.0% (95% CI: 23.4% - 32.7%). These prevalence figures are slightly higher than that for hypermetropia from the BNBLVS (23.7%). However, the reported differences in prevalence between the BNBLVS and the aforementioned systematic review may be due to the minor dissimilarities in the ages of subjects and in the definitions of refractive errors for myopia and hypermetropia between the studies.

Findings from a series of RAAB studies conducted between 2010 and 2012 in persons aged 50 years and older in eight Districts in Bangladesh were very similar to those of the BNBLVS in that cataract was the main cause of blindness (75.8%) and of severe visual impairment (73.6%) whilst refractive error was the principal condition associated with moderate visual impairment (63.6%).⁴²⁰ These findings, at least ten years following the BNBLVS, reiterate the inordinately high burden of blindness due to cataract that was identified in the national survey as a cause of blindness (79.63%) as well as visual impairment being very much associated with uncorrected refractive errors.

In the BNBLVS, refractive error was the second most common cause of <6/12 vision in the better eye (18.87%), after cataract, whilst being the ocular condition responsible for blindness in only two individuals, ie 1.23% of all subjects who were blind. These findings differ from those reported in several other population-based studies in which refractive error was determined to be the main cause of moderate and severe visual impairment.^{259,421-422}

Discussion

The APEDS population-based study in urban and rural areas near Hyderabad, India refractive error was the cause in 16.3% of all cases of blindness, that which is notably greater than that identified in the BNBLVS.²⁹⁴ However, it merits highlighting that cataract blindness was substantially higher in Bangladesh than in the APEDS survey thereby diminishing the contribution of refractive error in the BNBLVS.

Globally, the GBD-VLEG likewise reported on the importance of refractive error to visual impairment and blindness, citing it as the main cause of moderate and severe visual impairment and the second leading cause of blindness worldwide.²⁵⁹ As of 2010, there were an estimated 108 million visually impaired or blind persons due to refractive error. Notably, as in other world regions, South Asian countries experienced a reduction of the age-standardised prevalence in persons 50 years and older of visual impairment (<6/18 to $\geq 3/60$) due to uncorrected refractive error from 18.5% to 14.6% over the period 1990 – 2010.⁴²³ Likewise, the age-standardised prevalence of blindness in persons 50 years and older reduced from 2.3% to 1.5%. However, despite such favourable age-specific prevalence reductions, the actual number of individuals blind due to uncorrected refractive error increased globally by more than 500,000, whereas the number of visually impaired persons increased by over 13 million. Such increases were associated with increased population growth and longer life expectancy.

In the specific case of South Asia as of 2010, the percentages of visual impairment (65.4%) and blindness (36.0%) attributable to uncorrected refractive error – based on a cause fraction methodology analysis – were by far the highest worldwide. Such findings draw attention to the large need for refractive error detection and spectacle provision throughout the South Asia region, including Bangladesh¹²².

7.7 Prevalence of low vision and need for rehabilitation services

The results obtained in this survey concerning functional low vision amongst Bangladeshi adults aged 30 years and older comprise the first ever epidemiological profile on low vision in the country, with a prevalence of 0.58% in persons aged 30 years and older.

In terms of the causes of low vision reported in the survey, severe refractive error not resolvable through correction to achieve a visual acuity $>6/18$ was the main cause of functional low vision followed by age-related macular degeneration. Several other cases of low vision were due to retinal diseases and optic nerve conditions. Only one individual was found to have low vision due to glaucoma while none was due to diabetic retinopathy.

Being older, not being literate and living in the remote north-eastern area of the country, in Sylhet Division, were shown to be factors associated with increased odds of having low vision. However, neither gender differences nor being from rural (or urban) settings were linked to increased likelihood of low vision status within this survey. As stated previously (Section 6.7), by means of extrapolation to the Bangladeshi population at the time of the survey, it was estimated that over 250,000 adults had low vision and would have potentially benefited from rehabilitative services.

Notably, by comparison, the reported prevalence of 0.58% is lower than that of similar population-based surveys in India and Pakistan. In the case of the Andhra Pradesh Eye Disease Study (APEDS), conducted in 24 urban (Hyderabad) and 70 rural settings in the state of Andhra Pradesh (total population of 75 million persons), the age-sex and rural-urban adjusted prevalence of low vision was 1.05%.⁴²⁴ The principal causes of low vision identified amongst the 10,293 subjects were: retinal diseases, especially age-related macular degeneration, retinitis pigmentosa and chorioretinitis (35.2%), amblyopia (25.7%), optic atrophy (14.3%) and glaucoma (11.4%). The causes reported from the APEDS survey are similar to those from the Bangladesh study, with the exception of severe refractive error not resolvable by refractive correction, as found in the latter survey. In APEDS, low vision

Discussion

(especially due to retinal disease and optic atrophy) was associated with older ages, with more than half of those with low vision being 60 years or older and of lower socio-economic status.

In relation to the Pakistan National Blindness and Visual Impairment Survey (PNBVIS), (on which the author of this dissertation was the Project Co-ordinator), the functional low vision age-sex standardised prevalence was 1.7% amongst the 16,507 subjects aged 30 years and older who were examined.⁴²⁵ By contrast with the Bangladesh and APEDS surveys, the main causes of low vision in the PNBVIS were corneal conditions – mainly due to scarring-related opacities in the rural areas (34.3%) – and retinal diseases (30.3%), which were most prominent in urban settings. Glaucoma, amblyopia and optic atrophy were also identified as causes of low vision. In the PNBVIS, functional low vision was shown to be associated with older age, rural settings and a low level of formal education.

Prevalence of functional low vision results were also reported for ten of the twelve RAAB studies carried out in Bangladesh between 2006 and 2013.²¹⁴⁻²¹⁹ The prevalence findings ranged from 0.4% (in three Districts) to much higher levels (1.5% in one and 1.6% in two other Districts). By comparison, the prevalence results obtained in some, though not all, of the Bangladeshi RAAB studies were quite similar to the prevalence of functional low vision identified in the national survey, ie 0.58%.

Discussion

Table 7.7.1. Prevalence of functional low vision amongst persons aged 50 years and older in Bangladesh RAAB studies (n = 10).

District (Year)	Prevalence of Functional Low Vision (%)
Cox's Bazar (2010)	0.4
Satkhira (2012)	0.4
Barisal (2013)	0.4
Tangail (2011)	0.5
Satkhira (2006)	1.0
Jamalpur (2010)	1.0
Narail (2010)	1.3
Kushtia (2009)	1.5
Kishoreganj (2010)	1.5
Gazipur (2010)	1.6

When comparing the results of the national survey with those of the aforementioned ten RAAB studies, the three posterior segment diseases – glaucoma, macular degeneration and, in only one District, diabetic retinopathy – were responsible for similar proportions of the FLV cases in six of the districts (ranging from 16.2% to 27.3%) as to that identified in the survey. However, in the other six districts, much lower levels of FLV due to posterior segment diseases (PSD) were found (ie from 2.0% to 13.3%).

It merits pointing out that these districts with substantially lower functional low vision due to PSD were those in which the cataract surgical coverage was also significantly lower (eg 53% in Natore wherein PSD prevalence was 2.3%).²¹⁷ This pattern of low CSC with a low level of posterior segment disease across the six districts with low FLV draws attention to the dynamic between a higher proportion of cataract bilateral blindness precluding one being diagnosed with FLV. This is on account of the case definition for FLV excluding those with cataract as a potential cause of impaired vision.

Discussion

Moreover, in practical terms, in the presence of mature or advanced cataract, examination of the retina under field conditions, *viz.*, with a direct ophthalmoscope, is either partially or completely obscured. Thus, identification of ocular conditions such as macular degeneration³⁰⁶ may not be fully possible even following cyclopegic mydriasis.

Provision and uptake of low vision services

In a broader context, the uptake of low vision rehabilitative services has been less than optimal even in more developed settings, for example in Australia and Canada. In Melbourne, it was identified that a lack of awareness about the nature of rehabilitative services for low vision, issues concerning transport to the low vision clinic amongst the visually impaired and being in poor health were associated with low levels of attendance to low vision services amongst those who had been referred for care.⁴²⁶⁻⁴²⁷

In a separate Melbourne-based study, barriers to accessing low vision services were related to a lack of understanding and awareness about low vision care and the potential benefit of such services; limitations on behalf of eye care professionals and agencies providing such care resulting in an inconsistent implementation of referral guidelines as well as transport / logistical issues for attending the low vision clinic.⁴²⁸

In Montreal, satisfactory levels of uptake of low vision services was linked with a) being visually impaired for fewer years compared with those who did not attend the specialist clinic and b) having a greater degree of residual, functional vision which enabled those patients to attend for rehabilitation.⁴²⁹⁻⁴³⁰ Similar findings to those of Melbourne and Montreal have been reported elsewhere (Adelaide,⁴³¹ Ontario,⁴³² Finland⁴³³).

Studies on barriers to low vision services have been undertaken in several settings.⁴³⁴⁻⁴³⁵ Findings from a comprehensive literature review of low vision service provision identified a number of barriers to accessing low vision services from the perspective of patients diagnosed with low vision.⁴³⁶ Said factors included: misconceptions about low vision services (eg whether services were designated for those who were blind or for those with residual,

Discussion

functional vision); miscommunication about such services from eye care professionals (ie that low vision services may not be useful, due to the cause of vision loss and the stage of low vision not being amenable to improvement even with the use of appropriate low vision devices); lack of awareness by patients about low vision care; concerns over the location of low vision clinics and the transport required to access the facility; belief on behalf of the patient that her/his visual impairment was insufficient to warrant low vision care; the perceived cost of low vision devices and services; co-morbidities of physical and mental health conditions; and, finally, the income and educational levels of the patient and her/his family and their impact on uptake of low vision services.

Results from the only global survey on low vision services thus far conducted reported in 2011 that provision of low vision services were available in only 65% of the 178 countries surveyed.⁴³⁷ These were mainly developed countries whereas 35% of countries had no low vision services; these latter countries were mostly low and middle income developing countries (LMIC). Furthermore, it is important to highlight that coverage was substantially inadequate (less than <50% of the level of need for services) in more than half of those countries with service provision. In the LMIC settings with low vision services, the lack of health professionals having been trained in low vision care – including ophthalmologists and optometrists – impacted negatively on the degree and type of low vision care provided, ie mainly clinical in nature with limited input from social, educational or rehabilitative services for persons with low vision. This global survey also pointed out that in more than 95% of the developing countries with low vision care, as distinct from more developed settings, such services were almost exclusively financed by international non-government organisations (INGOs), with little or no support from government contributions. This was raised as a concern as to the medium-to-longer term sustainability of low vision service provision within developing settings, particularly given projected increased funding needs due to increased life expectancy and overall population growth within developing countries in the coming decades.

Discussion

The global survey reported on the most common barriers to accessing low vision services, as follows: lack or absence of low vision care, especially in LMIC settings; cost of care; distance to the nearest low vision service, particularly affecting those persons living in remote, rural areas;⁴³⁸ being female; lack of functional referral low vision service networks; and, the perception by eye care professionals that ‘nothing more could be done’⁴³⁷ for persons with severe visual impairment in need of low vision services.

Limitation of the BNBLVS functional low vision analysis

The results concerning those subjects from the BNBLVS with functional low vision were presented in Section 6.7 of this dissertation. In total, 68 subjects fulfilled the WHO definition for functional low vision based on their visual acuity, lens opacity status and in terms of the specific diagnosis causing visual impairment. The relatively small number of subjects that met the inclusion criteria, corresponding to a prevalence of 0.58% in persons aged 30 years and older, was relatively similar to reported findings from other population-based studies from Bangladesh²¹⁷ and India.²⁹⁴

The statistical analysis undertaken on low vision subjects included both univariate methods, Odds ratio results, t-tests) as well as development of a multiple binary logistic regression model for estimating the effects of the explanatory variable(s) upon subjects having functional low vision. Those shown to be statistically significant in the binary logistic regression model included the age of the individual, the administrative Division of residence and one’s literacy status (Table 6.7.4). However, employment status was not identified as being associated with functional low vision in the same logistic regression model even though it was shown to be predictive of the dependent variable upon univariate analysis per χ^2 testing (Table 6.7.3).

Albeit that the sub-group of those with functional low vision consisted of only 68 subjects, the univariate and the multiple binary logistic model analyses identified the aforementioned three explanatory variables as being statistically significantly associated with functional low vision, though not employment status. Consideration of the potentially biased effect of these results due to the relatively small sample size merits mentioning. Due to the

Discussion

limited number of subjects with low vision within the BNBLVS cohort, a Type II error – accepting a false null hypothesis – may have occurred.⁴³⁹ In this context an explanatory variable, eg gender, may have been shown not to be associated with functional low vision due to potentially inadequate power of the study to detect an association resulting from the effect of the small sample on the power of the study.⁴⁴⁰

Alternatively, it has been pointed out that systematic bias towards rejecting a null hypothesis may occur with logistic regression when analysing the association of an explanatory variable with the outcome due to increased standard error leading to overestimation of the effect, ie Odds ratio result, in studies with small sample sizes.⁴⁴⁰⁻⁴⁴¹

Finally, key concerns arise when discussing functional low vision in terms of eye health care service delivery within the Bangladeshi context, including that of rehabilitation for individuals with FLV. These include:

- * the lack of properly trained professional eye care personnel (ophthalmologists, optometrists, orthoptists) to diagnose and provide appropriate rehabilitative care for persons with FLV.⁴⁴²

- * the lack of dedicated functional low vision clinics within the country in addition to the unavailability of adequate numbers and types of low vision aids, eg telescopes, magnifiers, computer-based devices used for optimising residual vision.⁴⁴³⁻⁴⁴⁵

- * lack of referral pathways within eye care service delivery for those in need of low vision care, ie lack of co-ordination and communication amongst primary eye care workers,⁴⁴⁶ mid-level ophthalmic personnel and ophthalmologists with low vision care practitioners of which few exist in the country.⁴⁴⁷

- * inadequate financial support for functional low vision services due in part to the competing and simultaneous need for funding of increased cataract surgical service delivery throughout the country.

Discussion

In the case of Bangladesh, accessing a low vision clinic has been severely limited due to a number of inter-related reasons. The principal factor had been the non-existence, until post-2003, of a dedicated service for patients in need of low vision rehabilitation. This obvious detriment was and has continued to be further compounded by the lack of qualified optometrists and orthoptists capable of delivering rehabilitative care.⁴⁴⁸ To date, one ophthalmologist has been trained in low vision care outside of the country by an international non-governmental organisation (INGO)⁴⁴⁹ in order to deliver a dedicated, hospital-based low vision service for children and adolescents, that which is supported by that particular development agency.

Thus, despite the effectiveness of low vision rehabilitation in terms of increasing the quality of life of a visually impaired individual, several supply barriers (eg staff, equipped clinics, financial support) and demand constraints (eg awareness about services) to care provision still need to be resolved in Bangladesh.

7.8 Eye care services development in the context of Bangladesh

This final sub-section of the Discussion deals with a series of related topics focusing on global developments in eye health strategic policies and on eye care programme implementation in Bangladesh following the completion of the survey and dissemination of the main results of the study.

Over the past two decades, a series of global eye health strategic policy initiatives were developed and implemented – to a greater or lesser degree both globally and within specific countries, including Bangladesh. The sequence of these worldwide eye care policies includes:

1999 – WHO and IAPB joint Global Initiative Vision 2020 – The Right to Sight⁷⁹

2003 – WHA Resolution 56.26 on the Elimination of Avoidable Blindness⁴⁵⁰

2006 – WHA Resolution 59.25 on the Prevention of Avoidable Blindness and Visual Impairment⁴⁵²

2009 – Adoption of Resolution WHA62.1 Prevention of Avoidable Blindness and Visual Impairment, endorsing the Global Action Plan (2009 – 2013) for the Prevention of Avoidable Blindness and Visual Impairment¹⁰⁹

2013 – Universal Eye Health: A Global Action Plan 2014 - 2019²⁸¹

Underpinning a revised strategic approach to eye service policy and implementation globally is the joint WHO – IAPB *Vision 2020 – The Right to Sight Global Initiative Strategy for Prevention of Avoidable Blindness*. It is noteworthy that the BNBLVS was conducted in the period 1999 – 2000, at a time when a major collective reconsideration on the future of eye care services was taking place amongst international bodies, such as the IAPB, the WHO, national health authorities and international and national non-governmental organisations. The need for such a re-think was critical given the increasing burden of visually impaired and blind persons globally over several decades, through to the late 1990s, when Vision 2020 was conceptualised and developed.

Discussion

In response to the health challenges for millions of individuals and their families as well as the socio-economic and productivity loss consequences caused by vision loss,²²¹ Vision 2020 prioritises three key strategies for ameliorating the global burden of visual impairment and blindness.⁹ These are:

- * eye disease control through population-based research and evidence-based treatment methods
- * human resource development across all cadres of ophthalmic personnel
- * infra-structure, equipment and appropriate, cost-effective technology for management of eye diseases within communities.

In support of enhanced implementation of Vision 2020 policy the main objectives of the Global Action Plan (GAP)¹⁰⁹ for the period 2009 – 2013 were:

- * to strengthen advocacy to increase Member States' political, financial and technical commitment in order to eliminate avoidable blindness and visual impairment;
- * to develop and strengthen national policies, plans and programmes for eye health and prevention of blindness and visual impairment;
- * to increase and expand research for the prevention of blindness and visual impairment;
- * to improve co-ordination between partnerships and stakeholders at national and international levels for the prevention of blindness and visual impairment, and,
- * to monitor progress in elimination of avoidable blindness at national, regional and global levels.

Following on from the prior Global Action Plan (2009-2013), the WHO integrated universal health coverage elements – such as strengthening of eye care services⁴⁵³ through integration with general healthcare delivery⁴⁵⁴ – in

Discussion

the policy outlining the subsequent five-year strategy for improving eye care delivery globally.⁴⁵⁵ Thus the three major objectives of the policy, entitled Universal Eye Health Global Action Plan 2014 – 2019²⁸¹, are:

- * to generate evidence on the magnitude and causes of visual impairment and eye care services and to use it to monitor progress, identify priorities and advocate for greater political and financial commitment by Member States to eye health;

- * to develop and implement integrated national eye health policies, plans and programmes to enhance universal eye health (UEH) with activities in line with WHO's Framework for Action for Strengthening Health Systems to Improve Health Outcomes;⁴⁵⁶

- * to enhance multi-sectorial engagement and effective partnerships to strengthen eye health.

Essential to the 2014 - 2019 global eye health action plan are a) the principles of universal access through equity to eye care^{310,312} and b) evidence-based practice in terms of reduction of the prevalence of priority visually impairing / blinding conditions.⁴⁵⁷

In the Bangladeshi context, Vision 2020 was ratified in 2001, being one of the first countries in the WHO South East Asian Region (SEARO) to have formally committed to pursue the principal goal of reducing avoidable blindness.

At the time that Vision 2020 was approved by the Government of Bangladesh,¹⁸ the burden of blindness and visual impairment in adults aged 30 years and older – as outlined in this dissertation – was very large. The high magnitude of impaired vision and blindness was inextricably associated with the inadequate and limited resources existed to deal with the levels of blindness – especially due to cataract (more than 500,000 cases) – and uncorrected refractive errors that were identified by the BNBLVS.

Discussion

In support of implementation of Vision 2020 in Bangladesh, in 2001 the Government adopted a five-year National Eye Care Plan – the first ever developed in the country.³⁵⁹ Thus, for the period 2001–2006, this plan would guide the prioritised strategies and actions towards eliminating avoidable blindness by 2020.

One of the key targets outlined in the initial National Eye Care Plan was to increase the cataract surgical rate (CSR) from 536 surgeries / million population / year in 1999 to a CSR of 1,500 by 2010. As of 2008, the CSR had risen to approximately 1100, according to the Directorate General of Health Services.⁴⁵⁸

Subsequent to the end of the first National Eye Care Plan, in 2007 a National Vision 2020 Advisory Committee was established. This marked the first instance that the National Eye Care Programme was assigned a Line Director within the Ministry of Health and Family Welfare (MHFW). Key responsibilities of the Advisory Committee included providing technical and advisory support for operationalising the national plan. Furthermore, District Vision 2020 Committees – 64 in total – were organised in collaboration with international non-governmental organisations (INGOs), District and sub-District level public health officials, local NGOs, private hospitals / clinics and representative community groups. The role of these District Vision 2020 Committees has been to identify the eye care needs (eg through carrying out RAAB studies) and to develop the district eye care service plans collaboratively with the service providers present in a particular District (infrastructure up-grading, human resource development, acquisition of ophthalmic equipment).^{18,359}

From an operational planning perspective, two key priority actions were initially emphasised in the implementation period from 2006–2011, as highlighted in the WHO action plan for elimination of avoidable blindness outlined for that time period.⁴⁵⁹ Infrastructure development of District-based secondary levels hospitals for delivery of cataract surgery and increased involvement of sub-District health clinics in visual acuity testing, refractive error correction and cataract case referral were prioritised.⁴⁶⁰

Discussion

Subsequently, the main objectives of the sectoral strategic plan of the Government of Bangladesh Health, Population and Nutrition Sector Development Programme (HPNSDP) for the period 2011–2016 were developed in line with the principal strategies of Vision 2020.⁴⁶¹⁻⁴⁶² These included further infrastructural development and up-grading of both secondary and primary eye care facilities within Districts, enhanced support for all cadres of ophthalmic staff and in the supply of appropriate equipment for provision of essential services.

Key, salient components and activities of the HPNSDP Operational Plan from 2011–2016 included:

* Advocacy and co-ordination

Effective co-ordination and co-operation between government, INGOs / NGOs and private eye care service providers in respect of human resources development and the distribution and type of eye care delivery, eg by geographical area, so to avoid duplication.

* Planning and research

Strengthening of District Vision 2020 Committees in order to carry out the following functions: to conduct population-based assessments of visual impairment / blindness at District and sub-District level and to develop District-level eye care operational plans for delivery of essential eye care services that were required within the District, especially cataract surgery and correction of refractive errors through spectacle provision.

* Human resource development

Training, recruitment and retention of ophthalmologists, ophthalmic nurses, technicians and assistants as well as community-based primary eye care workers for the provision of comprehensive eye care programmes, including visual acuity testing and cataract screening and referral to surgery.

Additional elements of this operational plan were: capacity development of the National Eye Care Programme administration; equipment procurement

Discussion

and maintenance; monitoring and supervision of the delivery of eye care referral and treatment within the Districts; establishment of sub-speciality ophthalmic units within tertiary level hospitals for diagnosis and clinical management of posterior segment disease such as glaucoma and age-related macular degeneration.⁴⁶¹

From a WHO South-East Asia Region (SEARO) perspective, a situational analysis of member countries identified the degree to which progress had been made as of 2012 on the Vision 2020 indicators.⁴⁶³ The major findings reported for Bangladesh related to the following findings:

- * the extremely low level of government financing for eye health in 2010 (US \$ 557,000, ie 0.4 cents per person);
- * the inadequately low cataract surgical rate (CSR) and the increasing ageing population contributing to the high cataract backlog – those accumulated visually impairing cataract cases that have not yet been operated upon;
- * the low level of primary eye care service delivery (limited to visual acuity testing in only selected areas where trained personnel were available);
- * the absence of a case referral and feedback system; limited human resources for eye health delivery especially of mid-level ophthalmic personnel, and
- *the disproportionately large number of ophthalmologists working in urban settings, mainly Dhaka.

Additional concerns regarding eye care service and implementation of Vision 2020 strategies, as reported by WHO SEARO, included the lack of accessibility and affordability of eye care services (including high out-of-pocket expenditures), the lack of co-ordination of programmes across government, INGO / NGO and private providers as well as the challenges of low levels of awareness amongst the general population regarding eye health, amongst other pertinent blindness prevention issues.

As highlighted in the aforementioned SEARO situational analysis, despite the notable increase in the CSR from 536 surgeries / million / year in the fifteen

Discussion

years of implementation of successive eye care plans, the total of cataract surgeries performed in 2014 (185,176) was still very inadequate. This quantity corresponds to a CSR of only 1,193 surgeries / million population / year.²²⁷ It should be stated that without substantial improvements in cataract surgical services delivery, the backlog of visually impaired and blind due to cataract will increase due to increased life expectancy and increased population especially amongst those over 60 years of age. It has been estimated that the CSR for Bangladesh should be at least 4,000 surgeries / million / year, approximately three times the rate that exists presently.¹⁷

Assuming the incidence of blinding cataract to be 20% of the prevalence, approximately 150,000 new blinding cataract cases occur annually at present.^{75,88} Thus, though the number of surgeries being performed nationally exceed the incident cases, two additional caveats need to be considered when interpreting the actual impact of the cataract output that has been achieved post-BNBLVS.

Firstly, as the number of cataract surgeries is low compared to the estimated need, the cataract backlog remains unacceptably large. It is recommended that population dynamics modelling be carried out in order to up-date the estimate of the magnitude of unoperated blinding cataract cases.^{77,153} This could be undertaken based on up-dated prevalence of cataract blindness data (eg RAAB studies) and recent census figures that would be more indicative of the present age- and sex-specific breakdown of the national population.

Secondly, it merits pointing out the deleterious impact on survival amongst those with blinding cataract. As reported in a study from China, it is has been identified in that persons blind due to operable cataract have a significantly higher risk of death (pooled hazard ratio 1.43; 95% CI 1.21 – 2.02; $p < 0.001$) than subjects without cataract.³¹⁹ More generally, visual impairment was shown to be associated with a two-fold (Odds ratio 2.34) increased risk of death over a five-year follow-up period in an Australian cohort.⁴⁶⁴

Discussion

Eye care service delivery infrastructure

As of 2018, provision of eye care services in Bangladesh is characterised by a total of 221 healthcare facilities, ranging from primary healthcare clinics⁴⁶⁵ to tertiary, specialist hospitals.^{163,466} The vast majority (84.6%) were secondary level healthcare facilities, such as District hospitals and NGO-administered units (Figure 7.8.1).³⁷⁵ The type of eye care services in these secondary level units were mainly out-patient consultation (eg eye testing, refraction services), referral for specialist care to tertiary centres and, in some instances, cataract surgery. The provision of cataract surgery was contingent upon three key factors, namely, the availability of a trained surgical ophthalmologist, adequate equipment for carrying out surgeries (eg operating microscope) and capacity to deliver post-op, follow-up ophthalmic care.

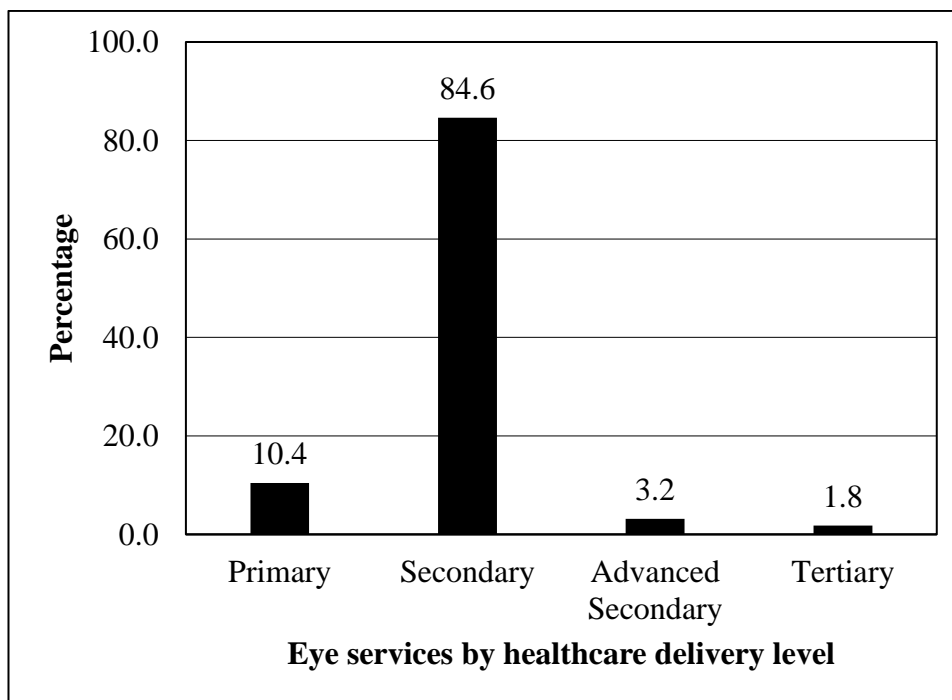


Figure 7.8.1. Distribution of eye care service delivery level in Bangladesh in 2018 (n = 221).

Of the 221 eye care facilities – of any service level – approximately one-half (100; 45.3%) were non-government-supported (Figure 7.8.2) whilst the remaining were either private (65; 29.3%) or administered by the Bangladesh Ministry of Health and Family Welfare (56; 25.4%).⁴⁶⁷⁻⁴⁶⁸

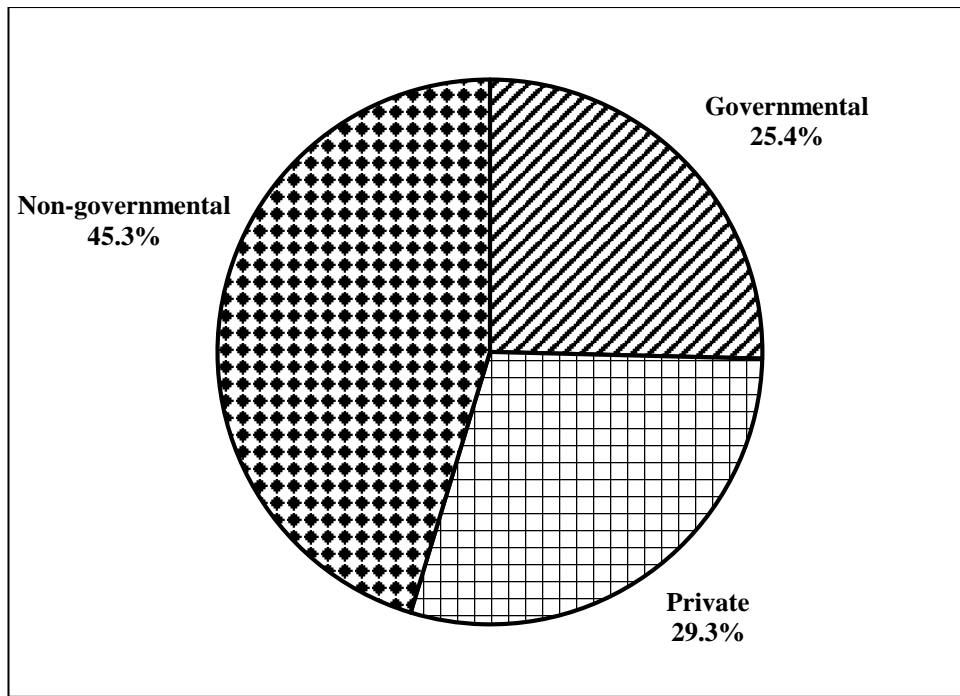


Figure 7.8.2. Distribution of healthcare facilities providing eye care services, by type (n = 221).⁴⁶⁷

Approximately one-half (45.3%) of the facilities that provide eye care services in Bangladesh are administered by non-government organisations, eg a facility supported by an INGO in conjunction with a national NGO agency as the implementing partner. One such example of this is the collaboration between ORBIS International and the Bangladesh National Society for the Blind (BNSB) network of five hospitals that provides surgical services at District-level.⁴⁶⁹ As of 2017, ORBIS had carried out screening of around five million adults and children and provided treatments to nearly 3.7 million people. ORBIS also supported the establishment of the initial two paediatric eye care centres in the country in collaboration with the government, 22 vision centres in remote and underserved areas, 1,000 community-based outreach programs, and the country's first modern eye bank.

Similar successful collaborative programmes of eye care are being supported by other INGOs such as Sightsavers (UK-based agency working in the country for over 50 years), the Fred Hollows Foundation (Australian organisation in Bangladesh since 2007) and Helen Keller Foundation (US-based body providing community-based services, including prevention of

Discussion

xerophthalmia through Vitamin A capsule distribution programme).⁴⁷⁰ Despite the vital and effective contributions made through such INGO-NGO-Ministry of Health and Family Welfare collaborations one key limitation or challenge to this model of eye services delivery is the financial sustainability of such efforts.^{455,471} As previously noted, eye care service funding from the Government of Bangladesh was extremely low, comprising only 3% of all healthcare budget financing, being the least funded health services speciality.⁴⁷² Dependence on external funding from INGOs for the organisation, financing and delivery of eye care services leads to inevitable limitations as each of these organisations have global operations with commitments to other country programmes in South Asia and Africa. Thus, increase of financing from the Government of Bangladesh through increased budgetary allocation to eye care services is of paramount importance.⁴⁷³

In the Bangladeshi context, the most relevant challenges for implementing the strategies outlined in the two WHO / IAPB Global Action Plans continue to be the large blindness burden due to cataract in the country. This situation is characterised by: a) the on-going insufficient cataract surgical coverage and related cataract surgical rate; b) the insufficient number of qualified ophthalmologists and mid-level ophthalmic personnel who are needed to deliver the required level and quality of eye care in the country; c) the very limited level of financing provided to eye care by the government.⁴⁷⁴ Relatedly, the scope for achieving a greater level of integration of eye care programmes within the broader government health system is limited, most especially due to the dearth of essential eye health delivery within the primary health care structure,⁸⁶ eg lack of outreach cataract and refractive error screening programmes within communities.^{373,400}

While the Bangladesh Action Plan of 2014 recognises the increasing incidence of chronic eye diseases due to ageing, eg glaucoma²⁵⁸ and age-related macular degeneration⁴⁷⁵⁻⁴⁷⁷ that is occurring globally, a double burden of blinding ocular conditions may well ensue due to the on-going challenge of cataract blindness combined with the increasing presence of the

Discussion

aforementioned chronic eye conditions, as well as that of diabetic retinopathy.²⁶¹

Several key, positive factors already exist which favour additional progress towards reducing the burden of blindness and visual impairment in Bangladesh.⁴⁷⁸ Conversely, numerous challenges and limitations still remain which exacerbate the existing situation characterised by unacceptably high numbers of persons with loss of vision or blindness mainly due to operable cataract and uncorrected refractive error. This is most particularly the case for specific sub-groups within the Bangladeshi population, namely females,⁴⁷⁹⁻⁴⁸³ elderly persons⁴⁸⁴⁻⁴⁸⁵ and those living in rural areas.⁴⁸⁶⁻⁴⁸⁷

In line with the World Health Organization's Universal Eye Health Global Action Plan,²⁸¹ the National Eye Care programme in Bangladesh developed its own 2014–2019 eye health strategy.⁴⁷⁰ The core elements of this plan are:

- * The overall goal of reducing blindness by half, from age-sex standardised prevalence of 1.53% to 0.70% by 2020.
- * Increase the adult CSR from 1,164 per million population in 2009 to 1,600 by 2020.
- * Achieve 70% removal of cataract surgery backlog by 2017 and 100% by 2020.
- * More than three community health care providers per union in GoB/NGO/private sector are capable to identify and refer cases of refractive error, cataract and suspected cases of glaucoma by 2020.
- * Creation and posting of mid-level ophthalmic personnel (optometrists and orthoptists) in 70% of the sub-District *Upazila* Health Complexes (UHC) by 2017 and in 100% by 2020;

While the aforementioned specific activity-related targets were overtly outlined in the five-year strategy, it is worth highlighting that the baseline levels were either not known for the majority of the 2020 goals or no action was being taken for a specific eye-related issue. For instance, somewhat

Discussion

surprisingly, this National Eye Care Programme (NECP) document did not have information as to the how many of the 64 District hospitals were actually carrying out cataract surgery, as of 2014. Furthermore, in terms of the recognised absence of involvement in delivery of eye care, the baseline assessment for this plan indicated that none of the 481 *Upazila* Health Complex primary health care centres were involved in the diagnosis of cataract or of refractive errors.¹⁸

As such, whilst the development of the 2014-2019 eye health strategy with defined targets is commendable, the overwhelming lack of detailed information in the plan is indicative of the very low level of eye care services and limited trained human resources and hospital infrastructure capacity for delivery of such an aspirational plan.⁴⁸⁸

Central to achieving further significant progress in reducing the prevalence of avoidable blindness and visual impairment is the role of advocacy on the part of all relevant stakeholders for the pursuit of this and other related goals. Across sectors – government departments, non-governmental agencies and communities themselves – the importance of advocating and supporting expansion of eye care services in order to close the gap on the needs for prevention and treatment is evident.⁴⁸⁹ Advocacy has yielded ‘buy-in’ by governments globally,⁴⁵⁷ including that of Bangladesh through its overt support of a National Eye Care Programme, Co-ordinator and Work Plan. Similarly, the benefit of advocating for enhanced, equitable eye care delivery has been demonstrated in various settings, including India^{87,130,490-491} and Nepal nationally,⁴⁹² in the North West Frontier Province of Pakistan³¹¹ and throughout the Oceania region⁴⁹³ in relation to improved detection and referral of cases of uncorrected refractive errors.

Human resources for eye health service delivery

Consideration of a select set of population-based indicators provide a profile of the low level of eye care delivery within the country at the time of the BNBLVS and subsequently. This information relates to both the limited human resources involved in diagnosing and treating eye conditions as well as the deficient output / productivity of the existent eye care facilities and its

Discussion

staff. Specifically, as per a situational analysis conducted in 2000 by the Bangladesh National Council for the Blind, a total of 426 ophthalmologists existed in the country, of which 306 were fully qualified whilst the remaining 120 were trainees in the speciality.¹⁷ It merits highlighting that 53% of the country's ophthalmologists were based in Dhaka Division – a disproportionately high (113%) level given the predominantly rural population of the country. For instance, Barisal Division had only 13% of the number of ophthalmologists recommended by the IAPB (1 per 200,000 population). In fact, with the exception of Dhaka Division, each of the other five Divisions had fewer ophthalmologists than required.

Of those who had completed their specialist training, only approximately two-thirds (68%) were trained in extra-capsular cataract extraction with intra-ocular lens (ECCE with IOL) surgical procedure – the principal sight-restoration technique for cataract surgery at the time. The main explanation for this situation was that not all ophthalmologists were fully surgically trained during their Diploma in Ophthalmology (DO) clinical experience, eg to perform cataract surgery. Rather, approximately one-third of DO qualified ophthalmologists were essentially trained to be medical ophthalmologists with responsibilities for diagnosing and treating non-surgical conditions as well as for referring surgical cases – including cataract – to fully qualified (often more 'senior' colleagues) who would carry out the surgical procedures required.

Further assessments in the ensuing years concerning the number of ophthalmologists indicate favourable increases have occurred – in line with Vision 2020 principles. By 2006, a health workforce survey reported that approximately 625 ophthalmologists – across all grades and years of experience – were working in Bangladesh.⁴⁹⁴ Of these, 350 (55.9%) were based in Dhaka Division alone, indicative of the on-going disproportionate geographical distribution of ophthalmologists across the country. By 2012, there were an estimated 900 ophthalmologists in Bangladesh,⁴⁶³ whereas, as of 2015, the IAPB reported 1,100 ophthalmologists in the country, though not all of these were involved in delivery of surgical services.⁴⁹⁵

Discussion

The potential for expanding cataract services in order to reduce the existent backlog and impending incident cases should be explored through focusing on a) substantive development of a primary eye care services model,^{65,496-498} b) expansion of government – non-governmental organisation collaborative service delivery programmes⁴⁹⁹⁻⁵⁰⁴ and c) adoption and implementation of innovative surgical training strategies.⁵⁰⁵⁻⁵⁰⁶ Examples of successful programmes of specialised re-training / up-grading of personnel include: the two-year re-training of Basic Eye Doctors (BED) in Cambodia (training medical graduates to perform cataract surgery, comprising more than 25% of all cataract surgeons in the country);⁵⁰⁷ and training non-physician, ie ‘clinical officers’ and other healthcare personnel as ‘cataract-only surgeons’, as has been widely implemented in East Africa in order to reduce the backlog of cataract surgical cases.⁵⁰⁸ Despite the clear need for substantial increase in cataract surgical output in Bangladesh, it is unlikely that cataract surgery being performed by medical personnel other than ophthalmologists would not be sanctioned by Bangladeshi health authorities.

Rather, over the short-to-medium term, ie in the next five to ten years, progress on reducing the backlog of cases of visual impairment and blindness due to cataract would at best appear to be gradual at best. Favourably, scope for initiatives such as the re-training of medical graduates in cataract surgery may be leveraged in the wider perspective of ‘task-shifting’ and/or ‘task-sharing’ of responsibilities for provision of ophthalmic care in discussion with the Ophthalmological Society of Bangladesh (OSB) and the Bangladesh College of Physicians and Surgeons (the body responsible for post-graduate specialisation training).⁵⁰⁹⁻⁵¹⁰

However, the further training of ophthalmologists for managing certain retinal diseases which inevitably are on the increase – age-related macular degeneration, diabetic retinopathy, glaucoma, is costly and not available to those already qualified as ophthalmologists.⁵¹¹⁻⁵¹⁴ Therefore, negotiation on the basis of task-shifting, as has been accomplished elsewhere, may not be as feasible within the Bangladeshi context.

Discussion

Considering more widely the issue of the adequacy of qualified human resources for delivery of eye care services, various concerns arise concerning mid-level ophthalmic personnel (MLOP).⁵¹⁵⁻⁵¹⁸ As recently as 2012, the situational analysis of the on-going progress and challenges concerning Vision 2020, conducted by the WHO South-East Asia Region (SEARO) authorities, reported eye health personnel to be inadequate in comparison with the number required to provide essential services. Particular concern was raised regarding the ‘negligible number’ of existent MLOPs.^{463,494}

Expanding the number of service delivery-oriented MLOP cadres, including community-based eye health care promoters, should ultimately be seen as a central strategy for strengthening more comprehensive eye health services within the country.⁵¹⁹⁻⁵²⁰ It is important to emphasise the critical nature of the concomitant expansion and reinforcement of the primary eye care component that is needed regarding eye care service delivery in Bangladesh. Highly relevant to strengthening community-based components of eye care programmes include awareness raising and eye health promotion within both impoverished rural and urban settings concerning eye health conditions, the existence of treatment(s), (eg cataract surgery, spectacles for refractive correction) and providing information and support to beneficiaries as to where and how they may access and receive affordable / subsidised treatment – in full or partially.⁵²¹⁻⁵²⁴

Of note, to date, it remains unclear as to whether the profession of optometry – a key mid-level ophthalmic cadre – is formally recognised in Bangladesh. This situation exists despite two training initiatives having been advanced over the past eight years, namely one a four-year BSc in Optometry (intake of approximately 20 students per year) in the Institute of Community Ophthalmology in the newly formed Chittagong Medical University and a one-year Diploma course at South Asia University in Dhaka.⁵²⁵ Although official approval of these academic professional training programmes is pending, these and similar future mid-level ophthalmic personnel (MLOP) training courses would be valuable contributions to redressing the dearth of MLOP staff throughout Bangladesh.

Discussion

One key element of primary eye care service development⁵²⁶⁻⁵²⁷ is the outreach team approach with ophthalmic assistants, technicians and eye health promotion personnel whose basic eye treatment, cataract screening and referral activities would be conducted within the several thousand village communities and impoverished urban slum settings of the country.^{59,202,528}

Finally, the re-orientation towards district level service provision in accord with the Universal Eye Health strategy should be considered as another means for increasing access to cataract surgical and refractive error services.⁵²⁹ Each of the 64 Districts that comprise Bangladesh has a government-funded hospital with an ophthalmologist appointed to each facility. However, the surgical equipment needed to carry out cataract surgery, e.g. operating microscope, is not available in each of the district hospitals at present.⁵³⁰ Notwithstanding such limitations, District level service provision has been shown to be an effective means of increasing access to cataract surgery, especially in rural areas, and to increase the possibility of referral for other conditions needing treatment. Likewise, the development and implementation of successful referral systems are often contingent upon provision of locally-available treatment, which in the case of Bangladesh could administratively be oriented around a district model for eye care service provision inclusive of cataract outreach screening and refractive error assessment and referral, especially amongst those of limited financial resources in both rural and urban settings.^{62,531}

A summary of some of the key strengths and limitations / constraints in terms of eye care service policy and practice is shown in Table 7.8.1.

Discussion

Table 7.8.1. Assessment of the strengths and limitations of eye care service-related issues in Bangladesh.

Strengths	Limitations
Commitment from Government of Bangladesh (GoB) for Vision 2020 principles; ¹⁸ National Eye Care Programme ratified by GoB, National Eye Health Programme Co-ordinator appointed, <i>in situ</i> ; ³⁵⁹ National Eye Health Plan 2015 – 2020 developed and being implemented. ⁴⁷⁰	Very limited funding from Government of Bangladesh for strengthening the National Eye Care Programme, whereby further expansion of District-level eye care services is hindered. ⁴⁷²
Cost-effective surgical treatment for cataract with manual small incision cataract surgery (MSICS); ¹³⁹ all cataract surgeries involve placement of IOL for enhanced sight-restoration. ²¹⁴⁻²¹⁹	Inaccessible to the majority of the population as many Districts outside of the main urban settings do not have a cataract surgical unit; ³⁹⁶ gender ⁴⁸⁰⁻⁴⁸⁴ and financial inequities limit access to large percentage of the population. ^{62,528}
Increasing numbers of ophthalmologists nationally have been trained in recent years; ⁴⁶¹ additional MLOP training opportunities are being developed. ⁵²⁵	Many, approximately one-half, ie ~500, are medical / ‘staff grade’ ophthalmologists and are not experienced in performing cataract surgery; too few MLOP for level of need, with only 1,200 for entire country. ⁴⁹⁵

(continued)

Discussion

Table 7.8.1. Assessment of the strengths and limitations of eye care service-related issues in Bangladesh.

<p>Strong collaborative relations between GoB and INGOs/NGOs in the planning and delivery of eye care services.⁴⁹⁹</p>	<p>Sustainability of provision of required level of eye care services⁴⁵⁵ – ranging from primary eye care (PEC)⁴⁶⁵ to surgical treatments⁴⁷³ – is at risk due to constrained GoB financial support for essential eye care services in addition to limited human resources within GoB public health and ophthalmic services.⁶⁹</p>
<p>The Cataract Surgical Rate (CSR) has increased from as low as 500 surgeries/million population/year in 2000 to 1,193 surgeries/million population/year, as of 2015.²²⁷</p>	<p>The CSR is approximately one-third of the level of surgical output that is required, based on the existent backlog of cataract blind cases in addition to the incident cases of persons blind or visually impaired due to cataract. The CSR in Bangladesh is by far the lowest of the South Asia region, with Bhutan second lowest at 1,553 surgeries/million population/year.²²⁷</p>

8.0 Conclusion

The Bangladesh National Blindness and Low Vision Survey provided a comprehensive set of findings, on a nationally representative basis, as to the prevalence, causes and magnitude of blindness and visual impairment in adults. Amongst the various important results obtained by this detailed study was that of identifying the central role cataract has in the epidemiological profile of blindness and visual impairment in the country.

Cataract, responsible for nearly 80% of blindness in the survey, acts as the major challenge for eye care service delivery in numerous manners. With too few ophthalmologists and mid-level ophthalmic personnel to adequately treat existent cases of visually impairing cataract, the backlog of unattended persons continues to increase. With that, deleterious personal and community-wide health and socio-economic consequences accrue unnecessarily, given the treatable nature of cataract.

Eye health care service development, in line with the principles and strategies of Vision 2020 – The Right to Sight, has indeed progressed since the time when the survey was conducted. An increase in the number of ophthalmologists has occurred though there are still too few to achieve the ultimate goal of preventing avoidable blindness by 2020. Nonetheless, conscience of the multitude of financial, logistic and health challenges faced by an under-funded National Eye Care Programme, the progress attained through partnerships between the Government of Bangladesh health authorities and several international and national non-governmental organisations is commendable and promising, though limited compared to that required. However, increased implementation of appropriate eye care services must be sustained in order to adequately meet the needs for cataract surgery and provision of spectacles to persons with uncorrected refractive errors, the second most common vision-impairing condition.

Recognition by those responsible for eye care delivery in Bangladesh of the significance of the findings of the BNBLVS was the catalyst needed to pursue improvements in service provision. This is most evident when considering

Conclusion

that the most disadvantaged sectors of the Bangaldeshi society were identified as being of highest risk of vision loss without treatment. Thus, the elderly, females, those who were economically inactive / unemployed, those who could not read nor write and finally, rural dwellers – the majority of the population – were shown to be more likely to suffer from vision loss.

This dissertation has been an opportunity to communicate, in parts thoroughly, the important information acquired through the national survey. This document is itself limited in its delivery and expression of the significance of the BNBLVS, as this study served to highlight the collective effort needed to mitigate the suffering caused by blindness and visual impairment in Bangladesh.

Finally, in closing, the verse of Rabindranath Tagore, Bengali Nobel Prize winning poet seems apropos, given the challenges – and rewards – that lay ahead for delivering adequate, timely and equitable eye care services to all Bangladeshis.⁵³³

‘I slept and dreamt that life was joy. I awoke and saw that life was service. I acted and behold, service was joy.’

9.0 References

1. Ferris F, Tielsch JM. Blindness and visual impairment - a public health issue for the future as well as today. *Arch Ophthalmol* [Internet]. 2004 [cited 3 Mar 2019];122(4):451-452. Available from: <https://jamanetwork.com/journals/jamaophthalmology/fullarticle/416235>
2. Brilliant LB, Pokhrel RP, Grasset NC, Lepkowski JM, Kolstad A, Hawks W, et al. Epidemiology of blindness in Nepal. *Bull World Health Organ* [Internet]. 1985;63(2):375-386. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2536402/pdf/bullwho00085-0180.pdf>
3. Memon M S. Prevalence and causes of blindness in Pakistan. *J Pak Med Assoc* [Internet]. 1992 [cited 3 Mar 2019];42(8):196–198. Available from: <https://jpma.org.pk/PdfDownload/5120>
4. World Health Organization. Elimination of avoidable blindness and launching of regional Vision 2020. Report of a SEARO/IAPB meeting in South-East Asia. Vision 2020 - the Right to Sight. New Delhi, India: World Health Organization Regional Office for South-East Asia, 2000. 35 p. Available from: http://apps.searo.who.int/PDS_DOCS/B3557.pdf
5. Pararajasegaram R. The global initiative for the elimination of avoidable blindness. *Community Eye Health*. 1998;11(26):29.
6. Brundtland GH. Endorsement of the global initiative Vision 2020: the right to sight. *Community Eye Health*. 1999;12(29):16.
7. Pararajasegaram R. Vision 2020 - the right to sight: from strategies to action. *Am J Ophthalmol* [Internet]. 1999;128(3):359-60. Available from: [https://doi.org/10.1016/S0002-9394\(99\)00251-2](https://doi.org/10.1016/S0002-9394(99)00251-2)
8. Johnson GJ. Vision 2020: The right to sight: report on the sixth general assembly of the International Agency for the Prevention of Blindness (IAPB). *Community Eye Health*. 1999;12(32):59-60.
9. Thylefors B. Vision 2020: The Right to Sight – global initiative for the elimination of avoidable blindness. In: Pararajasegaram R, Rao, GN, editors. World blindness and its prevention. Volume 6. Proceedings of the Sixth General Assembly of the International Agency for the Prevention of Blindness (IAPB); 1999 5th-10th September; Beijing, China. Hyderabad (IN): IAPB; 2001. p 25-33.

References

10. Foster A. Vision 2020 – the Right to Sight. *Trop Doct* [Internet]. 2003;33(4):193-4. Available from:
<https://journals.sagepub.com/doi/pdf/10.1177/004947550303300401>
11. Pararajasegaram R. Prevention of blindness, Bangladesh. New Delhi: World Health Organization South-East Asia Region; 1978 Mar. 13 p. Report No.: SEA/Ophthal/14. 17 p.
12. Choudhury MI. Incidence and causes of blindness amongst the rural population [abstract]. *Bangladesh Med Res Counc Bull* [Internet]. 1976;2(1):71-4. Available from:
<https://www.ncbi.nlm.nih.gov/pubmed/?term=Choudhury+MI.+Incidence+and+causes+of+blindness+amongst+the+rural+population>
13. Queguiner P, Bouat C, Dulaurent L, Vitte S. [La cataracte au Bangladesh – épidémiologie - traitement.] *Rev Int Trach Pathol Ocul Trop Subtrop Sante Publique*. 1989;66(3-4):143-7. French.
[https://www.unboundmedicine.com/medline/citation/2488660/\[The_cataract_in_Bangladesh._Epidemiology--treatment\]](https://www.unboundmedicine.com/medline/citation/2488660/[The_cataract_in_Bangladesh._Epidemiology--treatment]).
14. World Health Organization. Vitamin and Mineral Nutrition Information System (VMNIS). WHO global database on Vitamin A deficiency. Prevalence of xerophthalmia – 1982-1983. Bangladesh nutritional blindness study. [Internet]. Available from:
https://www.who.int/vmnis/vitamina/data/database/countries/bgd_vita.pdf?ua=1
15. Cohen N, Rahman H, Sprague J, Jalil MA, Leemhuis de Regt E, Mitra M. Prevalence and determinants of nutritional blindness in Bangladeshi children [abstract]. *World Health Stat Q* [Internet]. 1985;38:317-30. Available from:
<https://www.popline.org/node/418755>
16. Islam MS. Pattern of eye diseases in rural areas of Kishoreganj District. *J Bangladesh Coll Phys Surg*. 1996;14(2):64-8.
17. Gilbert C. Cataract surgical services in Bangladesh - the need and current service provision. Paper presented at: Bangladesh Situational Analysis and Planning Workshop; 2000 Oct 15th-17th; Dhaka (BD). National Institute of Ophthalmology.
18. Hussain AMZ. Strategy for national eye care for Vision 2020 in Bangladesh [Internet]. Dhaka (BD): Social Sector Management Foundation (SSMF); 2014.49 p. Available from:
http://ssmfb.org/images/pdf/national_eye_care.pdf

References

19. United Nations Development Programme (UNDP). Human Development Report 2001 – making new technologies work for human development [Internet]. New York (US): Oxford University Press, Inc., 2001. p. 264. Available from:
http://hdr.undp.org/sites/default/files/reports/262/hdr_2001_en.pdf
20. United Nations Department of Economic and Social Affairs (DESA), Population Division. UNdata. Bangladesh general information - surface area (km²) [Internet]. New York (US): UN Secretariat, 2016. Available from:
<http://data.un.org/en/iso/bd.html>
21. Government of the People's Republic of Bangladesh. Ministry of Planning. Statistics Division. Bangladesh Bureau of Statistics. Population census 2001 preliminary report [Internet]. Dhaka (BD): Bangladesh Bureau of Statistics, 2001. 44 p. Available from:
<http://catalog.ihnsn.org/index.php/catalog/127/download/28952>
22. United States Census Bureau. International Data Base (IDB). Bangladesh population data – 1999 [Internet]. Maryland (US): United States Census Bureau. Available from:
<https://www.census.gov/population/international/data/idb>
23. United Nations. Population Division. Department of Economic and Social Affairs (UN-DESA). Population in 1999 and 2000: all countries. [Internet]. Available from: <https://www.un.org/popin/popdiv/pop1999-00.pdf>
24. Government of the People's Republic of Bangladesh. Ministry of Planning. Statistics Division. Bangladesh Bureau of Statistics. Statistics Bangladesh. Statistical pocket book 2016 [Internet]. Dhaka (BD): Bangladesh Bureau of Statistics, 2017. Available from:
http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/d6556cd1_dc6f_41f5_a766_042b69cb1687/PocketBook2016.pdf
25. United Nations. Department of Economic and Social Affairs. Population Division (2015). World population prospects: the 2015 revision - Volume I: comprehensive tables [Internet]. New York (US). 345 p. Available from:
https://population.un.org/wpp/Publications/Files/WPP2015_Volume-I_Comprehensive-Tables.pdf
26. Population Reference Bureau. 2016 World Population Data Sheet – with a special focus on human needs and sustainable resources [Internet]. Washington, [US]: Population Reference Bureau. 2016. Available from:
<https://www.prb.org/wp-content/uploads/2016/08/prb-wpds2016-web-2016.pdf>

References

27. The World Bank. DataBank – population density (people per square kilometre of land area) [Internet]. Washington, DC (US): The World Bank. 2016. Available from: <https://data.worldbank.org/indicator/en.pop.dnst>
28. United Nations. Department of Economic and Social Affairs. Population Division (2017). World population prospects: the 2017 revision - Volume I: comprehensive tables [Internet]. New York (US). p. 346. Available from: https://population.un.org/wpp/Publications/Files/WPP2017_Volume-I_Comprehensive-Tables.pdf
29. The World Bank. DataBank – fertility rate, total (births per woman) [Internet]. Washington DC (US): The World Bank. 2016. Available from: <https://data.worldbank.org/indicator/SP.DYN.TFRT.IN>
30. United States Census Bureau. International Data Base (IDB). Population pyramid graph - Bangladesh – 2000 and 2015. Maryland (US): United States Commerce Department. Available from: <https://www.census.gov/population/international/data/idb>
31. Khuda B, Hossain MB. Fertility decline in Bangladesh: towards an understanding of major causes. Health Transition Rev. 1996;Supplement 6:155-67. Available from: <https://www.jstor.org/stable/pdf/40652257.pdf?refreqid=excelsior%3Ad5d91c9c10a0031aade95040cb4ee66b>
32. Caldwell JC, Khuda B, Caldwell B, Pieris I, Caldwell P. The Bangladesh fertility decline: an interpretation. Popul Dev Rev. 1999;25:67-84. Available from: <https://www.jstor.org/stable/pdf/172372.pdf?refreqid=excelsior%3Adf3fca0ea0ca411925b87fb76a5740c2>
33. Bairagi R, Datta AK. Demographic transition in Bangladesh: what happened in the 20th century and what will happen next? Asia Pac Popul J [Internet]. 2001 [cited 2016 Apr 18];16(4):3-16. Available from: <https://www.unescap.org/sites/default/files/APPJ-Vol-16-No-4.pdf>
34. Kamal SMM. Fertility decline in Bangladesh: understanding the future direction and contribution of demographic components. J App Sci Tech. 2010;7:99-104. Available from: https://www.researchgate.net/publication/215509831_Fertility_Decline_in_Bangladesh_Understanding_the_Future_Direction_and_Contribution_of_Demographic_Components/download
35. United Nations Population Fund (UNFPA). The impact of demographic transition on socioeconomic development in Bangladesh: future prospects

References

and implications for public policy [Internet]. Dhaka (BD): UNFPA Bangladesh Country Office; 2015. p. 147. Available from:

<https://bangladesh.unfpa.org/sites/default/files/pub-pdf/4.%20Demographic%20Impact%20Study.pdf>

36. Hug L, Sharrow D, You D and UN Inter-agency Group for Child Mortality Estimation (UN-IGME). Levels and trends in child mortality - report 2017 [Internet]. New York (US): United Nations Children's Fund (UNICEF). 2017. p. 37. Available from:

https://www.unicef.org/publications/files/Child_Mortality_Report_2017.pdf

37. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ORC Macro [Internet]. Bangladesh demographic and health survey 2004 [Internet]. Dhaka (BD) and Calverton, Maryland (US): NIPORT, Mitra and Associates, ORC Macro. 2005. p. 343. Available from:

[https://dhsprogram.com/pubs/pdf/FR165/FR-BD04\[FR165\].pdf](https://dhsprogram.com/pubs/pdf/FR165/FR-BD04[FR165].pdf)

38. Streatfield PK, Karar ZA. Population challenges for Bangladesh in the coming decades. *J Health Popul Nutr.* 2008;3:261-72. Available from:

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2740702/pdf/jhpn0026-0261.pdf>

39. Haub C. Fertility down, but population decline still not in sight. Washington (US): Population Reference Bureau. 2002. Available from:

<https://www.prb.org/fertilitydownbutpopulationdeclinestillnotinsight/>

40. United Nations. Population Division. Department of Economic and Social Affairs (UN-DESA). Part One. Report of the expert group meeting on completing the fertility transition [Internet]. New York (US): UN-DESA. 2002. p. 23. Available from:

<https://www.un.org/en/development/desa/population/publications/pdf/fertility/completing-fertility/FinalreportPartOne.pdf>

41. World Bank. DataBank - Health, Nutrition and Population Statistics. Life expectancy at birth – total (years). Bangladesh – 2015. Washington, DC (US): The World Bank. Available from:

<https://databank.worldbank.org/data/reports.aspx?source=health-nutrition-and-population-statistics>

42. United Nations Development Programme (UNDP). Human development report 2000 – human rights and human development. New York: Oxford University Press, Inc.; 2000. Available from:

http://hdr.undp.org/sites/default/files/reports/261/hdr_2000_en.pdf

References

43. United Nations Development Programme (UNDP). Human development report 2015 – work for human development. New York: Oxford University Press, Inc.; 2015. Available from:
http://hdr.undp.org/sites/default/files/2015_human_development_report.pdf
44. United States Census Bureau. International Data Base (IDB). Population pyramid graph - Bangladesh – 2030 and 2050. Washington, DC (US): US Department of Commerce; 2016. Available from:
<https://www.census.gov/population/international/data/idb>
45. National Institute of Population Research and Training (NIPORT) Bangladesh, Mitra and Associates, and ICF International. 2016. Bangladesh demographic and health survey 2014. Dhaka (BD): NIPORT, Mitra and Associates, and ICF International; 2016. Chapter 5. Fertility. p. 49-64. Available from: <https://dhsprogram.com/pubs/pdf/FR311/FR311.pdf>
46. Government of the People’s Republic of Bangladesh. Ministry of Planning. Bangladesh Bureau of Statistics (BBS). 2014 Statistical year book [Internet]. Dhaka (BD): BBS; 2016. p. 560. Available from:
<http://203.112.218.65:8008/WebTestApplication/userfiles/Image/SubjectMatterDataIndex/YB-2014.pdf>
47. Government of the People’s Republic of Bangladesh. Ministry of Planning. Bangladesh Bureau of Statistics (BBS). Statistical pocket book Bangladesh 2016 [Internet]. Dhaka (BD): BBS; 2017. Chapter III. Area population household and housing characteristics. p. 45-106. Available from:
http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/d6556cd1_dc6f_41f5_a766_042b69cb1687/PocketBook2016.pdf
48. General Economics Division. Bangladesh Planning Commission. Government of the People’s Republic of Bangladesh. Millennium development goals Bangladesh progress report 2015 [Internet]. p. 124. Dhaka. 2015. Available from:
https://www.undp.org/content/dam/bangladesh/docs/MDG/MDGs%20Bangladesh%20Progress%20Report_%20PDF_Final_September%202015.pdf
49. Government of the People’s Republic of Bangladesh and the United Nations Country Team in Bangladesh [Internet]. Millennium development goals Bangladesh progress report 2005. Dhaka. 2005. 87 p. Available from:
http://planipolis.iiep.unesco.org/sites/planipolis/files/ressources/bangladesh_mdg_report.pdf
50. The World Bank. Bangladesh poverty assessment – assessing a decade of progress in reducing poverty, 2000-2010 [Internet]. Bangladesh Development

References

Series Paper Number 31. Dhaka: The World Bank Office: 2013. p. 227.
Available from:

<http://documents.worldbank.org/curated/en/109051468203350011/pdf/785590NWP0Bang00Box0377348B0PUBLIC0.pdf>

51. United Nations Development Programme (UNDP). Human Development Report 2011 – sustainability and equity – a better future for all [Internet]. New York: Oxford University Press, Inc. 2011. p. 176. Available from:

http://hdr.undp.org/sites/default/files/reports/271/hdr_2011_en_complete.pdf

52. Government of the People’s Republic of Bangladesh. Ministry of Planning. General Economics Division (GED). Millennium development goals (MDGs): end-period stocktaking and final evaluation (2000-2015). [Internet]. Dhaka (BD): General Economics Division. 2016. p. 112. Available from:

http://plancomm.portal.gov.bd/sites/default/files/files/plancomm.portal.gov.bd/files/4e4ab41c_e818_4019_bebe_9d64282a6513/MDG%20Final%20Evaluation%20Report%202016.pdf

53. Government of the People’s Republic of Bangladesh. Ministry of Planning. Bangladesh Bureau of Statistics (BBS). Preliminary report on household income and expenditure survey 2016 [Internet]. Dhaka (BD): BBS. 2017. p. 132. Available from:

<http://catalog.ihsn.org/index.php/catalog/7399/download/87340>

54. Asian Development Bank. Poverty in Bangladesh: poverty data [Internet]. Economic Research and Regional Cooperation Department. Development Economics and Indicators Division. Manila (PH): ADB. 2018. Available from: <https://www.adb.org/countries/bangladesh/poverty>

55. Asian Development Bank (ADB). Economic Research and Regional Cooperation Department. Development Economics and Indicators Division. Basic statistics 2018 [Internet]. Manila (PH): ADB. 2018. p. 6. Available from:

<https://www.adb.org/sites/default/files/publication/419891/basic-statistics-2018.pdf>

56. United Nations Development Programme (UNDP). Human Development Report 2009. Overcoming barriers: human mobility and development [Internet]. New York: Oxford University Press, Inc. 2009. p. 217. Available from:

http://hdr.undp.org/sites/default/files/reports/269/hdr_2009_en_complete.pdf

References

57. United Nations Development Programme (UNDP). Human Development Report 2016. Human development for everyone. Technical notes [Internet]. New York: Oxford University Press, Inc. 2016. p. 16. Available from: http://hdr.undp.org/sites/default/files/hdr2016_technical_notes.pdf
58. Ezeh A, Oyeboode O, Satterthwaite D, Chen Y-F, Ndugwa R, Sartori J, et al. The history, geography, and sociology of slums and the health problems of people who live in slums. *Lancet* [Internet]. 2017;389:547-8. Available from: [http://dx.doi.org/10.1016/S0140-6736\(16\)31650-6](http://dx.doi.org/10.1016/S0140-6736(16)31650-6)
59. Afsana K, Wahid SS. Health care for poor people in the urban slums of Bangladesh. *Lancet* [Internet]. 2013;382(9910):2049-51. Available from: [https://doi.org/10.1016/S0140-6736\(13\)62295-3](https://doi.org/10.1016/S0140-6736(13)62295-3)
60. Sen A. What's happening in Bangladesh? *Lancet* [Internet]. 2013;382(9909):1966-8. Available from: [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(13\)62162-5/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(13)62162-5/fulltext)
61. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2012 [Internet]. Dhaka: Management Information System. Directorate General of Health Services; 2012. Chapter 18 - National eye care; p. 214-6. Available from: http://www.dghs.gov.bd/licts_file/images/Health_Bulletin/HB2012_CH/HB2012_CH18_National-Eye-Care.pdf
62. Khan JAM, Ahmed S, Evans TG. Catastrophic healthcare expenditure and poverty related to out-of-pocket payments for healthcare in Bangladesh – an estimation of financial risk protection of universal health coverage. *Health Policy Plan* [Internet]. 2017;32(8):1102-1110. Available from: <https://doi.org/10.1093/heapol/czx048>
63. Makinen M, Waters H, Rauch M, Almagambetova N, Bitran R, Gilson L et al. Inequalities in health care use and expenditures: empirical data from eight developing countries and countries in transition. *Bull World Health Organ* [Internet]. 2000;78(1):55-65. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2560608/pdf/10686733.pdf>
64. United Nations Development Programme (UNDP). Human Development Report 2014 – sustaining human progress: reducing vulnerabilities and building resilience – a better future for all [Internet]. New York (US): UNDP. 2014. p. 216. Available from: <http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf>
65. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2016 [Internet]. Dhaka (BD):

References

- Management Information System. Directorate General of Health Services; 2016. Chapter 4 – Primary healthcare; p. 49-62. Available from: <http://www.dghs.gov.bd/images/docs/Publicaations/HB%202016%20 2nd edition 13 01 17.pdf>
66. Ministry of Planning. Statistics Division. Bangladesh Bureau of Statistics. Report of the household income and expenditure survey 2010. Bangladesh Bureau of Statistics [Internet]. Dhaka (BD): 2010. Chapter 8. Health. p. 97-127. Available from: <http://203.112.218.65:8008/WebTestApplication/userfiles/Image/LatestReports/HIES-10.pdf>
67. Mahamud RA, Sarker AM, Sultana M, Islam Z, Khan J, Morton A. Distribution and determinants of out-of-pocket health expenditures in Bangladesh. *J Prev Med Public Health* [Internet]. 2017;50:91-9. Available from: <https://doi.org/10.3961/jpmph.16.089>
68. Raban MZ, Dandona R, Dandona L. Variations in catastrophic health expenditure estimates from household surveys in India. *Bull World Health Organ* [Internet]. 2013;91(10):726-35. Available from: <https://www.who.int/bulletin/volumes/91/10/12-113100.pdf?ua=1>
69. Government of the People’s Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2016 [Internet]. Dhaka (BD): Management Information System. Directorate General of Health Services; 2016. Chapter 18 – Financing healthcare; p. 198-202. Available from: <http://www.dghs.gov.bd/images/docs/Publicaations/HB%202016%20 2nd edition 13 01 17.pdf>
70. Molla AM, Chi C, Núñez Mondaca AL. Predictors of high out-of-pocket healthcare expenditure: an analysis using Bangladesh household income and expenditure survey, 2010. *BMC Health Serv Res* [Internet]. 2017;17:94. Available from: <https://doi.org/10.1186/s12913-017-2047-0>
71. Government of the People’s Republic of Bangladesh. Ministry of Health and Family Welfare. Health Economics Unit. Bangladesh national health accounts 1997 – 2012. Research Paper 42a. [Internet]. Dhaka: Health Economics Unit. 2015. Chapter 2. Total health expenditure. p. 11-8. Available from: <http://www.heu.gov.bd/pdf/bnha%201997-2012.pdf>
72. Government of the People’s Republic of Bangladesh. Ministry of Health and Family Welfare. Health Economics Unit. Bangladesh national health accounts 1997 – 2012. Research Paper 42a. [Internet]. Dhaka: Health Economics Unit. 2015. Chapter 7. Out-of-pocket expenditure by household. p. 47-9. Available from: <http://www.heu.gov.bd/pdf/bnha%201997-2012.pdf>

References

73. Thylefors B, Négrel AD, Pararajasegaram R, Dadzie KY. Global data on blindness. *Bull World Health Organ* [Internet]. 1995;73(1):115-21. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2486591/pdf/bullwho00405-0112.pdf>
74. Kalache A. Ageing: a global perspective. *Community Eye Health*. 1999;12(29):1-4.
75. Johnson GJ, Foster A. Prevalence, incidence and distribution of visual impairment. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 3-28.
76. Sommer A. Toward affordable, sustainable eye care. *Int Ophthalmol* [Internet]. 1994;18(5):287-92. Available from: <https://link.springer.com/content/pdf/10.1007/BF00917832.pdf>
77. Dandona L. Estimation of cataract blindness in India. *Ophthalmology* [Internet]. 1999;106(1):5-6. Available from: [https://www.aaojournal.org/article/S0161-6420\(99\)90041-6/pdf](https://www.aaojournal.org/article/S0161-6420(99)90041-6/pdf)
78. Arnold J. Global cataract blindness: the unmet challenge. *Br J Ophthalmol* [Internet]. 1998;82(6):593-4. Available from: <https://bjo.bmj.com/content/bjophthalmol/82/6/593.full.pdf>
79. World Health Organization. Programme for the Prevention of Blindness and Deafness. Global initiative for the elimination of avoidable blindness [Internet]. World Health Organization. Geneva (CH): 2000. 46 p. Available from: <http://www.who.int/iris/handle/10665/63748>
80. Pararajasegaram R. The global initiative for the elimination of avoidable blindness. *Community Eye Health*. 1998;11(26):29.
81. Garms RC. The global initiative: launch of Vision 2020. *Community Eye Health*. 1998;11(28):56-7.
82. Brundtland GH. Endorsement of the global initiative Vision 2020: the right to sight. *Community Eye Health*. 1999;12(29):16.
83. World Health Organization. Management of cataract in primary health care services. 2nd ed. Geneva (CH): World Health Organization; 1996. 34 p.
84. World Health Organization. Strategies for the prevention of blindness in national programmes – a primary health care approach. 2nd ed. Geneva (CH): World Health Organization; 1997. 104 p.

References

85. Konyama K. Essential components of primary eye care. *Community Eye Health*. 1998;11(26):19-21.
86. Khan MA, Soni M, Khan MD. Development of primary eye care as an integrated part of comprehensive health care. *Community Eye Health*. 1998;11(26):24-6.
87. Blanchet K, Patel D. Applying principles of health system strengthening to eye care. *Indian J Ophthalmol* [Internet]. 2012;60(5):470–474. Available from: <http://www.ijo.in/text.asp?2012/60/5/470/100553>
88. Minassian DC, Mehra V. 3.8 million blinded by cataract each year – projections from first study of incidence of cataract blindness in India. *Br J Ophthalmol* [Internet]. 1990;74(6):341-3. Available from: <https://bjo.bmj.com/content/bjophthalmol/74/6/341.full.pdf>
89. Foster A. Cataract and "Vision 2020 – the right to sight" initiative. *Br J Ophthalmol* [Internet]. 2001;85(6):635-7. Available from: <https://bjo.bmj.com/content/bjophthalmol/85/6/635.full.pdf>
90. Anjum KM, Qureshi MB, Khan MA, Jan N, Ali A, Ahmad K, et al. Cataract blindness and visual outcome of cataract surgery in a tribal area in Pakistan. *Br J Ophthalmol* [Internet]. 2006;90(2):135-8. Available from: <https://bjo.bmj.com/content/bjophthalmol/90/2/135.full.pdf>
91. Isaacs R, Ram J, Apple D. Cataract blindness in the developing world. *J Agromedicine* [Internet]. 1996;3(4):7-21. Available from: https://www.tandfonline.com/doi/abs/10.1300/J096v03n04_02
92. Dineen B, Bourne RRA, Jadoon Z, Shah SP, Khan MA, Foster A, et al on behalf of the Pakistan National Eye Survey Study Group. Causes of blindness and visual impairment in Pakistan. The Pakistan national blindness and visual impairment survey. *Br J Ophthalmol* [Internet]. 2007;91(8):1005-1010. Available from: <https://bjo.bmj.com/content/bjophthalmol/91/8/1005.full.pdf>
93. Jadoon Z, Shah SP, Bourne R, Dineen B, Khan MA, Gilbert CE, et al. Cataract prevalence, cataract surgical coverage and barriers to uptake of cataract surgical services in Pakistan: the Pakistan national blindness and visual impairment survey. *Br J Ophthalmol* [Internet]. 2007;91(10):1269-73. Available from: <https://bjo.bmj.com/content/bjophthalmol/91/10/1269.full.pdf>
94. Finger RP. Cataracts in India: current situation, access, and barriers to services over time. *Ophthalmic Epidemiol* [Internet]. 2007;14(3):112-8. Available from: <https://doi.org/10.1080/09286580601114967>

References

95. Murthy GV, Gupta SK, Bachani D, Jose R, John N. Current estimates of blindness in India. *Br J Ophthalmol* [Internet]. 2005;89(3):257-60. Available from: <https://bjo.bmj.com/content/bjophthalmol/89/3/257.full.pdf>
96. Dandona L, Dandona R, John RK. Estimation of blindness in India from 2000 through 2020: implications for blindness control policy. *Natl Med J India* [Internet]. 2001;14:327-34. Available from: <http://archive.nmji.in/archives/Volume-14/issue-6/original-articles-1.pdf>
97. Limburg H, Vaidyanathan K, Pampattiwa KN. Cataract blindness on the rise? Results of a door-to-door examination in Mohadi. *Indian J Ophthalmol* [Internet]. 1996;44:241-4. Available from: <http://www.ijo.in/text.asp?1996/44/4/241/24570>
98. Taylor HR. Cataract: A global public health challenge. In: Pararajasegaram R, Rao GN (Ed.) *World Blindness and its Prevention*. Volume 6. Proceedings of the Sixth General Assembly of the International Agency for the Prevention of Blindness (IAPB); 1999 5th-10th September; Beijing, China. Hyderabad, India: IAPB; 2001. p. 37-46.
99. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, Mariotti SP. Global data on visual impairment in the year 2002. *Bull World Health Organ* [Internet]. 2004;82:844-51. Available from: <https://www.who.int/bulletin/volumes/82/11/en/844.pdf?ua=1>
100. Vajpayee RB, Joshi S, Saxena R, Gupta SK. Epidemiology of cataract in India: combating plans and strategies. *Ophthalmic Res* [Internet]. 1999;31(2):86-92. Available from: <https://doi.org/10.1159/000055518>
101. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *Br J Ophthalmol* [Internet]. 2012;96(5):614–618. Available from: <https://bjo.bmj.com/content/bjophthalmol/96/5/614.full.pdf>
102. World Health Organization. Coding instructions for the WHO / PBL eye examination record (Version III). Geneva (CH): World Health Organization; 1988. 17 p. Report No.: PBL / 88.1.
103. Dandona L, Dandona R. Revision of visual impairment definitions in the International Statistical Classification of Diseases. *BMC Med* [Internet]. 2006;4:7. Available from: <https://doi.org/10.1186/1741-7015-4-7>
104. Bastawrous A, Hennig BD. The global inverse care law: a distorted map of blindness. *Br J Ophthalmol* [Internet]. 2012;96(10):1357–8. Available from: <https://bjo.bmj.com/content/bjophthalmol/96/10/1357.2.full.pdf>

References

- 105 Resnikoff S. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bull World Health Organ* [Internet]. 2008;86:63-70. Available from:
<https://www.who.int/bulletin/volumes/86/1/07-041210.pdf?ua=1>
106. Uncorrected refractive error: the major and most easily avoidable cause of vision loss. *Community Eye Health*. 2007;20(63):37-9.
107. Holden BA, Sulaiman S, Knox K. The challenge of providing spectacles in the developing world. *Community Eye Health*. 2000;13(33):9-10.
108. World Health Organization. Prevention of Blindness and Visual Impairment. Change the definition of blindness [Internet]. Geneva (CH): World Health Organization. 2008. 5 p. Available from:
<https://www.who.int/blindness/Change%20the%20Definition%20of%20Blindness.pdf>
109. World Health Organization. Action plan for the prevention of avoidable blindness and visual impairment, 2009-2013 [Internet]. Geneva (CH): World Health Organization. 2010. 27 p. Available from:
https://www.who.int/blindness/ACTION_PLAN_WHA62-1-English.pdf
110. Dandona L, Dandona R. What is the global burden of visual impairment? *BMC Med* [Internet]. 2006;4:6. Available from:
<https://doi.org/10.1186/1741-7015-4-6>
111. Pascolini D, Mariotti SP, Pokharel GP, Pararajasegaram R, Etya'ale D, Négrel AD, et al. 2002 global update of available data on visual impairment: a compilation of population-based prevalence studies. *Ophthalmic Epidemiol* [Internet]. 2004;11:67-115. Available from:
<https://doi.org/10.1076/oep.11.2.67.28158>
112. Resnikoff S, Keys TU. Future trends in global blindness. *Indian J Ophthalmol* [Internet]. 2012;60:387-95. Available from:
<http://www.ijo.in/text.asp?2012/60/5/387/100532>
113. Dandona R, Dandona L. Refractive error blindness. *Bull World Health Organ* [Internet]. 2001;79(3):237-43. Available from:
[https://www.who.int/bulletin/archives/79\(3\)237.pdf?ua=1](https://www.who.int/bulletin/archives/79(3)237.pdf?ua=1)
114. Shah SP, Jadoon MZ, Dineen B, Bourne RR, Johnson GJ, Gilbert CE, Khan MD. Refractive errors in the adult Pakistani population: the National Blindness and Visual Impairment Survey. *Ophthalmic Epidemiol* [Internet]. 2008;15(3):183-90. Available from:
<https://doi.org/10.1080/09286580802105822>

References

115. Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bull World Health Organ* [Internet]. 2008;86:63–70. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2647357/pdf/07-041210.pdf>
116. Naidoo KS, Wallace DB, Holden BA, Minto H, Faal HB, Dube P. The challenge of uncorrected refractive error: driving the agenda of the Durban Declaration on refractive error and service development. *Clin Exp Optom* [Internet]. 2010;93:131-6. Available from: <https://doi.org/10.1111/j.1444-0938.2010.00455.x>
117. Bourne R, Price H, Stevens G, Group GBD Vision Loss Expert Group. Global burden of visual impairment and blindness. *Arch Ophthalmol* [Internet]. 2012;130(5):645-7. Available from: <https://doi.org/10.1001/archophthalmol.2012.1032>
118. World Health Organization. Global data on visual impairments 2010 [Internet]. Geneva (CH): World Health Organization. 2012. p. 14. Available from: <https://www.who.int/blindness/GLOBALDATAFINALforweb.pdf>
119. Stevens GA, White RA, Flaxman SR, Price H, Jonas JB, Keeffe J et al (Vision Loss Expert Group). Global prevalence of vision impairment and blindness: magnitude and temporal trends, 1990-2010. *Ophthalmology* [Internet]. 2013;120:2377-2384. Available from: [https://www.aaojournal.org/article/S0161-6420\(13\)00480-6/pdf](https://www.aaojournal.org/article/S0161-6420(13)00480-6/pdf)
120. Bourne RRA, Stevens GA, White RA, Smith JL, Flaxman SR, Price H, et al. Causes of vision loss worldwide, 1990–2010: a systematic analysis. *Lancet Glob Health* [Internet]. 2013;1(6):e339-e49. Available from: [https://doi.org/10.1016/S2214-109X\(13\)70113-X](https://doi.org/10.1016/S2214-109X(13)70113-X)
121. Bourne RR, Jonas JB, Flaxman SR, Keeffe J, Leasher J, Naidoo K, et al. Prevalence and causes of vision loss in high-income countries and in Eastern and Central Europe: 1990-2010. *Br J Ophthalmol* [Internet]. 2014;98(5):629-38. Available from: <https://bjo.bmj.com/content/bjophthalmol/98/5/629.full.pdf>
122. Jonas JB, George R, Asokan R, Flaxman SR, Keeffe J, Leasher J, et al. Prevalence and causes of vision loss in Central and South Asia: 1990-2010. *Br J Ophthalmol* [Internet]. 2014;98:592-8. Available from: <https://bjo.bmj.com/content/bjophthalmol/98/5/592.full.pdf>
123. Wong TY, Zheng Y, Jonas JB, Flaxman SR, Keeffe J, Leasher J, et al. Prevalence and causes of vision loss in East Asia: 1990-2010. *Br J Ophthalmol* [Internet]. 2014;98(5):599-604. Available from:

References

<https://bjo.bmj.com/content/bjophthalmol/98/5/599.full.pdf>

124. Jose R, Rathore AS, Rajshekhar V, Sachdeva S. National Programme for Control of Blindness (NPCB) in the Eleventh Five-year Plan Period. *Community Eye Health*. 2008;21(68):S115-S116.

125. Bachani D. National programme development for prevention of blindness in India. In: Pararajasegaram R, Rao, GN, editors. *World blindness and its prevention*. Volume 6. Proceedings of the Sixth General Assembly of the International Agency for the Prevention of Blindness (IAPB); 1999 5th-10th September; Beijing, China. Hyderabad, India: IAPB; 2001. p 379-394.

126. Agarwal LP. National programme for prevention of visual impairment and control of blindness. *Indian J Ophthalmol* [Internet]. 1977;25:1-5. Available from: <http://www.ijo.in/text.asp?1977/25/4/1/34605>

127. Jose R, Bachani D. World bank assisted cataract blindness control project. *Indian J Ophthalmol* [Internet]. 1995;43:35-43. Available from: <http://www.ijo.in/text.asp?1995/43/1/35/25277>

128. Dandona L, Dandona R, Anand R, Srinivas M, Rajasekhar V. Outcome and number of cataract surgery in India: policy issue for blindness control. *Clin Exp Ophthalmol* [Internet]. 2003; 31: 23-31. Available from: <https://onlinelibrary.wiley.com/doi/epdf/10.1046/j.1442-9071.2003.00595.x>

129. Khairallah M, Kahloun R, Bourne R, Limburg H, Flaxman SR, Jonas JB, Keeffe J et al, Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010. *Invest Ophthalmol Vis Sci* [Internet]. 2015;56(11):6762-9. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2465334&resultClick=1>

130. Le H-G, Ehrlich, JR, Venkatesh R, Srinivasan A, Kolli A, Haripriya, A et al. A sustainable model for delivering high-quality, efficient cataract surgery in southern India. *Health Aff (Millwood)* [Internet]. 2016;35(10):1783-1790. Available from: <https://doi.org/10.1377/hlthaff.2016.0562>

131. Ravilla T, Ramasamy D. Efficient high-volume cataract services: the Aravind model. *Community Eye Health* 2014;27(85):7-8.

132. Thulasiraj RD, Sundaram RM. Optical services through outreach in South India: a case study from Aravind Eye Hospitals. *Community Eye Health*. 2006;19(58):29-30.

133. Natchiar G, Thulasiraj R, Sundaram RM. Cataract surgery at Aravind Eye Hospitals: 1988-2008. *Community Eye Health*. 2008;21(67):40-2.

References

134. Qureshi BM, Mansur R, Al-Rajhi A, Lansingh V, Eckert K, Hassan K, et al. Best practice eye care models. *Indian J Ophthalmol* [Internet]. 2012;60:351-7. Available from: <https://doi.org/10.4103/0301-4738.100526>
135. Dandona L, Dandona R, Shamanna BR, Naduvilath TJ, Rao GN. Developing a model to reduce blindness in India: The international centre for advancement of rural eye care. *Indian J Ophthalmol* [Internet]. 1998;46:263-8. Available from: <http://www.ijo.in/text.asp?1998/46/4/263/24182>
136. Kovai V, Krishnaiah S, Shamanna BR, Thomas R, Rao GN. Barriers to accessing eye care services among visually impaired populations in rural Andhra Pradesh, South India. *Indian J Ophthalmol* [Internet]. 2007;55:365-71. Available from: <http://www.ijo.in/text.asp?2007/55/5/365/33823>
137. Rao GN, Khanna RC, Athota SM, Rajshekar V, Rani PK. Integrated model of primary and secondary eye care for underserved rural areas: The LV Prasad Eye Institute experience. *Indian J Ophthalmol* [Internet]. 2012;60:396-400. Available from: <https://dx.doi.org/10.4103%2F0301-4738.100533>
138. Vashist P, Gupta SK, Murthy GV. A model for eye care service delivery to urban underprivileged populations in New Delhi. *Community Eye Health*. 2005;18:s65-7.
139. Khan MJ. Bangladesh Model of Eye Care (Modular Eye Care, MEC). *Community Eye Health*. 2000;13(34):24-5.
140. Johnson GJ. Improving outcome of cataract surgery in developing countries. *Lancet* [Internet]. 2000;355(9199):158-9. Available from: [https://doi.org/10.1016/S0140-6736\(99\)00404-3](https://doi.org/10.1016/S0140-6736(99)00404-3)
141. Hannan Z. Case finding in the community: experience of *Jatiya Andha Kallyan Somiti* in Comilla, Bangladesh. *Community Eye Health*. 2002; 15(43):40-2.
142. Chittagong Eye Infirmary and Training Complex. Community services. Available from: http://www.ctgeyeinfirmary.info/?page_id=107.
143. Shakoor SA. Community ophthalmology. *J Bangladesh Acad Ophthalmol (JBAO)* [Internet]. 2011;18(1):4-5. Available from: <http://www.osb.com.bd/archives/Journals/BAO/JBAO%20VOL%2018%20NO1%20JANUARY%202011.pdf>
144. Gilbert C. The importance of primary eye care. *Community Eye Health*. 1998;11(26):17-9.

References

145. Konyama K. Essential components of primary eye care. *Community Eye Health*. 1998;11(26):19-21.
146. Dandona R, Dandona L, Naduvilath T J, Nanda A, McCarty CA. Design of a population-based study of visual impairment in India: the Andhra Pradesh eye disease study. *Indian J Ophthalmol* [Internet] 1997;45:251-7. Available from: <http://www.ijo.in/text.asp?1997/45/4/251/14990>
147. Dandona L, Dandona R, Naduvilath TJ, McCarty CA, Nanda A, Srinivas M, et al. Is current eye-care-policy focus almost exclusively on cataract adequate to deal with blindness in India? *Lancet* [Internet]. 1998;351(9112):1312-6. Available from: [https://doi.org/10.1016/S0140-6736\(97\)09509-3](https://doi.org/10.1016/S0140-6736(97)09509-3)
148. Congdon NG, Taylor HR. Age-related cataract. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 105-19.
149. Gilbert C, Foster A. Childhood blindness in the context of VISION 2020 - the right to sight. *Bull World Health Organ* [Internet]. 2001;79:227-32. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2566382/pdf/11285667.pdf>
150. Gogate P, Gilbert C. Blindness in children: a worldwide perspective. *Community Eye Health*. 2007;20(62):32-3.
151. Kemmanu V, Hegde K, Giliyar SK, Shetty BK, Kumaramanickavel G, McCarty CA. Prevalence of childhood blindness and ocular morbidity in a rural pediatric population in southern India: the Pavagada Pediatric Eye Disease Study-1, *Ophthalmic Epidemiol* [Internet]. 2016;23:185-192. Available from: <https://doi.org/10.3109/09286586.2015.1090003>
152. Minassian DC. Epidemiological methods in prevention of blindness. *Eye (Lond)* [Internet]. 1988;2 Suppl:S3-12. Available from: <https://www.nature.com/articles/eye1988128.pdf>
153. Bhattacharjee J, Devadethan, Sharma RS, Saini NK, Datta KK. Methods for estimating prevalence and incidence of senile cataract blindness in a district. *Indian J Ophthalmol* [Internet]. 1996;44(4):207-11. Available from: <http://www.ijo.in/text.asp?1996/44/4/207/24562>
154. Islam BS. Birth and death registration in Bangladesh [Internet]. Government of the People's Republic of Bangladesh, Ministry of Planning. Dhaka (BD): Ministry of Planning. 2013. 30 p. Available from: <http://www.sesric.org/imgs/news/image/829-s4-presentation-bangladesh.pdf>

References

155. International Development Law Organization (IDLO). Strengthening the legal protection framework for girls in India, Bangladesh, Kenya and Liberia – Bangladesh country report [Internet]. Rome (IT): IDLO; 2010. p. 92. Available from: http://www.idlo.org/doccalendar/bangladeshreport_final.pdf
156. Government of the People's Republic of Bangladesh, Bangladesh Bureau of Statistics. Statistical pocketbook of Bangladesh 1997. Dhaka (BD): Ministry of Planning. Statistics Division; 1998. 419 p.
157. Murthy GV, Gupta S, Ellwein LB, Munoz SR, Bachani D, Dada VK. A population-based eye survey of older adults in a rural district of Rajasthan: I. Central vision impairment, blindness, and cataract surgery. *Ophthalmology* [Internet]. 2001;108(4):679-85. Available from: [https://www.aaojournal.org/article/S0161-6420\(00\)00579-0/fulltext](https://www.aaojournal.org/article/S0161-6420(00)00579-0/fulltext)
158. Dhake PV, Dole K, Khandekar R, Deshpande M. Prevalence and causes of avoidable blindness and severe visual impairment in a tribal district of Maharashtra, India. *Oman J Ophthalmol* [Internet]. 2011;4(3):129-34. Available from: <https://dx.doi.org/10.4103%2F0974-620X.91269>
159. Minassian DC. Epidemiological research methods: an outline. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 31-41.
160. Minassian DC. Cross-sectional studies. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 42-52.
161. Lemeshow S, Hosmer DW Jr, Klar J, Lwanga SK on behalf of the World Health Organization. Adequacy of sample size in health studies. Chichester (GB): John Wiley and Son Ltd.; 1990. Part II. Foundations of sampling and sampling theory. Chapter 8. Basic sampling concepts – cluster sampling. p. 83-6.
162. Magnani R. Sampling guide [Internet]. Washington (US): Food and Nutrition Technical Assistance (FANTA) Project. FHI 360; 1999. Chapter 3. Selecting the sample. p. 21-34. Available from: http://www.managingforimpact.org/sites/default/files/resource/fanta_2012_sampling_guide_with_addendum.pdf
163. Eye Care Bangladesh. Tertiary eye care – National Institute of Ophthalmology and Hospital [Internet]. Dhaka: Eye Care Bangladesh; 2018. Available from: <http://eyecarebd.net/national-institute-of-ophthalmology-and-hospital/>

References

164. Elliott DB, Flanagan JG. Chapter 3, Assessment of visual function. In: Elliott DB, editor. *Clinical procedures in primary eye care*. 4th ed. Philadelphia (US): Saunders Elsevier; 2013. p. 29-81.
165. Stevens S. How to measure intraocular pressure: Schiötz tonometry. *Community Eye Health*. 2008;21(66):34.
166. Rosser DA, Laidlaw DA, Murdoch IE. The development of a 'reduced logMAR' visual acuity chart for use in routine clinical practice. *Br J Ophthalmol* [Internet]. 2001;85:432-6. Available from: <http://dx.doi.org/10.1136/bjo.85.4.432>
167. Bourne RR, Rosser DA, Sukudom P, Dineen B, Laidlaw DA, Johnson GJ, et al. Evaluating a new logMAR chart designed to improve visual acuity assessment in population-based surveys [Internet]. *Eye (Lond)*. 2003;17:754-8. Available from: <https://doi.org/10.1038/sj.eye.6700500>
168. Bourne RR, Sukudom P, Foster PJ, Tantisevi V, Jitapunkul S, Lee PS, et al. Prevalence of glaucoma in Thailand: a population-based survey in Rom Klao District, Bangkok [Internet]. *Br J Ophthalmol*. 2003 Sep;87(9):1069-74. Available from: <https://doi.org/10.1136/bjo.87.9.1069>
169. Dean AG, Dean JA, Coulombier D, Brendel KA, Smith DC, Burton AH, et al. *Epi Info, version 6: a word processing, database, and statistics program for public health on IBM-compatible microcomputers*. Atlanta (US): Centers for Disease Control and Prevention; 1996. p. 595.
170. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* [Internet]. 1986;328:307–10. Available from: [https://doi.org/10.1016/S0140-6736\(86\)90837-8](https://doi.org/10.1016/S0140-6736(86)90837-8)
171. Bland JM, Altman DG. Measuring agreement in method comparison studies. *Stat Methods Med Res* [Internet] 1999;8:135-60. Available from: <https://journals.sagepub.com/doi/pdf/10.1177/096228029900800204>
172. Nikon Corporation. Nikon auto refract-keratometer 'Retinomax K-plus II'. Tokyo (JP): Nikon Corporation. Available from: <https://www.nikon.com/products/industrial-metrology/support/information/info11001.htm>
173. World Health Organization. *International classification of diseases and related health problems – tenth revision (ICD-10)*. Geneva (CH): WHO; 2000. Chapter VII. Diseases of the eye and adnexa (H00-H59). Available from: <https://icd.who.int/browse10/2015/en#/H54>.

References

174. Mehra V, Minassian DC. A rapid method of grading cataract in epidemiological studies and eye surveys. *Br J Ophthalmol* [Internet]. 1988;72:801-3. Available from: <https://bjo.bmj.com/content/bjophthalmol/72/11/801.full.pdf>
175. Philippin H, Shah P, Burton M. Detecting possible glaucoma with only limited equipment: a crucial first step. *Community Eye Health*. 2012;25(79-80):48-9.
176. Johnson GJ, Quigley HA. The glaucomas. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 222-39.
177. Foster PJ, Buhrmann R, Quigley HA, et al The definition and classification of glaucoma in prevalence surveys *Br J Ophthalmol* [Internet]. 2002;86:238-42. Available from: <http://dx.doi.org/10.1136/bjo.86.2.238>
178. Rahman MM, Rahman N, Foster PJ, Haque Z, Zaman AU, Dineen B, et al. The prevalence of glaucoma in Bangladesh: a population based survey in Dhaka division. *Br J Ophthalmol* [Internet]. 2004;88:1493-7. Available from: <https://bjo.bmj.com/content/bjophthalmol/88/12/1493.full.pdf>
179. Evans J. Age-related macular degeneration. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 356-69.
180. Klein BEK, Klein R. Diabetic retinopathy. In: Johnson, GJ, Minassian DC, Weale RA, West, SK, editors. *The epidemiology of eye disease*. 2nd ed. London: Arnold; 2003. p. 341-55.
181. IBM Corporation. *IBM SPSS statistics for Windows, Version 23.0*. Armonk, NY (US): IBM Corporation. Available from: <http://www-01.ibm.com/support/docview.wss?uid=swg21476197>
182. Field A. *Discovering statistics using SPSS*. 2nd ed. London: Sage Publications; 2005. 779 p.
183. Pallant J. *SPSS survival manual – a step-by-step guide to data analysis for Windows*. 3rd ed. Milton Keynes (UK): McGraw Hill Open University Press; 2007. 335 p.
184. de Sousa MH, Nunes da Silva N. [Estimativas obtidas de um levantamento complexo]. *Rev Saúde Pública* [Internet]. 2003;37:662-70. Portuguese. Available from: <http://dx.doi.org/10.1590/S0034-89102003000500018>

References

185. Kolenikov S, Pitblado J. Chapter 29. Analysis of complex health survey data. In: Johnson TP, editor. Handbook of health survey methods. Hoboken (US): John Wiley and Sons, Inc.; 2015. p. 755-804.
Available from: <https://doi.org/10.1002/9781118594629.ch29>
186. Hosmer DW, Lemeshow S. Applied logistic regression. 2nd ed. New York: Wiley-Interscience Publication; 2000. 375 p.
187. Bewick V, Cheek L, Ball J. Statistics review 14: Logistic regression. Crit Care [Internet]. 2005;9(1):112-8. Available from:
<https://ccforum.biomedcentral.com/track/pdf/10.1186/cc3045>
188. O'Connor AM. Interpretation of odds and risk ratios. J Vet Intern Med [Internet]. 2013;27(3):600-3. Available from:
<https://onlinelibrary.wiley.com/doi/epdf/10.1111/jvim.12057>
189. Daly LE, Bourke GJ, McGilvray J. Interpretation and uses of medical statistics. Fourth ed. Oxford (GB): Blackwell Scientific Publications; 1991. 441 p.
190. Limburg H, Foster A, Vaidyanathan K, Murthy GV. Monitoring visual outcome of cataract surgery in India. Bull World Health Organ [Internet]. 1999;77(6):455-60. Available from:
[https://www.who.int/bulletin/archives/77\(6\)455.pdf?ua=1](https://www.who.int/bulletin/archives/77(6)455.pdf?ua=1)
191. Limburg H. Monitoring cataract surgical outcomes: methods and tools. Community Eye Health. 2002;15(44):51-3.
192. Limburg H, Foster A. Cataract surgical coverage: An indicator to measure the impact of cataract intervention programmes. Community Eye Health. 1998;11(25):3-6.
193. Limburg H. Monitoring and evaluation of intervention programmes for cataract and for refractive errors in India [doctoral dissertation]. [Utrecht (NL)]: Utrecht University; 1999. 232 p.
194. Polack S, Kuper H. Measuring the impact of cataract services in the community. Community Eye Health. 2014;27(85):15.
195. Green MD, Freedman DM, Gordis L. Reference guide on epidemiology [Internet]. In: National Research Council. Reference manual on scientific evidence. 3rd edition. Washington (US): The National Academies Press; 2011. p. 549-632. Available from: <https://www.nap.edu/read/13163/chapter/12>

References

196. Pan American Health Organization (PAHO). Standardization: a classic epidemiological method for the comparison of rates. *Epidemiol Bull* [Internet]. 2002;23(3):9-12. Available from: <http://www.bvsde.paho.org/bvsea/fulltext/comparison.pdf>
197. Murdoch I. People and eyes: statistics in ophthalmology. *Community Eye Health*. 1998;11(27):43.
198. Bourne RR, Dineen BP, Huq DM, Ali SM, Johnson GJ. Correction of refractive error in the adult population of Bangladesh: meeting the unmet need. *Invest Ophthalmol Vis Sci* [Internet]. 2004;45(2):410-7. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2162985&resultClick=1>
199. Niyadurupola N, Astbury N. Endophthalmitis: controlling infection before and after cataract surgery. *Community Eye Health*. 2008;21(65):9-10.
200. Niyadurupola N, Astbury N. Postoperative endophthalmitis. *Community Eye Health*. 2015;28(90):32-3.
201. Government of the People's Republic of Bangladesh. Ministry of Planning. Statistics and Informatics Division. Bangladesh Bureau of Statistics. Bangladesh standard classification of occupations - 2012. Dhaka (BD): Bangladesh Bureau of Statistics; 2012. 313 p.
202. Khan JA, Trujillo AJ, Ahmed S, Siddiquee AT, Alam N, Mirelman AJ, et al. Distribution of chronic disease mortality and deterioration in household socioeconomic status in rural Bangladesh: an analysis over a 24-year period. *Int J Epidemiol* [Internet]. 2015;44(6):1917-26. Available from: <https://doi.org/10.1093/ije/dyv197>
203. Chandrashekhara TS, Bhat HV, Pai RP, Nair SK. Prevalence of blindness and its causes among those aged 50 years and above in rural Karnataka, South India. *Trop Doct* [Internet]. 2007;37(1):18-21. Available from: <https://doi.org/10.1258%2F004947507779952113>
204. Thulasiraj RD, Nirmalan PK, Ramakrishnan R, Krishnadas R, Manimekalai TK, Baburajan NP, et al. Blindness and vision impairment in a rural south Indian population: the Aravind Comprehensive Eye Survey. *Ophthalmology* [Internet]. 2003;110(8):1491-8. Available from: [https://www.aaojournal.org/article/S0161-6420\(03\)00565-7/pdf](https://www.aaojournal.org/article/S0161-6420(03)00565-7/pdf)
205. Casson RJ, Newland HS, Muecke J, McGovern S, Durkin S, Sullivan T, et al. Prevalence and causes of visual impairment in rural Myanmar: the Meiktila Eye Study. *Ophthalmology* [Internet]. 2007;114(12):2302-8.

References

Available from: [https://www.aaojournal.org/article/S0161-6420\(07\)00128-5/pdf](https://www.aaojournal.org/article/S0161-6420(07)00128-5/pdf)

206. Pokharel GP, Regmi G, Shrestha SK, Negrel AD, Ellwein LB. Prevalence of blindness and cataract surgery in Nepal. *Br J Ophthalmol* [Internet]. 1998;82(6):600-5. Available from:

<https://bjo.bmj.com/content/bjophthalmol/82/6/600.full.pdf>

207. Athanasiov PA, Edussuriya K, Senaratne T, Sennanayake S, Selva D, Casson RJ. Cataract in central Sri Lanka: cataract surgical coverage and self-reported barriers to cataract surgery. *Clin Exp Ophthalmol* [Internet]. 2009;37(8):780-4. Available from:

<https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1442-9071.2009.02152.x>

208. Mörchen M, Langdon T, Ormsby GM, Meng N, Seiha D, Piseth K, Keefe JE. Prevalence of blindness and cataract surgical outcomes in Takeo Province, Cambodia. *Asia Pac J Ophthalmol (Phila)* [Internet]. 2015;4(1):25-31. Available from: <http://www.apjo.org/Apjo/pdf/id/135.html>

209. Nirmalan PK, Thulasiraj RD, Maneksha V, Rahmathullah R, Ramakrishnan R, Padmavathi A, Munoz SR, Ellwein LB. A population based eye survey of older adults in Tirunelveli district of south India: blindness, cataract surgery, and visual outcomes. *Br J Ophthalmol* [Internet]. 2002;86(5):505-12. Available from:

<https://bjo.bmj.com/content/bjophthalmol/86/5/505.full.pdf>

210. Thulasiraj RD, Rahamathulla R, Saraswati A, Selvaraj S, Ellwein LB. The Sivaganga eye survey: I. Blindness and cataract surgery. *Ophthalmic Epidemiol* [Internet]. 2002;9(5):299-312. Available from:

<https://doi.org/10.1076/oep.9.5.299.10334>

211. Ravilla T. Inequities in eye care in South Asia. *Community Eye Health*. 2016;29(95):S01-S03.

212. Nangia V, Jonas JB, Gupta R, Khare A, Sinha A. Visual impairment and blindness in rural central India: the Central India Eye and Medical Study. *Acta Ophthalmol* [Internet]. 2013;91(5):483-6. Available from:

<https://onlinelibrary.wiley.com/doi/full/10.1111/j.1755-3768.2012.02447.x>

213. Mactaggart I, Polack S, Murthy G, Kuper H. A population-based survey of visual impairment and its correlates in Mahabubnagar district, Telangana State, India. *Ophthalmic Epidemiol* [Internet]. 2018;25(3):238-245. Available from: <https://doi.org/10.1080/09286586.2017.1418386>

214. Wadud Z, Kuper H, Polack S, Lindfield R, Akm MR, Choudhury KA, et al. Rapid assessment of avoidable blindness and needs assessment of

References

- cataract surgical services in Satkhira District, Bangladesh. *Br J Ophthalmol* [Internet]. 2006;90(10):1225-9. Available from: <https://bjophthalmol.com/content/bjophthalmol/90/10/1225.full.pdf>
215. Wadud Z, Muhit MA. Report on the rapid assessment of avoidable blindness in Narail and Jamalpur Districts, Bangladesh [Internet]. Dhaka, Bangladesh: Child Sight Foundation; 2010. Available from: <http://raabdata.info/repository/>
216. Muhit MA. Report on the rapid assessment of avoidable blindness in Gazipur, Kishoreganj and Cox's Bazar Districts of Bangladesh [Internet]. Dhaka, Bangladesh: Child Sight Foundation; 2011. Available from: <http://raabdata.info/repository/>
217. Muhit MA. Report on the rapid assessment of avoidable blindness in Tangail, Kushtia and Natore Districts in Bangladesh [Internet]. Dhaka, Bangladesh: Child Sight Foundation; 2012. Available from: <http://raabdata.info/repository/>
218. Wadud Z, Muhit MA. Report on the rapid assessment of avoidable blindness in Brahmanbaria and Satkhira Districts of Bangladesh [Internet]. Dhaka, Bangladesh: Child Sight Foundation; 2013. Available from: <http://raabdata.info/repository/>
219. Muhit MA. Rapid assessment of avoidable blindness (RAAB) in Barisal Division of Bangladesh [Internet]. Dhaka, Bangladesh: Child Sight Foundation; 2013. Available from: <http://raabdata.info/repository/>
220. Stevens GA, White RA, Flaxman SR, Price H, Jonas JB, Keeffe J, et al. Global prevalence of vision impairment and blindness: magnitude and temporal trends, 1990-2010. *Ophthalmology* [Internet]. 2013;120:2377-84. Available from: [https://www.aaajournal.org/article/S0161-6420\(13\)00480-6/pdf](https://www.aaajournal.org/article/S0161-6420(13)00480-6/pdf)
221. Frick KD, Foster A. The magnitude and cost of global blindness: an increasing problem that can be alleviated. *Am J Ophthalmol* [Internet]. 2003;135:471-6. Available from: [https://doi.org/10.1016/S0002-9394\(02\)02110-4](https://doi.org/10.1016/S0002-9394(02)02110-4)
222. Muecke J, Sia DIT, Newland H, Casson RJ, Selva D. Perspective on ophthalmic support in countries of the developing world. *Clin Experiment Ophthalmol* [Internet]. 2013;41:263-71. Available from: <https://doi.org/10.1111/j.1442-9071.2012.02869.x>

References

223. Murthy G, Gupta SK, John N, Vashist P. Current status of cataract blindness and Vision 2020: the right to sight initiative in India. *Indian J Ophthalmol*. 2008 Nov-Dec;56(6):489-94. Available from: <https://doi.org/10.4103/0301-4738.42774>
224. Verma R, Khanna P, Prinja S, Rajput M, Arora V. The national programme for control of blindness in India. *Australas Med J* [Internet]. 2011;4(1):1-3. Available from: <http://dx.doi.org/10.4066/AMJ.2011.505>
225. Bourne RRA, Flaxman SR, Braithwaite T, Cicinelli MV, Das A, Jonas JB, et al. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Glob Health* [Internet]. 2017;5(9):e888-e97. Available from: [https://doi.org/10.1016/S2214-109X\(17\)30293-0](https://doi.org/10.1016/S2214-109X(17)30293-0)
226. He M, Wang W, Huang W. Variations and trends in health burden of visual impairment due to cataract: a global analysis. *Invest Ophthalmol Vis Sci* [Internet]. 2017;58(10):4299-306. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2652822&resultClick=1>
227. Trevelyan J, Ackland P. Global action plan indicators – the data in full. Cataract surgeries performed, Bangladesh, 2014 [Internet]. London (GB): International Agency for the Prevention of Blindness (IAPB). Available from: <https://atlas.iapb.org/global-action-plan/gap-indicators/>
228. Kapoor H, Chatterjee A, Daniel R, Foster A. Evaluation of visual outcome of cataract surgery in an Indian eye camp. *Br J Ophthalmol* [Internet]. 1999;83(3):343-6. Available from: <https://bjo.bmj.com/content/bjophthalmol/83/3/343.full.pdf>
229. Bachani D, Gupta SK, Murthy GV, Jose R. Visual outcomes after cataract surgery and cataract surgical coverage in India. *Int Ophthalmol* [Internet]. 1999;23(1):49-56. Available from: <https://link.springer.com/content/pdf/10.1023%2FA%3A1006435312612.pdf>
230. Gupta SK, Murthy GV, Sharma N. Longitudinal study on visual outcome and spectacle use after intracapsular cataract extraction in northern India. *BMC Ophthalmol* [Internet]. 2003;3:9. Available from: <https://bmcophthalmol.biomedcentral.com/track/pdf/10.1186/1471-2415-3-9>
231. Snellingen T, Shrestha JK, Huq F, Husain R, Koirala S, Rao GN, et al. The South Asian cataract management study: complications, vision outcomes, and corneal endothelial cell loss in a randomized multicenter clinical trial comparing intracapsular cataract extraction with and without

References

anterior chamber intraocular lens implantation. *Ophthalmology* [Internet]. 2000;107(2):231-40. Available from:

[https://www.aaojournal.org/article/S0161-6420\(99\)00008-1/pdf](https://www.aaojournal.org/article/S0161-6420(99)00008-1/pdf)

232. Natchiar GN, Thulasiraj RD, Negrel AD, Bangdiwala S, Rahmathallah R, Prajna NV, et al. The Madurai Intraocular Lens Study. I: A randomized clinical trial comparing complications and vision outcomes of intracapsular cataract extraction and extracapsular cataract extraction with posterior chamber intraocular lens. *Am J Ophthalmol* [Internet]. 1998;125(1):1-13. Available from: [https://doi.org/10.1016/S0002-9394\(99\)80229-3](https://doi.org/10.1016/S0002-9394(99)80229-3)

233. Shrestha JK, Pradhan YM, Snellingen T. Outcomes of extracapsular surgery in eye camps of eastern Nepal. *Br J Ophthalmol* [Internet]. 2001;85(6):648-52. Available from:

<https://bjo.bmj.com/content/bjophthalmol/85/6/648.full.pdf>

234. Gogate P. Clinical trial of manual small incision surgery and standard extracapsular surgery. *Community Eye Health*. 2003;16(48):54-5.

235. Gogate PM, Deshpande M, Wormald RP, Deshpande R, Kulkarni SR. Extracapsular cataract surgery compared with manual small incision cataract surgery in community eye care setting in western India: a randomised controlled trial. *Br J Ophthalmol* [Internet]. 2003;87(6):667-72. Available from: <https://bjo.bmj.com/content/bjophthalmol/87/6/667.full.pdf>

236. Gurung A, Karki DB, Shrestha S, Rijal AP. Visual outcome of conventional extracapsular cataract extraction with posterior chamber intraocular lens implantation versus manual small-incision cataract surgery. *Nepal J Ophthalmol*. 2009;1(1):13-9. Available from:

<https://www.nepjol.info/index.php/NEPJOPH/article/view/3668>

237. Wang H, Zhang Y, Li Z, Wang T, Liu P. Prevalence and causes of corneal blindness. *Clin Exp Ophthalmol* [Internet]. 2014;42(3):249-53. Available from: <https://onlinelibrary.wiley.com/doi/epdf/10.1111/ceo.12164>.

238. Gupta N, Vashist P, Tandon R, Gupta SK, Dwivedi S, Mani K. Prevalence of corneal diseases in the rural Indian population: the Corneal Opacity Rural Epidemiological (CORE) study. *Br J Ophthalmol* [Internet]. 2015 Feb;99(2):147-52. Available from:

<https://bjo.bmj.com/content/bjophthalmol/99/2/147.full.pdf>

239. Dandona R, Dandona L. Corneal blindness in a southern Indian population: need for health promotion strategies. *Br J Ophthalmol* [Internet]. 2003 Feb;87(2):133-41. Available from:

<https://bjo.bmj.com/content/bjophthalmol/87/2/133.full.pdf>

References

240. Govekar KP, Sharma MK. Blindness and visual impairment in Delhi Region. *Nat J Comm Med* [Internet]. 2014;5(4):370-2. Available from: <http://www.njcmindia.org/home/download/600>
241. Sapkota YD, Sunuwar M, Naito T, Akura J, Adhikari HK. The prevalence of blindness and cataract surgery in Rautahat district, Nepal. *Ophthalmic Epidemiol* [Internet]. 2010;17(2):82-9. Available from: <https://doi.org/10.3109/09286581003624947>
242. Sherchan A, Kandel RP, Sharma MK, Sapkota YD, Aghajanian J, Bassett KL. Blindness prevalence and cataract surgical coverage in Lumbini Zone and Chetwan District of Nepal. *Br J Ophthalmol* [Internet]. 2010;94(2):161-6. Available from: <https://bjo.bmj.com/content/bjophthalmol/94/2/161.full.pdf>
243. Zainal M, Ismail SM, Ropilah AR, Elias H, Arumugam G, Alias D, et al. Prevalence of blindness and low vision in Malaysian population: results from the National Eye Survey 1996. *Br J Ophthalmol* [Internet]. 2002;86(9):951-6. Available from: <https://bjo.bmj.com/content/bjophthalmol/86/9/951.full.pdf>
244. Longini IM Jr, Yunus M, Zaman K, Siddique AK, Sack RB, Nizam A. Epidemic and endemic cholera trends over a 33-year period in Bangladesh. *J Infect Dis*. 2002;186(2):246-51. Available from: <https://doi.org/10.1086/341206>
245. Cohen N, Jalil MA, Rahman H, Matin MA, Sprague J, Islam J, et al. Landholding, wealth and risk of blinding malnutrition in rural Bangladeshi households. *Soc Sci Med* [Internet]. 1985;21:1269-72. Available from: [https://doi.org/10.1016/0277-9536\(85\)90276-X](https://doi.org/10.1016/0277-9536(85)90276-X)
246. Khattry SK, West KP Jr, Katz J, LeClerq SC, Pradhan EK, Wu LS, et al. Epidemiology of xerophthalmia in Nepal - a pattern of household poverty, childhood illness, and mortality. The Sarlahi Study Group. *Arch Ophthalmol* [Internet]. 1995;113(4):425-9. Available from: <https://dx.doi.org/10.1001/archophth.1995.01100040039024>
247. Hossain MM, Mohiuddin AA, Akhanda AH, Hossain MI, Islam MF, Akonjee AR, et al [Abstract]. Pattern of ocular trauma. *Mymensingh Med J* [Internet]. 2011;20(3):377-80. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/21804497>
248. Talukder AK, Halder SK, Sultana Z, Bhuiyan SI. Epidemiology and outcome of non-viral keratitis [Abstract]. *Mymensingh Med J* [Internet]. 2011;20(3):356-61. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/21804493>

References

249. Moid MA, Akhanda AH, Islam S, Halder SK, Islam R Epidemiological aspect and common bacterial and fungal isolates from suppurative corneal ulcer in Mymensingh Region [Abstract]. *Mymensingh Med J* [Internet]. 2015;24(2):251-6. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/26007250>
250. Getshen K, Srinivasan M, Upadhyay MP, Priyadarsini B, Mahalaksmi R, Whitcher JP. Corneal ulceration in South East Asia. I: a model for the prevention of bacterial ulcers at the village level in rural Bhutan. *Br J Ophthalmol* [Internet]. 2006;90(3):276-8. Available from: <https://bjo.bmj.com/content/bjophthalmol/90/3/276.full.pdf>
251. Maung N, Thant CC, Srinivasan M, Upadhyay MP, Priyadarsini B, Mahalakshmi R, et al. Corneal ulceration in South East Asia. II: a strategy for the prevention of fungal keratitis at the village level in Burma. *Br J Ophthalmol* [Internet]. 2006;90(8):968-70. Available from: <https://bjo.bmj.com/content/bjophthalmol/90/8/968.full.pdf>
252. Srinivasan M, Upadhyay MP, Priyadarsini B, Mahalakshmi R, Whitcher JP. Corneal ulceration in South-East Asia III: prevention of fungal keratitis at the village level in south India using topical antibiotics. *Br J Ophthalmol* [Internet]. 2006;90(12):1472-5. Available from: <https://bjo.bmj.com/content/bjophthalmol/90/12/1472.full.pdf>
253. Talukder AK, Sultana Z, Jahan I, Khanam M, Bhuiyan SI, Rahman MB. Management of infective corneal ulcer: epidemiology needs to be evaluated as priority basis [Abstract]. *Mymensingh Med J* [Internet]. 2016;25(3):415-20. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/27612884>
254. Yasmin R, Ahmad R, Sultana N, Sayed S, Ahmad SA, Zaman F, et al. Eye problems among the workers in re-rolling mill exposed to high temperature. *Work* [Internet]. 2013;46(1):93-7. Available from: <https://dx.doi.org/10.3233/WOR-2012-1473>
255. Khan AK. Ocular injury: prevalence in different rural population of Bangladesh. *Bangladesh Med Res Counc Bull* [Internet]. 2013 Dec;39(3):130-8. Available from: <http://dx.doi.org/10.3329/bmrcb.v39i3.20314>
256. Talukder AK, Sultana Z, Jahan I, Khanam M, Rahman M, Rahman MF, et al. Antibiotic resistance: new challenge in the management of bacterial eye infections [Abstract]. *Mymensingh Med J* [Internet]. 2017;26(1):29-36. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/28260752>
257. Mir R. New era of cornea transplantation in Bangladesh [Abstract]. *Transplantation* [Internet]. 2017;101:S104. Available from:

References

<https://dx.doi.org/10.1097/01.tp.0000525141.99931.bb>

258. Bourne RRA, Taylor HR, Flaxman SR, Keeffe J, Leasher J, Naidoo K, et al. Number of people blind or visually impaired by glaucoma worldwide and in world regions 1990-2010: a meta-analysis. PLoS ONE [Internet]. 2016;11(10):e0162229. Available from:

<https://doi.org/10.1371/journal.pone.0162229>

259. Nangia V, Jonas JB, George R, Lingam V, Ellwein L, Cicinelli MV, et al. Prevalence and causes of blindness and vision impairment: magnitude, temporal trends and projections in South and Central Asia. Br J Ophthalmol [Internet]. 2018;Nov 8 [online first]. Available from:

<https://bjo.bmj.com/content/bjophthalmol/early/2018/11/04/bjophthalmol-2018-312292.full.pdf>

260. Dandona L, Dandona R, Naduvilath TJ, McCarty CA, Rao GN. Population-based assessment of diabetic retinopathy in an urban population in southern India. Br J Ophthalmol [Internet]. 1999;83(8):937-40. Available from: <https://bjo.bmj.com/content/bjophthalmol/83/8/937.full.pdf>

261. Leasher JL, Bourne RR, Flaxman SR, Jonas JB, Keeffe J, Naidoo K, et al. Global estimates on the number of people blind or visually impaired by diabetic retinopathy: a meta-analysis from 1990 to 2010. Diabetes Care [Internet]. 2016;39:1643-9. Available from: <https://doi.org/10.2337/dc15-2171>

262. Biswas T, Islam A, Rawal LB, Islam SM. Increasing prevalence of diabetes in Bangladesh: a scoping review. Public Health [Internet]. 2016 Sep;138:4-11. Available from: <https://doi.org/10.1016/j.puhe.2016.03.025>

263. Rahim MA, Hussain A, Azad Khan AK, Sayeed MA, Keramat Ali SM, Vaaler S. Rising prevalence of type 2 diabetes in rural Bangladesh: a population-based study. Diabetes Res Clin Pract [Internet]. 2007;77(2):300-5. Available from: <https://doi.org/10.1016/j.diabres.2006.11.010>

264. Sultana M, Mahumud RA, Sarker AR. Burden of chronic illness and associated disabilities in Bangladesh: evidence from the Household Income and Expenditure Survey. Chronic Dis Transl Med [Internet]. 2017;3(2):112-122. Available from: <https://doi.org/10.1016/j.cdtm.2017.02.001>

265. Islam FM, Chakrabarti R, Dirani M, Islam MT, Ormsby G, Wahab M, et al. Knowledge, attitudes and practice of diabetes in rural Bangladesh: the Bangladesh population-based diabetes and eye study (BPDES). PLoS One [Internet]. 2014;9(10):e110368. Available from:

<https://doi.org/10.1371/journal.pone.0110368>

References

266. Bhowmik B, Munir SB, Ahmed KR, Siddiquee T, Diep LM, Wright E, et al. Anthropometric indices of obesity and type 2 diabetes in Bangladeshi population: Chandra Rural Diabetes Study (CRDS). *Obes Res Clin Pract* [Internet]. 2014;8(3):e201-98. Available from: <https://doi.org/10.1016/j.orcp.2013.06.001>
267. Biswas T, Garnett SP, Pervin S, Rawal LB. The prevalence of underweight, overweight and obesity in Bangladeshi adults: data from a national survey. *PLoS One* [Internet]. 2017;12(5):e0177395. Available from: <https://doi.org/10.1371/journal.pone.0177395>
268. Saquib N, Saquib J, Ahmed T, Khanam MA, Cullen MR. Cardiovascular diseases and type 2 diabetes in Bangladesh: a systematic review and meta-analysis of studies between 1995 and 2010. *BMC Public Health* [Internet]. 2012;12:434. Available from: <https://doi.org/10.1186/1471-2458-12-434>
269. Rahaman KS, Majdzadeh R, Holakouie Naieni K, Raza O. Knowledge, attitude and practices (KAP) regarding chronic complications of diabetes among patients with type 2 diabetes in Dhaka. *Int J Endocrinol Metab* [Internet]. 2017;15(3):e12555. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5702002/pdf/ijem-15-03-12555.pdf>
270. Hussain A, Rahim MA, Azad Khan AK, Ali SM, Vaaler S. Type 2 diabetes in rural and urban population: diverse prevalence and associated risk factors in Bangladesh. *Diabet Med* [Internet]. 2005;22(7):931-6. Available from: <https://doi.org/10.1111/j.1464-5491.2005.01558.x>
271. Islam FMA, Chakrabarti R, Dirani M, Islam MT, Ormsby G, Wahab M, et al. Knowledge, attitudes and practice of diabetes in rural Bangladesh: the Bangladesh Population-based Diabetes and Eye Study (BPDES). *PLoS One* [Internet]. 2014;9(10):e110368. Available from: <https://doi.org/10.1371/journal.pone.0110368>
272. Islam FMA, Bhowmik JL, Islam SZ, Renzaho AM, Hiller JE, et al. Factors associated with disability in rural Bangladesh: Bangladesh Population-based Diabetes and Eye Study (BPDES). *PLoS One* [Internet]. 2016;11(12):e0165625. Available from: <https://doi.org/10.1371/journal.pone.0165625>
273. Rahman M, Nakamura K, Kizuki M. Socioeconomic differences in the prevalence, awareness, and control of diabetes in Bangladesh. *J Diabetes Complications* [Internet]. 2015;29(6):788-93. Available from: <https://doi.org/10.1016/j.jdiacomp.2015.04.011>

References

274. Islam FM, Chakrabarti R, Islam SZ, Finger RP, Critchley C. Factors associated with awareness, attitudes and practices regarding common eye diseases in the general population in a rural District in Bangladesh: The Bangladesh Population-based Diabetes and Eye Study (BPDES). *PLoS One* [Internet]. 2015;10(7):e0133043. Available from: <https://doi.org/10.1371/journal.pone.0133043>
275. Islam SM, Alam DS, Wahiduzzaman M, Niessen LW, Froeschl G, Ferrari U, et al. Clinical characteristics and complications of patients with type 2 diabetes attending an urban hospital in Bangladesh. *Diabetes Metab Syndr* [Internet]. 2015;9(1):7-13. Available from: <https://doi.org/10.1016/j.dsx.2014.09.014>
276. Congdon NG. Prevention strategies for age-related cataract: present limitations and future possibilities. *Br J Ophthalmol* [Internet]. 2001;85(5):516-20. Available from: <http://dx.doi.org/10.1136/bjo.85.5.516>
277. Gohdes DM, Balamurugan A, Larsen BA, Maylahn C. Age-related eye diseases: an emerging challenge for public health professionals. *Prev Chronic Dis* [Internet]. 2005;2(3):1-6. Available from: https://www.cdc.gov/pcd/issues/2005/jul/pdf/04_0121.pdf
278. Nargis N, Thompson ME, Fong GT, Driezen P, Hussain AKMG, Ruthbah UH, et al. Prevalence and patterns of tobacco use in Bangladesh from 2009 to 2012: evidence from International Tobacco Control (ITC) Study. *PLoS ONE* [Internet]. 2015;10(11):e0141135. Available from: <https://doi.org/10.1371/journal.pone.0141135>
279. Sapkota YD, editor. The epidemiology of blindness in Nepal: 2012 [Internet]. Kathmandu, Nepal: Nepal Netra Jyoti Sangh (NNJS); 2012. Available from: <http://nnjs.org.np/uploads/files/epidemiology-of-blindness-nepal.pdf>
280. World Health Organization. Action plan for the prevention of avoidable blindness and visual impairment 2009-2013. Geneva (CH): World Health Organization. 2010. 27 p. Available from: https://www.who.int/blindness/ACTION_PLAN_WHA62-1-English.pdf
281. World Health Organization. Universal eye health – a global action plan 2014-2019. Geneva (CH): World Health Organization. 2013. 22 p. Available from: https://www.who.int/blindness/AP2014_19_English.pdf
282. Sapkota YD, Pokharel GP, Nirmalan PK, Dulal S, Maharjan IM, Prakash K. Prevalence of blindness and cataract surgery in Gandaki Zone, Nepal. *Br J Ophthalmol* [Internet]. 2006;90(4):411-6. Available from: <https://bjo.bmj.com/content/bjophthalmol/90/4/411.full.pdf>

References

283. Pradhan S, Deshmukh A, Giri Shrestha P, Basnet P, Kandel RP, Lewallen S, et al. Prevalence of blindness and cataract surgical coverage in Narayani Zone, Nepal: a rapid assessment of avoidable blindness (RAAB) study. *Br J Ophthalmol* [Internet]. 2018;102(3):291-294. Available from: <https://bjophthalmol.com/content/bjophthalmol/102/3/291.full.pdf>
284. Li S, Xu J, He M, Wu K, Munoz SR, Ellwein LB. A survey of blindness and cataract surgery in Doumen County, China. *Ophthalmology* [Internet]. 1999;106(8):1602-8. Available from: [https://www.aaojournal.org/article/S0161-6420\(99\)90459-1/pdf](https://www.aaojournal.org/article/S0161-6420(99)90459-1/pdf)
285. Li Z, Cui H, Liu P, Zhang L, Yang H, Zhang L. Prevalence and causes of blindness and visual impairment among the elderly in rural southern Harbin, China. *Ophthalmic Epidemiol* [Internet]. 2008;15(5):334-8. Available from: <https://doi.org/10.1080/09286580802227386>
286. Zhao J, Ellwein LB, Cui H, Ge J, Guan H, Lv J, Ma X, Yin J, Yin ZQ, Yuan Y, Liu H. Prevalence and outcomes of cataract surgery in rural China the China Nine Province survey. *Ophthalmology* [Internet]. 2010;117(11):2120-8. Available from: [https://www.aaojournal.org/article/S0161-6420\(10\)00250-2/pdf](https://www.aaojournal.org/article/S0161-6420(10)00250-2/pdf)
287. Li EY, Liu Y, Zhan X, Liang YB, Zhang X, Zheng C, et al. Prevalence of blindness and outcomes of cataract surgery in Hainan Province in South China. *Ophthalmology* [Internet]. 2013;120(11):2176-83. Available from: [https://www.aaojournal.org/article/S0161-6420\(13\)00334-5/pdf](https://www.aaojournal.org/article/S0161-6420(13)00334-5/pdf)
288. Shen W, Yang Y, Yu M, Li J, Wei T, Li X, Li J, Su X, Zhong H, Yuan Y. Prevalence and outcomes of cataract surgery in adult rural Chinese populations of the Bai nationality in Dali: the Yunnan minority eye study. *PLoS One* [Internet]. 2013;8(4):e60236. Available from: <https://doi.org/10.1371/journal.pone.0060236>
289. Zhang L, Cui H, Zhao J, Ellwein LB, Li Z, Li M, Yu N, Wang Y, Gao X. [Prevalence of blindness and moderate and severe visual impairment among adults aged 50 years or above in Shuangcheng City of Heilongjiang Province: the China Nine-Province Survey] [Abstract]. *Zhonghua Yan Ke Za Zhi* [Internet]. 2014;50(3):173-8. Available from: http://zhzkzz.yiigle.com/CN112142201403/91050.htm?locale=zh_CN
290. Zhang X, Li EY, Leung CK, Musch DC, Tang X, Zheng C, He M, Chang DF, Lam DS. Prevalence of visual impairment and outcomes of cataract surgery in Chaonan, South China. *PLoS One* [Internet]. 2017;12(8):e0180769. Available from: <https://doi.org/10.1371/journal.pone.0180769>

References

291. Zhang G, Tham YC, Gong H, Ren F, Morige J, Dai W, et al. Blindness, low vision and cataract surgery outcome among adults in Hohhot of Inner Mongolia: a Rapid Assessment of Avoidable Blindness (RAAB) study. *Br J Ophthalmol* [Internet]. 2018;102(12):1653-7. Available from: <https://bjo.bmj.com/content/bjophthalmol/102/12/1653.full.pdf>
292. Khanna RC, Marmamula S, Krishnaiah S, Giridhar P, Chakrabarti S, Rao GN. Changing trends in the prevalence of blindness and visual impairment in a rural district of India: systematic observations over a decade. *Indian J Ophthalmol* [Internet]. 2012;60(5):492-7. Available from: <http://www.ijo.in/text.asp?2012/60/5/492/100560>
293. Bachani D, Murthy GV, Gupta KS. Rapid assessment of cataract blindness in India [abstract]. *Indian J Public Health* [Internet]. 2000;44(3):82-9. Available from: <http://www.ijph.in/article.asp?issn=0019-557X;year=2000;volume=44;issue=3;page=82;epage=9;aulast=Bachani;type=0>
294. Dandona L, Dandona R, Srinivas M, Giridhar P, Vilas K, Prasad MN, et al. Blindness in the Indian state of Andhra Pradesh. *Invest Ophthalmol Vis Sci* [Internet]. 2001;42(5):908-16. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2162530>
295. Vijaya L, George R, Arvind H, Baskaran M, Raju P, Ramesh SV, et al. Prevalence and causes of blindness in the rural population of the Chennai Glaucoma Study. *Br J Ophthalmol* [Internet]. 2006;90(4):407-10. Available from: <http://dx.doi.org/10.1136/bjo.2005.081406>
296. Neena J, Rachel J, Praveen V, Murthy GV; Rapid Assessment of Avoidable Blindness India Study Group. Rapid assessment of avoidable blindness in India. *PLoS One* [Internet]. 2008;3(8):e2867. Available from: <https://doi.org/10.1371/journal.pone.0002867>
297. Murthy GV, Vashist P, John N, Pokharel G, Ellwein LB. Prevalence and vision-related outcomes of cataract surgery in Gujarat, India. *Ophthalmic Epidemiol* [Internet]. 2009;16(6):400-9. Available from: <https://doi.org/10.3109/09286580903315809>
298. Chariwala R. Rapid assessment of avoidable blindness and willingness to pay for cataract surgery in tribal region of Surat District of Gujarat State, India [Dissertation]. London: London School of Hygiene and Tropical Medicine, 2011. Available from: https://www.lshtm.ac.uk/library/MSc_CEH/2010-11/100905.pdf

References

299. Khanna RC, Pallerla SR, Eeda SS, Gudapati BK, Cassard SD, Rani PK, Shantha GP, Chakrabarti S, Schein OD. Population based outcomes of cataract surgery in three tribal areas of Andhra Pradesh, India: risk factors for poor outcomes. *PLoS One* [Internet]. 2012;7(5):e35701. Available from: <https://doi.org/10.1371/journal.pone.0035701>
300. Guruprasad BS, Krishnamurthy D, Narendra DP, Ranganath BG, Shamanna RB. Changing scenario of cataract blindness in Kolar District, Karnataka, South India. The utility of rapid assessment of avoidable blindness in reviewing programs. *Ophthalmic Epidemiol* [Internet]. 2013;20(2):89-95. Available from: <https://doi.org/10.3109/09286586.2012.759597>
301. Patil S, Gogate P, Vora S, Ainapure S, Hingane RN, Kulkarni AN, Shammanna BR. Prevalence, causes of blindness, visual impairment and cataract surgical services in Sindhudurg district on the western coastal strip of India. *Indian J Ophthalmol* [Internet]. 2014;62(2):240-5. Available from: <https://dx.doi.org/10.4103%2F0301-4738.128633>
302. Gurudasani B, Shukla AK, Burkule S, Shekokar P, Raut M. Prevalence of cataract and cataract blindness in Wardha District. *Sch J of App Med Sci* [Internet]. 2014;2(4C):1361-1366. Available from: <https://saspublisher.com/wp-content/uploads/2014/07/SJAMS-24C1361-1366.pdf>
303. Gupta N, Vashist P, Malhotra S, Senjam SS, Misra V, Bhardwaj A. Rapid assessment of visual impairment in urban population of Delhi, India. *PLoS One* [Internet]. 2015;10(4):e0124206. Available from: <https://doi.org/10.1371/journal.pone.0124206>
304. Lepcha NT, Chettri CK, Getshen K, Rai BB, Ramaswamy SB, Saibaba S, et al. Rapid assessment of avoidable blindness in Bhutan. *Ophthalmic Epidemiol* [Internet]. 2013;20(4):212-9. Available from: <https://doi.org/10.3109/09286586.2013.794902>
305. Thoufееq U, Das T, Limburg H, Maitra M, Panda L, Sil A, et al. First rapid assessment of avoidable blindness survey in The Maldives: prevalence and causes of blindness and cataract surgery. *Asia Pac J Ophthalmol (Phila)* [Internet]. 2018;7(5):316-320. Available from: <http://www.apjo.org/Apjo/pdf/id/558.html>
306. Khan SA, Das T, Kumar SM, Nutheti R. Low vision rehabilitation in patients with age-related macular degeneration at a tertiary eye care centre in southern India. *Clin Exp Ophthalmol* [Internet]. 2002;30(6):404-10. Available from: <https://onlinelibrary.wiley.com/doi/epdf/10.1046/j.1442-9071.2002.00569.x>

References

307. Raman R, Gella L, Srinivasan S, Sharma T. Diabetic retinopathy: An epidemic at home and around the world. *Indian J Ophthalmol* [Internet]. 2016;64(1):69-75. Available from: <http://www.ijo.in/text.asp?2016/64/1/69/178150>
308. Limburg H, Kumar R, Bachani D. Monitoring and evaluating cataract intervention in India. *Br J Ophthalmol* [Internet]. 1996;80(11):951-5. Available from: <https://dx.doi.org/10.1136%2Fbjo.80.11.951>
309. Dineen B, Foster A, Faal H. A proposed rapid methodology to assess the prevalence and causes of blindness and visual impairment. *Ophthalmic Epidemiol* [Internet]. 2006;13(1):31-4. Available from: <https://doi.org/10.1080/09286580500473787>
310. Blanchet K, Finger RP. A need for more equity in prevention of blindness. *Ophthalmic Epidemiol* [Internet]. 2015;22(5):293-4. Available from: <https://doi.org/10.3109/09286586.2015.1081250>
311. Khan MD. The Duke Elder lecture: the challenge of equitable eye care in Pakistan. *Eye (Lond)* [Internet]. 2011;25(4):415-24. Available from: <https://doi.org/10.1038/eye.2010.186>
312. Ramke J, Zwi AB, Palagyi A, Blignault I, Gilbert CE. Equity and blindness: closing evidence gaps to support universal eye health. *Ophthalmic Epidemiol* [Internet]. 2015;22(5):297-307. Available from: <https://doi.org/10.3109/09286586.2015.1077977>
313. Khanna R, Raman U, Rao GN. Blindness and poverty in India: the way forward. *Clin Exp Optom* [Internet]. 2007;90(6):406-14. Available from: <https://doi.org/10.1111/j.1444-0938.2007.00199.x>
314. Gilbert CE, Shah SP, Jadoon MZ, Bourne R, Dineen B, Khan MA, et al. Poverty and blindness in Pakistan: results from the Pakistan national blindness and visual impairment survey. *BMJ* [Internet]. 2008;336(7634):29-32. Available from: <https://doi.org/10.1136/bmj.39395.500046.AE>
315. Rao GN. The Barrie Jones Lecture - eye care for the neglected population: challenges and solutions. *Eye (Lond)* [Internet]. 2015;29(1):30-45. Available from: <https://doi.org/10.1038/eye.2014.239>
316. Khanna R, Murthy G. Inequities in cataract surgical coverage in South Asia. *Community Eye Health*. 2016;29(95):S06-S09.
317. Congdon N, Thomas R. How can we solve the problem of low uptake of cataract surgery? *Ophthalmic Epidemiol* [Internet]. 2014;21(3):135-7. Available from: <https://doi.org/10.3109/09286586.2014.912333>

References

318. Murthy G, John N, Shamanna BR, Pant HB. Elimination of avoidable blindness due to cataract: where do we prioritize and how should we monitor this decade? *Indian J Ophthalmol* [Internet]. 2012;60(5):438-45. Available from: <https://doi.org/10.4103/0301-4738.100545>
319. Song E, Sun H, Xu Y, Ma Y, Zhu H, Pan CW. Age-related cataract, cataract surgery and subsequent mortality: a systematic review and meta-analysis. *PLoS One* [Internet]. 2014;9(11):e112054. Available from: <https://doi.org/10.1371/journal.pone.0112054>
320. Polack S, Kuper H, Wadud Z, Fletcher A, Foster A. Quality of life and visual impairment from cataract in Satkhira District, Bangladesh. *Br J Ophthalmol* [Internet]. 2008;92(8):1026-30. Available from: <https://bjo.bmj.com/content/bjophthalmol/92/8/1026.full.pdf>
321. Zhou JB, Guan HJ, Zhu DQ, Sang AM, Gu HY, Fan XQ, et al. Improvement in visual function and quality of life following a blindness prevention surgery program in a rural area of Eastern China. *Exp Ther Med* [Internet]. 2013;5(6):1725-1731. Available from: <https://doi.org/10.3892/etm.2013.1037>
322. Dandona L, Dandona R, Naduvilath TJ, McCarty CA, Mandal P, Srinivas M, et al. Population-based assessment of the outcome of cataract surgery in an urban population in southern India. *Am J Ophthalmol* [Internet]. 1999;127(6):650-8. Available from: [https://doi.org/10.1016/S0002-9394\(99\)00044-6](https://doi.org/10.1016/S0002-9394(99)00044-6)
323. Gogate P, Kulkarni AN. Comparison of cataract surgery in a base hospital and in peripheral eye camps. *Community Eye Health*. 2002;15(42):26-7.
324. Murthy GV, Ellwein LB, Gupta S, Tanikachalam K, Ray M, Dada VK. A population-based eye survey of older adults in a rural district of Rajasthan: II. outcomes of cataract surgery. *Ophthalmology* [Internet]. 2001;108(4):686-92. Available from: [https://www.aaojournal.org/article/S0161-6420\(00\)00578-9/pdf](https://www.aaojournal.org/article/S0161-6420(00)00578-9/pdf)
325. Anand R, Gupta A, Ram J, Singh U, Kumar R. Visual outcome following cataract surgery in rural Punjab. *Indian J Ophthalmol* [Internet]. 2000;48(2):153-8. Available from: <http://www.ijo.in/text.asp?2000/48/2/153/14884>
326. Lewallen S, Courtright P. Gender and use of cataract surgical services in developing countries. *Bull World Health Organ*. 2002;80(4):300-3. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2567777/pdf/12075366.pdf>

References

327. Thulasiraj RD, Reddy A, Selvaraj S, Munoz SR, Ellwein LB. The Sivaganga Eye Survey: II. outcomes of cataract surgery. *Ophthalmic Epidemiol* [Internet]. 2002;9(5):313-24. Available from: <https://doi.org/10.1076/ojep.9.5.313.10339>
328. Nirmalan PK, Thulasiraj RD, Maneksha V, Rahmathullah R, Ramakrishnan R, Padmavathi A, et al. A population-based eye survey of older adults in Tirunelveli District of south India: blindness, cataract surgery, and visual outcomes. *Br J Ophthalmol* [Internet]. 2002;86(5):505-12. Available from: <https://bj.o.bmj.com/content/bjophthalmol/86/5/505.full.pdf>
329. Lindfield R, Polack S, Wadud Z, Choudhury KA, Rashid AK, Kuper H. Causes of poor outcome after cataract surgery in Satkhira District, Bangladesh. *Eye (Lond)* [Internet]. 2008;22(8):1054-6. Available from: <https://www.nature.com/articles/6702836.pdf>
330. Thanigasalam T, Reddy SC, Zaki RA. Factors associated with complications and postoperative visual outcomes of cataract surgery; a study of 1,632 cases. *J Ophthalmic Vis Res* [Internet]. 2015;10(4):375-84. Available from: <http://www.jovr.org/text.asp?2015/10/4/375/158892>
331. Ruit S, Tabin GC, Nissman SA, Paudyal G, Gurung R. Low-cost high-volume extracapsular cataract extraction with posterior chamber intraocular lens implantation in Nepal. *Ophthalmology* [Internet]. 1999;106(10):1887-92. Available from: [https://doi.org/10.1016/S0161-6420\(99\)90397-4](https://doi.org/10.1016/S0161-6420(99)90397-4)
332. Prajna NV, Chandrakanth KS, Kim R, Narendran V, Selvakumar S, Rohini G, et al. The Madurai Intraocular Lens Study. II: Clinical outcomes. *Am J Ophthalmol* [Internet]. 1998;125(1):14-25. Available from: [https://doi.org/10.1016/S0002-9394\(99\)80230-X](https://doi.org/10.1016/S0002-9394(99)80230-X)
333. Fletcher A, Vijaykumar V, Selvaraj S, Thulasiraj RD, Ellwein LB. The Madurai Intraocular Lens Study. III: Visual functioning and quality of life outcomes. *Am J Ophthalmol* [Internet]. 1998;125(1):26-35. Available from: [https://doi.org/10.1016/S0002-9394\(99\)80231-1](https://doi.org/10.1016/S0002-9394(99)80231-1)
334. Marmamula S, Khanna RC, Shekhar K, Rao GN. Outcomes of cataract surgery in urban and rural population in the South Indian State of Andhra Pradesh: rapid assessment of visual impairment (RAVI) project. *PLoS One* [Internet]. 2016;11(12):e0167708. Available from: <https://doi.org/10.1371/journal.pone.0167708>
335. Matta S, Park J, Palamaner Subash Shantha G, Khanna RC, Rao GN. Cataract surgery visual outcomes and associated risk factors in secondary level eye care centers of LV Prasad Eye Institute, India. *PLoS One* [Internet]. 2016;11(1):e0144853. Available from:

References

<https://dx.doi.org/10.1371%2Fjournal.pone.0144853>

336. Thapa SS, Khanal S, Paudyal I, Twyana SN, Ruit S, van Rens GH. Outcomes of cataract surgery: a population-based developing world study in the Bhaktapur district, Nepal. *Clin Exp Ophthalmol* [Internet]. 2011;39(9):851-7. Available from:

<https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1442-9071.2011.02576.x>

337. Li Z, Song Z, Wu S, Xu K, Jin D, Wang H, Liu P. Outcomes and barriers to uptake of cataract surgery in rural northern China: the Heilongjiang Eye Study. *Ophthalmic Epidemiol* [Internet]. 2014;21(3):161-8. Available from:

<https://doi.org/10.3109/09286586.2014.903499>

338. Bourne R, Dineen B, Jadoon Z, Lee PS, Khan A, Johnson GJ, et al. Outcomes of cataract surgery in Pakistan: results from The Pakistan National Blindness and Visual Impairment Survey. *Br J Ophthalmol* [Internet]. 2007;91(4):420-6. Available from:

<https://bjo.bmj.com/content/bjophthalmol/91/4/420.full.pdf>

339. Lau J, Michon JJ, Chan WS, Ellwein LB. Visual acuity and quality of life outcomes in cataract surgery patients in Hong Kong. *Br J Ophthalmol* [Internet]. 2002;86(1):12-7. Available from:

<https://bjo.bmj.com/content/bjophthalmol/86/1/12.full.pdf>

340. Bourne RR, Dineen BP, Ali SM, Huq DM, Johnson GJ. Outcomes of cataract surgery in Bangladesh: results from a population based nationwide survey. *Br J Ophthalmol* [Internet]. 2003;87(7):813-9. Available from:

<http://dx.doi.org/10.1136/bjo.87.7.813>

342. Nangia V, Jonas JB, Gupta R, Khare A, Sinha A. Prevalence of cataract surgery and postoperative visual outcome in rural central India Central India Eye and Medical Study. *J Cataract Refract Surg* [Internet]. 2011;37(11):1932-8. Available from:

[https://www.jcrsjournal.org/article/S0886-3350\(11\)01218-1/pdf](https://www.jcrsjournal.org/article/S0886-3350(11)01218-1/pdf)

343. Yuen L, Do NH, Vu QL, Gupta S, Ambrosio E, Congdon N. Cataract surgical outcomes, visual function and quality of life in four rural districts in Vietnam. *Clin Exp Ophthalmol* [Internet]. 2011;39(2):119-25. Available from:

<https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1442-9071.2010.02427.x>

344. Paul P, Kuriakose T, John J, Raju R, George K, Amritanand A, et al. Prevalence and visual outcomes of cataract surgery in rural South India: a cross-sectional study. *Ophthalmic Epidemiol* [Internet]. 2016;23(5):309-15. Available from:

<https://doi.org/10.1080/09286586.2016.1212991>

References

345. Venkatesh R, Muralikrishnan R, Balent LC, Prakash SK, Prajna NV. Outcomes of high volume cataract surgeries in a developing country. *Br J Ophthalmol* [Internet]. 2005;89(9):1079-83. Available from: <https://doi.org/10.1136/bjo.2004.063479>
346. Limburg H, Foster A, Gilbert C, Johnson GJ, Kyndt M, Myatt M. Routine monitoring of visual outcome of cataract surgery. Part 2: Results from eight study centres. *Br J Ophthalmol* [Internet]. 2005;89(1):50-2. Available from: <https://bjo.bmj.com/content/bjophthalmol/89/1/50.full.pdf>
347. Lindfield R, Kuper H, Polack S, Eusebio C, Mathenge W, Wadud Z, et al. Outcome of cataract surgery at one year in Kenya, the Philippines and Bangladesh. *Br J Ophthalmol* [Internet]. 2009;93(7):875-80. Available from: <http://dx.doi.org/10.1136/bjo.2008.152744>
348. Khandekar RB, Jain BK, Sudhan AK, Pandey KP. Visual acuity at 6 weeks after small incision cataract surgery and role of audit in predicting visual acuity. *Eur J Ophthalmol* [Internet]. 2010;20(2):345-52. Available from: <https://doi.org/10.1177%2F112067211002000214>
349. Congdon N, Yan X, Lansingh V, Sisay A, Müller A, Chan V, et al. Assessment of cataract surgical outcomes in settings where follow-up is poor: PRECOG, a multicentre observational study. *Lancet Glob Health* [Internet]. 2013;1(1):e37-45. Available from: [https://doi.org/10.1016/S2214-109X\(13\)70003-2](https://doi.org/10.1016/S2214-109X(13)70003-2)
350. Ahangar A, Sufi AR, Nabi M, Rather MH. Causes of subnormal vision in patients following cataract surgery at a tertiary hospital in Kashmir. *Int Ophthalmol* [Internet]. 2014;34(5):1083-90. Available from: <https://link.springer.com/content/pdf/10.1007%2Fs10792-014-9913-0.pdf>
351. Yuan J, Wang X, Yang LQ, Xing YQ, Yang YN. Assessment of visual outcomes of cataract surgery in Tujia nationality in Xianfeng County, China. *Int J Ophthalmol* [Internet]. 2015;8(2):292-8. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4413593/pdf/ijo-08-02-292.pdf>
352. Mörchen M, Ang C, Mao N, Bonn TS. Sustainable cataract surgical outcome monitoring: multifaceted intervention in Cambodia. *J Cataract Refract Surg* [Internet]. 2017;43(4):572-573. Available from: <https://doi.org/10.1016/j.jcrs.2017.03.003>
353. Ormsby GM, Morchen M, Fotis K, Skiba DG, Chim C, Keeffe JE. Barriers to the uptake of cataract surgery and eye care after community outreach screening in Takeo Province, Cambodia. *Asia Pac J Ophthalmol (Phila)* [Internet]. 2017;6(3):266-72. Available from:

References

<http://apjo.org/Apjo/pdf/id/476.html>

354. Chandrashekhar TS, Bhat HV, Pai RP, Nair SK. Coverage, utilization and barriers to cataract surgical services in rural South India: results from a population-based study. *Public Health* [Internet]. 2007;121(2):130-6. Available from: <https://doi.org/10.1016/j.puhe.2006.07.027>

355. Naumann GOH. Future of cataract surgery in adults. In: Pararajasegaram R, Rao, GN, editors. *World blindness and its prevention*. Volume 6. Proceedings of the Sixth General Assembly of the International Agency for the Prevention of Blindness (IAPB); 1999 5th-10th September; Beijing, China. Hyderabad, India: IAPB; 2001. p 59-61.

356. Limburg H, Kumar R. Follow-up study of blindness attributed to cataract in Karnataka State, India. *Ophthalmic Epidemiol* [Internet]. 1998;5(4):211-23. Available from: <https://doi.org/10.1076/oep.5.4.211.4193>

357. Limburg H. Cataract surgical services – manual for rapid assessment for cataract surgical services [Internet]. Geneva (CH): World Health Organization; 2001. 60 p. Available from: https://apps.who.int/iris/bitstream/handle/10665/67847/WHO_PBL_01.84.pdf?sequence=1&isAllowed=y

358. Mactaggart I. Working with communities to improve their eye health. *Community Eye Health*. 2014;27(88):61-3.

359. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. National eye care plan for implementation of Vision 2020 in Bangladesh [Internet]. Dhaka: Bangladesh National Council for the Blind (BNCB); 2005. 40 p. Available from: http://nec.gov.bd/opr_pdf/national_eye_care_plan.pdf

360. Hossen A, Westhues A. Improving access to government health care in rural Bangladesh: the voice of older adult women. *Health Care Women Int* [Internet]. 2011;32(12):1088-110. Available from: <https://doi.org/10.1080/07399332.2011.603862>

361. Ramke J, Petkovic J, Welch V, Blignault I, Gilbert C, Blanchet K, et al. Interventions to improve access to cataract surgical services and their impact on equity in low- and middle-income countries. *Cochrane Database Syst Rev* [Internet]. 2017;11:CD011307. Available from: <https://doi.org/10.1002/14651858.CD011307.pub2>

362. Gurung R. Cataract surgical outcome and gender-specific barriers to cataract services in Tilganga Eye Centre and its outreach microsurgical eye clinics in Nepal. *Community Eye Health*. 2007;20(61):14-5.

References

363. Lewallen S, Mousa A, Bassett K, Courtright P. Cataract surgical coverage remains lower in women. *Br J Ophthalmol* [Internet]. 2009;93(3):295-8. Available from: <https://doi.org/10.1136/bjo.2008.140301>
364. Zhao J, Jia L, Sui R, Ellwein LB. Prevalence of blindness and cataract surgery in Shunyi County, China. *Am J Ophthalmol* [Internet]. 1998 Oct;126(4):506-14. Available from: [https://doi.org/10.1016/S0002-9394\(98\)00275-X](https://doi.org/10.1016/S0002-9394(98)00275-X)
365. Bassett KL, Noertjojo K, Liu L, Wang FS, Tenzing C, Wilkie A, et al. Cataract surgical coverage and outcome in the Tibet Autonomous Region of China. *Br J Ophthalmol* [Internet]. 2005;89(1):5-9. Available from: <https://doi.org/10.1136/bjo.2004.048744>
366. Haider S, Hussain A, Limburg H. Cataract blindness in Chakwal District, Pakistan: results of a survey. *Ophthalmic Epidemiol* [Internet]. 2003;10(4):249-58. Available from: <https://doi.org/10.1076/oep.10.4.249.15907>
367. Khandekar R, Mohammed AJ. Coverage of cataract surgery per person and per eye: review of a community-based blindness survey in Oman. *Ophthalmic Epidemiol* [Internet]. 2004;11(4):291-9. Available from: <https://doi.org/10.1080/09286580490515143>
368. Snellingen T, Shrestha BR, Gharti MP, Shrestha JK, Upadhyay MP, Pokhrel RP. Socioeconomic barriers to cataract surgery in Nepal: the South Asian cataract management study. *Br J Ophthalmol* [Internet]. 1998;82(12):1424-8. Available from: <https://bjo.bmj.com/content/bjophthalmol/82/12/1424.full.pdf>
369. He M, Chan V, Baruwa E, Gilbert D, Frick KD, Congdon N. Willingness to pay for cataract surgery in rural southern China. *Ophthalmology* [Internet]. 2007;114(3):411-6. Available from: [https://www.aaojournal.org/article/S0161-6420\(06\)01310-8/fulltext](https://www.aaojournal.org/article/S0161-6420(06)01310-8/fulltext)
370. Sapkota YD, Pokharel GP, Dulal S, Byanju RN, Maharjan IM. Barriers to uptake cataract surgery in Gandaki Zone, Nepal. *Kathmandu Univ Med J (KUMJ)* [Internet]. 2004;2(2):103-12. Available from: <http://www.kumj.com.np/issue/6/103-112.pdf>
371. O'Donnell O. Access to health care in developing countries: breaking down demand side barriers. *Cad Saude Publica* [Internet]. 2007;23(12):2820-34. Available from: <http://dx.doi.org/10.1590/S0102-311X2007001200003>
372. Finger RP, Ali M, Earnest J, Nirmalan PK. Cataract surgery in Andhra Pradesh state, India: an investigation into uptake following outreach

References

- screening camps. *Ophthalmic Epidemiol* [Internet]. 2007;14(6):327-32. Available from: <https://doi.org/10.1080/01658100701486814>
373. Congdon NG, He M. Screening and managing eye disease in 2010: an Asian perspective. *Am J Ophthalmol* [Internet]. 2010;150(2):141-3. Available from: <https://doi.org/10.1016/j.ajo.2010.04.003>
374. Kandel RP, Rajashekaran SR, Gautam M, Bassett KL. Evaluation of alternate outreach models for cataract services in rural Nepal. *BMC Ophthalmol* [Internet]. 2010;10:9. Available from: <https://doi.org/10.1186/1471-2415-10-9>
375. Eye Care Bangladesh. Secondary eye care [Internet]. Dhaka: Eye Care Bangladesh; 2018. Available from: <http://eyecarebd.net/secondary-eye-care/>
376. Marmamula S, Madala SR, Rao GN. Prevalence of uncorrected refractive errors, presbyopia and spectacle coverage in marine fishing communities in South India: Rapid Assessment of Visual Impairment (RAVI) project. *Ophthalmic Physiol Opt*. 2012;32(2):149-55. Available from: <https://doi.org/10.1111/j.1475-1313.2012.00893.x>
377. Neena J, Rachel J, Praveen V, Murthy GV; Rapid Assessment of Avoidable Blindness India Study Group. Rapid assessment of avoidable blindness in India. *PLoS One*. 2008;3(8):e2867 [Internet]. Available from: <https://doi.org/10.1371/journal.pone.0002867>
378. Marmamula S, Keefe JE, Rao GN. Rapid assessment methods in eye care: an overview. *Indian J Ophthalmol*. 2012;60(5):416-22 [Internet]. Available from: <https://doi.org/10.4103/0301-4738.100539>
379. Bettadapura GS, Donthi K, Datti NP, Ranganath BG, Ramaswamy SB, Jayaram TS. Assessment of avoidable blindness using the rapid assessment of avoidable blindness methodology. *N Am J Med Sci* [Internet]. 2012;4(9):389-93. Available from: <https://doi.org/10.4103/1947-2714.100982>
380. Mactaggart I, Wallace S, Ramke J, Burton M, Bastawrous A, Limburg H, et al. Rapid assessment of avoidable blindness for health service planning. *Bull World Health Organ* [Internet]. 2018;96(10):726-728. Available from: <https://doi.org/10.2471/BLT.18.217794>
381. Das T. Blindness and visual impairment profile and rapid assessment of avoidable blindness in South East Asia: analysis of new data. 2017 APAO Holmes Lecture. *Asia Pac J Ophthalmol (Phila)* [Internet]. 2018;7(5):312-315. Available from: <https://doi.org/10.22608/APO.2017425>

References

382. Kocur I, Limburg H, Resnikoff S. Rapid Assessment of avoidable blindness – past, present, and future. *Asia Pac J Ophthalmol (Phila)* [Internet]. 2018;7(5):282-283. Available from: <https://doi.org/10.22608/APO.2018345>
383. Vanneste G. Breaking down barriers – how to increase the cataract surgical rate. A practical guide for eye units in developing countries [Internet]. Dar es Salaam (TZ): Christoffel Blinden Mission (CBM); 2000. 39 p.
384. Abdullah KN, Al-Sharqi OZ, Abdullah MT. Barriers to the uptake of eye care services in developing countries: a systematic review of interventions. *Health Educ J* [Internet]. 2012;72(6):742–54. Available from: <https://journals.sagepub.com/doi/pdf/10.1177/0017896912461193>
385. Chang MA, Congdon, NG, Baker, SK, Bloem, MW, Savage, H, Sommer, A. The surgical management of cataract: barriers, best practices and outcomes. *Int Ophthalmol* [Internet]. 2008; 28(4): 247-260. Available from: <https://doi.org/10.1007/s10792-007-9121-2>
386. van Loenhout JA, Delbiso TD, Gupta S, Amatya K, Kushner AL, Gil Cuesta J, et al. Barriers to surgical care in Nepal. *BMC Health Serv Res* [Internet]. 2017;17(1):72. Available from: <https://doi.org/10.1186/s12913-017-2024-7>
387. Syed A, Polack S, Eusebio C, Mathenge W, Wadud Z, Mamunur AKM, et al. Predictors of attendance and barriers to cataract surgery in Kenya, Bangladesh and the Philippines. *Disabil Rehabil* [Internet]. 2013;35(19): 1660-7. Available from: <https://doi.org/10.3109/09638288.2012.748843>
388. Ahmed S. Eye care in rural communities: reaching the unreached in Sunderbans. *Community Eye Health*. 2016;29(93):14.
389. Hosain GMM, Chatterjee N. Health-care utilization by disabled persons: a survey in rural Bangladesh. *Disabil Rehabil* [Internet]. 1998;20(9):337-45. Available from: <https://doi.org/10.3109/09638289809166091>
390. Geneau R, Massae P, Courtright P, Lewallen S. Using qualitative methods to understand the determinants of patients' willingness to pay for cataract surgery: a study in Tanzania. *Soc Sci Med* [Internet]. 2008;66(3):558-68. Available from: <https://doi.org/10.1016/j.socscimed.2007.09.016>
391. Ensor T, Cooper S. Overcoming barriers to health service access: influencing the demand side. *Health Policy Plan* [Internet]. 2004 Mar;19(2):69-79. Available from: <https://doi.org/10.1093/heapol/czh009>

References

392. Thiede M, Koltermann KC. Access to health services: analyzing non-financial barriers in Ghana, Rwanda, Bangladesh and Vietnam using household survey data; a review of the literature [Internet]. New York: United Nations Children's Fund (UNICEF); 2013. 61 p. Available from: https://www.unicef.org/health/files/Access_to_Health_Services-Ghana-Bangladesh-Vietnam-Rwanda_2013.pdf
393. O'Connell TS, Bedford KJ, Thiede M, McIntyre D. Synthesizing qualitative and quantitative evidence on non-financial access barriers: implications for assessment at the district level. *Int J Equity Health* [Internet]. 2015;14:54. Available from: <https://doi.org/10.1186/s12939-015-0181-z>
394. Vaidyanathan K, Limburg H, Foster A, Pandey RM. Changing trends in barriers to cataract surgery in India. *Bull World Health Organ* [Internet]. 1999;77(2):104-9. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2557599/pdf/10083707.pdf>
395. Shrestha MK, Thakur J, Gurung CK, Joshi AB, Pokhrel S, Ruit S. Willingness to pay for cataract surgery in Kathmandu valley. *Br J Ophthalmol* [Internet]. 2004;88(3):319-20. Available from: <https://bjo.bmj.com/content/bjophthalmol/88/3/319.full.pdf>
396. Alam MF, Chongsuvivatwong V, Mahmud H, Gupta PS. Comparison of accessibility among vision-impaired patients visiting mobile and stationary hospitals in rural Bangladesh. *J Health Popul Nutr* [Internet]. 2013;31(2):223-30. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3702344/pdf/jhpn0031-0223.pdf>
397. Dandona R, Dandona L, John RK, McCarty CA, Rao GN. Awareness of eye diseases in an urban population in southern India. *Bull World Health Organ* [Internet]. 2001;79(2):96-102. Available from: [https://www.who.int/bulletin/archives/79\(2\)96.pdf?ua=1](https://www.who.int/bulletin/archives/79(2)96.pdf?ua=1)
398. Fletcher AE, Donoghue M, Devavaram J, Thulasiraj RD, Scott S, Abdalla M, et al. Low uptake of eye services in rural India: a challenge for programs of blindness prevention. *Arch Ophthalmol* [Internet]. 1999;117:1393-9. Available from: <https://dx.doi.org/10.1001/archopht.117.10.1393>
399. Dhaliwal U, Gupta SK. Barriers to the uptake of cataract surgery in patients presenting to a hospital. *Indian J Ophthalmol*. 2007 Mar-Apr;55(2):133-6. Available from: <http://www.ijo.in/text.asp?2007/55/2/133/30708>

References

400. Vanneste G. Community based case-finding and rehabilitation: detection of cataract patients and post-operative follow-up. *Community Eye Health*. 1998;11(28):54-6.
401. Zhang M, Wu J, Li L, Xu D, Lam DS, Lee J, et al. Impact of cataract screening outreach in rural China. *Invest Ophthalmol Vis Sci*. 2010;51(1):110-4. Available from: <https://doi.org/10.1167/iovs.09-4190>
402. Finger RP, Kupitz DG, Holz FG, Chandrasekhar S, Balasubramaniam B, Ramani RV, et al. Regular provision of outreach increases acceptance of cataract surgery in South India. *Trop Med Int Health* [Internet]. 2011;16(10):1268-75. Available from: <https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1365-3156.2011.02835.x>
403. Zhou JB, Guan HJ, Qu J, Yang XJ, Peng D, Gu HY. A study on the awareness of cataract disease and treatment options in patients who need surgery in a rural area of Eastern China. *Eur J Ophthalmol* [Internet]. 2008;18(4):544-50. Available from: <https://doi.org/10.1177%2F112067210801800407>
404. Liu T, Congdon N, Yan X, Jin L, Wu Y, Friedman D, et al. A randomized, controlled trial of an intervention promoting cataract surgery acceptance in rural China: the Guangzhou uptake of surgery trial (GUSTO). *Invest Ophthalmol Vis Sci* [Internet]. 2012;53(9):5271-8. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2165917&resultClick=1>
405. Zhang XJ, Jhanji V, Leung CK, Li EY, Liu Y, Zheng C, et al. Barriers for poor cataract surgery uptake among patients with operable cataract in a program of outreach screening and low-cost surgery in rural China. *Ophthalmic Epidemiol* [Internet]. 2014;21(3):153-60. Available from: <https://doi.org/10.3109/09286586.2014.903981>
406. Coupland N, Coupland J. Discourses of ageism and anti-ageism. *J Aging Stud* [Internet]. 1993;7(3):279-301. Available from: [https://doi.org/10.1016/0890-4065\(93\)90016-D](https://doi.org/10.1016/0890-4065(93)90016-D)
407. Melese M, Alemayehu W, Friedlander E, Courtright P. Indirect costs associated with accessing eye care services as a barrier to service use in Ethiopia. *Trop Med Int Health* [Internet]. 2004;9(3):426-31. Available from: <https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1365-3156.2004.01205.x>
408. Ormsby GM, Arnold AL, Busija L, Mörchen M, Bonn TS, Keeffe JE. The impact of knowledge and attitudes on access to eye-care services in Cambodia. *Asia Pac J Ophthalmol (Phila)*. 2012;1(6):331-5. Available from: <https://doi.org/10.1097/APO.0b013e31826d9e06>

References

409. Yin Q, Hu A, Liang Y, Zhang J, He M, Lam DS, et al. A two-site, population-based study of barriers to cataract surgery in rural China. *Invest Ophthalmol Vis Sci* [Internet]. 2009;50(3):1069-75. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2126160&resultClick=1>
410. Kovai V, Prasadarao BV, Paudel P, Stapleton F, Wilson D. Reasons for refusing cataract surgery in illiterate individuals in a tribal area of Andhra Pradesh, India. *Ophthalmic Epidemiol* [Internet]. 2014;21(3):144-52. Available from: <https://doi.org/10.3109/09286586.2014.903980>
411. Marmamula S, Khanna RC, Shekhar K, Rao GN. A population-based cross-sectional study of barriers to uptake of eye care services in South India: the rapid assessment of visual impairment (RAVI) project. *BMJ Open* [Internet]. 2014;4(6):e005125. Available from: <https://bmjopen.bmj.com/content/bmjopen/4/6/e005125.full.pdf>
412. Dandona R, Dandona L, Srinivas M, Giridhar P, McCarty CA, Rao GN. Population-based assessment of refractive error in India: the Andhra Pradesh eye disease study. *Clin Exp Ophthalmol*. 2002 Apr;30(2):84-93. Available from: <https://doi.org/10.1046/j.1442-6404.2002.00492.x>
413. Dandona R, Dandona L, Naduvilath TJ, Srinivas M, McCarty CA, Rao GN. Refractive errors in an urban population in Southern India: the Andhra Pradesh Eye Disease Study. *Invest Ophthalmol Vis Sci* [Internet]. 1999;40(12):2810-8. Available from: <https://iovs.arvojournals.org/article.aspx?articleid=2199832&resultClick=1>
414. Holden BA, Sulaiman S, Knox K. The challenge of providing spectacles in the developing world. *Community Eye Health*. 2000;13(33):9-10.
415. Dabideen R, Minto H, Naidoo K. Sourcing acceptable spectacles. *Community Eye Health*. 2007;20(63):47.
416. Uncorrected refractive error: the major and most easily avoidable cause of vision loss. *Community Eye Health*. 2007;20(63):37-9.
417. Naidoo K, Govender P, Holden B. The uncorrected refractive error challenge. *Community Eye Health*. 2014;27(88):74-5.
418. Holden BA, Wilson DA, Jong M, Sankaridurg P, Fricke TR, Smith EL III, et al. Myopia: a growing global problem with sight-threatening complications. *Community Eye Health*. 2015;28(90):35.
419. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive

References

- errors: systematic review and meta-analysis. *J Curr Ophthalmol* [Internet]. 2017;30(1):3-22. Available from: <https://doi.org/10.1016/j.joco.2017.08.009>
420. Muhit M, Minto H, Parvin A, Jadoon MZ, Islam J, Yasmin S, et al. Prevalence of refractive error, presbyopia, and unmet need of spectacle coverage in a northern district of Bangladesh: rapid assessment of refractive error study. *Ophthalmic Epidemiol* [Internet]. 2018;25(2):126-32. Available from: <https://doi.org/10.1080/09286586.2017.1370119>
421. Naidoo KS, Leasher J, Bourne RR, Flaxman SR, Jonas JB, Keeffe J, et al. Global vision impairment and blindness due to uncorrected refractive error, 1990-2010. *Optom Vis Sci* [Internet]. 2016;93(3):227-34. Available from: <http://dx.doi.org/10.1097/OPX.0000000000000796>
422. Shah SP, Jadoon MZ, Dineen B, Bourne RR, Johnson GJ, Gilbert CE, Khan MD. Refractive errors in the adult Pakistani population: the National Blindness and Visual Impairment Survey. *Ophthalmic Epidemiol* [Internet]. 2008;15(3):183-90. Available from: <https://doi.org/10.1080/09286580802105822>
423. Flaxman SR, Bourne RRA, Resnikoff S, Ackland P, Braithwaite T, Cicinelli MV, et al. Global causes of blindness and distance vision impairment 1990-2020: a systematic review and meta-analysis. *Lancet Glob Health* [Internet]. 2017;5(12):e1221-e1234. Available from: [https://doi.org/10.1016/S2214-109X\(17\)30393-5](https://doi.org/10.1016/S2214-109X(17)30393-5)
424. Dandona R, Dandona L, Srinivas M, Giridhar P, Nutheti R, Rao GN. Planning low vision services in India: a population-based perspective. *Ophthalmology* [Internet]. 2002;109(10):1871-8. Available from: [https://doi.org/10.1016/S0161-6420\(02\)01183-1](https://doi.org/10.1016/S0161-6420(02)01183-1)
425. Shah SP, Minto H, Jadoon MZ, Bourne RR, Dineen B, Gilbert CE, et al. Prevalence and causes of functional low vision and implications for services: the Pakistan National Blindness and Visual Impairment Survey. *Invest Ophthalmol Vis Sci*. 2008;49(3):887-93. Available from: <https://doi.org/10.1167/iovs.07-0646>
426. O'Connor PM, Mu LC, Keeffe JE. Access and utilization of a new low-vision rehabilitation service. *Clin Exp Ophthalmol* [Internet]. 2008;36:547-52. Available from: <https://doi.org/10.1111/j.1442-9071.2008.01830.x>
427. Lim HY, O'Connor PM, Keeffe JE. Low vision services provided by optometrists in Victoria, Australia. *Clin Exp Optom* [Internet]. 2008;91(2):177-82. Available from: <https://doi.org/10.1111/j.1444-0938.2007.00214.x>

References

428. Pollard TL, Simpson JA, Lamoureux EL, Keeffe JE. Barriers to accessing low vision services. *Ophthalmic Physiol Opt* [Internet]. 2003;23(4):321-7. Available from: <https://doi.org/10.1046/j.1475-1313.2003.00123.x>
429. Overbury O, Wittich W. Barriers to low vision rehabilitation: the Montreal Barriers Study. *Invest Ophthalmol Vis Sci* [Internet]. 2011;52(12):8933-8. Available from: <https://doi.org/10.1167/iovs.11-8116>
430. Wittich W, Canuto A, Overbury O. Overcoming barriers to low-vision rehabilitation services: improving the continuum of care. *Can J Ophthalmol* [Internet]. 2013;48(6):463-7. Available from: <https://doi.org/10.1016/j.jcjo.2013.05.013>
431. Matti AI, Pesudovs K, Daly A, Brown M, Chen CS. Access to low-vision rehabilitation services: barriers and enablers. *Clin Exp Optom* [Internet]. 2011;94(2):181-6. Available from: <https://doi.org/10.1111/j.1444-0938.2010.00556.x>
432. Gold D, Zuvella B, Hodge WG. Perspectives on low vision service in Canada: a pilot study. *Can J Ophthalmol* [Internet]. 2006;41(3):348-54. Available from: <https://doi.org/10.1139/I06-025>
433. Laitinen A, Koskinen S, Rudanko SL, Martelin T, Laatikainen L, Aromaa A. Use of eye care services and need for assistance in the visually impaired. *Optom Vis Sci* [Internet]. 2008;85(5):341-9. Available from: <https://doi.org/10.1097/OPX.0b013e31816bea29>
434. Chiang PP, Marella M, Ormsby G, Keeffe J. Critical issues in implementing low vision care in the Asia-Pacific region. *Indian J Ophthalmol* [Internet]. 2012;60(5):456-9. Available from: <http://www.ijo.in/text.asp?2012/60/5/456/100549>
435. Kumar H, Monira S, Rao A. Causes of missed referrals to low-vision rehabilitation services: causes in a tertiary eye care setting. *Semin Ophthalmol* [Internet]. 2016;31(5):452-8. Available from: <https://doi.org/10.3109/08820538.2014.962170>
436. Lam N, Leat SJ. Barriers to accessing low-vision care: the patient's perspective. *Can J Ophthalmol* [Internet]. 2013;48(6):458-62. Available from: <https://doi.org/10.1016/j.jcjo.2013.02.014>
437. Chiang PP-C, O'Connor PM, Le Mesurier RT, Keeffe JE. A global survey of low vision service provision. *Ophthalmic Epidemiol* [Internet]. 2011;18(3):109-21. Available from: <https://doi.org/10.3109/09286586.2011.560745>

References

438. Sathyan S, Davis J, Antony RC, Mathew S, Jyothi R. Demographic and clinical profile of patients presenting at the low vision clinic of a tertiary eye care facility in Kerala. *Kerala J Ophthalmol* [Internet]. 2016;28:48-52. Available from: <http://www.kjophthal.com/text.asp?2016/28/1/48/193866>
439. Button KS, Ioannidis JP, Mokrysz C, Nosek BA, Flint J, Robinson ES, et al. Power failure: why small sample size undermines the reliability of neuroscience. *Nat Rev Neurosci* [Internet]. 2013;14(5):365-76. Available from: <https://doi.org/10.1038/nrn3475>
440. Lemeshow S, Hosmer DW Jr, Klar J, Lwanga SK. Adequacy of sample size in health studies [Internet]. Chichester (UK): John Wiley & Sons Ltd (on behalf of the World Health Organization) 1990. 239 p. Available from: https://apps.who.int/iris/bitstream/handle/10665/41607/0471925179_eng.pdf;jsessionid=9C656B8832F34484530F011BDBB4DB50?sequence=1
441. Nemes S, Jonasson JM, Genell A, Steineck G. Bias in odds ratios by logistic regression modelling and sample size. *BMC Med Res Methodol* [Internet]. 2009;9:56. Available from: <https://doi.org/10.1186/1471-2288-9-56>
442. Jose J, Thomas J, Bhakat P, Krithica S. Awareness, knowledge, and barriers to low vision services among eye care practitioners. *Oman J Ophthalmol* [Internet]. 2016;9(1):37-43. Available from: <https://doi.org/10.4103/0974-620X.176099>
443. Minto H, Awan H. Establishing low vision services at secondary level. *Community Eye Health*. 2004;17(49):5.
444. Enoch JM. Low vision care in India: a time for action! *Vis Impair Res* [Internet] 2008;10:35–43. Available from: <https://doi.org/10.1080/13882350802406905>
445. Minto H, Butt IA. Low vision devices and training. *Community Eye Health*. 2004;17(49):6-7.
446. Yasmin S. An integrated low vision service: Sri Lanka. *Community Eye Health*. 2012;25(77):16.
447. Khan SA, Shamanna B, Nuthethi R. Perceived barriers to the provision of low vision services among ophthalmologists in India. *Indian J Ophthalmol* [Internet]. 2005;53(1):69-75. Available from: <http://www.ijo.in/text.asp?2005/53/1/69/15293>

References

448. Prasad R. Successful expansion of low vision rehabilitation services by collaboration with programs of optometry: Nepal and Jordan. *Int Congr Ser* [Internet]. 2005;1282:267-70. Available from: <https://doi.org/10.1016/j.ics.2005.05.086>
449. Minto H, Awan H. Guidelines for setting up a low vision programme for children. *Community Eye Health*. 2001;14(40):60-1.
450. Fifty-sixth World Health Assembly - WHA 56.26. The resolution of the World Health Assembly on the elimination of avoidable blindness. *Community Eye Health*. 2003;16(46):17.
451. World Health Organization. WHA56.26 – elimination of avoidable blindness. In: Fifty-sixth World Health Assembly – resolutions and decisions [Internet]. Geneva (CH): World Health Organization. 2003. p. 53. Available from: <https://apps.who.int/iris/bitstream/handle/10665/259836/WHA56-2003-REC1-eng.pdf?sequence=1&isAllowed=y>
452. World Health Organization. WHA59.25 – prevention of avoidable blindness and visual impairment. In: Fifty-ninth World Health Assembly – resolutions and decisions [Internet]. Geneva (CH): World Health Organization. 2006. p. 35-7. Available from: http://apps.who.int/gb/ebwha/pdf_files/WHA59-REC1/e/WHA59_2006_REC1-en.pdf
453. Faal H. Reaching into the district: strengthening the eye care team. *Community Eye Health*. 2004;17(51):36-7.
454. Taylor K. Eye care within a health system strengthening approach. Briefing Paper 5. [Internet]. Sydney (AU): The Fred Hollows Foundation; 2014. p. 37-43. Available from: http://www.icoph.org/dynamic/attachments/resources/the_fred_hollows_foundation_models_of_innovative_financing_for_eye_health.pdf
455. McDonald L, Taylor K. Practical pathways to universal eye health – improving the availability, accessibility, affordability and acceptability of eye care services [Internet]. Sydney (AU): The Fred Hollows Foundation; 2015. Available from: http://www.icoph.org/dynamic/attachments/resources/the_fred_hollows_foundation_models_of_innovative_financing_for_eye_health.pdf
456. World Health Organization. Everybody's business – strengthening health systems to improve health outcomes : WHO's framework for action [Internet]. Geneva (CH): World Health Organization; 2007. Available from: https://www.who.int/healthsystems/strategy/everybodys_business.pdf

References

457. Blanchet K, Gordon I, Gilbert CE, Wormald R, Awan H. How to achieve universal coverage of cataract surgical services in developing countries: lessons from systematic reviews of other services. *Ophthalmic Epidemiol* [Internet]. 2012;19(6):329-39. Available from: <https://doi.org/10.3109/09286586.2012.717674>
458. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2008 [Internet]. Dhaka: Management Information System. Directorate General of Health Services; 2008. National eye care; p. 56-7. Available from: http://dghs.gov.bd/bn/licts_file/images/Health_Bulletin/HealthBulletin2008.pdf
459. World Health Organization. International Agency for the Prevention of Blindness. Global initiative for the elimination of avoidable blindness: action plan 2006–2011. Geneva (CH): World Health Organization. 2007. 89 p. Available from: <https://www.iapb.org/wp-content/uploads/VISION-2020-Action-Plan-2006-2011.pdf>
460. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. National eye care operational plan 2005-2010 [Internet]. Dhaka: Management Information System. Directorate General of Health Services. 2006. 16 p. Available from: <http://www.dghs.gov.bd/images/docs/OP/NEC%20OP%202011-2016%20upgrade.pdf>
461. Government of the People's Republic of Bangladesh. Ministry of Health and Family Welfare. Health, Population and Nutrition Sector Development Program (HPNSDP) 2011-2016. Dhaka (BD): Directorate General of Health Services. 2011. Section 4.8 National eye care (NEC) p 102-8. Available from: http://www.mohfw.gov.bd/index.php?option=com_docman&task=doc_download&gid=1641&lang=en
462. Government of the People's Republic of Bangladesh. Ministry of Health and Family Welfare. Strategic plan for Health, Population and Nutrition Sector Development Program (HPNSDP) 2011-2016. Dhaka (BD): Planning Wing. 2011. 69 p. Available from: http://www.nationalplanningcycles.org/sites/default/files/country_docs/Bangladesh/nhp_bangladesh.pdf
463. World Health Organization Regional Office for South-East Asia. Situational analysis of Vision 2020 in the WHO South-East Asia region [Internet]. New Delhi (IN): World Health Organization. 2012. 44 p. Available from: http://apps.searo.who.int/PDS_DOCS/B4920.pdf

References

464. McCarty CA, Nanjan MB, Taylor HR. Vision impairment predicts 5 year mortality. *Br J Ophthalmol* [Internet]. 2001;85(3):322-6. Available from: <https://doi.org/10.1136/bjo.85.3.322>
465. Eye Care Bangladesh. Primary eye care [Internet]. Dhaka: Eye Care Bangladesh; 2018. Available from: <http://eyecarebd.net/primary-eye-care/>
466. Eye Care Bangladesh. Advanced secondary eye care [Internet]. Dhaka: Eye Care Bangladesh; 2018. Available from: <http://eyecarebd.net/advanced-secondary-eye-care/>
467. Eye Care Bangladesh. Division-wise distribution of ownership of the facilities in Bangladesh [Internet]. Dhaka: Eye Care Bangladesh; 2018. Available from: <http://eyecarebd.net/wp-content/uploads/2015/02/Division-wise-Distribution-of-Ownership-of-the-Facilities-in-Bangladesh-in-pecent-Map-757x1024.jpg>
468. Eye Care Bangladesh. Division-wise types of the facilities in Bangladesh [Internet]. Dhaka: Eye Care Bangladesh; 2018. Available from: <http://eyecarebd.net/wp-content/uploads/2015/02/Division-wise-Types-of-the-Facilities-in-Bangladesh-in-pecent-Map-757x1024.jpg>
469. Orbis International. Where we work – success in Bangladesh [Internet]. New York (US): Orbis International. Available from: <https://www.orbis.org/en/where-we-work/asia/bangladesh>
470. INGO Forum, National Eye Care, International Agency for the Prevention of Blindness – South-East Asia (IAPB-SEA). Bangladesh plan of action for Vision 2020: 2015-2020 [Internet]. Vision 2020 Workshop Report; 2014 Oct 20-21; Dhaka. Available from: <https://www.iapb.org/wp-content/uploads/Vision-2020-Workshop-2014-Report-Bangladesh.pdf>
471. McDonald L, Taylor K. Reducing avoidable blindness: a challenge with two parts and its implications for resource allocation. Briefing Paper 2 [Internet]. Sydney (AU): The Fred Hollows Foundation; 2014. p. 8-14. Available from: http://www.icoph.org/dynamic/attachments/resources/the_fred_hollows_foundation_models_of_innovative_financing_for_eye_health.pdf
472. Government of the People’s Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2016 [Internet]. Dhaka: Management Information System. Directorate General of Health Services; 2016. Chapter 18 – Financing healthcare; p. 198-202. Available from: http://www.dghs.gov.bd/images/docs/Publicaations/HB%202016%20_2nd_edition_13_01_17.pdf

References

473. Government of the People's Republic of Bangladesh. Ministry of Health and Family Welfare. 4th Health, population and nutrition sector program (HPNSP) - national eye care operational plan 2017-2022. Dhaka (BD): Directorate General of Health Services. 2017. 80 p. Available from: <http://www.dghs.gov.bd/images/docs/OP/2018/NEC.pdf>
474. Judson K, Courtright P, Ravilla T, Khanna R, Bassett K. Impact of systematic capacity building on cataract surgical service development in 25 hospitals. *BMC Ophthalmol* [Internet]. 2017;17(1):96. Available from: <https://doi.org/10.1186/s12886-017-0492-5>
475. Wong TY, Loon SC, Saw SM. The epidemiology of age related eye diseases in Asia. *Br J Ophthalmol* [Internet]. 2006;90(4):506-11. Available from: <http://dx.doi.org/10.1136/bjo.2005.083733>
476. Wong WL, Su X, Li X, Cheung CM, Klein R, Cheng CY, et al. Global prevalence of age-related macular degeneration and disease burden projection for 2020 and 2040: a systematic review and meta-analysis. *Lancet Glob Health* [Internet]. 2014;2(2):e106-16. Available from: [https://doi.org/10.1016/S2214-109X\(13\)70145-1](https://doi.org/10.1016/S2214-109X(13)70145-1)
477. Jonas JB, Bourne RR, White RA, Flaxman SR, Keeffe J, Leasher J, et al. Visual impairment and blindness due to macular diseases globally: a systematic review and meta-analysis. *Am J Ophthalmol* [Internet]. 2014;158(4):808-15. Available from: <https://doi.org/10.1016/j.ajo.2014.06.012>
478. Mactaggart I, Ricard P. How to empower communities to take action on improving eye health. *Community Eye Health*. 2014;27(88):64-6.
479. Mayuzumi K. Rethinking literacy and women's health: a Bangladesh case study. *Health Care Women Int* [Internet]. 2004;25(6):504-26. Available from: <http://dx.doi.org/10.1080/07399330490444803>
480. Tareque MI, Begum S, Saito Y. Gender differences in disability-free life expectancy at old ages in Bangladesh. *J Aging Health* [Internet]. 2013;25(8):1299-312. Available from: <https://doi.org/10.1177/0898264313501388>
481. Capacity Building Service Group. Fred Hollows Foundation. Gender analysis on eye health care services in Barisal Division [Internet]. Dhaka (BD): Fred Hollows Foundation. 2016. Available from: http://cbsg-bd.org/control-panel/pages/pdf/Synopsis_Gender_Analysis_on_Eye_Care_Services.pdf

References

482. Shefali MK. Research report on gender in eye care in Bangladesh [Internet]. Dhaka (BD): Kishoreganj Eye Hospital [updated 2015 Nov; cited 2018 Aug 15]. Available from: <http://kehbd.org/new/wp-content/uploads/2015/11/RESEARCH-REPORT-Gender-in-Eye-Care-in-Bangladesh.pdf>
483. Carmody A. Innovative solutions for eye care for women in Bangladesh [Internet]. Dhaka (BD): Fred Hollows Foundation; [updated 2017 Mar 8; cited 2018 Jul 16]. Available from: <https://www.iapb.org/news/innovative-solutions-for-eye-care-for-women-in-bangladesh/>
484. Hossen A, Westhues A. Improving access to government health care in rural Bangladesh: the voice of older adult women. *Health Care Women Int* [Internet]. 2011;32(12):1088-110. Available from: <https://doi.org/10.1080/07399332.2011.603862>
485. Abdullah KN, Abdullah MT. Management and planning for primary eye care of the elderly: the need to create public awareness of age-related cataract in Pakistan. *Community Eye Health*. 2002;15(43):45-6.
486. Hashemi H, Yekta A, Jafarzadehpur E, Doostdar A, Ostadimoghaddam H, Khabazkhoob M. The prevalence of visual impairment and blindness in underserved rural areas: a crucial issue for future. *Eye (Lond)* [Internet]. 2017;31(8):1221-8. Available from: <https://www.nature.com/articles/eye201768.pdf>
487. Diabetic Association of Bangladesh (BADAS). Extension of diabetic retinopathy care in Bangladesh. In: *Statistical Yearbook 2015-2016* [Internet]. Dhaka; Diabetic Association of Bangladesh; 2017. p. 48-50. Available from: https://www.dab-bd.org/images/Annual/AnnualReport_15_16.pdf
488. Ahmed SM, Hossain MA, Rajachowdhury AM, Bhuiya AU. The health workforce crisis in Bangladesh: shortage, inappropriate skill-mix and inequitable distribution. *Hum Resour Health* [Internet]. 2011;9:3. Available from: <https://doi.org/10.1186/1478-4491-9-3>
489. Rabi MM, Al Rajhi A, Qureshi MB, Gersbeck J. Enhancing advocacy for eye care at national levels: what steps to take for the next decade? *Middle East Afr J Ophthalmol* [Internet]. 2012;19(1):75-82. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3277028/?report=printable>
490. Thulasiraj R. Advocacy to improve the delivery of eye care. *Community Eye Health*. 2007;20(64):66-7.

References

491. Murthy GV. Eye care in South Asia, 1988-2018: developments, achievements and future challenges. *Community Eye Health*. 2017;30(100):99-101.
492. Upadhyay MP. Rethinking eye care: from exclusion to equity. *Nep J Oph* [Internet]. 2010;2(3):1-2. Available from: <https://doi.org/10.3126/nepjoph.v2i1.3696>
493. du Toit R, Ramke J, Naduvilath T, Brian G. Awareness and use of eye care services in Fiji. *Ophthalmic Epidemiol* [Internet]. 2006;13(5):309-20. Available from: <https://doi.org/10.1080/09286580600826629>
494. International Agency for the Prevention of Blindness. Human Resource Development Working Group. Global human resource development assessment for comprehensive eye care. Peshawar (PK): Pakistan Institute of Community Ophthalmology; 2006. Table 31: Gap analysis in relation to the number of ophthalmic allied personnel in SEA. p. 67. Available from: https://www.iapb.org/wp-content/uploads/Global-HR-Development-Assessment-for-Comprehensive-Eye-Care_2006.pdf
495. Trevelyan J, Ackland P. Global action plan indicators – the data in full. Number of ophthalmologists, Bangladesh, 2015 [Internet]. London (GB): International Agency for the Prevention of Blindness (IAPB). Available from: <https://atlas.iapb.org/global-action-plan/gap-indicators/>
496. Qureshi MB, Konyama K, Shamanna BR. Effective eye care delivery - district comprehensive eye care model. In: Gilbert C, Raman U, Francis V. editors. *World blindness and its prevention*. Volume 7. Proceedings of the Seventh General Assembly of the International Agency for the Prevention of Blindness (IAPB); 2004 20th-24th September; Dubai, UAE. Hyderabad, India: IAPB; 2005. p 143-146.
497. Hnin H, Tan HY, Agrawal K, Agrawal R. Pursuit of an ideal model for community eye health – non-governmental organisations (NGOs). *Nepal J Ophthalmol* [Internet]. 2017;9(18):108-11. Available from: <https://doi.org/10.3126/nepjoph.v9i2.19251>
498. Sg PK, Bhattacharya S, Vishwakarma P, Kundu S, Kurian E. Effective engagement of community health workers in primary eye care in India. *Community Eye Health*. 2018;31(102):S13-4.
499. BRAC (Building Resources Across Communities). BRAC and Sightsavers sign tripartite agreement with Government for Vision Bangladesh Project [Internet]. Dhaka (BD): BRAC; 2011. Available from: <http://www.brac.net/latest-news/item/460-brac-and-sightsavers-sign-tripartite-agreement-with-government-for-vision-bangladesh-project>

References

500. BRAC (Building Resources Across Communities). Eye care interventions [Internet]. Dhaka (BD): BRAC; 2011. Available from: <http://www.brac.net/health-nutrition-population/item/871-eye-care-interventions>
501. Sightsavers. Strategic evaluation of the Vision Bangladesh Project [Internet]. Cambridge: Cambridge Economic Policy Associates, Ltd.; 2014. 61 p. Available from: <https://www.sightsavers.org/wp-content/uploads/2017/11/Vision-Bangladesh-Evaluation.pdf>
502. Rashid MM. Vision Bangladesh's experience in implementing eye health services [Internet]. Paper presented at: 8th Public-Private Dialogue (PPD) 2015 Workshop; 2015 Mar 10-13; Copenhagen, Denmark. Available from: <http://www.publicprivatedialogue.org/workshop%202015/2015%20-%20Public%20Private%20Dialogue%20in%20Bangladesh4.pdf>
503. Awan H, Khan NU. Strategic evaluation of Dhaka Urban Comprehensive Eye Care Project (DUCECP) - evaluation report [Internet]. Dhaka (BD): Sightsavers and Avicenna Consulting (Pvt) Ltd; 2015. Available from: https://www.sightsavers.org/wp-content/uploads/2017/11/71031_DUCECP_2015_Final_Eval_Report2.pdf
504. Sightsavers. Bangladesh government quadruples its eye care budget [Internet]. Dhaka (BD): Sightsavers; 2017. Available from: <https://www.sightsavers.org/news/2017/06/bangladesh-eye-care-budget/>
505. Abiose A. Human resource development for 2020. In: Pararajasegaram R, Rao, GN, editors. World blindness and its prevention. Volume 6. Proceedings of the Sixth General Assembly of the International Agency for the Prevention of Blindness (IAPB); 1999 5th-10th September; Beijing, China. Hyderabad, India: IAPB; 2001. p 25-33.
506. Upadhyay MP. Human resource development for Vision 2020: an evidence-based approach. In: Gilbert C, Raman U, Francis V. editors. World blindness and its prevention. Volume 7. Proceedings of the Seventh General Assembly of the International Agency for the Prevention of Blindness (IAPB); 2004 20th-24th September; Dubai, UAE. Hyderabad, India: IAPB; 2005. p 161-164.
507. Caritas Cambodia. Takeo Eye Hospital summary report 1997–2017 [Internet]. Phnom Penh (KH): Caritas Cambodia; 2017. 13 p. Available from:

References

<http://www.caritascambodia.org/teh/images/stories/AnnualReport2017/Summary-Report-20-years-of-CTEH-english.pdf>

508. Lewallen S, Etya'ale D, Kello AB, Courtright P. Non-physician cataract surgeons in Sub-Saharan Africa: situation analysis. *Trop Med Int Health* [Internet]. 2012;17(11):1405-8. Available from:

<https://doi.org/10.1111/j.1365-3156.2012.03084.x>

509. World Health Organization. Task shifting: rational redistribution of tasks among health workforce teams – global recommendations and guidelines [Internet]. Geneva (CH): World Health Organization; 2008. 88 p. Available from:

<http://www.who.int/iris/handle/10665/43821>

510. Eliah E, Lewallen S, Kalua K, Courtright P, Gichangi M, Bassett K. Task shifting for cataract surgery in eastern Africa: productivity and attrition of non-physician cataract surgeons in Kenya, Malawi and Tanzania. *Hum Resour Health* [Internet]. 2014;12 Suppl 1:S4. Available from:

<https://doi.org/10.1186/1478-4491-12-S1-S4>

511. Asghar S, Khan AK, Ali SM, Sayeed MA, Bhowmik B, Diep ML, et al. Incidence of diabetes in Asian-Indian subjects: a five year follow-up study from Bangladesh. *Prim Care Diabetes* [Internet]. 2011;5(2):117-24. Available from:

[https://www.primary-care-diabetes.com/article/S1751-9918\(11\)00003-9/pdf](https://www.primary-care-diabetes.com/article/S1751-9918(11)00003-9/pdf)

512. Ahmed KR, Karim MN, Bhowmik B, Habib SH, Bukht MS, Ali L, et al. Incidence of diabetic retinopathy in Bangladesh: a 15-year follow-up study. *J Diabetes* [Internet]. 2012;4(4):386-91. Available from:

<https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1753-0407.2012.00208.x>

513. Biswas T, Islam A, Rawal LB, Islam SM. Increasing prevalence of diabetes in Bangladesh: a scoping review. *Public Health* [Internet]. 2016;138:4-11. Available from:

<http://dx.doi.org/10.1016/j.puhe.2016.03.025>

514. Islam SM, Alam DS, Wahiduzzaman M, Niessen LW, Froeschl G, Ferrari U, et al. Clinical characteristics and complications of patients with type 2 diabetes attending an urban hospital in Bangladesh. *Diabetes Metab Syndr* [Internet]. 2015;9(1):7-13. Available from:

<https://doi.org/10.1016/j.dsx.2014.09.014>

515. du Toit R, Brian G. Mid-level cadre providing eye care in the context of Vision 2020. *N Z Med J*. 2009 Mar 13;122(1291):77-88. Available from:

http://www.nzma.org.nz/_data/assets/pdf_file/0005/17798/Vol-122-No-1291-13-March-2009.pdf

References

516. Okwen M, Lewallen S, Courtright P. Primary eye care skills scores for health workers in routine and enhanced supervision settings. *Public Health* [Internet]. 2014;128(1):96-100. Available from: <https://www.sciencedirect.com/science/article/pii/S0033350613003442?via%3Dihub>
517. Paudel P, Cronje S, O'Connor PM, Rao GN, Holden BA. Clinical competency of 1-year trained vision technicians in Andhra Pradesh, India. *Ophthalmic Epidemiol* [Internet]. 2015;22(6):409-16. Available from: <https://doi.org/10.3109/09286586.2015.1082605>
518. Arora S, Mathur U, Datta P. Competency-based assessment as a reliable skill building strategy for allied ophthalmic personnel. *Community Eye Health*. 2018;31(102):S5-6.
519. Hannan Z. Case finding in the community: experience of *Jatiya Andha Kallyan Somiti* in Comilla, Bangladesh. *Community Eye Health*. 2002;15(43):40-2.
520. El Arifeen S, Christou A, Reichenbach L, Osman FA, Azad K, Islam KS, et al. Community-based approaches and partnerships: innovations in health-service delivery in Bangladesh. *Lancet* [Internet]. 2013;382(9909):2012-26. Available from: [https://doi.org/10.1016/S0140-6736\(13\)62149-2](https://doi.org/10.1016/S0140-6736(13)62149-2)
521. Dineen B. Health promotion and community participation in eye care services. *Community Eye Health*. 1999;12(31):35-6.
522. Abdullah KN, Abdullah MT. Management and planning for primary eye care of the elderly: the need to create public awareness of age-related cataract in Pakistan. *Community Eye Health*. 2002;15(43):45-6.
523. Hubley J, Gilbert C. Eye health promotion and the prevention of blindness in developing countries: critical issues. *Br J Ophthalmol* [Internet]. 2006;90(3):279-84. Available from: <https://bjo.bmj.com/content/bjophthalmol/90/3/279.full.pdf>
524. Misra V, Vashist P, Singh SS, Malhotra S, Gupta V, Dwivedi SN, et al. Awareness and eye health-seeking practices for cataract among urban slum population of Delhi: The North India eye disease awareness study. *Indian J Ophthalmol* [Internet]. 2017;65(12):1483-1488. Available from: https://doi.org/10.4103/ijo.IJO_585_16
525. Institute of Community Ophthalmology. Bachelor of science in optometry (B.Optom). Chittagong (BD): Chittagong Eye Infirmary and

References

Training Complex; 2018. 2 p. Available from: <http://icoedu.org/bachelor-of-optometryb-optomm/>

526. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2015 [Internet]. Dhaka: Management Information System. Directorate General of Health Services; 2015. Chapter 16 – Health workforce situation in Bangladesh; p. 146-57. Available from: http://www.dghs.gov.bd/images/docs/Publicaations/HB%202015_1st_edition_31122015.pdf

527. Government of the People's Republic of Bangladesh, Ministry of Health and Family Welfare. Health Bulletin 2016 [Internet]. Dhaka: Management Information System. Directorate General of Health Services; 2016. Chapter 2 – Healthcare network in Bangladesh; p. 19-23. Available from: http://www.dghs.gov.bd/images/docs/Publicaations/HB%202016%20_2nd_edition_13_01_17.pdf

528. Rahman MM, Gilmour S, Saito E, Sultana P, Shibuya K. Health-related financial catastrophe, inequality and chronic illness in Bangladesh. PLoS ONE [Internet]. 2013;8(2):e56873. Available from: <https://doi.org/10.1371/journal.pone.0056873>

529. Das T, Ackland P, Correia M, Hanutsaha P, Mahipala P, Nukella PB, et al. Is the 2015 eye care service delivery profile in Southeast Asia closer to universal eye health need! Int Ophthalmol [Internet]. 2018;38(2):469-80. Available from: <https://link.springer.com/content/pdf/10.1007%2Fs10792-017-0481-y.pdf>

530. Huq DMN. Situation analysis in Bangladesh. The regional workshop on prevention of avoidable blindness and visual impairment in SEAR [Internet]. Madurai (IN): Lions Aravind Institute of Community Ophthalmology (LAICO). 2011 Sep 22nd - 24th. Available from: http://www.aurosiksha.org/content/pdf/Prof%20Deen_AP.pdf0

531. Islam MR, Rahman MS, Islam Z, Nurs CZ, Sultana P, Rahman MM. Inequalities in financial risk protection in Bangladesh: an assessment of universal health coverage. Int J Equity Health [Internet]. 2017;16(1):59. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5381038/pdf/12939_2017_Article_556.pdf

533. United Nations Academic Impact (UNAI). Honouring Rabindranath Tagore [Internet]. New York (US): United Nations; 2013. Available from: <https://academicimpact.un.org/content/honouring-rabindranath-tagore>

10. Appendices

Appendix 1. PhD Research Proposal – Bangladesh National Blindness and Low Vision Prevalence Survey of Bangladesh

Figure 1. Map of Bangladesh with rural and urban survey cluster sites

Figure 2. Examination protocol - Bangladesh National Blindness and Low Vision Prevalence Survey

Figure 3. Bangladesh National Blindness and Low Vision Prevalence Survey Proforma

Appendix 2. List of Survey Clusters, by Division, District, *Thana* / *Upazila*, Union *Parashad*, Village / Block and Rural / Urban setting

Appendix 3. Personal publications related to the epidemiology of blindness and eye care service provision

Appendices

Appendix 1. PhD Research Proposal

The National Blindness and Low Vision Prevalence Survey of Bangladesh

PhD Research Proposal

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Appendices

Introduction

Current demographic estimates indicate that the population of Bangladesh exceeds 130 million inhabitants.¹ To date, no nation-wide study has been conducted concerning the extent of blindness in Bangladesh nor into the main causes of vision loss or impairment.

Given the strategies of the World Health Organization's (WHO) 'Global Initiative for the Elimination of Avoidable Blindness by 2020 (Vision 2020)',² the deficit of this vital information is particularly serious. The absence of reliable population-based epidemiological data on blindness and low vision in Bangladesh is a substantial impediment to the effective national planning of eye care programmes for this poor and densely populated country.

To date only two blindness research studies from Bangladesh have been carried out and these merit mention, despite their methodological limitations, as these represent what thus far has been reported about 'all cause' blindness in the country. The first published study on blindness in Bangladesh was based on a 1981 population-based survey (183,000 subjects) carried out in rural areas only.³ In this study, which involved a quite simplified ocular examination as part of the national census, the definition of blindness was based on a visual acuity of less than 1/60 – more restrictive than the WHO definition of best corrected vision of less than 3/60 in the better eye. According to this definition, the study identified a prevalence of blindness of 0.56% for all ages. Cataract accounted for 46.8% of blindness, corneal opacities including trachoma for 31.4%, trauma 11.9%, glaucoma 5.2%, and choroidal and retinal conditions 4.6%.

Over a decade later, in 1993, a small-scale study (2,663 subjects) was carried out in a delimited area within one of the 64 administrative districts that comprise Bangladesh.⁴ In this survey, a prevalence rate of 1.49% for blindness (best corrected visual acuity less than 3/60 in the better eye) amongst persons of all ages was identified. It merits pointing out, however, that the research design, small sample size, unclear operational definitions and limited data analysis of this study were not sufficiently scientifically rigorous. As such it would be imprudent to consider the findings of this study as a veritable indication of blindness for the whole of Bangladesh.

In order to re-dress the dearth of blindness and low vision data amongst adults for this populous country, a nation-wide survey was designed. This present document outlines this study, which aims to identify the prevalence and specific causes of blindness and visual impairment throughout Bangladesh, as well as providing information on the relative needs of the urban and rural areas of the six main regional administrative divisions of the country. Issues relating to quality of life, visual functioning and population projections for visual disability in Bangladesh are also investigated as are the surgical outcomes of persons operated for cataract and the refractive error status of the study sample, with extrapolations for the adult population of the country.

Objectives

- To establish the age- and sex-specific prevalence rates of blindness and low vision in adults 30 years of age and older in Bangladesh.
- To identify the causes of blindness and visual impairment within the study sample.
- To evaluate cataract service delivery by measuring cataract surgical coverage (CSC) level as well as to identify visual functioning outcomes of surgery amongst all aphakes and pseudophakes.

Appendices

- To identify the socio-economic and cultural barriers to up-take of eye care service provision amongst severely visually impaired and blind subjects.
- To determine the level of impact that visual impairment has upon one's quality of life and visual functioning as identified by means of two validated questionnaires.

Research Question

What is the prevalence and causes of blindness and visual impairment in the adult population of Bangladesh in the year 2000?

Materials and Methods

Subjects

The principal inclusion criterion of the study was an age of 30 years or older. According to the official 1991 national census data, with updated estimates for 1996, there are an estimated 44 million persons within this target age group (33.6% of the total population).^{5,6} Demographic data indicate that the majority of the population resides in rural areas (79.9%) while a lesser proportion is located in urban zones (20.1%). The age of 30 years has been chosen as the threshold figure for the following reasons. In view of the 57.5-year life expectancy in Bangladesh,^{1,7} it was felt that this age range would best represent the period of adulthood. In addition, the national independence of Bangladesh occurred in 1971; this event serves as a useful age verification marker for those persons unsure of their exact age (compulsory birth registration only began in Bangladesh in 1999).

Sample size

The calculation of the sample size was based upon an estimation of the prevalence of blindness among adults 30 years and older. Several population-based studies concerning blindness prevalence were reviewed with regard to the minimal age of subjects examined as well as concerning geographical region.⁸⁻¹⁵ An example of such a study was that conducted in urban Hyderabad, Andhra Pradesh, India in which the age-adjusted blindness prevalence rate for persons 30 years and older was 2.53% according to presenting visual acuity and 2.23% as per best corrected acuity (the WHO definition for blindness).¹⁶ Age-specific prevalence rates for blindness and low vision derived from other studies indicated similar levels to that found in Hyderabad, with increased age-specific rates being identified amongst older individuals.¹²⁻¹⁵

Based upon the target age population of National Blindness and Low Vision Prevalence Survey of Bangladesh⁷ of 30 years and older (44 million adults), a blindness prevalence estimate of 2.5% for Bangladesh adults was considered. Utilising a random sampling error of 0.35% and a design effect of 1.5 due to the cluster sampling strategy, a sample size of 11,463 subjects was calculated.¹⁷ This figure was increased by an approximate further 10% (12,900 subjects) in order to increase the likelihood of attaining the minimal sample size in case of lower than expected participation by enumerated subjects. The 95% confidence interval projection for the adult blindness prevalence rate was 2.23% – 2.77%.

Sampling strategy

Multi-stage stratified cluster random sampling, with probability proportional-to-size (PPS) procedures, was adopted as the strategy for the selection of a cross-sectional, nationally representative sample of the population.¹⁸ For the purposes of this survey, a rural cluster consisted of a village while an urban cluster comprised a street block. Stratification of the sample according to rural and urban residence (corresponding to official municipality ordinance status)¹⁹ was incorporated in the sample selection process. Within each of the six regional administrative divisions in Bangladesh, a proportional number of clusters in relation

Appendices

to the overall national population were identified based upon official census data. In total, 154 cluster sample sites were therefore selected by PPS, of which 104 were rural villages while the remaining 50 were urban block areas. The rural cluster areas consisted of 100 subjects, while the urban study areas consisted of 50 subjects each. The logistical advantages of this sampling strategy included efficiency in terms of time, transport and subject enumeration and subsequent examination per cluster (Figure 1).

Household enumeration and subject identification

Prior to the examination of subjects, enumeration of eligible subjects in each cluster site was undertaken, i.e. 100 adults for each rural site and 50 for each urban cluster. Households were identified in a systematic manner by proceeding round in a clock-wise direction from a randomly identified reference point within the cluster.¹⁸ Subject identification involved the two-person enumeration teams serially assigning a number to each household and registering the names and ages of all habitual occupants until the required number of eligible subjects aged 30 years and older was attained for a given cluster. All eligible subjects were informed that they would be asked to attend for an examination in their community in the near future.

Ethical approval

The Bangladesh Medical Research Council provided written ethical approval for this survey in March 1999.

Training of personnel

Two UK-based personnel – an ophthalmologist and an epidemiologist were responsible for providing training to the Bangladeshi survey team members concerning the subject interview process, the enumeration methodology and the ophthalmic examination process. Three ophthalmologists, three ophthalmic nurses and six medical technicians comprised the three ophthalmic sub-teams. Other non-medical staff included six enumerators, one enumeration quality control supervisor, three interviewers, three post-enumeration logisticians and two data processors. All participants of the survey team underwent specialised training during a month-long period, which was followed by a pilot study in three rural villages.

The survey interviewers were trained on the content and protocol for completing the demographic information interview schedule questionnaire (a modified WHO/PBL Version III)²⁰ as well as the visual functioning (VF) and quality of life (QOL) instruments.^{21,22}

Both inter- and intra-observer agreement were determined (Cohen kappa coefficient for agreement, k)²³ amongst the ophthalmic nurses (visual acuity testing)²⁴ and, separately, for the ophthalmologists (intra-ocular pressure measurement, optic disc assessment and lens opacity grading²⁵). In addition, observer agreement was confirmed with the interviewers for the visual functioning and quality of life instruments.

Survey data collection process

Prior to the ophthalmic examination, personal and demographic data (age, sex, literacy status, previous school attendance, occupation, land tenure status, religious affiliation) were obtained by the interviewer for each of the enumerated subjects that attended the eye examinations. If the subject was unable or had difficulty in responding to questions at any time, a relative was subsequently asked for clarification. Oral informed consent was sought from each subject by the senior ophthalmic nurse, following explanation of the procedures to be conducted.

Appendices

Operational definitions used in the ophthalmic examination

The WHO categories of visual impairment²⁶ were used for this study. Blindness was defined as a corrected visual acuity of less than 3/60 (20/400, 0.05) in the better eye. Low vision was defined as corrected visual acuity of less than 6/18 (20/60, 0.3) but equal to or better than 3/60 in the better eye (comprising categories 1 and 2 in ICD-10). Category 1 is visual impairment, less than 6/18 to 6/60, and category 2, severe visual impairment, corresponds to visual acuity less than 6/60 to 3/60. Subjects whose presenting visual acuity was worse than 6/12 in either eye were targeted in this study for further examination. Visual fields were not tested due to logistic and technical difficulties in a primarily rural population. Therefore, fields were not used in the definition of blindness, nor of glaucoma.

Below are found condition-specific definitions for the main diseases causing visual impairment.

Cataract was defined as any opacity visualised with a direct ophthalmoscope through an undilated pupil. The grading system used was that of Mehra and Minassian.²⁵

Myopia was defined as a spherical equivalent refractive error of less than -0.50 diopters. Myopia was further categorised as low myopia (-0.50 dioptres to -5.00 dioptres), high myopia (-5.25 dioptres to -10 dioptres) and extreme myopia (>-10 dioptres).²⁷

Hypermetropia was defined as a spherical equivalent refractive error of more than +0.50 diopters. Hypermetropia was further categorised as low hypermetropia (+0.50 dioptres to +5.00 dioptres), high hypermetropia (+5.25 dioptres to +10 dioptres) and extreme hypermetropia (>+10 dioptres).

From a population-based distribution of intraocular pressure (IOP) measured by Schiøtz tonometry techniques on a sub-sample during the main survey, the 95%, 97.5%, and 99.5% percentiles for IOP were calculated. A subject was recorded as a glaucoma case if the optic cup/disc ratio (CDR) was ≥ 0.7 in either eye in the presence of an IOP of $\geq 97.5\%$ ile. Glaucoma suspects included those with a CDR of ≥ 0.7 and IOP $< 97.5\%$ ile ('normotensive glaucoma'), and those where the optic discs were obscured but the IOP was $> 99.5\%$ ile. Ocular hypertensives were defined as those subjects with a CDR (in either eye) of < 0.7 and an IOP $\geq 97.5\%$ ile.

Age-related maculopathy (ARM) was defined as the presence of any one of the following: soft drusen or reticular drusen, hyper- or hypo-pigmentation of the retinal pigment epithelium (RPE).

Late ARM or age-related macular degeneration (ARMD) was subdivided into non-exudative geographic atrophy of the RPE in the absence of sub-retinal neovascular changes and exudative changes where neovascular ARM with RPE detachment, haemorrhages, and/or fibrous scars were evident.

Diabetic retinopathy was subdivided into three types: non-proliferative, proliferative and maculopathy. These were not mutually exclusive, as the latter two types, for example, may co-exist. Cases of suspected diabetic retinopathy, in the absence of a history of diabetes mellitus, underwent a random blood glucose test to detect hyperglycaemia (defined as $> 11.0\text{mmol/l}$).

Appendices

Data analysis

A systematic, decision-making approach was implemented concerning the identification of the cause(s) of low vision and/or blindness for each subject, based on the ocular examination findings. Accordingly, one singular cause of low vision or blindness was identified for each subject with presenting visual acuity less than 6/12. The decision-making process as to which possible condition was causing the subject to be visually impaired was based on the WHO recommendation that the cause should be the pathology 'most amenable to treatment or prevention'.²⁰

In accordance with the Coding Instructions for the WHO/PBL Prevention of Blindness Proforma, (Version III), the survey ophthalmologist would record all ocular disorders - for each eye separately - that were identified in the course of examining all subjects with <6/12 VA in either one or both eyes. After listing 'all causes of blindness or low vision for each eye', the ophthalmologist identified which of these disorders was the main cause of low vision or blindness for each eye separately. Next, the ophthalmologist decided which the principal disorder responsible for low vision or blindness for the subject was, taking into account the main cause for each individual eye. When more than one singular ocular disorder was present, one of which was secondary to the other, the 'primary' cause to be selected as the principal visual disorder was that which was 'most readily curable' or, if not curable, that which was 'most easily preventable'. The final decision concerning the major cause of visual impairment for a particular subject was determined after considering the disorder in either eye that was 'most amenable to treatment or prevention'.²⁰

Based on the criteria of 'most readily curable or most easily preventable', the following ranking system for determination of the cause of low vision or blindness was utilised:

- Uncorrected aphakia
- Refractive errors / amblyopia (in the presence of a lens opacity graded 0 or 1 with SE ≥ 0.5 or ≤ -0.5)
- Cataract (when lens opacity grading was adjudged to be '2A', '2B' or '3')
- Corneal opacities and phthisis
- Glaucoma
- Anterior uveitis
- Posterior segment disorders

All information from the personal data records and the visual examinations data was processed in a specially designed database in Epi Info (Version 6.04b).²⁸ In order to ensure optimal data quality control, all questionnaire data was sequentially entered into the database twice by two experienced data processors specially trained to work with this database. Validation of the doubly-entered data was then performed and any corrections needed were made prior to proceeding on the data analysis in Epi Info and SPSS (Statistical Package for the Social Sciences, Chicago, Illinois).²⁹

The prevalences for blindness and low vision were estimated, while accounting for design effects caused by the cluster sampling strategy according to the Taylor Linearised Deviation variance estimate approach.³⁰ Multiple logistic regression was carried out in order to investigate the associations of gender, age, area of residence and literacy status with visual impairment. The 95% confidence intervals for the prevalence estimates and regression odds ratios (OR) were also determined. Finally, p values less than 0.05 were taken to be statistically significant for χ^2 and logistic regression analysis.

Appendices

Appendices

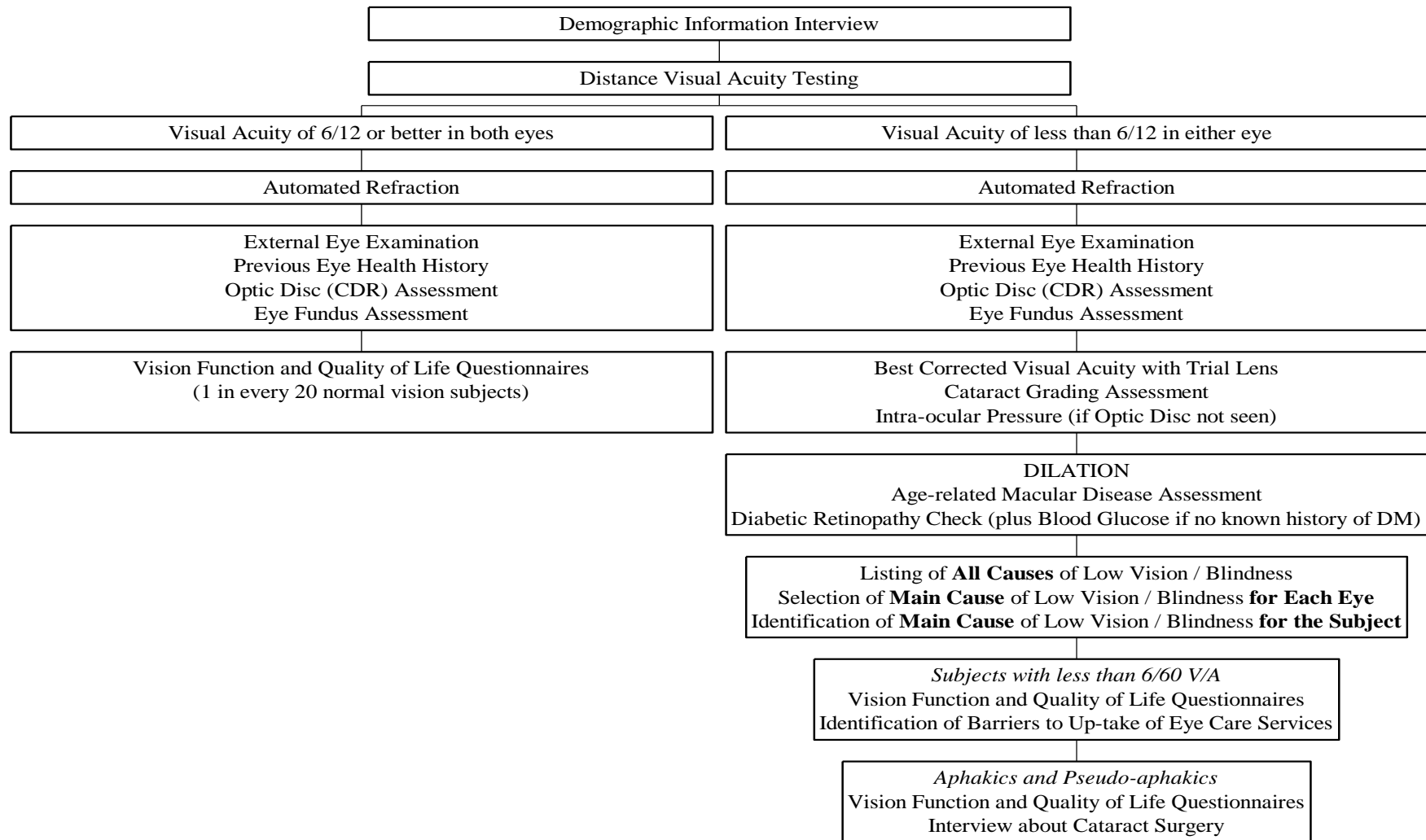
Figure 1 presents in map format the distribution of the rural and urban clusters for this national blindness and low vision survey. A flow chart which outlines the full examination procedure is presented in Figure 2. Also attached is a copy of the data collection instrument used in this study (Figure 3), which was a specially modified version of the WHO Prevention of Blindness standardised proforma.²⁰

Figure 1. Map of Bangladesh with rural and urban sample cluster sites



Appendices

Figure 2. Examination protocol - Bangladesh National Blindness and Low Vision Prevalence Survey



Appendices

Figure 3. Bangladesh National Blindness and Low Vision Prevalence Survey Proforma

Bangladesh National Blindness Survey
Demographic Information

Subject Serial Number Household Serial Number Personal Identification Number (PIN)

Day	Month	Division	District	Upozila / Thana	Union / Ward	Village / Block	Urban House Number
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Name of Subject _____ Sex: ^{1 = Female} ^{2 = Male} Age (years)

Have you ever attended school? ^{1 = Yes} ^{2 = No} Highest level of school attended? ^{1 = Primary} ^{2 = Secondary} ^{3 = College / University}

What kind of work, if any, do you mainly do? _____ If you work in agriculture, do you work on: ^{1 = Your own land or your family's land} ^{2 = Rental land} ^{3 = Someone else's land}

Are you able to read and write? ^{1 = Easily} ^{2 = With difficulty} ^{3 = Not at all}

Highest class / grade completed at that level?

What is your religion? ^{1 = Islam} ^{2 = Hinduism} ^{3 = Buddhism} ^{4 = Christianity} ^{5 = Other}

<p>Visual Acuity</p> <p>Unaided <input type="checkbox"/> With Glasses <input type="checkbox"/></p> <p><u>Can Be Tested</u></p> <p style="text-align: center;">R L</p> <p>Number letters seen at 4m: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Misses at least 1 E on top line at 4m, move to 1m.</p> <p style="text-align: center;">R L</p> <p>Number letters seen at 1m: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <hr/> <p><u>Cannot see at 1m</u> (Please tick correct box)</p> <p style="text-align: center;">R L</p> <p>Counting fingers (at 1m): <input type="checkbox"/> <input type="checkbox"/></p> <p>Hand movements: <input type="checkbox"/> <input type="checkbox"/></p> <p>Perception of light: <input type="checkbox"/> <input type="checkbox"/></p> <p>No perception of light: <input type="checkbox"/> <input type="checkbox"/></p> <hr/> <p><u>Cannot be tested</u></p> <p style="text-align: center;">R L</p> <p>Believed blind: <input type="checkbox"/> <input type="checkbox"/></p> <p>Believed not blind: <input type="checkbox"/> <input type="checkbox"/></p> <p style="text-align: center;">GREEN CARD / RED CARD</p> <p>Green card <input type="checkbox"/> Red card <input type="checkbox"/></p> <p>Note: Red card for those 24 letters or less.</p>	<p style="text-align: center;">Refraction</p> <p>Right Eye: Average Refractive Error*:</p> <p>Sphere ± <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Cylinder ± <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Axis <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Refraction result for Right Eye is: Automated <input type="checkbox"/> Manual <input type="checkbox"/></p> <hr/> <p>Left Eye: Average Refractive Error*:</p> <p>Sphere ± <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Cylinder ± <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Axis <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Refraction result for Left Eye is: Automated <input type="checkbox"/> Manual <input type="checkbox"/></p> <p style="text-align: center;">For Green Cards</p> <p>If auto-refractor not available, please tick the following box. <input type="checkbox"/></p> <hr/> <p style="text-align: center;">For Red Cards</p> <p>If no automated refraction result obtainable and subject is a Red Card: do objective refraction and write result above.</p> <p>If manual refraction impossible, tick box: Right Eye <input type="checkbox"/> Left Eye <input type="checkbox"/></p>	<p style="text-align: center;">Eye Examination</p> <p>Previous Eye History</p> <p>History of diabetes: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Entropion: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Evidence of surgery: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Type of previous surgery: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Eyelid: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Cataract: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p style="text-align: center;">R L</p> <p>Time (in months) since cataract surgery: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Location: ^{1 = Hospital} <input type="checkbox"/> ^{2 = Eye Camp} <input type="checkbox"/></p> <p style="text-align: center;">Place of surgery</p> <p>Intracapsular Technique: <input type="checkbox"/> <input type="checkbox"/></p> <p>Extracapsular Technique: <input type="checkbox"/> <input type="checkbox"/></p> <p>Couching: <input type="checkbox"/> <input type="checkbox"/></p> <p>P/C Intraocular lens: ^{1 = With} <input type="checkbox"/> ^{2 = Without} <input type="checkbox"/></p> <p>A/C Intraocular lens: ^{1 = With} <input type="checkbox"/> ^{2 = Without} <input type="checkbox"/></p> <p>Using aphakic spectacles: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Glaucoma: ^{1 = Medical} <input type="checkbox"/> ^{2 = Surgical} <input type="checkbox"/> ^{3 = No treatment} <input type="checkbox"/></p> <p>Other Surgery: _____</p>	<p style="text-align: center;">Eye Examination</p> <p>Un-dilated Optic Disc Cup / Disc Ratio (CDR):</p> <p style="text-align: center;">R L</p> <p>CDR < 0.70 <input type="checkbox"/> <input type="checkbox"/></p> <p>CDR ≥ 0.70 <input type="checkbox"/> <input type="checkbox"/></p> <p>Unable to see Optic Disc <input type="checkbox"/> <input type="checkbox"/></p> <p>Note: Dilate Green Cards if Optic Disc not visible.</p> <p>If either eye has CDR ≥ 0.70, please record Schiottz intra-ocular pressure (IOP) measurement.</p> <p style="text-align: center;">R L</p> <p>IOP <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <hr/> <p style="text-align: center;">Note: Green Cards Only</p> <p>Diabetic Retinopathy: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Retinitis Pigmentosa: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>ARMD: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Unable to see fundus: ^{1 = Yes} <input type="checkbox"/> ^{2 = No} <input type="checkbox"/></p> <p>Comments: _____</p> <hr/> <p style="text-align: center;">Note: Red Cards Remain Please complete back of record form.</p>
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(continued)

Appendices

Figure 3. Bangladesh National Blindness and Low Vision Prevalence Survey Proforma

Bangladesh National Blindness Survey

Visual Acuity with auto-refraction result in trial frame: (If auto-refraction impossible, do manual refraction.)									
R		L		R		L			
Number letters seen at 4m: <input type="text"/> <input type="text"/>		Misses at least 1 'E' on top line at 4m, move to 1m.		Number letters seen at 1m: <input type="text"/> <input type="text"/>					

Cataract Grading											
R		L		R		L		R		L	
0 (No opacity of natural lens) <input type="checkbox"/> <input type="checkbox"/>		2B (Opacity >1/2 reflex) <input type="checkbox"/> <input type="checkbox"/>		4 (Aphakia) <input type="checkbox"/> <input type="checkbox"/>							
1 (Small opacities <1mm) <input type="checkbox"/> <input type="checkbox"/>		3 (Total opacity, no reflex) <input type="checkbox"/> <input type="checkbox"/>		5 (Obscured e.g. corneal opacity) <input type="checkbox"/> <input type="checkbox"/>							
2A (Opacity <1/2 reflex) <input type="checkbox"/> <input type="checkbox"/>											
If known to have IOL, is there a post-capsular opacity?				1 = Yes <input type="checkbox"/> <input type="checkbox"/>		2 = No <input type="checkbox"/> <input type="checkbox"/>		IOP (if Optic Disc not seen) <input type="text"/> <input type="text"/>			

Dilate Subject with Tropicacyl Plus to at least 6mm											
(Note: Remember to check CDR in both eyes)											
Unable to see fundus RE <input type="checkbox"/>					Unable to see fundus LE <input type="checkbox"/>						
Diabetes Age-Related Macular Disease					Age-Related Macular Disease						
Diabetic Retinopathy		R		L		ARMD		R		L	
None		<input type="checkbox"/>		<input type="checkbox"/>		None		<input type="checkbox"/>		<input type="checkbox"/>	
Non-proliferative		<input type="checkbox"/>		<input type="checkbox"/>		Age-related maculopathy (drusen, hyper/hyper pigmentation of RPE)		<input type="checkbox"/>		<input type="checkbox"/>	
Proliferative and end-stage		<input type="checkbox"/>		<input type="checkbox"/>		Age-related macular degeneration:					
Maculopathy		<input type="checkbox"/>		<input type="checkbox"/>		a) dry or geographic atrophy		<input type="checkbox"/>		<input type="checkbox"/>	
Take blood glucose to confirm diabetes (Only if subject reports no known history of diabetes).					OR						
Blood glucose (mmol/L) <input type="text"/> <input type="text"/> <input type="text"/>					b) wet or neovascular membrane, disciform scar <input type="checkbox"/> <input type="checkbox"/>						

Disorder	Causes of Low Vision or Blindness		Main Cause of Low Vision or Blindness in Each Eye		Most Preventable Cause of Low Vision or Blindness in this Subject	Other RE	Medication	Spectacles	Glaucoma treatment	Cataract surgery	Eyeball surgery	Action needed (all which apply)	No current action needed	Current Action Needed
	For each eye Mark all which apply		Mark only 1 cause per eye											
	R	L	R	L										
Phthisical, disorganised or absent globe	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Refractive error	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Cataract	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
'After cataract'	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Uncorrected aphakia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Corneal central opacity*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Anterior uveitis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Glaucoma	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Optic atrophy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Diabetic retinopathy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Other vascular retinopathy*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Chorioretinitis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Macular degeneration (all causes)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Other:*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
Underlying causes					Comments									
No listed underlying cause	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>										
Trauma	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>										
Congenital / Neonatal factor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>										
Measles/ Vitamin A deficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>										
Surgical procedure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>										
Optional Factor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>										

Appendices

Appendix 2. List of Survey Clusters – Administrative Strata (Division, District, Thana / Upazila, Union / Parashad, Village / Block) by Rural / Urban setting

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
1	Barisal	Pirojpur	<i>Pirojpur Sadar</i>	Kalakhali	Pukharia	Rural
2	Barisal	Jhalokati	<i>Rajapur</i>	Mathbari	Pukhari Jana	Rural
3	Barisal	Barisal	<i>Gournadi</i>	Batajore	Harhar	Rural
4	Barisal	Barisal	<i>Muladi</i>	Gachhua	Saidergaon	Rural
5	Barisal	Bhola	<i>Charfesson</i>	Aminabad	D. Suberchar	Rural
6	Barisal	Patuakhali	<i>Bauphal</i>	Boga	Boga	Rural
7	Barisal	Patuakhali	<i>Mirzagonj</i>	Majidbari	Khatasaia	Rural
8	Barisal	Barguna	<i>Betagi</i>	Kajirabad	D. Kajirabad	Rural
9	Barisal	Jhalokati	<i>Nalchity</i>	2	Surjapasha	Urban
10	Barisal	Barisal	<i>Barisal</i>	10	Oxford Mission	Urban
11	Chittagong	Brahmanbaria	<i>Brahmanbaria Sadar</i>	D. Natai	Narasinghswar	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
12	Chittagong	Brahmanbaria	<i>Nabinagar</i>	Sreerampur	Gopalpur	Rural
13	Chittagong	Comilla	<i>Brahmanpara</i>	Shashidal	Uttar Bagra	Rural
14	Chittagong	Comilla	<i>Daudkandi</i>	Uttar Elliotgong	Banskhola	Rural
15	Chittagong	Comilla	<i>Comilla Sadar</i>	Bijoypur	Sreeballabpur	Rural
16	Chittagong	Comilla	<i>Muradnagar</i>	Muradnagar	Herarerkanda	Rural
17	Chittagong	Chandpur	<i>Faridganj</i>	D. Gobindapur	Gobindapur	Rural
18	Chittagong	Chandpur	<i>Matlab</i>	Kalakanda	Uttar Purba Nilerchara	Rural
19	Chittagong	Lakshmipur	<i>Lakshmipur</i>	D. Hamchadi	Nandapur	Rural
20	Chittagong	Noakhali	<i>Begumganj</i>	Bazra	Barahinnagar	Rural
21	Chittagong	Noakhali	<i>Hatiya</i>	Charking	Uttar Char Ishwar Roy	Rural
22	Chittagong	Noakhali	<i>Noakhali Sadar</i>	Noannai	Sree Rampur	Rural
23	Chittagong	Feni	<i>Sonagazi</i>	Charchandia	D. Charchandia	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
24	Chittagong	Chittagong	<i>Chandanaish</i>	Dohazari	Jamirjuri	Rural
25	Chittagong	Chittagong	<i>Mireshwarai</i>	Dhum	Naherpur	Rural
26	Chittagong	Chittagong	<i>Raozan</i>	Bagaon	Gaschi	Rural
27	Chittagong	Chittagong	<i>Sitakunda</i>	Salimpur	D. Salimpur	Rural
28	Chittagong	Cox's Bazar	<i>Ramu</i>	Fatekharkul	Mandalpara	Rural
29	Chittagong	Rangamati	<i>Kaptai</i>	Chandraghona	Kalabagan	Rural
30	Chittagong	Comilla	<i>Comilla Sadar</i>	3	Kandirpar	Urban
31	Chittagong	Lakshmipur	<i>Lakshmipur Sadar</i>	3	Shamsherbad	Urban
32	Chittagong	Chittagong	<i>Chandgaon</i>	27	Chandgaon Main	Urban
33	Chittagong	Chittagong	<i>Chittagong Port</i>	38	D. Madhya Halishar	Urban
34	Chittagong	Chittagong	<i>Double Mooring</i>	18	Uttar Pathantali	Urban
35	Chittagong	Chittagong	<i>Kotwali</i>	1	Bagmoniram	Urban

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
36	Chittagong	Chittagong	<i>Pahartoli</i>	21	Paschim Nasirabad	Urban
37	Chittagong	Chittagong	<i>Panchlaish</i>	11	Solakbahar	Urban
38	Chittagong	Khagrachhari	<i>Khagrachhari Sadar</i>	2	Khagrampur	Urban
39	Dhaka	Netrokona	<i>Kalmakanda</i>	Kalmakanda	Basaura	Rural
40	Dhaka	Netrokona	<i>Purbadhala</i>	Agia	Agia	Rural
41	Dhaka	Mymensingh	<i>Fulbaria</i>	Fulbaria	Kalakanda	Rural
42	Dhaka	Mymensingh	<i>Haluaghat</i>	Dhara	Kutura	Rural
43	Dhaka	Mymensingh	<i>Muktagacha</i>	Bragram	Bahenga	Rural
44	Dhaka	Mymensingh	<i>Phulpur</i>	Kamaria	Kadamtali	Rural
45	Dhaka	Sherpur	<i>Nakhla</i>	Pathakata	Kaiyakuri Kanda	Rural
46	Dhaka	Sherpur	<i>Sreebardi</i>	Tantehati	Bhatpur	Rural
47	Dhaka	Jamalpur	<i>Jamalpur Sadar</i>	Rangachha	Dari Hamidpur	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
48	Dhaka	Jamalpur	<i>Sarishabari</i>	Mahadun	Sanakair	Rural
49	Dhaka	Tangail	<i>Ghatail</i>	Rasulpur	Arkandarbaid	Rural
50	Dhaka	Tangail	<i>Madhupur</i>	Dhopakhali	Chara Bhanga	Rural
51	Dhaka	Tangail	<i>Sakhipur</i>	Jadabpur	Talepabad Kalmegha	Rural
52	Dhaka	Kishoreganj	<i>Hossainpur</i>	Sidhla	Dakshin Dhulihar	Rural
53	Dhaka	Kishoreganj	<i>Kishoreganj Sadar</i>	Rashidabad	Rashidabad	Rural
54	Dhaka	Manikganj	<i>Gheor</i>	Baratia	Jagamathdia	Rural
55	Dhaka	Manikganj	<i>Singair</i>	Jamirta	Sudkkhira	Rural
56	Dhaka	Dhaka	<i>Gulshan</i>	Satarkul	Khilbarirtek	Rural
57	Dhaka	Dhaka	<i>Nawabganj</i>	Sholla	Sholla	Rural
58	Dhaka	Gazipur	<i>Kaliakair</i>	Madhyapara	Kathantali	Rural
59	Dhaka	Gazipur	<i>Sreepur</i>	Sreepur	Channapara	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
60	Dhaka	Narsingdi	<i>Palash</i>	Gazaria	Noakanda	Rural
61	Dhaka	Narayanganj	<i>Araihazar</i>	Kalapaharia	Jhukandi	Rural
62	Dhaka	Narayanganj	<i>Narayanganj Sadar</i>	Sunailpara	New Colony	Rural
63	Dhaka	Munshiganj	<i>Seradjdikhan</i>	Baluchar	Chanderchar	Rural
64	Dhaka	Faridpur	<i>Boalmari</i>	Boalmari	Shibpur	Rural
65	Dhaka	Faridpur	<i>Nagar Kanda</i>	Ramnagar	Narsinghpur	Rural
66	Dhaka	Rajbari	<i>Rajbari Sadar</i>	Chandani	Chandani	Rural
67	Dhaka	Gopalganj	<i>Muksudpur</i>	Maharagpur	Uttar Narayanpur	Rural
68	Dhaka	Modaripur	<i>Shibachar</i>	Banshkandi	Uttar Banshkandi	Rural
69	Dhaka	Shariatpur	<i>Naria</i>	Naria	Kaliabita Zelepar	Rural
70	Dhaka	Mymensingh	<i>Mymensingh Sadar</i>	5	Charpara	Urban
71	Dhaka	Jamalpur	<i>Jamalpur Sadar</i>	3	Purba Fulbaria	Urban

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
72	Dhaka	Tangail	<i>Tangail Sadar</i>	5	Balukkandi	Urban
73	Dhaka	Dhaka	<i>Cantonment</i>	1	Kachukhet	Urban
74	Dhaka	Dhaka	<i>Demra</i>	47	Purba Jurain	Urban
75	Dhaka	Dhaka	<i>Dhanmondi</i>	17	Charakghata	Urban
76	Dhaka	Dhaka	<i>Gulshan</i>	72	Gulshan Control U-Block	Urban
77	Dhaka	Dhaka	<i>Kotwali</i>	32	Nawab Katara	Urban
78	Dhaka	Dhaka	<i>Lalbag</i>	23	Shahid Nagar	Urban
79	Dhaka	Dhaka	<i>Mirpur</i>	2	Mirpur Sector 12	Urban
80	Dhaka	Dhaka	<i>Mirpur</i>	5	Rainkhola	Urban
81	Dhaka	Dhaka	<i>Mirpur</i>	9	Kallyanpur	Urban
82	Dhaka	Dhaka	<i>Mohammadpur</i>	13	Banshbari	Urban
83	Dhaka	Dhaka	<i>Motijheel</i>	54	T And T Colony	Urban

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
84	Dhaka	Dhaka	<i>Ramna</i>	66	Malibag	Urban
85	Dhaka	Dhaka	<i>Sabujbag</i>	56	Meradia	Urban
86	Dhaka	Dhaka	<i>Savar</i>	Aminbazar	Bara Bardeshi	Urban
87	Dhaka	Dhaka	<i>Sutrapur</i>	44	Ultiganj	Urban
88	Dhaka	Dhaka	<i>Tejgaon</i>	71	D. Paschim Tejgaon	Urban
89	Dhaka	Gazipur	<i>Gazipur Sadar</i>	6	Dattapara	Urban
90	Dhaka	Narayanganj	<i>Bandar</i>	10	Jamipara Esha	Urban
91	Dhaka	Narayanganj	<i>Narayanganj Sadar</i>	8	Rasulbag	Urban
92	Dhaka	Madaripur	<i>Madaripur</i>	3	Char Muguria	Urban
93	Khulna	Kustia	<i>Kumarkhali</i>	Jadu Boyra	Uttar Chandpur	Rural
94	Khulna	Meherpur	<i>Gangni</i>	Sholotaka	Sholotaka	Rural
95	Khulna	Chuadanga	<i>Jibannagar</i>	Uthali	Kashipur	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
96	Khulna	Jhenaidah	<i>Shailkupa</i>	Abaipur	Abaipur	Rural
97	Khulna	Narail	<i>Kalia</i>	Benda	Bornal	Rural
98	Khulna	Jessore	<i>Bagherpara</i>	Roypur	Roypur	Rural
99	Khulna	Jessore	<i>Jessore Sadar</i>	Narendrapur	Sreepadi	Rural
100	Khulna	Satkhira	<i>Debhata</i>	Noapara	Nangla	Rural
101	Khulna	Satkhira	<i>Sheymnagar</i>	Padmapukur	Padmapukur	Rural
102	Khulna	Khulna	<i>Dumuria</i>	Sobhana	Sobhana	Rural
103	Khulna	Bagerhat	<i>Chitalmari</i>	Barabaria	Barabaria	Rural
104	Khulna	Bagerhat	<i>Rampal</i>	Banshtali	Talbunia	Rural
105	Khulna	Meherpur	<i>Meherpur Sadar</i>	3	Shajipara	Urban
106	Khulna	Jhenaidah	<i>Kaliganj</i>	3	Babra	Urban
107	Khulna	Jessore	<i>Jessore.Sadar</i>	2	Puratan Kasba	Urban

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
108	Khulna	Khulna	<i>Daulatpur</i>	28	Bunapara	Urban
109	Khulna	Khulna	<i>Khalishpur</i>	25	Uttar Kashipur	Urban
110	Khulna	Khulna	<i>Khulna Sadar</i>	6	Beni Babu Road	Urban
111	Khulna	Khulna	<i>Sunadanga</i>	16	Noor Nagar	Urban
112	Rajshahi	Panchagar	<i>Panchagar</i>	Amaruhan	Sonartan	Rural
113	Rajshahi	Thakurgaon	<i>Thakurgaon</i>	Begunbari	Purba Begunb	Rural
114	Rajshahi	Dinajpur	<i>Bochagonj</i>	Atgaon	Kakduar	Rural
115	Rajshahi	Dinajpur	<i>Dinajpur</i>	Auliapur	Mahabbatpur	Rural
116	Rajshahi	Nilphamari	<i>Domar</i>	Domar	Chikanmati	Rural
117	Rajshahi	Nilphamari	<i>Nilphamari</i>	Tupamari	Tupamari	Rural
118	Rajshahi	Lalmonirhat	<i>Patgram</i>	Jogatbar	Nazirgumani	Rural
119	Rajshahi	Rangpur	<i>Mithapukur</i>	Emadpur	Rahmatpur	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
120	Rajshahi	Rangpur	<i>Rangpur Sadar</i>	Haridebpur	Uttar Gokalpur	Rural
121	Rajshahi	Kurigram	<i>Kurigram Sadar</i>	Ghogadaha	Arazikumarpur	Rural
122	Rajshahi	Kurigram	<i>Ulipur</i>	Pandul	Hazipara	Rural
123	Rajshahi	Gaibandha	<i>Gobindagonj</i>	Shakhahar	Baniali	Rural
124	Rajshahi	Gaibandha	<i>Sundargonj</i>	Dahabanda	Hurabhaya	Rural
125	Rajshahi	Joypurhat	<i>Panch Bibi</i>	Balighata	Balighata	Rural
126	Rajshahi	Bogra	<i>Dhunat</i>	Kalarpara	Hashkali	Rural
127	Rajshahi	Bogra	<i>Sariakandi</i>	Chandan Baisha	Char Chandan Baisha	Rural
128	Rajshahi	Bogra	<i>Sonatola</i>	Tekani Chukanaigar	Masharpara	Rural
129	Rajshahi	Naogaon	<i>Mohadebpur</i>	Cheragpur	Shalbari	Rural
130	Rajshahi	Naogaon	<i>Raninagar</i>	Ekdala	Banamalikuri	Rural
131	Rajshahi	Natore	<i>Lalpur</i>	Walia	Fhulbari	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
132	Rajshahi	Nawabgonj	<i>Nachole</i>	Nachole	Bechenda	Rural
133	Rajshahi	Rajshahi	<i>Bagmara</i>	Ganipur	D. Daulatpur	Rural
134	Rajshahi	Rajshahi	<i>Paba</i>	Harian	Char Khidirpur	Rural
135	Rajshahi	Serajgonj	<i>Kazipur</i>	Gandhail	Kalikapur	Rural
136	Rajshahi	Serajgonj	<i>Shahjadpur</i>	Rupabati	Chakima	Rural
137	Rajshahi	Pabna	<i>Bera</i>	Bharenga	Batiakhara	Rural
138	Rajshahi	Pabna	<i>Santhia</i>	Ataikola	Kumirgari	Rural
139	Rajshahi	Dinajpur	<i>Dinajpur</i>	1	D. Ghasipara	Urban
135	Rajshahi	Serajgonj	<i>Kazipur</i>	Gandhail	Kalikapur	Rural
136	Rajshahi	Serajgonj	<i>Shahjadpur</i>	Rupabati	Chakima	Rural
137	Rajshahi	Pabna	<i>Bera</i>	Bharenga	Batiakhara	Rural
138	Rajshahi	Pabna	<i>Santhia</i>	Ataikola	Kumirgari	Rural

Appendices

Cluster	Division	District	Thana / Upazila	Union / Parashad	Village / Block	Rural / Urban
139	Rajshahi	Dinajpur	<i>Dinajpur</i>	1	D. Ghasipara	Urban
140	Rajshahi	Nilphamari	<i>Saidpur</i>	3	Officer Colony	Urban
141	Rajshahi	Rangpur	<i>Rangpur Sadar</i>	3	Mistrypara	Urban
142	Rajshahi	Bogra	<i>Adamdighi</i>	2	Santahar	Urban
143	Rajshahi	Naogaon	<i>Naogaon Sadar</i>	3	Uttar Par Naogaon	Urban
144	Rajshahi	Rajshahi	<i>Raypara</i>	1	Guripara	Urban
145	Rajshahi	Rajshahi	<i>Boalia</i>	27	Raninagar	Urban
146	Rajshahi	Pabna	<i>Ishwardi</i>	1	Rahimpur	Urban
147	Sylhet	Sunamganj	<i>Dowarabazar</i>	Lakshmipur	Matgaon	Rural
148	Sylhet	Sylhet	<i>Balaganj</i>	Dewanbazar	Nasiarpur	Rural
149	Sylhet	Sylhet	<i>Gowainghat</i>	Purba Jaflong	Baurbhag	Rural
150	Sylhet	Sylhet	<i>Zakiganj</i>	Zakiganj	Sarishakuri	Rural

Appendices

Cluster	Division	District	<i>Thana / Upazila</i>	<i>Union / Parashad</i>	Village / Block	Rural / Urban
151	Sylhet	Moulvibazar	<i>Moulvibazar Sadar</i>	Mustafapur	Hilaipur	Rural
152	Sylhet	Hobiganj	<i>Chunarughat</i>	Ahmadabad	Sondarpur	Rural
153	Sylhet	Hobiganj	<i>Nabiganj</i>	Inathganj	Agna	Rural
154	Sylhet	Moulvibazar	<i>Moulvibazar Sadar</i>	3	Dharkapan	Urban
Total						104 Rural 50 Urban

Appendix 3. Personal publications related to the epidemiology of blindness and eye care service provision

Bangladesh

Bourne RR, Dineen B, Modasser Ali S, Mohammed Noorul Huq D, Johnson GJ. The National Blindness and Low Vision Prevalence Survey of Bangladesh: research design, eye examination methodology and results of the pilot study. *Ophthalmic Epidemiol.* 2002 Apr;9(2):119-32.

Dineen BP, Bourne RR, Ali SM, Huq DM, Johnson GJ. Prevalence and causes of blindness and visual impairment in Bangladeshi adults: results of the National Blindness and Low Vision Survey of Bangladesh. *Br J Ophthalmol.* 2003 Jul;87(7):820-8.

Bourne RR, Dineen BP, Ali SM, Huq DM, Johnson GJ. Outcomes of cataract surgery in Bangladesh: results from a population based nationwide survey. *Br J Ophthalmol.* 2003 Jul;87(7):813-9.

Bourne RR, Rosser DA, Sukdom P, Dineen B, Laidlaw DA, Johnson GJ, Murdoch IE. Evaluating a new logMAR chart designed to improve visual acuity assessment in population-based surveys. *Eye (Lond).* 2003 Aug;17(6):754-8.

Bourne RR, Dineen BP, Ali SM, Noorul Huq DM, Johnson GJ. Prevalence of refractive error in Bangladeshi adults: results of the National Blindness and Low Vision Survey of Bangladesh. *Ophthalmology.* 2004 Jun;111(6):1150-60.

Bourne RR, Dineen BP, Huq DM, Ali SM, Johnson GJ. Correction of refractive error in the adult population of Bangladesh: meeting the unmet need. *Invest Ophthalmol Vis Sci.* 2004 Feb;45(2):410-7.

Rahman MM, Rahman N, Foster PJ, Haque Z, Zaman AU, Dineen B, Johnson GJ. The prevalence of glaucoma in Bangladesh: a population based survey in Dhaka Division. *Br J Ophthalmol.* 2004 Dec;88(12):1493-7.

Appendices

Pakistan

Bourne R, Dineen B, Jadoon Z, Lee PS, Khan A, Johnson GJ, Foster A, Khan D; Pakistan National Eye Survey Study Group.. The Pakistan national blindness and visual impairment survey--research design, eye examination methodology and results of the pilot study. *Ophthalmic Epidemiol.* 2005 Oct;12(5):321-33.

Jadoon MZ, Dineen B, Bourne RR, Shah SP, Khan MA, Johnson GJ, Gilbert CE, Khan MD. Prevalence of blindness and visual impairment in Pakistan: the Pakistan National Blindness and Visual Impairment Survey. *Invest Ophthalmol Vis Sci.* 2006 Nov;47(11):4749-55.

Bourne R, Dineen B, Jadoon Z, Lee PS, Khan A, Johnson GJ, Foster A, Khan D. Outcomes of cataract surgery in Pakistan: results from The Pakistan National Blindness and Visual Impairment Survey. *Br J Ophthalmol.* 2007 Apr;91(4):420-6.

Dineen B, Bourne RR, Jadoon Z, Shah SP, Khan MA, Foster A, Gilbert CE, Khan MD; Pakistan National Eye Survey Study Group.. Causes of blindness and visual impairment in Pakistan. The Pakistan national blindness and visual impairment survey. *Br J Ophthalmol.* 2007 Aug;91(8):1005-10.

Jadoon Z, Shah SP, Bourne R, Dineen B, Khan MA, Gilbert CE, Foster A, Khan MD; Pakistan National Eye Survey Study Group.. Cataract prevalence, cataract surgical coverage and barriers to uptake of cataract surgical services in Pakistan: the Pakistan National Blindness and Visual Impairment Survey. *Br J Ophthalmol.* 2007 Oct;91(10):1269-73.

Shah SP, Dineen B, Jadoon Z, Bourne R, Khan MA, Johnson GJ, De Stavola B, Gilbert C, Khan MD. Lens opacities in adults in Pakistan: prevalence and risk factors. *Ophthalmic Epidemiol.* 2007 Nov-Dec;14(6):381-9.

Appendices

Gilbert CE, Shah SP, Jadoon MZ, Bourne R, Dineen B, Khan MA, Johnson GJ, Khan MD; Pakistan National Eye Survey Study Group.. Poverty and blindness in Pakistan: results from the Pakistan national blindness and visual impairment survey. *BMJ*. 2008 Jan 5;336(7634):29-32.

Shah SP, Minto H, Jadoon MZ, Bourne RR, Dineen B, Gilbert CE, Khan MD; Pakistan National Eye Survey Study Group.. Prevalence and causes of functional low vision and implications for services: the Pakistan National Blindness and Visual Impairment Survey. *Invest Ophthalmol Vis Sci*. 2008 Mar;49(3):887-93.

Shah SP, Jadoon MZ, Dineen B, Bourne RR, Johnson GJ, Gilbert CE, Khan MD. Refractive errors in the adult pakistani population: the national blindness and visual impairment survey. *Ophthalmic Epidemiol*. 2008 May-Jun;15(3):183-90.

Taylor AE, Shah SP, Gilbert CE, Jadoon MZ, Bourne RR, Dineen B, Johnson GJ, Khan MD; Pakistan National Eye Survey Study Group.. Visual function and quality of life among visually impaired and cataract operated adults. The Pakistan National Blindness and Visual Impairment Survey. *Ophthalmic Epidemiol*. 2008 Jul-Aug;15(4):242-9.

Nigeria

Dineen B, Gilbert CE, Rabiou M, Kyari F, Mahdi AM, Abubakar T, Ezelum CC, Gabriel E, Elhassan E, Abiose A, Faal H, Jiya JY, Ozemela CP, Lee PS, Gudlavalleti MV. The Nigerian national blindness and visual impairment survey: Rationale, objectives and detailed methodology. *BMC Ophthalmol*. 2008 Sep 22;8:17.

Appendices

Additional peer-reviewed ophthalmology publications

Dineen B. Health promotion and community participation in eye care services. *Community Eye Health*. 1999;12(31):35-6.

Bourne RRA, Rosser DA, Sukudom P, Dineen B, Laidlaw DAH, Johnson GJ, Murdoch IE. Evaluating a new logMAR chart designed to improve visual acuity assessment in population-based surveys. *Eye*. 2003 Aug; 17(6):754-758.

Wedner S, Dineen B. Refractive errors. *Trop Doct*. 2003 Oct;33(4):207-9.

Dineen B, Foster A, Faal H. A proposed rapid methodology to assess the prevalence and causes of blindness and visual impairment. *Ophthalmic Epidemiol*. 2006 Feb;13(1):31-4.

Mpyet C, Dineen BP, Solomon AW. Cataract surgical coverage and barriers to uptake of cataract surgery in leprosy villages of north eastern Nigeria. *Br J Ophthalmol*. 2005 Aug;89(8):936-8.

Faye M, Kuper H, Dineen B, Bailey R. Rapid assessment for prioritisation of trachoma control at community level in one district of the Kaolack Region, Senegal. *Trans R Soc Trop Med Hyg*. 2006 Feb;100(2):149-57.

Oye JE, Kuper H, Dineen B, Befidi-Mengue R, Foster A. Prevalence and causes of blindness and visual impairment in Muyuka: a rural health district in South West Province, Cameroon. *Br J Ophthalmol*. 2006 May;90(5):538-42.