pwc.com.au

The Value of Sight

The Fred Hollows Foundation

A quantification of the benefits associated with eliminating avoidable blindness and visual impairment

February 2013

pwc

Mr Brian Doolan
Chief Executive Officer
The Fred Hollows Foundation
Level 2, 61 Dunning Avenue
Rosebery NSW 2018

August 2012

Dear Brian

Subject: The Value of Sight – a quantification of the benefits associated with eliminating avoidable blindness and visual impairment

We are pleased to provide this report, which analyses the benefits of eliminating avoidable blindness and visual impairment. It forms the second piece of the benefits work and third of the series that examines the cost to eliminate and the benefits of elimination of avoidable blindness and visual impairment.

The approach to quantify benefits in this analysis draws on the literature review undertaken in the benefits framework development phase. We have also engaged in external expert opinion to review this piece and assist to verify our assumptions. The process to quantify the benefits has affirmed that the benefits are substantive but has revealed a number of data limitations in this sector.

We would like to thank The Fred Hollows Foundation, SightSavers and Light for the World as well as the key stakeholders with whom we engaged in consultations for taking the time to review our work and for the valuable advice and input they have provided. We would also like to thank Kirsten Armstrong of Three Rivers for her advice throughout this project. We trust that this report makes a valuable contribution to the understanding of the substantial benefits that would arise from the elimination of avoidable blindness and visual impairment.

Yours sincerely

Jeremy Thorpe
Partner
Economics and Policy

PricewaterhouseCoopers, ABN 52 780 433 757
Darling Park Tower 2, 201 Sussex Street, GPO BOX 2650, SYDNEY NSW 1171
T +61 2 8266 0000, F +61 2 8266 9999, www.pwc.com.au

Glossary

DALY	Disability Adjusted Life Year
FHF	The Fred Hollows Foundation
GP	General practitioner
IAPB	International Agency for the Prevention of Blindness
MDG	Millennium Development Goal
NGO	Non-government organisation
PwC	PricewaterhouseCoopers
QALY	Quality Adjusted Life Year
US	United States Dollars
WHO	World Health Organization

Executive summary

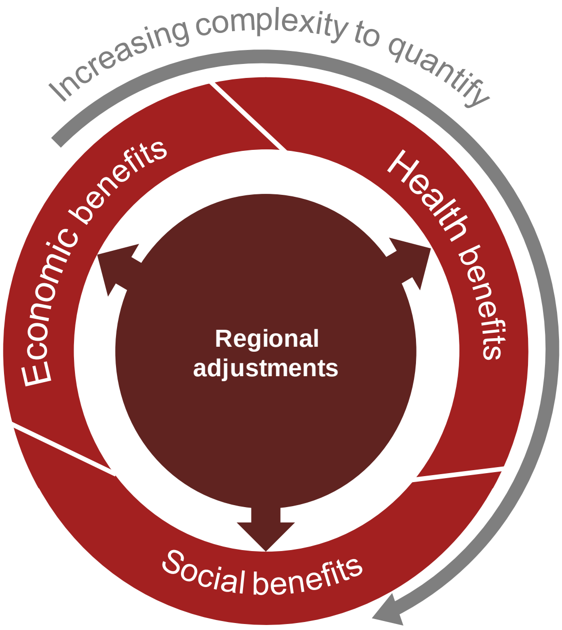
The World Health Organisation (WHO) estimated that in 2010, globally there are 32.4 million people who were blind, and a further 190.6 million people who were visually impaired to the point that their ability to function is negatively impacted (Stevens, pers comms, 2013) [1]. A large proportion of the world's blind and visually impaired live in low and middle income countries, with approximately 80% of cases avoidable (Resnikoff & Pararajesegaram 2001). The elimination of avoidable blindness and visual impairment is therefore expected to have a significant impact in developing countries.

This analysis aims to quantify, to the degree that is possible, the benefits of eliminating avoidable blindness and visual impairment within a framework that incorporates economic, health and social benefits. It is the analysis that combines the health, economic and social benefits of eliminating avoidable blindness and visual impairment on a global scale, to address the mission of VISION 2020. As such, it differs to past studies, both in terms of geographic scope, as well as disease scope, by addressing all causes of avoidable blindness and visual impairment.

This benefits analysis follows *The Price of Sight*, a previous piece of work carried out by PwC and Three Rivers for The Fred Hollows Foundation, IAPB, Sightsavers, Light for the World, CBM and Operational Eyesight Universal that estimates the level of investment required to eliminate avoidable blindness and visual impairment by 2020.

The quantification of benefits is based on the **"benefits framework"** developed in phase 1 of this project, a critical precursor to this analysis (depicted below).

High level benefits framework



Quantified benefits

This quantification of benefits estimates the value of those benefit indicators that are able to be quantified in dollar terms, aggregated to provide a global estimate by WHO sub-region, using available prevalence data. The

[1] These revised data are lower than the previous calculations and are based on the WHO's estimates of declining trends in visual impairment and blindness. A large portion of the difference stems from the newer reduced estimate of visual impairment in China. New data were attained from Stevens, personal comms in 2013. Previous data was from WHO 2010.

focus of this analysis is the benefit of achieving the principal goal of VISION 2020 – The Right to Sight, which is "to eliminate avoidable blindness and vision loss" globally. We have quantified benefits in terms of **the benefit that can be achieved from the additional investment made to eliminate avoidable blindness and visual impairment,** which allows for an equal comparison with the costs estimated in *The Price of Sight*.

This analysis quantifies the benefit accrued globally from the additional investment required to eliminate avoidable blindness and visual impairment. That is, the investment beyond what is already being spent by each country in eye health. As such, benefits will be realised from the elimination of both:

- the current backlog (or prevalence of avoidable blindness and visual impairment)
- the future incidence of avoidable blindness and visual impairment for those who would not be treated within the current health system scope, but could be treated if additional investment was made.

Benefits that are quantified in this analysis are:

- Economic benefits: productivity benefit for those with avoidable blindness and visual impairment, the productivity benefit for carers of those with avoidable blindness and visual impairment and the dead weight loss value per person with avoidable blindness and visual impairment.
- Health benefits: direct health system savings, comprised of the averted health costs associated with co-morbidities.
- Wellbeing benefit: or improved quality of life in terms of Disability Adjusted Life Years (DALYs) averted (a monetary value has not been assigned to this benefit).

Benefits not able to be quantified due to a lack of supporting data that have been analysed qualitatively are:

- increased primary education
- reduced extreme poverty
- increased independence, self esteem and improved social networks
- increased gender equality.

Key quantitative results

The total value of the combined economic and health benefits that have been quantified in monetary terms is **$843.5 billion** (USD, 2009) accrued globally over a ten year period, from 2011 to 2020.

This total benefit result, compared to the total cost estimated to eliminate avoidable blindness and visual impairment in the previous *Price of Sight* report (detailed further below), shows a 2:1 benefit to cost ratio. It should be noted that the benefit value is representative only of those benefits that were able to be quantified and does not encompass a number of other social benefits, which implies that the overall net benefit is likely to be even larger than reported in this analysis.

The benefit value from avoidably blind and visually impaired persons returning to employment is estimated at **$670.0 billion** (USD, 2009). An additional benefit of **$43.5 billion** (USD, 2009) is estimated to accrue to carers of avoidably blind and visually impaired persons. Table 1 shows the benefit values disaggregated by developed countries and developing countries. For the purpose of this analysis, and drawing on the classifications specified by the WHO, developed countries are classified as those with mortality stratum A. Developing countries are those within WHO sub-regions mortality strata B-E.

The results below show that the productivity benefit to both avoidably blind and visually impaired persons and to carers and the benefit of averted falls are weighted towards developing countries. The deadweight loss benefit is the only benefit which is heavily weighted towards the developed world, and this can be explained largely due to the economic circumstances in these countries, with the government spending a higher portion of expenditure on health services – a key driver of dead weight loss.

If we examine the total proportionate distribution of benefits, **the developing world accrues 61% of the total**. Whilst this is still below the respective proportionate share of population in these regions, it emphasises the greater value of investing in eye health in developing countries.

Table 1: Summary of 2011-2020 global benefit value by benefit category (USD, 2009 billions)

Benefit	Total benefit value	Developed countries (WHO Stratum A) benefit value	Developing countries (WHO Strata B-E) benefit value
Share of population		14%	86%
Economic	**802.0**	**308.0**	**494.0**
Productivity benefit to avoidably blind and visually impaired persons	670.0	206.9	463.0
Productivity benefit to carers	43.5	14.7	28.8
Deadweight loss benefit to avoidably blind and visually impaired persons	88.5	86.3	2.2
Health	**41.4**	**18.4**	**23.0**
Averted falls benefit	41.4	18.4	23.0
TOTAL	**843.5**	**326.4**	**517.1**

In addition to the benefits valued in monetary terms, other benefits such as total DALYs averted and social benefits (e.g. increased gender equality and improved social networks) must be considered.

Including qualitative benefits ensures that the full spectrum and extent of benefits expected to be realised, particularly in developing countries are properly recognised and accounted for. Once these additional health and social benefits are considered, the proportionate share of the total benefit from eliminating avoidable blindness and visual impairment is likely to be even more heavily weighted in developing countries.

The DALYs analysis affirms this notion, as **94%** of the world's DALYs associated to visual impairment is borne by developing countries. Social benefits not quantified in the initial benefit estimates that are likely to be realised predominantly in the developing world include:

- reduced extreme poverty
- increased primary education
- increased gender equality.

Each of these are analysed qualitatively in Section 4.

Recognising the full extent of the benefits in the developing world

In addition to recognising those benefits that are not quantified, it is important to take into account the difference in Purchasing Power Parity (PPP) between developed and developing countries. This relates to the fact that one US dollar buys a much larger quantity of goods and services in the developing countries compared to in those that are considered developed. The true monetary benefit in developing countries therefore is expected to be much greater than what these results initially suggest. This is better contextualised by examining the average benefit per person in the developed and developing world. For the developed world, or those countries with mortality stratum A, the average benefit per person (including those without avoidable blindness or visual impairment) is **$343.30 over 10 years, or $34.30 per year** (USD, 2009) compared to the developing world in which it is **$88.30 over 10 years, or $8.30 per year** (USD, 2009). Whilst the dollar value of the benefit per person is lower in the developing world, it is important to recognise that this value carries with it additional weight if the significantly lower cost of goods and services in this region is taken into account.

Lessons drawn from this analysis

Comparisons to other studies

As noted, many studies analyse blindness or visual impairment and its implications, however they do not have a common scope to this analysis in terms of geography, cause, or impact. Where this analysis estimates the value of the benefit from eliminating all causes of avoidable blindness and visual impairment, other studies tend to be limited in their geographic scope, for example, focusing on one country, analysing a limited age range, or focusing on one (or few) causes of blindness and visual impairment. As such, there is a limit to the extent to which a fair comparison can be made with previous research. However, in many instances we have drawn on the methodologies outlined in previous research with the purpose to extend them to a global scale, or to apply them to more than one condition where appropriate.

Data gaps and limitations

A number of lessons have been learned during this quantification exercise and some key data limitations have been exposed. More precision in the prevalence data, a better understanding of the level of employment and the average income in the avoidable blind and visually impaired population would be beneficial for further analyses. At present the assumptions have been drawn from research focusing on developed countries. The quantification would be enhanced with more data that is specific to developing countries.

Benefit estimates are based on the most recent unpublished data on the prevalence of those impacted by blindness and visual impairment (severe and moderate). However, there remains considerable uncertainty around the exact number of people that are blind or otherwise visually impaired. This report relies on the central estimate of 223 million; though there is a 95% likelihood that the true estimate lies somewhere between 206 million and 261 million (Stevens, pers comms, 2013). This confidence interval suggests that estimates from this analysis should be treated as indicative and with caution. Future analyses into the cost-effectiveness of eliminating avoidable blindness would therefore benefit greatly from research that increases the precision of these data.

As the impact of avoidable blindness and visual impairment extends beyond affected individuals, for example to their carers, it is important to explore these implications. At present, there is some understanding of the extent to which blind persons in developed countries (based on Australian data) use carers. Equivalent data for developing countries is not, to our knowledge, available. Further, the extent to which care giving takes away from productive or leisure time falls under a broad assumption in this analysis. It would be ideal to understand the age distribution of carers and the corresponding impact on their lives.

There is also limited data on the incidence and impact of falls in both developed but especially in developing countries. As falls area key co-morbidity for avoidable blindness and visual impairment, especially for those older individuals affected by these conditions it is of key importance to understand the extent of this impact, the implications to the individual and the cost to the health system.

This analysis deliberately errs towards the side of conservatism. We acknowledge that there exist other benefits that could be quantified, such as the benefit of reduced welfare expenditure on persons for whom avoidable blindness and visual impairment is eliminated, a multiplier impact on the wider economy that would stem from increased consumption from increased income, and the future value of additional educational attainment for children with curable uncorrected refractive error. These have not been quantified at this stage because there is insufficient data to make reliable assumptions.

Publications in this series

This report is the third in a series of four that aims to address the mission of VISION 2020 – the global initiative for the elimination of avoidable blindness and visual impairment, a joint program of the World Health Organisation and the International Agency for the Prevention of Blindness. Here, we seek to analyse the benefits of eliminating avoidable blindness and visual impairment. This analysis was undertaken subsequent to the benefits framework, to organise and categorise the benefits to eliminating avoidable blindness and visual impairment. The benefits work provides a counter piece to the initial *The Price of Sight* report, which estimated the cost to eliminate avoidable blindness and visual impairment. The report that will follow this benefits analysis will bring together both the cost and benefit components of the elimination of avoidable blindness and visual impairment.

Combined, these analyses provide a cost benefit analysis that uses the best data available concerning eye health. These benefits results indicate that the investment to eliminate avoidable blindness and visual impairment is worthwhile.

A separate publication will directly consider the comparison between the costs and benefits of eliminating avoidable blindness and visual impairment

In all, the series focusing on the goal of VISION 2020 comprises the following reports:

- *The Price of Sight* – The global cost of eliminating avoidable blindness
- A benefits framework for eliminating avoidable blindness and visual impairment
- *The Value of Sight* – A quantification of the benefits associated with eliminating avoidable blindness and visual impairment (this report)
- A summary of the cost to eliminate avoidable blindness and visual impairment and corresponding benefits (to follow).

Contents

Glossary ii

Executive summary iii

1 Background 1

2 Overview of approach 5

3 Results of the benefit analysis 12

4 Additional social benefits 18

5 Lessons from this quantification exercise 23

Appendices 25

Appendix A References and key guiding research 27

Appendix B Economic and health benefits – Detailed methodology 34

Appendix C Regions 41

Appendix D Case Studies: Australia and India 44

Benefits of eliminating avoidable blindness and visual impairment 45

Case study: Australia 50

Case study: India 57

Discussion 62

Quantifying benefits globally 64

References 65

1 Background

Scope

PwC and The Fred Hollows Foundation have agreed that the scope of this piece of work is to quantify, to the degree that is possible, the benefits of eliminating **avoidable blindness and visual impairment** within a framework that incorporates economic, health and social benefits. This report presents the results of this analysis.

The quantification is based on the **"benefits framework"** developed in phase 1 of this project, a critical precursor to this analysis. More detail of the approach taken to develop the benefits framework is provided below.

This is the first analysis in which the health, economic and social benefits of eliminating avoidable blindness and visual impairment are brought together on a global scale, addressing the goal of VISION 2020. As such, it differs to past studies which are varied in terms of their geographic scope (eg country versus global analysis) and also their analysis of different causes of blindness and visual impairment. Further, past studies tend to provide estimates of the economic cost as opposed to the benefit.

Summary of The Price of Sight

This benefits quantification follows a previous piece of work carried out by PwC, The *Price of Sight*, which estimated the level of investment needed to eliminate **avoidable blindness and visual impairment** by 2020. The required investment was estimated for both the development of the primary and secondary health systems over a ten year period (2010-2020).

The key results were:

- The direct investment required to treat the backlog of avoidable blindness and visual impairment over 10 years, to 2020 was estimated to be $23.1 billion (USD, 2009). This excludes the cost of treating the backlog of age related macular degeneration which is not considered as 'avoidable'.
- An additional investment of $394.2 billion (USD, 2009) over ten years was estimated to eliminate avoidable blindness and visual impairment globally.
- Limiting the focus to developing countries then this additional investment is reduced to $128.2 billion, or the equivalent of $2.20 USD per capita per year over this 10 year period.

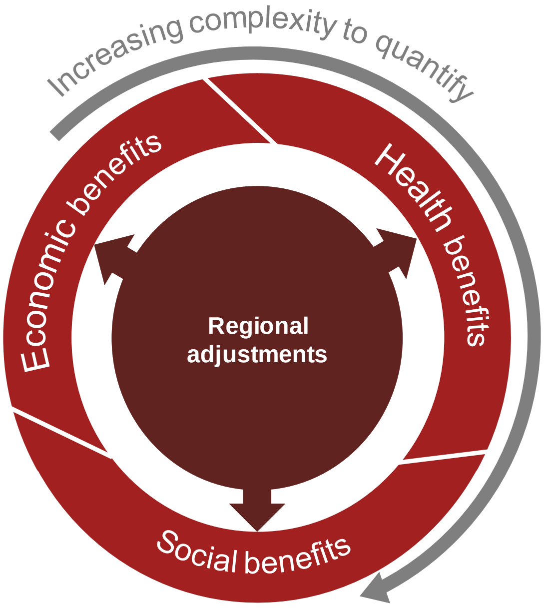
Benefits of eliminating avoidable blindness and visual impairment phase 1 – high level benefits framework

The first phase of this analysis involved the development of a benefits framework, to clearly identify the benefits that could potentially be quantified. This framework development phase comprised the following three steps:

1. Literature scan: an array of health databases and publicly available information was reviewed prior to engaging with a panel of subject matter experts who assisted to provide relevant peer reviewed journal articles. The scan identified research related to blindness, avoidable blindness and visual impairment, benefits and costs.
2. Benefits identification and categorisation: based on the literature scan and the emerging themes, the benefits were identified as either quantitative or qualitative, and were grouped into health, economic or social benefit categories.
3. Subject matter expert interviews: these were conducted to gain further insight into the initial benefits identified and to gather additional information and evidence including information that was not publically available.

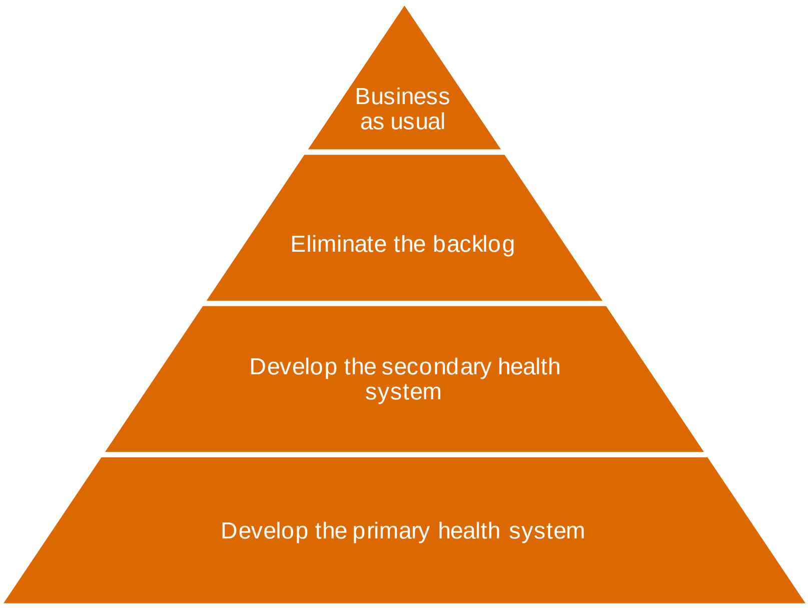
The benefits framework is depicted in Figure 1 below.

Figure 1: High level benefits framework



Alongside the identification of these benefits, four different levels of investment were specified, based on the costing framework that was developed for the estimate of the investment required to eliminate avoidable blindness. These are depicted in Figure 2 and described below.

Figure 2: Levels of investment



Eliminate the backlog: this is particularly relevant to the developing world, where access to basic health care resources is limited. It encompasses those persons who are already blind or visually impaired.

Develop the secondary system: this refers to the development of hospital and other secondary health services to enable more widespread and improved treatment of patients with or at risk of avoidable blindness or visual impairment.

Develop the primary health system: this encompasses improved access to basic health care which is pertinent in much of the developing world and is expected to have the most long term preventative benefits.

Defining the benefits

The economic, health and social benefits identified from the literature scan and expert interviews are detailed below. It should be noted that not all of these benefits were able to be quantified due to data limitations encountered upon reviewing available literature and data sources. Where these benefits have not been able to be quantified, a qualitative analysis has been undertaken.

Table 2 displays some examples of the benefit indicators that are likely to accrue from eliminating avoidable blindness and denotes those that are quantified in the report by the orange shading. Some of the indicators have altered from their original definitions as per the benefits framework largely due to data availability.

Table 2: Benefit example indicators (shading indicates quantified in report)

Examples of economic benefits from eliminating avoidable blindness
• Increased employment to the visually impaired and carer
• Increased productivity
• Reduced welfare costs
• Achieving universal primary education (MDG 2) by either the ability for current carers to receive education or visually impaired children to access education
Examples of health benefits from eliminating avoidable blindness
• Improved quality of life/reduced burden of disease (DALYs averted)
• Reduced co-morbidities and mortality (including HIV/AIDS and malaria-MDG 6)
• Reduced child mortality (MDG 4)
• Reduced hospitalisations, length of stay and other health system costs (possibly including emergency department presentation and ambulatory care where applicable)
Examples of social benefits from eliminating avoidable blindness
• Increased independence • Increased self-esteem and improved social networks • Reduced extreme poverty and hunger (MDG 1) • Increased gender equality • Increased community participation

Benefits of eliminating avoidable blindness and visual impairment phase 2 –quantification

The analysis presented in this report brings together the data collected with methodologies from the literature to compile an estimation of the benefit value from eliminating avoidable blindness and visual impairment globally according to the Benefits Framework defined in Phase 1.

As a first task, two case studies were compiled – one for India and one for Australia to test the methodology, data, inputs and assumptions for the approach to quantify the benefits of eliminating avoidable blindness and visual impairment. We provided the initial estimates calculated in these case studies to an independent reviewer for feedback and verification and from this have proceeded to quantify the benefits on a global scale. The case studies are included in Appendix D.

The initial estimates from the global quantification will be disseminated amongst key subject matter experts to seek feedback and comments. These will be incorporated to form a finalised estimate of the value of benefits derived from eliminating avoidable blindness and visual impairment.

2 Overview of approach

Overall approach to valuing benefits

The benefits quantification takes the value of those benefits outlined in the framework that are able to be quantified, aggregated to provide a global estimate by WHO sub-region, drawing on available prevalence data. The focus of this analysis is the benefit of achieving the principal goal of VISION 2020 – The Right to Sight, which is "to eliminate avoidable blindness and vision loss" globally. We have quantified benefits in terms of that **benefit that can be achieved from the additional investment made to eliminate avoidable blindness and visual impairment** which will allow for an equal comparison with the costs estimated in *The Price of Sight*.

The benefit value will accrue from two sources:

1 The benefit from treating the backlog

2 The benefit from treating the portion of incidence that is not able to be treated under the current health system

The benefits that have been valued in monetary terms are the:

- **productivity benefit for those with avoidable blindness and visual impairment,** a portion of whom were not previously working due to their condition and would enter the workforce upon treatment.

- **productivity benefit for carers** of those with avoidable blindness and visual impairment who would no longer be forgoing education, productive time or leisure time to care for an individual affected by avoidable blindness and visual impairment (usually a family member or friend).

- **dead weight loss value** per person with avoidable blindness and visual impairment which stems from the additional tax revenue that the government must raise to fund the associated direct health costs. Thus, regions with higher average direct health system costs are expected to incur a larger DWL cost. The size of this extra tax burden will depend on the means in which the government chooses to raise additional revenue and also the proportion of a country's direct health costs funded by the government.

- **direct health system savings** (health benefit) – made up of the averted health costs associated with co-morbidities which are a direct result of avoidable blindness and visual impairment. The literature indicated the most notable co-morbidity relating to blindness and visual impairment to be falls (Cruess et al. 2008). This is the only potential health saving we have been able to measure.

We have also quantified the wellbeing benefit, or improved quality of life benefit in terms of Disability Adjusted Life Years (DALYs) averted. However, due to limited global data on the value of a statistical life, this health benefit was not expressed in monetary terms, explained in more detail below.

The detailed methodology for both the economic and health benefits is provided in Appendix B.

This approach differs to that used in the *Price of Sight* analysis, which was able to be built on an individual country basis, whereas the benefits presented in this report could only be estimated for WHO sub-regions. This is because blindness and visual impairment prevalence data is only available for WHO sub-regions, and not for individual countries. A more in-depth explanation of data limitations is provided in the detailed methodology in Appendix B, with region definitions provided in Appendix C.

It is important to distinguish between the approach used in this analysis and that used in other studies. Gordois et al 2011, Taylor et al 2006 and Frick et al 2007 (to note some examples) estimate the economic cost of blindness and visual impairment rather than the cost to eliminate avoidable blindness and visual impairment. Another alternate approach is a cost of illness study, which is one standard approach to estimate the economic impact of an illness. This study type generally encompasses direct health costs, indirect costs, productivity losses related to morbidity or premature mortality and the intangible costs associated with illness (Shamanna & Rao 1998). Here, our approach differs in that we seek to identify the investment required to eliminate avoidable blindness and visual impairment, and the benefits associated with doing so, which aligns with the mission of VISION 2020.

Benefits that were not able to be quantified due to a lack of supporting data have been analysed qualitatively. These are:

- increased primary education
- reduced extreme poverty
- increased independence, self esteem and improved social networks
- increased gender equality

Quantifying the benefits of eliminating avoidable blindness versus blindness and visual impairment

It is recognised that the productivity and health benefit value of eliminating avoidable blindness in an individual is likely to be greater than the benefit value that accrues to an individual with avoidable visual impairment, because the condition is more severe. In this analysis however, a common approach and assumption base is applied for both avoidable blindness and avoidable visual impairment for these benefits. This decision is based on the following:

- In their 2006 study, Rein et al. found that the average annual earnings for the visually impaired were only 10% higher when compared to the blind. This difference was deemed to be not significant.
- There was a limited amount of research and data found in the literature review detailing earning differentials between the blind and visually impaired in developing countries.

Without a more substantive evidence base detailing global earning differentials between the avoidably blind and visually impaired, an accurate weighting assumption was not able to be drawn.

While it is acknowledged that if benefit quantification was limited to blindness alone, we may be able to overcome this data limitation with a more robust set of assumptions, we have elected to quantify the benefits of eliminating both avoidable blindness and visual impairment, based on the following two key points:

- it aligns with the goal of VISION 2020 'to eliminate avoidable blindness and vision loss' – being the driving scope for this analysis
- an equal comparison is sought between the results of this benefits analysis and those derived from *The Price of Sight*, which also specifically examines the costs of eliminating avoidable blindness and visual impairment.

Elimination of the backlog versus incidence

This analysis quantifies the benefit accrued from the additional investment required to eliminate avoidable blindness and visual impairment. That is, the investment beyond what is already being spent by each country in eye health. As such, benefits will be realised from the elimination of both:

- the current backlog (or prevalence of avoidable blindness and visual impairment)
- the future incidence of avoidable blindness and visual impairment for those who would not be treated within the current health system scope, but could be treated if additional investment was made.

Quantifying benefits from the latter category draws on the approach taken in the *Price of Sight* analysis where we estimated the required growth in the eye care workforce based on workforce ratios specified by the VISION

2020 Human Resource Development Working Group. Under this approach, many developed countries required no additional investment as their health workforce already operated within this ratio, a reflection that the present system can support the new incidence of avoidable blindness and visual impairment in such countries. In these cases, no benefit value has been estimated to eliminate new incidence. Countries with an eye health workforce operating within specified workforce ratios have their entire benefit attributable to the elimination of the avoidable blindness and visual impairment backlog.

In countries where growth in the health workforce was required to reach ratios specified by the VISION 2020 Human Resource Development Working Group (as assumed in The *Price of Sight*), the total benefit comprises both the benefit value from eliminating the backlog in addition to the benefit value associated with eliminating the incremental incidence which would be treated assuming additional investments are made.

The benefit value that accrues to the elimination of the avoidable blindness and visual impairment backlog is assumed to be evenly distributed over the ten year period 2011-2020, to remain consistent with the *Price of Sight* analysis.

Determining the timeframes for benefits quantification

A primary step in the quantification of the benefits resulting from the elimination of avoidable blindness and visual impairment is the determination of an appropriate timeframe in which benefits are likely to be realised, relative to the level of investment made.

The key question asked was: does avoidable blindness and visual impairment require an annual investment in order for benefits to accrue each year **(prevalence approach)**, or can avoidable blindness and visual impairment be eliminated with a single intervention type investment, producing a longer term/lifetime benefit **(lifetime approach)**?

To address this, we drew on some eye health expertise to better understand the possible treatment pathways of the various causes of avoidable blindness and visual impairment. A lifetime approach is used to quantify the benefit value associated with the elimination of cataract and uncorrected refractive error (URE). This is because both these conditions are treated with an intervention investment (for example surgery) which will produce a long term benefit. For these causes, minimal further treatment or intervention is required. For all other causes of avoidable blindness and visual impairment, a prevalence approach is used because these causes require an ongoing (annual) investment to monitor treatment and prevent further progression. As such, an annual investment is assumed to produce a corresponding annual benefit value. Blindness and visual impairment caused by age-related macular degeneration (AMD) is not included in this analysis as it is not an avoidable cause of blindness or visual impairment. This assumption is consistent with *The Price of Sight* report. These assumptions are detailed further in Table 3.

Table 3: Benefit timeframe by disease

Disease	Intervention	Outcome	Value	Timeframe
Glaucoma	Treatment focused	Manage disease to prevent blindness	Benefit measured in terms of average annual earnings	'Prevalence approach': year on year benefit resulting from annual investment.
Cataract	Intervention focused	Treat with intervention to produce long term benefits	Lifetime benefit based on assumption of an average of 10 productive years lost due to blindness (Shamanna, BR, Dandona, L, Rao, GN, 1998)	'Lifetime approach' (assumed to be 10 years)
URE	Intervention focused	Treat with intervention to produce long term benefits	Lifetime benefit based on assumption of an average of 10 productive years lost due to blindness (Shamanna, BR, Dandona, L, Rao, GN, 1998)	'Lifetime approach' (assumed to be 10 years)
Diabetic Retinopathy	Treatment focused	Manage disease to prevent blindness	Benefit measured in terms of average annual earnings	'Prevalence approach': year on year benefit resulting from annual investment.
Trachoma and Onchocerciasis	Treatment focused	Manage disease to prevent blindness	Benefit measured in terms of average annual earnings	'Prevalence approach': year on year benefit resulting from annual investment.
Other	Treatment focused	Manage disease to prevent blindness	Benefit measured in terms of average annual earnings	Prevalence approach': year on year benefit resulting from annual investment.

Prevalence data and approach

Regional disaggregation

Benefits are quantified by World Health Organization subregions which are as follows:

- AFRO (D, E) – Africa
- AMRO (A, B, D) – Americas
- EMRO (B, D) – Eastern Mediterranean
- EURO (A, B, C) – Europe
- SEARO (B, D) – South-East Asia
- WPRO (A, B) – Western Pacific.

Each subregion maps individual countries according to patterns of child and adult mortality where 'A' indicates the lowest mortality rates and 'E' includes those countries with the highest rates (WHO 2012). Mortality stratum 'A' indicates developed countries whilst the remaining mortality strata (B through E) comprise the world's developing counties (WHO 2003).

Please refer to Appendix C for a more detailed description of each region, including the countries included in each region.

Prevalence data

Globally, it is estimated that in 2010, there were a total of **223 million** persons who were visually impaired, of which **32.4 million** were blind (World Health Organisation, 2013). The remaining 190.6 million were affected by moderate or severe low vision.

These total prevalence numbers are disaggregated by WHO mortality strata sub region for this analysis (see description of WHO mortality strata sub-regions in Appendix C).

It is important to highlight that these figures are lower than the prevalence estimates (Pascolini & Mariotti 2010) of 285 million visually impaired persons, of which 39 million were blind. Pascolini and Mariotti's data is based on population based studies that included 53 surveys from 39 countries pertaining to the years 2001 to 2008. The more recent prevalence numbers are lower given that they have been calculated based on the World Health Organisation's estimates of declining trends in visual impairment and blindness. A large portion of the difference between the two sets of prevalence data stems from the estimate of visual impairment in China, which is significantly lower in the prevalence data that we have used for this quantification.

To determine the prevalence broken down by cause of visual impairment, we drew upon the proportions put forward in Pascolini and Mariotti's published prevalence data (2011). Globally, the major causes of VI reported were uncorrected refractive error (42%) and cataract (33%). There have been a number of other recent estimates of the prevalence of visual impairment that differ from the prevalence figures used in this benefits quantification. For example, Gordois et al (2011) estimated that in 2010, there were a total of 733 million people visually impaired, including 156 million people with blindness, the five major causes of blindness being URE (50%), cataract (23%), glaucoma (6%), AMD (5%) and diabetic retinopathy (3%). The prevalence estimates in this study are derived from a review by Reskinoff et al (2004) which examined surveys on visual impairment and blindness up to 2002. In terms of the projected growth, Gordois et al (2011) have estimated the prevalence of visual impairment to 2020, showing a 26% increase from the 2010 estimates, totalling 929 million persons by 2020. We have drawn on Gordois et al's projected growth of prevalence by WHO sub-region to calculate the projected annual growth in prevalence when estimating the benefits of eliminating avoidable blindness and VI out to 2020, this detailed further below.

Confidence in the most recent prevalence data

Benefit estimates are based on the most recent unpublished data on the prevalence of those impacted by blindness and visual impairment (severe and moderate). However, there remains considerable uncertainty around the exact number of people that are blind or otherwise visually impaired. This report relies on the central estimate of 223 million; though there is a 95% likelihood that the true estimate lies somewhere between 206 million and 261 million (Stevens, pers comms, 2013). This confidence interval suggests that estimates from this analysis should be treated as indicative and with caution. Future analyses into the cost-effectiveness of eliminating avoidable blindness would therefore benefit greatly from research that increases the precision of these data.

Prevalence projections to 2020

Whilst the point prevalence of visual impairment, including blindness uses the most recent data, prevalence projections in Gordois et al's 2011 study were used as the basis of our calculation of the annual incidence of avoidable blindness and visual impairment to 2020 in lieu of other prevalence projection data. Gordois et al predict the 2020 prevalence of blindness and visual impairment across each WHO mortality strata sub-region. The average annual growth rate in each sub-region was determined, using the 2010 prevalence figures detailed in Gordois et al 2011 as the base year.

Gordois et al note that they have based their prevalence projections on the United Nations World Population Prospects (2008 Revision Population Database). The projected increase in the prevalence of persons with blindness and visual impairment globally is 26.8% over 10 years, however, we have applied the prevalence increase assumption by WHO sub-region in our model as the forecasts from 2010 to 2020 vary by sub-region from 0.36% in EUR-C to 43% in EMR-B.

The full list of prevalence projection assumptions is provided in Appendix C.

'Working age' population for the productivity benefit

To determine the proportion of prevalence of the avoidably blind and visually impaired of working age in each WHO sub region, we have summed the total number of persons aged 15-65 who are blind or visually impaired in each WHO mortality strata sub region and divided this by total prevalence (all ages) in that region. This calculation is based on the recent prevalence data (Stevens, pers comms, 2013) which disaggregates prevalence by five year age brackets (for example, 0-4, 5-9, 10-14). These figures are presented on an individual country basis, and so are aggregated to a WHO sub region level.

In examining previous studies, it was noted that the disaggregation of prevalence specifically by working age (15-65) group is not readily available. For example, in Pascolini and Mariotti's 2011 study, prevalence is disaggregated into the following age groups: 14 years and under, 15 to 19 years and over 50 years. They comment that smaller age groups were not considered because data by country are most appropriately aggregated by larger age groups to retain a higher level of certainty (Pascolini & Mariotti 2011). Forward et al (2012) confirm this broad data limitation, noting that not one study of the 84 large population based studies that have been conducted globally has examined the prevalence of visual impairment in young adults.

The fact that we have been able to access the recent WHO prevalence data, which is easily disaggregated by working age has meant that we have avoided a productivity benefit estimate that is based on a heavy assumptions-based estimate of the number of avoidably blind and visually impaired persons of working age.

It should be noted that our estimate of the productivity benefit to avoidably blind and visually impaired persons does not encompass the productivity benefit accruing to those persons who earn a living from participating in 'grey' or black market economies. This is due to the fact that the total productivity benefit accruing to this group is calculated based on global employment statistics, which do not reflect the extent of the productive activity in these markets. This factor highlights the conservative nature of the productivity benefit.

Quantifying the wellbeing benefit in terms of Disability Adjusted Life Years averted

The well being benefit or the 'improved quality of life' benefit, as it is termed in the benefits framework, is quantified using Disability Adjusted Life Years (DALYs), expressed as total DALYs averted.

Incremental Cost Effectiveness Ratio (ICER) analyses typically focus on the incremental cost of an intervention and the associated achieved outcomes, for example, 'what is the incremental cost of treatment, per life year saved'. This would then be compared to the Value of Statistical Life. In this series of analyses, the net cost (cost minus benefits) is negative, which indicates that it is not necessary to incorporate the value of life years saved, since on a pure net cost basis, the investment is positive. As such, the well being benefit is reported as total DALYs averted.

Limit to scope of benefit indicators

We have limited our scope to those benefits that are best supported by assumptions outlined by academic literature that could be adapted to apply to each region. There are some economic benefits that we recognise would be realised in the event of the elimination of avoidable blindness and visual impairment but without further evidence that would support assumptions, we have not incorporated them because data availability is very limited. These include:

- Economic benefit of the reduced welfare costs in developed countries. This benefit is in addition to the deadweight loss costs averted, as it is the extra saving made in developed counties from reduced welfare payments. We note that this benefit would be very difficult to quantify in developing countries that lack a formal social safety net.

- Economic benefit of the multiplier effect. This benefit is associated with the increase in productivity, which implies an increase in disposable income and correspondingly, increased consumption. The marginal propensity to consume by individuals that have had avoidable blindness and visual impairment conditions eliminated would generate additional benefit to the economy. However this benefit is a flow-on benefit that would be realised after the initial increase in income and furthermore, the magnitude of the impact is not known. This report focuses primarily on the direct benefit impact of eliminating avoidable blindness and visual impairment.

3 Results of the benefit analysis

The total value of the combined economic and health benefits that have been quantified in monetary terms is **$843.5 billion** (USD, 2009) accrued over a ten year period, from 2011 to 2020. The benefit is comprised of:

- Productivity benefit to avoidably blind and visually impaired persons
- Productivity benefit to carers
- Deadweight loss benefit to avoidably blind and visually impaired persons
- The health system savings arising from averted falls

The breakdown of these benefits is outlined in Table 4 below. In addition to these benefits, the wellbeing benefit has been quantified in terms of DALYs averted, the results detailed below. For those benefits that were unable to be quantified, a qualitative analysis is provided later in this report.

This total benefit result, compared to the total cost estimated to eliminate avoidable blindness and visual impairment in the previous *The Price of Sight* report (detailed further below), shows a 2.1 benefit to cost ratio.

Table 4: Summary of global benefit value by benefit category (USD 2009 billions)

Benefit	Total benefit value (2011-2020)	Developed countries (WHO Stratum A) benefit value (2011-2020)	Developing countries (WHO Strata B-E) benefit value (2011-2020)
Share of population		14%	86%
Economic	**802.0**	**308.0**	**494.0**
Productivity benefit to avoidably blind and visually impaired persons	670.0	206.9	463.0
Productivity benefit to carers	43.5	14.7	28.8
Deadweight loss benefit to avoidably blind and visually impaired persons	88.5	86.3	2.2
Health	**41.4**	**18.4**	**23.0**
Averted falls benefit	41.4	18.4	23.0
TOTAL	**843.5**	**326.4**	**517.1**

Recognising the full extent of the benefits in the developing world

The results above show that the productivity benefit to both avoidably blind and visually impaired persons and to carers and the benefit of averted falls are weighted towards developing countries. The deadweight loss benefit is the only benefit which is heavily weighted towards the developed world, which is largely accountable to the economic circumstances in these countries, with the government spending a higher portion of expenditure on health services – a key driver of dead weight loss.

If we examine the total proportionate distribution of benefits, **the developing world accrues 61% of the total**. Whilst this is still below the respective proportionate share of population in these regions, it still emphasises the greater value of investing in eye health in developing countries.

In addition to the benefits valued in monetary terms, other benefits such as total DALYs averted and social benefits (e.g. increased gender equality and improved social networks) must be considered.

Including qualitative benefits ensures that the full spectrum and extent of benefits expected to be realised, particularly in developing countries are properly recognised and accounted for. Once these additional health and social benefits are considered, the proportionate share of the total benefit from eliminating avoidable blindness and visual impairment is likely to be even more heavily weighted towards developing countries.

The DALYs analysis affirms this notion, as **94%** of the world's DALYs associated to visual impairment is borne by developing countries. Social benefits not quantified in the initial benefit estimates that are likely to be realised predominantly in the developing world include:

- reduced extreme poverty
- increased primary education
- increased gender equality.

Each of these are analysed qualitatively in Section 4.

In addition to recognising those benefits that are not quantified, it is important to take into account the difference in Purchasing Power Parity (PPP) between developed and developing countries. This relates to the fact that one US dollar buys a much larger quantity of goods and services in the developing countries compared to in those that are considered developed. The true monetary benefit in developing countries therefore is expected to be much greater than what these results initially suggest. This is better contextualised by examining the average benefit per person in the developed and developing world. For the developed world, or those countries with mortality stratum A, the average benefit per person (including those without avoidable blindness or visual impairment) is **$343.30 over 10 years, or $34.30 per year** (USD, 2009) compared to the developing world in which it is **$88.30 over 10 years, or $8.30 per year** globally (USD, 2009).

Benefit value by WHO sub-region and WHO mortality strata

This initial benefits quantification is built up from the WHO sub-regions classified by 5 mortality strata based on the level of adult and child mortality. A breakdown of those benefits quantified in monetary terms by sub-region is provided in Table 5, whilst an analysis of each separate mortality strata is provided in Appendix C. Discussion around each of the benefits quantified in monetary terms is below.

Table 5:Global benefit value by benefit category and WHO sub-region 2011-2020 (USD 2009 billions)

Benefit		Economic			Health	Total
Sub-region	Share of population	Productivity benefit to blind and visually impaired persons	Productivity benefit to carers	DWL benefit to blind and visually impaired persons	Averted falls benefit	
Afr D	5.8%	16.0	1.6	0.1	0.6	**18.2**
Afr E	6.5%	13.0	1.1	0.1	0.4	**14.6**
Amr A	5.2%	79.4	4.6	0.4	5.3	**89.7**
Amr B	7.2%	66.6	3.9	0.2	3.6	**74.3**
Amr D	1.2%	6.8	0.5	0.0	0.3	**7.6**
EMR B	2.4%	16.1	1.8	0.1	1.4	**19.4**
EMR D	6.3%	16.1	2.3	0.1	1.1	**19.6**
EUR A	6.4%	105.0	8.1	85.8	10.2	**209.1**
EUR B1	2.5%	10.5	1.7	0.1	1.4	**13.7**
EUR B2	0.8%	1.3	0.0	0.0	0.1	**1.4**
EUR C	3.5%	22.9	1.4	0.1	1.7	**26.1**
Sear B	4.8%	29.1	1.6	0.2	1.4	**32.3**
Sear D	20.9%	68.6	5.0	0.3	3.4	**77.3**
Wpr A	2.3%	22.6	2.0	0.2	3.0	**27.8**
Wpr B1	20.5%	180.5	7.3	0.7	7.0	**195.5**
Wpr B2	1.6%	5.4	0.2	0.0	0.2	**5.8**
Wpr B3	1.9%	10.2	0.4	0.1	0.4	**11.1**
Total	**100%**	**670.0**	**43.5**	**88.5**	**41.4**	**843.5**

Productivity benefit to blind and visually impaired persons and carers

If avoidable blindness and visual impairment were to be eliminated, the benefit from these persons returning to employment is estimated at **$670 billion** (USD, 2009). An additional benefit of **$43.5billion** (USD, 2009) is estimated to accrue to carers of the avoidably blind and visually impaired, which sums to a total productivity benefit of **$713.5 billion** (USD, 2009).

Table 6 below shows the distribution of the productivity benefit accrued to both the blind and visually impaired and carers in the developed world compared to the developing. The respective share of the global population is also provided.

Table 6: Summary of benefits in the developed and developing world

Region	Total productivity benefit to blind and visually impaired persons	Total productivity benefit to carers	DWL benefit to blind and visually impaired persons	Averted falls benefit	Share of population
Developed (mortality stratum A)	30.9 %	33.9 %	97.5 %	44.4 %	14.0%
Developing (mortality strata B-E)	69.1 %	66.1 %	2.5 %	55.6 %	86.0%

Deadweight loss (DWL) Benefit

The total DWL benefit is estimated to be $88.5 billion, arising out of tax revenue savings by the government relating to direct health costs. This benefit is realised primarily by developed countries, with 97.5% of the total DWL benefit accrued to those WHO regions with mortality stratum A.

This is expected given that DWL is driven by average health system expenditure (which is equal to the falls costs in our analysis) and the proportion of health costs funded by the government, both of which are higher in developed countries. More detail surrounding how this benefit has been quantified is provided in Appendix B.

Averted falls benefit

The total averted falls benefit estimated to be realised from the elimination of avoidable blindness and visual impairment is **$41.4billion** (USD, 2009). More detail surrounding how this benefit has been quantified is provided in Appendix B.

Wellbeing benefit

The well-being benefit is expressed in terms of Disability Adjusted Life Years (DALYs) averted in 2004, where one DALY represents the loss of the equivalent of one year of full health. More detail regarding the methodology around this benefit is provided in Appendix B.

Table 7 below presents the total number of DALYs averted in 2004, disaggregated by WHO mortality-strata subregion. Globally, the elimination of avoidable blindness and visual impairment is expected to result in a wellbeing benefit of **51.5 million (DALYs) averted in 2004**. This figure has been built up from estimates stipulated in the Global Burden of Disease 2004 Update (World Health Organisation, 2004). The causes of blindness and visual impairment are trachoma, glaucoma, cataracts and refractive errors. Whilst the DALYs associated to 'Macular degeneration and other' are presented in the WHO 2004 data, they are not included in the total given that visual impairment caused by macular degeneration is not avoidable.

Combined, the Western Pacific B (WPR B) and the South East Asian Region D (SEAR D) bear over half of the world's DALYs associated to visual impairment, at 58% of the total. Examining each subregion's proportionate share of total DALYs, it is evident that the wellbeing benefit from eliminating avoidable blindness and visual impairment is heavily weighted towards the developing world, accruing **94%** of the total wellbeing benefit.

Table 7: DALYs averted by WHO subregion (2004)

Sub-region	DALYs (000s)	Global DALY share
Afr D	3,074	6.0%
Afr E	3,897	7.6%
Amr A	1,135	2.2%
Amr B	2,243	4.3%
Amr D	409	0.8%
EMR B	1,063	2.1%
EMR D	3,313	6.4%
EUR A	1,456	2.8%
EUR B	876	1.7%
EUR C	975	1.9%
Sear B	2,994	5.8%
Sear D	13,416	26.0%
Wpr A	270	0.5%
Wpr B	16,363	31.7%
Total	51,484	100%

A summary of the total DALYs averted by mortality-strata is detailed in Table 8. The total DALYs averted benefit is observed to be greatest in the mortality-strata B grouping, comprising 46% of the total benefit, which is higher than this region's share of the population which stands at 38%. A similar case exists for the developing counties, whereby the proportionate DALY share is significantly higher than the population share.

Table 8: DALYs averted by WHO mortality strata (2004)

Mortality Stratum	DALYs (000s)	DALY share	Population share
Developed countries	2,861	5.5%	14.0%
Developing countries	48,623	94.3%	86.0%
Total	**51,484**	100%	100%

Sensitivity Analysis

As noted, benefit estimates are based on the most recent unpublished prevalence data which estimate that 223 million people are blind or otherwise visually impaired (Stevens, pers comms, 2013). There is a confidence interval around this estimate, with the actual prevalence expected to be somewhere between 206 million to 261 million. This uncertainty in the prevalence data suggests that the calculated benefits should be treated as indicative and with caution. Uncertainty ranges are larger for individual countries than they are globally.

It should also be noted, however, that whilst the actual dollar estimates are sensitive to the uncertainties associated with current data sources, the overall benefit of eliminating avoidable blindness is likely to remain weighted toward developing counties, irrespective of the prevalence estimate (presuming that the prevalence remains heavily skewed in favour of developing countries – a strong assumption in our opinion). Nonetheless, future research efforts will be well placed to increase the precision of these estimates.

Acknowledging that the prevalence data that underpins the analysis is also subject to uncertainty, a sensitivity analysis was conducted around key assumptions.

Sensitivity around potential income of treated avoidably blind and visually impaired persons

We report the following sensitivity ranges around the productivity benefit:

- **Base case assumption:** persons with avoidable blindness and visual impairment that are treated earn 70% of average income (see option 1)
- **Option 1:** persons with avoidable blindness and visual impairment that are treated earn as per specified in OECD statistics or GDP/capita data for countries not within the OECD (average income)
- **Option 2:** persons with avoidable blindness and visual impairment that are treated earn 63% (Rein et al 2006, see Appendix B) of average income as defined in option 1

The results of the sensitivity analysis provide an upper range of $957.1 billion (using the assumption scenario outlined in option 1) and a lower range of $603.0 billion (using the assumption scenario outlined in option 2) to the productivity benefit to persons treated for avoidably blindness and visual impairment.

Table 9: Sensitivity analysis – Productivity benefit to avoidably blind and visually impaired persons over 10 years (USD billions 2009)

	Low range: Income at 63% of average	Base case: income at 70% of average	High rage: income at regional average
Sensitivity range around potential income	603.0	670.0	957.1

Sensitivity around the number of carers

It is assumed that in developed countries, there exists a ratio of 1 carer per 2 persons affected by avoidable blindness and visual impairment based on Australian data. This increases to 1 carer per person affected by avoidable blindness and visual impairment for countries in WHO sub-regions B through E on an equidistant scale.

In the instance that a common carer ratio for 1 carer per 2 persons affected by avoidable blindness and visual impairment is representative of the picture globally, we have tested this as part of the sensitivity analysis. If there are fewer carers, the productivity benefit due to eliminating avoidable blindness and visual impairment reduces from $43.5 billion over 10 years to $33.5 billion over 10 years.

Table 10: Sensitivity analysis – Productivity benefit to carers over 10 years (USD billions 2009)

	Low range: one carer per two persons affected by avoidable blindness and visual impairment	Base case: carer ranges depending on mortality stratum
Sensitivity range around carer numbers	33.5	43.5

4 Additional social benefits

The health and economic benefits that stem from the elimination of avoidable blindness and visual impairment will have the added impact of producing several social benefits. The following social benefits have been identified:

- Increased primary education
- Reduced extreme poverty
- Increased independence, self-esteem, & improved social networks
- Increased gender equality
- Reduced childhood mortality.

While increased independence, self esteem and improved social networks are benefits that will be realised in all populations, reduced childhood mortality and morbidity, reduced extreme poverty and increased gender equality are considered to be especially pertinent in developing countries. These benefits differ to the health and economic benefits identified in that their quantification is not a straightforward task. In the realm of the social impacts associated to the elimination of avoidable blindness and visual impairment, the literature has been extensive in identifying the correlations, however is limited when it has come to attaching values to these outcomes given the difficulty of doing so.

To allow for an understanding of these benefits, a qualitative analysis for each is provided below as well as comments on how they could potentially be quantified in the future.

Increased primary education

Avoidable blindness and visual impairment may contribute to preventing children from receiving an education, in two ways – those who cannot participate in education because of their avoidable blindness or visual impairment condition and those who cannot participate in education because they are carer for another individual (family member or friend) who suffers from avoidable blindness or visual impairment. Therefore, this emphasises that eliminating avoidable blindness and visual impairment can not only contribute to achieving Millennium Development Goal 2: Achieving Universal Primary Education, it also shows the pecuniary benefit from increasing income due to higher participation in education during childhood.

The WHO reports that 12 million children aged under 15 years are affected by uncorrected refractive error (URE) which can be diagnosed and corrected. However, there is no further disaggregation by age. As such, it is not clear how many years of potential education are lost due to URE. For children aged 14 that are treated in 2011, they have potentially missed up to 9 years of education (depending on when the condition was acquired) that would impact on future potential income. A child with URE aged 10 years that is treated in 2011 may have missed up to 5 years of education and so on. Without the age stratification and age that URE is acquired it is difficult to quantify the impact in monetary terms using a bottom-up approach consistent to the rest of the analysis.

A top down analysis provides an indication of the extent to which productivity may increase if URE in children is eliminated. Smith et al (2009) estimate that in 2007 there was an estimated cost to the global economy of $268.8 billion (international dollars after PPP adjustment) resulting from URE. In the most recent prevalence data, WHO reports that 43% of visual impairment is caused by URE. In addition, it is noted that 12 million children are affected by this condition, comprising 9.8% of the total number of individuals affected by URE. Placing this number in the context of the Smith et al estimate, an economic productivity benefit in the order of $26.3 billion could potentially be gained by treating children aged under 15 for URE. However, this is a proxy only taking a top down approach of their global estimate.

Children who care for other individuals affected by avoidable blindness and visual impairment are accounted for in the productivity benefit associated with carers, where we assume that persons who are no longer carers gain productivity equal to 10% of annual wage (whether it be because they can work more, or even if they are children, or retired as they would gain this in terms of education or leisure time).

Reduced extreme poverty

Globally, the prevalence of blindness is five times higher in poor countries (Resnikoff et al 2004). The eradication of visual impairment will have a positive impact in terms of reduced global poverty, particularly in the developing world, and is aligned to achieving Millennium Development Goal 1: The Eradication of Extreme Poverty and Hunger. Poverty and blindness are believed to be intrinsically linked, with those populations living in extreme poverty being predisposed to visual impairment, and visual impairment exacerbating poverty through reduced employment possibilities. The term poverty must be understood to encompass not only economic measures such as low income and unemployment, but other social and psychological elements. These include access to education and healthcare, limited social interaction, limited marriage prospects and higher exposure to violence and social stigma (Gilbert & Faal, 2005).

Khanna et al (2007) underscore the very cyclical correlation between extreme poverty and visual impairment in India, noting that on one side, vision loss severely impacts people from accessing a means of livelihood and independent living, while on the other hand persons living in poverty are more likely to suffer from conditions that can cause vision loss. Avoidable blindness in particular, is often caused by factors linked to low socio-economic development. For example, poor sanitation and water quality act as a breeding ground for the bacterium causing trachoma, while malnutrition and vitamin A deficiency are also causative factors to visual impairment. Khanna et al (2007) stress that in addressing blindness and poverty together, resources should be directed towards the development of areas most in need.

Kuper et al (2010) undertook a study to analyse whether cataract surgery alleviated poverty in Kenya, the Philippines and Bangladesh. Poverty was measured through household per capita expenditure, asset ownership and self-rated wealth. Results indicated a marked increase in per capita expenditure and self rated wealth, believed to be attributable to those individuals who had undergone the surgery being significantly more likely to participate in productive activities. Kuper et al note that this finding lends empirical support to the cyclical association between blindness and disability.

In their study exploring the association between blindness and deprivation in Pakistan, Gilbert et al (2008) lend additional support. Associations between visual impairment and poverty were measured by a cluster level deprivation index and a household level poverty indicator. Results showed that the prevalence of total blindness was more than three times higher in poor clusters than in affluent clusters, with lower access to eye care services in these poorer clusters observed to be a main contributory factor.

The fact that millions of people in Africa, Latin America and Asia are living in extreme poverty has a serious impact on global visual impairment, with countries such as India and sub-Saharan Africa bearing a largely disproportionate share of the world's blindness. Human resource development is deemed one of the greatest barriers to good eye health in Africa – while it has over 14% of the world's population and at least a quarter of the global burden of disease, Africa has less than 2% of the world's health workforce (VISION 2020, 2010). Development of these areas, particularly in relation to basic health service access including eye care, hygiene and nutrition, is critical to realise the full extent of this social benefit.

Investment in the primary and health care sectors to eliminate avoidable blindness and visual impairment are likely to have flow on benefits to reduce poverty more broadly. The SAFE Strategy is an example where investment spans across the primary and secondary health systems. The first component of the strategy: surgery, falls under secondary care, while antibiotics, facial cleanliness and environmental change are examples of preventative care initiatives and fall under the primary system.

CASE STUDY: SAFE STRATEGY

In 1997, the WHO organised the Alliance for the "Global Elimination of Trachoma by 2020" and recommended the 'SAFE ' strategy as a basic framework for dealing with trachoma. The strategy consists of:

- Surgery
- Antibiotic treatment
- Facial cleanliness
- Environmental change

The SAFE Strategy is currently being implemented in over 30 countries to eliminate the backlog of the disease, and will no doubt play a huge part in reducing future incidence of trachoma through positive changes in sanitation and primary care. (The End in Sight, 2011). The 'E' component of the strategy focuses on improving water supplies to prevent the spread of the disease and ties in with MDG 7: Ensuring environmental sustainability.

There is a body of evidence available that specifically focuses on the benefits of the preventative components of the strategy in low income countries. Ngondi et al (2008) undertook a study testing the impacts of the SAFE strategy in southern Sudanese communities, finding that hygiene and environmental factors were key in protecting against active trachoma. Polack et al (2006) undertook a study examining the relationship between prevalence of active trachoma in children and water availability and use in a Tanzanian village, finding that there was a lower prevalence of trachoma amongst children who regularly used water for personal hygiene. Roba et al (2010) have drawn the same positive correlation, underlining the value of simple preventative measures in low income countries where trachoma is especially rampant.

There is also considerable evidence supporting the surgical and antibiotic elements of the strategy. To reach the subset of people with late stage trachoma who require surgery effectively, a high volume of operations needs to be performed at the community level. Bowman et al (2000) have shown that in the Gambia region, making trichiasis surgery available at the community level has increased acceptance rates from 44% in health centres to 66%. Kuper et al (2003) have carried out a detailed critical review of the SAFE strategy, adding strong support for the efficacy of the surgery and antibiotics components in decreasing the backlog of trichiasis and rapidly reducing the prevalence of trachoma in children.

Morocco is an example where the strategy has been successfully implemented. The Ministry of Health in Morocco has adopted a policy of decentralisation and devolution which have enabled the health service to maximise the resources available for the prevention of trachoma in endemic regions (Chami et al, 2004). It was also the first country to use the mass distribution of azithromycin for antibiotic treatment of the disease.

Aboriginal communities in Australia are an example where limited progress has been made in combating the disease. Taylor (2001) highlights the extent of the issue, particularly given that Australia is the only developed country in which trachoma still exists. Whilst the SAFE strategy has been accepted and implemented by the Federal Government, until recently little has been seen to have changed in comparison to the marked progress observed in developing countries. While Wright (2007) undertook a study examining the impact of the SAFE strategy in two Aboriginal communities, finding that the 'A' and 'F' aspects were found to be statistically significant against the prevalence of trachoma, it is reiterated that the implementation of the strategy in Australia has been less than optimal. It is only much more recently, after the 2009 commitment by the Australian Government, that enhanced activities have begun to result in an appreciable eduction in trachoma prevalence in many outback Aboriginal communities (Adams et al, 2009).

As noted in the benefits framework, developing the primary care sector can impact a far greater range of people, and provide broader benefits than those that may be achieved from restoring the sight of those with avoidable blindness and visual impairment. One study has recognised the importance of the primary sector in relation to diabetic retinopathy, with research showing that early diagnosis and timely treatment can prevent vision loss in more than 90% of patients with diabetes, yet approximately half of all people with diabetic retinopathy are diagnosed at a stage when it is too late for treatment to be effective (Ferris, 1993). The benefits arising from early diagnosis of conditions such as this will have a more profound impact in terms of long term prevention of eye disease and maintenance of general health.

Experts in the field have stressed the need for eye health to be incorporated into general health, commenting that it is too often separated as a splinter group. This is particularly so in low-income countries where health services are scarce, in which case it has been recommended that preventative eye screening be performed at the same time as immunisations and the delivery of other basic health services. As such, a benefit to this investment will be to impact on poverty in a general sense.

Increased independence, self esteem and improved social networks

Loss of sight severely hinders an individual's ability to attend to their day to day activities, leading to a dependence on carers and feelings of incompetency on behalf of the blind individual. Long et al (1996) observed that individuals with visual impairment travelled infrequently by themselves and were dissatisfied with the number of opportunities they had to leave their homes as well as reporting feelings of difficulty using public transport. In their analysis on informal care associated to visual impairment in Australia, Keeffe et al (2009) observed that the most common type of care provided was around transportation, which was used by 78.9% of participants. Assistance on personal affairs, including banking, personal correspondence, and other similar activities was noted to be the second most common type of care utilised. The provision of care in the areas of home help and social activities were the next two most utilised. These findings lend significant support to the benefits of increased independence and improved social networks that would transpire if avoidable blindness and visual impairment was eliminated.

Several studies have documented the association between loss of sight and feelings of loneliness and isolation, which contribute to sentiments of low self-esteem. For example, Nyman et al (2010) produced an extensive review of the psychological impact of visual impairment, with results showing an increased risk of depression and mental illness and reduced quality of life and social functioning compared to sighted individuals. Horowitz (2003) reviewed population based studies, examining the link between depression and visual impairment, finding that visually impaired adults were 2 to 5 times more likely to experiencing depression symptoms compared to their non-impaired peers.

Whilst this benefit is highly important, the path to its quantification is undefined and not adequately framed in monetary values.

Increased gender equality

In a meta-analysis of population based prevalence surveys, Abou-Gareeb et al (2001) found that women account for approximately 64.5% of all blind people. While this disparity is consistent across women in both industrialised and developing regions, the association between blindness and gender disparities is more prominent in developing countries. Eliminating avoidable blindness and visual impairment will therefore play a positive contribution in terms of striving to achieve Millennium Development Goal 3: Promoting Gender Equality.

A primary contributing factor to women bearing a greater proportion of the blindness burden in developing regions is their role as the primary caretaker, looking after children who have a higher predisposition to infectious causes of vision loss such as trachoma. In their study analysing the risk of active trachoma in Tanzanian Women, Congdon et al (1993) observed that prevalence of active trachoma in women increased with the total number of young children cared for, and with the number of infected children cared for. Courtright et al (2004) and Cromwell et al (2009) have documented similar results in their analysis of available evidence on women and their share of the global trachoma burden. A review of prevalence based studies indicated statistically significant increased odds of trachomatous trichiasis in women in 17 out of 24 included studies in the developing world (Cromwell et al 2009).

Women are also less likely to receive eye correcting surgery compared to men in developing regions. Nirmalan et al (2003) documented the inequalities when it came to receiving cataract surgery in India, finding that despite the cataract blindness burden being higher amongst women, they were less likely to receive surgery. A study undertaken by Lewallen and Courtright substantiates this correlation, finding cataract surgical coverage rates 1.2-1.7 times higher for males than for females in their review of coverage rates in developing countries. Lower access to surgery amongst women in these regions may be due to less disposable income and control of finances and a lower likelihood of travelling outside their village to a hospital due to their role as primary caregiver.

A study undertaken by the Nepal Gender and Eye Health Group underlines the existence of a gender gap, noting that the utilisation of eye care services by women is disproportionately low in Nepalese study group. It was also found that less than 15 percent of the total service users in the study were children, despite children constituting 40% of Nepal's population, indicating an even more prominent gap amongst children.

Women are often subjected to gender discrimination in the developing world, which is exacerbated with the presence of a disability such as blindness. This is a major contributory factor in terms of women having less access to basic health care services and eye correcting surgery, while also placing them in a disadvantaged position in terms of caring for themselves and their family.

Reduced childhood mortality and morbidity

This benefit will be realised primarily in developing countries. Although there are other factors that interplay in child mortality and morbidity, Gilbert & Foster (2001) have explicitly highlighted the correlation between socioeconomic development and under 5 years mortality rates and childhood blindness, remarking an estimated prevalence of 0.3/1000 children in high income countries, compared to 1.5/1000 children in low income countries with a high under 5 years mortality rate.

In a study undertaken by Kello & Gilbert (2003), it was found that 68% of children in the sample had severe VI as a result of potentially avoidable causes. The two primary preventable causes were identified as Vitamin A Deficiency (VAD) and measles. These findings are consistent across the developing world, with VAD being the leading cause of avoidable blindness in children. There are an estimated 250 000 to 500 000 vitamin A-deficient children who become blind every year, half of them dying within 12 months of losing their sight (WHO). VAD is further known to greatly increase the risk of severe illness and death from common childhood infections such as diarrhoea and measles, making it a critical global public health issue, especially in low income regions such as Africa and South-East Asia.

This benefit was not quantified independently as it is encompassed in the total 'DALYs averted' benefit. The GBD study DALY estimates incorporate the prevalence of visual impairment across ages 0 to over 80 years. Given that it is outlined in the GBD study that the total DALYs are derived from Years of Life Lost due to Disability (YLD) and Years of Life Lost due to premature mortality (YLL), it is expected that both childhood morbidity and mortality are both accurately included in these totals.

We have intentionally avoided placing a monetary value on this benefit due to contention in the academic field around doing so and identifying an appropriate value of statistical life for each region. Further, there is likely to an element of double counting with other benefits where a monetarised value is reported.

5 Lessons from this quantification exercise

Comparisons to other studies

As noted, many studies analyse blindness or visual impairment and its implications, however they do not have a common scope to this analysis in terms of geography, cause, or impact. Where this analysis has a global scope, estimating the value of the benefit from eliminating all causes of avoidable blindness and visual impairment, other studies tend to be limited in their geographic scope, for example, focusing on one country, analysing a limited age range, or focusing on one (or few) causes of blindness and visual impairment.

In addition, the difference between estimates generated in a number of other studies (such as Taylor et al 2006, Gordon et al 2011 and Roberts et al 2010) and this analysis can be attributed to the fact that this series of analyses examines benefits attributable to the additional investment required to eliminate avoidable blindness and visual impairment, rather than the total economic cost associated to blindness and visual impairment.

As such, there is a limit to the extent to which a comparison can be made with previous research. However, in many instances we have drawn on the methodologies outlined in previous research with the purpose to extend them to a global scale, or to apply them to more than one condition where appropriate.

Data gaps and limitations

A number of lessons have been learned during this quantification exercise and some key data limitations have been exposed. A better understanding of the level of employment and the average income in the avoidable blind and visually impaired population would also be beneficial for further analyses. At present the assumptions applied here have been drawn from research focusing on developed countries. The quantification would be enhanced with more data that is specific to developing countries.

As the impact of avoidable blindness and visual impairment extends beyond the individuals with the conditions, for example to carers, it is important to explore these implications. At present, there is some understanding of the extent to which blind persons in developed countries (based on Australian data) use carers. Equivalent data for developing countries is, to our knowledge, not available. Further, the extent to which care giving takes away from productive or leisure time falls under a broad assumption in this analysis. It would be ideal to understand the age distribution of carers and the corresponding impact on their lives. For example data on the number of carers who are of school age and would otherwise be engaging in education and data on the number of carers at retirement age who would otherwise engage in leisure time is desirable.

There is limited data on the incidence and impact of falls in both developed but especially in developing countries. As falls are an important co-morbidity for avoidable blindness and visual impairment, especially for those older individuals affected by these conditions it is of key importance to understand to what extent this impacts across different countries and the implications to the individual and the cost to the health system.

Additional relevant literature or data on the extent of welfare payments in developing countries and on the potential multiplier effect will enhance further research on the extent to which benefits are attained from the elimination of avoidable blindness and visual impairment.

Appendices

Appendix A	References and key guiding research	27
Appendix B	Economic and health benefits – Detailed methodology	34
Appendix C	Regions	41
Appendix D	Case Studies: Australia and India	44

Appendix A References and key guiding research

Abou-Gareeb I., Lewallen S., Bassett Kl & Courtright P. 2001, Gender and Blindness: A meta-analysis of population-based prevalence surveys, Opthalmological Epidemiology (8): 39-56.

Access Economics, 2010, The Global Cost of Visual Impairment, available at: http://www.amdalliance.org/user_files/documents/Global%20cost%20of%20VI_FINAL%20report.pdf, accessed 10 July 2012

Access Economics, 2009, The economic impact of visual impairment in the UK adult population.

Australian Bureau of Statistics (ABS), 2009, Survey of Disability, Ageing and Carers, available at: http://www.abs.gov.au/ausstats/abs@.nsf/e8ae5488b598839cca25682000131612/c258c88a7aa5a87eca2568a9001393e8!OpenDocument, accessed 10 July 2012.

Bowland, B, Beghin, J, 1998, Robust estimates of value of a statistical life for developing economies: an application to pollution and mortality in Santiago,

Congdon N., West S., Vitale S., Katala S. & Mmbaga BOO. 1993, Exposure to Children and Risk of Active Trachoma in Tanzanian Women. *American Journal of Epidemiology,* 137(3): 366–72.

Courtright P. & West S. 2004, Contribution of sex-linked biology and gender roles to disparities with trachoma, *Emerging Infectious Diseases*, 10(11): 2012-2016.

Courtright P. & Lewallen S. 2007, Improving gender equity in eye care: advocating for the needs of women, Community Eye Health Journal, 20(64): 68-69.

Courtright P., Basset K., Lewallen S. & Abou-Gareeb I. 2001, Gender and blindness: a meta-analysis of population-based prevalence surveys, Ophthalmic Epidemiology, Feb; 8(1): 39-56.

Cromwell EA., Courtright P., King JD., Rotondo LA., Ngondi J. & Emerson PM. 2009, The excess burden of trachomatous trichiasis in women: a systematic review and meta analysis, Transactions of the Royal Society of Tropical Medicine and Hygiene, Oct; 103(10): 895-892.

Cruess AF, Zlateva G, Xu X et al., 2008, Economic burden of bilateral neovascular age-related macular degeneration: multi-country observational study, PharmacoEconomics, 26(1)

Dandona, L, Dandona, R, Srinivas, M et al, 2001, Blindness in the Indian State of Andhra Pradesh, Investigative Ophthalmology and Visual Science, 42(5)

Forward, H, Hewitt, A, Mackey, D, 2012, Missing X and Y: a review of participant ages in population-based eye studies, Clinical and Experimental Ophthalmology, 40: 305-319.

Frick KD., Gower EW., Kempen JH. & Wolff JK. 2007, Economic Impact of Visual Impairment and Blindness in the United States, Archives of Ophthalmology, 125(4): 544-550.

Gilbert E., Shah SP., Jadoon MZ., Bourne R., Dineen B., Khan MA., Johnson GJ. & Khan MD. 2008, Poverty and Blindness in Pakistan: Results from the Pakistan National Blindness and Visual Impairment Survey, British Medical Journal, 336: 29-32.

Gilbert C. & Faal H. 2007, 'Convincing governments to act: Vision2020 and the Millennium Development Goals', Community Eye Health Journal, December, 20(64): 62-64.

Gilbert, C, Foster, A, 2001, Blindness in children: control priorities and research opportunities, British Journal of Ophthalmology, 85:1025-1027

Gordois A., Cutler H., Pezzullo L., Gordon K., Cruess A., Winyard S., Hamilton W. & Chua 2011, An estimation of the worldwide economic and health burden of visual impairment, Global Public Health: An international journal for research, policy and practice, 1-17.

Gordon, K, Cruess, A et al, 2011, The cost of vision loss in Canada, Canadian Journal of Ophthalmology, 46(4)

Horowitz A. 2003, Depression and vision and hearing impairments in later life, Generations, 27(1): 32-38.

Household, Income and Labour Dynamics Survey, 2005

International Labour Organisation Unemployment Statistics, available at: http://www.ilo.org/global/statistics-and-databases/lang--en/index.htm, accessed 1 July 2012.

Kello, A, Gilbert, C, 2003, Causes of severe visual impairment and blindness in children in schools for the blind in Ethiopia, British Journal of Ophthalmology, 87: 526-530

Keeffe K., Chou SL. & Lamoureaux EL. 2009, 'The Cost of Care for People with Impaired Vision in Australia', Archives of Ophthalmology, 127(10) pp. 1377-1381.

Khanna, R, Raman, U, Rao, G, 2007, Blindness and poverty in India: the way forward, Clin Exp Optom, 90 (6)

Long RG., Boyette, LW. & Griffin-Shirley N. 1996, Older Persons and Community Travel: the effect of visual impairment, Journal of Visual Impairment and Blindness, 90: 302-313.

Miller, t, 2000, Variations between countries in values of statistical life, 2000, Journal of Transport Economics and Policy, 34,2

OECD Average Annual Wage Statistics, 2009, available at: http://stats.oecd.org/Index.aspx?QueryId=25148, accessed 10 July 2012.

Pascolini, D, Mariotti, S, 2011, Global estimates of visual impairment, British Journal of Ophthalmology

PwC and Three Rivers Consulting, 2011, The Price of Sight: the global cost of eliminating avoidable blindness, available at: http://www.hollows.org.au/our-work/the-price-of-sight

PwC, 2012, A benefits framework for eliminating avoidable blindness and visual impairment, available at: http://www.hollows.org.au/our-work/the-price-of-sight

Rein, D, Zhang, P, Wirth, K et al, 2006, The Economic Burden of Major Adult Visual Disorders in the United States, Archives Ophthalmology, 124.

Resnikoff S. & Pararajasefaram R. 2001, 'Blindness prevention programmes: past, present, and future', Policy and Practice, Bulletin of the World Health Organization, 79 (3): 222-226.

Resnikoff, S, Pascolini, D, Mariotti, SP et al, 2004, Global data on visual impairment in the year 2002, Bulletin WHO, 82

Roberts, C et al, 2010, Economic cost of visual impairment in Japan, Archives of Ophthalmology, 128(6)

Shamanna, BR, Dandona, L, Rao, GN, 1998, Economic burden of blindness in India, Community Eye Care, 46(3)

Smith TST., Frick K., Holden BA., Fricke TR. & Naidoo KS. 2009, 'Potential lost productivity resulting from the global burden of uncorrected refractive error', Bulletin of the World Health Organisation, 87: 431-437.

Stevens, G. Personal communication, on behalf of the Global Burden of Disease Vision Loss Expert Group, 2013.

Taylor, H, Pezzullo, M, Keeffe, J, 2006, The economic impact and cost of visual impairment in Australia, British Journal of Ophthalmology, 90

Tseng, V, Yu, F, Lum, F, Coleman, A, 2012, Risk fractures following cataract surgery in medicare beneficiaries, JAMA, 308 (5)

Venkata, G, Murthy, S, Gupta, S et al, 2005, Current estimates of blindness in India, British Journal of Ophthalmology, 89

Vision 2020 Australia, 2005, Eliminating Avoidable Blindness in the South-East Asia and Pacific Region- Submission to the Parliamentary Secretary for Foreign Affairs and Trade.

World Development Indicators, 2009, available at: http://data.worldbank.org/data-catalog/world-development-indicators, accessed 10 July 2012.

World Health Organisation, 2004, Global Burden of Disease Update

Other resources

Access Economics 2004, Clear Insight: The Economic Impact and Cost of Vision Loss in Australia, as published at www.cera.org.au Accessed 1 November 2011.

Access Economics 2006, Centrally Focussed: The Impact of Age-Related macular Degeneration, as published at www.cera.org.au. Accessed 1 November 2011.

Adams KS., Burgess JA., Dharmage SC. & Taylor H. 2009, Trachoma surveillance annual report, as published on www.health.gov.au, accessed 16 November 2011.

Aldy J. E. & Viscusi W.K. 2007, Age differences in the Value of Statistical Life, Resources for the Future.

Baltussen R., Sylla M., Mariotti SP. 2004, Cost-effectiveness Analysis of Cataract Surgery: A Global and Regional Analysis, Bulletin of the World Health Organization, 82(5): 338-45.

Boer MR., Pluijm SMF., Lips P., Moll AM., Volker-dieben HJ. Deeg DJH. & van Rens GHMB. 2004, Different aspects of visual impairment as risk factors for falls and fractures in older men and women, Journal of Bone and Mineral Research, 19(9): 1539-1547.

Bowman RJC., Soma OS., Alexander N., Milligan P., Rowley J., Faal H., Foster A., Bailey RL & Johnson GJ. 2000, ‘Should Trichiasis Surgery be offered in the village? A Community Randomized Trial of Village vs. Health Center-Based Surgery’, Tropical Medicine & International Health, 5: 528–33.

Brown MM., Brown GC., Sharma S., Busbee B. & Brown H. 2001, Quality of Life Associated with Visual Loss, American Academy of Ophthalmology, 108: 643-648.

Casten R. & Rovner B. 2008, Depression in Age-Related Macular Degeneration, Journal of Visual Impairment & Blindness, 102(10): 591-601.

Chami Y., Hammou J. & Mahjour J. 2004, Lessons from the Moroccan National Trachoma Control Programme, Community Eye Health Journal, 17(52): 59.

Coleman AL., Stone K., Ewing SK., Nevitt M., Cummings S., Cauley JA., Ensrud KE., Harris EL., Hochverg MC., Mangione CM. 2004, Higher risk of multiple falls among elderly women who lose visual acuity, American Academy of Ophthalmology, 111(5): 857-862.

Courtright, P. 2002, Gender and Blindness, World Health Organisation, as published at www.emr.who.int, accessed 1 October 2011.

Cruess A., Gordon KD., Bellan L., Mitchell S. & Pezzullo ML. 2011, 'The cost of vision loss in Canada. 2. Results, Canadian Journal of Ophthalmology, 46(4) pp. 315-318.

Emerson PM., Lindsay SW., Walraven GE., Faal H., Bogh C., Lowe K. & Bailey LR. 1999, Effect of Fly Control on Trachoma and Diarrhoea, The Lancet Infectious Diseases, 353: 1401–1403.

Evans JR., Fletcher AE., Wormald RP. 2007, Depression and Anxiety in Visually Impaired Older People, American Academy of Ophthalmology, 114(2): 283-286.

Faal H. & Gilbert C. 2007, Convincing Governments to Act: VISION 2020 and the Millennium Development Goals, Community Eye Health Journal, Dec; 20 (64): 57-59.

Ferris FL. 1993, 'How Effective Are Treatments for Diabetic Retinopathy?' Journal of the American Medical Association, 269(10): 1290-1291.

Frick KD., Foster A., Bah M. & Faal H. 2005, Analysis of the Costs and Benefits of the Gambian Eye Care Program, Archives of Ophthalmology, 123(1): 239-243.

Frick KD. & Foster A. 2003. 'The Magnitude and Cost of Global Blindness: An Increasing Problem that can be Alleviated', American Journal of Ophthalmology, 135(4): 471-476.

Frick KD., Hanson CL. & Jacobson GA. 2003, Global Burden of Trachoma and Economics of the Disease, American Journal of Tropical Medicine and Hygiene, 69(5 Suppl): 1:10.24.

Frick KD., Keuffel DL. & Bowman RJC 2001, 'Epidemiological, demographic, and economic analyses: Measurement of the value of trichiasis surgery in The Gambia', Ophthalmic Epidemiology 8(2-3): 191-201.

Gaebler S. 1993, Predicting Which Patient Will Fall Again...and Again, Journal of Advanced Nursing, Dec; 18(12): 1895-1902.

Goldzweig CL., Rowe S., Wenger N., MacLean CH. & Shekelle PG. 2004, Preventing and Managing Visual Disability in Primary Care, Journal of the American Medical Association, 291(12): 1497-1502.

Gordon KD., Cruess AF., Bellan L., Mitchell S. & Pezzullo L. 2011, 'The cost of vision loss in Canada 1. Methodology', Canadian Journal of Opthalmology, 46(4): pp. 310-314.

International Coalition for Trachoma Control, 2011, The End in Sight, as published at: www.iehu.unimelb.edu.au, accessed 16 November 2011.

Javitt JC. 1993, The Cost-Effectiveness of Restoring Sight, Archives of Ophthalmology 111(12): 1615.

Keefe JE., Lezzullo L., Nesbitt S. & Taylor H. 2005, The Costs of Low Vision and Blindness: Preventing Vision Loss Can Save Governments Money', Cataract and Refractive Surgery Today, October edition: 44-46.

Kuang TM., Tsai SY., Hsu WM., Cheng CY., Liu JH et al. 2008, Visual Impairment and Falls in the Elderly: The Shihpai Eye Study, Journal of Chinese Medical Association, 71(9) 467-472.

Kuper H., Polack S., Mathenge W., Eusebio C., Wadud Z., Rashid M. & Foster A. 2010, Does Cataract Surgery Alleviate Poverty? Evidence from a multi-centre intervention study conducted in Kenya, the Philippines and Bangladesh, Public Library of Science, 5 (11).

Kuper H., Solomon AW, Buchan J., Zondervan M., Foster, A. & Mabey D., 2003, A Critical Review of the SAFE Strategy for Prevention of Blinding Trachoma, The Lancet Infectious Diseases, 3: 372–81.

Kallstrand-Ericson J. & Hildingh C. 2009, Visual impairment and falls: A register study, Journal of Clinical Nursing, 18(3): 366-372.

Levine R 2007, Controlling onchocerciasis (river blindness) in sub-Saharan Africa. Case studies in global health: Millions saved, as published at http://www.cgdev.org/doc/millions/MS_case_7.pdf, accessed 25 October, 2011

Lewallen S. & Courtright P., 2002, Gender and Use of Cataract Surgical Services in Developing Countries, Bulletin of the World Health Organisation, 80(4): 300-303.

Lewallen D., Mousa A., Bassett K. & Courtright P. 2008, Cataract surgical coverage remains lower in females, British Journal of Ophthalmology, 93(3): 295-298.

Lopez, AD, Mathers, C, Murray, C et al, 2006, Global Burden of Disease and Risk Factors

Mecaskey JW., Knirsch CA., Kumaresan J. & Cook JA. 2003, The Possibility of Eliminating Blinding Trachoma, The Lancet Infectious Diseases, 3: 728-734.

Miller M. & Weaver Moore L. 2003, Older Men's Experience of Living with Severe Visual Impairment, Journal of Advanced Nursing, 43(1): 10-18.

Naidoo K., 2007, Poverty and Blindness in Africa, Clinical and Experimental Optometry, 90(6): 415-421.

Nepal Gender and Eye Health Group, 2010, Policy Brief: Gender Equity in Health: Lessons from Eye Care, April.

Neyal J., Ammary-Risch MPH., Suber S. et al, 2011, The Primary Care Physician's Role in Preventing Blindness in Patients with Diabetes, Journal of the National Medical Association, 103(3)

Ngondi, J., Matthews F., Reacher M., Baba S., Brayne C. & Emerson P. 2008, Associations between active trachoma and community intervention with antibiotics, facial cleanliness, and environmental improvement (A, F, E), PLoS Neglected Tropical Diseases 2(4).

Nyman SR., Gosney MA., Victor CR. 2010, Psychosocial Impact of Visual Impairment in Working Age Adults, British Journal of Ophthalmology, 94: 1427-1431.

Odom JV., Odom CV. & Leys MJ. 2011, Does Improving Vision Reduce the Risk of Falls? A Review, Insight: Research and Practice in Visual Impairment and Blindness, (2)

Patino CM., McKean-Cowdin R., Azen SP., Allison JC., Choudhury F. & Varma R. 2010, Central and Peripheral Visual Impairment and the Risk of Falls and Falls with Injury, the American Academy of Ophthalmology, 117(2): 199-206.

Polack S., Kuper H., Solomon AW., Massae PA., Abuelo C., Cameron E., Valdmanis V., Mahande., Foster A. & Mabey D. 2006, The relationship between prevalence of active trachoma, water availability and its use in a Tanzanian village, Transactions of the Royal Society of Tropical Medicine and Hygiene, 100(11): 1075-1083.

Polack, S, Brooker, S, Kuper, H, 2005, Mapping the global distribution of trachoma, Bulletin of the World Health Organisation, 83:913-919.

Roba AA., Wondimu A., Patel D. & Zondervan M. 2010, Effects of intervention with the SAFE strategy on trachoma across Ethiopia, Journal of Epidemiological Community Health, 65: 626-631.

Rog M., Swenor B., Cajas-Monson LC., Mchiwe W., Kiboko S., Mkocha H. & West S. 2011, A cross-sectional survey of water and clean faces in trachoma endemic countries in Tanzania, BMC Public Health, 11: 495.

Rovner BW. & Ganguli M. 1998, Depression and Disability Associated with Impaired Vision: the MoVies Project, Journal of the American Geriatrics Society, 46: 617-619.

Smith AF. & Smith JG. 1996, The Economic Burden of Global Blindness: a price too high, British Journal of Ophthalmology, 80(4): 276-277.

Sogbesan E. & Yutho U. 2000, Cambodia's National Eye Care Programme and VISION 2020: The Right to Sight, Community Eye Health, 13(36): 57-59.

Taylor HR., Pezzullo ML. & Keeffe J.E. 2006, The Economic Impact and Cost of Visual Impairment in Australia, British Journal of Ophthalmology, 90: 272-275.

Taylor HR. 2001, Australia is the only developed country in the world where blinding trachoma still exists, The Medical Journal of Australia, 175: 371-372.

Varma R., Lee PP., Goldberg I. & Kotak S. 2011, An Assessment of Health and Economic Burdens of Glaucoma, American Journal of Opthalmology, 152: 515-522.

Weale M. 2011, A Cost-Benefit Analysis of Cataract Surgery Based on the English Longitudinal Survey of Ageing, Journal of Health Economics, 30(4): 730-739.

World Health Organisation 1997, 'Vision 2020 Report: Global Initiative for the Elimination of Avoidable Blindness', as published on the WHO website.

World Health Organisation 2002, Success in Africa: The Onchocerciasis Control Programme in West Africa 1974-2002 as published on the WHO website.

World Health Organisation, 2009, World Sight Day Report: gender and eye health, equal access to care, as published on WHO website.

Wright HR. 2008, Trachoma in Australia: an evaluation of the SAFE strategy and the barriers to its implementation, Department of Ophthalmology, The University of Melbourne, as published at dtl.unimelb.edu.au, accessed 10 November 2011.

Key guiding research

While a wide range of literature was referred to for an all-inclusive backdrop to inform this analysis, there were several key sources which were consistently referred in the methodology appropriated for this quantification. These are detailed in Table 11 below:

Table 11: Key Sources

Source	Overview	Key elements appropriated
Gordois, A, Cutler, H, Pezzullo, L et al, 2011	This study provides an estimate of the worldwide costs of visual impairment and the associated health burden, using a prevalence based model. Methodology and results detailed in this study are consistent with the Access Economics Report: Global Economic Cost of Visual Impairment (2010).	• The proportions in which the prevalence data is disaggregated by WHO mortality-strata subregions are applied against the prevalence data specified by Pascolini & Mariotti 2011. • Blindness and visual impairment prevalence growth rates (across WHO mortality-strata subregions) from 2010 to 2020 are used as the basis for the calculation of the annual incremental incidence able to be treated, and the associated benefit. • The weighting methodology (based on GDP/capita) outlined in the calculation of direct health costs was applied to calculate the direct benefit associated to falls averted.
Stevens, G. Personal communication, on behalf of the Global Burden of Disease Vision Loss Expert	Revised data are lower than the previously as calculations are based on the WHO's estimates of declining trends in visual impairment and blindness and a large portion of the difference stems from the newer reduced	• This study is the key source of the prevalence data used to quantify benefits.

Source	Overview	Key elements appropriated
Group, 2013	estimate of visual impairment in China. New data were attained from Stevens, personal communications in 2013. Previous data is from WHO 2010.	
Gordon, K, Crues, A, Bellan, L, 2011	This study outlines the methodology and results in the estimation of the burden of vision loss in Canada. The total cost was broken down into the loss of well-being, direct health costs, productivity losses including employment participation and absenteeism, dead weight losses and cost of care.	• The methodology surrounding productivity losses and loss of wellbeing in the form of DALYs was incorporated into our model. • The key assumption appropriated here was that the employment rate in the blind and visually impaired population is 32% which was critical in determining the 'employment gap' to which the productivity benefit was quantified.
Shamanna, BR, Dandona, L, 1998	This paper estimates the economic burden of blindness in India.	The following assumptions were appropriated in our benefits quantification: 1. The average number of working years lost due to adult blindness is 10 years. 2. 10% of the productive time of one economically productive member of the family of each blind person is lost in taking care of the dependent blind.
Cruess, A, Zlateva, G et al, 2008	This study documents the economic burden of bilateral neovascular age-related macular degeneration. It is a cross sectional observational study of 401 patients in Canada, France, Germany, Spain and the UK.	Our assumption of the estimated falls costs per blind and visually impaired person is built from the average annual falls costs per patient across the five countries documented in this study.
Tseng, V, Yu, F et al, 2012	This study determines the association of cataract surgery with subsequent fracture risk in US Medicare beneficiaries with diagnosis of cataract.	This recent study was used to validate the findings in the study by Cruess et al, 2008. Tseng et al 2012 found that the fracture incidence in the sample population (over 1 million) was 5.4%. This was aligned with the prevalence of falls-related fractures in the Cruess et al study, which ranged from 1.3% in the UK to 7.9% in Spain.

Appendix B Economic and health benefits – Detailed methodology

Economic benefits – Detailed methodology

The following economic benefits have been quantified in this initial benefits quantification:

- The productivity benefit for those persons with avoidable blindness and visual impairment
- The productivity benefit for carers of those persons with avoidable blindness and visual impairment
- The dead weight loss value per person with avoidable blindness and visual impairment.

Productivity benefit to the avoidable blind and visually impaired

The value of benefit arises from those avoidably blind and visually impaired persons who were not previously working due to their condition, returning to employment.

Key data

There were several key data elements used for the calculation of increased employment in this group. These are detailed in Table 12 below, along with the respective sources.

Table 12: Data elements required to calculate increased employment in the avoidably blind and visually impaired

Input	Data Source(s) and comments
Unemployment Rate	International Labor Organisation: This database draws on a number of sources, primarily labour surveys across the world. Rates were taken from 2008 where available; however in some cases, the latest available unemployment rate dated back to 1999.
Participation Rate	World Development Index, 2006-2009
Average annual wage	70% of average annual salary (based on Rein et al 2006) For OECD countries, this data was obtained from OECD statistics (USD 2009). For other countries, no reliable data was found and thus GDP/capita was used as a proxy. GDP per capita data was sourced from World Bank 2009 Indicators.
Inflation rate	World Bank 2009 Indicators
Annual mortality rate	Calculated based on Crude Death Weights, sourced from World Bank Indicators 2009

Key assumptions

The total productivity benefit realised by the avoidably blind and visually impaired draws on the following assumption:

1 The employment rate in the avoidably blind and visually impaired population: This was assumed to be 32% globally, taken from Gordon et al 2011. This is about 50% of the national employment rate for Canada. Applying this employment rate in the blind and visually impaired group against the average employment rate across each WHO mortality strata subregion, the average employment gaps in the developed and developing worlds were very similar, at 26% and 28% respectively. Given that this assumption was based on the Canadian population, sensitivity analysis has been applied, recognising that

the employment rate in the avoidably blind and visually impaired population may be lower in the developing world.

Approach

It was assumed that in the absence of avoidable blindness and visual impairment, individuals would be employed at the same rate as the national average (Roberts et al, 2010). Based on this, the average 'employment gap' was calculated for each WHO mortality-strata subregion. The employment gap represents the difference between the assumed employment rate in the blind and visually impaired population of 32% and the average sub-regional employment rate. As mentioned above, the average employment gaps for the developed and developing world were calculated to be 26% and 28% respectively. The productivity benefit was then calculated based on this differential.

As explained in above, depending on the cause of avoidable blindness or visual impairment, a 'lifetime' or a 'prevalence' approach has been assumed. The lifetime benefit has been assumed as the value of ten productive years, based on Shamanna et al (1998), who assume that the average number of working years lost due to adult blindness is ten years. For avoidable blindness and visual impairment caused by URE and cataract, a 'lifetime' benefit is quantified, whilst for all other causes an annual benefit has been quantified (the prevalence approach). The sum comprises the total productivity benefit accrued to avoidably blind and visually impaired persons.

It is recognised that avoidably blind persons may earn less after treatment compared to visually impaired persons, and thus a weighting approach to the productivity benefit was discussed in the review process. In their study on the Economic Burden of Major Adult Visual Disorders in the United States, Rein et al (2006) analysed the earnings differential between these two groups, finding that visually impaired persons earned on average 10% more than their blind counterparts. Based on this finding, the differential was assumed not to be significant and thus no weightings were assigned in this analysis.

Sensitivity analysis

The productivity benefit is the principal driver of the total benefit of eliminating avoidable blindness and visual impairment globally and draws on the assumed employment rate in the avoidably blind and visually impaired population (as detailed above).

Sensitivity around potential income of treated avoidably blind and visually impaired persons

It is acknowledged that the estimated 32% employment rate in visually impaired persons in Gordon et al's 2011 Canadian study may not reflect the employment rate in this group in the developing world.

It is recognised that blindness is likely to have detrimental consequences for children and young adults in terms of educational and employment opportunities (Forward et al, 2012). Upon the restoration of sight, it is assumed that those persons who were previously avoidably blind or visually impaired are less likely to secure a well paid job based on a likely lower standard of education and/or less work experience. However, there may be instances where some persons treated from avoidable blindness and visual impairment are able to earn an average income. In others, it may be that earnings are substantially lower.

For these reasons, we have conducted a sensitivity analysis around the average yearly earnings. The sensitivity analysis is drawn from the Rein et al (2006) analysis of average annual earnings in the blind and visually impaired. It is estimated that:

- the average annual earnings of the visually impaired are 70% of a person with normal vision
- the average annual earnings of the blind are 63% of a person with normal vision

As such, we report the following sensitivity ranges around the productivity benefit:

- **Option 1:** persons with avoidable blindness and visual impairment that are treated earn as per specified in OECD statistics or GDP/capita data for countries not within the OECD

- **Option 2:** persons with avoidable blindness and visual impairment that are treated earn 70% of average income (as in option 1)
- **Option 3:** persons with avoidable blindness and visual impairment that are treated earn 63% of average income (as in option 1)

Productivity benefit to carers

If avoidable blindness and visual impairment were eliminated globally, a benefit would result in terms of the lost earnings averted from informal care giving.

Key assumptions

In order to determine the value of the productivity benefit realised by carers to persons with avoidable blindness and visual impairment, the following key assumptions were made:

1. All carers are at a productive loss, regardless of age: It has been assumed that all carers, including children and older persons who no longer of working age, would experience a productivity loss caring for avoidable blind and visually impaired persons. For children, education and leisure time is sacrificed and for those carers not of working age, leisure time and wellbeing is still being sacrificed in caring. Both of these opportunity costs are assumed to have the same value as productive working time. This assumption is consistent with the opportunity cost methodology followed in the Global Economic Cost of Visual Impairment study by Access Economics (2011) to calculate the cost of informal care. In this analysis, it is assumed that time spent providing informal care could alternatively be used in education, the paid workforce or in leisure activities, where the value of each is equal.

2. The amount of time in a carer's annual lost productivity is either 5% or 10% of total annual productivity: This assumption has been made based on a study by Shamanna et al (1998), in which it was assumed that 10% of the productive time of one economically productive member of the family of each blind person is lost in taking care of the dependent blind. In a later study, Smith et al. (2009) also used these assumptions. 10% has been assumed for all WHO regions which are categorised as 'developing', ie if they are defined as sitting within mortality strata B through to E. In Australia's Household, Income and Labour Dynamics survey, it was also found that annual gross household income for carers was 15% less on average when compared with non-carers (HILDA 2005). Based on this literature, we have taken a conservative approach for developed regions, that is, those with mortality stratum A, and have assumed that the productivity loss associated with informal caring is 5% of total productivity.

3. The total number of carers ranges between 0.5-1 carers per blind person: Depending on the WHO mortality-strata sub region, the number of carers is assumed to vary. This assumption draws from the results of the Survey of Disability, Ageing and Carers (SDAC), conducted by the Australian Bureau of Statistics in 2009. The primary objective of the survey was to collect information about three population groups: people with disability, older people, people who provide assistance to older people and people with disability.

Specifically we have examined the number of people who have listed eye disorders (retinal disorders, glaucoma, sight loss, other diseases of the eye and adnexa) as a main condition, and that fall into the following two groups:

- Has disability and profoundly limited in core activities
- Has disability and is severely limited in core activities.

Half of the people in these groups reported having at least one carer. For this analysis, we assume that people who have listed eye disorders as a main condition and who are also profoundly or severely limited in core activities are blind. Based on this, it can be assumed that in Australia and other developed countries, a productivity benefit accrues to one carer for every second blind person.

For other regions, we have assumed the following number of carers needed per blind person:

- Mortality strata A regions – 0.5

- Mortality strata B regions – 0.67
- Mortality strata C regions – 0.83
- Mortality strata D/E regions – 1.

The carer ratio for the regions within mortality strata D/E is drawn from an assumption that there are less care services available in developing countries than in developed countries.

The carer ratios for mortality strata B and C were selected on the basis of equidistance between 1 and 0.5 carers. It is important to note that the number of carers refers to the number for avoidably blind persons.

Approach

The calculation of the productivity benefit realised by carers is broken down by cause of blindness and visual impairment, similarly to the benefit accruing to the blind and visually impaired.

Sensitivity analysis

It is assumed that in developed countries, there exists a ratio of 1 carer per 2 persons affected by avoidable blindness and visual impairment based on Australia data. This increases to 1 carer per person affected by avoidable blindness and visual impairment for countries in WHO sub-regions B through E on an equidistant scale.

In the instance that a common carer ratio for 1 carer per 2 persons affected by avoidable blindness and visual impairment is representative of the picture globally, we have tested this as part of the sensitivity analysis. The logic that backs our current assumption is that there are likely to be less care services available for persons affected by blindness and visual impairment, hence a larger number of informal carers will be necessary to assist with day to day activities.

Deadweight loss averted to the avoidably blind and visually impaired

The concept of a deadweight loss (DWL) cost tied to avoidable blindness and visual impairment stems from the fact that additional tax revenue must be raised by government to fund the associated direct health costs.

Approach

To estimate the global benefit of DWL averted, we have followed the methodology outlined in the global Access Economics 2011 report which multiplies three variables:

- Total health care system cost of visual impairment
- The proportion of health care system costs funded by government (the WHO indicator of ‘general government expenditure on health as a percentage of all health expenditure’ is used as a proxy). This assumes that government expenditure on vision loss is proportionate to government spending on all other diseases
- The Marginal Cost of Public Funds (MCPF): A standardised assumption made about the MCPF across all countries, draws on available literature detailing the MCPF. Access Economics assumes the MCPF at 1.20. As such, for every extra dollar of tax revenue raised, a cost of $0.20 is incurred

This analysis estimates the incremental benefit of averting avoidable blindness and visual impairment, rather than the entire cost of vision loss to an economy. As such, the approach taken to estimate the benefit of eliminating avoidable blindness and VI uses the following inputs:

- **Total health care system cost of** avoidable blindness and visual impairment –in this benefit, this equates to the cost of the additional health system expenditures due to vision loss only – that is, co-morbidities. The principal co-morbidity identified was falls is accordingly assumed to be the only direct health system cost averted in this calculation.

- **Proportion of health costs funded by the government** – As per the Access Economics assumption, we assume that government expenditure on vision loss is proportionate to government spending on all other diseases.

- **Marginal cost of public funds** – As per the Access Economics assumption, we assume that the MCPF is 1.20.

The DWL per person per year multiplies these three elements.

Health benefits – detailed methodology

The health benefits quantified in this initial benefits analysis are:

- The direct health system savings, in terms of falls costs averted

- The well-being benefit, quantified in terms of DALYs.

Reduced child mortality and morbidity was identified in the benefits framework as a health benefit that would be realised if avoidable blindness and visual impairment was eliminated. This has not been quantified separately, explained in detail below.

Falls costs averted

Assumptions

We assume that the direct health benefit of eliminating avoidable blindness and visual impairment stems from the additional health system expenditures that occur due to vision loss, ie co-morbidities.

An analysis of the burden of blindness and vision loss in the UK by Access Economics (2008) notes that the only two co-morbidities of statistical significance, likely to be causally related to visual impairment are falls and depression. While several studies highlight the positive correlation between depressive symptoms and visual impairment, the evidence is limited compared to that detailing falls. Based on our literature review and availability of supporting data, we have assumed that the increased cost of falls relating to avoidable blindness and visual impairment on the health system is the primary co-morbidity included in our benefits quantification.

A study by Cruess et al (2007) on the burden of neovascular age related macular degeneration estimates the health system costs in relation to falls caused by visual impairment in Canada. A total mean fall related cost/AMD subject was approximated at $138.14 CAN/year (2005). Whilst this study is specifically in relation to vision loss caused by AMD, it is assumed that the cause of vision loss is irrelevant to the cost of causally related falls.

Lotery, Xu et al (2005) conducted a similar study in the UK, estimating health care utilisation costs for AMD patients. Total fall related costs/year for AMD patients were estimated at 25.27 pounds. Cruess, Zlateva et al (2008) carried out a multi country, cross-sectional observational study that documented health care utilisation costs associated to AMD in Canada, France, Germany, Spain and the UK. Cost estimates for falls caused by AMD in Canada and UK were consistent with the approximations provided in Cruess (2007) and Loterly et al (2005). In addition, total fall-related costs/AMD patient in France, Germany and Spain were estimated at 40.05, 7.28 and 150 Euros respectively (2005).

These estimates represent an average across the sample population in each country study. The incidence of falls in each country ranges from 0.90% in Germany to 11.82% in Spain, with the sample population standing at n=83 and n=89 respectively. Cruess, Zlateva et al (2008) also document the incidence of falls-related fractures in their cross country study, which ranges from 1.3% in the UK to 7.9% in Spain.

These results are aligned to recent findings by Tseng, Yu et al (2012), on the association of cataract surgery with subsequent fracture risk in the USA. Tseng, Yu et al examine, a sample population of over 1 million, in which it was found that the overall 1-year fracture incidence was 1.3% for hip fractures, and 5.4% for any fractures and treatment of cataract could reduce this by 16%. Whilst this study represents very recent analysis of the association between cataract diagnosis and fractures, it does not provide economic analysis. For this reason, our falls-cost assumption is built from Cruess et al (2008), from which an average falls costs per VI person of $133 USD (2009) has been estimated.

Approach

To determine the approximate average annual falls cost per capita in each country, we have applied a weighting approach using GDP/capita as the basis. This assumption is appropriated from the Access Economics 2010 Report on the Global Economic Cost of Visual Impairment. The average falls cost per capita due to VI in each WHO sub region is then used to calculate the total regional health benefit, using the same approach for timing used for the productivity benefit quantification (that is either lifetime or prevalence).

Wellbeing benefit

Approach

Our review of the literature identified that there were two principal established methodologies from to base this quantification –the Quality Adjusted Life Years (QALYs) approach or the Disability Adjusted Life Years Approach.

DALYs are used over QALYs to quantify ‘improved quality of life’ for two key reasons:

- The QALY method relies substantially on quality of life tools such as the EQ-5D in its quantification of health values. There are several drawbacks attached to the use of these tools. Firstly, many only cover level of function, rather than providing an all-encompassing view of health status including conditions such as psychological states for example. The use of QOL questionnaires is subject to issues surrounding biased, self-reported responses from patients, without standardised values.

- DALYs are designed to examine disease burden from a population perspective using average life expectancy, compared to QALYs which stem from a clinical tradition, measuring the effectiveness of specific interventions on groups of individuals (Gold, 2002). Given that this analysis intends to provide an estimate of the global benefit of eliminating avoidable blindness and visual impairment, the DALYs method was identified as more suitable.

The 2004 World Health Organisation Global Burden of Disease (GBD) update has been used to obtain estimated DALYs averted that would transpire if avoidable blindness and visual impairment was eliminated.

This represents the most recently available data, released in 2008, nothing that there is another update due for release in 2012. The GBD Study quantifies the health effects of over 100 diseases and injuries, disaggregated by WHO regions and further introduced the DALY as a single measure to quantify the burden of diseases, injuries and risk factors.

The 2004 GBD update provides accredited values for the total number of ‘Standard DALYs’ for each WHO subregion for the following causes of avoidable blindness and visual impairment:

- Trachoma

- Glaucoma

- Cataracts

- Refractive errors

- Macular degeneration and other (includes macular degeneration and other age-related causes of vision loss not correctable by provision of glasses or contact lenses).

Given that we have identified macular degeneration as un-avoidable, it is not included in the total DALYs averted benefit.

The sum of the total DALYs stipulated for trachoma, glaucoma, cataracts and refractive errors results in a global wellbeing benefit of **51.5 million Disability Adjusted Life Years (DALYs) averted.**

Appendix C Regions

Region definitions

Region definitions are based on WHO sub-regions as per tabulated below.

Table 13: WHO Member States by region and mortality stratum

Region and mortality stratum	Description	Broad grouping	Member states
Africa D	Africa with high child and high adult mortality	High mortality developing	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Togo
Africa E	Africa with high child and very high adult mortality	High mortality developing	Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
Americas A	Americas with very low child and very low adult mortality	Developed	Canada, Cuba, United States of America
Americas B	Americas with low child and low adult mortality	Low-mortality developing	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela (Bolivarian Republic of)
Americas D		High-mortality developing	Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru
South East Asia B	South-East Asia with low child and low adult mortality	Low-mortality developing	Indonesia, Sri Lanka, Thailand

Region and mortality stratum	Description	Broad grouping	Member states
South East Asia D	South-East Asia with high child and high adult mortality	High-mortality developing	Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal, Timor-Leste
Europe A	Europe with very low child and very low adult mortality	Developed	Andorra, Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom
Europe B	Europe with low child and high adult mortality	Developed	Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Slovakia, Tajikistan, The former Yugoslav Republic of Macedonia, Serbia and Montenegro, Turkey, Turkmenistan, Uzbekistan
Europe C	Europe with low child and high adult mortality	Developed	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
Eastern Mediterranean B	Eastern Mediterranean with low child and high adult mortality	Low-mortality developing	Bahrain, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates
Eastern Mediterranean D	Eastern Mediterranean with high child and high adult mortality	High-mortality developing	Afghanistan, Djibouti, Egypt,* Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen
Western Pacific A	Western Pacific with very low child and very low adult mortality	Developed	Australia, Brunei Darussalam, Japan, New Zealand, Singapore
Western Pacific-B	Western Pacific with low child and low adult mortality	Low-mortality developing	Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam

Projected prevalence

The following table outlines the assumptions used for the increase in prevalence between 2011 and 2020.

Region	Estimated growth in prevalence 2010-2020	Estimated annual growth
Afr D	34.5%	3.0%
Afr E	28.9%	2.6%
Amr A	14.7%	1.4%
Amr B	27.7%	2.5%
Amr D	29.7%	2.7%
EMR B	42.5%	3.6%
EMR D	36.3%	3.1%
EUR A	9.5%	1.0%
EUR B1	10.3%	1.0%
EUR B2	24.0%	2.6%
EUR C	0.4%	0.0%
Sear B	31.5%	2.7%
Sear D	31.1%	2.7%
Wpr A1	21.6%	1.9%
Wpr A2	4.9%	0.5%
Wpr B1	23.3%	2.1%
Wpr B2	39.9%	3.4%
Wpr B3	33.2%	2.9%

Source: Gordois et al 2011.

Appendix D Case Studies: Australia and India

Benefits of eliminating avoidable blindness and visual impairment

Case studies for Australia and India

We have developed two benefits quantification case studies in order to better understand the value of the benefits derived from eliminating avoidable blindness and visual impairment on a country basis, using Australia and India as case examples. The purpose of these is to clarify the methodology behind the benefits quantification and to confirm the assumptions and data used.

Australia and India have been chosen for the case studies as they differ in terms of economic development, and because data and previous research are available for both these countries. As such, for these countries, we were able to compile prevalence data by disease.

In both of these case examples, we have valued the following benefits associated with the elimination of avoidable blindness and visual impairment:

- direct health system savings (health benefit)
- productivity benefit for those with avoidable blindness or visual impairment (economic benefit)
- productivity benefit for carers of those with avoidable blindness or visual impairment (economic benefit)
- dead weight loss value per person with avoidable blindness (economic benefit)

Further, we have reported the benefit attributable to improved quality of life, built from an estimated number of Disability Adjusted Life Years (DALYs) averted and the Value of a Statistical Life in each country. This benefit however has not been included in the total 'tangible' benefit for two key reasons:

1. To avoid double counting the economic and health benefits already quantified
2. To avoid a benefit result which is weighted heavily towards the value of the DALYs averted, the methodology behind which may be subject to significant scrutiny in the literature in terms of it being an accurate reflection of true value.

We have quantified benefits in terms of **that benefit that can be achieved from the additional investment required to eliminate avoidable blindness.** That is, investment beyond current expenditure on eye health to focus on that component of the cost needed to achieve the elimination of avoidable blindness as per the VISION 2020 goal. This includes the investment to treat:

- the current backlog and
- the portion of incidence that cannot be treated under current health expenditure as based on assumptions made in the costing methodology which draw from the VISION 2020 optimal eye healthcare workforce ratios.

We intend to undertake the same approach in the global quantification, which will include these same benefits reported at a regional level.

This discussion document provides:

- a high level overview of the benefits framework for eliminating avoidable blindness and VI

- an explanation of the approach used to determine the timeframe for which benefits are realised, based on cause of blindness or visual impairment

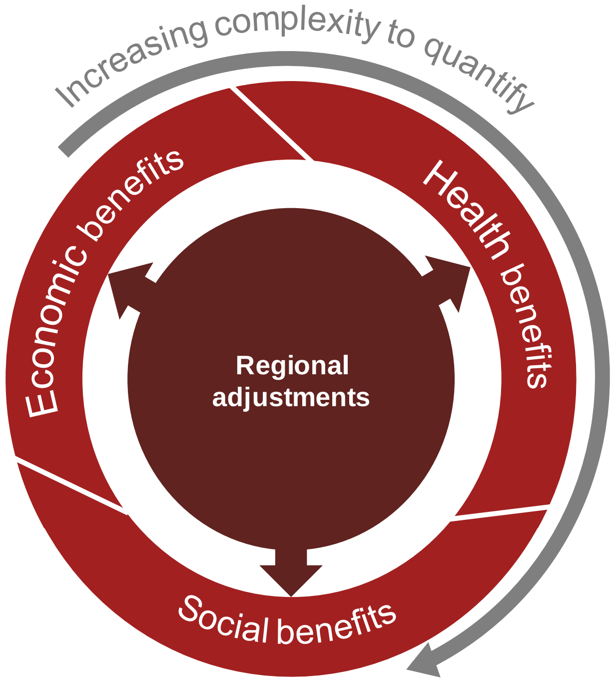
- a case study for Australia which quantifies benefits and reports the increase to wellbeing from eliminating avoidable blindness and visual impairment

- a case study for India that quantifies benefits and reports the increase to wellbeing from eliminating avoidable blindness and visual impairment

Understanding the potential impact of avoidable blindness

PwC and The Fred Hollows Foundation have agreed that the scope of the benefits quantification, to the degree that is possible, sits within a framework that incorporates economic, health and social benefits. This **"benefits framework"**, developed in a previous phase of work, categorises the benefits of eliminating avoidable blindness globally. The framework is depicted in Figure 3.

Figure 3: High level benefits framework



Defining the benefits

Table 14: Health benefits

Examples of health benefits from eliminating avoidable blindness
• Improved quality of life/reduced burden of disease (DALYs averted; QALYs gained) • Reduced co-morbidities & mortality (including HIV/AIDS and malaria-MDG 6) • Reduced child mortality (MDG 4) • Reduced hospitalisations, length of stay and other health system costs (possibly including emergency department presentation and ambulatory care where applicable)

Table 15: Economic benefits

Examples of economic benefits from eliminating avoidable blindness
• Increased employment to the visually impaired and carer • Increased productivity • Reduced welfare costs • Achieving universal primary education (MDG 2) by either the ability for current carers to receive education or visually impaired children to access education

Table 16: Social benefits

Examples of social benefits from eliminating avoidable blindness
• Increased independence • Increased self-esteem and improved social networks • Reduced extreme poverty and hunger (MDG 1) • Increased gender equality • Increased community participation

Approach

Determining timeframes

A primary step in the quantification of the benefits resulting from the elimination of avoidable blindness and visual impairment globally is the determination of an appropriate timeframe in which these benefits are likely to be realised, relative to the level of investment made.

The key question was: does avoidable blindness and visual impairment require a yearly investment in order for benefits to accrue each year **(prevalence approach),** or can it be eliminated with a single intervention type investment, producing a longer term/lifetime benefit **(lifetime approach)?**

To address this, we drew upon internal eye health resources to better understand the possible treatment pathways of the various causes of avoidable blindness and visual impairment. A lifetime approach has been assumed for quantifying the benefits associated with elimination of cataract and uncorrected refractive error (URE). This is because both of these conditions are treated with an intervention investment, for example surgery, which will produce a long term benefit, with minimal further treatment/intervention required. For all other causes of blindness and visual impairment, a prevalence approach has been assumed, based on the reasoning that these causes require ongoing investment in monitoring and treatment to prevent further progression. In these cases, a yearly investment in treatment/prevention will produce a corresponding yearly benefit.

These assumptions are detailed further in the table below.

Table 17: Benefit timeframe by disease

Disease	Intervention	Outcome	Value	Timeframe
Glaucoma	Treatment focused	Treat regularly to prevent progressing to blindness	Benefit measured in terms of average annual earnings	Year on year benefit resulting from annual investment
Cataract	Intervention focused	Treat with surgery/interventi on type approach to produce a long term benefit.	Lifetime benefit based on assumption of an average of 10 productive years lost due to blindness (Shamanna, BR, Dandona, L, Rao, GN, 1998)	Lifetime value

Disease	Intervention	Outcome	Value	Timeframe
URE	Intervention focused	Treat with intervention to produce long term benefits	Lifetime benefit based on assumption of an average of 10 productive years lost due to blindness (Shamanna, BR, Dandona, L, Rao, GN, 1998)	Lifetime value
Diabetic Retinopathy	Prevention/ treat chronic disease	Manage disease to prevent blindness	Benefit measured in terms of average annual earnings	Year on year benefit resulting from annual investment
Trachoma/ Onchocercia sis	Prevention/ treatment focused	Manage disease to prevent blindness	Benefit measured in terms of average annual earnings	Year on year benefit resulting from annual investment

Elimination of the backlog versus incidence

The approach taken in this analysis quantifies the benefit accrued from the additional investment required to eliminate avoidable blindness and visual impairment. That is, the investment above that is already being spent in eye health. As such, benefits will be realised from both:

- the elimination of the current backlog (or prevalence of blindness and visual impairment)
- the elimination of future incidence of those with avoidable blindness and visual impairment who would not be treated within the current health system scope, but could be treated if additional investment was made.

The elimination of the latter category draws on the approach taken in the cost analysis where we estimated the required growth in the eye care workforce based on workforce ratios specified by the VISION 2020 Human Resource Development Working Group. Under this approach, no additional investment was required to grow the Australian eye health workforce, a reflection that the system can currently support the new incidence of avoidable blindness and visual impairment. Thus no benefit has been included for eliminating new incidence for Australia and the entire benefit is attributable to the elimination of the backlog.

This differs in the case of India, where it was documented in the cost report that the average growth across the primary and secondary eye health sector of 110% was required to increase the workforce and associated infrastructure and training. It has been assumed that if this is achieved, the health system could support the entire incidence. **Thus, the benefit quantified relates to the incremental incidence that corresponds to the required additional investment in the eye health system to eliminate avoidable blindness and visual impairment as well as elimination of the current backlog.**

For the benefits accruing to the elimination of the backlog, it has been assumed that these will be evenly distributed over a ten year period, in line with the cost analysis.

Economic benefits

Productivity benefit

We assume that the productivity benefits from the elimination of avoidable blindness and visual impairment would accrue to the following key parties:

1. the avoidably blind and visually impaired: a proportion of whom were not previously working due to their condition would enter the workforce
2. the informal carers: these individuals would no longer be forgoing productive time or leisure time to care for an avoidably blind or visually impaired family member or friend

Deadweight loss cost averted

The elimination of avoidable blindness and visual impairment would bring with it the benefit of averted deadweight loss (DWL). The cost of DWL tied to blindness and visual impairment, and other disease burdens, stems from the additional tax revenue that the government must raise to fund the associated direct health costs. Thus, regions with higher average direct health system costs are expected to incur a larger DWL cost. The size of this extra tax burden will depend on the means in which the government chooses to raise additional revenue and also the proportion of a country's direct health costs funded by the government.

The total economic benefit is equal to the sum of these benefits.

Health benefit

Direct health system costs averted

The direct health system benefit is assumed to accrue only to those expenditures which are a direct result of avoidable blindness and visual impairment– that is, co-morbidities. The literature indicated the most notable co-morbidity relating to vision loss to be falls (Cruess et al. 2008). The value of falls related costs is assumed to encompass the entire direct health benefit if avoidable blindness and visual impairment were to be eliminated.

Wellbeing benefit

It can be assumed that all causes of avoidable blindness and visual impairment will have an impact on an individual's quality of life or wellbeing. In accordance with the literature, this benefit is quantified in terms of Disability Adjusted Life Years (DALYs) averted. As noted, this benefit is not included in the total monetary benefit.

Reporting

All results are reported as 2009 USD as per *The Price of Sight* report.

Case study: Australia

Introduction

The prevalence of visual impairment in Australia is estimated to be 433,473 (World Health Organisation, 2013), of which 7% are blind. .

These prevalence estimates form the basis of our quantification of the productivity and health benefits that could potentially be realised in Australia if avoidable blindness and visual impairment was eliminated.

Economic benefits

Productivity Benefits – blind and visually impaired persons

As explained above, in the case of Australia, a productivity benefit is only assumed to be realised from the elimination of the backlog or current prevalence of avoidable blindness and visual impairment.

For all cases of blindness and visual impairment caused by glaucoma and diabetic retinopathy (comprising approximately 5% of all VI in Australia), it is assumed that annual recurring investment in treatment and prevention is required to sustain the benefits realized, and thus the prevalence (yearly) approach is used for quantification.

For all other causes (excluding AMD), of which cataract and URE comprise approximately 76% (Taylor et al 2005), a lifetime approach (10 years) has been used, based on the fact that these causes are treated with an intervention type of treatment, with minimal ongoing investment required. A one off investment is assumed to produce a long term benefit.

Key assumptions used for calculation

In order to determine the value of the productivity benefit realised each year, the following key assumptions/inputs were used:

Assumption	Value	Source
Total Prevalence of blindness and visual impairment ((2010)	433,473	World Health Organisation, 2013
% of total prevalence due to AMD	10%	Taylor et al 2005
% of total prevalence that are of working age (15-65)	29%	World Health Organisation, 2013
Employment rate in blind and visually impaired population	32%	Gordon et al, 2011
Employment rate in Aust. population	62%	Based on national participation rate and employment rate, ABS 2012
Additional proportion who would be working if avoidable blindness and visual impairment was eliminated	30%	Based on above assumptions
Average annual wage	$53,751	OECD, USD 2009
Inflation rate	3.6%	The World Bank Group 2012 (4 year average)

Assumption	Value	Source
Discount rate	1.55%	Taylor et al, 2006
Annual mortality rate	1%	Index Mundi Country Facts
Average number of productive years lost due to blindness and visual impairment	10	Shamanna, Dandona, Rao 1998

Approach:

The productivity benefit realised by avoidably blind and visually impaired persons was calculated based on the number of blind and visually impaired persons who fall within the 15-65 age bracket. This was calculated drawing on the prevalence data obtained from the World Health Organisation (2013) which is broken down by 5 year age intervals. The proportion of blind and visually impaired persons within this age bracket is estimated at 29%.

The two key factors were then applied to this proportion of working age persons:

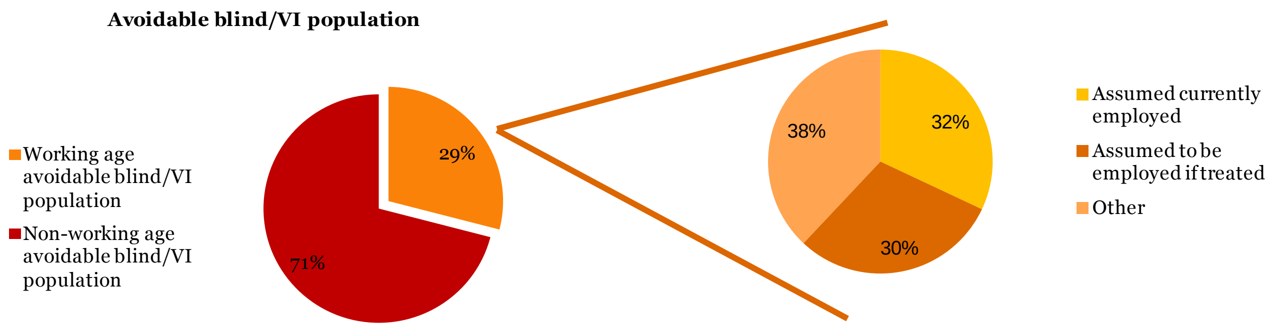
1 The percentage of the Australian population that is employed, obtained by multiplying the national participation rate by the employment rate. This is calculated to be 62%

2 The current employment rate in the blind and visually impaired population, assumed to be 32% (Gordon et al, 2011)

Therefore, assuming that in absence of blindness and visual impairment, people would be employed at the same rate as the national average, there would be an additional 30% of persons working. This assumption is consistent with the literature (Taylor et al 2006, Roberts et al 2010).

Based on the methodology outlined, **only 9%of the total prevalence of blindness and visual impairment is accounted for in the quantification of the productivity benefit**. This is depicted in Figure 4.

Figure 4: Proportion of blind and visually impaired persons accruing a productivity benefit in Australia



Finally, depending on the cause of avoidable blindness or visual impairment, a lifetime benefit or a yearly benefit has been assumed and applied to the number of persons aged 15-65 that would newly be working if their sight was restored. The lifetime benefit has been assumed as the value of ten productive years, based on a study undertaken by Shamanna et al (1998), in which it was assumed that the average number of working years lost due to adult blindness is ten years.

It is recognised that blind persons may be likely to earn less when working compared to visually impaired persons, and thus the application of a weighting approach to the productivity benefit was discussed as part of the review process. In their study on the Economic Burden of Major Adult Visual Disorders in the United States, Rein et al (2006) analysed the earnings differential between these two groups, finding that visually impaired persons earned on average 10% more than their blind counterparts. Based on this finding, the differential was assumed not to be significant and thus no weightings were assigned in our quantification of this benefit.

It is further acknowledged that blindness will have detrimental consequences for children and young adults in terms of educational and employment opportunities (Forward et al, 2012). Upon the restoration of sight, it is assumed that those persons who were previously blind are less likely to secure a well paid job based on a likely lower standard of education and/or less work experience. For these reasons, we have conducted a sensitivity analysis around the average yearly earnings to assure the robustness of our model. The base average yearly earnings for Australia is assumed to be $53,751 USD (OECD Average Annual Wages, 2009). Rein et al (2006)'s analysis of average annual earnings in the visually impaired and blind indicates that the average annual wage for a person with vision impairment is 70% of someone with normal vision. Further, they show that a blind person earns approximately 63% of the annual wage of a person with normal vision. We report the following sensitivity ranges around the productivity benefit for persons with blindness and visual impairment.

- Base case assumption: persons with avoidable blindness and visual impairment that are treated earn 70% of average income ($53,751 USD)
- Option 1: persons with avoidable blindness and visual impairment that are treated earn the average income of someone with normal vision ($53,751 USD)
- Option 2: persons with avoidable blindness and visual impairment that are treated earn 63% of average income ($53,751 USD)

The results of the sensitivity analysis provide an upper range of $18 billion (using the assumption scenario outlined in option 1) and a lower range of $11.5 billion (using the assumption scenario outlined in option 2) to the productivity benefit to persons treated for avoidable blindness and visual impairment.

Productivity benefits – carers

Key assumptions used for calculation:

In order to determine the value of the productivity benefit realised by carers to persons with avoidable blindness and visual impairment, the following key assumptions were made:

1. That all carers are at a productive loss, regardless of their age, in them caring for the avoidable blind and visually impaired

It has been assumed that all carers, including children and older persons who no longer fall within the working age bracket, would experience a productivity loss caring for avoidable blind and visually impaired persons. For those carers who are not of working age, leisure time and wellbeing is still being sacrificed in caring, and this is assumed to have the same value as productive working time. This assumption is consistent with the opportunity cost methodology followed in the Global Economic Cost of Visual Impairment study by Access Economics (2011) to calculate the cost of informal care. In this analysis, it is assumed that time spent providing informal care could alternatively be used in the paid workforce or in leisure activities, where the value of each is equal.

2. The value placed on the productivity lost due to caring is equal to 5% of a person's total average yearly productivity.

This assumption has been made based on a study by Shamanna et al (1998), in which it was assumed that 10% of the productive time of one economically productive member of the family of each blind person is lost in taking care of the dependent blind, and 5% of productivity is lost in caring for each person with moderate or severe VI. In a later study, Smith et al. (2009) also used these assumptions. In Australia's Household, Income and Labour Dynamics survey, it was also found that annual gross household income for carers was 15% less on average when compared with non-carers (HILDA 2005). Based on this literature, we have taken a conservative approach and assumed the productivity loss for caring is 5% of total productivity, which based on the average yearly earnings in Australia ($53,751), is equal to $2,688 a year.

3. That 50% of blind persons require care from a carer

We have based this assumption on the results of the Survey of Disability, Ageing and Carers (SDAC), conducted by the Australian Bureau of Statistics in 2009. The primary objective of the survey was to collect information about the following three population groups:

3 People with a disability

4 Older people

5 People who provide assistance to older people and people with disabilities.

Specifically we have examined the number of people who have listed eye disorders (retinal disorders, glaucoma, sight loss, other diseases of the eye and adnexa) as a main condition, and that fall into the following two groups:

1 Has disability and profoundly limited in core activities

2 Has disability and is severely limited in core activities.

Half of the people in these groups reported having at least one carer. For this analysis, we assume that people who have listed eye disorders as a main condition and who are also profoundly or severely limited in core activities are blind. Based on this, we have only accounted for a productivity benefit accruing to one carer for every second blind person.

Approach

The calculation of the productivity benefit realised by carers uses the same approach as the respective quantification of the productivity benefit accrued by persons with avoidable blindness and visual impairment, with the timing approach varying by cause.

The two key differences in terms of inputs were:

1 The number of carers realising a productivity benefit is not equal to the number of blind and visually impaired persons realising a productivity benefit. The number of carers was assumed to be half the number of blind persons. The proportion of total prevalence of visually impaired persons that are blind was calculated based on the regional disaggregation of prevalence data by severity of VI in Pascolini and Mariotti's 2011 global study. Whilst Australia falls within the Western Pacific Region (WHO region delineation), an analysis of the country studies from which the prevalence data is built up indicates that an Australian study was not included, with the estimate being built from second and third world countries. Therefore, upon consultation with an expert in the field, it was recommended that we assume the same proportionate breakdown for the European Region for Australia, expected to provide a more accurate reflection.

2 The yearly (and lifetime) value of the carer benefit was substantially less than the value of the benefit for blind and visually impaired persons, aligned with the assumption that 5% of productivity is lost for carers.

A summary of the productivity benefit accruing to the avoidable blind and visually impaired and carers is provided in Table 18 below.

Table 18: Productivity benefit to the avoidably blind and visually impaired and carers – Australia (millions USD 2009)

Who	Cause	Timeframe	Productivity benefit over 10 years)	Productivity benefit (sensitivity analysis of 63% to average annual earnings)	Productivity benefit (sensitivity analysis of 70% to average annual earnings)
Blind and visually	Glaucoma	Prevalence	$264.0	$166.3	$184.8

impaired persons	Diabetic Retinopathy	Prevalence	176.0	$110.9	$123.2
	All other causes	Lifetime	$17,074.3	$10,756.8	$11,952.0
Carers	Glaucoma	Prevalence	$5.7	$5.7	$5.7
	Diabetic Retinopathy	Prevalence	$3.8	$3.8	$3.8
	All other causes	Lifetime	$478.9	$478.9	$478.9
TOTAL			**$18,002.7**	**$11,522.4**	**$12,748.4**

Deadweight loss cost averted

The concept of a deadweight loss cost tied to avoidable blindness and visual impairment stems from the fact that additional tax revenue must be raised by government to fund the associated direct health costs. To estimate the global benefit of DWL averted in Australia, we have followed the methodology outlined in the global Access Economics 2011 report which multiplies three variables:

1. total health care system cost of VI
2. the proportion of health care system costs funded by government using the WHO indicator of 'general government expenditure on health as a percentage of all health expenditure' as a proxy. This assumes that government expenditure on vision loss is proportionate to government spending on all other diseases
3. the marginal cost of public funds. A standardised assumption made about the Marginal Cost of Public Funds (MCPF) across all countries, draws on available literature detailing the MCPF. Access Economics have assumed that the MCPF was 1.20. This means that for every extra dollar of tax revenue raised, there is a cost of $0.20 incurred.

In this benefits quantification, the incremental benefit of averting avoidable blindness and visual impairment is estimated, rather than the entire cost of vision loss to an economy. As such, the approach taken to estimate the benefit of eliminating avoidable blindness and visual impairment uses the following for the Australian case study:

- **Total health care system cost of VI** – in our model, this equates to the cost of the additional health system expenditures due to vision loss only – that is, co-morbidities. The principal co-morbidity identified in the literature was falls which accordingly has been assumed to be the only direct health system cost averted (of significant economic value) if avoidable blindness and visual impairment was eliminated. The average falls related cost per person averted is assumed to be $133 USD 2009 (Cruess et al. 2008).
- **Proportion of health costs funded by the government** – As per the Access Economics assumption, we assume that government expenditure on vision loss is proportionate to government spending on all other diseases. For Australia, this is 74.5%.
- **Marginal cost of public funds** – As per the Access Economics assumption, we assume that the MCPF is 1.20.

The DWL per person each year was calculated by multiplying these three elements.

Over the 10 year period from 2011-20, the total DWL cost averted that can be achieved from eliminating avoidable blindness and visual impairment is **$37.9 million.**

This differs substantially to Access Economics (2004) who estimated the economic impact of vision loss in Australia. Here, DWL associated with transfer payments is calculated at $208 million in 2004. The vast difference can be attributed to the different approach taken in this calculation which quantifies DWL associated with all transfer payments and the distorting impact they have on work and consumption choices, rather than with the incremental direct health cost. It was assumed that 5% of total welfare payments (comprising carer payments, allowances, unemployment benefits, and disability support pension), and 28.8% of total tax revenue were dead weight losses. The total DWL was equal to the sum of these components.

This case study is an initial step towards finalising a set of assumptions as such requiring an approach that can be easily replicated on a global scale. To enable this we follow the methodology set in Access Economics (2011), outlined above, which examines the economic costs associated to visual impairment on a global scale.

Total economic benefit

Over the 10 year period from 2011-20, the total productivity benefit to persons with avoidable blindness and visual impairment and carers that can be achieved from eliminating all causes of avoidable blindness and visual impairment is estimated between $11.5billion and $18billion USD. This is equal to the sum of the dead weight loss averted and the productivity benefit to the avoidable blind and visually impaired and carers.

Health benefits

Direct health system costs averted – Falls

The direct health benefit from eliminating avoidable blindness and visual impairment is accrued from the additional health system expenditures that occur due to vision loss. The principal additional source of health expenditure attributable to visual impairment identified in the literature is falls. Cruess et al. (2008) have drawn upon pre-existing literature to document the mean falls related costs due to age-related macular degeneration in the UK, Canada, France, Germany and Spain. The average annual cost of falls per visually impaired person across these countries was calculated to be **$133 USD** (2009). We have calculated the benefit of avoided falls related costs using this estimate as a basis.

The benefit of reduced falls related costs is calculated assuming the same approach for timing that is used for the calculation of the productivity benefit (that is, either lifetime or prevalence).

Consistent with the assumption made earlier that ten years of productivity are lost on average with vision loss (Shamana et al. 1998), the lifetime direct health benefit per person was obtained by multiplying the average annual savings by ten, resulting in a total life time direct savings of **$1,333**.

Over the 10 year period from 2011-20, the total direct health care cost averted was calculated at **$506.8 million** USD 2009.

Wellbeing benefit

We have estimated the total number of DALYs for Australia to be **37,714** based on the 2004 Global Burden of Disease (GBD) data which is disaggregated by WHO subregions. This is based on the most recent publicly available DALY data. Taylor et al (2006) estimate the total DALYs for Australia to be **41,187** in 2004, which is based on less recent GBD data. Taylor et al (2006) estimate the Value of a Statistical Life Year (VSLY) to be $162,561 AUD 2004. If the average inflation rate in Australia over the past five years of 5% is applied, along with the average 2009 AUD/USD exchange rate, this is the equivalent to a VSLY of **$161,657 USD 2009** (World Development Indicators). The total value of the wellbeing benefit is assumed to be the value of total DALYs averted which is obtained by multiplying these two key inputs. This results in a benefit of **$6.1 billion** in 2009 USD in a single year, which is in line with the figure put forward by Taylor et al (2006) of $6.7 billion in 2004 AUD. **The wellbeing benefit over ten years is thus equal to $61 billion 2009 USD.**

Results summary

In total, the tangible benefits arising from the elimination of avoidable blindness and visual impairment in Australia accrue to between **$11.9 and $18.5 billion** (USD 2009) over 10 years. The monetary value of DALYs averted over a ten year period is equal to $61 billion (USD 2009). As discussed, this latter benefit is not included in our total benefit for eliminating avoidable blindness and visual impairment in Australia to avoid double counting the productivity benefit, and also given the amount of scrutiny that surrounds assigning a monetary value to DALYs.

Table 19: Benefits valuation over 10 years – Australia

Benefits – tangible	Value (billions, 2009 USD)	Value (billions, 2009 USD) with sensitivity around annual wage
Total economic benefit	$18.0	$11.5– 12.64
Direct health cost system (falls)	$0.5	$0.5
TOTAL	$18.5	$12.0--13.3
Benefits –intangible		
Wellbeing benefit	$61	$61

Case study: India

Introduction

Developing countries bear the majority of the global burden of blindness and visual impairment, most of which are avoidable or treatable. India represents a significant share of the world's population (approximately one sixth), and an even larger share of the developing world's population corresponding to a substantial proportion of the world's blindness and visual impairment. The prevalence of visual impairment in India is estimated to be $67.1 million (WHO Prevalence data, 2013). The average annual incidence is estimated from examining the increase in prevalence from 2000 to 2010 – estimated to be 474,197.

This prevalence estimate forms the basis of the benefits quantification that can be realised in India if avoidable blindness and visual impairment was eliminated.

In India, benefits were assumed to accrue across two levels:

1. the elimination of the current backlog (or prevalence of blindness and visual impairment)
2. the elimination of future incidence of those with avoidable blindness and visual impairment who would not be treated within the current health system scope.

This differs to Australia, where it was assumed that no benefit would accrue from future incidence given that the current health workforce does not require growth to reach VISION 2020 Human Development Working Group ratios.

Referring back to the *Price of Sight* report, it was estimated that in India, an average growth of 110% (across the primary and secondary health system) is required for the health system to be able to support the entire incidence. Thus, part of the benefit comprises the **incremental incidence that could be treated if this investment was made**. The remaining component of the benefit is realised by the elimination of the current backlog.

Economic benefits

Productivity benefits – Blind and visually impaired persons

The following assumptions were used to quantify the productivity benefit that is realised by blind and visually impaired persons.

Key assumptions used for calculation

Assumption	Value	Source
Total Prevalence of blindness and visual impairment (2010)	67,096,144	World Health Organisation (WHO) 2013 Prevalence data
Employment rate in blind and visually impaired population	32%	Gordon et al, 2011
Employment rate in Indian population	55%	Calculated from participation rate and unemployment rate from World Development Indicators
Additional proportion who would be working if avoidable blindness and visual impairment was eliminated	23%	Based on above
% of prevalence of working age, determined as 15-65	54%	WHO 2013 Prevalence data

Assumption	Value	Source
Mortality rate	1%	Index Mundi Country Facts
Discount rate	6%	Taylor et al, 2004
Average yearly earnings	$1,241	USD 2009, GDP per capita as proxy, World Development Indicators
Average number of productive years lost due to blindness and visual impairment	10	Shamanna, Dandona, Rao 1998

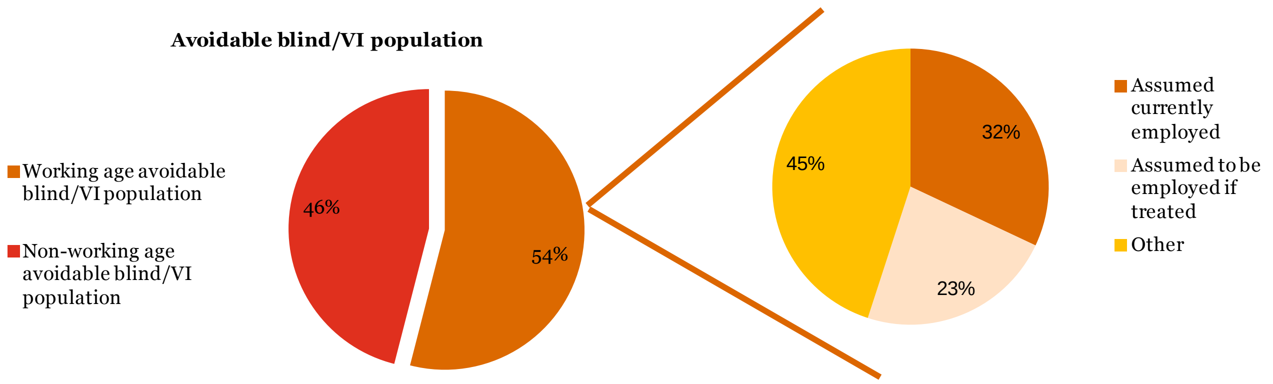
Approach:

The approach to quantifying the productivity benefit that would accrue to the blind and visually impaired in India follows a very similar approach to that followed in the Australian example. The assumptions that have a significant impact on the final productivity benefit are explained in more detail below:

- A productivity benefit to blind and visually impaired persons was only included for those individuals aged 15-65, assuming that 54% of the total prevalence falls within this group (WHO, 2013).

- The employment rate in the Indian blind and visually impaired population is assumed to be 32% (Gordon et al, 2011). Based on the national participation and unemployment rate in India, this translates to an additional 23% of the total prevalence that would be working and accruing a productivity benefit in India. Again, it is assumed that in the absence of blindness and visual impairment, people would be employed at the same rate as the national average (Taylor et al 2006, Roberts et al 2010). This equates to only 12% of the total prevalence of blind and visually impaired persons accruing a productivity benefit. This is depicted in Figure 5 below.

Figure 5: Proportion of avoidably blind and visually impaired persons accruing a productivity benefit in India



Similarly to the approach taken in the Australian study, the productivity benefit is disaggregated by eye condition in order to determine an appropriate time period for the accrual of benefits. For avoidable blindness and visual impairment caused by Cataract and URE (comprising approximately 85% of all cases), a lifetime benefit is assumed. For all other causes, a prevalence approach (year on year) benefit is assumed.

Whilst the OECD provides average wage data for Australia, in absence of equivalent data for India, GDP per capita was used as a proxy. This was **$1,241 USD (2009)** (World Development Indicators 2009).

Similar to the Australian case study, sensitivity analysis was conducted around the average annual earnings based on the proportionate breakdown given by Rein et al (2006) in their analysis of average annual earnings of the blind and visually impaired compared to a person with normal sight. The lower bound proportions applied to the average annual earnings were 63% and 70%.

Due to limited data detailing the prevalence of AMD as a proportion of total visual impairment, and the knowledge drawn from the literature that AMD comprises a very small prevalence of the total, it has not been removed from total prevalence as in the Australian case.

Productivity Benefits – carers

Key assumptions used for calculation

The following key assumptions used for the productivity benefit quantification have been applied for India. Specifically these are:

1. That all carers are at a productive loss, regardless of their age, in them caring for the visually impaired

2. The value placed on the productivity lost due to caring is equal to 10% of a person's total average yearly productivity.

3. Number of carers: in the Australian example, we have assumed one carer for every second blind person only, our methodology explained in detail above. Taking into account that this data is particular only to Australia and that there is likely to be more limited access to aids and resources for avoidable blindness and visual impairment in India, **we have assumed one carer per blind person.**

Summary of productivity benefits to the blind and visually impaired and carers

Over the 10 year period from 2011-20, the total productivity benefit to the blind and visually impaired and carers that can be achieved from eliminating all causes of visual impairment is estimated between **$70.5 billion and $106.2 billion USD**. This is outlined in Table 20 below.

Table 20: Productivity benefit over 10 years – India

Who	Cause	Timeframe	Productivity benefit (millions USD, 2009)	Productivity benefit applying sensitivity analysis of 63% to average annual earnings (millions USD, 2009)	Productivity benefit applying sensitivity analysis of 70% to average annual earnings (millions USD, 2009)
Blind and Visually Impaired persons	Cataract	Lifetime	$67,984	$42,830	$47,589
	URE	Lifetime	$20,552	$12,948	$14,387
	All other	Prevalence	$7,819	$4,926	$5,473
Carers	Cataract	Lifetime	$6,934	$6,934	$6,934
	URE	Lifetime	$2,096	$2,096	$2,096

All other[2]	Prevalence	$797	$797	$797
TOTAL		**$106,183**	**$70,531**	**$77,276**

Deadweight loss cost averted

We have used the same methodology to calculate the deadweight loss for India as we have for Australia, using the methodology in the Access Economics Global Economic Cost of Visual Impairment study (2011). The key inputs are:

- **The direct health expenditure per person per year**: this is assumed to equal falls related costs.
- **The proportion of health costs funded by the government**: using the WHO indicator of 'general government expenditure on health as a percentage of all health expenditure' as a proxy
- **The Marginal Cost of Public Funds (MCPF)**: Access Economics have assumed that the MCPF was 1.20 which we have also done. This means that for every extra dollar of tax revenue raised, there is a cost of $0.20 incurred

Over the 10 year period from 2011-20, the total deadweight loss cost averted that can be achieved from eliminating avoidable blindness and visual impairment is $175.3 million.

Total economic benefit

The total economic benefit is equal to the sum of the total productivity benefit and the averted DWL benefit. This is estimated between $70.7 billion and $106.4 billion USD.

Health benefit

Direct health system costs averted – falls

The approach follows that taken in the Australian case study, where the direct health benefit from eliminating avoidable blindness and visual impairment is accrued from the cost averted of those additional health system expenditures specifically correlated to vision impairment. This was singled down to falls related expenditure based on the literature (Cruess et al. 2008).

Whilst in the Australian example we have used an average across a number of developed countries, provided in the literature (Cruess et al 2008), this was assumed to be an overestimate for developing countries such as India. To downsize this estimate, we have used a weighting approach using GDP/capita as a basis (Access Economics, 2011). This resulted in an estimated annual falls related costs due to blindness and visual impairment in India of **$4.98.**

The benefit of reduced falls related costs is calculated assuming the same timing approach that is used for the calculation of the productivity benefit (that is, either lifetime or prevalence).

Over the 10 year period from 2011-20, the total direct health care cost due to falls averted was calculated at **$3,190 million** USD 2009.

[2] Note that this includes AMD prevalence which is assumed to be minimal in India.

Wellbeing benefit

In lieu of literature specifically measuring the loss of wellbeing associated to blindness and visual impairment in India, we have estimated the total DALYs based on the 2004 Global Burden of Disease data which is disaggregated by WHO subregions.

The most recent data on the global burden of disease that is publicly available is for 2004, released in 2008. A more recently updated version is scheduled for release in 2012. This data provides the number of DALYs for various diseases, broken down by WHO subregions. India falls in the South East Asian Region D subregion (SEAR D), which is defined as South East Asia with high child and high adult mortality. It is comprised of the following countries: Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal and Timor-Leste. The total number of DALYs for the SEAR D region (from trachoma, glaucoma, cataracts, macular degeneration and other) is 7.2 million.

In order to obtain an approximate number of DALYs for India, the proportionate share of the regional population was applied to the total regional number of DALYs. Given that India comprises 73% of the population in the region, it also bears the majority of the DALY burden which was estimated to be **5.3 million DALYs.**

In a 2010 study, Shanmugam estimates the value of a statistical life in India to be US $1.107 million (1990). If the average inflation rate from 1991 to 2010 in the United States of 2.2% is applied, this is equal **to $1.67 million in 2009 dollars.**

The Value of a Statistical Life (VSLY) was calculated following the approach used in Roberts et al.'s study on the economic cost of visual impairment in Japan, with the number of discount years assumed to be 40. Using the average discount rate for future life years in India, as determined in Shanmugam's 2010 study, of 3.75%, the VSLY was determined to be $80,000 (USD, 2009).

The total benefit associated to DALYs averted in India was then obtained by multiplying the total number of DALYs by the VSLY. This is equal to $431 billion in 2004, and **$4,310 billion USD** over ten years.

Results summary

In total, the tangible benefits arising from the elimination of avoidable blindness and visual impairment in India accrue to between **$73.9 and $109.6 billion** (USD 2009) over 10 years.

Similarly to the Australian case study, we have not included the value of DALYs averted in our total to avoid double counting, and also due to the scrutiny surrounding the estimation of a value of a statistical life and the extent to which the value of DALYs is a true reflection of wellbeing.

Table 21: Benefits valuation – India

Benefits – tangible	Value (billion USD)	Value (billions USD) with sensitivity around average annual earnings
Total economic benefit	$106.4	$70.7 - $77.5
Direct health benefit	$3.2	$3.2
TOTAL	**$109.6**	**$73.9-80.7**
Benefits – intangible		
Wellbeing benefit	$4,310	$4,310

Discussion

The development of case studies focusing on Australia and India has been extremely valuable as an initial step in the global quantification of the benefits of eliminating avoidable blindness and visual impairment in that it has drawn attention to some key issues relating to data limitations, assumptions and the most appropriate approach. Our overall approach was reviewed by two subject matter experts who have conducted extensive public health research in blindness. In addition to validating each key assumption used with these experts, some overarching recommendations were put forward. These recommendations and the respective outcomes are detailed below.

1. Applying a weighting to the productivity benefit based on the severity of visual impairment: to address this recommendation, the literature was consulted. In their study on the Economic Burden of Major Adult Visual Disorders in the United States, Rein et al (2006) analysed the earnings differential between the blind and the visually impaired, finding that visually impaired persons only earned an average of 10% more than their blind counterparts. Based on this result, the differential was assumed not to be significant and thus no weightings were assigned in our quantification of this benefit. However, to ensure the robustness of our model and in acknowledgement that blind individuals who have their sight restored are less likely to secure a well-paid job due to an assumed lower level of education and/or work experience to date, a sensitivity analysis has been undertaken around the average annual earnings. A lower bound analysis was undertaken, assuming that avoidable blind and visually impaired persons earn 67% of the average annual earnings of a person with normal sight.

2. Expressing our results in terms of Purchasing Power Parity (PPP): following detailed discussion, this recommendation has not been taken forward due to the following reasons:

- All the benefits included in our quantification have been converted into 2009 USD from a number of other units for consistency. Given that all monetary amounts are in the same terms for both the Australian and Indian case studies, it is deemed that converting these amounts into a second unit for cross comparison would not add value.

- We have chosen to express our results in 2009 USD to match those results provided in *The Price of Sight* report to allow for easy comparison and analysis.

- The latest PPP exchange rates as listed on the International Monetary Fund are from the year 2008, four years out of date (IMF 2008).

Further, the key assumptions supporting our methodology that were discussed, including the outcome or change that arose is detailed in Table 22 below.

Table 22: Verification of assumptions

Discussion point	Outcome
1. **Quantifying benefits accruing from the additional investment required to eliminate avoidable blindness and visual impairment, above current eye health expenditure. This is divided into:** – **Backlog** – **Future incidence that would not be treated within the current eye health system scope, but could be treated if additional investment was made in the eye health system.**	This assumption recognises that whilst there is an ongoing cost to the eye health system, there is no associated benefit in countries where there is no growth required to support future incidence of persons that become avoidably blind and visually impaired. It was raised that in countries such as Australia, where no further growth in the health system was required to support the future incidence of avoidable blindness and visual impairment and thus where no future incidence benefit has been quantified, there would still be ongoing costs that would have to be accommodated. These are captured in the *Price of Sight* report. This assumption allows a more direct comparison to be made with the *Price of Sight* analysis.
2. **Determining the appropriate timeframe for quantifying benefits based on cause of blindness and visual impairment: prevalence (year-long benefit) versus lifetime approach (10 year benefit).**	It was raised that this is more applicable in developed countries where the risk of surgical complication is significantly lower, and may not be as true for developing countries. Given that we have assumed the 'lifetime' benefit for avoidable blindness and visual impairment caused by these conditions to include ten years only, we have not assumed that there will be no recurrent costs for the remainder of a person's life. The added complexity that would be required to provide an accurate estimate of the average ongoing year to year costs associated to these conditions has resulted in retaining this assumption.
3. **Quantifying direct health benefits to be those additional costs relating to falls.**	Whilst it was acknowledged that there are other co morbidities associated with avoidable blindness and visual impairment, it was agreed that falls was the major one and the one that could best be quantified based on the literature available. As such, this assumption has been retained.
4. **Employment rate in blind and visually impaired population assumed to be 32% (Gordon et al, 2011, The Cost of Vision Loss in Canada)**	This was deemed to be acceptable. It was raised that for OECD countries, there might be country specific literature which would be more accurate, this is not the case for developing countries. To progress towards a global quantification built up on regional estimates, we will use 32% going forwards.
5. **Assuming that all carers are at a productive loss regardless of age.**	This assumption was deemed to be appropriate.
6. **Assuming that 50% of blind persons in Australia require a carer, and that 100% of blind persons require a carer in India.**	Both these assumptions were deemed to be acceptable.

Quantifying benefits globally

The purpose of developing both the Australian and Indian case studies has been to clarify the approach and assumptions used to quantify the benefits of eliminating avoidable blindness and visual impairment on a country scale, prior to estimating the benefits globally.

The global quantification will follow the same approach used in the case studies to be built up on a regional basis, using Pascolini and Mariotti's 2011 prevalence data as a basis.

The global quantification will encompass the same benefits as identified and quantified in each of the case studies. These are the:

- direct health system savings attributable to falls
- productivity benefit for those with avoidable blindness or visual impairment
- productivity benefit for carers of those with avoidable blindness or visual impairment
- dead weight loss value per person with avoidable blindness or visual impairment.

Each of these benefits will be quantified following the same approach used in the case studies. Whilst the assumptions used are largely the same in the Australian and Indian case studies, there are a few variations which are the result of one country's economic position. The reasoning behind these differences will be drawn out further in the global quantification, where we will follow a pre-defined set of assumptions for each region.

As similar to the approach taken in the case studies, we will report the estimated number of DALYs averted on a regional basis in our global quantification, but will not include these in the quantified 'tangible' benefit total for the reasons outlined in this discussion paper, namely to avoid double counting and ending up with a benefit heavily weighted towards a DALY value.

Where our approach taken varies significantly from other analyses of this nature, such as Access Economics (2011), we will outline where the divergences lie. All benefits will be reported in 2009 USD on a global scale, consistent with the cost analysis, facilitating comparison and analysis.

References

Access Economics, 2004, The Economic Impact and Cost of Vision Loss in Australia, available at: http://www.cera.org.au/uploads/CERA_clearinsight_overview.pdf, accessed 10 July 2012.

Dandona, L, Dandona, R, Srinivas, M, et al, 2001, Blindness in the Indian State of Andhra Pradesh, *Investigative Ophthalmology & Visual Science*, 42(5)

Dirani, M, Crowston, J, Taylor, P et al, 2011, Economic impact of primary open-angle glaucoma in Australia, Clinical and Experimental Ophthalmology, 39

Index Mundi Country Facts, available at: http://www.indexmundi.com/facts/indicators/SP.DYN.CDRT.IN/compare?country=au#country=au:in

International Monetary Fund, 2008, Purchasing Power Parity conversion rates, available at: http://www.imf.org/external/pubs/ft/weo/2009/01/weodata/weorept.aspx?sy=2007&ey=2014&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=60&pr1.y=3&c=193%2C534%2C111&s=PPPEX&grp=0&a, viewed 10 July 2012.

Nangia, V, Jonas, J et al, 2011, Prevalence of age-related macular degeneration in rural central India, *The Central India Eye and Medical Study*, Retina, 31(6)

Shanmugam, KR, 2011, Discount rate for health benefits and the value of life in India, *Economics Research International*.

Su, Z, Wang, BQ, Buys, Y, Prevalence of visual impairment and blindness & Survey of barriers to eye care in a south Indian population.

Taylor, H, Keeffe, J, Vu, H et al, 2005, Vision loss in Australia, *Medical Journal of Australia, 182, 11*

Taylor 2009, Natioanl Indigenous Eye Heath Survey – Minum Barrent (Tracking Eyes), Centre for Eye Research Australia 2009 & the University of Melbourne, available at: http://www.cera.org.au/uploads/pub_NIEHS_summary.pdf, viewed 14 December 2012.

Venkata, G, Murthy, S, Gupta, S et al, 2005, Current estimates of blindness in India, *British Journal of Ophthalmology, 89*

pwc.com.au