The Economic and Social Cost of Visual Impairment and Blindness in India

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This research was supported by funding from Seva Foundation.

Foreword

If you ever wondered about the cost of not addressing avoidable blindness, this paper will map out the implications in one of the world's largest economies - India. The costs of poor eye health will increase over time as India ages and becomes wealthier. Poor eye health imposes a recurring cost to the Indian economy equivalent to 0.6% of GDP (INR 1.2 trillion) resulting in a substantial constraint on the country's growth aspirations. Most of this loss is due to reductions in economic productivity. Avoidable blindness reduces the probability of working by 30%, and those who remain in employment are 20% less productive. Caregivers spend 5 to 10% of their time taking care of those with blindness and the worst forms of visual impairment.

A country that aspires to be a $5 trillion economy cannot afford constraints to economic growth like poor eye health. Over the past 42 years, Seva Foundation has worked tirelessly to support our partners across India as they pioneered inexpensive and effective procedures. Today, in a majority of cases, vision losses can be mitigated - cheaply - with glasses or cataract surgery.

Seva is committed to ending avoidable blindness in our lifetime. This paper is the beginning of us demonstrating that eye health is a fantastic investment in the grand scheme of global health and development. Read on to see more clearly why Seva has a commitment to end avoidable blindness in our lifetime and the cost to us all if we don't.

Kate Moynihan
Executive Director, Seva Foundation

Executive Summary

This report estimates the economic and social costs of moderate and severe visual impairment (MSVI) and blindness in India. Using evidence from the recently published Lancet Commission on Global Eye Health and other sources, we estimate the costs of reduced employment, elevated mortality risk, education loss for children, productivity loss in employment, welfare loss for the non-employed and caregiver costs associated with MSVI and blindness. To the best of our knowledge, no study at a regional or national level has attempted to bring together all these different streams into one estimate for low-and-middle-income settings. The costs of poor eye health in India in 2019 is estimated at INR 1,158 billion (range: INR 947 -1,427 billion) or Int$ 54.4 billion (range: Int$ 44.5-67.0 billion), accounting for all six cost streams. The largest cost is for loss of employment, while the second largest category of cost is for caregiver time. A more conservative estimate focusing only on employment loss and elevated mortality risk yields a cost of INR 504 billion (range: INR 348-621 billion) or Int$ 23.7 billion (range: Int$ 16.3-29.2 billion). Overall, the results show that poor eye health imposes a non-trivial recurring cost to the Indian economy equivalent to 0.47% to 0.70% of GDP in the primary scenario, a substantial constraint on the country's growth aspirations. The costs of poor eye health will increase over time as India ages and becomes wealthier unless further progress is made in reducing the prevalence of MSVI and blindness.

1. Introduction

Despite notable progress over several decades, the burden of poor eye health in India remains large. According to the most recent National Blindness and Visual Impairment Survey 2015-2019 there were an estimated 4.8 million people suffering from blindness and 29.2 million people with moderate or severe visual impairment (MSVI) in 2017. Understanding the economic and social costs of visual impairment and blindness is critical for efficient resource allocation. Two studies have estimated the economic cost of poor eye health in India, though both estimates are for reference years more than 20 years old (Shamanna, Dandona and Rao, 1998; Frick and Foster, 2003). Shamanna, Dandona and Rao (1998) estimated the cost of blindness in 1997 at INR 159 billion (USD 4.4 billion) focusing on productivity losses of those aged 16 to 64, plus caregiver time for all the estimated 9.6 million blind people in that year. Frick and Foster (2003) estimated the cost of blindness and low vision in 2000 at USD 0.81 billion and USD 0.95 billion respectively. The dramatically different estimates for the cost of blindness are attributable to the fact that Frick and Foster (2003) used a lower rate of productivity loss for blind people (60% vs 95%), accounted for labour force participation and unemployment, and did not include caregiver costs.[1]

[1] The report 'Status of Child Health in India' by Orbis cites a document by Shamanna and Mannava (2020) that estimates the cost of blindness in India at INR 8.9 billion or USD 11.6 billion in 2020 but does not provide further details on how this figure was calculated. The citation Shamanna and Mannava (2020) - *Cost -Benefit Analysis of Investing in Child Eye Health and Development of utility weights and geography based indices for child eye health outcomes* does not appear to be a publicly available document.

Given how much has changed in the landscape of eye care in India over the last twenty years, including the definition of blindness and visual impairment used within the country (Ministry of Health and Family Welfare, 2017), a fresh look is warranted. This study combines information on three recent, important publications to estimate the economic and social costs of MSVI and blindness in India using the latest evidence, data, and methods. The first report is the recently released Lancet Commission on Eye Health, which provides the most up-to-date literature summary of the productivity and health impacts of blindness and MSVI globally (Burton et al., 2021). The second report is the National Blindness and Visual Impairment Survey which provides the most recent nationally representative figures for MSVI and blindness in India (Ministry of Health and Family Welfare, 2020). The third is the Reference Case Guidelines for the Conduct for Benefit-Cost Analysis in Global Health and Development which provides best practice guidance for valuing mortality risk reduction and changes in time use (Robinson et al., 2019).

We report a central estimate of the cost of MSVI and blindness in India in 2019 at INR 1,158 billion (Int$ 54.4 billion) or 0.57% of GDP. This figure incorporates six mutually exclusive categories of loss: reduced employment, elevated mortality risk, education loss for children, productivity loss in employment, productivity loss for the non-employed and caregiver costs. The results indicate that loss of employment is the greatest contributor to the total cost of poor eye health, followed by caregiver costs and productivity loss in employment. Additionally, MSVI generates a substantially higher welfare cost than blindness in India, contributing more than 80% of the total burden. This is predominantly driven by the fact that MSVI is six times more prevalent than blindness. Lastly, in terms of age sub-groups those aged 50-64 contribute approximately 70% to the total economic and social costs of poor eye health. This is because the prevalence of MSVI and blindness increases dramatically at these age groups, and they are still assumed to be in the workforce, generating large employment and income losses.

The central estimate is based on a series of parameters drawn from the literature, for which there is some uncertainty. Therefore, we conduct probabilistic sensitivity analysis, with 95% of results falling in a range of INR 947-INR 1,427 billion (Int$ 44.5-67.0 billion) per year or 0.47%-0.70% of GDP. Additionally, we present results of a more conservative scenario focusing only on employment loss and elevated mortality risk, based on a review and meta-analysis respectively from the recently released Lancet Global Commission (Burton et al., 2021). In this case the cost is INR 504 billion (Int$ 23.7 billion) or 0.25% of GDP, with 95% of the probabilistic estimates failing in the range INR 348-621 billion (Int$ 16.3-29.2 billion) or 0.17-0.31% of GDP.

This study contributes to the broader literature that estimates the economic impacts of poor eye health both nationally and globally (Smith and Smith, 1996; Shamanna, Dandona and Rao, 1998; Frick and Foster, 2003; Rein et al., 2006; Smith et al., 2009; Gordois et al., 2012; Köberlein et al., 2013; Naidoo et al., 2019; Bastawrous and Suni, 2020; Marques et al., 2021). Most studies have predominantly focused on lost income associated with reduced employment participation with only a few addressing caregiver costs, lost productivity in employment and learning losses. Overall, this report indicates that poor eye health imposes a non-trivial, recurrent cost to the Indian economy, one that will likely increase over time as India ages and becomes wealthier, unless further progress is made in reducing the prevalence of MSVI and blindness.

2. Method

2.1. Estimation of the prevalence of MSVI and Blindness by 5-year age cohort

The reported figures in this analysis are for the year 2019, the most recent year for which most data are readily available and were not affected by the COVID-19 pandemic. The first step in this analysis is to estimate the extent of MSVI and blindness across the country. The recently completed National Blindness and Visual Impairment Survey notes that for those above 50 the prevalence of MSVI is 11.77% while the prevalence of blindness is 1.99% (Ministry of Health and Family Welfare, 2020). For those under 50 the equivalent numbers are 0.38% and 0.05%, while across age groups the prevalence is 2.19% and 0.36% respectively. Further age sub-division is required for a more precise estimate of eye health costs. This is because eye health challenges increase with age, while each category of welfare impact tends to decrease with age.[2] Therefore applying a flat MSVI and blindness prevalence across the two age groups is likely to overstate the cost of eye health problems. Microdata from the National Blindness and Visual Impairment Survey were not available to disaggregate into more precise age sub-groups. However, the Global Burden of Disease provides modelled estimates of prevalence rates for 'blindness and vision loss' across 5-year age cohorts (IHME, 2019). We use these to estimate the relative difference in MSVI and blindness prevalence across 5-year age cohorts and calibrate the figures so that prevalence of MSVI and blindness nationwide matches what is reported in the National Blindness and Visual Impairment Survey. The results are depicted in Figure 1 and Figure 2 below, with a comparison to age-constant estimates reported in National Blindness and Visual Impairment Survey across the two sub-groups.

To estimate the total number of people suffering from MSVI and blindness, we draw population numbers for 5-year age cohorts from the Government of India's population projections based on 2011 Census Data (Ministry of Health and Family Welfare, 2019), and multiply by our age-stratified prevalence rates (Table 1). For the remainder of this report, estimates are based on the age-adjusted prevalence figures.

[2] Mortality risk impacts are most closely tied to age since welfare costs are proportional to life expectancy. For education, employment, and productivity losses these welfare costs are age dependent insofar as they only accrue over certain age ranges (5-14 for education losses, 15-64 for employment and productivity losses) but not at older ages.

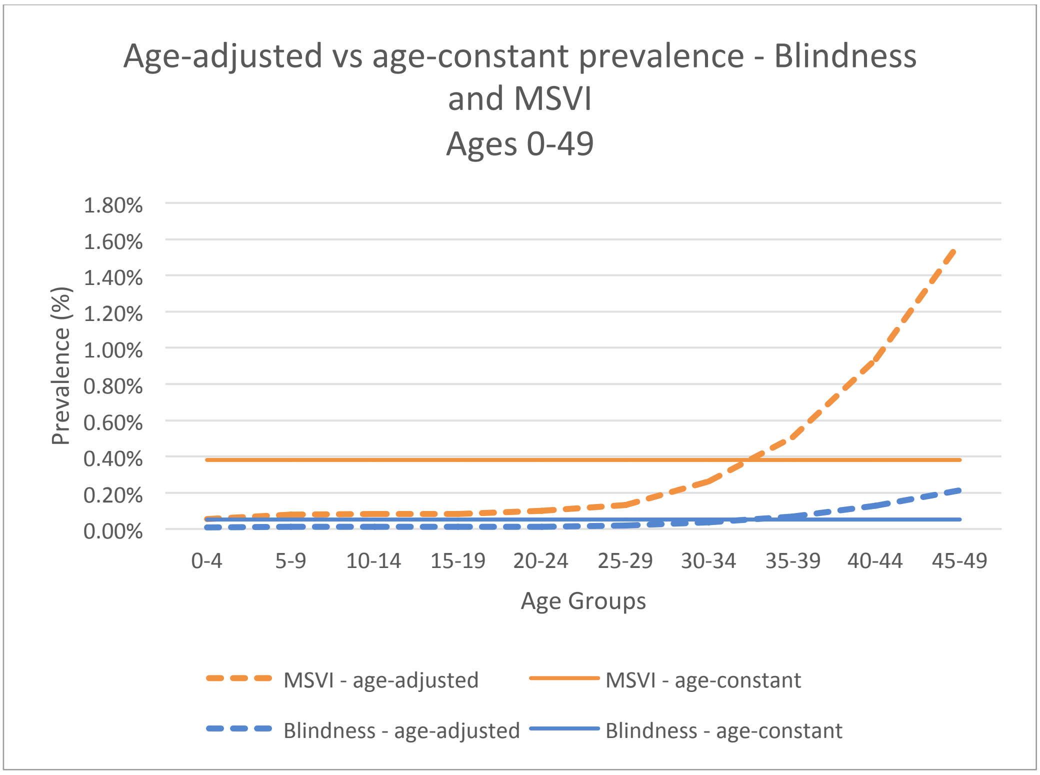

Figure 1: Age-adjusted vs age-constant prevalence of MSVI and blindness, 0-49 year olds

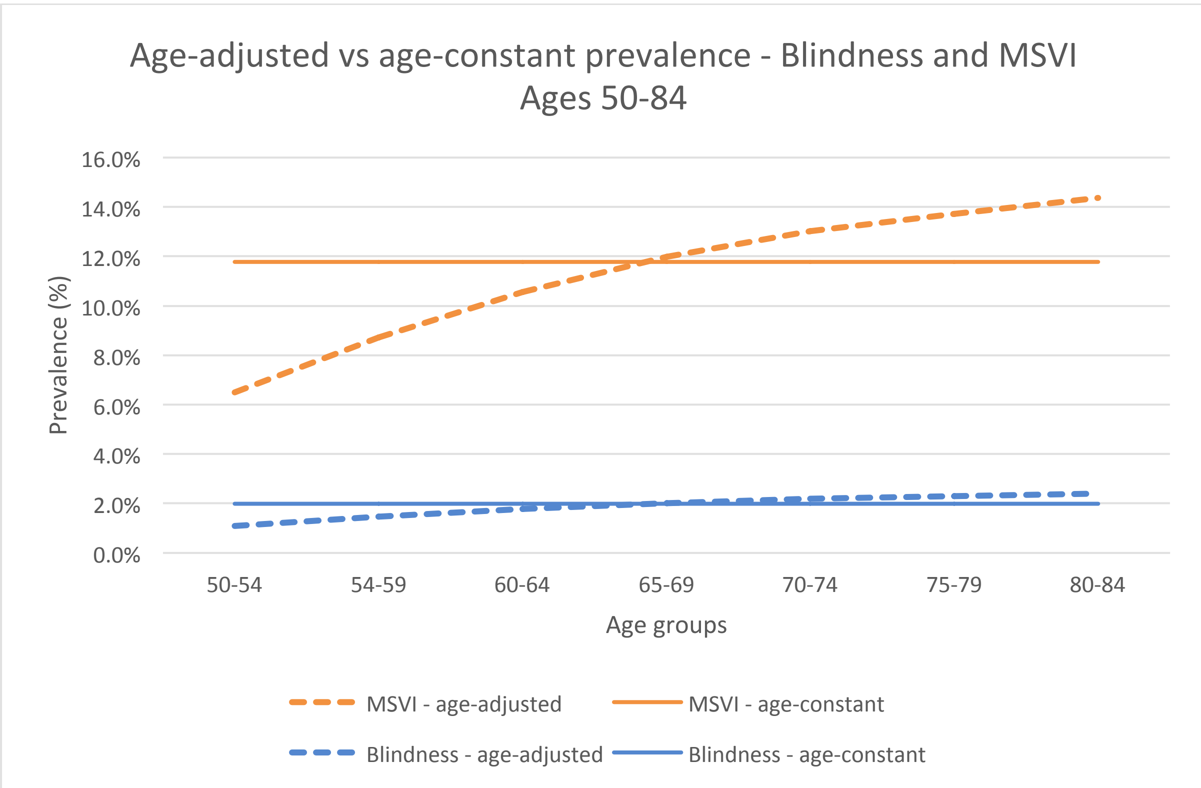

Figure 2: Age-adjusted vs. age-constant prevalence of MSVI and blindness, 50-84 year olds

Table 1: Prevalence of MSVI and Blindness by 5-year age cohort		
Age Group	MSVI (millions)	Blindness (millions)
0-4	0.06	0.01
5-9	0.09	0.01
10-14	0.10	0.01
15-19	0.10	0.01
20-24	0.12	0.02
25-29	0.16	0.02
30-34	0.28	0.04
35-39	0.49	0.07
40-44	0.81	0.11
45-49	1.24	0.17
50-54	4.42	0.74
54-59	4.89	0.82
60-64	4.65	0.78
65-69	3.99	0.67
70-74	3.30	0.55
75-79	2.38	0.40
80-84	2.11	0.35
Total	29.19	4.79

2.2. Social and Economic Costs

Six different social and economic costs of poor eye health are considered. These are:

1. Loss of employment
2. Elevated mortality risk
3. Education loss for children
4. Reduce productivity in employment
5. Caregiver costs
6. Productivity loss of unpaid work

Table 2 summarizes the estimation approach to calculate the costs of MSVI and Blindness.

Table 2: Summary of estimation approach for welfare costs of MSVI and Blindness			
Welfare cost	Impact from MSVI	Impact from Blindness	Source
Loss of employment	30.2% reduction in employment	30.2% reduction in employment	Based on review in Burton et al., (2021); Marques et al., (2021)
Elevated mortality risk	1.26 = 10-year all-cause mortality risk ratio relative to no visual impairment	1.92 = 10-year all-cause mortality risk ratio relative to no visual impairment	Based on meta-analysis reported in Burton et al. (2021) and Ehrlich et al., (2021)
Education loss for children	3.6% reduction in future income	5.5% reduction in future income	Based on evidence in Ma et al., (2014, 2018) Glewwe, Park and Zhao, (2016), Aslam et al., (2010)
Reduced productivity in employment	20% productivity loss	20% productivity loss	Based on evidence in Rein et al., (2006); Foley and Chowdhury, (2007); Finger et al., (2012); Reddy et al., (2018)
Caregiver costs	5% of productive time for one person	10% of productive time for one person	Assumption following Naidoo et al., (2019)
Productivity loss of unpaid work	20% loss of productivity in household, non-market activities with value of loss estimated at 50% of wages	20% loss of productivity in household, non-market activities with value of loss estimated at 50% of wages	Assume same loss as for productivity in employment; Welfare loss valuation from Whittington and Cook, (2019)

Loss of employment: Burton et al., (2021) and the related study Marques et al., (2021) summarize the literature on employment loss associated with MSVI and blindness. Across 15 countries, they find that the average loss of employment associated with MSVI or blindness is 30.2%. There was no specific figure for India or South Asia, so we apply this global average figure in this analysis. Furthermore, the studies report that the literature did not differentiate between blindness and MSVI, so the 30.2% employment loss is applied to both.

Income is proxied by GDP per capita, reported as INR 148,936 in 2019 (World Bank, 2021). The employment-to-population ratio is 46% (World Bank, 2021). Working age is assumed to be 15 to 64 as per other studies estimating the economic costs of eye health(Shamanna, Dandona and Rao, 1998; Frick and Foster, 2003; Bastawrous and Suni, 2020; Burton et al., 2021; Marques et al., 2021). Following Burton et al., (2021) the economic cost of lost employment is calculated as the prevalence of MSVI or blindness multiplied by the employment-to-population ratio, GDP per capita and the reduction in employment of 30.2%.

Elevated mortality risk: Burton et al., (2021) and the related study Ehrlich et al., (2021) conduct a meta-analysis on studies that estimate mortality risk from MSVI and blindness. Their results indicate that visual acuity <6/12 is associated with an elevated mortality risk of 29% compared to no vision impairment. Visual acuity <6/18 is associated with an elevated mortality risk of 43% compared to better vision. Lastly, visual acuity <6/60 has an elevated mortality risk of 89% compared to visual acuity <6/18. These results combine multiple states of visual impairment relative to other states e.g. the first finding essentially defines the risk of mortality from mild, moderate, severe and blindness on average is 1.29 times higher than no visual impairment. To make these findings useful for this analysis, we need to estimate risk ratios for individual states relative to no visual impairment. We solve three simultaneous equations to estimate all-cause mortality risk ratios for mild, moderate and severe visual impairment. Specifically:

$$1.29 * RR_{no} = \frac{\omega_{mild}*RR_{mild}+\omega_{mod}*RR_{mod}+\omega_{sev}*RR_{sev}}{\omega_{mild}+\omega_{mod}+\omega_{sev}} \quad (1)$$

$$1.43 * \frac{(\omega_{no}*RR_{no}+\ \omega_{mild}*RR_{mild})}{\omega_{no}+\omega_{mild}} = \frac{\omega_{mod}*RR_{mod}+\omega_{sev}*RR_{sev}}{\omega_{mod}+\omega_{sev}} \quad (2)$$

$$1.89 * \frac{(\omega_{no}*RR_{no}+\ \omega_{mild}*RR_{mild})}{\omega_{no}+\omega_{mild}} = RR_{sev} \quad (3)$$

Where ω_k and RR_k represent the population weights and relative risks for visual impairment states, k = no, mild, moderate or severe. Population weights for each state of visual impairment are drawn from the National Blindness and Visual Impairment Survey, while RR_{no} = 1, by definition. Solving by simultaneous equations, the results are presented in Table 2. It is important to note that these hazard ratios are reported over a median and mean[3] follow up time frame of 10 years.

[3] From Figure 6 of Burton *et al.* (2021), the follow up time for measuring mortality varies from 17 months to 210 months. The median and mean of follow up time across the studies is 120 months and 119.5 months respectively.

Table 3: 10-year mortality risk ratios of visual impairment relative to no visual impairment		
Visual impairment status	10-year all-cause mortality risk ratio, relative to no visual impairment, RR_k	Population weight, ω_k
No visual impairment (VA > 6/12)	1.00	94.5%
Mild visual impairment (VA 6/12 – 6/18)	1.16	2.9%
Moderate visual impairment (VA 6/18 – 6/60)	1.26	1.8%
Severe visual impairment (VA <6/60)	1.90	0.7%

Source: 10-year all-cause mortality risk ratios are authors' estimates. Population weights are from Ministry of Health and Family Welfare, (2020). Note that the population weight for severe visual impairment also includes those who are blind.

To estimate the welfare cost of elevated mortality, we source age-specific all-cause mortality rates from the Global Burden of Disease (IHME, 2019) and estimate additional deaths attributable to MSVI and blindness using calculated risk ratios from Table 2. For conservatism we assume the MSVI mortality risk is 1.26, the risk of moderate severe impairment only, while the mortality risk from blindness is 1.90, corresponding to the risk of severe visual impairment and blindness. Lifetables from WHO are used to estimate years of life lost from these conditions (WHO, 2021). The results indicate that MSVI and blindness lead to 32,900 additional deaths per year combined, or around 422,000 life years.

Table 3: Mortality and life years lost from MSVI and Blindness in India, 2019				
Age Group	MSVI - additional mortality in 2019	Blindness - additional mortality in 2019	MSVI - additional life years lost in 2019	Blindness - additional life years lost in 2019
0-4	11	5	809	382
5-9	1	1	99	47
10-14	1	1	86	41
15-19	2	1	131	62
20-24	4	2	228	107
25-29	6	3	301	142
30-34	14	7	632	298
35-39	32	15	1,305	616
40-44	71	33	2,526	1,191
45-49	154	73	4,815	2,271
50-54	890	520	23,931	13,984
54-59	1,483	867	33,812	19,758
60-64	2,103	1,229	39,752	23,228
65-69	2,738	1,600	41,889	24,477
70-74	3,519	2,057	42,586	24,884
75-79	3,866	2,259	35,570	20,785
80-84	5,867	3,428	38,720	22,625
Total	20,763	12,099	267,191	154,897

Source: Estimates by the authors

Life years lost are converted to welfare losses following recommendations of the Reference Case for the Conduct of Benefit-Cost Analysis in Global Health and Development (Robinson et al., 2019). Specifically, we first calculate the value of statistical life (VSL) of India, and then divide by half the life expectancy at birth to identify the value of statistical life year (VSLY). The ratio of VSL to income per capita is estimated using the following equation:

$$VSL\ income\ ratio = \left[\frac{GDP\ per\ capita\ (India)}{GDP\ per\ capita\ (USA)}\right]^{e-1} \times 160 = 52.4$$

where the elasticity of income, e = 1.5 and GDP per capita and GDP per capita are measured in PPP terms. Using this equation and noting an income per capita of INR 148,936 for 2019 the VSL of India is estimated at INR 7,812,000. [4] The VSLY is estimated at INR 255,100 in 2019. The sum of life years lost is multiplied by the VSLY to estimate the welfare losses from increased mortality risk.

[4] Note that while the ratio is calculated using PPP figures, the VSL to income ratio can be applied to any figure in International dollars, USD or local currency units with the resulting VSL in the same unit. For an application of this see Cropper *et al.*, (2019).

Education loss for children: Children who suffer from poor eyesight do not learn as much in school as those without visual impairment (Burton et al., 2021). To the best of our knowledge there is no rigorous evidence from India on the impact of MSVI and blindness on schooling outcomes. Three studies from China have estimated the impact of experimentally encouraging or providing eyeglasses to school students. Across three studies, the results suggest increased test scores with a range of 0.11 to 0.25 standard deviations (Ma et al., 2014, 2018; Glewwe, Park and Zhao, 2016). For this study, we adopt the midpoint value 0.18 standard deviation test score loss as the base case estimate for MSVI. This may be an underestimate since the referenced studies looked at the benefits of addressing general myopia which includes impacts less severe than MSVI.

Less learning in school implies lower earnings in adulthood. To translate this figure into a future productivity loss, we note that a 1 standard deviation improvement in test scores is correlated with a 20% increase in adult income in India (Aslam et al., 2010). A 0.18 reduction in test scores is therefore equal to a 3.6% loss in future income for each year a child suffers MSVI while in school. For blind children we assume that they do not go to school, or learn minimally, experiencing a reduction in future income equivalent to reported returns to one year of schooling from primary school education – 5.5% (Agarwal, 2011). A stream of future GDP per capita is estimated using the time series of GDP and population growth rates (middle-of-the-road scenario) from Shared Socioeconomic Pathways database managed by the International Institute for Applied Systems Analysis (Riahi et al., 2017).

We consider only two age cohorts as suffering education loss from MSVI and blindness – children aged 5-9 years old and 10-14 years old. The estimated loss from MSVI is 3.6% multiplied by the appropriate net enrolment rate[5] (World Bank, 2021) and the stream of future income (proxied by GDP per capita) from ages 15-64 assuming an 8% discount rate. A similar calculation is done for blindness. Per child figures (Table 4) are multiplied by the prevalence of MSVI and blindness for the appropriate age cohorts to estimate welfare cost in 2019.

Table 4: Estimated future income loss per child from poorer education outcomes associated with one year of MSVI and Blindness

Age Group	Future income loss from one year of MSVI (INR)	Future income loss from one year of blindness (INR)
5-9	76,160	116,355
10-14	87,130	133,115

[5] For 5-9 year old children the primary net enrolment rate of 92% is used. For 10-14 year old children the secondary net enrolment rate of 62% is used (World Bank, 2021).

Productivity Loss in Employment: The Lancet Commission was not able to provide a formal estimate of productivity losses from MSVI and blindness while in employment. Only one high quality study was referenced that demonstrated that the provision of spectacles to correct presbyopia in tea pickers increased productivity by 22% (Reddy et al., 2018). While the evidence base is limited, there is additional supporting literature that suggests, conditional on employment, individuals with MSVI and blindness are much less productive than those without visual impairment. A study from South India noted that cataract surgery increased household income and reduced prevalence of poverty after one year (Finger et al., 2012). In that study, a non-trivial proportion of individuals with visual impairment at baseline were working (43%). People who are blind and in employment earn lower wages, suggestive of reduced productivity from their condition (Foley and Chowdhury, 2007). Lastly, wage data from the US notes that those with MSVI earn 29.7% less than those without, while those who are blind earn 36.5% less (Rein et al., 2006). In this analysis we assume productivity reduction of 20% due to MSVI or blindness, conditional on employment as a reasonable, albeit imprecise, estimate. Due to imprecision in the data, we do not assume different rates between MSVI and blindness.

To estimate welfare costs, we take the fraction of individuals employed with MSVI and blindness. Earlier we noted that the loss of employment from blindness is 30.2%, so by definition those counterfactually employed would be 1-30.2% = 69.8% multiplied by the employment to population ratio (46%). This figure is then multiplied by the prevalence of MSVI or blindness, the 20% reduction in productivity assumed above, and the GDP per capita in 2019 as a proxy for income.

Caregiver Costs: There is evidence from high income countries that people with MSVI or blindness require significant caregiver time. The systematic review by Köberlein et al., (2013) shows an average caregiver time of 5.8 hours per week for those with visual acuity 6/18 rising to 94 hours per week for those with visual acuity 6/60. As a percentage of a typical 40 hour working week, these represent 14.5% to more than 200% of time dedicated to caregiving. It is likely that these percentages would be lower in India, where substantially lower household incomes and limited safety nets make it less likely household members would divert time away from income generating activities. Costing studies have included caregiver costs for those suffering from MSVI and blindness (Naidoo et al., 2019). Following Naidoo et al., (2019) we assume that 5% of productive time is required to assist those with MSVI and 10% of productive time is required for those who are blind. These figures are multiplied by GDP per capita to estimate the costs per of caregiver time per person with MSVI and blindness respectively.

Productivity Loss of Unpaid Work: With an employment-to-population ratio of 46%, less than half of the working age population is employed in India. The remainder, mostly women, are typically engaged in household activities. Data from time use surveys indicates that women aged 15-64 spend almost 6 hours per day on unpaid activities, with men of the same age range, spending almost one hour per day (OECD, no date). A household that contains one woman and one man of working age, would therefore spend 50 hours per week on domestic activities. Suffering from MSVI or blindness is likely to impede these activities, particularly considering the evidence that those with visual impairment suffer from lower employment-related productivity, mobility and social status (Finger et al., 2012; Reddy et al., 2018; Burton et al., 2021).

To the best of our knowledge no study has estimated the productivity loss for unpaid work from MSVI or blindness. Therefore, we adopt the equivalent value of productivity loss in employment, i.e. 20%, as a reasonable estimate of the productivity loss for non-employed. We value the productivity decrease at the extra time it would take to generate production of the same level as a non-blind or non-MSVI person and use the recommendations from Robinson et al., (2019) and Whittington and Cook, (2019), which suggest that changes in time use could be benchmarked at 50% of market wages. A range of 25-75% tested in sensitivity analyses. As with the other categories of loss, income is proxied by GDP per capita in 2019. We only include losses for those aged 15 to 64.

3. Results

3.1 Point estimates

Table 5 and Figure 3 summarize the results of the analysis. Overall, the results suggest that the costs of poor eye health in India in 2019 were INR 1,158 billion (Int$ 54.4 billion) summing across all six categories of loss. This is equivalent to 0.57% of GDP in 2019. The economic and social costs of MSVI are more than four times the cost of blindness. This result is mostly driven by the fact that MSVI is significantly more prevalent than blindness across India. In terms of categories of cost, loss of employment represents the largest cost (INR 409 billion) followed by caregiver costs (INR 289 billion). Education loss for children, as well as elevated mortality risk figures are relatively small.

Since there are differences in the evidence base for each type of cost, we also report results based on a more conservative scenario valuing loss of employment and elevated mortality risk only. These two impact estimates are derived from a review and meta-analysis of the most recent evidence as reported in the Lancet Commission on Global Eye Health and could be considered a relatively stronger evidence base (Burton et al., 2021). This conservative scenario indicates a total cost of INR 504 billion or 0.25% of GDP.

Table 5: Estimated social and economic costs by type of impact, INR millions						
	Main Scenario - All six cost categories (INR, millions)			Conservative Scenario - only two cost categories (INR, millions)		
	MSVI	Blindness	Total	MSVI	Blindness	Total
Loss of employment	352.1	57.0	409.1	352.1	57.0	409.1
Elevated mortality risk	60.1	34.9	95.0	60.1	34.9	95.0
Education loss for children	11.5	2.4	13.9	-	-	-
Reduced productivity in employment	162.8	26.4	189.1	-	-	-
Caregiver costs	217.4	71.4	288.8	-	-	-
Productivity loss of unpaid work	139.1	22.5	161.6	-	-	-
TOTAL	943.0	214.6	1,157.5	412.2	91.9	504.1
% of GDP	0.46%	0.11%	0.57%	0.20%	0.05%	0.25%

Source: Estimate by the authors, all figures are for 2019

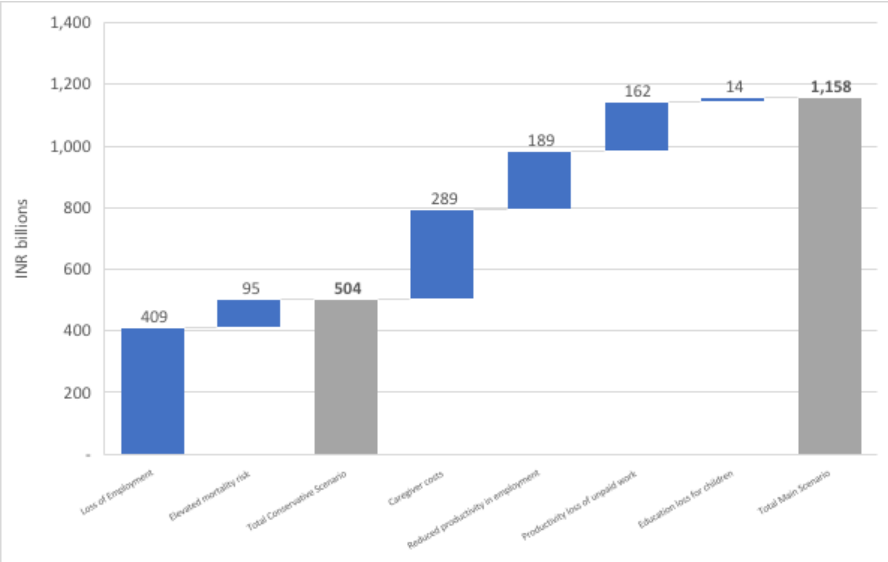

Figure 3: Social and economic costs of MSVI and Blindness in India, 2019 (INR billions)

The age group associated with the greatest costs are the 50-64 year age group (Table 6). This is because the prevalence of blindness and MSVI increases substantially at these ages, and these people are assumed to still participate in the workforce.
Source: Estimate by the authors, all figures are for 2019.

Table 6: Total costs of MSVI and blindness by age group, INR millions				
	0-14	15-49	50-64	65-84
Main Scenario	16.6	172.7	794.4	173.8
Conservative Scenario	0.3	78.1	369.0	56.6

3.2 Probabilistic estimates

To determine the impact of uncertainty on the reported results, a probabilistic sensitivity analysis is conducted by varying several parameters simultaneously across 10,000 Monte Carlo simulations.

We vary a range of parameters, including the main effect sizes of each category of loss (Table 7). Except for mortality risk, all the distributions are assumed to be uniform, given the generally limited number of studies from which the parameters are drawn. Additionally, since many of the effects are likely to be the same or larger for blindness than MSVI, the parameter values for five out of the six categories are a function of the draw for MSVI.

Productivity loss is assumed to range uniformly from 19.5% to 43.5% for both MSVI and blindness. The lower value is the employment loss from the EuroStat database, while the upper value is the maximum regional estimate of employment loss (High Income North America) reported in Marques et al., (2021). All-cause mortality risks for MSVI and blindness are assumed to be normally distributed with means equal to the values previously estimated from Table 3. Standard deviations are calculated by first solving the simultaneous equations using the low end and high end of each of the 95% confidence intervals reported in Ehrlich et al., (2021), and then taking half the average distance between these values and the mean. Productivity loss in employment for both MSVI and blindness is assumed to range uniformly from 17% to 23%, proportionally equivalent to the same sized confidence interval reported in Reddy et al., (2018), the most representative study of productivity loss within the Indian context.

Caregiver costs are assumed to vary uniformly from 2.5% to 10% for MSVI, with blindness equal to 2x the cost following the same proportional differential assumed in the main analysis. The future income loss for being in school with one year of MSVI is assumed to range from 2.2% to 5.0%, based on the lower and upper bound of improvement in test scores from correcting visual impairment reported in the literature (i.e. 0.11 s.d from Ma et al., (2014) and 0.25 s.d. from Ma et al., (2018)) and converted into future productivity gains reported in the main analysis. The impact from blindness is assumed to equal 1.53x the draw from MSVI, assuming the same proportional differential in the main analysis. Finally, for productivity loss of unpaid work, the value of productivity loss is assumed to equal the draw from productivity loss in employment. However, the value of this loss is assumed to vary uniformly from 25% to 75% following Whittington and Cook, (2019).

Table 7: Parameters and distributions for probabilistic sensitivity analysis		
Parameter	MSVI	Blindness
Productivity loss in employment	Uniform distribution with a range = 19.5% to 43.5%	Same draw as for MSVI
10-year all-cause mortality risk	Normal distribution with mean = 1.26 and standard deviation = 0.06	Normal distribution with mean = 1.90 and standard deviation = 0.26
Productivity loss in employment	Uniform distribution with a range = 17% to 23%	Same draw as for MSVI
Caregiver costs	Uniform distribution with a range = 2.5% to 10%	2x the draw for MSVI
Education loss for children (future income loss for one year of visual impairment)	Uniform distribution with a range = 2.2% to 5.0%	1.53x the draw for MSVI
Productivity loss of unpaid work	Productivity loss: equal to draw from productivity loss in employment Value of time: uniform distribution with range = 25% to 75%	Same draw as for MSVI

The results of the probabilistic sensitivity analysis are presented as a cumulative distribution function (Figure 4). The results show that 95% of the results lie between INR 947 billion and INR 1,427 billion (0.47% to 0.70% of GDP) with a median of INR 1,187 billion (0.58% of GDP) for the main scenario. For the conservative scenario (cumulative distribution function not shown), 95% of the results lie between INR 348 billion and INR 621 billion (0.17% to 0.31% of GDP) with a median of INR 482 billion (0.24% of GDP).

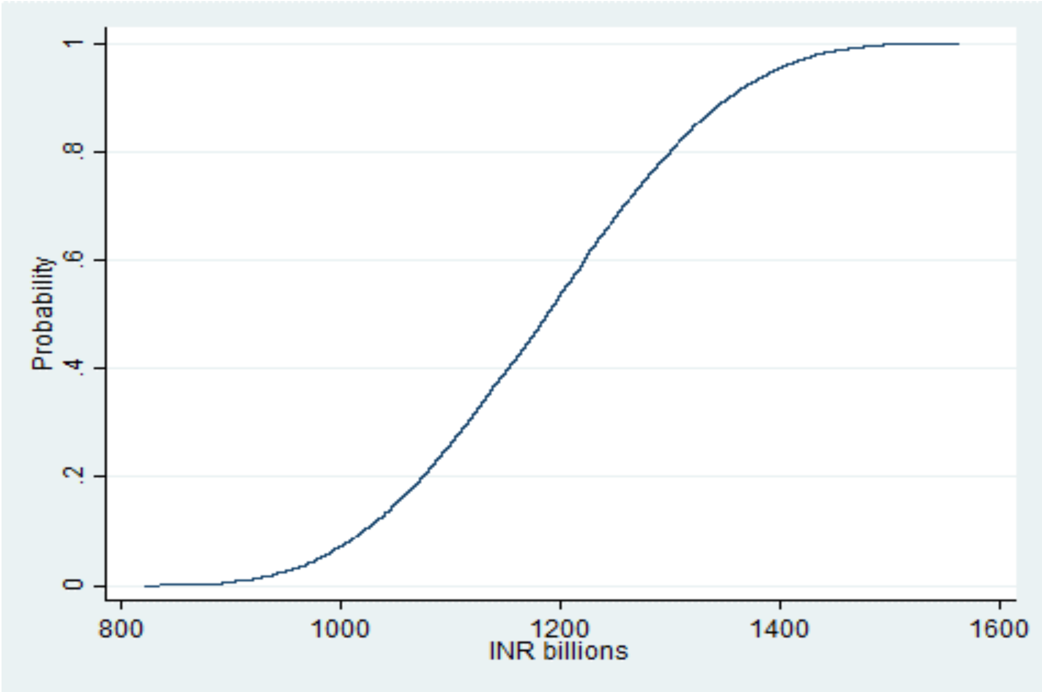

Figure 4: Cumulative distribution function: social and economic costs of MSVI and blindness

4. Discussion and Conclusion

This report estimates the economic and social costs of MSVI and blindness in India. To the best of our knowledge this is the first detailed estimate for India in the last 20 years. We estimate the costs of six streams of potential impacts: loss of employment, elevated mortality risk, education loss for children, productivity loss in employment, caregiver costs and productivity loss of unpaid work. The analysis indicates that the total welfare cost of MSVI and blindness in India in 2019 equalled INR 1,158 billion (range: INR 947 billion to INR 1,427 billion) or 0.57% of GDP (range: 0.47% to 0.70%).

MSVI and blindness impose mostly immediate productivity losses on the Indian economy, both for those who are in the workforce or those who take care of them. Therefore, poor eye health represents a non-trivial constraint towards reaching the country's growth goals such as becoming a $5 trillion economy by 2024-2025. The analysis indicates that around 80% of the loss is associated with MSVI, with the remainder associated with blindness. Those aged 50-64 contribute approximately 70% to the total economic and social costs of poor eye health.

Age is notable risk factor for blindness and MSVI (Burton et al., 2021). Additionally, welfare costs increase as the economy grows since loss of employment, education, productivity, as well as the willingness-to-pay for mortality risk reduction is proportional to GDP per capita. Therefore, the welfare costs of poor eye health will continue to grow over time as India ages and becomes wealthier.

This analysis draws upon the most up-to-date evidence on impacts as presented in Burton et al., (2021), as well as data from the most recent National Blindness and Visual

Impairment Survey (Ministry of Health and Family Welfare, 2020) and the best practice methodology for estimating mortality risk reduction and changes in time use from Robinson et al., (2019). Nevertheless, there is still some uncertainty around the effects used in this analysis. Therefore, we present an additional scenario including only two impacts that were highlighted in the recent Lancet Global Commission on Global Eye Health (Burton et al., 2021), namely reduced employment and elevated mortality risk, and for which there is arguably a stronger evidence base. While the evidence for the remaining impacts is drawn from fewer studies, and in some cases are less representative of India, it is unlikely that these other impacts would equal zero, and so ignoring them altogether would represent an underestimate of the challenge of MSVI and blindness in India. We believe that the range estimated under the probabilistic sensitivity analysis for the main scenario, INR 947 billion to INR 1,427 billion, or 0.47% to 0.70% of GDP, represents the most realistic cost estimate of MSVI and blindness in India.

There are several limitations to our analysis. We do not include intangible quality of life impacts for those who suffer from MSVI or blindness, nor do we include the costs of mild vision impairment in this assessment. Including these would raise the cost of poor eye health in India. Additionally, since microdata from the most recent Blindness and Visual Impairment Survey (Ministry of Health and Family Welfare, 2020) were unavailable, we drew upon Global Burden of Disease modelling to estimate the prevalence by 5-year age cohorts. If we had instead used the flat 0-49 and 50+ prevalence rates for MSVI and blindness reported in the survey (without further age-adjustment), the costs of MSVI and blindness increase by 17%.

The total loss from a particular problem is just part of information required for improved and efficient resource allocation. The extent to which interventions can mitigate the impacts of a given problem, and their cost are other key inputs. Previous research indicates that some interventions to address eye health are efficient uses of resources in India. For example, Shamanna, Dandona and Rao, (1998) estimated that a one-off investment of USD 0.15 billion in cataract surgery could return USD 1.1 billion per year in higher income (1997 figures). More recently, Le et al., (2016) estimate that it would cost USD 2.6 billion to eliminate cataract related blindness and low vision in India, yielding USD 16 billion in benefits in the first year alone. Put together, these findings indicate that poor eye health is a large yet solvable problem in the Indian context.

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