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# Analysis of Costs and Benefits of the Gambian Eye Care Program

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**Objective:** To estimate the net benefit of the Gambian Eye Care Program (GECP) using a limited definition of benefits from a societal perspective.

**Methods:** The number of cases of blindness avoided was modeled using population projections, population-based blindness survey estimates from 1986 and 1996, and reported blindness-related mortality differences. Benefits were measured as lifetime productivity gains that resulted from the cases of blindness avoided between the surveys. Costs included all contributions to GECP between the surveys.

**Results:** In 1996, 1658 fewer individuals were blind than would have been without GECP. The present value of costs was US $1.28 million (1995 dollars). Although the net benefit between the blindness surveys was negative, the net lifetime benefit was US $1.01 million (1995 dollars), yielding an internal rate of return of 10%. In the primary sensitivity analysis, assuming similar benefits to Senegalese citizens, who accounted for 30% of patients, the internal rate of return was 19%. Upper bound sensitivity analyses result in internal rates of return higher than 20%.

**Conclusion:** In one sub-Saharan African country with avoidable blindness due to cataract and eye infections, the internal rate of return of a national eye care program was substantial when using a limited definition of benefit.

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BLINDNESS IMPOSES A SUBSTANTIAL economic burden worldwide.[1-4] As the population ages, even if age-specific blindness prevalence rates remain constant, the overall prevalence of blindness will increase. VISION 2020[1] aims to eliminate avoidable blindness by creating awareness, increasing resources for eye care, and facilitating improvements in national eye care services. A conservative estimate of the global burden of blindness has shown that more than $100 billion in potential lost productivity could be avoided if interventions promoted by VISION 2020 are as successful as hoped.[1] Although $100 billion would be a small fraction of the gross domestic product in the United States, it would represent a substantial gain relative to sub-Saharan African economies.[5]

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The Gambian Eye Care Program (GECP) has demonstrated a decrease in the crude prevalence of blindness from 0.70% to 0.42% between 1986 and 1996.[6,7] The prevalence in 1986 was similar to the global prevalence of blindness.[8] Although the prevalence in 1996 was somewhat higher than the levels anticipated for sub-Saharan Africa after VISION 2020 (0.33%),[1] this was achieved after only 11 years of implementation.



Modeling the net benefits of GECP, the objective of this study, requires several assumptions. Nearly all assumptions bias the results against a positive net benefit. A positive net benefit despite the assumptions would suggest that GECP is a viable model for all of sub-Saharan Africa.

## METHODS

### PREVALENCE AND MAGNITUDE OF BLINDNESS

Faal et al[6,7] reported from national population-based surveys that the crude prevalence of blindness in the Gambia was reduced by 40% between 1986 and 1996, from 0.70% to 0.42%. The entire decrease was attributed to GECP because no nongovernmental organizations focused on blindness prevention in the Gambia during the 11-year period other than those affiliated with GECP. Although the prevalence is expected to be representative of the population of the Gambia, the age distribution of the sample did not match the age distribution

**Table 1. Inputs to the Gambian Eye Care Program Provided by the Government and Donors**

| The Gambian Government | Sight Savers International | Other Donors* |
|---|---|---|
| Salaries for personnel | Hospital improvements | Cataract camp |
| Accommodation | Ophthalmic and other equipment† | Used spectacles transport |
| Drug supplies and materials | Motorcycle and parts purchase† | |
| Water and electricity | Training eye and medical staff | |
| Telecommunications | Some salaries, benefits, and allowances | |
| Transport costs | Running costs of units | |
| Equipment maintenance | Drug supplies and materials | |
| Patient feeding | Rent | |
| Land‡ | Eye care administration | |
| | Transport costs | |
| | Audits and inspections | |

*These costs were estimated.
†Capital costs are treated as expenses at the time of purchase.
‡Land value is not included. This leads to an underestimate of the true costs, although it is a reasonable reflection of the budgetary costs.

of the population in US Census Bureau figures. Thus, the number of cases of blindness avoided in each year between 1986 and 1996 was projected based on the following algorithm. First, the yearly population of the Gambia in 5-year age intervals was obtained from the US Census Bureau.[9] Second, age-specific prevalence rates of blindness were obtained from the published data for 1986 and from a re-analysis of the 1996 data.[6] Third, to project the number of cases of blindness, assuming that GECP had not been implemented, the age-specific prevalence rates reported for 1986 were multiplied by each year's population projections. Fourth, the prevalence within each age range was assumed to decrease by a constant proportion annually throughout the 11-year period, starting with the reported age-specific prevalence in the 1986 population and ending with the age-specific prevalence calculated for 1996.

## COST OF GECP

The expenditures for GECP from the Gambian government, Sight Savers International (West Sussex, England), and other donors began in 1986 and continued through 1996, with expenditures in Gambian dalasis and British pounds. Annual figures were obtained from GECP and the Overseas Department of Sight Savers International. These represent all known costs of blindness prevention in the Gambia during the 11 years of interest, since there were no nongovernmental agencies that dealt with blindness prevention in the Gambia other than those affiliated with GECP. All costs were converted into 1995 US dollars by the following algorithm. First, data were obtained from GECP on all expenditures in various currencies. These were adjusted to 1995 levels using the within-country inflation rates available in the World Bank data.[5] Second, the 1995 figures were translated into US dollars using the currency exchange rates from World Bank data.[5] Third, the expenditures reported during years 2 through 11 were discounted to the present value at the start of the program using a 3% discount rate. The present value indicates the value of money at the start of the program that would be required to fund the entire program if the interest rate for money that is not spent until a later period is the same as the discount rate. **Table 1** lists the inputs to GECP.

An opportunity cost for land use was not calculated. Capital expenditures were assessed at the time of purchase rather than across time based on the foregone interest earnings on the expenditure and changes in value, as would be the case when using a shadow-price-of-capital approach.[10] Costs for the donated cataract camp time and donated used spectacles were estimated.

## CALCULATION OF PRODUCTIVITY GAIN FOR 1986 TO 1996

The method of valuing 1 year of blindness used in the projection of the potential gains if the VISION 2020 program were as successful as envisioned can also be used in the estimate of the net benefit of a country-specific national eye care program. This method does not assume that the value of all individuals' time is the mean value of productivity or that the productivity loss is likely to be limited because of less than full employment.[11,12] Additionally, it is impossible to determine the importance of team production or the possibility of high penalties for productivity shortfalls that may affect the value of lost productivity.[13] The method assumes that accommodations were not made to help blind individuals be as productive as nonblind individuals, although there is only a partial loss of productivity. Furthermore, this method assumes that individuals who avoid blindness become completely productive.

The specific algorithm included the following steps. First, gross domestic product or gross national income per capita data were obtained for the years 1986 through 1996 in 1995 US dollars from World Bank data.[5] Second, the gross domestic product per capita was adjusted in proportion to the blindness weighting for disability-adjusted life-years (60%).[4] This is a lower figure than has been used in other articles that estimated the productivity lost due to blindness.[2,3] Third, it was assumed that if all blind individuals aged 15 to 64 years, regardless of sex, were not blind, they would have the same probability of being in the labor force and of being employed as the general population. Although there are data readily available on the labor force participation in the Gambia, there were no data on the unemployment rate. We therefore used the mean from the data on unemployment from sub-Saharan African countries in the 1986 to 1996 period.[5] Thus, for an individual between the ages of 15 and 64 years, the loss was assumed to be the gross domestic product per capita multiplied by 0.6 as mentioned previously, multiplied by the percentage of adults in the labor force, multiplied by 1 minus the unemployment rate. Fourth, individuals 65 years and older were assumed to be half as productive as younger adults aged 15 to 64 years. Fifth, each blind individual, regardless of age, was assumed to require one tenth of 1 productive adult's time, causing an additional productivity loss.

## LIFETIME BENEFITS FOR 1986 TO 2050

To project the lifetime benefits through 2050, we used the population estimates available from the US Census Bureau. All available gross domestic product or gross national income figures available through the year 2002 were used, and it was assumed that the gross national income per capita remained stable from 2002 until 2050.[5,14] We further assumed that (1) no additional cases of blindness would be avoided after 1996; (2) blind individuals have a relative risk of mortality of 2.3 compared with nonblind individuals (although other figures are available in the literature),[15-17] and (3) there was no migration. To determine the number of cases of blindness avoided from 1997 to 2050, we aged cases that had been prevented before 1996 through the remainder of their lives or until the youngest were 54 years old in 2050. The lifetime present value of the net benefit was calculated along with the internal rate of return (IRR). The IRR is the discount rate at which the net present value would just equal zero, and a recom-

mendation to adopt a program can be made if the social discount rate is believed to be lower than the IRR.[10]

### SENSITIVITY AND THRESHOLD ANALYSES

Three sensitivity analyses favorable to GECP were performed. The primary sensitivity analysis assumed that the benefits in the Gambia represent only 70% of the total, since 30% of the treatments were for Senegalese citizens. The second assumed that blind individuals lose 100% of their productivity rather than 60%.[2,3] The third assumed that all cases of blindness averted would result in a 60% productivity increase, not adjusting for labor force participation and unemployment. Although this does not directly capture the benefits to subsistence farmers, it provides an upper bound estimate. Two thresholds were calculated. The first allows for the possibility that the conservative base case estimate of productivity gain is excessive and calculates the minimum proportion of the base case productivity gain at which, in combination with other base case assumptions, the net benefit is nonnegative. The second allows for the possibility that some of the decrease in the prevalence of blindness may have occurred even without GECP and determines the minimum percentage of cases avoided that would need to be attributed to GECP to have a nonnegative net benefit, assuming base case productivity loss.

**Table 2. Estimated Population and Prevalence of Blindness in the Gambia Without and With GECP by Year**

| Year | Population | Projected Prevalence Without GECP, % | Estimated Prevalence With GECP, % |
|---|---|---|---|
| 1986 | 826 679 | 0.60* | |
| 1987 | 858 433 | 0.58 | 0.56 |
| 1988 | 891 486 | 0.57 | 0.52 |
| 1989 | 925 867 | 0.57 | 0.50 |
| 1990 | 961 606 | 0.56 | 0.47 |
| 1991 | 998 523 | 0.55 | 0.45 |
| 1992 | 1 036 442 | 0.55 | 0.44 |
| 1993 | 1 075 398 | 0.55 | 0.43 |
| 1994 | 1 115 210 | 0.54 | 0.42 |
| 1995 | 1 155 682 | 0.54 | 0.41 |
| 1996 | 1 196 782 | 0.54 | 0.40 |

Abbreviation: GECP, the Gambian Eye Care Program.
*This is slightly lower than the 0.7% figure that is published but is a result of using US Census Bureau population figures that represent a somewhat different distribution of ages than was suggested in the data of Faal et al.[6] The age-adjusted decrease in prevalence reported by Faal and colleagues was 0.55/0.7 = 0.79. Applying the 1996 age-specific prevalence rates to the 1986 population and calculating the ratio of the population prevalence to 0.60%, we observe a ratio of 0.75, suggesting a larger decrease from a smaller base and implying an uncertain effect on the estimated productivity gains.

## RESULTS

### PREVALENCE AND MAGNITUDE OF BLINDNESS

Between 1986 and 1996 the population of the Gambia increased 45%, from 827 000 to 1 197 000, with the prevalences of blindness given in **Table 2**. The 1986 prevalence rate using the US Census Bureau figures was 0.60%, and applying the 1996 age-specific prevalence rates obtained from a supplemental analysis of the data to the 1986 population yielded a prevalence of 0.45%. Previously reported prevalence rates were 0.70% for 1986 and 0.55% (age adjusted) for 1996.[6,7] This suggests a mismatch between the population sampled and the population data provided by the US Census Bureau; however, the proportional decrease in the prevalence rate appears to be similar. We project that 1658 cases of blindness were averted in 1996 from GECP. Of these, 1083 individuals (65.3%) were between the ages of 15 and 64 years, and 313 (18.9%) were children 14 years or younger (**Table 3**).

### COST OF GECP

The cost of GECP, converted to 1995 US dollars and measured as a present value, was US $1.28 million. In the first

**Table 4. Total Costs of the Gambian Eye Care Program by Year**

| Year | 1995 US $ | Present Value of 1995 US $ in 1986 | % of Total |
|---|---|---|---|
| 1986 | 82 270 | 82 270 | 6 |
| 1987 | 82 487 | 80 085 | 6 |
| 1988 | 51 416 | 48 465 | 4 |
| 1989 | 117 638 | 107 656 | 8 |
| 1990 | 52 308 | 46 475 | 4 |
| 1991 | 198 607 | 171 320 | 13 |
| 1992 | 52 509 | 43 975 | 3 |
| 1993 | 184 913 | 150 351 | 12 |
| 1994 | 412 632 | 325 735 | 25 |
| 1995 | 248 548 | 190 492 | 15 |
| 1996 | 44 498 | 33 165 | 3 |
| **Total** | **1 527 826** | **1 279 988** | **100** |

**Table 3. Person-years of Blindness Avoided by Age Group and Year**

| | Person-years of Blindness Avoided by Age | | | |
|---|---|---|---|---|
| Year | 0-14 y | 15-64 y | ≥65 y | Total |
| 1987 | 43 | 169 | 27 | **239** |
| 1988 | 83 | 320 | 52 | **455** |
| 1989 | 119 | 457 | 77 | **653** |
| 1990 | 153 | 579 | 102 | **834** |
| 1991 | 184 | 690 | 126 | **1000** |
| 1992 | 214 | 789 | 152 | **1154** |
| 1993 | 241 | 877 | 178 | **1295** |
| 1994 | 266 | 955 | 205 | **1426** |
| 1995 | 290 | 1024 | 233 | **1547** |
| 1996 | 313 | 1083 | 262 | **1658** |

**Table 5. Discounted Program Costs, Productivity Gain, and Net Loss and Benefit by Year for the Gambian Eye Care Program**

| Year | Discounted Program Cost, 1995 US $ | Discounted Productivity Gain, 1995 US $ | Discounted Net Loss or Benefit, 1995 US $* |
|---|---|---|---|
| 1986 | 82 270 | 0 | (82 270) |
| 1987 | 80 085 | 22 308 | (57 777) |
| 1988 | 48 465 | 41 219 | (7246) |
| 1989 | 107 656 | 57 872 | (49 784) |
| 1990 | 46 475 | 70 594 | 24 119 |
| 1991 | 171 320 | 80 974 | (90 346) |
| 1992 | 43 975 | 89 855 | 45 880 |
| 1993 | 150 351 | 96 871 | (53 480) |
| 1994 | 325 735 | 99 903 | (225 833) |
| 1995 | 190 492 | 102 508 | (87 983) |
| 1996 | 33 110 | 104 962 | 71 851 |
| **Total** | **1 279 934** | **767 065** | **(512 869)** |

*Net loss figures are in parentheses. Numbers do not always total because of rounding.

6 years, 38% of the costs ($584 700) were incurred (**Table 4**). The Gambian government and Sight Savers International were responsible for most of the expenses and spent 26% and 74%, respectively.

## NET BENEFIT FOR 1986 TO 1996

**Table 5** gives the discounted program costs and productivity gains by year of implementation. During the first 6 years of the program, the net loss was approximately $263 000, and during the last 5 years the net loss was $250 000, leading to a net loss during the 11 years of implementation of $513 000 after having spent $1.28 million. During the 11 years of implementation, there were positive net benefits only in the last year and in 2 other years marked by limited spending.

## LIFETIME BENEFITS FOR 1986 TO 2050

Calculating the net gains from 1986 (beginning of GECP) until 2050 (when the youngest individual helped by 1996 would be 54 years old) indicated a net gain of $1.01 million (**Table 6**), consistent with an IRR of 10%. With no discounting, the total spending was $1.5 million, the total benefit was $4.5 million, and the net benefit was $2.9 million.

## SENSITIVITY AND THRESHOLD ANALYSES

If the benefits to Gambian citizens are assumed to be only 70% of the total, with the remainder going to Senegalese citizens not reflected in the prevalence data, the IRR would be 19%. If blind individuals were assumed to lose all productivity and only the Gambian benefits were counted, the IRR would be 21%. If all cases of blindness averted resulted in increased productivity, with all other assumptions being those made in the base case analysis, the IRR would be 42%. Both threshold analyses use a 3% discount rate. Using initial assumptions about productivity gain and the population affected, at least 56% of the cases of blindness avoided would have to be attributable to GECP for the program to have a positive lifetime net benefit. Similarly, using initial assumptions, only 56% of the initial productivity gain needs to be achieved (perhaps unemployment in the Gambia is higher than in other parts of sub-Saharan Africa) for GECP to have a positive net benefit.

**Table 6. Present Value of Net Lifetime Benefits in the Decades From 1986 to 2050 for the Gambian Eye Care Program**

| Period | Net Gains and Losses, 1995 US $* |
|---|---|
| 1986-1995 | (584 720) |
| 1996-2005 | 658 433 |
| 2006-2015 | 434 026 |
| 2016-2025 | 254 323 |
| 2026-2035 | 156 423 |
| 2036-2045 | 67 876 |
| 2046-2050 | 20 493 |
| **Total** | **1 006 854** |

*Net loss figure is in parentheses.

## COMMENT

The GECP is associated with a long-term positive net benefit if avoiding blindness allows individuals to be more economically productive across time. Although the program was not projected to break even until 2004—18 years after its inception—the stream of costs and benefits suggests a 10% IRR by the time the youngest individual who was helped during the implementation would be 54 years old.

This positive net benefit was projected despite assumptions and methodological choices that were made to bias against a positive net benefit. The primary sensitivity analysis that extended the benefits calculation to Senegalese citizens who obtained care yielded an IRR of 19%. Even this IRR may be conservative, since the benefits were simply scaled up, although Senegal consistently has a higher level of economic output per capita than the Gambia.

Additional sensitivity analyses demonstrated upper bounds estimates of the IRR above 20% if all cases of blindness averted resulted in increased productivity or if a 100% productivity loss were assumed. Furthermore, less than two thirds of the base case productivity gain would need to be attributable to GECP for the program to have a nonnegative net benefit at the standard discount rate. These analyses support the conclusion that this program is likely to have a substantial positive net benefit.

A specific assumption that limited the projected benefit was the exclusion of the effect of averting blindness on quality of life.[18,19] Several other assumptions about economic growth limited the projected benefit because we assumed no real per capita economic growth after 2002 and that the labor force participation rate and unemployment rate would remain stable. Finally, we assumed conservatively that there were no additional cases of blindness averted after 1996. This implies that all of the resources used during the first 11 years of implementa-

tion reverted to operating relatively inefficiently after the 11 years studied, an unlikely outcome.

One assumption not previously discussed may bias the results in favor of a positive net benefit, although its effect is expected to be relatively small. The changing prevalence of low vision was ignored, although Faal and colleagues[6,7] showed an increase between 1986 and 1996. If individuals who do not become blind remain significantly visually impaired instead of having no visual impairment, this would change the benefit calculation.

Although the prevalence rates at the population level in this study are not identical to the published rates as a result of using different census figures, the ratio of the reported age-adjusted rates in 1986 and 1996 was similar to the ratio of the prevalence calculated for 1986 in this study and the figure that comes from applying 1996 age-specific prevalence rates to 1986 population data. If the published prevalence rate of 0.7% were closer to reality, the IRR would be 13%.

The GECP has other effects that have not been valued in this analysis. An estimated 320 000 people with eye disease were treated during the 11-year period; this suggests a reduction in eye disease or symptoms from eye disease that may extend beyond acuity and field impairments. Furthermore, the effects of improved infrastructure and human resources likely to continue after 1996 were excluded but could result in long-term benefits for population health.

The reduction in blindness between 1986 and 1996 was mainly the result of a reduction in blindness from cataract. Cataract was responsible for 55% of all blindness in 1986 (prevalence, 0.36%) and 45% in 1996 (prevalence, 0.18%). This 50% reduction in cataract blindness was consequent on increasing human resources necessary to provide cataract surgery from 1 to 6 people, reducing the distance to travel to access cataract surgery from 500 to less than 60 km, increasing hospital beds dedicated to patients receiving eye care from 7 to 63, and increasing the cataract surgical rate from fewer than 300 operations per million to approximately 1500 per million in 1996. The analysis that suggests that less than two thirds of the base case projected benefit would need to occur to yield a positive net benefit indicates that changes in cataract blindness alone may yield a positive net benefit.

For the remainder of sub-Saharan Africa, the economic projections imply potential lifetime net benefits of $800 million for $1.0 billion of expenditures throughout 11 years. However, these projections should be interpreted cautiously because (1) the Gambia is a small country with a centralized program, (2) the population density is high for the region, and (3) the prevalence of blindness in the Gambia was only 70% of the prevalence that Thylefors et al[8] suggested for the region. As a result, the outcomes and the initial investment for an eye care program may differ in other settings.

To improve the estimate of the economic benefits from eye care programs, the effect on the level of productivity needs to be accurately measured. Although there is a suggestion of the need for care for blind individuals from family members that could affect the family members' productivity, the proportion of time necessary and the productivity loss for blind individuals were both assumed rather than estimated.[3]

For a population of 800 000 to 1 200 000, GECP cost $1.28 million during its first 11 years (approximately $0.11 per person per year). During that period, the prevalence of blindness decreased substantially, mainly due to a 50% reduction in blindness from cataract. Although the program costs are greater than the economic benefits during the 11-year implementation period, the lifetime benefits suggest a substantial gain and a favorable IRR with a high upper bound. These findings are important for health policy, particularly for the VISION 2020 initiative, to eliminate avoidable blindness.

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## REFERENCES

1. Frick KD, Foster A. The magnitude and cost of global blindness: an increasing problem that can be alleviated. *Am J Ophthalmol*. 2003;135:471-476.
2. Smith AF, Smith JG. The economic burden of global blindness: a price too high! *Br J Ophthalmol*. 1996;80:276-277.
3. Shamanna BR, Dandona L, Rao GN. Economic burden of blindness in India. *Indian J Ophthalmol*. 1998;46:169-172.
4. Murray CJL, Lopez AD, eds. *The Global Burden of Disease*. Boston, Mass: Published for the World Health Organization and World Bank, Harvard University Press; 1996:413.
5. *World Development Indicators 2001* [book on CD-ROM]. Washington, DC: The World Bank; 2001.
6. Faal H, Minassian D, Sowa S, Foster A. National survey of blindness and low vision in The Gambia: results. *Br J Ophthalmol*. 1989;73:82-87.
7. Faal H, Minassian DC, Dolin PJ, Mohamed AA, Ajewole J, Johnson GJ. Evaluation of a national eye care programme: re-survey after 10 years. *Br J Ophthalmol*. 2000;84:948-951.
8. Thylefors B, Negrel AD, Pararajasegaram R, Dadzie KY. Global data on blindness. *Bull World Health Organ*. 1995;73:115-121.
9. US Census Bureau International Database . Available at: http://www.census.gov/ipc/www/idbacc.html. Accessed April 1, 2004.
10. Boardman AE, Greenberg DH, Vining AR, Weimer DL. *Cost-Benefit Analysis: Concepts and Practice*. Upper Saddle River, NJ: Prentice Hall; 1996.
11. Gold MR, Siegel JE, Russell LB, Weinstein MC. *Cost-Effectiveness in Health and Medicine*. New York, NY: Oxford University Press; 1996.
12. Koopmanschap MA, Rutten FF, van Ineveld BM, van Roijen L. The friction cost method for measuring indirect costs of disease. *J Health Econ*. 1995;14:171-189.
13. Pauly MV, Nicholson S, Xu J, et al. A general model of the impact of absenteeism on employers and employees. *Health Econ*. 2002;11:221-231.
14. World Bank Group Data and Statistics. Available at: http://www.worldbank.org/data/countrydata/countrydata.html. Accessed January 7, 2004.
15. Pion SD, Kamgno J. Demanga-Ngangue, Boussinesq M. Excess mortality associated with blindness in the onchocerciasis focus of the Mbam Valley, Cameroon. *Ann Trop Med Parasitol*. 2002;96:181-189.
16. Taylor HR, Katala S, Munoz B, Turner V. Increase in mortality associated with blindness in rural Africa. *Bull World Health Organ*. 1991;69:335-338.
17. Blohme J, Tornqvist K. Visually impaired Swedish children: the 1980 cohort study–aspects on mortality. *Acta Ophthalmol Scand*. 2000;78:560-565.
18. Schemann JF, Leplege A, Keita T, Resnikoff S. From visual function deficiency to handicap: measuring visual handicap in Mali. *Ophthalmic Epidemiol*. 2002;9:133-148.
19. Brown GC. Vision and quality-of-life. *Trans Am Ophthalmol Soc*. 1999;97:473-511.