THE ECONOMICS OF CHILDHOOD EYE DISEASES AND DEVELOPING AND TESTING OF QUALITY-OF-LIFE UTILITY VALUES

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DOCTOR OF PHILOSOPHY (Ph. D)

in

Health Sciences

(Public Health)

by

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CERTIFICATE

This is to certify that the thesis entitled **"The Economics of Childhood Eye Diseases and Developing and Testing of Quality-of-Life Utility Values"** submitted by **Sunny Mannava** bearing **Reg. No. 19MUPH04** in partial fulfilment of the requirements for award of **Doctor of Philosophy** in **Public Health** is a bonafide work carried out by him under my supervision and guidance.

This thesis is free from plagiarism and has not been submitted previously in part or in full to this or any other university or institution for award of any degree or diploma. The student has the following publications before submission of the thesis for adjudication and has produced evidence for the same.

1. Mannava S, Borah R, Shamanna B. Current estimates of the economic burden of blindness and visual impairment in India: A cost of illness study. *Indian J Ophthalmol*. 2022;70(6):2141. doi:10.4103/IJO.IJO_2804_21.

2. Shamanna BR, Mannava S, Borah R, Sethu S, Chandra D. Cost-benefit analysis of investing in child eye health. *(Orbis International, ed.)*. New Delhi; 2022. doi:10.13140/RG.2.2.14514.38082.

3. Mannava, S., & Shamanna, B. R. (2023). Cost-effectiveness analysis of child eye health interventions in India. *European Journal of Public Health*, 33(Supplement_2), ckad160-1301. doi: 10.1093/eurpub/ckad160.1301.

The student has presented in the following conferences:

1. "Current estimates of the economic burden of blindness in India" at the Eye Health in a Changing World - Virtual International Conference and Trade Fair, October 2020. doi:10.13140/RG.2.2.21951.89768

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DECLARATION

I, **Sunny Mannava**, hereby declare that this thesis entitled **"The Economics of Childhood Eye Diseases and Developing and Testing of Quality-of-Life Utility Values"** submitted by me under the guidance and supervision of **Prof. B. R. Shamanna**, School of Medical Sciences, University of Hyderabad, is a bonafide research work. I also declare that it has not been submitted previously in part or in full to this University or any other University or Institution for the award of any degree or diploma. A report on plagiarism statistics from the University Librarian is enclosed. I hereby agree that my thesis can be deposited with the shodhganga/INFLIBNET.

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I would like to begin by expressing my gratitude to my God and savior Jesus Christ and submit this thesis to His glory.

'...whatever you do, do it all for the glory of God.' - 1 Corinthians 10:13

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This thesis is dedicated to my family members and my supervisor Prof. B. R. Shamanna for their limitless support, encouragement and to you as a reader

ABSTRACT

India has a large population and thereby a lot of people with blindness and vision impairment specially amongst children. There have been a lot of eye health programs implemented to address blindness and vision impairment in India in the past two decades which have reduced the burden of avoidable eye diseases significantly. This PhD work has aimed to study the economics of childhood eye diseases and thereby contribute to the literature the economic burden of blindness and vision impairment and estimate the QALY utility values which can be used to undertake economic evaluations of eye care programs in India. We have used secondary data to undertake the burden of disease study; and used prospective longitudinal study design for comparison of change in utility values before and after intervention. We have used EQ-5D-Y health state valuation tool. Costs of interventions were calculated at prevailing rates. Sensitivity analyses were performed to account for uncertainties in the data. Data analyses were performed using R application. The estimated net loss of GNI due to blindness in India is INR 845 billion (Int$ 38.4 billion). Net loss of GNI due to blindness in children is INR 13 billion. The total cumulative loss of GNI due to blindness is INR 19,512 billion and cumulative loss due to avoidable blindness is INR 11,778.6 billion. The average improvement of the utility values of vision impairment, blindness, strabismus, pediatric cataract, and amblyopia was 0.15. The ICER for blindness is INR 36,783 and pediatric cataract is INR 95,769. From the study, we have found that the interventions to address blindness and vision impairment are cost-effectiveness and are lower than the willingness to pay of individuals in India. Early intervention of eye diseases

in children significantly reduces the cumulative loss of GNI specially due to avoidable causes. The utility values estimated in this study contribute to the literature and help in conducting economic evaluations of eye health programs and undertake informed decisions regarding scarce resource allocation.

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Abbreviations

QALY	Quality Adjusted Life Year
DALY	Disability Adjusted Life Years
VisQoL	Vision related Quality of Life
vNM	Von Neumann–Morgenstern
VAS	Visual Analogue Scale
B-VAS	Baseline Visual Analogue Scale Score
PI-VAS	Post-Intervention Visual Analogue Scale Score
BCVA	Best Corrected Visual Acuity
ICD-10	International Classification of Diseases-10th Revision
RCT	Randomized Control Trial
RE	Refractive Error
NAD	No Abnormality Detected
ONH	Optic Nerve Hypoplasia
VKC	Vernal Kerato-Conjunctivitis
PCG	Primary Congenital Glaucoma
POAG	Primary Open Angle Glaucoma
PACG	Primary Angle Closure Glaucoma
AMD	Age Related Macular Degeneration
NICE	The National Institute for Health and Care Excellence
DR	Diabetic Retinopathy
CEA	Cost-Effectiveness Analysis
CUA	Cost-Utility Analysis
CoI	Cost of Illness
HTA	Health Technology Assessment
DCE	Discrete Choice Experiments
WTP	Willingness To Pay
GNI	Gross National Income
GDP	Gross Domestic Product
GNP	Gross National Product
ICER	Incremental Cost-Effectiveness Ratio
VI	Vision Impairment
MiVI	Mild Vision Impairment
MoVI	Moderate Vision Impairment
SeVI	Severe Vision Impairment
MSVI	Moderate and Severe Vision Impairment
EQ-5D-Y	EuroQol-Five-Dimension-Youth
HUI	Health Utility Index
SF-6D	Short From-Six Dimension
NEI-VFQ	National Eye Institute-Visual Function Questionnaire
TTO	Time Trade Off
SG	Standard Gamble

RS	Rating Scale
INR	Indian Rupee
GBP	Great Britain Pound Sterling
USD	United States Dollar
PPP	Purchasing Power Parity
AGR	Annual Growth Rate
CI	Confidence Interval
IQR	Inter-Quartile Range
GEE	Generalized Estimating Equation
IMF	International Monetary Fund
WHO	World Health Organization
COVID	COrona VIrus Disease
IPCEC	Integrated People-Centered Eye Care
UK	United Kingdom
USA	United States of America
SNC	Shri Sadguru Netra Chikitsalaya
MRN	Medical Record Number
IEC	Institutional Ethics Committee

Nomenclature

List of symbols

CL_{Xi} Cumulative loss of GNI

N_i Net loss of GNI

DW_x Disability Weights

U Utility Value

β Generalized Estimating Equations parameter

Δ Difference between two measures

CHAPTER 1

Introduction

India, with a large population in the world also has a high number of young people which has a demographic dividend for the country; however, it also shows that the economic burden of diseases also would be very high over the lifetime of individuals to the country. Eye diseases and blindness are few such conditions. Blindness and vision impairment are majorly caused due to cataract and refractive error in India with a large proportion of blind children than the rest of the world, blindness affects close to 2% of those aged above 50 years in India.[2–6] There are a lot of eye care programs aimed at reducing the burden of blindness and vision impairment.[7–10] These programs are constantly competing with other healthcare programs and interventions for scarce financial resources. Funding agencies rely on adequate knowledge and scientific evidence related to these programs and interventions to prioritize and allocate these scarce resources.

The use of "Health Economics" helps us in studying and understanding various programs and interventions and make informed economic decisions on allocation of scarce resources.[11] "Cost of illness", "Cost-effectiveness", and "Cost utility" analyses are few methods used to evaluate programs and interventions.[12] "Cost of illness" method is used to study the burden of a disease, "cost-effectiveness" analysis is used to study the effectiveness of a program or intervention according to the costs and consequences of the program or intervention which are measured in standard units , "cost utility" analysis is used to study whether a program or intervention produces outcomes that incorporates "quality and length of life" which is usually expressed as "Quality Adjusted Life Years (QALYs)".[13] To study the "quality of life" related to a specific condition such as blindness, researchers need to rely on dis-aggregate data and values such as utility values which are condition specific and change according to the presence of co-morbidities, socio-economic condition, and geographic location of the individual. The utility values allow the stakeholders to use them as common denominators to analyse and compare costs versus consequences and take programmatic decisions.

1.1 Rationale

Although there has been considerable development in the reduction of the prevalence of avoidable blindness in India, these developments particularly focused on addressing cataract and refractive errors amongst adult population. Research proves that early intervention in a child's eye health leads to better overall development, health, and socio-economic outcomes later in life.[14–16] However, due to lack of data related to precise outcomes, utility values and cost of interventions, researchers find it incomplete to advocate for an economic argument to key stakeholders including policy makers to invest in child eye health, particularly early screening, and detection of eye diseases. In developed economies with universal healthcare, HTAs are undertaken periodically to evaluated programs and interventions. As India embarks on adopting and framing key HTA guidelines under the National insurance schemes, its implementation is needed in various fields, and eye health. Our objectives are to present the overall economic burden of disease which would inform key stakeholders towards an economic argument, followed by estimating utility values for eye health conditions and outcomes, and thereby be in a position to perform a cost-effectiveness analysis using these utility values which would complete HTA of eye health conditions and interventions. These aims are achieved using a cost-of-illness study, utility assessment, and finally plan for a cost-effectiveness analysis.

1.2 Research objective

To study the economics of child eye health in India such as methods and practices to undertake full economic evaluations of eye care interventions and programs in India.

1.3 Organization of thesis

This thesis is structured to provide a systematic and comprehensive exploration of the research topic. It is organized into the following chapters, each serving a specific purpose:

Chapter 1: Introduction

This chapter, which you are currently reading, lays the foundation for the research. It introduces the aim, research question, and significance of the study. It also provides an overview of the organisation of the thesis.

Chapter 2: Background

This chapter provides a brief overview of the various methods of economic evaluations.

Chapter 3: Review of Literature

This chapter conducts an extensive review of the literature related to cost-of-illness studies, various utility value estimations, methodologies, existing literature on cost-effectiveness analysis in general and specific to ophthalmology, costing methodologies, Willingness To Pay (WTP), and gaps in the existing literature, . It examines prior research, theoretical frameworks, and empirical studies related to the research topic. This chapter aims to establish the context in which the current study is situated.

Chapter 4: Objectives

This section provides the three objectives of my PhD thesis.

Chapter 5: Methods

In this chapter, the research methodology employed in the study is detailed. It includes information on data collection methods, data analysis techniques, and the rationale behind these choices. Additionally, ethical considerations are discussed.

Chapter 6: Results

Chapter 6 presents the key findings of the three objectives. It includes tables, figures, and descriptions of the "economic burden of blindness and vision impairment", utility value estimations, cost data, and "cost-effectiveness" analysis.

Chapter 7: Discussion and Recommendations

This chapter engages in a thorough discussion of the research findings. It explores the implications of the results, highlights their significance to child eye health and economic evaluations; strengths and limitations and future directions of research.

Chapter 8: Conclusion

This chapter offers conclusive remarks and recommendations based on the research outcomes.

References

Lists all the references cited in the thesis in IEEE citation style.

Appendix

It includes study tools such as the instruments and forms used in the research.

Throughout the thesis, an effort has been made to maintain clarity and coherence, ensuring that readers can follow the logical progression of the research. We encourage readers to refer to the specific chapters of interest for a detailed exploration of each aspect of the study.

1.4 List of publications

1. Mannava, S., Borah, R. R., & Shamanna, B. R. (2022). Current estimates of the economic burden of blindness and visual impairment in India: A cost of illness study. Indian Journal of Ophthalmology, 70(6), 2141-2145.

2. Shamanna BR, Mannava S, Borah R, Sethu S, Chandra D. Cost-benefit analysis of investing in child eye health. (Orbis International, ed.). New Delhi; 2022. doi:10.13140/RG.2.2.14514.38082.

3. Mannava, S., & Shamanna, B. R. (2023). Cost-effectiveness analysis of child eye health interventions in India. *European Journal of Public Health*, 33(Supplement_2), ckad160-1301. doi: 10.1093/eurpub/ckad160.1301.

Manuscripts under preparation:

4. Mannava, S., Borah, R. R., & Shamanna, B. R. (2023). Developing and testing of QALY utility values for specific eye conditions in India.

5. Mannava, S., Borah, R. R., & Shamanna, B. R. (2023). Cost-effectiveness analysis of investing in child eye health.

CHAPTER 2

Background

"Cost of illness" (CoI) studies help us in studying and understanding the financial impact of a disease and are expressed as loss of productivity, costs related to medical or surgical treatment of eye conditions, cost of hospitalisation, and partially estimate the "cost to the society".[17–19] We have used this methodology to estimate the economic costs related to blindness and vision impairment. Although, it is possible to study the economic costs associated with any type of ocular condition, due to lack of condition specific data and region specific population prevalence, and economic data, we focused only on blindness and vision impairment. This study estimated the data for the year 2020 in terms of the productivity losses due to persons not being able or partially able to work due to blindness and vision impairment.

Cost Utility analysis is used to study the significance of an intervention or a healthcare program on an person's quality and length of life and is quantified using Quality Adjusted Life Year (QALY) measures.[20] These analyses are significant as they highlight the societal impact of an intervention or program. Utility values are integral part of QALY measures as they are specific to the eye condition and the socio-economic condition of the individual. Utility Values are an individuals preferred health state scored on a scale of '0' and '1' where '0' is a health state equivalent to death and '1' is a health state equivalent to being in perfect health.[21] There are various ways of measuring an individual's health state, such as by using generic choice based preference methods such as EuroQol-Five Dimension questionnaire, Health Utility Index, and Short Form Six Dimension which are based on multi-attribute utility theory.[22–24] The other methods include time-trade off, standard gamble, and Visual

Analogue Scale (VAS). In our research we could not find tools specific to elicit a child's health apart from EQ-5D-Y and hence we have used this measure to study the utility values for child eye health outcomes; this also allows us to compare the interventions horizontally with any specialization.

Cost-Effectiveness Analyses (CEA) are used to study the costs and consequences in terms of the effectiveness of an intervention using specific outcome variables such as improvement in quality of vision, quality of life, life expectancy, improvement in visual acuity, and reduction in Intra-Ocular Pressure (IOP). The consequences are typically projected over a time horizon such as the improvement in the patients health condition over a period of time, or improvement in the longevity or length of life such as patients surviving at the end of a clinical trial. CEAs help in measuring the cost per unit improvement in the outcome variable over a period of time. CEAs of eye health interventions and programs help in studying the cost per intervention or program and comparing them with other programs to understand the most effective intervention or program according to patient or society's Willingness To Pay (WTP). This study aimed at understanding the cost-effectiveness of various interventions related to child eye health conditions.

CHAPTER 3

Review of Literature

Child eye health is a critical component of overall well-being and development, with profound implications for individuals, families, and societies as a whole.[25–27] The economic dimensions of child eye health are long-term costs and quality of life for the affected individual as both are affected with an early intervention. However, it is important to recognize that the importance of these early interventions may vary depending on the specific eye condition, and larger socio-economic and demographic context.[28] The sections in this review of literature will delve into the key concepts of economic evaluation or Health Technology Assessments (HTAs), methodologies used in HTAs, current evidence and finding in relation to childhood eye conditions.

3.1 Epidemiology of Childhood Eye Diseases

Globally, there are close to 295.1 million people with moderate to severe vision impairment and 43.3 million people blind.[29] There are close to 5 million (0.36%) blind people, 35 million vision impaired people, and 250,000 children with blindness in India.[2] Blindness and vision impairment are majorly caused due to cataract and refractive errors respectively in India.[2, 3, 5, 14]. According to Wadhwani et. al, the incidence of childhood blindness and vision impairment in North India was estimated as 0.42 per thousand, and 5.92 per thousand respectively, and a higher prevalence of “Moderate to Severe Vision Impairment” (MSVI) was observed amongst adolescents.[4] Low income countries have a

Parameter	Number (%)
Total Population	1.38 Billion
Total Children	399 Million (29%)
Blindness (Overall)	4.95 Million (0.36%)
Blindness (Children)	0.24 million (0.06%)
Vision Impairment (Children)	2.05-13.6 per 1,000 children
Childhood Cataract	0.63-13.6 per 1,000 children

Table 3.1: Prevalence estimates - India
[2, 3, 14]

higher prevalence of childhood cataract compared to high income countries.[30] There are very few global epidemiological data on children and young adults as there are very few studies carried out on children.[31] The prevalence and incidence estimates of blindness and vision impairment in India are presented in the Table 3.1.

3.1.1 Causes of Childhood Blindness and Vision Impairment in India

The major causes of blindness in children in India are due to whole globe anomalies, retinal, lenticular, corneal, and glaucoma.[14]. According to population based studies, the major causes are due to cornea related and refractive errors.[14] With the highest number of pre-term births in the world, there is a higher risk of Retinopathy of Prematurity (RoP) for children in India.[32, 33] The various causes of blindness as per the anatomical site are listed in the table 3.2

Anatomical Site	Percentage of Blindness (%)
Whole Globe	16.7-54.4
Retina	3.3-44.4
Cornea	8.1-35.7
Lens	6-42.9
Optic Nerve	5.4-28.6
Glaucoma	2.6-29.6
Uvea	1.1-14.3
Other	0.8-40.2

Table 3.2: Percentage of Blindness in India as per the Anatomical Site [14]

3.1.2 Healthcare Spending in India and the Impact of Childhood Blindness and Vision Impairment on the National Economy

Blindness and vision impairment led to a loss of USD 410.7 billion PPP in productivity globally.[34] Productivity loss due to blindness was USD 43.6 billion PPP, and due to MSVI was USD 367.1 billion PPP.[34] A recent systematic review has estimated the globally USD 193.36 billion PPP are lost in productivity due to vision impairment and the direct medical costs were USD 2,645.06 billion PPP in 2018, however there was high variation in the data and the methods used in various studies were very different from each other and there is a lack of generalizability from the data.[35] There were limited data available on the economic impact of childhood blindness and vision impairment globally.[35] In India, the average expenditure on eye ailments per stay is INR 2605, INR 18,767 and INR 10,912 in

Type	Expenditure (INR)
Total Expenditure on Healthcare	1.33% of GDP
Average Expenditure in Public Hospitals	2,605
Average Expenditure in Private Hospitals	18,767
Average Expenditure in Other (NGO) Hospitals	10,912

Table 3.3: Healthcare Expenditure in India

public hospitals, private hospitals and others, including NGO hospitals respectively which indicates that people spend more than six times at a private hospital for care, compared to a Government enabled facility.[36] India spent about 1.33 percent of GDP in health sector in 2017-18, compared to 1.19 percent in 2015-16; table 3.3 describes overall expenditure at various types of hospitals in India.[36] Data specific to spending on child eye care were not available.

It is evident from the literature that the prevalence of blindness specially amongst children is particularly high in India. As evident from global data, the productivity losses due to eye ailments is significantly high. However, such data are not available for eye care in India in order to make informed choices.

3.2 Health Economics and Ophthalmology

Health economics is a specialized field of economics which helps in studying the allocation of scarce resources in healthcare. It involves the application of economic principles and methodologies to analyze the ”production, distribution, and consumption” of health and healthcare services.[11, 37] It helps in studying and understanding about healthcare resource allocation, healthcare policy, and the efficiency and effectiveness of healthcare systems. Economic evaluation is a fundamental tool within health economics. It is used to assess the economic implications of eye care interventions, programs, and policies. Economic evaluations are used to study and determine:[38]

- Efficiency: Whether eye care resources are being used efficiently. They help in identifying which intervention or programs provide most health benefit for a given amount of money.[12, 39]
- Resource allocation: To guide resource allocation decisions. These are particularly true on taking decision on prioritizing resources towards a cost-effective intervention or program.[11]
- Informed decision making: Economic evaluation provides a holistic view of the intervention or program thereby helping evidence-based decision making on which policies to implement.[12]
- Value for money: Economic evaluations help in studying whether a particular cost related to an eye care intervention produces the best consequences for the individual and the community at large. They help in these comparisons and help identify opportunities to improve efficiency of spending in eye care.[40, 41]

In our literature review, we have found very few studies related to eye care programs and evaluations and their economic evaluations. There were a few Health Technology Assessments (HTAs) done to study effectiveness of interventions such as surgical techniques in ophthalmology, and eye care programs using cost-benefit and cost-effectiveness analyses.[42–45] However, they do not inform about the societal perspective and hence to study the individual and societal perspectives of an intervention, cost-utility analyses need to be undertaken. A cost-effectiveness analysis study was undertaken in south India in 1991 which carried out a detailed costing of cataract surgery and barriers,[44] however, this study cannot be considered full economic evaluation according to the guidelines and modern methods of economic evaluations.[12] The use of health economics concepts in

Ophthalmology helps provide insights on costs of an intervention or an eye care program and their consequences in terms of institutional, individual, or societal perspectives. The methods used in HTAs are “Cost-Benefit Analysis, Cost of Illness analysis, Cost-Utility analysis, and Cost-Effectiveness analysis”; depending on the purpose, condition being analyzed, and the intervention, a specific type of HTA is undertaken by researchers and stakeholders.[11, 12] Cost-Benefit Analysis analyses a program or intervention using same denominator, where benefits are measured in monetary terms and are mostly carried out in market research. In this thesis we have given a background on “Cost of Illness analysis, Cost-Utility analysis, and Cost-Effectiveness analysis.”

3.2.1 Cost of Illness studies - Burden of Eye Diseases

A cost of illness study comprehensively quantifies the economic burden associated with a specific disease or health condition on the society.[17, 46, 47] This type of study uses assumptions and considers direct and indirect costs which include absenteeism and presenteeism, lost productivity, and caregiver’s loss of income due to the specific illness in order to estimate the economic burden of a disease or condition.[48] By estimating the total economic impact, policymakers and healthcare providers can better understand the financial implications of a disease and allocate resources effectively. The findings are also used for advocacy. They involve estimating the economic burden using components such as Direct Costs (medical costs related to a particular health condition such as consultation costs, treatment costs, and medication costs), Indirect Costs (costs related to missed working days, and caregiver’s forgone wages), and Intangible Costs (non-monetary consequences on the quality of life of the patient and caregiver).[49] They focus on the economic consequences of a disease and not on the cost of an intervention to address the disease. Lost productivity and absenteeism are estimated based on data related to percapita contribution to Gross National Income (GNI) and wages; these measures are different for each country and vary in each region of the country and often these data are not available for each region and hence researchers rely on surrogate measures or only estimate for the entire country.[34] GNI represents the cumulative income generated by both businesses and the total population.[50] Economic burden of a disease is influenced by total affected population. There was an economic burden of blindness study done in 1998 which estimate the total GNI loss due to blindness to be INR 572.4 billion after adjusting to inflation (reference year 2020).[51] Prevalence of blindness in India has almost halved in absolute numbers in the twenty years due to several initiatives by various stakeholders, however, there are no cost of illness studies carried out in India after that.

3.2.2 Cost-effectiveness Analysis (CEA)

A cost-effectiveness analysis (CEA) study evaluates the efficiency of two or more healthcare interventions or treatments in relation to each other by comparing the costs with their outcomes (consequences).[52, 53] They may use generic measures like QALY, but also use indicators or outcomes specific to the condition being studied to compare with the costs of the intervention.[40] They help in studying which interventions provide the best value for money to achieve the desired health outcome.[54] In CEA, efficiency is based on the ratio of inputs and outputs.[39] These comparisons are done using "Incremental Cost-Effectiveness Ratios" (ICERs) which can be used to setup thresholds for each intervention.[13] Criticism also exists in the scientific community on the use of thresholds in decision making without accounting for opportunity costs.[55] The denominator in an ICER is a measure of benefit often expressed in natural units such as number of QALYs gained or 'life years gained' due to an intervention.[56, 57] Few studies in ophthalmology have used both CEA and CUA together to show ICERs and cost per QALY or cost per a specific outcome gained post intervention and they are common in clinical trials.[45, 58–60] CEAs are used in situations where stakeholders have to make decisions in a limited budget, and limited number of options. [12] CEAs are often compared with Willingness to Pay (WTP) for the specific intervention as seen in a study where cost-effectiveness of amblyopia screening programs have shown that they are effective at a WTP USD 10,500.[57] CEAs rely on detailed measurement of costs associated with the condition and the intervention being analysed.

Cost Analysis

They rely on costs associated with interventions which are estimated in a "top-down" or a "bottom-up" or a mixed approach and often are harder to estimate and need huge financial and human resources to carry out such studies.[39, 40] Recently, methodological guidelines have been advised in carrying out such costing exercises and can drive research in this field specific to ophthalmology in India.[61] Costs associated with a condition may be related to a specific program or intervention. These costs can be anything related to costs associated with buying medication, availing surgical treatment, availing therapy, transport costs, boarding and lodging costs if a hospital is very far, and lost income due to absenteeism. When these costs are measured directly from the patient or societal perspective, it is called a bottom-up approach of measuring costs. When these costs are measured from institution or a hospital where the care is being delivered, this approach is called a top-down approach of measuring costs. It is often not possible to use either of these approaches in their entirety and hence a mixed method approach to costing is carried out where some costs are measured in a bottom-up approach and some are measured in a top-down approach.[11, 40] Once costs are measured, they are categorized as Direct Medical, Direct Non-Medical, and Indirect Costs. Effectiveness is measured in natural units such as cases prevented, years of life gained, or symptom free days. In costing, time horizon is important to measure costs as short-term or long-term, as an early intervention may have significant life-long impact. Discounting has to be undertaken while undertaking long-term analysis to account for time-value of money.[11] Cost have to be attributed to societal or individual perspective.[40] Sensitivity analyses have to be carried out to account for uncertainties in cost data. Various studies have used various methods of measuring cost data in healthcare but there are very limited number of costing studies undertaken in eye care in India.[12, 45, 62–65]

Incremental Cost-Effectiveness Ratio (ICER)

ICER is a ratio which measures the difference in costs of two interventions with the consequences (effectiveness) of the two interventions.[66] ICERs help us understand the cost per unit health gain compared to an alternative.[11, 66] They are particularly useful in determining if an intervention is cost-effective compared to an alternative.[66, 67]

Willingness to Pay

"Willingness to Pay" (WTP) is a concept in health economics that measures the monetary value individuals are willing to allocate to gain a specific health-related benefit or to avoid a health risk or negative outcome. WTP is influenced by various contextual factors such as an individual's income, preferences, health status, and the specific health benefit being considered. Estimating WTP accurately can be challenging due to factors like hypothetical bias, and disparities in income and access to healthcare and WTP is influenced by age, wealth, location, surgeon, co-morbidity, and marital status.[68–70] In our literature review, we have found studies in India which have studied the proportions such as number of people coming to the hospital who are willing to pay for a surgery or service but we did not find any study on actual WTP in monetary terms.[71–73] International literature search showed a WTP for cataract as low as USD three dollars to as high as GBP 1,964 (not adjusted for inflation, no currency conversion, and no discounting done on these values).[74, 75] A table of WTP for various interventions and ocular conditions from existing literature is provided in Tables 3.4 and 3.5.

In our literature review we have found evidence that there is a high variation in the WTP for a particular condition such as cataract from as low as USD 2.3 in Tanzania and Nepal and to as high as GBP 1,964 in the UK. This shows that WTP has high variability to socio-economic conditions and literacy of the population being studied. WTP is also influence by the specific types of questions asked to the participants in the studies and what type of

S. No.	Author, Year	Location	Type of Study	Condition-Intervention	WTP	Remarks
1	Gazzard et al, 2019[76]	UK	RCT	Glaucoma - Trabeculo-plasty	GBP 20,000 per QALY gained	
2	Ghahramani et al, 2022[68]	Iran	Survey	DR risk reduction due to DM	USD 374.5 Vs risking complications	
3	Zhang et al, 2021[77]	China	Survey	Cataract	USD 145	No QALY measure
4	Islam et al, 2019[78]	Bangladesh	Survey-Contingent valuation	Cataract - SICS and Phaco-emulsification	SICS - USD 93 Phaco - USD 126	
5	Dean et al, 2012[74]	Malawi	Survey	Cataract	USD 3	No QALY measure
6	Seid et al, 2021[79]	Ethiopia	Survey-Contingent valuation	Cataract	USD 17.5	No QALY measure
7	Frampton et al, 2014[80]	UK	Systematic Review	CEA of second eye cataract	GBP 1,750 per QALY	ICER

Table 3.4: Literature review of WTP studies

S. No.	Author, Year	Location	Type of Study	Outcome measure	WTP	Remarks
8	Wang et al, 2015[69]	China	Survey	Cataract	USD 968	No QALY measure
9	He et al, 2007[81]	China	Survey	Cataract	USD 55	No QALY measure
10	Ibrahim et al, 2018[82]	Nigeria	Survey	Cataract	USD 18.5-51.2	No QALY measure
11	Shrestha et al, 2004[83]	Nepal	Survey	Cataract	USD 2.3	No QALY measure
12	Ko et al, 2012[84]	China	Survey	Cataract - Senior Surgeon and imported IOL	USD 50-89.4	No QALY measure
13	Lewallan et al, 2006[85]	Tanzania	Survey	Cataract	USD 2.3	No QALY measure
14	Cooper et al, 2015[75]	UK	Survey	Cataract - Second Eye	GBP 1,964 per QALY	ICER
15	Ebri et al, 2023[86]	Nigeria	Survey	Spectacles for refractive error	USD 8.9	-

Table 3.5: Literature review of WTP studies - continued

alternative are offered to the standard treatment of choice to the participant.[12] Literature on WTP specific to eye care also suggests a lot of studies focusing predominantly on cataract, some on glaucoma and DR which is probably due to the fact that cataract is the major cause of curable blindness.[2] We could not find much literature specific to interventions to eliminate childhood blindness and vision impairment in India as it is evident from the literature that WTP is influenced by age and could be very different in children.[73, 87]

CEA results in a cost-effectiveness ratio that indicates how much additional benefit is obtained for each additional unit of cost when comparing different interventions. Policymakers and stakeholders can use this information to allocate resources efficiently.

3.2.3 Cost-Utility Analysis (CUA) - Utility Values and Quality Adjusted Life Years (QALYs)

A cost utility study focuses on studying the value of interventions and programs based on their impact on a patient's quality of life. "Quality-Adjusted Life Year" (QALY) is used as an outcome unit of measure in CUA. Costs are compared with QALYs which act as a common denominator for any intervention or program and allow comparisons horizontally. By comparing the costs of interventions with the gained QALYs, researchers and decision-makers can determine the cost-effectiveness of various treatments and interventions. QALYs rely on utility values which could be generic or condition specific and are influenced by the socio-economic condition of the individual or population.[38, 64, 88] Lack of literature on utility values for various ocular conditions often makes it difficult to carry out cost-utility analysis in India.

Quality Adjusted Life Years (QALY)

An individual's 'length of life' (reduced mortality) and 'quality of life' (reduced morbidity) are expressed using QALYs. QALY is a health benefit measure that is used to quantify the consequences of a health state with or without an intervention.[89] QALY establishes a common measure for health state for a year in full health. QALY is a preference-based health status measure. [12, 64] Each health condition is rated with a quality adjustment weight and the time lived in that particular condition is then multiplied with the weight to estimate the QALY; the same is repeated to estimate the gain in QALY post-intervention.[11, 90, 91] The health states and the health gains are measured using various methods to produce "condition specific measures" or "generic measures".[92] "Condition specific measures" show the health state due to a particular condition, a "generic measure" focuses on overall health by measuring various dimensions (physical and mental health) of a person's health which may be influenced by any type of disease or condition. The "generic measures" of health gain are expressed as "Quality Adjusted Life Years (QALY)" or "Disability Adjusted Life Years (DALY)", DALYs are also recommended in HTAs by WHO.[93] QALYs may have limitations related to theoretical assumptions wherein minor changes in the utility may be regarded as insignificant although clinically significant; context in which they are measured, often raising concerns about comparability of the data; and ethical issues such as weighing one life/ condition to be better than the other based on the value on a scale of '0' and '1'.[94]

Various methods of measuring preferences for health states

Health states are the preference values people put on their health condition which is influence by various factors discussed earlier.

Patient Reported Outcome Measures (PROMs):

"PROMs are any communication directly from the patients about their overall health which may be influenced by a specific condition." They are objectively measured without any interpretation by the care provider. They help in documenting about the patient's health across several dimensions and quantitatively score the health state.[95–97] PROMs focus on the patient's perspective and help in patient centered clinical decision making. They are increasingly used to understand the change in patient's perceived health state before and after an intervention.[97] They are used in all health and medical care fields including ophthalmology. PROMs consist of standardized questionnaires with specific response options for the patients. The questionnaires are checked for reliability, validity, and responsiveness for the condition which it is intended to be used. PROMs are used in research and clinical practice. Their use in regular clinical practice is increasingly advocated across various fields.[98] They are designed and adapted for use in different cultural and language setups. “EQ-5D, NEI-VFQ, SF6D, and HUI-3” are few of the PROMs used in health care and ophthalmology.

Measuring health state preference:

There are various ways of measuring the preferences for health states, we have highlighted the most used and suggested health state measures used generally and in ophthalmology.

- **Visual Analogue Scale (VAS)**
  - It measures health state on an interval scale such as a line between ‘0’ and ‘100’ where ‘0’ depicts a health state which is the worst possible such as being dead and ’100’ depicts being in healthiest state; individuals are asked to mark the current state of health on the scale. VAS is useful for tracking changes in an individual’s health state over time.
- **Standard Gamble**
  - It is based on “von Neumann and Morgenstern (vNM) utility theory”.[99, 100] It presents the participants with a choice between two hypothetical outcomes: a certain outcome, and a gamble with uncertain outcome. Respondents are asked to specify the probability of success (success of an intervention) at which they would be indifferent between the two options. Preference scores are derived from this probability thereby quantifying the trade-offs between certain and uncertain outcomes.

- **Time Trade-Off (TTO)**
  - Developed by Torrence et al., TTO is another widely used technique for assessing health state preferences.[101] TTO asks individuals to make trade-offs between "length of life" and "quality of life".[102] Survey participants are given a hypothetical situation in which they have to decide between a shorter lifespan in excellent health and a longer life while dealing with a particular health condition.[103] Preference scores are calculated by determining the number of years in optimal health that would be considered equal to a longer life of lower health quality.[103] These provide the trade-offs people are willing to accept, thereby studying the health preference.
- **Short Form 6D (SF6D)**
  - SF-6D is a preference-based tool that assesses an individual's health status based on six aspects: physical functioning, limitations in roles, social functioning, pain, mental well-being, and vitality.[104] It's derived from the Short Form 36 (SF-36) questionnaire, where a person's answers to questions related to these dimensions are transformed into numerical utility values through a specific scoring system.[23, 105]
- **Health Utilities Index (HUI)**
  - "The Health Utilities Index (HUI)" is a system of multi-attribute utility instruments. HUI measures health state preference across dimensions such as mobility, vision, hearing, speech, cognition, emotion, and pain.[106] There are two versions currently in-use namely HUI2 and HUI3, each with its own set of attributes and dimensions. Each of these instruments has its respective scoring system.[24]
- **EuroQol-5 Dimension (EQ-5D)**

- ”EQ-5D” is a widely utilized tool designed to assess health states across five dimensions: “mobility, self-care, typical activities, pain/discomfort, and anxiety/depression”.[107] This instrument employs econometric modeling to assign scores on a health value scale that ranges from 0.0 (representing a state of being deceased) to 1.0 (indicating perfect health).[88] To calculate the final utility value for a specific health condition or disease, individuals’ preference responses to each dimension are scored using value sets tailored to different populations.[108] A modified version known as EuroQol-5 Dimension-Youth (EQ-5D-Y) was developed to make the language more suitable for use among children and adolescents.[108–110] Various country-specific value sets, serving as scoring algorithms, are employed to score responses and calculate utility values.[109, 111]

- **National Eye Institute Visual Function Questionnaire (NEI-VFQ)**
  - It is a health assessment tool designed for specific health conditions, used to evaluate how vision-related issues affect the daily lives and overall well-being of individuals.[112–114] The “NEI-VFQ” 25-item questionnaire has been correlated with EQ-5D for the purpose of making comparisons.[115] However, it’s worth noting that there hasn’t been an adaptation of this instrument specifically tailored for children.[115, 116]

In addition to the mentioned methods of health preference measurement, one study proposes the computation of utility values based on visual acuity with the following equation:

“U = (0.374)(visual acuity in better-seeing eye) + 0.514”

This study was done on Canadian population and in an institutional setup, it may not be generalized as using visual acuity does not account for socio-demographic and economic factors.[117] A study compared “HUI-3”, “EQ-5D”, “VAS”, and “TTO” with “NEI-VFQ” for Diabetic Retinopathy (DR) and found that the use of “HUI-3” is suggested if the study takes a population based perspective.[118] HUI-3 is not available to be used amongst children and adolescents.

A summary of various types of instruments and their applicability are mentioned in the table 3.6

3.3 CEAs and Utility Value Estimates in Eye Care

A recent systematic review has indicated that there were very few cost-effectiveness analysis studies and the majority were cost-of-illness studies related to eye care undertaken anywhere in the world.[35] Most of the CEAs done in eye care are related to interventions for cataract, screening, AMD, and glaucoma. Most commonly used outcome measure is ICER showing cost per QALY gained. The utility values were measured mostly using EQ-5D or TTO methods. We have outlined various types of CEAs, CUAs, and Utility assessments in the Tables 3.7 and 3.8.

Utility values for blindness ranged from 0.55 in India to 0.26-0.65 in the USA. Most of the HTA studies are focused on CUA or CEA of cataract surgeries, glaucoma management, or AMD management. We discovered that all the interventions discussed in this context proved to be economically efficient and fell below the specified threshold for willingness to pay in the respective population, except for the AMD screening program in Japan, which was deemed not to meet the criteria for cost-effectiveness.[121] A study done in India analysed costs of providing eye care and the outcomes analysed as DALYs averted to provide ICER per DALY averted and found that screening programs and primary eye centres are most cost-effective.[137] Hence, CUA and CEA help in informed decision making and more so for programs and interventions targeted at child eye health.

Each of these study types plays a crucial role in health economics, providing insights into the economic impact, value, and efficiency of healthcare interventions and

Measure	Age Group	Description	Application	Underlying Theory
Visual Analog Scale (VAS)	Children and Adults	A scale where individuals rate their health on a line	Self-assessment of overall health	Subjective well-being
Standard Gamble	Adults	Measures utility by assessing willingness to take risks	Evaluating preferences for health states	vNM Utility Theory
Time Trade-Off (TTO)	Adults	Measures utility by trading time in perfect health	Assessing preferences for health-related quality	vNM Utility Theory
"SF-6D"	Adults	Derived from the SF-36 health survey	Calculation of QALYs	Utility Theory
Health Utilities Index (HUI)	All age groups	A thorough classification system for assessing one's health status	Assessing health status and QALY calculations	Multi-attribute utility theory
"EQ-5D"	Children and Adults	A standardized instrument with five dimensions	Determining HRQoL	Econometric Modelling
"NEI-VFQ-25"	Adults	Disease-specific questionnaire for visual functioning	Assessing the impact of eye conditions on vision	Vision-related quality of life

Table 3.6: Various Types of Health Preference Instruments

treatments. Their use in ophthalmology helps in advocacy for an intervention or a program, and in taking informed decisions related to allocation of scarce resources by various stakeholders and should be made a normal practice in evaluating healthcare programs and their outcomes.

Specific methodological guidelines exist in undertaking Health Technology Assessment (HTA) but their adoption in Ophthalmology specifically in India is rare and seldom practiced and published. This is particularly due to lack of both primary and secondary data related to the QALYs, prevalence of a condition, and costing strategies. Their adoption has shown evidence in strengthening health systems in various settings and are extensively used by various stakeholders such as NICE in the UK. The same can be reciprocated in the Indian context and help in informed decisions by the policy makers and stakeholders in India.

S. No.	Author, Year	Location	Type of HTA	Measured outcome	Parameter value
1	Newman-Casey, 2020[119]	UK	CUA	Glaucoma medication adherence	USD 29,600 per QALY gain
2	Zhu et al, 2017[120]	China	CUA	Cataract Sx in DR	USD 768 per QALY
3	Tamura et al, 2015[121]	Japan	CEA - Markov Model	AMD screening	USD 259,942 per QALY
4	Ma et al, 2016[122]	China	CUA	Cataract Surgery in AMD	”USD 1,400 per QALY
5	Hirneiss et al, 2006[123]	Germany	CUA	Penetrating Keratoplasty (PK)	USD 11,557 per QALY
6	Choi et al, 2018[124]	Korea	Utility assessment - EQ-5D	AMD	0.8765
7	Polack et al, 2015[42]	India	Utility assessment - TTO	DR	0.73
8	Saw et al, 2005[125]	Singapore	Utility assessment - TTO	POAG and PACG	0.88 for both
9	Kishimoto et al, 2012[126]	Japan	Utility values - TTO, VFQ14	Comitant strabismus, glaucoma, cataract	Strabismus - 0.852 Glaucoma - 0.810 Unilateral cataract - 0.727 Bilateral cataract - 0.663
10	Brown et al, 1999[127]	USA	Utility assessment - TTO	DR	0.77

Table 3.7: Review of Literature of Various HTAs and Utility Value Assessments

S. No.	Author, Year	Location	Type of HTA	Measured outcome	Parameter value
11	Gupta et al, 2005[43]	India	Utility assessment - TTO	Glaucoma	0.64
12	Sun et al, 2009[128]	China	Utility assessment - TTO	PACG	0.75
13	Brown et al, 2001[129]	USA	Utility assessment - TTO	Blindness	0.26-0.65
14	Brown et al, 2000[130]	USA	Utility assessment - TTO	AMD	0.72
15	Xue et al, 2019[131]	China	Utility assessment - RS	Dry Eye	0.89
16	Ben et al, 2021[132]	Brazil	Utility assessment - EQ-5D	DR	DR - 0.765 Blindness - 0.355
17	Choi et al, 2018[124]	Korea	Utility assessment - EQ-5D	Glaucoma	0.8968
18	Zhang et al, 2015[133]	China	Utility assessment - RS, SG, TTO methods	Glaucoma	0.77
19	Wagle et al, 2011[134]	Singapore	Utility assessment - TTO	Vitreous Floaters	0.89
20	Sahebjada et al, 2014[135]	Australia	Utility values - VisQol	Keratoconus	0.6
21	Smith et al, 2023[136]	USA	Utility assessment - TTO	Thyroid Eye Disease	0.44
22	Le et al, 2016[45]	India	CUA	Cataract	USD 195 per QALY

Table 3.8: Review of Literature of Various HTAs and Utility Value Assessments - Continued

CHAPTER 4

Aim & Objectives

Our study focus is to understand the economics of child eye health in India with the aim to provide an economic argument for policy prescriptions.

The specific objectives of this study are:

1. To study the Economic Burden of Blindness and Vision Impairment in India.

2. To calculate Utility Values for the purpose of assessing Quality-Adjusted Life Years (QALYs) in relation to particular eye conditions.

3. To undertake a Cost-Effectiveness analysis of Investing in child eye health using Incremental Cost Effectiveness Ratios (ICERs).

CHAPTER 5

Methods

Our first objective was based on Cost of Illness methodology using secondary data from published literature and government reports. The second and third objective had the same sample of participants who participated in primary data collection.

5.1 Definitions for the study

5.1.1 Blindness

- In the context of the Burden of Blindness Study, blindness is defined as having "presenting visual acuity worse than 3/60 in the better-seeing eye using Snellen meter acuity chart."

- In Utility Valuation and Cost-effectiveness Studies, blindness is defined as having "Best Corrected Visual Acuity of worse than 3/60 in the better-seeing eye, as assessed with the Snellen meter visual acuity chart."

5.1.2 Vision Impairment

- Mild Vision Impairment (MiVI):
  - "Presenting Visual Acuity in better seeing eye equal to or better than 6/18 (0.3 LogMAR) using Snellen meter acuity chart."[138]

- Moderate Vision Impairment (MoVI):
  - "Presenting Visual Acuity in better seeing eye worse than 6/18 (0.3 LogMAR) and equal to or better than 6/60 (0.1 LogMAR) using Snellen meter acuity chart."[138]
- Severe Vision Impairment (SeVI):
  - "Presenting Visual Acuity in better seeing eye worse than 6/60 (0.1 LogMAR) and equal to or better than 3/60 (0.05 LogMAR) using Snellen meter acuity chart."[138]

These definitions of vision impairment align with the criteria set forth by the International Classification of Diseases Tenth revision (ICD-10) classification and the categorization of Vision Impairment by the International Agency for Prevention of Blindness (IAPB).[138, 139]

5.2 Study Design

Our initial objective is a cost of illness study, as outlined in 'Current Estimates of the Economic Burden of Blindness and Vision Impairment in India: A Cost of Illness Study,' the study relied on secondary data, as is customary in cost of illness studies (Akobundu et al., 2006; Jo et al., 2014).[17, 46] Our second and third objectives were built upon a prospective longitudinal study design involving children aged 4 to 16 years. This study included a follow-up phase, during which the children underwent re-assessment six months after the intervention.

5.2.1 Study Duration

The primary data collection was undertaken over a period of one year. Initial pilot was undertaken in the month of April 2021. For the baseline study, the data collection was undertaken during the months of October and November 2021. Children were then followed up after six months post-intervention to get the the post-intervention utility values and cost data during the months of April to June 2022.

5.3 Sample Size

The prevalence of eye-related health conditions in children and the prevalence of blindness and impaired vision among individuals below 49 years of age stood at 6.54% and 23.8%, respectively. These statistics were derived from references (Kemmanu et al., 2018; and NPCB summary report 2020).[2, 140] To determine the required sample size for our study, we employed the subsequent formula:

$$n = \frac{4pq}{L^2}$$

Where:

- ‘p’ is the prevalence of blindness and vision impairment in India
- ‘q’ is the proportion of people with blindness and vision impairment
- ‘L’ is the allowable tolerable error. We have set this at 5% to have a confidence level of 95%. Thereby, our sample size is estimated

Therefore, our sample size is calculated as:

$$n = \frac{4 \times 0.238 \times 0.762}{0.05^2}$$

$$= 290$$

considering 10% not to respond, our final sample size was

$$290 + 29 = 319$$

We planned to include about **320** children in the study.

5.4 Study area and population

The study was conducted at the paediatric ophthalmology department of Shri Sadguru Netra Chikitsalaya (SNC) Eye Hospital, Chitrakoot in the state of Madhya Pradesh, India. We have selected this location for its centrality in India. The study population included all children visiting the hospital aged 4 to 16 years. In order to include congenital conditions, we have undertaken further data collection at the paediatric glaucoma/ ophthalmology clinic of Dr. Anil Kumar Mandal, "LV Prasad Eye Institute (LVPEI)", Hyderabad where we have included children with primary congenital glaucoma purposely. The study area location are mentioned in figures 5.1 and 5.2

5.5 Criteria for Inclusion and Exclusion criteria

5.5.1 Inclusion Criteria

- Children ranging from four to 16 years.
- Parents or caregivers of the children.

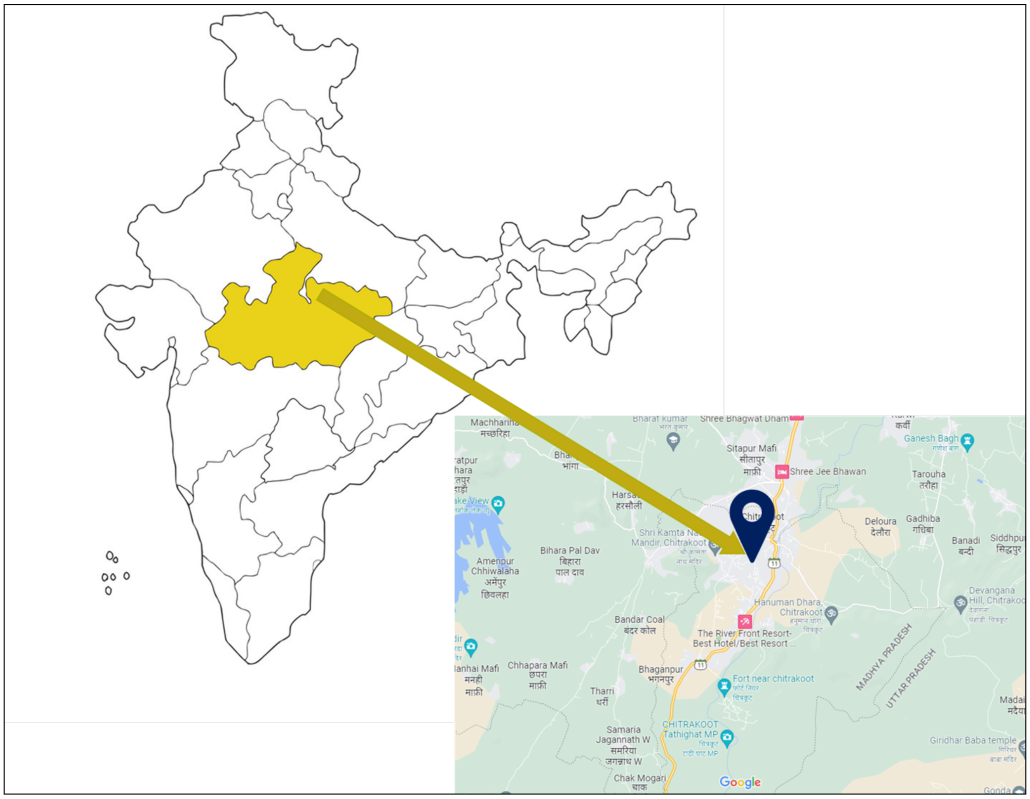

Figure 5.1: Map of “SNC Eye Hospital, Chitrakoot, Madhya Pradesh, India”

5.5.2 Exclusion criteria

- Children with intellectual and/ or mental disability.
- Children whose parents declined to provide consent.

5.6 Sampling Technique

Children were sampled randomly at the paediatric clinic of SNC Eye Hospital. All the registered patient Medical Record Numbers (MRN) were obtained and run through excel randomization formula each day to enumerate 20 children randomly in the clinic. Masking of the study sample was not undertaken and the data collection team were aware of the clinical characteristics of the participants.

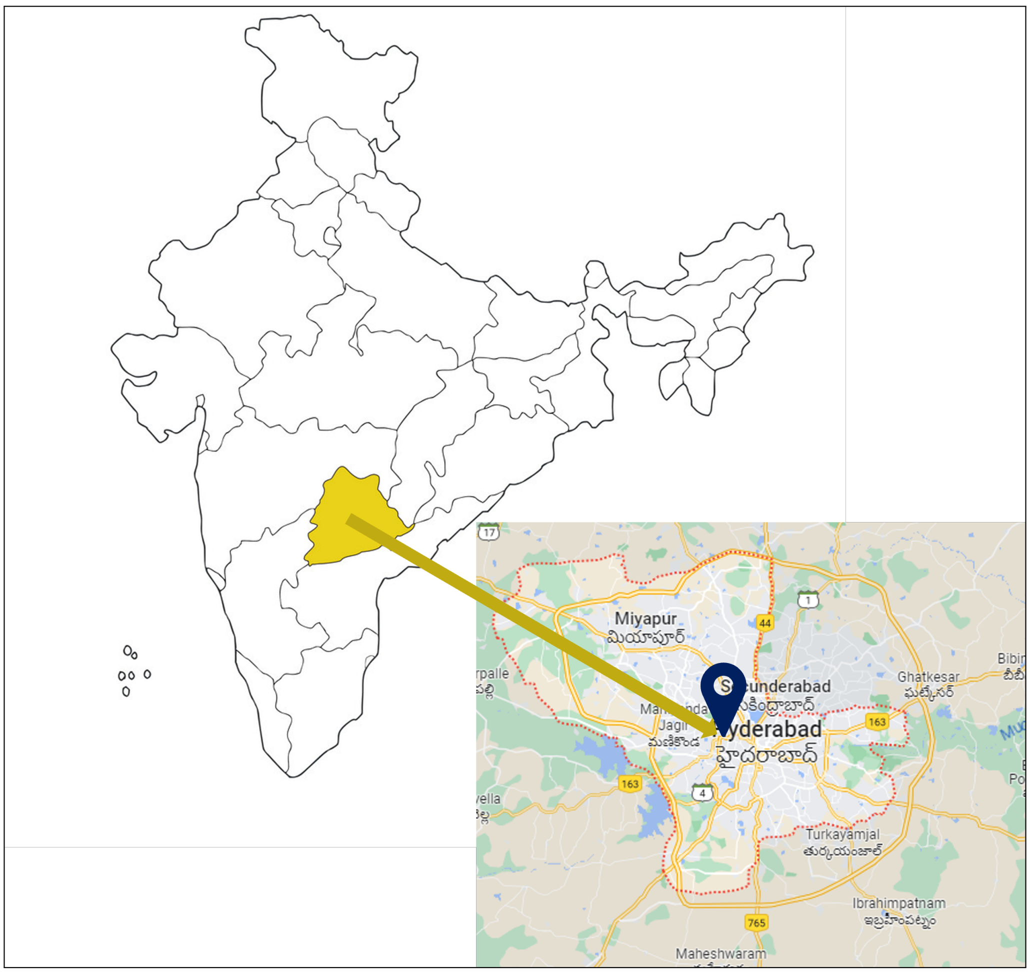

Figure 5.2: Map of “LV Prasad Eye Institute, Hyderabad, Telangana, India”

5.7 Study tools

Our study consisted of four data collection forms:

- Form 1 - Case sheet
- Form 2 - Enumeration form
- Form 3 - “EQ-5D-Y” instrument and VAS tool
- Form 4 - Cost data form

All the forms are attached as annexures **??** to **??**.

The data collection forms were piloted in an initial pilot done at the facility. The cost data forms followed the costing guidelines. “EQ-5D” instrument was already widely used generic preference based health measure and was available in English, Hindi, Telugu, Marathi, and Kannada. We have used the English and Hindi versions of the “EQ-5D-Y-3L” instrument after getting approval from the EuroQol group.

5.7.1 Data Collection Team

The data collection team were trained in explanation of the study through PIS, counter signing the consent and assent forms, filling the enumeration form with demographic details and case details of the participant, collecting cost data, and assisting participant with regards to the “EQ-5D-Y” instrument when a participant had any queries.

5.8 Study Process

For objectives two and three, the process is mentioned in figure 5.3:

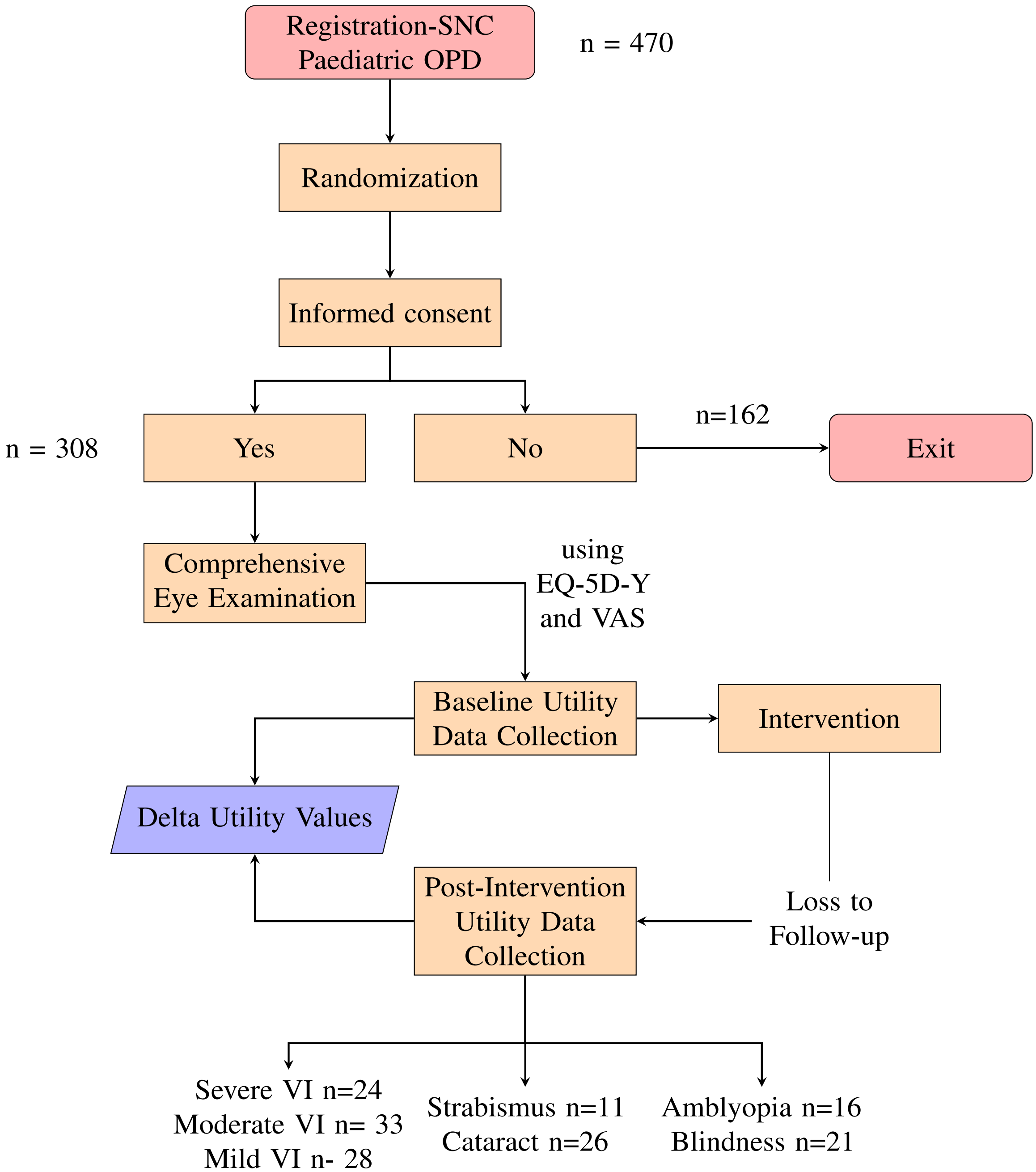

Figure 5.3: Sample numbers at baseline and post-intervention and the study process

5.9 COVID-19 Protocols

We adhered to the local government's COVID-19 protocols during the entire process of the study data collection. A COVID-19 risk assessment questionnaire was designed and followed during data collection.

5.10 Ethics Approval

The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of the University of Hyderabad. Approval number: UH/IEC/2020/222.

5.11 Objective 1: Current Estimates of the Economic Burden of Blindness and Vision Impairment in India: A Cost of Illness Study[1]

Our investigation into the economic impact of blindness and vision impairment employed the Cost of Illness methodology, as outlined in the study by Byford et al. (2000).[48] In our analysis, we quantified this economic burden in terms of lost productivity, specifically measured as the reduction in per-capita Gross National Income (GNI).[48] The foundational data needed for these calculations were sourced from pre-existing literature and governmental reports.

5.11.1 Demographic and Prevalence Estimates

We acquired population data by referencing prior studies and utilizing World Bank statistics. Subsequently, we calculated the overall count of individuals experiencing blindness and vision impairment using prevalence figures reported in published literature.[141–143] The term ”blindness” is defined as having a “presenting visual acuity worse than 3/60 in the better seeing eye”.[2, 138]

5.11.2 Data and Assumptions

We have calculated the financial impact of blindness by taking into account both the direct and indirect reductions in Gross National Income (GNI), as well as the economic productivity associated with blindness. The economic burden resulting from vision impairment was assessed by examining the potential reduction in productivity linked to different types of vision impairment. We compared all our estimations with the data from a prior study conducted in 1998 on the economic burden of blindness in India.[51] It was assumed that both Gross National Product (GNP) and Gross National Income (GNI) reported the same values.[50, 144]

Epidemiological data and assumptions for the estimates

- The estimated population of India in 2020 stands at 1.38 billion, with an annual growth rate (AGR) of 1.29%, based on data from 2011.[141, 142] Among this population, it is estimated that there are approximately 399 million children, accounting for around 29% of the total population.[145] These population statistics cover a time span from 2016 to 2020.

- Data were stratified according to the published prevalence of blindness and all four categories of vision impairment as defined by WHO and ICD-10.[2, 139]

- Prevalence of blindness is 0.36% (4.95 million), and the prevalence of prevalence of mild, moderate, and severe vision impairment is 2.92% (40 million), 1.84% (25 million), and 0.35% (4.8 million) of the population, respectively.[2]

- Labor force contribution of the population is 51.5% in 2020.[36, 146] We have assumed that 60% of blind adults contribute to the labor force.[51]

- We have considered mean age of children in India as 8 years and the mean life span of blind children to be between 40 years and 55 years.[51]

- We have assumed that children will start working from the age of 15 years and start contributing to the economy for 35 years to 40 years. Hence we have considered that on an average 35 to 40 working years are lost and thereby loss of GNI due to blindness in children over the life time of the children.[51]

- The loss of working years leads to a cumulative loss of GNI over the lifetime of the blind children. This loss may not be due to all blind children as few are still economically productive although at a reduced productivity level; and hence we have assumed that about 20% of blind individuals are economically productive at 25% of the actual productive workforce.[51]

- Individuals with vision impairment are economically productive but at various productivity levels due to various levels of vision impairment. We have used WHO disability weights for vision impairment as surrogate measures to estimate the potential loss of productivity due to vision impairment.[147]

- The prevalence of avoidable blindness is different in different age groups in India. We have considered 35% (30% to 40%) of blindness as due to avoidable causes (easily preventable and treatable) in children. 82.5% of blindness amongst adults is caused due to avoidable causes.[3, 14, 148]

- Indirect costs are calculated as the productive time lost by caregivers. We have assumed that caregivers lose about 10%, 5%, and 20% of their productive time taking care of blind adults, vision impaired, and blind children respectively.[51]

GNI and productivity loss estimates and assumptions

- Per-capita GNI:

$$\frac{\text{INR 192,394 billion}}{\text{1.38 billion}} = \text{INR 139,867}$$

- Per-capita GNI produced by the labor force:

$$\frac{\text{Per-capita GNI}}{\text{\% of labor force}} = \frac{\text{INR 139,867}}{0.515} = \text{INR 271,587}$$

- Direct loss of GNI due to blindness:

$$\text{Direct loss of GNI} = \text{Number of blind adults} \times 60\% \times \text{INR 271,587}$$

To calculate the cumulative loss of GNI, we assume that there is a direct loss of GNI as children start contributing to the economy at 15 years of age with an annual economic growth rate of 5% (total blind children $\times$ per-capita GNI produced by labor force at 5% growth rate for 35 years and 40 years)

- Indirect loss of GNI due to blindness:

$$\text{Number of blind persons} \times 0.1\ (10\%) \times \text{per-capita GNI by labor force}$$

For cumulative loss of GNI due to blindness in children, we have assumed that the caregiver spends 20% of the time taking care of blind children

- Economic Productivity of the blind:

  20% of blind adults are economically productive at 25% of the productivity level of a member of the labor force.

- Net loss of GNI due to blindness:

$$\text{Direct cost} + \text{Indirect cost} - \text{Economic productivity}$$

- Cumulative loss of GNI due to blindness over the lifespan of the blind is calculated using the formula:

$$\text{Cumulative Loss } (CL_{xi}) = N_1 + N_2 + \ldots + N_i$$

Where,

  - CL_{Xi} is the Cumulative Loss of GNI for 'X' adults or children for 'i' years of productivity loss.

- N_i is the Net loss of GNI for the year i.

$$N_i = P\left(1 + \frac{G}{100}\right)^i$$

- P is the Net loss of GNI for the base year
- GR is the Annual Growth Rate (5%)

- Cumulative loss of GNI due to blindness over the lifespan of blind adults:

$$CL_{A8} = N_1 + N_2 + \ldots + N_8$$

$$CL_{A10} = N_1 + N_2 + \ldots + N_{10}$$

  - Sum of net loss of GNI for 8 years and 10 years respectively at an annual growth rate (GR) of 5%.

- Cumulative loss of GNI due to blindness over the lifespan of blind children: The cumulative loss over 35years is:

$$CL_{C35} = N_1 + N_2 + \ldots + N_{35}$$

The cumulative loss over 40 years is:

$$CL_{C40} = N_1 + N_2 + \ldots + N_{40}$$

  - Sum of net loss of GNI for 35 years and 40 years respectively at an annual growth rate (GR) of 5%.
  - Assuming all children contribute to the labor force.
  - Caregivers spend 20% of their time taking care of the blind child.

- Cumulative loss of GNI due to avoidable blindness:

  Adults, for 8 years loss of productivity:

$$CL_{A8} \times 82.3\%$$

  Adults, for 10 years loss of productivity:

$$CL_{A10} \times 82.3\%$$

  Children, for 35 years loss of productivity:

$$CL_{C35} \times 35\%$$

  Children, for 40 years loss of productivity:

$$CL_{C40} \times 35\%$$

- Potential loss of productivity due to vision impairment (for each level of vision impairment)

$$\text{No. of vision impaired people} \times 60\% \times \text{INR } 271{,}587 \times DW_x$$

  Where DW_x is the Disability Weight of Vision Impairment category x:[147]

  - Mild VI: $DW_{mi} = 0.005$
  - Moderate VI: $DW_{mo} = 0.089$
  - Severe VI: $DW_{se} = 0.314$

- All the calculations are converted to international dollars (Int$) purchasing power parity (PPP) for the years 2020 and 1997.[149, 150]

$$\text{Int\$ } 1 = \text{INR } 22$$

$$\text{Int\$ } 1 = \text{INR } 9.75$$

- All the calculations that were done in 1997-98 are converted to current inflation rates and compared with 2020 data.
- 1 USD in 1997–98 is equal to 1.6 USD in 2020.[151]
- We considered 2020 as the base year for all of our calculations.

In this estimation, the calculation is done based on the burden of blindness and vision impairment in economic terms and its loss of productivity. To compare data between 1997 and 2020, we used 2020 as the base year and converted the 1997 data into Int$ Purchasing Power Parity (PPP) for the year 1997 and then used the US inflation rate to adjust the Int$ to the base year using standard methodology.[152]

Various parameters and data used in the study are presented in the table 5.1.

5.11.3 Statistical Analysis

Data were compiled and analyzed on Microsoft Excel 2016. To address potential data uncertainties, a sensitivity analysis was conducted.[11, 12]

Study Data Analysis Flow

Data on per-capita income and productivity losses were obtained from government reports. Since the latest official population data were only for the year 2011 (2011 census),[153] population data were obtained from the world bank data, and projections from published literature and our estimations at 2.5% AGR.[141, 142] Prevalence related

Parameter	Data/ Assumptions
Labor Force	51.5%
Labor Force participation of Blind Adults	60%
Working years - Adults	8 and 10 years
Working years - Children	35 and 40 years
Productivity of Blind	at 25% level
Proportion of productive bind	20%
Prevalence of Avoidable Blindness	35%
Caregiver's Loss of Productivity - Adults	10%
Caregiver's Loss of Productivity - Children	20%
Per-capita GNI	INR 139,867

Table 5.1: Parameters and Data used in the Economic Burden of Blindness and Vision Impairment in India

data were obtained from a national survey, a systematic review on childhood morbidity, and published literature.[2, 3, 14]. The comprehensive analysis of the secondary data are mentioned in the figure 5.4.

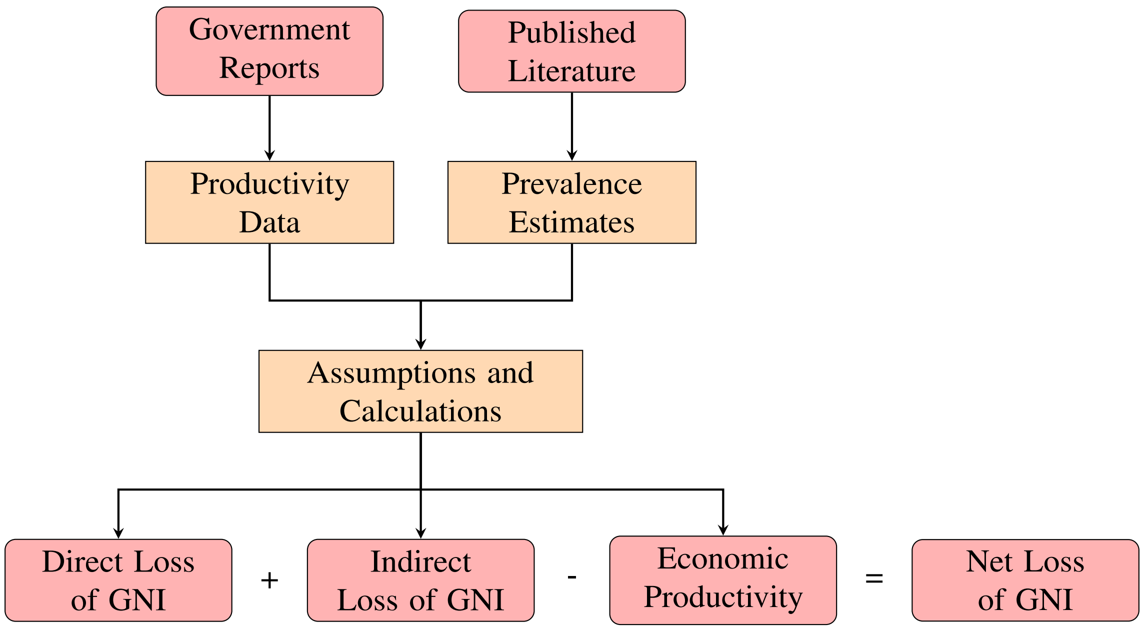

Figure 5.4: Flowchart describing the study analysis flow of objective 1

5.12 Objective 2: Development and Testing of Quality Adjusted Life Years (QALYs) Utility Values for Child Eye Health Conditions

5.12.1 Study Population

Children aged between 4 and 16 years of age with or without ocular condition and co-morbidities, and their caregivers were included in the study. Participants underwent a thorough eye examination conducted by either an ophthalmologist and/ or an optometrist. A demographic form documented the demographic details such as age, sex, socio-economic status, village name, refractive status, direct and indirect costs of treatment(s).

5.12.2 Comprehensive Eye Examination

Each child participant underwent comprehensive eye examination. Lea charts were used to measure visual acuity of children who are four to five years of age and Snellen acuity charts and LogMAR four meter full optotype charts were used to measure visual acuity of children above five years to 16 years of age. Tumbling E chart was used to measure visual acuity of children who could not comprehend or had reading difficulties of the regular charts. If the child was already wearing spectacles, the present glass prescription was recorded using lensometer. Refraction and Cycloplegic refraction was undertaken using retinoscopy and a post-mydriatic test was undertaken after 24 to 48 hours. A detailed documentation of the best corrected visual acuity, and refraction values was undertaken. Children underwent slit lamp examination and poster segment examination, and a final diagnosis was made and recommendation on the intervention was made. The interventions could be refractive (including binocular vision exercises), medical, and/ or surgical in nature depending on the diagnosis of the condition.

5.12.3 Baseline and Post-Intervention Data Collection

We have used Euro-Qol-Five-Dimension Youth (EQ-5D-Y) three level questionnaire to measure the health state of the individual as it is relevant to be used amongst this particular age group. The *EQ-5D-Y* tool is available in English and Hindi and is validated for Indian population. The *EQ-5D-Y* instrument assesses an individual's well-being in five dimensions: Mobility, Self-care, Usual activities, Pain/Discomfort, and Anxiety/Depression, as described in the work by van Reenen et al.[22] Additionally, the tool includes a Visual Analogue Scale (VAS) for quantifying the individual's present health condition on a scale ranging from 0 to 1. Participants are instructed to indicate their current health state by marking a point on this scale.[154] The data collection instrument, patient recruitment strategy, and the ocular conditions and the child's perceived health states were tested as part of a pilot study which was conducted initially on 57 individuals during which the data collection instrument, patient selection and eye conditions were tested. Proxy interviews were conducted with caregivers, typically the child's mother or father, for children aged four to eight years, especially when the child was unable to fully understand the questions. Hindi tool was used where the participant was not able to comprehend English questions. Participants presented with different diagnosed conditions during the data collection period. Untreated children and their health statuses were regarded as the initial baseline data points. The children were then followed up after six months post-intervention. The interventions included various treatments namely, spectacles to treat refractive errors, pseudophakia to treat cataracts, and patching and exercises to treat amblyopia and strabismus. As part of the follow-up data collection, we have included children who were part of the baseline data and have received treatment six months before. The subsequent full study was done on 308 participants. Scores for each dimension were individually computed employing the scoring algorithm based on the Indonesian value set designed for the EQ-5D-3L-Y instrument.[155] VAS scores were also used to compare utility values derived from dimensions and VAS scores. Conditions in individuals were classified based on their diagnosed condition according to the 11th edition of the International Classification of Diseases (ICD-11) and the World Health Organization's (WHO) criteria for blindness and visual impairment, using the definition of best-corrected visual acuity in the better seeing eye.[138] For "Primary Congenital Glaucoma (PCG)", the patients who were already diagnosed and have undertaken the "Combined Trabeculotomy Trabeculectomy (CTT)" treatment were purposively sampled to be included in this study. All participants were the patients of Dr. Anil Kumar Mandal who is the paediatric ophthalmology consultant at LVPEI. The PCG data collection was undertaken between November 2022 and February 2023. Since PCG is an extremely rare condition, our data sample was very low. We have relied on the participants to recall their health state at the time of taking the treatment as primary data collection at the time of receiving CTT treatment was not possible as the participants were infants and there is no tool to evaluate the health state at that age and it would not be appropriate also. Hence, we have included participants aged 6 to 16 years to be included in the study. This gave us the post-intervention utility value of children with PCG.

5.12.4 Study flow

Participant information Sheet (PIS) was used to make the participant understand about the study and any questions the participant had were addressed by the person collecting the data. Participants and/or their parents or caregivers who expressed their willingness to take part in the study provided informed consent and assent. The PIS form, Informed Consent, and Assent forms were available in English and Hindi for the participants and their caregivers to understand. The study flow for utility values for all the eye conditions and for PCG are described in the figures 5.5 and 5.6 respectively.

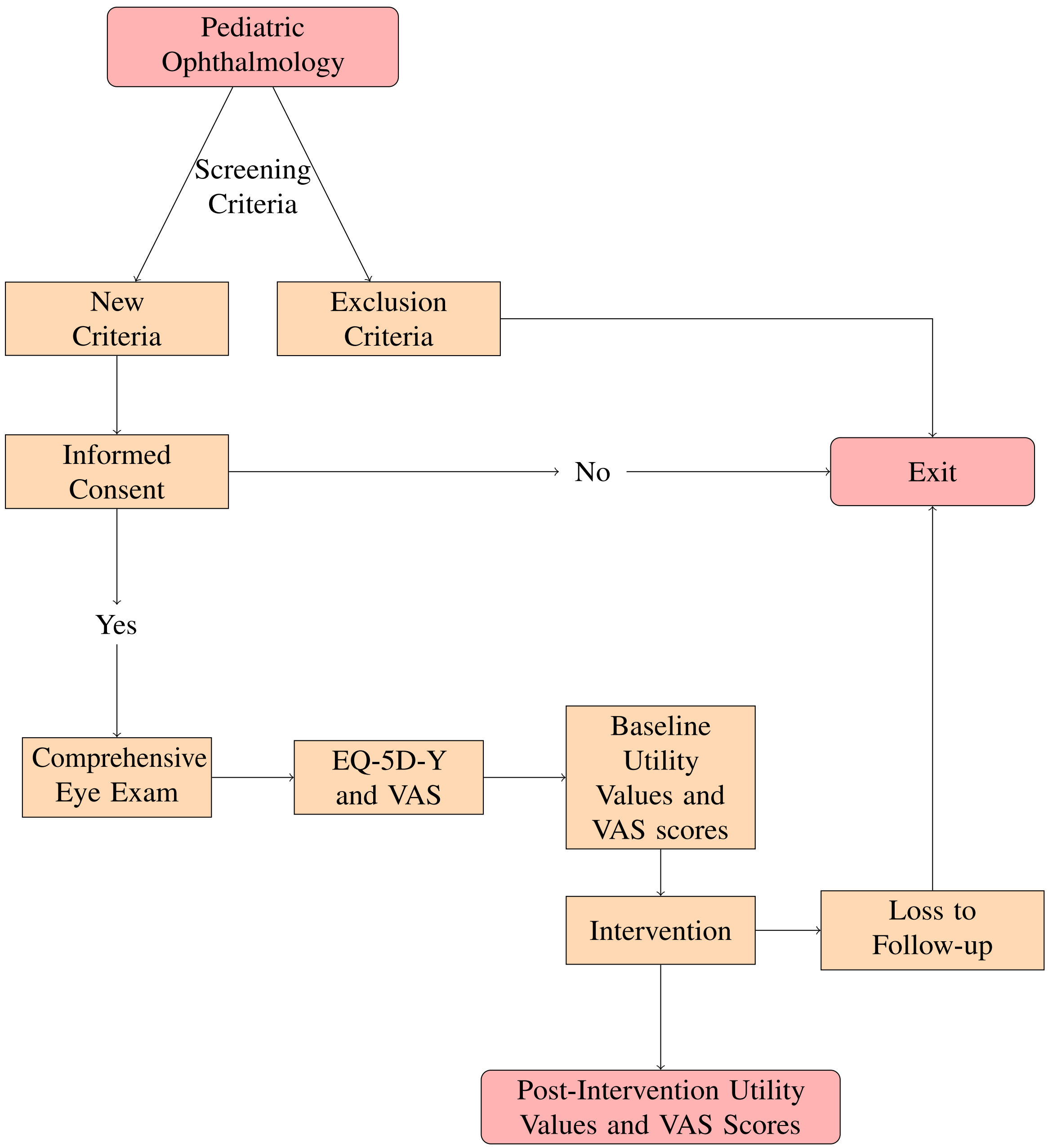

Figure 5.5: Flowchart describing the study flow at LVPEI for “Primary Congenital Glaucoma (PCG)” cases.

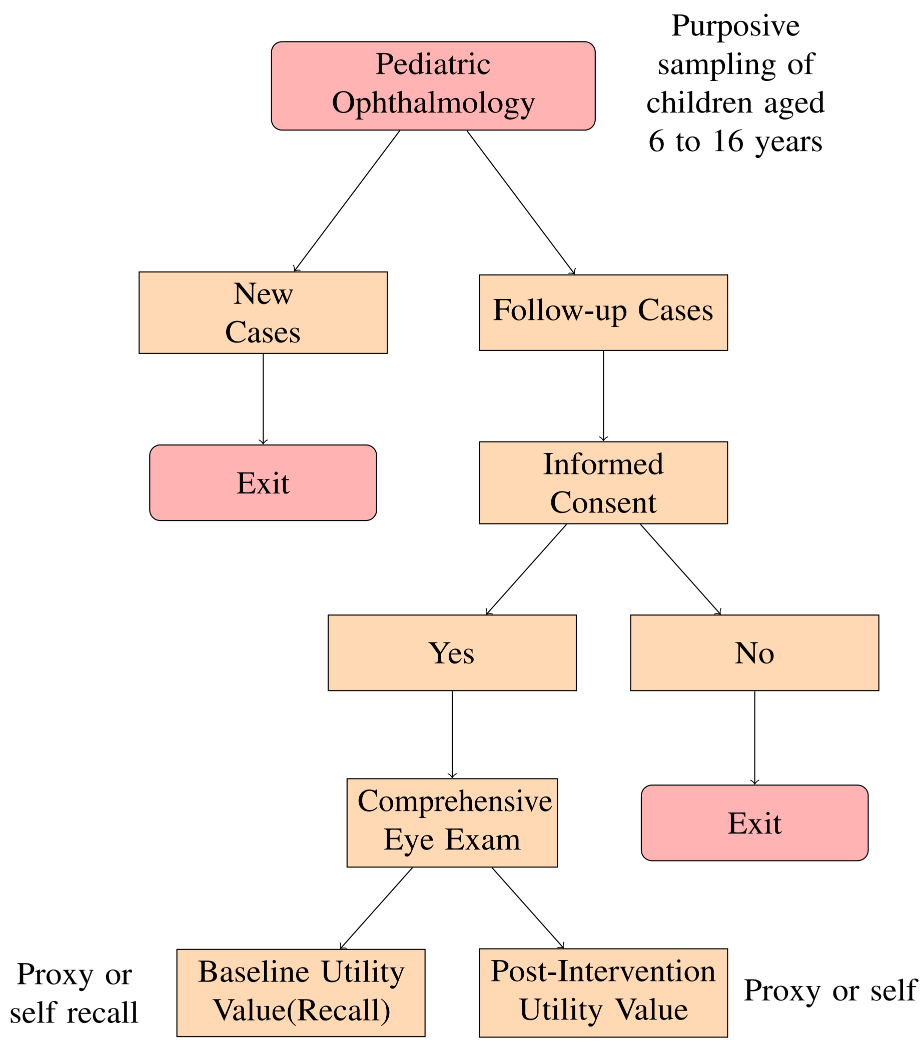

Figure 5.6: Flowchart describing the Utility Value study.

5.12.5 Data Analysis

Data were digitized on to Microsoft Excel application. All the personal identifiers of the participant were removed while documenting the data digitally thereby facilitating anonymous data analysis. Independent samples tests were used to analyse the change in the utility value after an intervention. The statistical analysis of the data was undertaken using R software (version 4.2.3).[156] Visual acuity, as assessed through Snellen acuity charts, was transformed into LogMAR visual acuity measurements using the "eye" and "eyedata" packages within the R software.[157, 158] Conditions were classified according to the refractive status, BCVA, and diagnosed pathology. Any pathological condition may have refractive error associated with it, and is classified under either category. All patients were classified using visual impairment classification also and a stratified analysis was undertaken. This classification allowed us to estimate the utility values for each ocular condition. The variation in best corrected visual acuity (BCVA) between the eyes was assessed using a Generalized Estimating Equation (GEE) model. To estimate the confidence interval around the median utility value and median BCVA, bootstrapping was employed, with a range of 1,000 to 10,000 replicates, as recommended for non-parametric data.[159]

Scoring Algorithm

The *EQ-5D-Y* tool is a relatively recent adaptation of the *EQ-5D* instrument designed specifically for the needs of children and teenagers. Since a person's health is not only dependent on the individual person but also influenced by society and socio-economic status, they tend to value health differently in different geographic locations or different countries. There are different weights for each dimension and its levels for different countries and populations, to allow comparability and generalizability between different regions and conditions. These weights act as anchor points for each dimension and population and are mapped and analysed after getting the sample responses from the participants. These weights are derived from population based value set studies.[109, 111, 160] An *EQ-5D* value set has been developed for the Indian population;[161] however, there isn't a specific value set tailored to India for the *EQ-5D-Y*, which is the youth version. Since Indonesian economy and population demographic characteristics are similar to India, we have used Indonesian value set to analyze the *EQ-5D-Y* data.[155, 162]

Each of the five dimensions is accompanied by three potential response levels from the participants, all of which are recorded.[107] The individual dimensions and their responses and coefficients are mentioned in the table 5.2. The scoring algorithm for the Indonesian Value Set [155]is as follows:

$$U = 1-(0.1317MO2+0.2265MO3+0.1017SC2+0.1793SC3+0.1441UA2$$

$$+0.2093UA3+0.1256PD2+0.2277PD3+0.1283AD2+0.2016AD3)^{1.9013}$$

So, if a response to all five dimensions is 13212, the utility value (U) would be:

$$U = 1-(0.1793+0.1441+0.1283)^{1.9013}$$

One each of the responses are scored for each dimension, the utility value is calculated. This is repeated for all the participants' data. The utility values are calculated for post-intervention data as well. Stratified analysis of the utility values for each of the eye condition is undertaken to estimate the utility values for each condition.

Dimension	**Level**	**Coefficient**
Mobility	1	0
	2	0.1317
	3	0.2256
Self Care	1	0
	2	0.1017
	3	0.1793
Usual Activities	1	0
	2	0.1441
	3	0.2093
Pain/ Discomfort	1	0
	2	0.1256
	3	0.2277
Anxeity/ Depression	1	0
	2	0.1283
	3	0.2016

Table 5.2: Indonesian Value Set Scoring System of EQ-5D-Y Instrument [155]

5.13 Objective 3: Cost-Effectiveness of Child Eye Health Interventions

5.13.1 Study Population

We have included children who were part of the baseline QALY utility value study and are visiting for a six months follow-up examination after undergoing treatment for their eye condition at the paediatric ophthalmology clinic of Shri Sadguru Netra Chikitsalya (SNC), Chitrakoot were included for this cost-effectiveness study. The participants included children and their parents or caregivers.

5.13.2 Cost Data

A detailed costing form was developed using costing guidelines mentioned in published literature.[11, 12, 61] We have used a mixed methods approach for cost data collection. Participants were interviewed either face-to-face or by phone, following their consent to take part in the research. The expense information was divided into three categories: Direct Medical Costs, Direct Non-Medical Costs, and Indirect Costs. Direct Medical Costs encompassed expenses associated with receiving medical services, including consultation fees, treatment expenses (e.g., medication, surgery, eyeglasses, and binocular exercises), and any other medical-related costs. Direct Non-Medical Costs covered outlays linked to travel for eye care, accommodation, meals, and any other miscellaneous expenses; the indirect costs included costs related to caregiver's forgone income or wage taking care of the child. We have considered all the costs to be societal as they are collected directly from the participants. The costs related to surgical treatment and binocular exercise were collected from the hospital. The costs of medication, and spectacles were collected from the participants. Since the cost data were cross-sectional, we have not used discounting to

Cost Category	**Cost Components**	**Collected from**
Direct Medical Costs	Medication Consultation Vision Therapy Intervention/ Surgery Other Medical	Participant Hospital Participant
Direct Non-Medical Costs	Food Travel Food Lodging Others related to visit	Participant
Indirect Costs	Forgone Income	Participant

Table 5.3: Cost Categories

calculate present value. All the cost data except intervention data were multiplied with the number of visits the participant has made to the hospital in the past six months period.The expenses were calculated for a duration of one year, specifically the present year. The raw data were then categorized to one of the three types of cost category. We have categorized the costs into each type of Vision Impairment, Blindness, Amblyopia, Cataract, and Strabismus. Patients who were not availing treatment such as surgery, or binocular exercises still had some costs associated with them such as medication, transport/ travel costs, consultation costs, and boarding and lodging costs for availing eye care. The expenses associated with not receiving any treatment were determined by subtracting treatment-related costs while retaining the Direct Non-Medical and Indirect Costs. A breakdown of expenses within each cost category is provided in the table 5.3.

5.13.3 Sensitivity Analysis

We encountered non-normally distributed cost data and resorted to computing medians and Inter-Quartile Ranges (IQR) for each cost category. One-way sensitivity analyses were carried out on each category of costs by calculating the median values of each type of cost and varying the data across its Inter-Quartile Range (IQR) using bootstrapping 1,000 replications to calculate confidence intervals as per the suggested methodology.[159] We have performed sensitivity analysis on each subgroup of the cost data for Blindness, Mild, Moderate, and Severe Vision Impairment, Amblyopia, Cataract, and Strabismus.

5.13.4 Study flow

Data were collected at the time of follow-up visit or if a patient had already undergone the follow-up visit, a telephonic interview of the participant was carried out to document the cost data. Data were predominantly collected from the child's parents or caregiver. The PIS form, Informed Consent, and Assent forms were available in English and Hindi for the participants and their caregivers to understand. Most of the interviews were carried out in the Hindi language. The figure 5.7 illustrates a comprehensive overview of the study's progression.

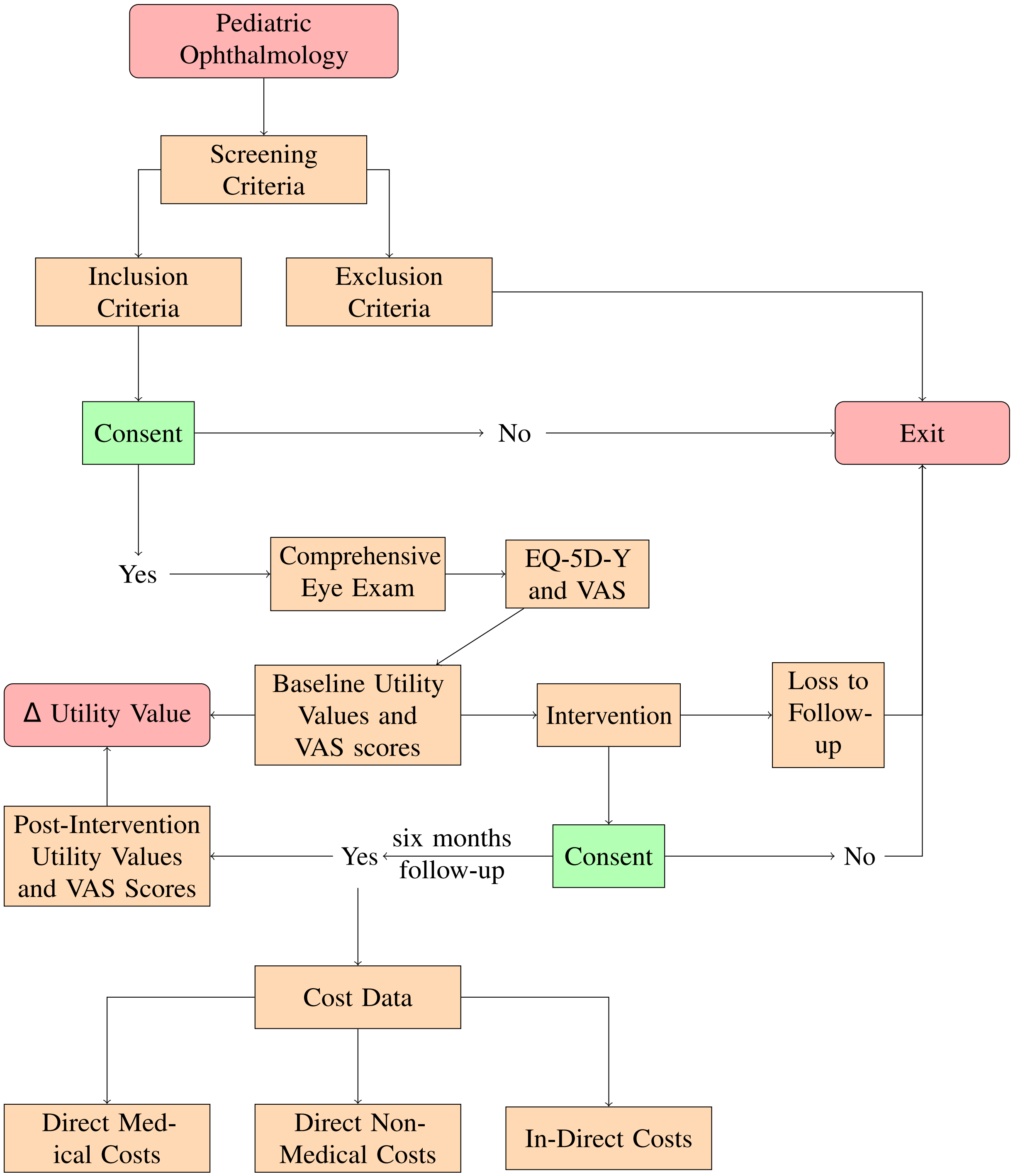

Figure 5.7: Flowchart describing the cost-effectiveness study

CHAPTER 6

Results

6.1 Objective 1: Current Estimates of the Economic Burden of Blindness and Vision Impairment in India - A Cost of Illness Study

6.1.1 Economic Burden of Blindness in India estimated in the year 2020

The estimated net loss of GNI due to blindness in India is INR 845 billion (Int$ 38.4 billion). Net loss of GNI due to blindness in children is INR 13 billion. The percapita net loss of GNI due to blindness is INR 170,624. The indirect loss of GNI due to blindness in children is INR 13 billion. The total cumulative loss of GNI due to blindness is INR 19,512 billion and cumulative loss due to avoidable blindness is INR 11,778.6 billion.[1]

We have compared these results with the data from a cost of illness study done in 1998;[51] the results are mention in figures 6.1 and 6.2.

We have estimated the Cumulative Loss of GNI due to Blindness and Avoidable Blindness in Adults and Children and compared the results with 1998 data and presented in figures 6.4 and 6.5.

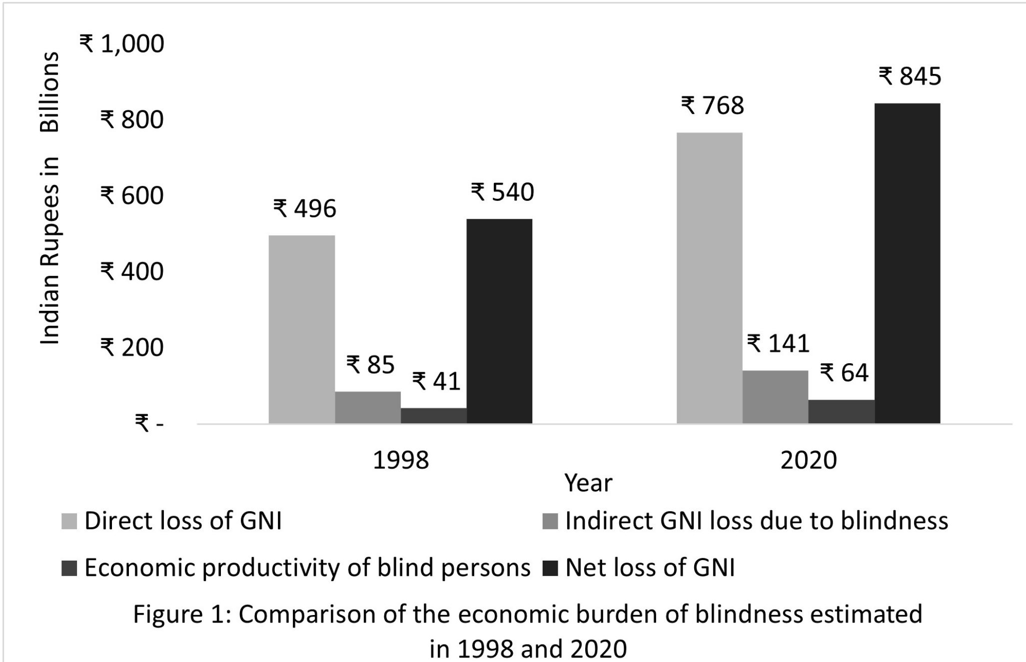

Figure 6.1: Comparison of the Economic Burden of Blindness estimated in 1998 and 2020

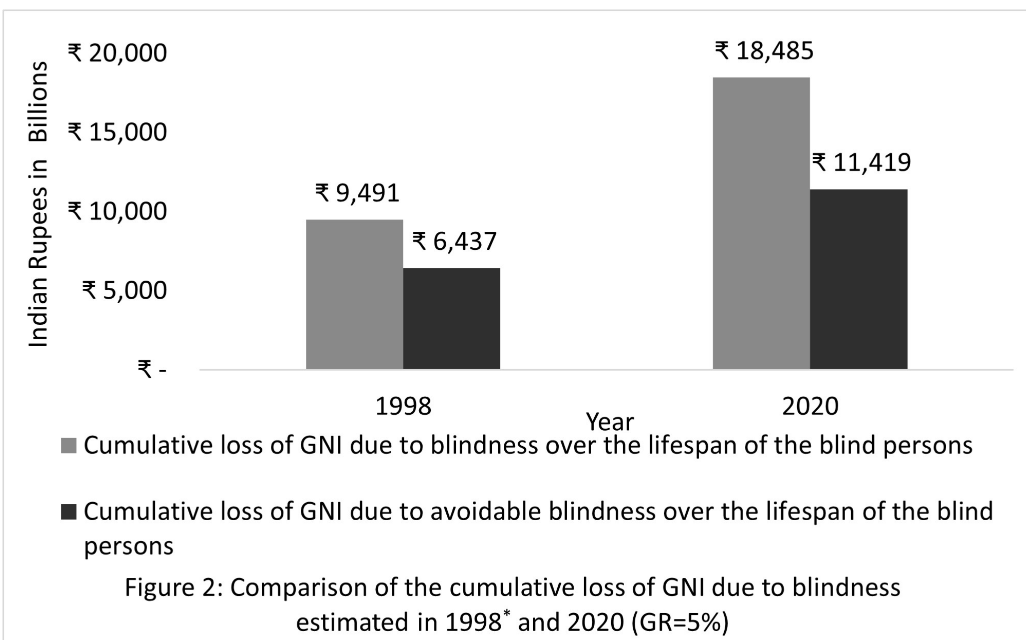

Figure 6.2: Comparison of the Cumulative Loss of GNI due to blindness estimated in 1998 and 2020

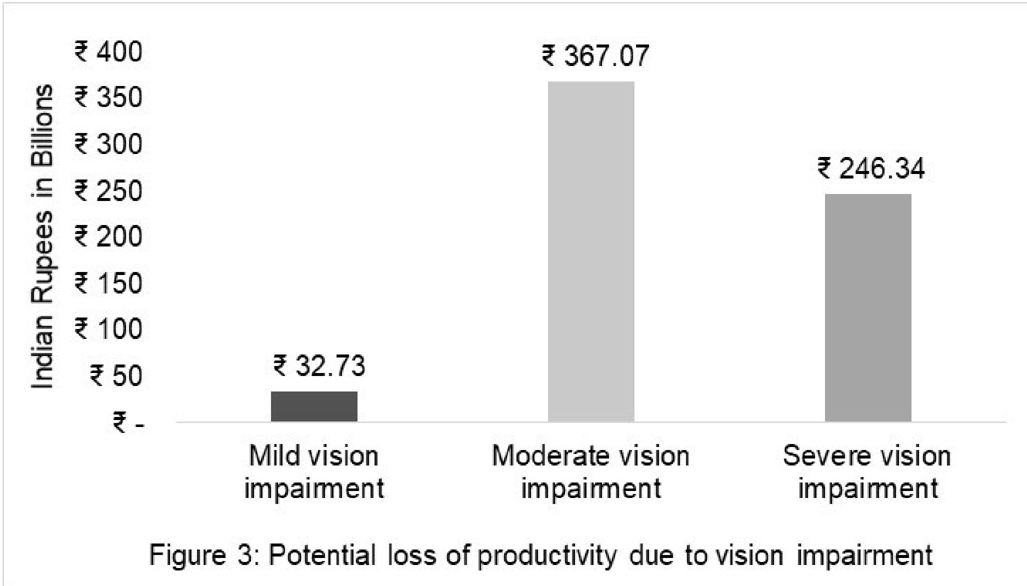

Figure 6.3: Potential loss of productivity due to various levels of vision impairment

6.1.2 Potential loss of productivity due to Vision Impairment in India estimated in the year 2020

The estimated economic potential total loss of productivity due to vision impairment in India is INR 646 billion and the percapita potential loss of productivity is INR 9,192.[1] The productivity losses for various levels of vision impairment are presented in figure 6.3

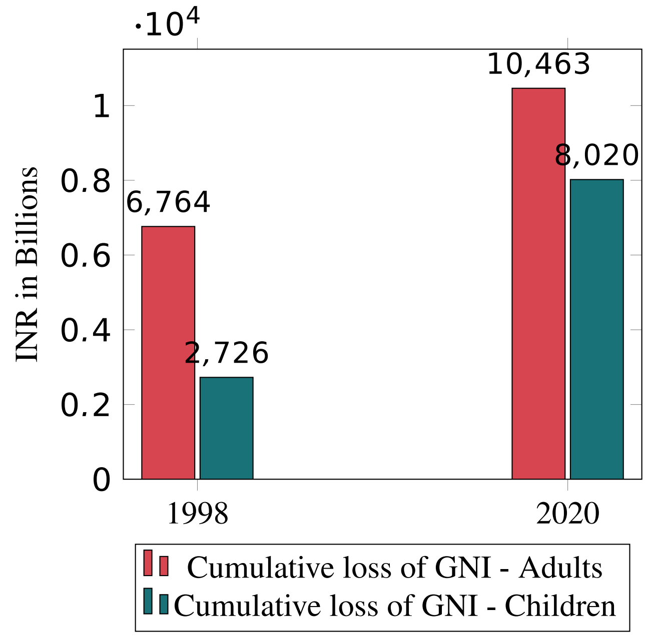

Figure 6.4: Comparison of Cumulative loss of GNI due to blindness in Adults and Children between 1998 and 2020.

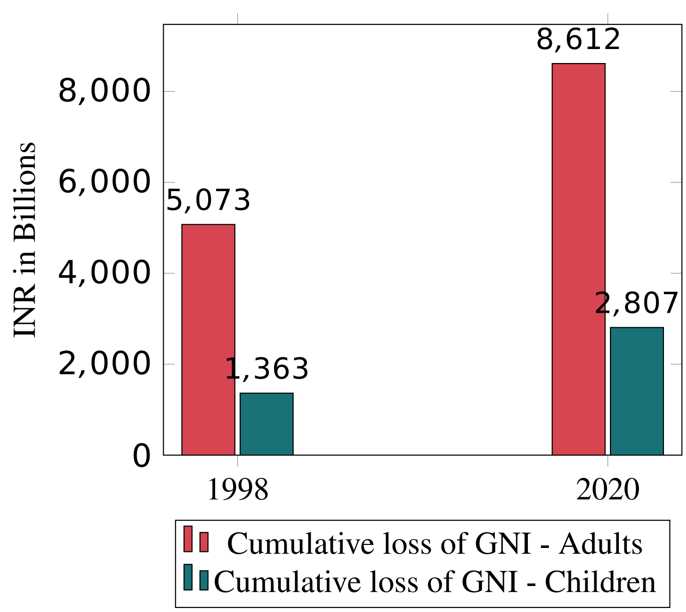

Figure 6.5: Comparison of Cumulative loss of GNI due to avoidable blindness in Adults and Children between 1998 and 2020.

6.2 Objective 2: Development and Testing of QALY Utility Values for Eye Health Outcomes

For this objective, out of the 308 individuals included in the study, two individuals were excluded from the results due to data inconsistencies; 306 individuals were included for final analysis. The table labeled as 6.1 provides information about the participants' demographic characteristics.

Total Participants (n)	306
Female Male	128 178
Median Age (Years) Female Male	11 (7-14) 11 (7-15 10.5 (7-13)
Annual income (INR)	120,000 (78,000-156,000)
Mode of administration of EQ-5D-Y	Count
Self Proxy	140 166

Table 6.1: Demographic details

A total of 46 eye conditions were identified at the baseline out of which 14 conditions were included for further post-intervention estimation of VAS scores and utility values.

6.2.1 VAS Scores

Mild VI VAS scores

The baseline VAS score for individuals with mild vision impairment stood at 0.8 (interquartile range (IQR): 0.57 - 0.95) with a 95% confidence interval of 0.7 - 0.9. Following the intervention, the VAS score for those with mild vision impairment increased to 0.9 (interquartile range: 0.79 - 1) with a 95% confidence interval of 0.82 - 1. There is no statistically significant difference between the median VAS scores post intervention and at baseline.

Moderate VI VAS scores

The baseline VAS score for individuals with moderate vision impairment was 0.8, with an interquartile range (IQR) between 0.61 and 0.9 and a 95% confidence interval (CI) of 0.7 to 0.85. After the intervention, the VAS score for those with moderate vision impairment increased to 0.87, with an IQR between 0.8 and 1 and a 95% CI of 0.8 to 0.93. This improvement in Visual Analog Scale (VAS) scores among individuals with moderate vision impairment is statistically significant. Furthermore, there has been a notable enhancement in LogMAR Best Corrected Visual Acuity (BCVA), which has improved from 0.5 to 0.34..

Severe VI VAS scores

The baseline VAS value for individuals with severe vision impairment stood at 0.7 (interquartile range 0.65 - 0.75) with a 95% confidence interval of 0.65 - 0.75. Following the intervention, the VAS value for severe vision impairment increased to 0.85 (interquartile range 0.79 - 0.86) with a 95% confidence interval of 0.8 - 0.85. These results indicate a statistically significant enhancement in VAS scores after the intervention among those experiencing severe vision impairment. Furthermore, the LogMAR Best Corrected Visual Acuity (BCVA) demonstrated notable improvement, transitioning from 1.2 to 0.0.

Blindness VAS scores

The baseline VAS value for individuals with blindness was recorded as 0.55 (with an interquartile range of 0.44 to 0.72) and a 95% confidence interval of 0.5 to 0.7. After the intervention, the VAS value for blindness increased to 0.65 (with an interquartile range of 0.5 to 0.8) and a 95% confidence interval of 0.5 to 0.8. Among those with severe vision impairment, a statistically significant improvement in VAS scores was observed following the intervention. Specifically, the LogMAR Best Corrected Visual Acuity (BCVA) improved from 2.0 to 1.5.

Amblyopia VAS scores

The baseline VAS score for Amblyopia stood at 0.75 (with an interquartile range of 0.55 to 0.85) and a 95% confidence interval ranging from 0.6 to 0.85. After the intervention, the VAS score for Amblyopia rose to 0.9 (with an interquartile range of 0.85 to 0.95) and a 95% confidence interval ranging from 0.85 to 0.95. There is a statistically significant enhancement in the VAS scores following the intervention, particularly among individuals with severe vision impairment. The average LogMAR Best Corrected Visual Acuity (BCVA) has improved from 0.33 to 0.29.

Pediatric cataract VAS scores

The baseline VAS score for Pediatric cataract stood at 0.7 (with an interquartile range of 0.52-0.9) and a 95% confidence interval between 0.6 and 0.8. After the intervention,

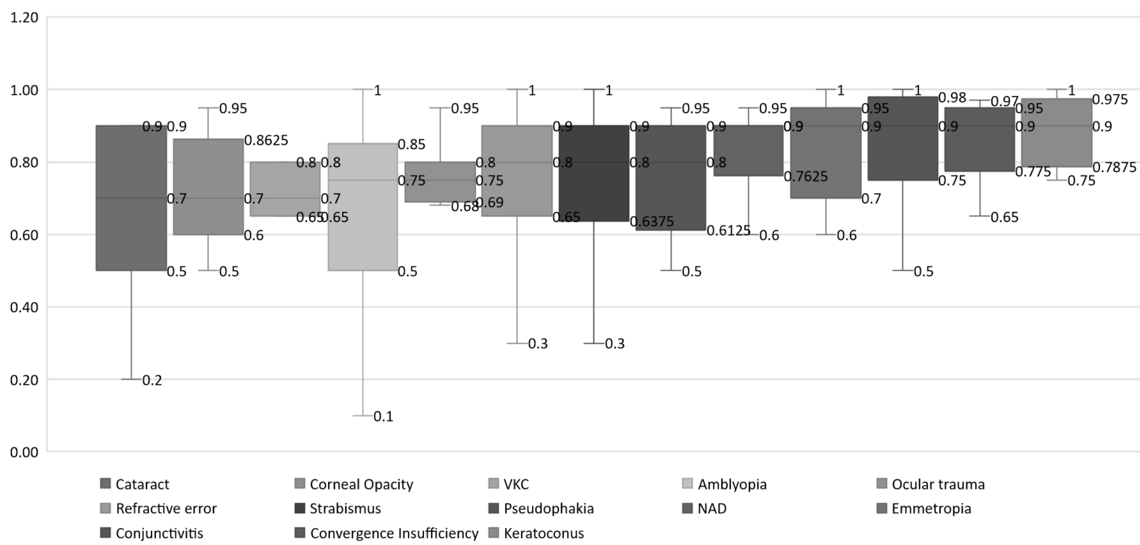

Figure 6.6: Graph of Baseline Visual Analogue Scale (VAS) Scores of various categories

the VAS value for Pediatric cataract increased to 0.8 (with an interquartile range of 0.65-0.9) and a 95% confidence interval between 0.7 and 0.85. Among individuals with severe vision impairment, there is a statistically significant enhancement in the VAS scores post-intervention. Specifically, the median LogMAR Best Corrected Visual Acuity (BCVA) has improved from 0.5 to 0.4.

Primary Congenital Glaucoma (PCG)

We have measured the post intervention VAS score of individuals with PCG. The median post intervention VAS score for PCG and IQR were 0.8 (0.67-0.9) and a 95% confidence interval of 0.7 to 0.8.

The baseline and post intervention median VAS scores are mentioned in the tables 6.2 and 6.3 and figures 6.6 and 6.7.

There is a negative correlation between best corrected visual acuity (BCVA) and VAS scores (-0.37).

Condition	ICD-10 Code	B-VAS Score	IQR	95% CI	LogMAR BCVA
RE	H52	0.8	0.65-0.9	0.75-0.9	0.3 (0.0-0.5)
NAD	-	0.9	0.79-0.9	0.825-0.9	0.0 (0.0-0.0)
Strabismus	H50	0.8	0.67- 0.9	0.75-0.88	0.2 (0.0-0.4)
Pediatric cataract	H25.9	0.7	0.52-0.9	0.6-0.8	0.5 (0.3-1.4)
Emmetropia	H52.0	0.9	0.75-0.85	0.8-0.9	0.0 (0.0-0.0)
Amblyopia	H53.0	0.75	0.55-0.85	0.65-0.85	0.2 (0.0-0.45)
Conjunctivitis	H10.9	0.9	0.8-0.98	0.85-0.95	0.0 (0.0-0.0)
Convergence insufficiency	H51.1	0.9	0.8-0.95	0.75.-0.95	0.0 (0.0-0.0)
Ocular Trauma	S00-T98	0.75	0.7-0.8	0.68-0.8	0.4 (0.0-0.5)
Pseudophakia	Z96.1	0.8	0.6-0.9	0.6-0.9	0.25 (0.2-0.9)
Corneal opacity	H17.9	0.7	0.6-0.79	0.6-0.9	0.2 (0.0-0.6)
Keratoconus	H18.6	0.9	0.86-0.92	0.75-1	0.55 (0.27-0.87)
ONH	H35.0	0.55	0.32-0.78	0.1-1	2.7 (2.25-2.70)
VKC	H10.1	0.7	0.68-0.75	0.65-0.8	0.0 (0.0-0.15)

B-VAS Score: Baseline Visual Analogue Scale Score, RE: Refractive Error, NAD: No Abnormality Detected, ONH: Optic Nerve Hypoplasia, VKC: Vernal Kerato-conjunctivitis

Table 6.2: Baseline Visual Analogue Scale (VAS) Score

Condition	ICD-10 Code	PI-VAS Score	IQR	95% CI	LogMAR BCVA
Mild VI	H54.9	0.90	0.79-1.00	0.82-10	0.4 (0.4-0.4)
Moderate VI	H54.9	0.87	0.80-1.00	0.80-0.93	0.5 (0.5-0.7)
Severe VI	H54.9	0.85	0.79-0.86	0.80-0.85	1.2 (1.1-1.3)
Blindness	H54.9	0.65	0.50-0.80	0.50-0.80	2.0 (1.72-2.3)
Strabismus	H50	0.85	0.70-0.96	0.70-0.97	0.2 (0.00-0.37)
Pediatric Cataract	H25.9	0.80	0.65-0.90	0.67-0.87	0.4 (0.30-0.85)
Amblyopia	H53.0	0.90	0.85-0.95	0.85-0.95	0.25 (0.15-0.34)
PCG	Q15.0	0.80	0.67-0.90	0.70-0.80	NA

PI-VAS Score: Post-Intervention Visual Analogue Scale Score, PCG: Primary Congenital Glaucoma, VI: Vision Impairment, NA: Not Available

Table 6.3: Post-Intervention VAS Scores

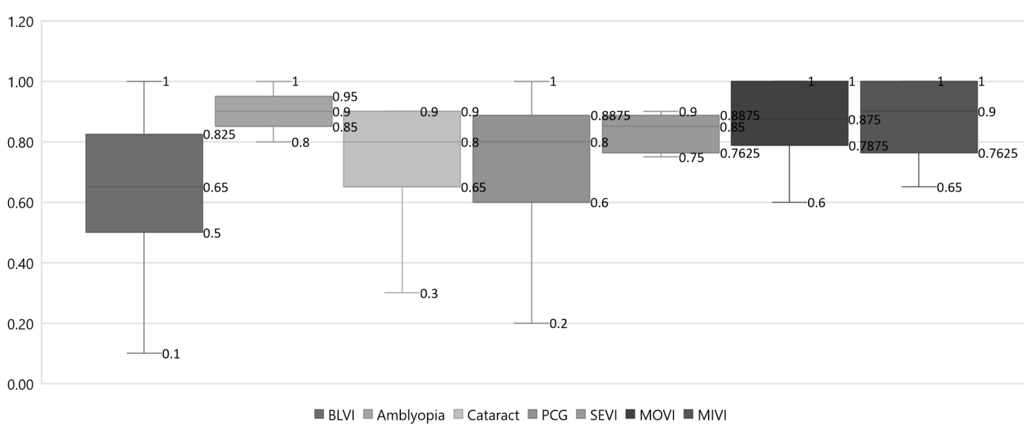

Figure 6.7: Post-Intervention Visual Analogue Scale Score

6.2.2 Utility Values

Mild Vision Impairment (MiVI)

The utility values were estimated using Indonesian value set scoring system. Using the value set, the estimated range of baseline utility values for all eye health conditions was -0.086 to 1.00; and the estimated range of post-intervention utility value for all eye health conditions was 0.08 to 1. We found statistically significant difference between baseline and post-intervention utility values for Mild VI using Wilcoxon Signed Rank test: V=126, p = <0.05, the utility values are mentioned in the figure 6.8.

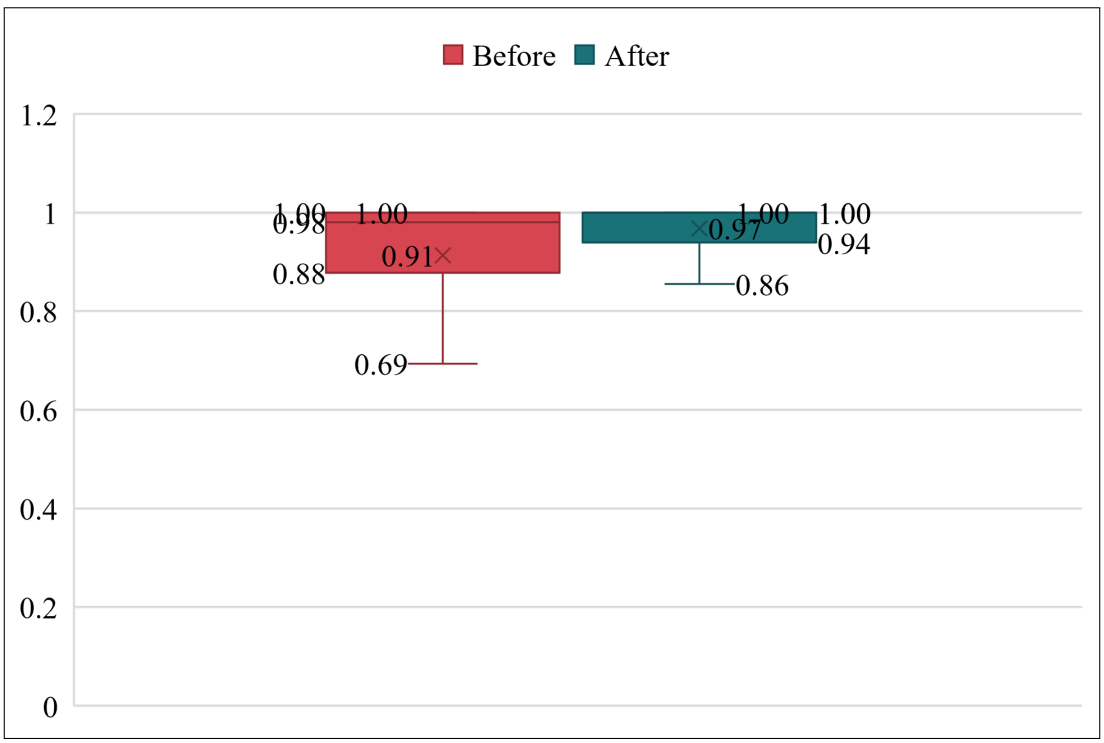

Figure 6.8: Baseline and post-intervention utility values - Mild VI

Moderate Vision Impairment (MoVI)

We found statistically significant difference between baseline and post-intervention utility values for Moderate VI using Wilcoxon Signed Rank test: V=528, p = <0.05, the utility values are mentioned in the figure 6.9.

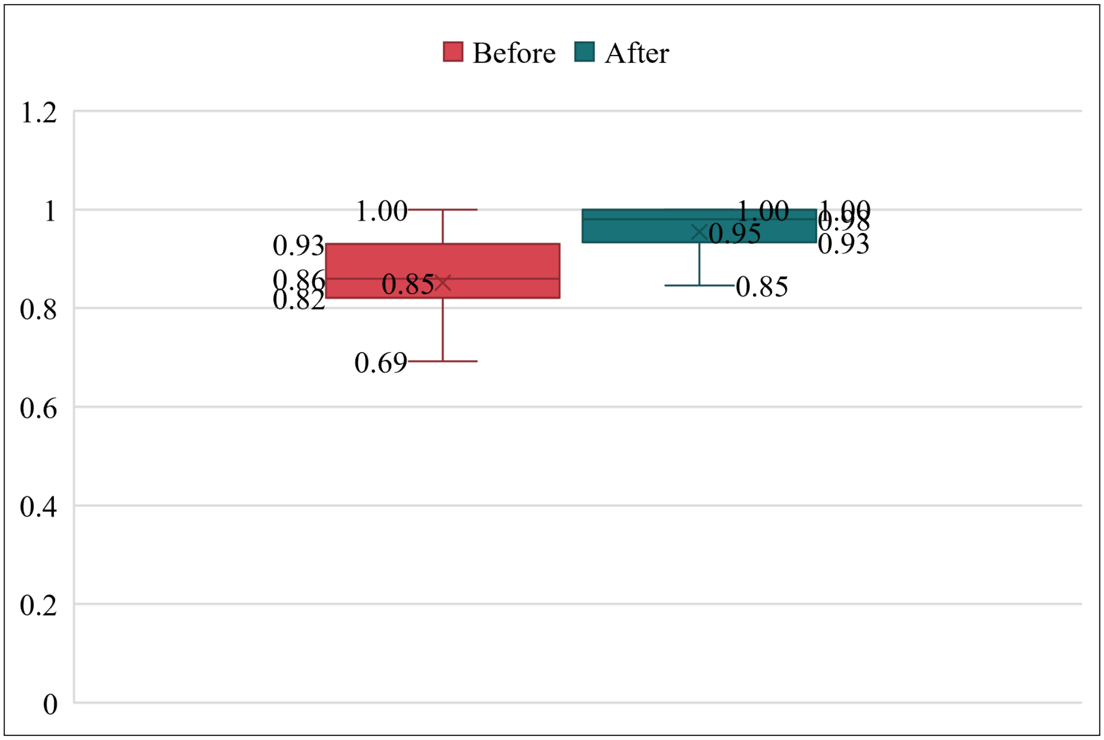

Figure 6.9: Baseline and post-intervention utility values - Moderate VI

Severe Vision Impairment (SeVI)

We found statistically significant difference between baseline and post-intervention utility values for Severe VI using Wilcoxon Signed Rank test: V=210, p = $<$0.05, the utility values are mentioned in the figure 6.10.

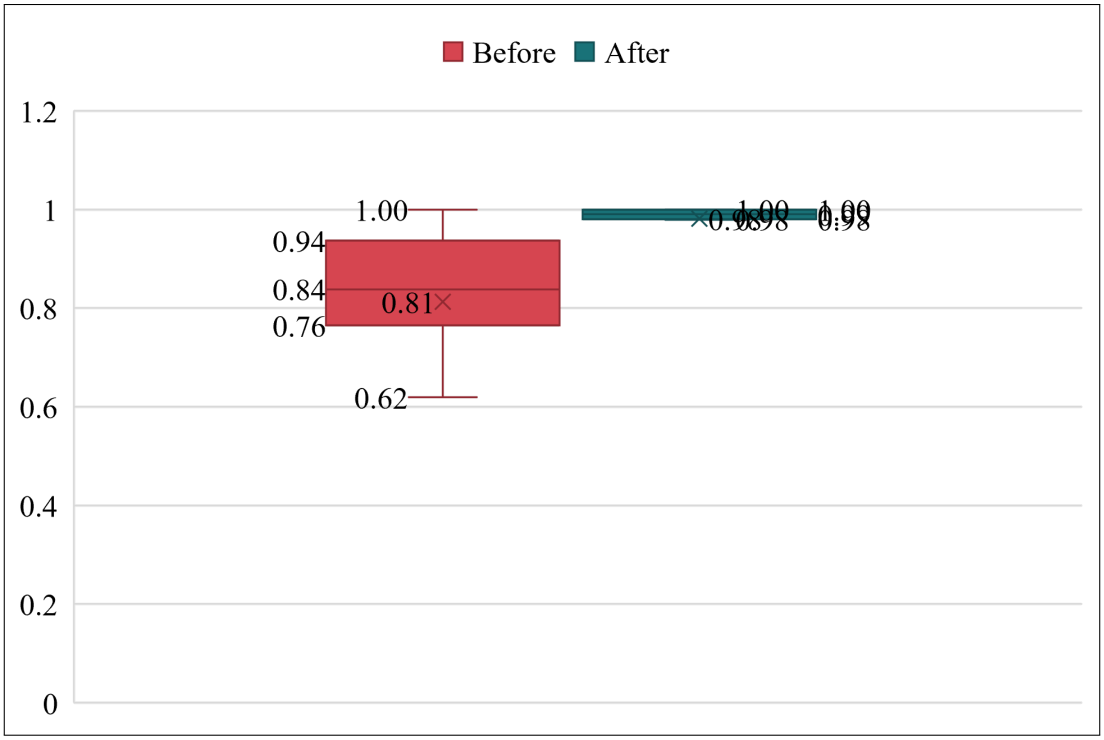

Figure 6.10: Baseline and post-intervention utility values - Severe VI

Blindness

We found statistically significant difference between baseline and post-intervention utility values for Blindness using Wilcoxon Signed Rank test: V=168, p = $<$0.05, the utility values are mentioned in the figure 6.11.

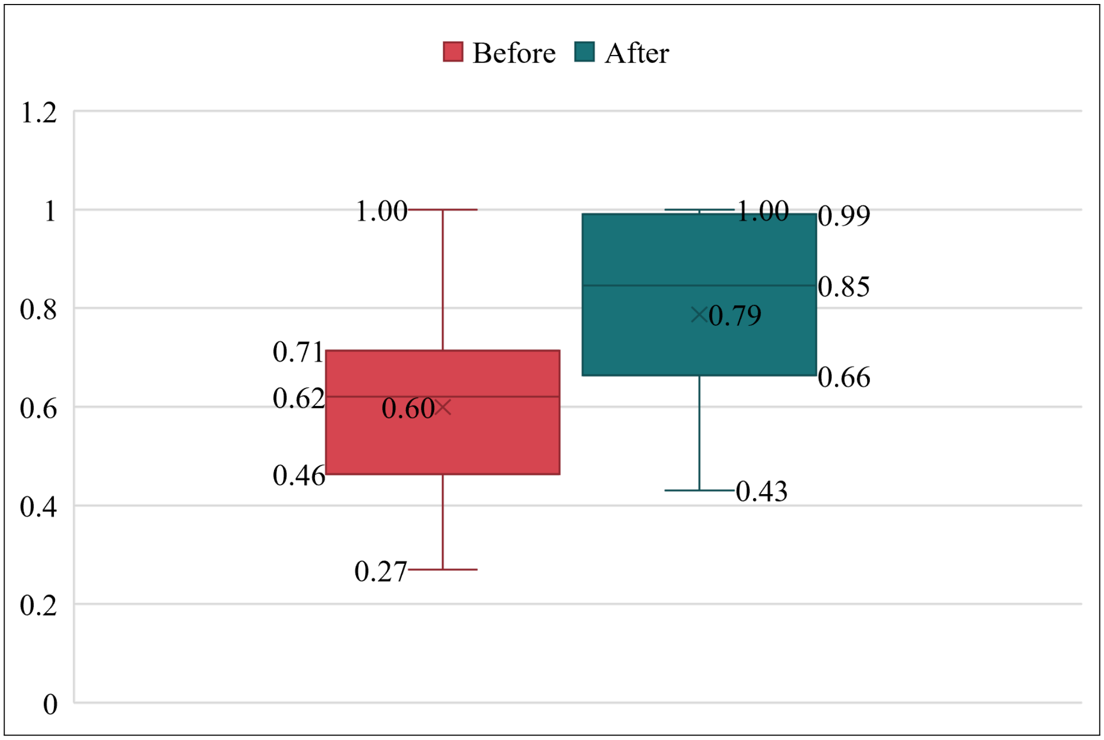

Figure 6.11: Baseline and post-intervention utility values - Blindness

Strabismus

We found statistically significant difference between baseline and post-intervention utility values for Strabismus using Wilcoxon Signed Rank test: V=231, p = <0.05, the utility values are mentioned in the figure 6.12.

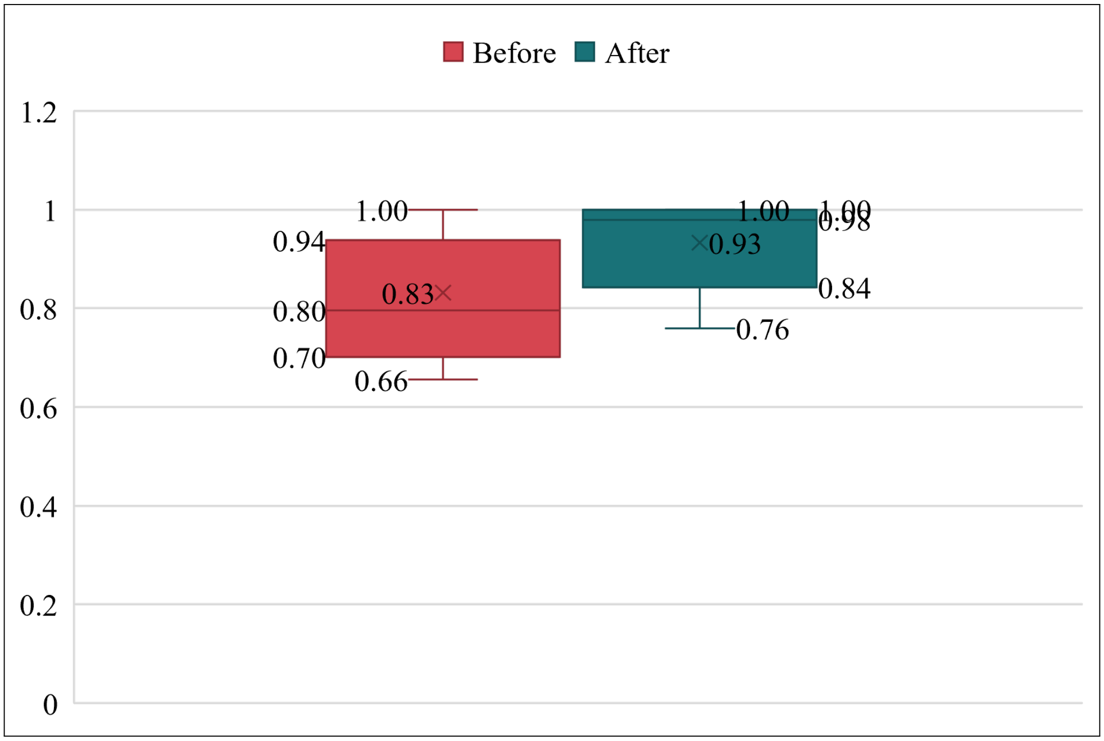

Figure 6.12: Baseline and post-intervention utility values - Strabismus

Pediatric cataract

We found statistically significant difference between baseline and post-intervention utility values for Pediatric cataract using Wilcoxon Signed Rank test: V=406, $p = <0.05$, the utility values are mentioned in the figure 6.13.

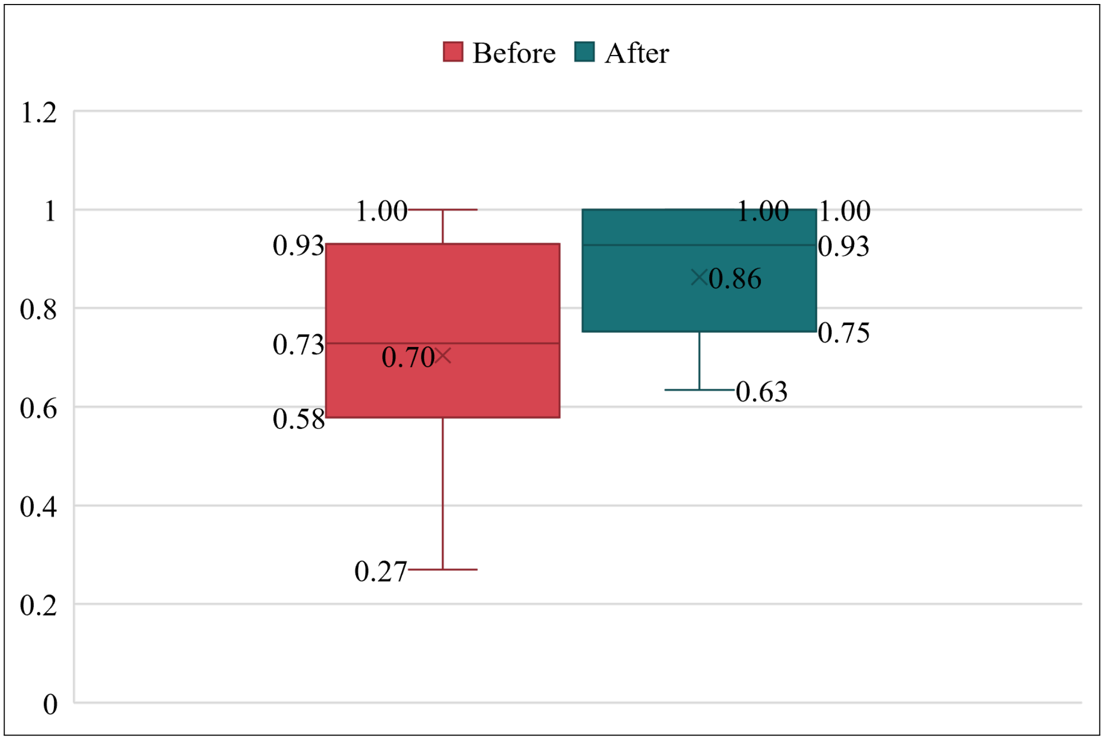

Figure 6.13: Baseline and post-intervention utility values - Pediatric cataract

Amblyopia

We found statistically significant difference between baseline and post-intervention utility values for Amblyopia using Wilcoxon Signed Rank test: V=128.5, $p = <0.05$, the utility values are mentioned in the figure 6.14.

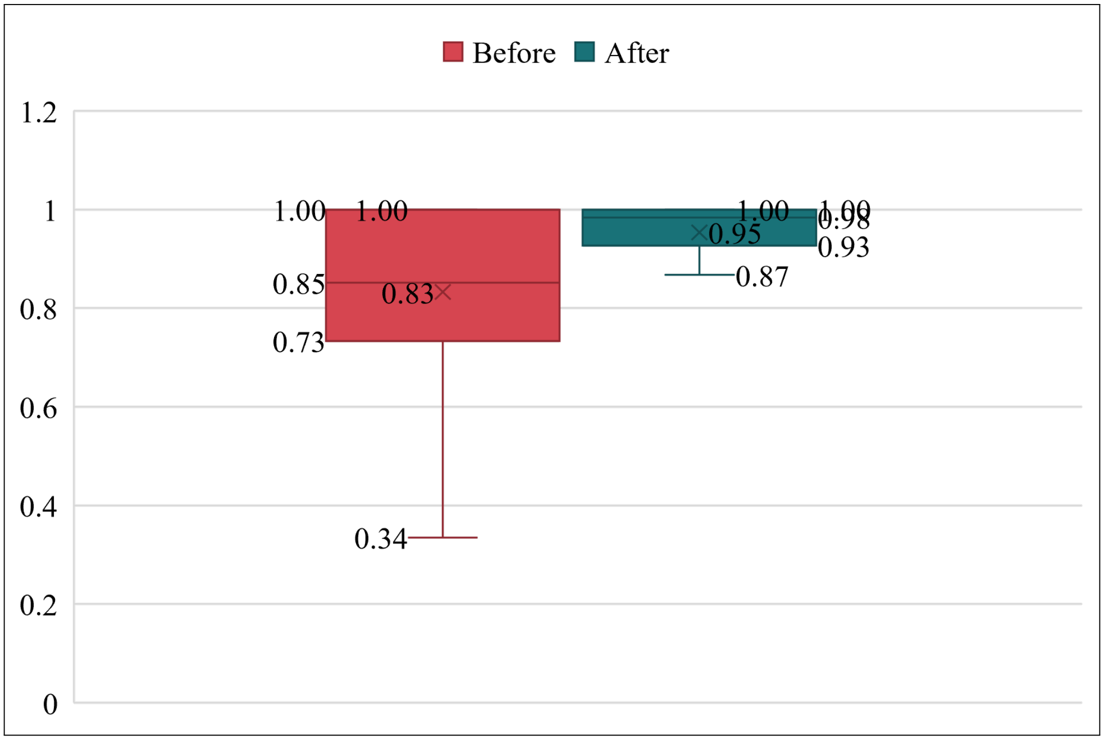

Figure 6.14: Baseline and post-intervention utility values - Amblyopia

Primary Congenital Glaucoma (PCG)

The median utility value for PCG was 1.00 post intervention.

Using Generalized Estimating Equations, we have found that there is no statistically significant difference in LogMAR VA or Utility values for a person with a specific condition between both eyes or only one eye (β = 0.034, p = 0.65), after controlling for age and gender. The median utility value estimates were higher than median VAS scores for all conditions at baseline and post-intervention as shown in tables 6.4 and 6.5.

The baseline and post-intervention utility values for different conditions and vision impairment are mentioned in table 6.6

Condition	ICD-10 Code	n	VAS (IQR)	UV (IQR)	BCVA
MiVI	H54.9	28	0.8 (0.57-0.95)	0.98 (0.84-1.00)	0.4 (0.4-0.4)
MoVI	H54.9	33	0.8 (0.6-0.9)	0.86 (0.82-0.93)	0.5 (0.5-0.7)
SeVI	H54.9	25	0.70 (0.65-0.75)	0.84 (0.77-0.93)	1.2 (1.1-1.3)
Blindness	H54.0	20	0.55 (0.44-0.72)	0.62 (0.50-0.71)	2.0 (1.72-2.3)
Strabismus	H50	36	0.8 (0.64-0.90)	0.80 (0.71-0.83)	0.2 (0.0-0.4)
Pediatric cataract	H25.9	31	0.7 (0.52-0.9)	0.73 (0.59-0.92)	0.5 (0.30-1.25)
Amblyopia	H53.0	23	0.75 (0.55-0.85)	0.85 (0.75-1.00)	0.2 (0.00-0.45)
NAD	-	49	0.9 (0.75-0.9)	0.97 (0.85-1)	0.0 (0.0-0.0)

VAS: Median Visual Analogue Score, IQR: Interquartile Range, UV: Median Utility Value, BCVA: Median Best Corrected Visual Acuity, MiVI: Mild Vision Impairment, MoVI: Moderate Vision Impairment, SeVI: Severe Vision Impairment, NAD: No Abnormality Detected, ONH: Optic Nerve Hypoplasia, VKC: Vernal Kerato-conjunctivitis

Table 6.4: Baseline VAS Scores and Utility Values

Condition	ICD-10 Code	n	PI-VAS (IQR)	PI-UV (IQR)	BCVA
MiVI	H54.9	28	0.9 (0.79-1.00)	1.00 (0.92-0.95)	0.4 (0.4-0.4)
MoVI	H54.9	33	0.87 (0.8-1.00)	0.98 (0.94-1.00)	0.5 (0.5-0.7)
SeVI	H54.9	25	0.85 (0.79-0.86)	0.98 (0.98-1.00)	1.2 (1.1-1.3)
Blindness	H54.0	20	0.65 (0.50-0.80)	0.85 (0.69-0.98)	2.0 (1.72-2.3)
Strabismus	H50	36	0.85 (0.70-0.96)	0.98 (0.88-1.00)	0.2 (0.0-0.4)
Pediatric cataract	H25.9	31	0.8 (0.65-0.90)	0.93 (0.78-1.00)	0.5 (0.30-1.25)
Amblyopia	H53.0	23	0.9 (0.85-95)	0.98 (0.93-1.00)	0.2 (0.00-0.45)

VAS: Median Visual Analogue Score, IQR: Interquartile Range, UV: Median Utility Value, BCVA: Median Best Corrected Visual Acuity, MiVI: Mild Vision Impairment, MoVI: Moderate Vision Impairment, SoVI: Severe Vision Impairment, NAD: No Abnormality Detected, ONH: Optic Nerve Hypoplasia, VKC: Vernal Kerato-conjunctivitis

Table 6.5: Post-Intervention VAS Scores and Utility Values

Condition	ICD-10 Code	BMUV	PIUV	ΔUV	p-value
Mild VI	H54.9	0.98	1.00	0.02	<0.05
Moderate VI	H54.9	0.86	0.98	0.12	<0.05
Severe VI	H54.9	0.84	0.99	0.15	<0.05
Blindness	H54.0	0.62	0.85	0.23	<0.05
Strabismus	H50	0.80	0.98	0.18	<0.05
Pediatric cataract	H25.9	0.73	0.93	0.20	<0.05
Amblyopia	H53.0	0.85	0.98	0.13	<0.05

MNUV = Baseline Median Utility Value, PIUV = Post-Intervention Utility Value, ΔUV = Difference between Post-Intervention and Baseline Median Utility Values, VI = Vision Impairment
Test of significance is using Wilcoxon Signed Rank Test

Table 6.6: Baseline and Post-Intervention Utility Values for various Eye Conditions

6.3 Objective 3: Cost-Effectiveness Analysis of Investing in Child Eye Health

6.3.1 Income and costs

We have included 306 participants in the costing study. The median annual family income was INR 120,000 (IQR 78,000 - 156,000). The median total direct medical cost in the treatment group was INR 2,275 (IQR 1,562 - 3,350) (95% CI 2,100 - 2,500). The median direct non-medical cost in the treatment group was INR 3,300 (IQR 2,600 - 3,950) (95% CI 3,200 - 3,450). The median indirect cost in the treatment group was INR 500 (IQR 300 - 900) (95% CI 500-500). The total cost of all interventions was INR 6,350 (IQR 5,178 - 8,188). We have estimated the cost of no treatment. The median total direct cost for the no-intervention group was INR 1,750 (IQR 950 - 2,200) (95% CI 1,600 - 1,850). The median total direct non-medical cost for the no-intervention group was INR 3,300 (IQR 2,600 - 3,950) (95% CI 3,200 - 3,450). The median total indirect cost for the no-intervention group was INR 500 (IQR 300 - 900) (95% CI 500 - 500). The median total cost of no-intervention was INR 5,625 (IQR 4,812 - 6,542) (95% CI 5,400 - 5,800).

Mild VI costs

The median total direct medical cost for those with mild VI was INR 2,675 (IQR 1,750 - 7,175), direct non-medical cost was INR 3,110 (IQR 2,250 - 3,592), indirect cost was INR 500 (IQR 275 - 671); for no-intervention, the median direct medical cost was INR 1,900 (IQR 1,588 - 2,712), the median direct non-medical cost was INR 3,110 (IQR 2,250 - 3,592), the median indirect cost was INR 500 (IQR 275 - 1,000). Sensitivity analysis of the costs related mild VI showed significant variation of total costs due to variation in the direct medical costs, a tornado diagram of the sensitivity analysis can be seen in figure 6.15

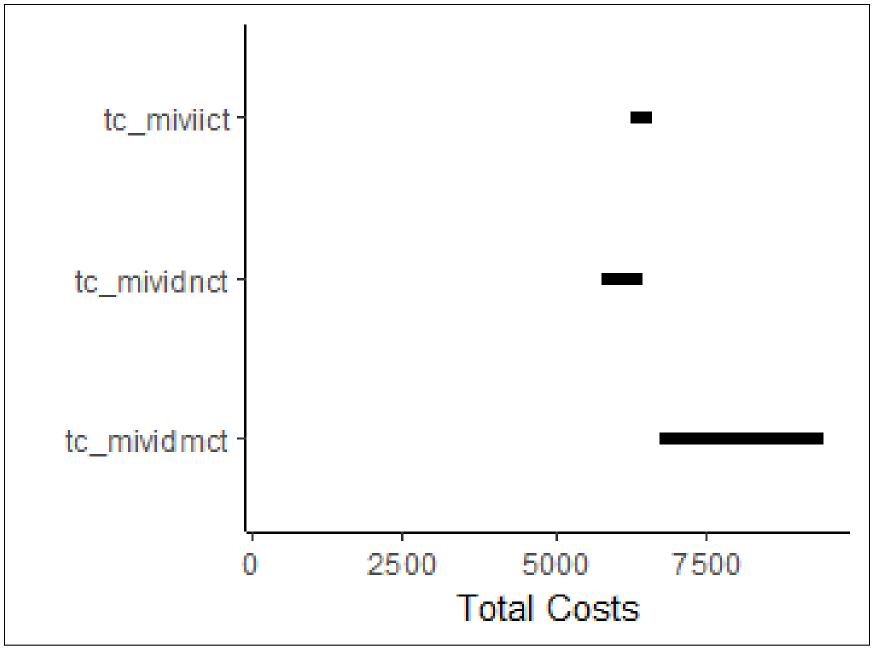

Figure 6.15: Tornado diagram of sensitivity analysis of Mild VI

Moderate VI costs

The median total direct medical cost for those with moderate VI was INR 3,350 (IQR 2,475 - 18,925), direct non-medical cost was INR 3,500 (IQR 2,850 - 4,375), indirect cost was INR 500 (IQR 300 - 1,000); for no-intervention, the median direct medical cost was INR 1,900 (IQR 1,500 - 2,525, the median direct non-medical cost was INR 3,500 (IQR 2,850 - 4,375), the median indirect cost was INR 500 (IQR 300 - 1,000). Sensitivity analysis of the costs related moderate VI showed significant variation of total costs due to variation in the direct medical costs, a tornado diagram of the sensitivity analysis can be seen in figure 6.16

Severe VI costs

The median total direct medical cost for those with severe VI was INR 2,450 (IQR 1,900 - 3,400), direct non-medical cost was INR 3,110 (IQR 2,450 - 4,000), indirect cost was INR 500 (IQR 300 - 1,100); for no-intervention, the median direct medical cost was

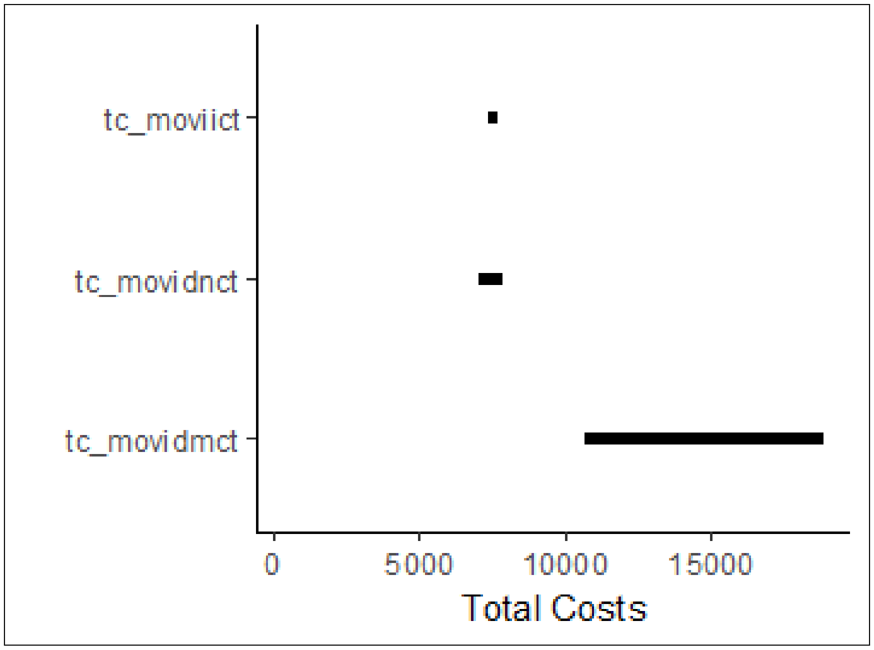

Figure 6.16: Tornado diagram of sensitivity analysis of Moderate VI

INR 1,900 (IQR 1,600 - 2,400), the median direct non-medical cost was INR 3,110 (IQR 2,450 - 4,000, the median indirect cost was INR 500 (IQR 300 - 1,100). Sensitivity analysis of the costs related to Severe VI showed minor variation of total costs due to variations in the direct medical costs and direct non-medical costs; a tornado diagram of the sensitivity analysis can be seen in figure 6.17

Blindness costs

The median total direct medical cost for those with blindness was INR 8,750 (IQR 2,700 - 18,900), direct non-medical cost was INR 3,800 (IQR 2,850 - 4,200), indirect cost was INR 600 (IQR 500 - 1,000); for no-intervention, the median direct medical cost was INR 1,650 (IQR 1,050 - 2,200), the median direct non-medical cost was INR 3,800 (IQR 2,850 - 4,200, the median indirect cost was INR 600 (IQR 500 - 1,000). Direct Medical Costs showed highest variation in the sensitivity analysis of Blindness related cost data. Tornado diagram of the sensitivity analysis is depicted in the figure 6.18.

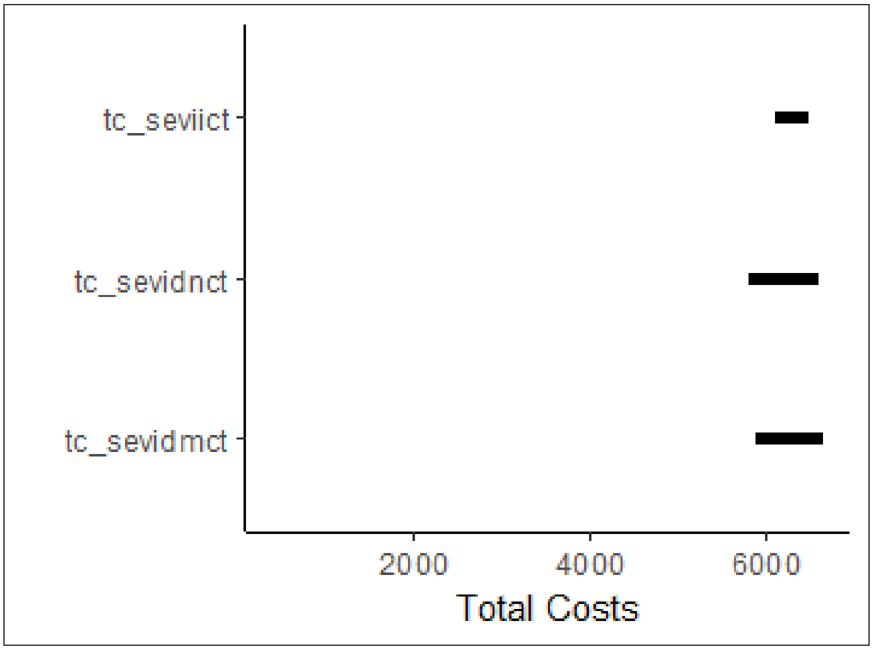

Figure 6.17: Tornado diagram of sensitivity analysis of Severe VI costs

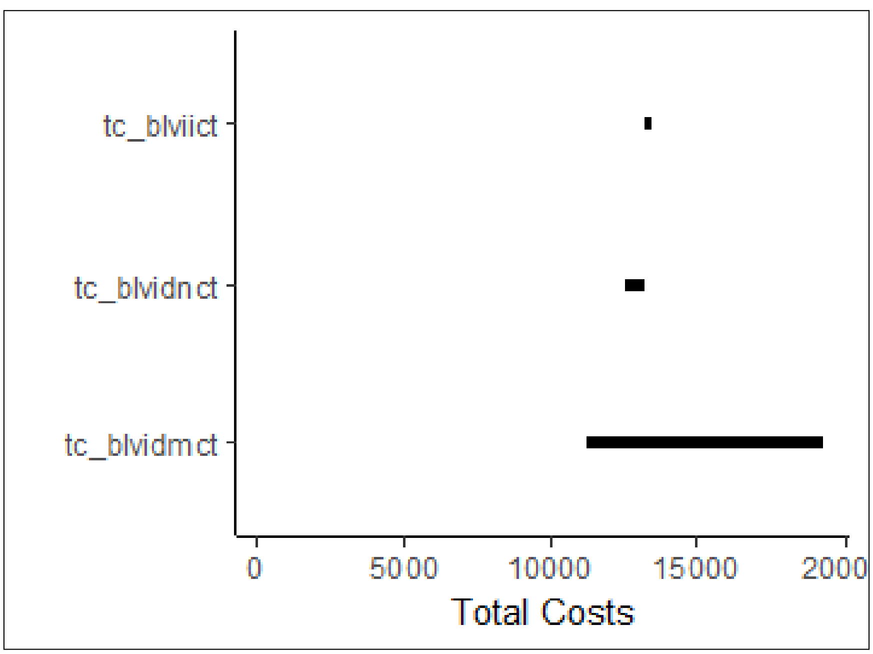

Figure 6.18: Tornado diagram of sensitivity analysis of Blindness related costs

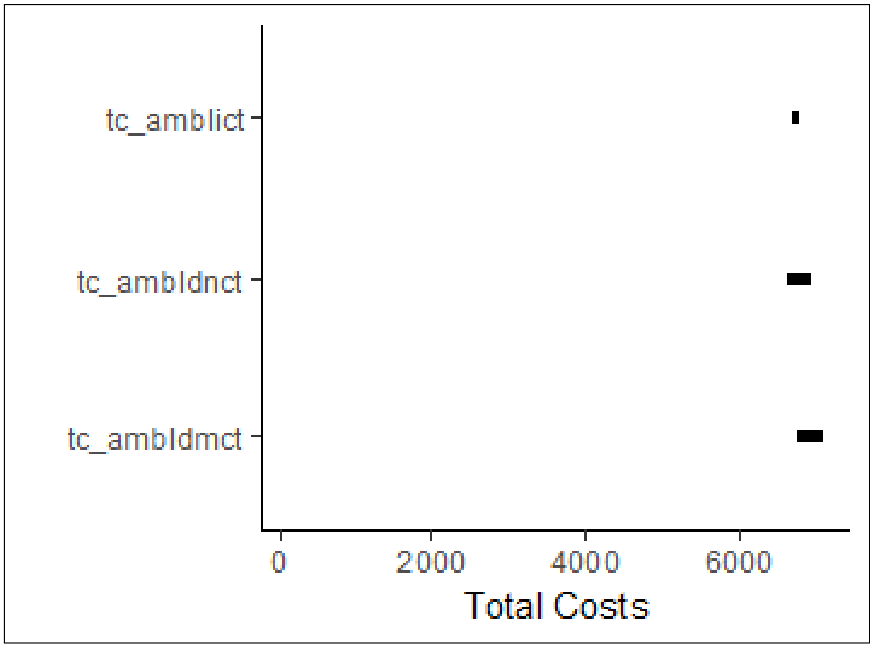

Figure 6.19: Tornado diagram of sensitivity analysis of Amblyopia related Costs

Amblyopia costs

The median total direct medical cost for those with Amblyopia was INR 2,700 (IQR 2,500 - 3,225), direct non-medical cost was INR 3,550 (IQR 3,225 - 3,900), indirect cost was INR 500 (IQR 350 - 550); for no-intervention, the median direct medical cost was INR 1,900 (IQR 1,375 - 2,450), the median direct non-medical cost was INR 3,550 (IQR 3,225 - 3,900 the median indirect cost was INR 500 (IQR 350 - 550). Sensitivity analysis of Amblyopia related costs showed not much of variation in all three categories of the costs and is depicted in the tornado diagram in figure 6.19

Pediatric cataract costs

The median total direct medical cost for those with Pediatric cataract was INR 13,300 (IQR 9,150 - 21,350), direct non-medical cost was INR 3,550 (IQR 2,650 - 4,000), indirect cost was INR 500 (IQR 300 - 1,100); for no-intervention, the median direct medical cost was INR 1,800 (IQR 1,100 - 2,200), the median direct non-medical cost was INR 3,550

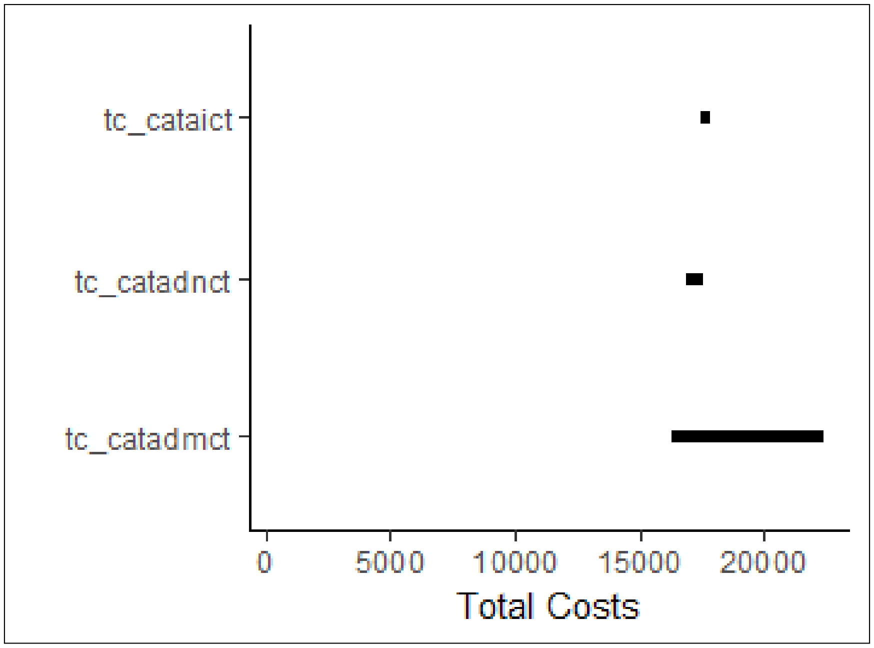

Figure 6.20: Tornado diagram of sensitivity analysis of Pediatric cataract related costs

(IQR 2,650 - 4,000 the median indirect cost was INR 500 (IQR 300 - 1,100). Sensitivity analysis of Pediatric cataract related costs showed significant variation in the direct medical costs and is depicted in the tornado diagram in figure 6.20

Primary Congenital Glaucoma (PCG)

The median total direct medical cost for those with PCG was INR 36,300 (IQR 6,150 - 83,300), direct non-medical cost was INR 9,375 (IQR 3,460 - 17,650), indirect cost was INR 1,700 (IQR 687 - 3,212).

Cost of interventions of various eye conditions are summarized in the table 6.7.

6.3.2 ICERs

The “Incremental Cost-Effectiveness Ratios (ICERs)” were expressed as cost per QALY per year for the specific condition and its intervention. We have estimated the baseline total costs for various conditions which we have analysed. The total costs for interventions for each of the conditions was also calculated as median total cost for that particular

Condition	Direct Medical Costs	Direct Non-Medical Costs	Indirect Costs	Total Costs
Mild VI (MiVI)	2,675	3,110	500	6535
Moderate VI (MoVI)	3,350	3,500	500	8,800
Severe VI (SeVI)	2,450	3,110	500	6,600
Blindness	8,750	3,800	600	14,000
Amblyopia	2,700	3,550	500	6,850
Pediatric cataract	13,300	3,550	500	18,150

MiVI: Mild Vision Impairment, MoVI: Moderate Vision Impairment, SeVI: Severe Vision Impairment

Table 6.7: Cost data of various eye conditions and their respective interventions (in Indian Rupees (INR))

condition. The numerator of the ICER is the difference between the cost of intervention and the cost of no treatment for that particular condition. The costs of intervention and no treatment are mentioned in the table 6.8.

The Incremental Cost-Effectiveness Ratios (ICERs) using VAS as denominator and QALY as denominator (measure of consequence) for various vision impairment categories, Amblyopia, and Pediatric cataract are mentioned in the table 6.9.

Amblyopia had the lowest ICER value and Pediatric cataract and Blindness had the highest ICER values.

Condition	Total cost with intervention	Total cost without intervention	Δ cost	Δ of outcomes (VAS scores)	Delta of outcomes (utility values)
MiVI	6,535	5,150	1,385	0.10	0.02
MoVI	8,800	6,000	2,800	0.07	0.12
SeVI	6,600	6,100	500	0.15	0.15
Blindness	14,000	5,540	8,460	0.10	0.23
Pediatric cataract	18,150	5,700	12,450	0.15	0.13
Amblyopia	6,850	6,250	600	0.10	0.20

MiVI: Mild Vision Impairment, MoVI: Moderate Vision Impairment, SeVI: Severe Vision Impairment, Δ cost: Difference between the cost of intervention and the cost of no intervention, Δ of outcomes: Change in the outcome without intervention and with intervention.

Table 6.8: Median total costs with and without intervention for each of the conditions (Expressed in Indian Rupees (INR)).

Condition	ICER in Indian Rupees (INR) per unit VAS per year	ICER in Indian Rupees (INR) per QALY
MiVI	13,850	69,250
MoVI	40,000	23,333
SeVI	3,333	3,333
Blindness	84,600	36,783
Pediatric Cataract	83,000	95,769
Amblyopia	6,000	3,000

MiVI: Mild Vision Impairment, MoVI: Moderate Vision Impairment, SeVI: Severe Vision Impairment.

Table 6.9: Incremental Cost-Effectiveness Ratios (ICERs)

CHAPTER 7

Discussion

This study has provided much needed scientific literature needed to undertake economic burden of disease studies which can be used for advocacy and raising awareness about blindness, vision impairment, and the need for early intervention in a specific targeted group of the population i.e children. It enables researchers and key stakeholders in carrying out cost-utility analyses of not only existing interventions but also any new intervention to address pediatric cataract, strabismus, amblyopia, vision impairment, and blindness. This paves way to studying the cost-effectiveness by estimating Incremental Cost-Effectiveness Ratios (ICERs) which enable stakeholders to compare these interventions and programs horizontally with other programs and assist in decision making in the allocation of scarce resources.

7.1 The Economic Burden of Blindness and Vision Impairment in India

The economic burden of blindness and vision impairment in India is very high. This is mainly due to increase in per-capita GNI, increased labor force participation, and increase in the overall population of the country although the prevalence has reduced. The long-term impact of childhood blindness and vision impairment has enormous effect on the economy as the cumulative economic burden is very high over the lifetime of the blind person. In this study, we have not estimated the exact loss of productivity by the caregiver, but have taken a conservative estimate which may undermine the overall indirect loss of GNI due to blindness. We have undertaken sensitivity analyses on the data related to the caregiver burden by varying the estimation by 10% as there is no published guideline on the exact caregiver burden. In accordance with existing guidelines, we have inflation adjusted the 1998 estimates to 2020 as the reference year using US Bureau of Labor Statistics, and all the prices were converted to international dollars (Int$) Purchasing Power Parity (PPP) using the International Monetary Fund (IMF). The availability of region specific prevalence estimates, per-capita gross state domestic product, minimum wage, and labor force participation would allow for a more geographically focused estimates which would assist key stakeholders to focus the much needed resources in regions which need them the most. The data and our estimates emphasise that such estimation studies need to be carried out periodically.

7.1.1 Strengths and Limitations

We have undertaken this study in order to understand details of economics of childhood eye diseases in India so that this literature may drive future research in this area of eye health economics. This is the first such cost of illness study on blindness and vision impairment in India for over two decades and produces valuable literature for many upcoming projects and studies. A study estimating the economic cost of Moderate and Severe Vision Impairment (MSVI) and Blindness was published soon after our findings were published. This study undertook a more welfare and societal approach to their estimations and found the economic burden of MSVI and blindness to be INR 1,158 billion.[15] Our estimation which is based on cost-of-illness methodology based on productivity losses, estimated the economic burden of MSVI and blindness to be INR 1,458 billion. Our estimates on the Economic Burden of Blindness and Vision Impairment in India relied on few projections such as population projections as the latest census data were not available and census was not undertaken in India due to COVID-19 situation in the year 2020-21. Although we compared the population projections from few sources, it is still an estimate and may under or over-represent the GNI losses due to blindness and vision impairment.

7.2 Development and Testing of Quality Adjusted Life Years (QALYs) Utility Values for Eye Health Outcomes

We have estimated the utility values using EQ-5D-Y instrument and its associated Visual Analogue Scale (VAS) which, at the time of this study are the only tools available to elicit the health state of a child aged four to 16 years. All other tools are not sensitive to children. The utility values were estimated after comprehensive eye examination and diagnosis of the condition in the child. In some instances, there were more than one condition diagnosed and the diagnosis was blinded from the data collector. We have used self reported instrument on children who could read and comprehend the questions, on children aged four to eight years, we have used proxy tool on their caregivers who are usually one of the parents. Also, there is a perception that it is only eyes and that the child is in perfect health in the rest of the body. We found that these are common observations in other studies. Our baseline utility value of blindness is 0.62 which is similar to findings in few other prior studies undertaken in India. The change in utility value post intervention for blindness was high due to high number of bilateral pediatric cataract patients where only one eye was operated at the time of this study data collection. Children with Severe vision impairment showed largest improvement in their utility value post-intervention indicating that providing a pair of spectacles for refractive correction can make significant improvement to their quality of life and also perhaps it is cost-effective. We have observed that children with amblyopia showed significant improvement in their utility values post-intervention from 0.75 to 0.9 indicating that amblyopia is one of the conditions which affects their quality of life negatively if untreated. According to their BCVA, children were categorized into one of the four visual impairment categories, which may also include those with conditions such as pediatric cataract, strabismus, and amblyopia. Our utility value estimations are similar to existing literature for Strabismus, pediatric cataract, and Blindness.[126, 129, 132]

Additional investigation is required to gain a deeper insight into how interventions affect the quality of life for children born with congenital conditions like congenital glaucoma, pediatric cataracts, RoP, and similar conditions. This is particularly important because these conditions can significantly diminish the long-term quality of life if left untreated during early childhood.

7.2.1 Strengths and Limitations

This study shows that the utility value has increased amongst all conditions as the health state improves with an average utility gain of 10% in all health conditions studied. These condition specific utility values are particularly useful in bridging the gap in knowledge and facilitate economic evaluations of child eye health interventions and outcomes using cost-utility analyses and cost-effectiveness analyses. To the best of our knowledge, when we initiated this study, it marked the inaugural attempt to assess the utility values associated with different eye conditions in children, encompassing blindness and visual impairment. Existing literature focused on adults. Our estimations of pediatric cataract, amblyopia and strabismus are based on the diagnosis even in one eye, which may have overestimated the utility value. However, we did analyze the inter-eye variability of LogMAR acuity and utility value using Generalized Estimating Equations (GEE) and found that there is no statistically significant difference when intervened in one eye or both eyes showing that an intervention even in one eye leads to significant utility gain. The use of proxy may have overestimated the utility value specially amongst those children who were congenitally blind and just because the parents did not want to show that their child is not so ill. We have used *EQ-5D-Y* instrument to measure health state preferences which has three levels which may be subject to ceiling effects as compared to five levels and our observations align to these ceiling effects specially amongst adolescent participants and when caregivers were responding proxy. There is an India specific value set for *EQ-5D-5L* adult instrument[161] but the *EQ-5D-Y* instrument does not have India specific value set and we relied on Indonesian value set and its scoring algorithm to estimate utility values as Indonesia has similar economic, socio-economic, and demographic spread in the country. However, we agree that this is not a true representation of utility values for eye health condition for India, we have also presented VAS scores which can be used as outcome measures in economic evaluations and as surrogates measures to utility values measured using *EQ-5D-Y*. Few of our utility value findings are similar to existing literature for few conditions; a comparison can be found in the Table 7.1. While glaucoma holds significant clinical importance, and congenital glaucoma is a leading cause of irreversible vision loss, we were unable to calculate the baseline utility values for this condition because of the extremely limited sample size at the study site and challenges in the proxy methodology used as the tool is sensitive to children aged above four years. We also observed that the *EQ-5D-Y* instrument may have been less sensitive in capturing ocular morbidity related health state compared to VAS, and this may be true as there is no vision related dimension in this instrument, we suggest the use of an adaptation of the *NEI-VFQ* which was done for adults to be used for children.[163]

7.3 Cost-Effectiveness Analysis of Investing in Child Eye Health

We have followed the HTA guidelines for costs and considered all the costs to be borne by the patients irrespective of who is paying for it; this allowed us to estimate the costs in a societal perspective as done in other studies.[15] The costs were categorized into direct medical costs, direct non-medical costs, and indirect costs in accordance with existing guidelines. The direct medical expenses encompassed expenses incurred by individuals.

Study	Sample size	Age Group (years)	Location	Tool	Parameter	Utility Value	Utility Value - Current Study
Current Study	306	4 to 16	India	EQ-5D-Y	Blindness	0.62	0.62
Polack et al, 2015	249	Above 40	India	TTO	Blindness	0.55	0.62
Brown et al, 2001	1500	Adults	USA	TTO	Blindness	0.26-0.65	0.62
Ben et al, 2021	206	Adults	Brazil	EQ-5D-3L	Blindness	0.355	0.62
Kishimoto et al, 2012	222	40-85	Japan	TTO	Strabismus pediatric cataract	0.852 0.727	0.8 0.73

Table 7.1: Comparison of Utility Values of Eye Conditions in different studies with the current study

However, the costs associated with surgical procedures were determined based on the hospital's pricing schedule, which varies depending on the treatment type and the patient category (non-paying, paying, or subsidized). This approach was implemented to maintain consistent treatment pricing for specific treatment types and patient categories. We have used both VAS scores and Utility Values for one year (QALY) as outcome measures (denominator) in order to calculate the ICER values. The change in utility values was much higher than the change in VAS scores for all types of conditions except mild VI and pediatric cataract thereby showing lower ICER values for those respective conditions. We have used sensitivity analyses on all types of cost estimates to account for costing uncertainties. We have noticed that the total expenses were sensitive to variations in direct medical expenditures, especially the expense associated with treatments. This may lead to change in ICER values for that particular treatment which is observed more amongst cataract treatments. The ICER is highest for Pediatric cataract, this is due to the minimal change in the utility value post-intervention and also because we have observed that the baseline utility was already high and most of the cases were traumatic in nature and unilateral thereby making the utility value to be estimated higher as perceived by the respondents. Hence, the cost per unit change in utility was also high amongst pediatric cataract interventions. Amblyopia had one of the lowest ICER values together with severe vision impairment indicating that timely intervention leads to a greater gain in quality of life utility and thereby valuing it to be highly effective. Our study shows that greater investment towards addressing conditions such as blindness, pediatric cataract, amblyopia, and severe vision impairment are needed and that these interventions are highly cost-effective and fall well below the Willingness to Pay (WTP) threshold.

7.3.1 Strengths and Limitations

This research represents the preliminary but seminal effort aimed at studying and understanding the expenses and outcomes associated with interventions for childhood eye conditions in the context of eye health. Our costing estimation followed methodological guidelines and have used mixed methods approach in primary data collection.[40, 61] Costing data are subject to recall biases and the existing COVID-19 pandemic situation might have led to increased costs for the participants as they had to rely on private transport and had to make special arrangements for boarding and lodging. Almost all of our participants were from lower socio-economic background and hence our data were mostly homogeneous in nature. We found greater variability in the overall costs due to variations in the direct medical costs, these are due to higher proportion of non-paying patients where the costs of treatment were very minimal. We have accounted for these variations through sensitivity analyses of all the cost parameters. We did not have WTP data for India, but the findings indicate a low cost of interventions and thereby indicating that all of the interventions were highly cost-effective considering WHO guidelines of WTP. Hence we could not provide

ICERs for WTP thresholds in this study.

7.4 Recommendations

1. Our study provides directions to health authorities to increase investment in healthcare, specially in child eye health and show that early intervention is very important in averting future loss of productivity.

2. There should be horizontal integration of these child eye health interventions to allow early detection of eye diseases which can be achieved through accelerated adoption of Integrated People Centred Eye Care by various stakeholder.[16]

3. Cost-of-illness studies are relevant for a particular time period and we recommend that they need to be undertaken periodically so that progress can be compared and future actions are planned efficiently and advocacy measures are undertaken.

4. State wise and condition specific availability of dis-aggregate data is important in order to undertake such studies.

5. We recommend that utility value estimations need to be undertaken for the remaining eye conditions, specifically glaucoma amongst children.

6. To assess health state preferences in Indian children, it is essential to customize NEI-VFQ and EQ-5D-Y and conduct a study for validation and value set mapping.[116]

7. The use of CEAs and CUAs have to be periodically undertaken to drive policy towards investing in child eye health and our findings will be helpful in undertaking these evaluations.

8. We recommend the use of full economic evaluations of eye care interventions and programs in India as recommended by existing literature.[12] We could not find full

economic evaluations of eye care programs and interventions in India during our literature searches.

CHAPTER 8

Conclusions and Future work

8.1 Conclusions

Our three objectives contribute valuable body of literature related to all three types of health economic evaluations specific to child eye health in India. The findings need to be used to drive policy, advocacy, undertake full economic evaluations using utility values and also undertake CEAs. Child eye health should be a focus area and should muster investments over other programs and interventions horizontally using utility findings and ICERs from this study. Future research should focus on understanding Willingness to Pay (WTP) for each condition and its intervention. These can be done by Discrete Choice Experiments (DCEs).[164] There is a need for India specific EQ-5D-Y value set.[161] Future research should focus on the long-term productivity losses, costs, and utility values specific few conditions such as Primary Congenital Glaucoma (PCG), Amblyopia, Refractive Errors, and Glaucoma using decision modelling, and condition probabilities. The results of this study should be employed to prioritize resource allocation, support advocacy efforts, conduct economic assessments, and aid in the implementation of Integrated People-Centered Eye Care (IPCEC) strategies.[16, 165]

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Appendices

APPENDIX A
Appendices

A.1 List of Publications from Current Thesis

Original article in Indian Journal of Ophthalmology

Special Focus, Community Ophthalmology, Original Article

Current estimates of the economic burden of blindness and visual impairment in India: A cost of illness study

Sunny Mannava, Rishi Raj Borah[1], Shamanna B R

Purpose: Currently, there are an estimated 4.95 million blind persons and 70 million vision impaired persons in India, out of which 0.24 million are blind children. Early detection and treatment of the leading causes of blindness such as cataract are important in reducing the prevalence of blindness and vision impairment. There are significant developments in the field of blindness prevention, management, and control since the "Vision 2020: The right to sight" initiative. Very few studies have analyzed the cost of blindness at the population level. This study was undertaken to update the information on the economic burden of blindness and visual impairment in India based on the prevalence of blindness in India. We used secondary and publicly available data and a few assumptions for our estimations. **Methods:** We used gross national income (GNI), disability weights, and loss of productivity metrics to calculate the economic burden of blindness and vision impairment based on the "cost of illness" methodology. **Results:** The estimated net loss of GNI due to blindness in India is INR 845 billion (Int$ 38.4 billion), with a per capita loss of GNI per blind person of INR 170,624 (Int$ 7,756). The cumulative loss of GNI due to avoidable blindness in India is INR 11,778.6 billion (Int$ 535 billion). The cumulative loss of GNI due to blindness increased almost three times in the past two decades. The potential loss of productivity due to vision impairment is INR 646 billion (Int$ 29.4 billion). **Conclusion:** These estimates provide adequate information for budgetary allocation and will help advocate the need for accelerated adoption of all four strategies of integrated people-centered eye care (IPCEC). Early detection and treatment of blindness, especially among children, is very important in reducing the economic burden; thus, there is a need for integrating primary eye care horizontally with all levels of primary healthcare.

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There are an estimated 4.95 million people blind (0.36% of the total population), 35 million people visually impaired (2.55%), and 0.24 million blind children in India.[1] Cataract and refractive error remain the leading causes of blindness and visual impairment, respectively, in India.[1–4] There have been significant developments in the field of blindness prevention, management, and control since the "Vision 2020: The right to sight" initiative[5] has been implemented over the last two decades. A recent study estimated the cost of blindness in terms of gross national income (GNI) per capita but on those aged above 50 years of age.[6] With many interventions in place for more than two decades now,[7] this study is undertaken to update the information on the economic burden of blindness and visual impairment in India based on the prevalence of blindness and visual impairment, GNI, and potential loss of productivity. This information at the national level has its utility in policy formulation and planning service delivery, including programmatic level budgetary provisions and allocations.

Methods

The methodology used is the "cost of illness" estimation.[6,8] We used secondary data and publicly available data in this study.

Demographic and prevalence of blindness and vision impairment data

We obtained demographic information such as the total population[9,10] and the total number of blind and vision-impaired people in India.[11] Data on the prevalence of blindness and vision impairment for the overall population and in children were obtained from the published literature.[1,2,12] Blindness is defined as "presenting visual acuity worse than 3/60 in the better eye"[1] in this study to compare the estimates previously estimated in 1998.[13]

Data for estimation of the economic burden of blindness and vision impairment in India

The economic burden of all blindness and vision impairment is expressed by considering the direct and indirect loss of GNI due to blindness and vision impairment and the economic productivity of the blind and visually impaired. We assumed that both GNI and gross national product are similar as this helps in comparison of the economic burden of blindness estimated in different time periods.[14] The economic burden of blindness was then estimated using multiple assumptions.

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These are the data and assumptions for the estimations:

- The total population of India as per current estimates is 1.38 billion[9,10] estimated at an annual growth rate (AGR) of 1.29% for the year 2020. There are 399 million children (29% of the population).[11] Population indicators range over a period from 2016 to 2020.
- We included all four levels of distance vision impairment as defined by WHO in the study.[15] Blindness is defined as presenting visual acuity worse than 3/60 in the better eye. Mild vision impairment is defined as presenting visual acuity worse than 6/12 to 6/18 in the better eye, moderate vision impairment is defined as presenting visual acuity worse than 6/18 to 6/60 in the better eye, and severe vision impairment is defined as presenting visual acuity worse than 6/60 to 3/60 in the better eye.[1,15]
- The estimated prevalence of blindness is 0.36% of the population (4.95 million).[1]
- The estimated prevalence of mild, moderate, and severe vision impairment is 2.92% (40 million), 1.84% (25 million), and 0.35% (4.8 million) of the population, respectively.[1]
- Per capita gross national income (GNI) is INR 139,867 (Int$ 6,357).[16]
- 51.5% of the population contributes to the labor force.[16,17] We assumed that 60% of blind adults contribute to the labor force.[13]
- The average age of children is considered as 8 years.[13] The average lifespan for blind children is assumed to be between 40 and 55 years.
- Primarily, the average number of working years considered lost due to blindness in children is estimated for 35 and 40 years due to the better survival rate of infants and the increase in life expectancy. All children are assumed to be economically productive after they attain 15 years of age.[13]
- We assumed that the productive time lost by caregivers is 10% taking care of blind adults[13] and 5% taking care of visually impaired persons. We assumed that caregivers lose 20% of the productive time taking care of blind children as more effort is needed.
- To calculate the cumulative loss of GNI, we assumed that 20% of the blind persons are economically productive at 25% of the actual productive workforce.[13]
- To calculate the GNI loss due to vision impairment, we used disability weights for vision impairment published by WHO.[18] Disability weights for vision impairment are used as substitutes for the relative reduction in employment due to vision impairment by assuming a direct relationship between productivity and disability weights.[19,20]
- Between 30% and 40% of blindness in children is due to avoidable (easily preventable and treatable) causes.[4] We assumed that 35% of blindness in children is avoidable.
- 82.3% of blindness among adults and 35% of blindness among children is due to avoidable causes.[2,21,22]

The formulas used for calculating the indicators used in this study are presented in Table 1.

In this estimation, the calculation is done based on the burden of blindness and vision impairment in economic terms and its loss of productivity. To compare data between 1997 and 2020, we used 2020 as the base year and converted the 1997 data into Int$ Purchasing Power Parity (PPP) for the year 1997 and then used the US inflation rate to adjust the Int$ to the base year.[26,27]

Ethical clearance

The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of the University of Hyderabad. Approval number: UH/IEC/2020/222.

Results

Economic burden of blindness in India estimated in the year 2020

Based on the assumptions, the net loss of GNI due to blindness in India is INR 845 billion (Int$ 38.4 billion). Per capita net loss of GNI per blind person is INR 170,624 (Int$ 7,756). Net loss of GNI due to blindness in adults and children is INR 832 billion and INR 13 billion respectively. The direct and indirect loss of GNI due to blindness in adults is INR 768 billion (Int$ 35 billion) and INR 128 billion (Int$ 5.8 billion) respectively. The indirect loss of GNI due to blindness in children is to the tune of INR 13 billion (Int$ 590 million). The economic productivity of blind adults is estimated as INR 64 billion (Int$ 2.9 billion). The total cumulative loss of GNI due to blindness (considering a loss of 10 and 35 working years for blind adults and children, respectively) is INR 19,512 billion (Int$ 887 billion). The cumulative loss of GNI due to avoidable blindness (considering a loss of 10 and 35 working years for blind adults and children, respectively) is INR 11,778.6 billion (Int$ 535.4 billion).

Estimates and comparison of the economic burden of blindness in 2020 and 1997–98 are presented in Table 2 and Figs. 1 and 2.

Potential loss of productivity due to vision impairment in India estimated in the year 2020

Based on the assumptions, the economic potential total loss of productivity due to vision impairment in India is INR 646 billion (Int$ 29 billion). The per capita loss of productivity due to vision impairment in India is INR 9,192 (Int$ 418). The loss of productivity due to mild, moderate, and severe vision impairment is presented in Fig. 3.

Discussion

Reduction in blindness and vision impairment and the economic impact in India

There is a substantial reduction in the prevalence of blindness in India compared with 1997–98 from 1% to 0.36% in 2020 by using the same definition of blindness. There is a nearly 50% reduction in vision impairment in 2020 from 2010 estimates.[1] This indicates that there have been sustained efforts toward the reduction of the prevalence of blindness in India in the last 22 years by various organizations and institutions.[4,13] Further, 62.6% of blindness is due to cataract in 2020 compared to 51.6% in 1997–98. The cumulative loss of GNI has almost doubled, and the cumulative loss of GNI due to avoidable causes has increased 1.8 times compared to 1997 data even after adjusting to inflation. These increases are largely due to the increase in per capita income, economic productivity, labor force, and lifespan, and a general increase in the proportion of avoidable causes of blindness. As these parameters increase, the economic impact of blindness is clearly more severe. The per capita net loss of GNI due to blindness in India is INR 644 (Int$ 28). Between 2016 and 2018, India spent around 3.8% of gross domestic product (GDP) on health care (which is INR 4,381 (~Int$ 199) per capita).[28] Government expenditure was 1.33% of GDP on health care in 2017–18.[17] The total expenditure that can be attributed to preventive care in India is 6.8% (INR 364.8 billion or ~ Int$ 17.37 billion) of the total expenditure.[28] The net loss of GNI due to avoidable causes of blindness in India is INR 689 billion (Int$ 31.3 billion), which is more than the expenditure on all preventable causes in India.[28] To reduce the burden of blindness and visual impairment in India and the subsequent sizeable negative impact

Orbis report

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Cost-effectiveness analysis of child eye health interventions in India

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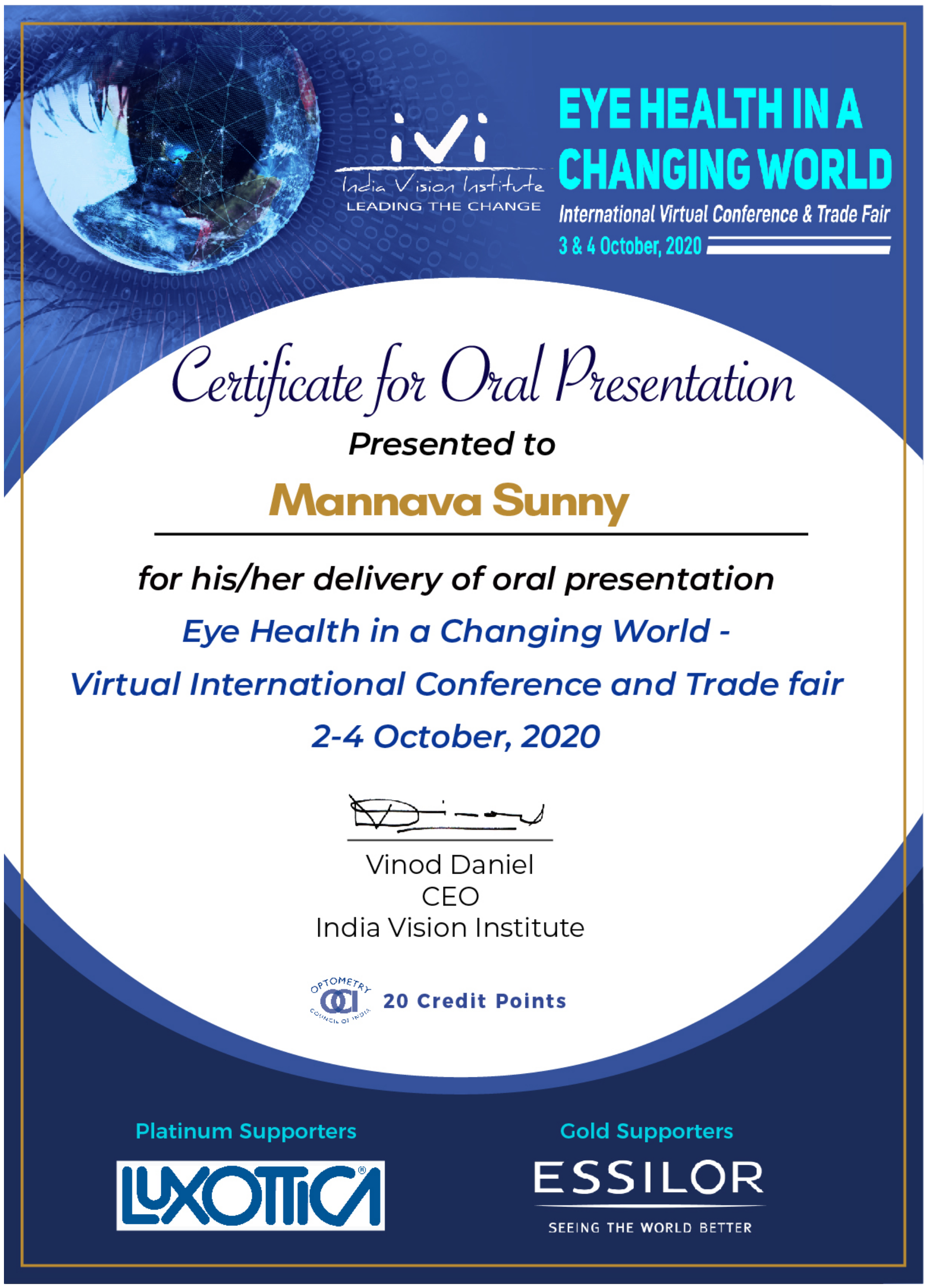
Background:
India has 4.8 million blind persons including 250,000 blind children, and 35 million visually impaired individuals. Prevalence of blindness is 0.36%, it was 1% two decades ago due to significant public health programs towards prevention and treatment by various stakeholders. Time is opportune for cost-effectiveness analyses of these programs. There is a lack of research evidence related to quality-of-life utility values for eye health conditions in India. This study aims to develop utility values for vision impairment and conduct cost-effectiveness analysis of eye health interventions for childhood vision impairment.
Methods:
Cross-sectional questionnaire-based study. 306 Children aged 4-16 years of age with unaddressed vision impairment included. Random sampling was done at a tertiary eye hospital in central India. EQ-5D-Y-3L questionnaire along with VAS score was used to measure utility measures for each of the vision impairment levels. Vision impairment was defined based on WHO classification. Mixed methods were used to collect cost data related to interventions, sensitivity analyses were performed to account for uncertainties. The protocol was approved by institutional ethics committee of university of Hyderabad (UH/IEC/2020/222).

Results:
Median utility value of mild and moderate vision impairment is 0.8 (95% CI 0.7-0.9), severe vision impairment is 0.7 (95% CI 0.65-0.75), and for blindness is 0.55 (95% CI 0.44-0.72). Willingness to pay (WTP) is USD 2,935. ICERs for mild, moderate, severe vision impairment and blindness are USD 81, USD 367, USD 44, USD 954 respectively.
Conclusions:
The utility value of 0.55 for blindness correlates with existing literature. ICERs for various levels of vision impairment show the interventions to be cost-effective. There is a significant improvement in utility values post intervention. The utility measures are recommended to be used to evaluate eye health programs, and as advocacy tools for preventive eye care.
Key messages:
- There is a significant improvement in utility values post-intervention and the interventions are highly cost-effective.
- Important decision-making tool for allocating scarce resources to preventive eye care services.

A.2 List of Conference presentations from current thesis

Eye Health in a Changing World — International Virtual Conference & Trade Fair



National Conference on Community Ophthalmology — Vision 2020 The Right to Sight India 2022

Condition specific utility weights for eye health outcomes

Sunny Mannava[1], B. R. Shamanna[1]

[1]School of Medical Sciences, University of Hyderabad, Hyderabad, Telangana, India

Introduction

There are an estimated 35 million people visually impaired (2.55%), and 0.24 million blind children in India. Various eye care programs in past many years led to the reduction in prevalence of blindness to 0.35% of the population in 2020. The cost effectiveness and utility of such programs can be assessed using measures such as Quality Adjusted Life Years (QALYs) which intern depend on utility weights for specific eye conditions and vary based on any comorbidity.

Objective

To measure these utility weights for each of the eye conditions and associated comorbidities.

Methods

Study Design

Cross sectional questionnaire based study

Sample

308 children aged between 4 years and 15 years

Inclusion criteria

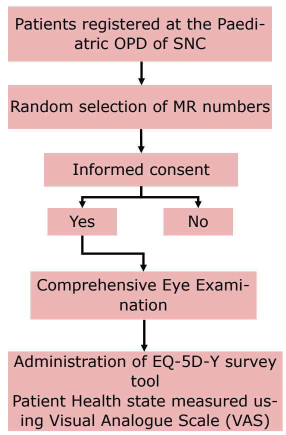
Children aged between 4 years and 15 years

Exclusion criteria

Emmetropes

Children visiting the outpatient department of Sadguru Netra Chikitsalaya were included randomly by using excel's random function on registered patient medical record numbers (MRNs).

Design



Utility weights are measured before giving an intervention and six months after the intervention. The data were not normally distributed and were analyzed using non-parametric statistical tests. The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of the University of Hyderabad. Approval number: UH/IEC/2020/222.

Results

Children are categorized based on best corrected visual acuity in better eye as per the World Health Organization (WHO) classification as blind, mild, moderate, and severe visual impairment with the respective eye condition. Utility weight for blindness amongst children is 0.57. Wilcoxon signed rank test indicated that the post-intervention utility weights were statistically significantly higher than pre-intervention utility weights amongst children with moderate and severe visual impairment (MSVI), Z=-3.06, p<0.05.

Category	n M=30 F=27	Utility weight (Before intervention)	Utility weight (After intervention)#	*Z*	*P*
Mild visual impairment	n=17 M=6 F=11	0.88	0.9	-0.35	0.72
Moderate and severe visual impairment (MSVI)	n=21 M=11 F=10	0.71	0.87	*-3.06*	*<0.05**
Blindness	n=19 M=13	0.57	0.84	*-3.14*	*<0.05**

**Wilcoxon signed rank test indicates that the post-intervention utility score is statistically significantly higher than the pre-intervention score*

#Children who have improved visual acuity after intervention

Conclusion

Utility weights are used programmatic evaluation by Governmental and Non-Governmental Organizations. The results of this study indicate that the utility weights are influenced by the patient's perceived health state and significantly improve after successful intervention amongst children. In this pilot study we tried to understand baseline utility weights as per visual impairment and blindness before and after intervention. Further research is need to understand the utility weights for various eye diseases such as cataract, glaucoma, RoP and others.

Conflicts of Interest

We do not have any conflicts of Interest.

Acknowledgements

We would like to thank University of Hyderabad Institution of Eminence.

We would like to thank Orbis International for their financial support in undertaking this research.

4th September 2022, 16th Annual Conference, VISION 2020: THE RIGHT TO SIGHT-INDIA

Research to Policy — IHOPE Conference 2022

sunnymannava@hotmail.com

From:	IHOPE LVPEIIIPHIIMA <teamihope2020@gmail.com>
Sent:	13 September 2022 12:58
To:	IHOPE LVPEIIIPHIIMA
Subject:	IHOPE Conference 2022 - Agenda
Attachments:	IHOPE_Agenda_Program Schedule.pdf

Dear Participant,

Thank you for registering for the IHOPE Conference 2022, on Research to Policy on the 23 and 24 Sep. We look forward to welcoming you in person for the same.

Timings - 23 Sep - 9 Am to 5 Pm and 24 Sep 9 Am to 4 PM

The Venue for the conference is -
Patodia Auditorium, 6th Floor
L V Prasad Eye Institute
Kallam Anji Reddy Campus
Banjara Hills
Hyderabad

The agenda for both days is attached FYI (you can visit our website www.ihope2020.org to know more about us)

An action packed two days, the conference program will have keynote talks and interactive panel discussions by well-known leaders. The program will pivot around four segments, namely Public Health, Big Data, Health Economics and Policy. There will be shortlisted free paper presentations from the submissions we received. To end the program we also have a pre launch discussion by the authors and contributors of the book "Flattening the Curve" .

16th European Public Health Conference 2023

University of Hyderabad
Sunny Mannava
SoMS, UoH, Hyderabad
Prof. C. R. Rao Road
500046 HYDERABAD
India

Date : 1-11-2023
Reg. No. : 389
Concerns : **16th European Public Health Conference 2023**

Dear Sunny Mannava,

Please find below confirmation of your registration for the 16th EPH Conference in the CCD, Dublin, Ireland.
Pre-conferences will take place on Wednesday 8 November 2023. The main-conference will start on Thursday 9 November 2023.

Your registration:
Main conference registration Student

Approaches and methods for cost-of-illness studies: national and international experiences
08/11/2023 09:00 - 12:30 Wicklow Hall 2a (Level 2)

Avoid printing and make a print screen of the code below:

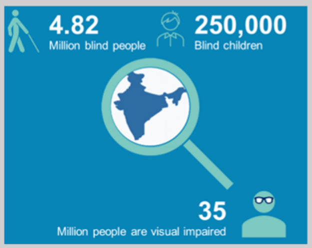
For more information on timings please check the programme on the website or download the Conference app.

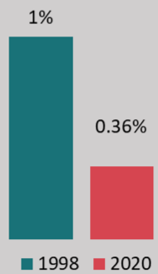
Download on the App Store
GET IT ON Google Play

Cost-effectiveness analysis of child eye health interventions in India

Sunny Mannava, B. R. Shamanna
School of Medical Sciences, University of Hyderabad

Background





Prevalence of Blindness and Vision Impairment in India

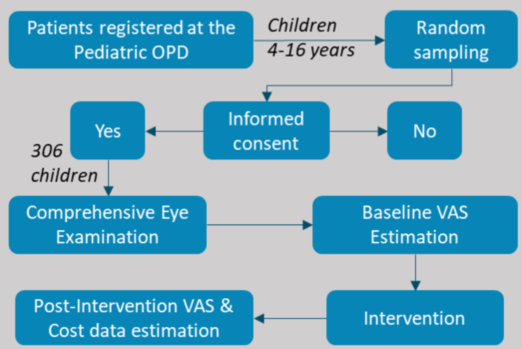
There is a lack of research evidence related to quality-of-life utility values for eye health conditions in India.

Aim: To develop utility values for vision impairment and conduct cost-effectiveness analysis of eye health interventions for childhood vision impairment.

Methods

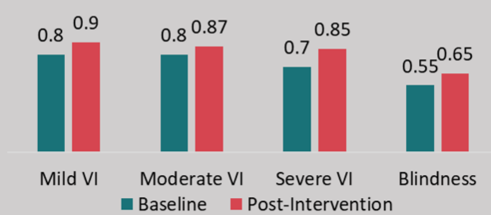
- Cross-sectional questionnaire based pre and post intervention study.
- Cost data – top down & bottom up.
- One-way sensitivity analyses on cost data.
- Confidence intervals - bootstrapping.

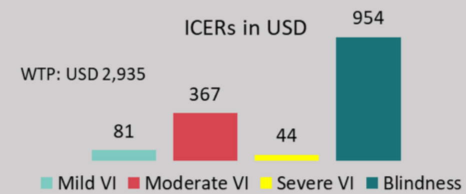
Study flow



- Used R for statistical analysis

Results





Conclusions

- The utility value of 0.55 for blindness correlates with existing literature.
- Significant improvement in utility values for all conditions post-intervention.
- ICERs show that the interventions are cost effective.

Key Messages

- Utility values to be used in economic evaluation and decision making for resource allocation.

Acknowledgements

- University of Hyderabad Institution of Eminence & Orbis International.

References

- Polack, S., Alavi, Y., Rachapalle Reddi, S., Kulothungan, V., & Kuper, H. (2015). Utility values associated with diabetic retinopathy in Chennai, India. *Ophthalmic epidemiology*, *22*(1), 20-27.
- Wadhwani, M., Vashist, P., Singh, S. S., Gupta, V., Gupta, N., & Saxena, R. (2020). Prevalence and causes of childhood blindness in India: A systematic review. *Indian journal of ophthalmology*, *68*(2), 311.

16th European Public Health Conference, Dublin, Ireland | 8-11 November 2023

A.3 Achievements

Fellowship grant - Performance Based Publication Incentive by Institution of Eminence (IoE)

प्रतिष्ठित संस्थान
INSTITUTION OF EMINENCE
राष्ट्रीय अपेक्षाएँ, वैश्विक मानक
National Needs, Global Standards

INSTITUTION OF EMINENCE

Performance-Based Publication Incentive Scheme for non-Net Fellows

CERTIFICATE

This is to certify that Mr. Mannava Sunny, Reg. No. 19MUPH04, Ph.D. Scholar, School of Medical Sciences, University of Hyderabad, is selected for the Performance-Based Publication Incentive Scheme for non-Net Fellows for the publication at Rs.12,000/- per month.

Date: 01-11-2023
Place: Hyderabad

M.Ghanashyam
Director, IoE 1/11/23

Director / निदेशक
Institution of Eminence / प्रतिष्ठित संस्थान
University of Hyderabad / हैदराबाद विश्वविद्यालय
Prof. C.R. Rao Road / प्रो. सी आर राव रोड
Gachibowli / गचीबोवली
Hyderabad - 500046/ हैदराबाद - ५०००४६

Launch of Report on Cost-benefit analysis of investing in child eye health at the Vision 2020 conference in Siliguri by Orbis India

Best poster award - Vision 2020 conference — Siliguri 2022

Best oral presentation award - IHOPE Research to policy conference — Hyderabad 2022

Travel Grant from Jhpiego to attend International Maternal and Newborn Health Conference, Cape Town 2023

sunnymannava@hotmail.com

From:	IMNHC Scholarships <scholarship@imnhc.org>
Sent:	18 February 2023 02:35
To:	IMNHC Scholarships
Subject:	IMNHC 2023: Scholarship Update
Categories:	Blue category

Hello,

Congratulations, your scholarship application has been accepted for the IMNHC 2023 to be held 8-11 May 2023 in Cape Town, South Africa!

In order to accept your scholarship, please log into your Dryfta account, and then click this link to complete the scholarship registration. Please note you must be logged into your Dryfta account **before** clicking the link. **Please complete the complimentary registration by 21 February to ensure your spot**.

More information regarding travel arrangements will be sent early next week, and please do not hesitate to reach out to scholarship@imnhc.org with any questions.

Once again, congratulations on your accepted scholarship application, and we look forward to seeing you in Cape Town in May.

Yours sincerely,

IMNHC Scholarships Team

On behalf of the AlignMNH Secretariat

Future Research Talent Scholarship Award Grant Letter & Award

Australian National University

Professor Sasha (Alexander) Mikheyev
Associate Dean (International)
ANU College of Science
and
Professor, ANU Research School of Biology

+61 2 6125 9131
frt.science@anu.edu.au

21 December 2022

Mr Sunny Mannava

G8, RIDGEFIELD & GIRIDHARI ISHTA APARTMENT,
KISMATPUR, Rangareddy, Telangana - 500030, INDIA.

Contact for enquiries:

e: frt.science@anu.edu.au

t: +61 2 6125 9131

Dear Sunny

Congratulations! On behalf of the Deans of the ANU College of Science, ANU College of Health and Medicine, and ANU College of Engineering, Computing & Cybernetics, I am delighted to advise that you have been selected as a Future Research Talent (FRT) scholar as part of the 2023 FRT program at the Australian National University (ANU) and I look forward to receiving your acceptance.

The FRT is a competitive and prestigious program that attracts the very best international students from high-quality Indian institutions and offers a valuable opportunity for India's emerging research talent to form international linkages and develop research skills at Australia's best university *(QS World University Rankings 2022/23).*

Award Title:	Future Research Talent (FRT) travel award
Conditions of award:	Please see attached
Award Value:	AUD$8,500

You should read this letter and *Conditions of Participation* and *The Code of Practice for Student Research Placements* carefully as together they set out your entitlements and obligations as an FRT scholar. The award will be paid in one instalment after you have arrived and commenced your research project at ANU.

Peter Baume Building #42
The Australian National University
Canberra 2600, ACT Australia
CRICOS Provider No. 00120C


Australian National University

2023 Future Research Talent Award

Presented to

Sunny Mannava

University of Hyderabad (UoH)

Professor Russell Gruen
Dean

ANU College of
Health and Medicine

Institution of Eminence Travel Grant for attending European Public Health Conference, Dublin 2023

IoE-Directorate
प्रतिष्ठित संस्थान-निदेशालय
University of Hyderabad
हैदराबाद विश्वविद्यालय
Gachibowli, Hyderabad – 500046
गचीबोवली, हैदराबाद - ५०००४६

प्रतिष्ठित संस्थान
INSTITUTION OF EMINENCE
राष्ट्रीय अपेक्षाएँ, वैश्विक मानक
National Needs, Global Standards

SANCTION ORDER

No. UoH-IoE/Travel/22/202

Date: 21-08-2023

To
Prof. B.R. Shammana,
School of Medical Sciences,
University of Hyderabad,
Hyderabad 500046.
Email: brsham@uohyd.ac.in

Sub : Sanction of Travel Grant to M. Sunny, Ph.D. scholar – Reg.
Ref : VC's approval dated : 21-08-2023.

Sir,

The approval and sanction of the Competent Authority is conveyed for the release of financial assistance of ***Rs.1,00,000/- (Rupees One Lakh only)*** towards registration fees, travel expenses and per-diem charges to M. Sunny (19MUPH04), School of Medical Sciences to attend conference entitled "16th European Public Health Conference" at Dublin, Ireland from 08-11-2023 to 11-11-2023 under IoE Travel Grant.

Terms & Conditions:

1. The concerned Faculty is permitted to reimburse the expenses incurred for the above on behalf of his student and bills for these expenses should be submitted within 15 days after completion of the conference.
2. PhD scholar is permitted to travel by Air in Economy class, by following all the established procedures/guidelines for air travel.
3. The IoE is obligated to extend the financial support to the extent of sanction conveyed and therefore the onus lies on to the Faculty to confine the expenses within the sanctioned amount.
4. PhD scholar should submit a brief report on the outcome and its relevance to the IoE Directorate after completion of the conference.
5. The above expenditure is chargeable under the Head: OH-31.03 – Travel Expenses, Subject to receipt of funds from MoE.

M. Thanashyam
21/8/23
Director, IoE

Director / निदेशक
Institution of Eminence / प्रतिष्ठित संस्थान
University of Hyderabad / हैदराबाद विश्वविद्यालय
Prof. C.R. Rao Road / प्रो. सी आर राव रोड
Gachibowli / गचीबोवली
Hyderabad - 500046/ हैदराबाद - ५०००४६

Copy to :

1. Dean, School of Medical Sciences
2. Deputy Registrar (IoE Cell, F&A) - with a request to create an account in FAMOUS
3. Travel Grant File
4. Master File

Two Credit Course on Project management from IIT - Kanpur

This certificate is computer generated and can be verified by scanning the QR code given below. This will display the certificate from the NPTEL repository, https://nptel.ac.in/noc/

Roll No: NPTEL21MG71S13580740

To
MANNAVA SUNNY
3-5-70/1, SIVANAGAR COLONY
HYDERGUDA, HYDERGUDA PO
HYDERABAD
TELANGANA - 500048
PH. NO :9848024252

Score	Type of Certificate
>=90	Elite+Gold
75-89	Elite+Silver
>=60	Elite
40-59	Successfully Completed
<40	No Certificate

No. of credits recommended by NPTEL:2

An additional 1 credit may be awarded if the University deems it fit, based on the actual student effort involved.

Elite

NPTEL Online Certification

(Funded by the Ministry of HRD, Govt. of India)

This certificate is awarded to

MANNAVA SUNNY

for successfully completing the course

Project Management

with a consolidated score of **69** %

Online Assignments	22.08/25	Proctored Exam	46.5/75

Total number of candidates certified in this course: **299**

Prof. Rajesh M.Hegde
Chairman, Centre for Continuing Education
IIT Kanpur

Jul-Sep 2021
(8 week course)

Prof. Satyaki Roy
NPTEL Coordinator
IIT Kanpur

Indian Institute of Technology Kanpur

FREE ONLINE EDUCATION swayam

Roll No:NPTEL21MG71S13580740

To validate and check scores: https://nptel.ac.in/noc

A.4 Institutional Ethics Committee (IEC) Approvals

IEC Approval Letter-2021

UNIVERSITY OF HYDERABAD

INSTITUTIONAL ETHICS COMMITTEE DECISION LETTER

IEC No. Application No:	UH/IEC/2020/222	Date of review	09-03-2021
Project Title:	Economic analysis of investing in child eye health and development and testing of quality of life utility weights for child eye health outcomes using health informatics		
Principal Investigator/ Co-PI:	PI: M. Sunny CI: Prof. B. R. Shamanna		
Participating Institutes if any	----	Approval from Participating Institute	---
Documents received and reviewed	----		
In case of renewal submission of update	Application and Permission letters submited		
Decision of the IEC:	Approved Duration: One year from date of approval		
Any other Comments Requirements for conditional Approval	----		
Members Present	Dr. A.S.Sreedhar, Prof. B. R. Shamanna, Dr. M. Varalakshmi, Sri.A. Madhava Rao, Dr. M. Srinivas, Dr. Deepa Srinivas, Dr. M.K. Arunasree and Ms. A. D. Shobhavath		

Please note:

a. Any amendments in the protocol must be informed to the Ethics committee and fresh approval taken.
b. Any serious adverse event must be reported to the Ethics Committee within 48 hours in writing (mentioning the protocol No. or the study ID)
c. Any advertisement placed in the newspapers, magazines must be submitted for approval.
d. If the conduct of the study is to be continued beyond the approved period, an application for the same must be forwarded to the Ethics Committee.
e. It is hereby confirmed that neither you nor any of the members of the study team participated in the decision making/voting procedures and declared conflict of interest.

A S Sreedhar 09/03/2021 | Shamanna 9/3/21 | 09/03/2021

Chairman (Dr. A S Sreedhar) | Member Secretary (Prof. B.R.Shamanna) | Convenor (Dr. M. Varalakshmi)

Address: School of Medical Sciences, University of Hyderabad, C. R. Rao Road, Gachibowli,Hyderabad-5000046
Tel (O): +91-040-23135470/23135471 Email: iec_uoh@uohyd.ernet.in, deanmd@uohyd.ernet.in

IEC Approval Letter-2020

Institutional Ethics Committee
University of Hyderabad

Justice TNC Rangarajan
Chairperson

Prof. Geeta K. Vemuganti
Member Secretary

Decision Letter of Institute Ethics Committee

IEC No. Application No:	UH/IEC/2020/222	**Date of review**	18-02-2020
Project Title:	Economic Analysis of Investing in Child Eye Health and Development and Testing of Quality of Life Utility Weights for Child Eye Health Outcomes Using Health Informatics		
Principal Investigator/ Co-PI:	PI: M. Sunny CI: Prof. B. R.Shamanna CI: Dr. Ajitha Katta		
Participating Institutes if any	----	**Approval from Participating Institute**	---
Documents received and reviewed	Protocol & ICF		
In case of renewal submission of update	----		
Decision of the IEC:	Approved after the conditions suggested at the IEC meeting were fulfilled on 03.03.2020 Duration: One year from date of approval		
Any other Comments Requirements for conditional Approval	----		
Members Present	Sri Justice Rangarajan, Prof. Geeta K. Vemuganti, Dr. C.T. Anitha, Dr. Savitri Sharma, Dr. Suvashisa Rana, and Dr. Insaf Ahmed		

Please note:

a. Any amendments in the protocol must be informed to the Ethics committee and fresh approval taken.
b. Any serious adverse event must be reported to the Ethics Committee within 48 hours in writing (mentioning the protocol No. or the study ID)
c. Any advertisement placed in the newspapers, magazines must be submitted for approval.
d. The results of the study should be presented in any of the academic forums of the hospital annually.
e. If the conduct of the study is to be continued beyond the approved period, an application for the same must be forwarded to the Ethics Committee.
f. It is hereby confirmed that neither you nor any of the members of the study team participated in the decision making/voting procedures.

Chairperson

(Justice Rangarajan)

Member Secretary

Geeta

(Prof. Geeta K Vemuganti)

Address : School of Medical Sciences, University of Hyderabad, C.R. Rao Road, Gachibowli, Hyderabad - 500 046
Tel (O) : +91-040-23135470 / 23013279
E-mail : iec_uoh@uohyd.ernet.in, deanmd@uohyd.erntd.in

A.5 Case Data Sheet

Data sheet-Self

Self

MR. No. / IP No.	
Full Name	

Age		Sex		Contact No.	
Parent/Guardian Name					
City/Village					
Address					
State					
Monthly family income					

Chief complaint	

Visual acuity (current visit)

UCVA		
CVA		
Primary diagnosis		
Follow-up date		

Spectacle power (in case of refractive error)

Eye	Sph	Cyl	Axis	VA
RE (distance)				
RE (add)				
LE (distance)				
LE (add)				

First visit date:		
UCVA		
CVA		

Spectacle power (in case of refractive error)

Eye	Sph	Cyl	Axis	VA
RE (distance)				
RE (add)				
LE (distance)				
LE (add)				

Data sheet-Proxy

Proxy

MR. No. / IP No.	
Full Name	

Age		Sex		Contact No.	
Parent/Guardian Name					
City/Village					
Address					
State					
Monthly family income					

Chief complaint	

Visual acuity (current visit)

UCVA		
CVA		
Primary diagnosis		
Follow-up date		

Spectacle power (in case of refractive error)

Eye	Sph	Cyl	Axis	VA
RE (distance)				
RE (add)				
LE (distance)				
LE (add)				

First visit date:		
UCVA		
CVA		

Spectacle power (in case of refractive error)

Eye	Sph	Cyl	Axis	VA
RE (distance)				
RE (add)				
LE (distance)				
LE (add)				

A.6 EQ-5D-Y and VAS Instrument

EQ-5D-Y

Describing your health TODAY

Under each heading, please tick the ONE box that best describes your health TODAY.

Mobility *(walking about)*

I have no problems walking about ☐

I have some problems walking about ☐

I have a lot of problems walking about ☐

Looking after myself

I have no problems washing or dressing myself ☐

I have some problems washing or dressing myself ☐

I have a lot of problems washing or dressing myself ☐

Doing usual activities *(for example, going to school, hobbies, sports, playing, doing things with family or friends)*

I have no problems doing my usual activities ☐

I have some problems doing my usual activities ☐

I have a lot of problems doing my usual activities ☐

Having pain or discomfort

I have no pain or discomfort ☐

I have some pain or discomfort ☐

I have a lot of pain or discomfort ☐

Feeling worried, sad or unhappy

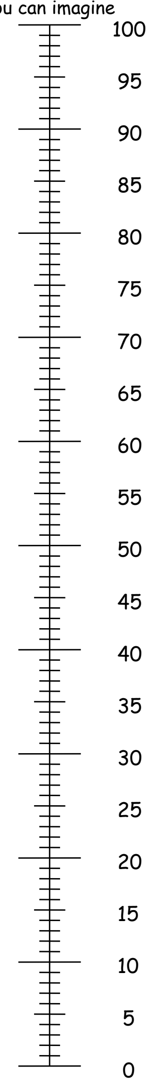
I am not worried, sad or unhappy ☐

I am a bit worried, sad or unhappy ☐

I am very worried, sad or unhappy ☐

How good is your health TODAY

The best health
you can imagine



The worst health
you can imagine

- We would like to know how good or bad your health is TODAY.
- This line is numbered from 0 to 100.
- 100 means the <u>best</u> health you can imagine.
  0 means the <u>worst</u> health you can imagine.
- Please mark an X on the line that shows how good or bad your health is TODAY.

A.7 Informed Consent Form-Hindi

Self

सूचित सहमति प्रपत्र

अध्ययन शीर्षक: बाल नेत्र स्वास्थ्य और विकास में निवेश का आर्थिक विश्लेषण और स्वास्थ्य सूचना का उपयोग कर बाल नेत्र स्वास्थ्य परिणामों के लिए जीवन उपयोगिता तथा गुणवत्ता का परीक्षण।

मेरा नाम मन्नावा सन्नी और मैं हैदराबाद विश्वविद्यालय के स्कूल ऑफ मेडिकल साइंसेज में छात्र हूं। मैं स्वास्थ्य सूचना का उपयोग कर बच्चे नेत्र स्वास्थ्य परिणामों के लिए जीवन की गुणवत्ता को मापने का एक शोध अध्ययन आयोजित करने की योजना बना रहा हूं। इसमें बच्चे और परिवार के सदस्यों के जीवन की गुणवत्ता के बारे में एक संरचित प्रश्नावली का उपयोग करते हुए साक्षात्कार के रूप में जानकारी का संग्रह शामिल होगा।

यदि आप अध्ययन में भाग लेने के इच्छुक हैं, तो आपको सामान्य रूप से अपने स्वास्थ्य के बारे में पांच सवालों के एक सेट का जवाब देना आवश्यक है। इसमें अधिक समय नहीं लगेगा। इससे आपको कोई नुकसान नहीं होगा। अगर आप इंटरव्यू के दौरान सहज नहीं हैं तो, इस अध्ययन से पीछे हट सकते हैं। अध्ययन खत्म करने के बाद हम जो सीखा उसके बारे में रिपोर्ट लिखेंगे । इस रिपोर्ट में आपका नाम शामिल नहीं होगा। इस अध्ययन में आपको किसी भी प्रकार का भुगतान नहीं किया जाएगा। अगर आप तय करते हैं कि आप इस अध्ययन में शामिल होना चाहते हैं, तो कृपया अपने नाम पर हस्ताक्षर करें।

मुझे इस अध्ययन के बारे में समझाया गया है और अध्ययन के बारे में सवाल या संदेह पूछने का अवसर भी मिला है । मैं समझता हूं कि मेरी भागीदारी स्वैच्छिक है और मैं बिना कोई कारण बताए किसी भी समय रोक सकता हूं । मैं यह भी समझता हूं कि व्यक्तिगत नाम और अन्य व्यक्तिगत जानकारी का उपयोग नहीं किया जाएगा।

मैं, ___________________________________, इस शोध अध्ययन में शामिल होना चाहते हैं।

______________________________ ____________

(हस्ताक्षर) (दिनांक)

प्रमुख अन्वेषक: मन्नावा सन्नी गवाह:

हस्ताक्षर हस्ताक्षर

A.8 Assent Form-Hindi

Proxy

सूचित सहमति

अध्ययन शीर्षक: बाल नेत्र स्वास्थ्य और विकास में निवेश का आर्थिक विश्लेषण और स्वास्थ्य सूचना का उपयोग कर बाल नेत्र स्वास्थ्य परिणामों के लिए जीवन उपयोगिता तथा गुणवत्ता का परीक्षण।

मेरा नाम मन्नावा सन्नी और मैं हैदराबाद विश्वविद्यालय के स्कूल ऑफ मेडिकल साइंसेज में छात्र हूं। मैं स्वास्थ्य सूचना का उपयोग कर बच्चे नेत्र स्वास्थ्य परिणामों के लिए जीवन की गुणवत्ता को मापने का एक शोध अध्ययन आयोजित करने की योजना बना रहा हूं। इसमें बच्चे और परिवार के सदस्यों के जीवन की गुणवत्ता के बारे में एक संरचित प्रश्नावली का उपयोग करते हुए साक्षात्कार के रूप में जानकारी का संग्रह शामिल होगा। प्रक्रियाओं में बच्चे के लिए कोई भावनात्मक या शारीरिक जोखिम शामिल नहीं है। अगर बच्चे को इंटरव्यू के दौरान असहज महसूस होता है तो वह स्वेच्छा से साक्षात्कार से पीछे हट सकता है। अध्ययन के परिणामों का उपयोग प्रकाशनों और प्रस्तुतियों में किया जा सकता है। डेटा को गोपनीय रूप से संभाला जाएगा। यदि परिणाम प्रकाशित या प्रस्तुत किए जाते हैं, तो व्यक्तिगत नाम और अन्य व्यक्तिगत जानकारी का उपयोग नहीं किया जाएगा। इस अध्ययन में आपको किसी भी प्रकार का भुगतान नहीं किया जाएगा।

प्रमुख अन्वेषक: मन्नावा सन्नी — संपर्क विवरण: 9848024252

<u>हस्ताक्षर</u> — sunnymannava@hotmail.com

माता-पिता की सहमति फॉर्म

मैं, श्री / सुश्री / श्रीमती ______________________________________के माता / पिता / अभिभावक ____अध्ययन के प्रपत्र और विवरण को पढ़ा है मुझे समझाया गया है। मैं पुष्टि करता / करती हूं कि मैंने उपरोक्त अध्ययन को समझा है। मैंने समझा है कि मेरी भागीदारी स्वैच्छिक है, और कभी भी वापस ले सकते है।

मैं इस अध्ययन से उत्पन्न होने वाले किसी भी डेटा के उपयोग को प्रतिबंधित नहीं करने से सहमत हूं। अध्ययन में मेरे बच्चा / बच्ची की भागीदारी से मैं पूरी तरह सहमत हूं।

माता / पिता / अभिभावक का नाम:	गवाह का नाम-
माता / पिता / अभिभावक के हस्ताक्षर:	गवाह के हस्ताक्षर:
दिनांक:	

A.9 Research Participant Pre-Visit Checklist for COVID-19

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University of Hyderabad

COVID-19 Research Participant Pre-Visit Check

Economic analysis of investing in child eye health and development and testing of quality of life utility weights for child eye health outcomes using health informatics

To prevent the spread of COVID-19 and reduce the potential risk of exposure, we are asking participants to complete a COVID-19 Pre-Visit Check before any study-related data collection (survey, eye examination and interviews) can take place. You will be asked to read six statements and declare that none of the statements apply to you. On the day of your examination a member of the research team will record your name and contact number for the purpose of facilitating contact tracing by the local health authority.

If any of the statements are applicable to you, we will need to cancel and reschedule the examination for a later date and ask that you follow ***government advice*** in India.

Please read the following six statements carefully:

(1) I have knowingly been exposed to someone with COVID-19 or displaying COVID-19 symptoms in the past 14 days.

(2) I have underlying health conditions which could put me at increased risk if I should contract COVID-19. A list of these conditions can be found here (#IndiaFightsCorona COVID-19 in India, Vaccination, Dashboard , Corona Virus Tracker | mygov.in).

(3) I have at present, or in the past 14 days had one or more of the following flu-like symptoms:
- Fever
- Breathlessness
- Cough
- Sore throat
- Loss of sense of smell or taste

(4) I have been notified by my local tracing system that I have been in close contact with a person with COVID-19 and have been asked to self-isolate.

(5) I have returned to India in the last 10 days, and require to quarantine and/or self-isolate. Please see India government rules for entering India.

(6) I have tested positive for COVID-19 in the last 7 days.

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University of Hyderabad

Declaration *Select one option*

I have read the six statements listed above and none of these statements apply to me: ☐ True ☐ False

Participant Name: ____

Participant Signature: ____

Date: ____

This form needs to be completed 24 hours before you take part in eye examination and interview related to the research study.

For Research Team Use

Research activity can proceed: ☐ Yes ☐ No

Researcher signature:

On day of visit:

Date of Visit: Time of Visit: Location:

Research Team Member(s) in attendance:

Participant contact number:

Please note if the participant has answered 'false' to the above declaration the research activity cannot take place face-to-face. The participant should be reminded to follow government advice in India.

We will only hold this information for 21 days after the final in-person interaction with the participant. It will then be destroyed.

Participant may contact the research team member by phone: +91 8886666803 or email: sunnymannava@hotmail.com in-case of any of the above mentioned symptoms develop after the examination and interview.

THE ECONOMICS OF CHILDHOOD EYE DISEASES AND DEVELOPING AND TESTING OF QUALITY-OF-LIFE UTILITY VALUES

by Sunny Mannava

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