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Global cost of correcting vision impairment from uncorrected refractive error

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Introduction

Uncorrected refractive error (URE) is the most common cause of vision impairment worldwide and the second most common cause of blindness.[1,2] The aim of this paper was to estimate the global cost of establishing and operating health-delivery systems that are capable of providing refractive care to all individuals who currently have vision impairment resulting from URE. The estimated cost can be compared to a previously published estimate of the annual cost of the productivity lost due to refractive vision impairment worldwide, of 269 000 million international dollars, equivalent to 202 United States dollars (US$).[3] The comparison provides an indication of the economic return that society might expect from the investment required to make refractive care accessible to all. We present an idealized account of the actions needed to solve the problem of URE globally, which can serve as a guide and provide an incentive for action. In reality, uncontrollable socioeconomic, cultural and political factors complicate the process and make the cost of eliminating URE unpredictable.

Methods

For this analysis, we used the current World Health Organization (WHO) definition of distance vision impairment: a visual acuity worse than 6/18 in the better eye.[4] For near vision impairment, since WHO has not specified a standard, we used the definition suggested by the International Agency for the Prevention of Blindness: "vision at the individual's required working distance worse than N8 in the better eye".[5]

As it has been reported that URE cannot be dealt with by existing eye care workers,[5] we have estimated the extra staff needed. In doing so, we adhered as closely as possible to each country's expectations of the specific personnel required to provide the various elements of refractive care.

Given the large number of individuals with URE, it was logical to assume that refractive care should be delivered in primary-care settings.[6] Moreover, WHO noted that, when refractive care is provided in primary care, the opportunity should also be taken to identify those who need treatment for eye disease.[7] Consequently, we based our costing of the infrastructure needed on a vision centre model that provides both refractive care and screening for ocular disease at the primary-care level.[8,9]

We combined data from several sources. Population data were mostly based on estimates for the middle of 2007 obtained from the International Data Base, a computerized database established by the United States Census Bureau that contains statistical tables of demographic data for 228 countries and areas of the world.[10,11] In doing this, we used the same population data as Smith et al.,[3] which enabled us to compare our findings with estimates of the cost of the productivity lost due to vision impairment made by those authors. Economic data included price level indices from the International Comparison Program of the World Bank[12] and the Asian Development Bank[13] and data on wage levels and resource use in health care were taken from WHO CHOICE databases.[14] Data on the prevalence of distance and near vision impairment due to URE in each country were obtained from the publications of Resnikoff et al.[1] and Holden et al.,[2] respectively. The number of cases of vision impairment in each country was derived by combining prevalence data with population data. To simplify reporting, we give estimates for the 14 subregions of the world used in the WHO publication *Global burden of disease 2002: data sources, methods and results*.[15]

New practitioners required

The number of new practitioners needed to provide clinical refraction services was estimated for each country by calculating how many refractive care practitioners were required to reach the ratio of 1:50 000 for the number of functional clinical refractionists to the population specified by WHO and the International Agency for the Prevention of Blindness[7] and by taking into account existing human resources. We defined a functional clinical refractionist as a person who spends 100% of his or her clinical time providing refraction services and estimated the equivalent number of full-time functional clinical refractionists available at present from the percentage of clinical time each particular type of professional spends on providing refraction services. For example, in Australia, although optometrists provide the majority of refraction services, they have other responsibilities and we estimated that the equivalent number of full-time functional clinical refractionists in the country was half the number of optometrists. Data sources for the number of practitioners who were providing refraction services worldwide are listed in Table 1.

Table 1. Data sources on existing refractive care practitioners, worldwide, 2006–2010
html, 11kb

There are individuals with vision impairment due to URE in many countries that do not require additional refractive care personnel because they exceed the functional clinical refractionists to population ratio specified by WHO and the International Agency for the Prevention of Blindness.[7] For example, an estimated 1.2 million people in Australia have distance or near vision impairment due to URE. Since the country has 2712 registered optometrists (equivalent to 1356 full-time refractionists), the functional clinical refractionists to population ratio is 1 to 15 069.[16,17] In countries like Australia, we assumed that the human resources required to provide clinical refraction services already existed and, consequently, that the cost of educating additional refractive care personnel would be zero.[18] In these cases, untreated vision impairment was regarded as resulting from difficulties accessing services.

We were unable to find any published data on the number of ophthalmic dispensing personnel required for the prevention of blindness. As dispensing personnel usually work in conjunction with refractive care personnel, our estimate for the number of dispensing personnel required in each region was a proportion of the number of functional clinical refractionists required. We varied the proportion with the average prevalence of refractive error in each region because, in areas where the prevalence is low, clinical staff will probably have to examine more people with normal vision or eye disease that require referral for each case of refractive error found. In contrast, dispensing personnel will be involved only when a refractive error is detected. Consequently, the ratio of dispensing personnel to functional clinical refractionists was taken to be 1:5 in Africa, 1:2 in Asia, 1:4 in Oceania and 1:3 in Europe, the eastern Mediterranean and the Americas. Given that these ratios were chosen arbitrarily, we used a ratio of 1:1 in every country when establishing an upper limit for costs.

Cost of educating practitioners

In estimating the cost of educating the new practitioners required to provide refractive care in each country, we made several assumptions about capital and running costs.

For economic reasons, we grouped together countries that were similar geographically and politically and assumed that a shared institution could provide education for a region requiring 1500 functional clinical refractionists. For example, we estimated the capital costs of the two educational facilities required in Anglophone eastern Africa for educating

2981 functional clinical refractionists in Ethiopia, Kenya, Uganda and the United Republic of Tanzania combined. When such combinations were not possible, we attempted to find a compromise. For example, we postulated that an institution in Mozambique could serve all of Lusophone Africa. In this case, the cultural and linguistic ties between populations were considered to outweigh the fact that the combined total of functional clinical refractionists required was only 585. The data sources for the capital and running costs of educational facilities for new refractive care practitioners are given in Table 2. When no data were available for a country, we extrapolated costs in similar countries by adjusting the price level index for differences in the cost of living between countries. Price level indices obtained from the World Bank provide a broad measure of costs rather than costs specific to education.[12] The cost of educating dispensing personnel was also included in educational costs. [illegible] an additional sum to cover continuing professional development for all personnel for a period of [illegible] years.

Table 2. Data sources for capital and running costs associated with educating refractive care practitioners, worldwide, 2006–2010
html, 5kb

Cost of new refractive care facilities

We estimated the cost of establishing, equipping and running refractive care facilities for the new practitioners required in each country. First, the number of new care facilities was estimated. When the functional clinical refractionists-to-population ratio was less than 1 to 50 000, we calculated the number of new practitioners required using the method described above. When the ratio was higher than 1 to 50 000, we used a problem-solving approach to estimate the cost of increasing the accessibility of the existing workforce. With the problem-solving approach, we estimated the number of new or redeployed personnel required from the total number of URE cases needing treatment by assuming that a full-time functional clinical refractionist can deal with 2067 cases of vision impairment due to URE per year on average and that [illegible] and provided with replacement spectacles every 5 years on average. The average of [illegible] cases per year was derived by assuming that a [illegible] practitioner works 5 days a week, has 6.2 weeks annual leave and sees six patients with vision impairment due to URE per day. Since half of these patients will have both distance and near vision impairment, in effect a total of nine cases of vision impairment due to URE will be dealt with per working day. Regardless of which method was used to estimate the number of new or redeployed practitioners needed, we calculated the number of care facilities required by dividing by 1.3, based on an estimation of approximately four practitioners for every three vision centres.

Second, the capital cost of establishing and equipping the new facilities required was estimated. In most cases, we used an average of US$ 50 000 per care facility, which was based on information provided by the international charity Sightsavers and published by the International Agency for the Prevention of Blindness.[5] The amount includes the cost of equipping care facilities with bulk-purchased equipment, such as clinical refractive equipment, ocular health screening equipment, ophthalmic dispensing equipment and accounting and business equipment, and the cost of start-up stock.

Third, we estimated the cost of running the new facilities required for a period of 5 years, on the assumption that costs would be recovered from charges to patients during this period. Running costs included salaries, rent and electricity, water, telephone and consumable costs. The cost of most of these items was derived from the WHO CHOICE database for each geographical subregion.[14] The cost of consumables was calculated on the assumption that 72.4% of individuals used ready-made spectacles and 27.6% used custom-made spectacles,[19] with the cost of each type being based on the real costs reported by the International Centre for Eyecare Education.[20] In addition, it was assumed that each refractive care unit paid salaries to 1.3 refractive care practitioners, 1 receptionist, 0.2 managers and several ophthalmic dispensing personnel determined for each region separately, and that every 20 refractive care units required a support team consisting of 1 programme director, 2 administrative officers, 1 clerk, 1 messenger, 1 finance director, 1 accountant, 1 public health specialist, 1 health educator, 1 social worker, 1 supplies manager, 4 cleaners and 4 security officers. Rent was calculated assuming that each refractive care unit had 1 consulting room 3.5 m × 3 m in size and 1 general purpose room 3.5 m × 4 m in size, that each fifth refractive care unit had 1 optical workshop 3.5 m × 3 m in size and that each twentieth refractive care unit required a room 6 m × 6 m in size for the support team.

We estimated an upper limit to the cost of establishing, equipping and running refractive care facilities by altering critical assumptions so that they reflected the most expensive scenarios. First, we assumed that one ophthalmic dispenser was employed for each clinical refractionist. Second, the ratio of ready-made to custom-made spectacles was assumed to be 20 to 80, which is in line with expectations in the developed world, rather than the ratio used for the main cost estimate, which assumed the lowest acceptable quality of care.[21]

Results

The estimated number of cases of distance and near vision impairment due to URE in WHO regions and subregions are listed in Table [illegible]. In addition, the table gives details of the existing number of functional clinical refractionists and of the number of new functional clinical refractionists required to deal with all cases of vision impairment due to URE. The [illegible] vision impairment due to URE in the middle of 2007 was around 158 million and the [illegible] URE was around 544 million. As some individuals will have both forms of vision impairment, we estimated the total number of cases of vision impairment due to URE in the world, which was around 703 million in 2007, rather than the number of individuals.

Table 3. Distance and near vision impairment due to uncorrected refractive error (URE) and number of functional clinical refractionists,[a] worldwide, 2006–2010
html, 12kb

Globally, the equivalent of around 167 000 full-time functional clinical refractionists were dealing with vision impairment due to URE in 2007. Fig. 1 shows the functional clinical refractionists to population ratio worldwide. We estimated that approximately 47 000 additional full-time functional clinical refractionists and 18 000 additional ophthalmic dispensers would be needed to deal with all cases of vision impairment due to URE. Other measures would have to be taken in some countries with an adequate number of personnel to overcome problems with access to care.

Fig. 1. Functional clinical refractionists to population ratio, worldwide, 2006–2010

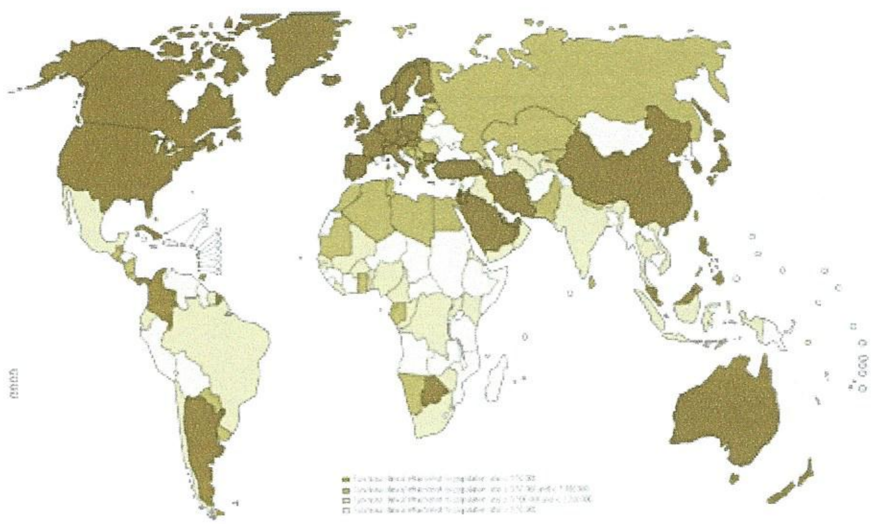


Table 4 summarizes the estimated investment required to educate new refractive care practitioners, including ophthalmic dispensing personnel, in WHO regions and subregions, to provide continuing professional development for 5 years, to establish the service delivery centres needed and to fund these centres for 5 years. The running costs of the centres included the cost of providing refractive care to the estimated backlog of 703 million cases of vision impairment due to URE. Globally, the total capital investment for establishing educational institutions with sufficient training capacity was estimated to be US$ 104 million. An additional US$ 46 million would cover continuing professional development for new personnel for the first 5 years of their careers. The total educational costs were US$ 543 million, which includes the capital costs of education, the cost of educating student refractive care personnel and student ophthalmic dispensers and the cost of continuing professional development for all new personnel for 5 years.

Table 4. Cost of education and new facilities for additional refractive care practitioners[a] required to correct vision impairment due to uncorrected refractive error, worldwide, 2006–2010
html, 13kb

Table 4 also shows that the estimated capital investment needed to establish service delivery facilities for the new and redeployed refractive care personnel required to deal with vision impairment resulting from URE worldwide was US$ 2620 million. In addition, it was estimated that these facilities would cost US$ 3380 million per year to operate for the first 5 years. Assuming that the revenue generated by the service would covers costs after the first 5 years, the total investment in service delivery required (i.e. capital costs and 5 years of running costs for new refractive care facilities) to deal with vision impairment resulting from URE was estimated to be US$ 19 501 million.

Consequently, the total estimated cost for educating the new refractive care and ophthalmic dispensing personnel, plus providing the service delivery facilities needed to deal with the backlog and all incident cases of distance and near vision impairment resulting from URE was US$ 20 045 million.

Our estimated upper limit for the cost of education and new facilities for the additional refractive care practitioners required to correct all vision impairment due to URE globally was US$ 28 452 million.

Discussion

Several considerations should be taken into account when interpreting the data reported in this paper. First, only the cost of correcting vision impairment as defined by WHO was estimated and not the cost of providing vision care to the world population at the level expected in developed countries, where the target acuity is 6/6 for distance vision and N5 for near vision and where many people want spectacles to correct refractive error that does not result in vision impairment. Although we estimate that globally over 3 000 million people have some level of refractive error, our calculations considered only the 703 million cases of distance or near vision impairment due to URE.

Second, the WHO protocol for eye examinations[22] states that, when visual loss is due to several coexisting primary disorders, the "most readily curable" disorder should be regarded as the cause of visual loss. It is possible, therefore, that the prevalence of vision impairment due to URE may have been overestimated.

It is rare for refractive care practitioners to be distributed throughout a country in a way that ensures equitable access for all communities and, generally, the poorer and more rural a community is, the more limited access to refractive care will be. Even in Europe, where there is an adequate number of practitioners, we estimated that an additional 2000 functional clinical refractionists as well as the redeployment of some existing refractive care personnel was required to overcome the geographical, financial and other barriers that restrict access to refractive care for some individuals with distance or near vision impairment due to URE. Consequently, our estimates included the cost of redeploying practitioners in countries where the poor distribution of service providers contributed to prevalence of vision impairment due to URE.

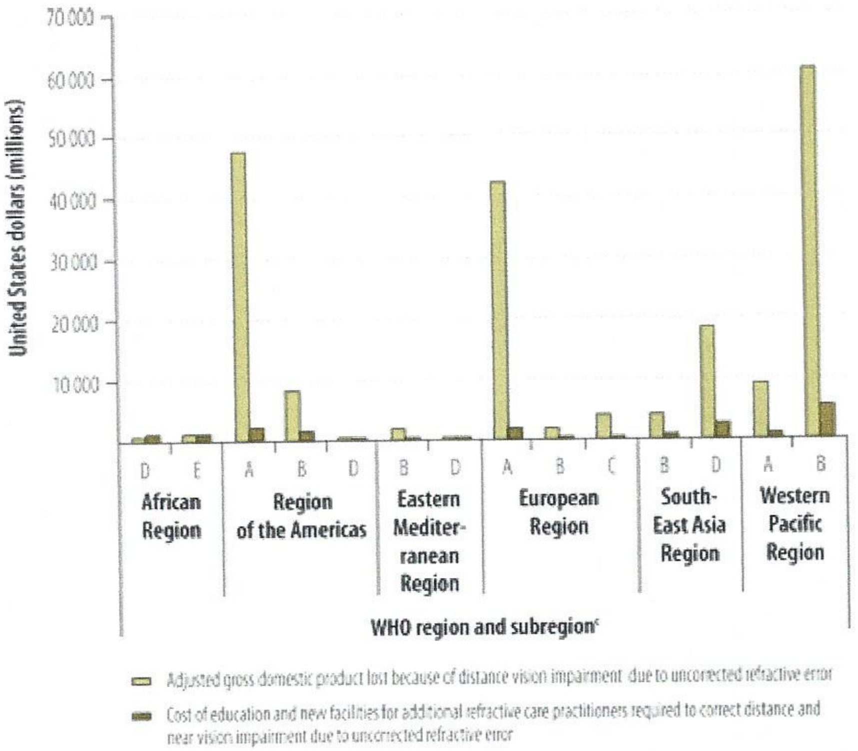
In our analysis, we chose not to anticipate innovative technologies that may be able to assess and correct refractive error at a lower cost because of the uncertainties involved. Our estimates of the costs of education and service delivery are, therefore, based on the use of current techniques and equipment.

Although we made several assumptions in estimating costs, we erred on the side of obtaining the highest estimates. In addition, our estimate of the upper limit of the costs, of US$ 28 000 million, was made by using the most extreme values for critical variables.

Smith et al.[3] estimated the value of the productivity lost because of distance vision impairment due to URE to lie between 121 400 million and 427 700 million International dollars (equivalent to US$ 91 300 million to US$ 327 700 million), depending on whether or not the figure was adjusted to take account of the labour force participation rate and the employment rate and was based on the assumption that people over 50 years of age do not contribute to the economy. These two figures give a range for the possible increase in global gross domestic product that would result from providing refractive care for all. In effect, it is the return on investment.

Fig. 2 shows a comparison between the estimated loss in gross domestic product due to distance vision impairment caused by URE in different regions and the cost of education and new facilities for the additional refractive care practitioners required to correct all vision impairment due to URE. There would be a substantial return on the investment required to deal with vision impairment resulting from URE in all regions except the African Region. Globally, the estimated rate of return on a total investment of US$ 20 045 million over 5 years, which is the total estimated cost of dealing with the backlog and all incident cases of vision impairment due to URE, would be 59%, even if it was assumed that all expenses were incurred in the first year and none of the benefits occurred until the last year and lasted only 1 year.

Fig. 2. Loss of gross domestic product due to uncorrected refractive error (URE)[a] and costs for additional refractive care practitioners required to correct vision impairment,[b] by WHO region, 2006–2010



WHO, World Health Organization.[a] The loss in gross domestic product is that resulting only from distance vision impairment caused by URE.[3][b] Refractive care practitioners include functional clinical refractionists, who spend 100% of their clinical time providing refraction services, and ophthalmic dispensers. The costs given are for the additional practitioners required to treat both distance and near vision impairment caused by URE.[c] World Health Organization subregion categories: A: very low child mortality and very low adult mortality; B: low child mortality and low adult mortality; C: low child mortality and high adult mortality; D: high child mortality and high adult mortality; and E: high child mortality and very high adult mortality.

Existing refractive care has not been able to deal with an estimated 703 million cases of vision impairment resulting from URE, which means that the needs of around 10% of the world's population have not been met. Although our estimate of the cost of establishing and operating the educational and refractive care facilities required to deal with vision impairment resulting from URE, of around US$ 20 000 million globally, can only be approximate, the return on investment would be substantial. Even our upper limit for the cost, which is US$ 28 000 million over 5 years, is considerably below the estimated economic cost of vision impairment due to URE, which has been estimated to be US$ 202 000 million each year.[3] The scale of this return on investment means that correcting vision impairment due to URE provides a good opportunity for global development.

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Competing interests:

None declared.

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