

# Refractive error blindness

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Recent data suggest that a large number of people are blind in different parts of the world due to high refractive error because they are not using appropriate refractive correction. Refractive error as a cause of blindness has been recognized only recently with the increasing use of presenting visual acuity for defining blindness. In addition to blindness due to naturally occurring high refractive error, inadequate refractive correction of aphakia after cataract surgery is also a significant cause of blindness in developing countries. Blindness due to refractive error in any population suggests that eye care services in general in that population are inadequate since treatment of refractive error is perhaps the simplest and most effective form of eye care. Strategies such as vision screening programmes need to be implemented on a large scale to detect individuals suffering from refractive error blindness. Sufficient numbers of personnel to perform reasonable quality refraction need to be trained in developing countries. Also adequate infrastructure has to be developed in underserved areas of the world to facilitate the logistics of providing affordable reasonable-quality spectacles to individuals suffering from refractive error blindness. Long-term success in reducing refractive error blindness worldwide will require attention to these issues within the context of comprehensive approaches to reduce all causes of avoidable blindness.

**Keywords:** Refractive errors/complications/etiology; Amblyopia/etiology (*source: MeSH*).

**Mots clés:** Troubles réfraction oculaire/complication/étiologie; Amblyopie/étiologie (*source: INSERM*).

**Palabras clave:** Errores de refracción/complicaciones/etiología; Amblyopia/etiología (*fuentes: BIREME*).

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## Introduction

Refractive error as a cause of blindness has not received much attention because many definitions of blindness have been based on best-corrected distance visual acuity, including the definition used in the International Statistical Classification of Diseases and Related Health Problems (1). However, in many parts of the world refractive error would become the second largest cause of *treatable* blindness after cataract if blindness were defined on the basis of presenting distance visual acuity (2–10). Refractive error is also one of the most common causes of visual impairment (3–5, 9–13).

Because of the increasing realization of the enormous need for correction of refractive error worldwide, this condition has been considered one of the priorities of the recently launched global initiative for the elimination of avoidable blindness: VISION 2020 — The Right to Sight (14, 15). For the most

part, refractive error can be easily corrected with spectacles, which makes it imperative that effective strategies be developed to eliminate this easily treatable cause of blindness.

This review presents a summary of the current and likely future issues related to blindness due to refractive error.

## Definition of blindness

Blindness is defined either in terms of best-corrected distance visual acuity (the most appropriate refractive correction) or presenting distance visual acuity (the individual's current refractive correction) in the better eye. The latter definition permits assessment of blindness due to refractive error, whereas the former does not. Although a large amount of data are available on the prevalence of blindness in different parts of the world (16), data on the prevalence of blindness due to refractive error are not readily available because the presenting distance visual acuity definition is not always used.

Also of importance in the definition of blindness is the level of visual acuity that is applied. Visual acuity levels of <3/60 or <6/60 in the better eye have been commonly used to define blindness (2–9). In addition, visual acuity levels <6/60 have sometimes been used to define blindness, for example in the USA (10).

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## Magnitude of refractive error blindness

We carried out a literature search to identify information from different parts of the world on the magnitude of blindness due to refractive error from population-based surveys of blindness published in 1990 or later. The findings are summarized in Table 1 (2–10).

With blindness defined as a presenting distance visual acuity  $< 3/60$  in the better eye, the prevalence of blindness due to refractive error has been reported to be as high as 0.20% in Pakistan (2) and India (7), for all age groups in the population considered together. If blindness is defined as presenting distance visual acuity  $< 6/60$  in the better eye, the prevalence of blindness due to refractive error in an Indian population was reported to be 0.36%, including 0.06% from amblyopia resulting from high uncorrected refractive error (7). These data suggest that about 1 of every 280 people in the study population were blind from uncorrected or inadequately corrected refractive error or from refractive error-related amblyopia.

A high prevalence of refractive error blindness (0.59%) was found among a population of Chinese over-50-years using the definition of presenting distance visual acuity  $< 6/60$  in the better eye (8). With this definition, the prevalence of blindness due to refractive error among those aged  $> 40$  years in an Indian study population was reported to be quite high (1.06%) (7). With blindness defined as a presenting visual acuity  $< 6/60$  in the better eye, the prevalence of refractive error blindness in the USA among individuals aged  $> 40$  years has been reported to 0.33% among Blacks and 0.24% among Whites (10). It must be kept in mind, however, that if only older age groups are considered, the prevalence of refractive error blindness is likely to be higher because of cumulative effects, than that for all age groups taken together.

The available data suggest that in India (7) and China (8) blindness due to natural refractive error is more common than that due to aphakia, whereas blindness due to aphakia is more common in some African countries (5, 6).

Studies carried out in schools for the blind have also reported blindness due to refractive error. For example, uncorrected myopia and aphakia were responsible for 3% of the blindness among blind-school children in Zimbabwe (17), while uncorrected aphakia and amblyopia were responsible for 5.1% of the blindness among blind-school children in India (18).

Although data on refractive error blindness have only recently started to become available, evidence suggests that blindness due to uncorrected or undercorrected high refractive error is a significant problem in developing and developed countries alike.

## Impact of refractive error blindness

Blindness due to uncorrected or inadequately corrected natural refractive error starts at a younger age than cataract, which manifests itself in old age (7). If the impact of blindness due to refractive error is considered in terms of blind-person-years, a person becoming blind due to refractive error at a young age, and which is not corrected, would suffer many more years of blindness than a person becoming blind from cataract in old age and would place a greater socioeconomic burden on society. In the Indian state of Andhra Pradesh, among the individuals who are blind currently, the total number of blind-person-years suffered over their lifetime by those blind due to refractive error was estimated to be about twice that suffered by those blind due to cataract (7).

Blindness due to natural refractive error can hinder education, personality development, and career opportunities, in addition to causing an economic burden on society. However, the impact of blindness from myopia may be different from that from hyperopia, since those blind due to myopia are likely to have better near vision than those who are so due to hyperopia. Though there are no data available on the economic loss as a result of blindness due to natural refractive errors, it would not be unreasonable to assume that it is probably significant since a large proportion of those affected are in the economically productive age group (7). However, this burden of economic loss may vary with the type of refractive error. Since aphakia is a cause of blindness among older age groups, the economic loss associated with it is likely to be less than that associated with blindness due to myopia and hyperopia.

## Detection of refractive error

Refractive error can be detected through routine examination of patients who present to clinics, or through vision screening of the population at large. The former approach may work satisfactorily in developed countries, but the latter is necessary in developing countries because a large majority of the population does not have access to reasonable quality eye care services. Vision screening is most commonly carried out on schoolchildren, which is a valuable method of identifying potentially treatable ocular abnormalities, including blindness due to refractive error and related amblyopia (19–21). School screening is performed in various ways, including simple visual acuity assessment by school teachers or paramedical professionals, and by using computers to assess vision. In developing countries, school-teachers have been most commonly used for vision screening of schoolchildren (19, 20). In recent years, vision screening has also included preschool children (21–23). However, current understanding of the natural history of refractive error and amblyopia is incomplete, thus limiting the prophylactic potential of early screening of preschool-age children (24).

Table 1. Prevalence of blindness due to refractive error reported from population-based surveys in selected countries

Year of publication	Country	Age groups studied (years)	Sample size	Prevalence of blindness	Prevalence of blindness due to refractive error	Type of refractive error responsible for blindness
<b>Blindness definition 1<sup>a</sup></b>						
1992	Pakistan (ref. 2)	All ages	29 139	1.78%	0.20%	Aphakia, natural refractive error
1996	Turkey (ref. 3)	All ages	7497	0.40%	0.05%	Aphakia
1997	Lebanon (ref. 4)	All ages	10 48	0.60%	0.08%	Myopia, hyperopia, aphakia
1997	Ethiopia (ref. 5)	All ages	7423	0.85%	0.04%	Aphakia
					0.03%	Natural refractive error
1998	Tunisia (ref. 6)	All ages	3547	0.80%	0.05%	Aphakia
2001	India (ref. 7)	All ages	10 293	1.34%	0.10%	Myopia
					0.01%	Hyperopia
					0.04%	Aphakia
					0.05%	Refractive-error-related amblyopia
<b>Blindness definition 2<sup>b</sup></b>						
1999	China (ref. 8)	>50	5342	4.37%	0.40%	Myopia, hyperopia
					0.19%	Aphakia
2001	Australia (ref. 9)	>40	4744	0.51%	0.11%	Myopia, hyperopia
2001	India (ref. 7)	All ages	10 293	1.84%	0.21%	Myopia
					0.03%	Hyperopia
					0.06%	Aphakia
					0.06%	Refractive-error-related amblyopia
<b>Blindness definition 3<sup>c</sup></b>						
1990	USA (ref. 10)	≥ 40 (Blacks)	2395	1.88%	0.33%	NA <sup>d</sup>
		≥ 40 (Whites)	2913	1.17%	0.24%	NA

<sup>a</sup> Presenting distance visual acuity <3/60 in the better eye.

<sup>b</sup> Presenting distance visual acuity <6/60 in the better eye.

<sup>c</sup> Presenting distance visual acuity ≤ 6/60 in the better eye.

<sup>d</sup> NA = not available.

Since in developed countries the majority of children attend schools or preschools, it is relatively easier to reach them by vision screening programmes. However, in developing countries many children do not attend school (25), and they are therefore missed by vision screening programmes conducted in schools. This problem can be overcome by the community vision screening approach.

The community vision screening approach involves door-to-door surveys by trained field workers to assess visual acuity and identify people with vision problems. This is followed by refraction by trained paramedical ophthalmic staff, provision of spectacles, and referral to the base hospital if any surgical or medical management is indicated (26). This approach is more useful than school screening because it covers "school-aged children" (instead of only "school-going children"), young adults, and the older population to identify and treat uncorrected refractive error. Community vision screening approaches involve more financial and human resources than school screening approaches, but community screening is likely to be more useful in dealing with refractive error blindness in the population, particularly when implemented as part of a comprehensive eye care programme (26).

## Treatment of refractive error

Most refractive errors are easily treatable by appropriate refractive correction. However, high refractive error in childhood may lead to amblyopia, resulting in permanent vision loss if it is not corrected during early childhood. Refractive correction can be by spectacles, contact lenses, or refractive surgery. Spectacles are the most commonly used form of refractive correction since they are the most inexpensive and the simplest of the three options; as such, they are the most appropriate treatment for refractive error in developing countries. However, all three forms of treatment for refractive error are relatively easily available and more affordable to individuals in developed countries.

Provision of spectacles is currently a challenge in many developing countries because of issues related to availability and affordability. There are often inequities in the availability of spectacles between urban and rural areas.

Different strategies have been tried to increase the availability and affordability of reasonable-quality spectacles, with varying degrees of success. These include manufacturing low-cost spectacles in developing countries using trained staff, an approach that has been tried in Africa and Asia (27), use of ready-

made spectacles with spherical correction for refractive errors (28), and provision of spectacles at cost price to the poor. Much work still needs to be carried out to optimize the logistics necessary to provide spectacles to all those who would otherwise be blind without them.

## Human resources and infrastructure

Depending on their availability in different parts of the world, refractive services are provided by various categories of eye care providers, including optometrists, ophthalmic technicians, opticians, and ophthalmologists.

Adequate numbers of trained personnel for carrying out refraction are currently not available in many developing countries (29). To meet this deficiency, more personnel need to be trained to perform reasonable-quality refraction, and permanent infrastructure needs to be developed in underserved areas so that adequate refractive services can be provided in the long term.

## Discussion

Even though the treatment of refractive error is simple and successful, the condition is still responsible for a significant amount of blindness in both developing and developed countries (2–10). Refractive error is also one of the leading causes of visual impairment in different parts of the world (3–5, 9–13). The burden of blindness due to refractive error, in terms of blind-person-years, is even more significant than the numbers indicate since refractive error blindness mostly starts at a young age and probably causes significant economic and social burden to societies. Recent data from India suggest that, in terms of blind-person-years among the individuals who are blind currently, the burden on society due to refractive error blindness is about twice that due to cataract blindness (7).

### Definition of blindness

Refractive error as a cause of blindness has been recognized only recently since many of population-based surveys of blindness have used best-corrected distance visual acuity to define blindness. This definition of blindness misses cases of refractive error blindness, since it does not take into account the level of vision with which people actually function in their daily lives. Those who have poor enough vision to qualify as “blind” due to uncorrected or inadequately corrected high refractive error are considered as “not blind” because their vision improves with best refractive correction. However, these people are actually blind because they function with poor vision due to lack of appropriate refractive correction. Because refractive error blindness is missed with the best-corrected distance visual acuity definition, assessments of blindness should be based

on presenting distance visual acuity if refractive error blindness is to receive its due attention and be eliminated. This definition would give the “real” magnitude of blindness in a population. Failure to acknowledge refractive error as a significant cause of blindness is further underscored by the finding that some children with poor vision due to uncorrected high refractive error have been identified in schools for the blind (17, 18).

### Refractive-error-related amblyopia

It is generally believed that blindness due to refractive-error-related amblyopia is not a significant problem. However, recent data from India suggest that this needs to be reconsidered. For example, in a population-based study in the Indian state of Andhra Pradesh, 0.06% of the population was blind due to refractive-error-related amblyopia (7). These data suggest that in the study population, 20% of those who had a high enough refractive error to be blind had developed dense amblyopia resulting in irreversible blindness. Blindness due to amblyopia resulting from uncorrected high refractive error may therefore not be insignificant, at least in some populations.

### “Index myopia”

“Index myopia” (myopia induced by development of nuclear cataract) should be kept in mind when determining blindness due to refractive error. For individuals blind due to moderate-to-severe nuclear cataract, placing a high negative dioptre lens in front of the eye may improve their vision somewhat and shift the vision category from “blind” to “not blind”. However, the real cause of poor vision in such cases is cataract (which induced the index myopia) and not refractive error, and clinically most of the patients with significantly advanced cataract would be advised to have surgery even if their vision improved slightly with a high negative correction. The caveat here is that there is a danger of “overestimating” refractive error blindness if poor vision resulting from cataract-related index myopia is attributed to refractive error. This would be a distortion, and could lead to inaccurate estimates and inappropriate strategies. Such a distortion would be somewhat analogous to the previous overestimation of blindness attributed to cataract in India because detailed dilated eye examinations were not carried out, resulting in misclassification of posterior segment blindness as cataract blindness (30).

### Provision of spectacles

It is a major public health failure that so many people continue to be blind in both developing and developed countries because they do not have the appropriate spectacles. The question therefore arises as to why these people are not able to obtain refractive correction. In developing countries, the reasons include a low rate of seeking refractive error correction (31) and limited access to treatment

because of generally inadequate infrastructure and human resources (29). It is surprising that also in developed countries there is a fairly high level of refractive error blindness, the reasons for which have not yet been fully elucidated (32). Attempts at reducing refractive error blindness need to address the following major issues: provision of adequate infrastructure and human resources to detect refractive error; making affordable spectacles available; and actually dispensing the spectacles.

### Comprehensive eye care

It would seem prudent to view the elimination of refractive error blindness as part of a comprehensive eye care approach, which would address also the other major causes of blindness. This would be more efficient and also facilitate long-term solutions for reducing blindness. This issue is particularly important in developing countries, where the scanty infrastructure and human resources have led to piecemeal approaches to blindness control, and which more often than not have failed to produce substantial results. Development of adequate facilities and reasonably trained human resources to tackle refractive error blindness should therefore be part of the overall framework to deal with blindness in a country. Some projects using this approach are showing success (26), but it needs to be tried on a much larger scale. Within this framework, particularly for refractive error, sufficient personnel to carry out refraction would have to be made available through good quality training.

Vision screening programmes in the community, including school screening, would probably make it possible to detect individuals suffering from refractive error blindness. Such screening programmes need to be implemented on a large scale. There are several questions that need to be addressed when planning such programmes, the most important of which are what age groups should be targeted for screening and how the services would be provided to those who need them. Reliable data on the prevalence of blindness due to refractive error and the distribution of refractive error obtained from population-based surveys would indicate the groups that need to be targeted for vision screening to reduce refractive error blindness. Data on the distribution of refractive error are available for some populations (33–46). In developing countries, there is a need to include all school-aged children in the screening rather than only school-going children, since many do not attend school.

Provision of services to individuals who need them after being identified through vision screening is as important as the vision screening itself. Provision of affordable, reasonable-quality spectacles is crucial for the effective delivery of eye care services. The emphasis in such vision screening programmes should not only be on the number of people screened, but also on the number who experience substantial improvement of vision with spectacles.

Aphakia after cataract surgery is also a significant cause of blindness in developing countries since many individuals with aphakia do not obtain adequate spectacles or lose them and do not have them replaced. These difficulties can be addressed, on the whole, through provision of cataract surgery with intraocular lens implantation, which would reduce the chances of blindness due to aphakia. In addition, provision of adequate refractive services for those with aphakia has to be tied with cataract blindness programmes.

Other issues that need to be addressed include the following: adequate understanding of the barriers to providing eye care services; and encouragement of eye health promotion activities. Some work has been carried out on the assessment of barriers to cataract surgery, but systematic data on barriers to refractive correction are quite scanty (31, 32). More research is needed in this area to plan strategies that would be effective in reducing refractive error blindness. Eye health promotion activities, including routine eye examinations, also need to be encouraged for long-term and sustainable reduction of blindness. However, in developing countries such activities would have to be planned carefully after taking into account the competing demands on the time and scanty financial resources of people in these countries.

Recent data suggest that there has been an increase in the prevalence of myopia in some parts of the world over the past few decades (34, 35, 41–43). The reasons for this are not clear but this trend could result in a higher prevalence of high myopia which, if not adequately corrected, could result in an increase in the number of people who are blind due to refractive error.

### Conclusions

Blindness due to refractive error is a substantial public health problem in many parts of the world. Its presence implies inadequate eye care services in the population concerned since treatment of refractive error is probably the simplest and most effective of eye care interventions. Elimination of avoidable blindness due to refractive error requires that the following be satisfied: a definition of blindness be used that consistently uses the presenting distance visual acuity definition; good-quality population-based data be available on the various aspects of refractive error blindness, including the barriers to refractive correction; adequate numbers of personnel be trained to carry out reasonable-quality refraction, especially in developing countries; effective screening programmes be developed to detect refractive error blindness in the population; provision of affordable reasonable-quality spectacles be facilitated through development of permanent infrastructure for eye care in the underserved areas; and in developing countries a rapid shift be made

towards cataract surgery with intraocular lens implantation.

Long-term success in reducing refractive error blindness worldwide depends on attention being paid to these issues within the context of comprehensive approaches to reduce all causes of avoidable blindness. ■

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## Résumé

### Vices de réfraction et cécité

D'après des données récentes, un grand nombre de personnes sont aveugles dans différentes parties du monde en raison d'un vice important de réfraction qui n'est pas convenablement corrigé par le port de lunettes. C'est seulement depuis peu que les vices de réfraction sont reconnus comme cause de cécité, la cécité étant de plus en plus souvent définie par l'acuité visuelle à l'examen. A la cécité due aux vices importants de réfraction qui surviennent naturellement, s'ajoute la correction optique inadaptée de l'aphakie, qui est également une cause considérable de cécité dans les pays en développement. Dans une population, l'existence d'une cécité due aux vices de réfraction indique que les services de soins oculaires généraux sont insuffisants, vu que la correction optique des vices de réfraction est peut-être la forme la plus simple et la plus

efficace de soins oculaires. Des stratégies telles que les programmes d'examen de la vision doivent être mises en œuvre à grande échelle pour déceler les sujets atteints de cécité due à un vice de réfraction. Dans les pays en développement, il faut former le personnel en nombre suffisant pour que la prestation du diagnostic et de la correction des vices de réfraction soit de qualité satisfaisante. Il faut aussi développer des infrastructures correctes dans les secteurs mal desservis du monde pour faciliter la logistique de l'approvisionnement en lunettes de qualité convenable à un prix abordable, pour les personnes atteintes de cécité due à un vice de réfraction. Le succès durable, à l'échelle de la planète, du recul de la cécité due aux vices de réfraction exigera une attention à ces questions dans le cadre des approches intégrées visant à réduire toutes les causes de cécité évitable.

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## Resumen

### Ceguera por errores de refracción

Datos recientes llevan a pensar que un gran número de personas de distintas partes del mundo están ciegas como consecuencia de errores de refracción no corregidos debidamente. La identificación de esos errores como causa de ceguera es algo reciente, y se debe al uso cada vez mayor de la agudeza visual de presentación como criterio de definición de la ceguera. Además de la ceguera por graves errores naturales de refracción, otra importante causa de ceguera en los países en desarrollo es la corrección inadecuada de la afaquia tras la cirugía de la catarata. La presencia de casos de ceguera por errores de refracción en una población indica que los servicios oftalmológicos son en general inadecuados en esa población, toda vez que el tratamiento de esos errores es quizá la forma más

sencilla y eficaz de atención oftalmológica. Es preciso aplicar a gran escala estrategias idóneas, por ejemplo programas de cribado de la vista, para detectar a las personas que sufran ceguera por errores de refracción, y es necesario que en los países en desarrollo se capacite al suficiente personal para corregir esos errores de manera aceptable. Asimismo, en las zonas del mundo subatendidas se debe desarrollar una infraestructura adecuada para facilitar la logística que permite ofrecer lentes asequibles de calidad razonable a quienes sufren ceguera por errores de refracción. Para conseguir reducir eficazmente a largo plazo esa forma de ceguera en todo el mundo habrá que prestar atención a estas cuestiones en el contexto de enfoques amplios tendentes a reducir todas las causas de ceguera evitable.

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