GLOBAL BLINDNESS AND VISUAL IMPAIRMENT

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THIS CHAPTER WILL INCLUDE A REVIEW OF:

- Blindness and visual impairment
- National blindness surveys
- Prevalence of main ocular conditions

BLINDNESS AND VISUAL IMPAIRMENT

DEFINITION OF BLINDNESS

A WHO study group in 1972 (1973) recommended a standardised method of testing and a uniform definition of blindness and visual impairment to enable global comparisons. Blindness is defined as a visual acuity (VA) less than 3/60 (20/400, 0.05) in the better eye with the best possible correction, or a visual field loss in each eye to less than 10° from fixation. Low vision was defined as VA of less than 6/18 (20/60, 0.3) but equal to or better than 3/60 in the better eye with best possible correction. This can be further separated into two categories namely, visual impairment, less than 6/18 to 6/60, and severe visual impairment less than 6/60 to 3/60. This standardised approach recommended by the study group allows for comparison across districts, regions and countries.

Subsequently in 1993, the 10th revision of the WHO International Statistical Classification of Diseases, Injuries, and Causes of Death was adopted and blindness was defined as visual acuity of less than 3/60, or a corresponding visual field loss to less than 10°, in the better eye with the best possible correction. Low Vision is defined as visual acuity of less than 6/18 but equal to or better than 3/60, or a corresponding visual field loss to less than 20°, in the better eye, with best possible correction. Visual impairment includes both low vision and blindness (see Tables 5-2 and 5.3) (World Health Organisation, 2011).

PREVALENCE OF BLINDNESS

The first global analysis of data on blindness indicated that in 1975 there were 28 million people blind. Estimates in 1990 showed that this figure would continue to increase, from 38 million in 1990 to 45 million in 2000.Projections based on the global population increase and ageing, predicted 58 million blind in 2010 and 75 million blind by 2020.

BLINDNESS AND VISUAL IMPAIRMENT(CONT.)

The estimated prevalence of blindness in 1990 ranged from 0.08% of children to 4.4% of persons aged over 60 years, with an overall global prevalence of 0.7%. It was also estimated that at least 7 million people become blind each year and that the number of blind people worldwide was increasing by 1–2 million per year.

CAUSES OF BLINDNESS

In 1999, the WHO estimated that globally there are 45 million persons who are blind and a further 135 million who have low vision and are at risk of being blind.The percentage distribution of the causes of global blindness among the estimated 45 million blind people in 2000 is summarized in Table 5-1.Prognoses are also indicated.

Table 5-1: *Percentage distribution of causes of global blindness*

GLOBAL CAUSES OF BLINDNESS	PERCENTAGE%	PROGNOSIS
Cataract and Refractive Error	60.0	Treatable
Glaucoma and Diabetic Retinopathy	15.0	Partly preventable, although more difficult
Trachoma, Vitamin A deficiency, Onchocerciasis	15.0	Preventable
Age-related macular degeneration and other diseases	10.0	More research required for preventative measures
Total	**100**	

More recently in 2002, Resnikoff *et al* (2004) estimated that the number of people with visual impairment was 161 million with 37 million blind and 124 million having low vision. This indicates a reduction in global blindness and a reversal of some of the earlier projections of an increase in blindness and can be attributed to global efforts at reducing blindness via the VISION 2020 program as well as national initiatives.

Previous, WHO estimates did not take into consideration the uncorrected refractive error or the presenting visual acuity in the presence of refractive error. The global estimates released in 2006 included the global magnitude of visual impairment due to uncorrected refractive errors and this added 153 million people to the previous figures for visual impairment.

At least 13 million children (aged 5–15) and 45 million working-age adults (aged 16–49) were affected globally. Thus, according to WHO estimates, there are approximately 314 million people around the world whose vision is impaired, either due to eye diseases or uncorrected refractive errors. Of this number, 45 million people are blind. This statistic does not include uncorrected presbyopia, the prevalence of which is unknown.

WHO has estimated that up to three-quarters of all blindness worldwide is avoidable. In children, about one-half of the causes can be prevented or treated. The patterns of the causes of blindness in adults and children vary considerably from region to region.

The data needs to be interpreted with caution, as global figures mask the realities at a country and intra country level. Concentration of services in major cities can improve the national and global figures while services in some parts of the world remain the same or are even worse.

The developing world carries a disproportionate burden of blindness and visual impairment and numerous studies have indicated this. Africa is home to 19.8% of the world's blind but only 11.5% of the population with preventable and treatable vision conditions being the leading cause of blindness. The prevalence of blindness by the WHO definition ranges from 0.1% to 0.2% in Established Market Economies to possibly as much as 1.3% in parts of Sub-Saharan Africa. The difference is often an indicator of the impact of socio-economic conditions on blindness prevention reflecting the capacity of nations to mobilise sufficient human resources as well as to develop the appropriate infrastructure. The causes of blindness also vary widely from region to region and within regions. However, despite this variation, cataract is still the leading cause of blindness.

BLINDNESS AND VISUAL IMPAIRMENT (CONT.)

***Table 5-2:** Blindness and Visual Impairment Definitions in the ICD-10*

CATEGORY OF VISUAL IMPAIRMENT		VISUAL ACUITY WITH BEST POSSIBLE CORRECTION	
		MAXIMUM LESS THAN:	**MINIMUM EQUAL TO OR BETTER THAN:**
1	*Low Vision*	6/18	6/60
		3/10 (0.3)	1/10 (0.1)
		20/70	20/200
2	*Low Vision*	6/60	3/60
		1/10 (0.1)	1/20 (0.05)
		20/200	20/400
3	*Blindness*	3/60	1/60 (finger counting at 1 metre)
		1/20 (0.05)	1/50 (0.02)
		20/400	5/300 (20/1200)
4	*Blindness*	1/60 (finger counting at 1 metre)	Light perception
		1/50 (0.02)	
		5/300	
5	*Blindness*	No light perception	
6	*Unqualified vision loss*	Undetermined or unspecified	

Note: If the extent of the visual field is taken into account, patients with a field no greater than 10° but greater than 5° around central fixation should be placed in category 3 and patients with a field no greater than 5° around central fixation should be placed in category 4, even if the central acuity is not impaired.

***Table 5-3:**Recommended Changes to Classification of Visual Impairment*

CATEGORY OF VISUAL IMPAIRMENT		PRESENTING DISTANCE VISUAL ACUITY	
		MAXIMUM LESS THAN:	**MINIMUM EQUAL TO OR BETTER THAN:**
0	*Mild or no visual impairment*		6/18
			3/10 (0.3)
			20/70
1	*Mild visual impairment*	6/18	6/60
		3/10 (0.3)	1/10 (0.1)
		20/70	20/200
2	*Severe visual impairment*	6/60	3/60
		1/10 (0.1)	1/20 (0.05)
		20/200	20/400
3	*Blindness*	3/60	1/60 (or finger counting at 1 metre)
		1/20 (0.05)	1/50 (0.02)
		20/400	5/300 (20/1200)
4	*Blindness*	1/60 (or finger counting at 1 metre)	Light perception
		1/50 (0.02)	
		5/300 (20/1200)	
5	*Blindness*	No light perception	
6	*Unqualified vision loss*	Undetermined or unspecified	

NATIONAL BLINDNESS SURVEYS

Numerous blindness surveys have been conducted in different countries. However, the methodology often varies in terms of the age group, the population being studied and, most importantly, as to whether it is a national survey or not, often compounding difficulties in comparisons between different countries.Nepal conducted the first national survey from 1979 to 1980 (Brilliant et al, 1985). All age groups were considered and blindness and visual impairment were defined according to the WHO recommendations.

The most comprehensive surveys have been in the USA. In each case, however, the age group was restricted to 40 years and above, or higher. In the Framingham Eye Study the prevalence of blindness was established as 0.6% among an affluent white population of an age group of 52-85 years with the definition of blindness being <6/60 (Kahn *et al*, 1977). *A survey*conducted in Baltimore amongst inner city black and white populations found a prevalence of blindness 0.9% amongst blacks and 0.5% amongst whites.

Studies in developing countries in Asia have also sought to quantify blindness and visual impairment. These population based studies have provided valuable information for both planning and service delivery. Dandona *et al*. (2001) conducted a blindness prevalence study in the Indian state of Andra Pradesh using a stratified, random, cluster, systematic sampling strategy. They examined a total of 10 293 people and found a prevalence of blindness of 1% and moderate visual impairment of 7.2% in the Andra Pradesh Eye Disease Study.

Jadoon *et al* (2006) conducted a national survey in Pakistan and examined a sample of 16,507 adults. The age- and gender-standardized prevalence of blindness was 2.7%.They estimated that there are 1,140,000 (962,000 – 1,330,000) blind adults in Pakistan (2003 statistics). They found the prevalence of blindness varied throughout the country, being highest in the provinces of Punjab and Baluchistan and lowest in the North West Frontier Province. Rural areas had a higher prevalence of blindness than did urban areas (3.8% vs. 2.5%, P 0.001). This data gives credence to the argument that RAABS results from a specific area cannot be used as an indication of national trends as intra country variability can create a false impression if a district chosen for RAABS has a higher or lower prevalence than the other districts.

In a study to determine the age, sex, and cause specific prevalences of blindness and visual impairment in adults 30 years of age and older in Bangladesh Dineen *et al*. (2003) examined a nationally representative sample of 11 624adults 30 years of age and older who were sampled using a multistage, cluster random sampling with probability proportional to size procedures. The definitions of blindness (<3/60) and low vision (<6/12 to >3/60) were based on the presenting visual acuity in the better eye. The percentage of bilaterally blind people was 1.53% (age standardised prevalence) while a further 13.8% had low vision (<6/12 VA) binocularly.

A national survey was conducted (1996) to determine the prevalence of blindness and low vision among the Malaysian population of all ages using a stratified two stage cluster sampling design (Zainal *et al*, 2002). The age adjusted prevalence of bilateral blindness and low vision was 0.29% (95% CI 0.19 to 0.39%), and 2.44% (95% CI 2.18 to 2.69%) respectively. Malaysia has four major ethnic groups, however there was no significant difference in the prevalence of bilateral low vision and blindness among the four ethnic groups nor between urban and rural residents.

The only national survey for the Caribbean comes from the Barbados Eye Study (Hyman *et al*, 2001).A total of 4709 people were examined. Low vision was found in 5.9% of the black, 2.7% of the mixed, and 3.0% of white or other participants. Bilateral blindness was similar for black and mixed race participants (1.7% and 1.6%, respectively) and was not found in whites. The prevalence of blindness was higher (P < 0.001) for men than women at each age group (0.5% versus 0.3% at ages 40-49 and 10.9% versus 7.3% at 80 years or more). Among black and mixed participants, the prevalence of low vision increased with age (from 0.3% at 40-49 years to 26.8% at 80 years or older).

Since 1999 studies have been conducted in Latin America using the RACS and RABS methodology. This has provided valuable information in the absence of national surveys. Limburg *et al* (2008) reviewed data from these population-based prevalence surveys in nine countries in Latin America, covering 30 544 people aged 50 years and older. The prevalence of bilateral blindness (VA 3/60 in the better eye with available correction) ranged from 1.3% in urban Buenos Aires, Argentina, to 4.0% in two rural districts of Peru; low vision from 5.9% in Buenos Aires to 12.5% in rural Guatemala. Avoidable blindness ranged from 43% in urban Brazil to 94% in rural Guatemala. The results of all the countries in the sampling frame are presented in Table 5-4 and 5-5. The authors argue that the results of these studies may represent the various situations on eye care services in Latin America. Results from Peru and Guatemala may represent the situation in the rural parts of Latin America with limited eye care services. The results from Paraguay, Venezuela, Mexico and Chile could represent areas with a combined rural and urban population with average availability of eye care services; and the results from Brazil, Argentina and Cuba could represent an urban situation with available eye care services.

NATIONAL BLINDNESS SURVEYS(CONT.)

***Table 5-4:** Adjusted prevalence of bilateral low vision (presenting VA<6/18-3/60 in better eye) in people aged 50 years and older by gender in Latin America.*

	PRESENTING VA <6/18-6.30		
	MALES	**FEMALES**	**TOTAL**
Country (survey area)	Prevalence (%)	Prevalence (%)	Prevalence (95% CI)
Paraguay (whole country	9.2	12.2	10.2 (9.5% to 12.0%)
Peru (Piura-Tumbes district)	17.8	19.6	18.7 (17.7% to 19.7%)
Argentina (part of Buenos Aires)	5.5	6.2	5.9 (5.1% to 6.8%)
Brazil (Campinas City)	5.8	6.6	6.3 (5.1% to 7.5 %)
Cuba (Havana)	10.6	12.4	11.6 (10.2 to 13.1)
Venezuela (whole country)	8.7	11.8	10.3 (8.9% to 11.7%)
Guatemala (4 provinces)	11.7	13.3	12.5 (11.2% to 13.8%)
Mexico ((Nuevo Lèon State)	9.9	7.8	8.8 (7.7% to 9.9%)
Chile (Bio Bio)	6.8	8.7	7.8 (6.8% to 8.8%)

***Source:** Limburget al, 2008*

***Table 5-5:** Causes of Bilateral Blindness (presenting VA<3/60 in better eye) in eight surveys (%)*

CAUSE OF BLINDNESS	**PERU (N=193)**	**ARGEN-TINA (N=49)**	**BRAZIL (N=44)**	**CUBA (N=65)**	**VENEZ-UELA (N=74)**	**GUATE-MALA (N=198)**	**MEXICO (N=57)**	**CHILE (N=47)**
Refractive error	1	6	2	0	4	2	0	2
Cataract, untreated	87	47	41	51	68	81	67	57
Aphakia, uncorrected	0	0	0	1	0	2	0	0
Total curable	**88**	**53**	**43**	**52**	**72**	**85**	**67**	**59**
Surgical complications	0	0	7	0	0	1	3	0
Trachoma	0	0	0	0	0	0	0	0
Phthisis	0	2	0	0	1	2	0	2
Other corneal scar	1	0	2	5	3	6	0	4
Total preventable	**1**	**2**	**9**	**5**	**4**	**9**	**3**	**6**
Total Avoidable	**89**	**55**	**52**	**57**	**76**	**94**	**70**	**65**
Total posterior segment	**12**	**44**	**47**	**43**	**25**	**7**	**30**	**34**

***Source:** Limburget al, 2008*

NATIONAL BLINDNESS SURVEYS(CONT.)

One of the first nationwide surveys in Africa was conducted in Gambia in 1986 (Faal *et al*, 1989). The sample size was 8,174 and included all age groups. The prevalence of blindness was found to be 0.7%. A national survey was conducted in 1996 and encompassed a study population of 13,046 people of all age groups. This study was conducted to evaluate the impact of the national eye care programme. The prevalence of blindness was 0.42% - an improvement (decrease in percentage) of 0.28% in the prevalence rate (Faal *et al*, 2000).

The other national survey conducted in sub-Saharan Africa took place in Cape Verde Islands.A population based survey was conducted in 1998 using a two-level cluster random sampling procedure and 3,803 persons of all ages were included in the sample.A total of 3,374 persons were examined and the prevalence of bilateral blindness (visual acuity in the better eye less than 3/60) was 0.8% (95% confidence interval [CI] 0.5-1.1), of bilateral low vision (6/18 to 3/60 in the better eye) 1.7% (95% CI: 1.3-2.2) and of monocular blindness 1.5% (95% CI: 1.2-2.0).

Recently rapid assessment studies have been conducted in specific regions of Nigeria and Western Rwanda. In the absence of a national survey and the enormous costs and time to conduct these surveys, they provide estimates of blindness and visual impairment in these regions.

In the past surveys by Loewenthal *et al* (1990) and Whitfield *et al* (1990) have shown a prevalence of blindness of 0.7% in a survey of 13 803 people of all ages living in rural areas across Kenya and 1.1% among Turkana (900 people examined) in northwest Kenya respectively.

Mathenge *et al* (2007a) found that the prevalence of bilateral blindness was 2.0% (95% confidence interval[CI], 1.5%–2.4%), and prevalence of bilateral visual impairment (VA of _6/18–_6/60) was 5.8% (95% CI, 4.8%–6.8%) in the sample of >50-year-olds in Nakuru district, Given that cataract is a major cause of blindness in this age group the higher prevalence is expected compared to the population based studies of the studies by Lowental *et al* (1990) and Whitfield *et al* (1990).

In comparison to the RAAB study in Kenya the study in post conflict Western Province of Rwanda byMathenge *et al* (2007b) resulted in 2,206 people being examined and an unadjusted prevalence of bilateral blindness of 1.8% (95% confidence interval [CI] 1.2%–2.4%), 1.3% (0.8%–1.7%) for severe visual impairment, and 5.3% (4.2%–6.4%) for visual impairment. Most bilateral blindness (65%) was due to cataract. The prevalence of blindness and visual impairment was lower than expected.

A study was conducted by Cook *et al* (1993). in Northern KwaZulu-Natal of South Africa in 1990. They examined 6,090 patients of all age groups. The prevalence of blindness was determined to be 1.0%.A 1993 study in the Hlabisa district in Ingwavuma in Northern KwaZulu-Natal of 6132 persons of all ages revealed a blindness prevalence of 0.96 % (Cook and Stulting, 1995). Cataract was the major cause of blindness with 59% blind due to cataract and 21% due to glaucoma. A high percentage of patients were blind due to the lack of spectacles as 20% were blind due to aphakia. This blindness prevalence was similar to the 1990 Northern Natal study which was 1% (Cook *et al*, 1993).

Despite most of the data from the previous studies indicating a prevalence of close to 1% and above, the National Guideline for the Prevention of Blindness in South Africa published in December 2002 (Department of Health, 2002) reported a 0.75% prevalence of blindness in the South African population. This strategy made sense as the national average had to accommodate for the better eye care services in the urban and semi urban areas as the studies were conducted in rural underserved areas.Furthermore, there was an improvement in eye care services since the previous studies.

PREVALENCE OF MAIN OCULAR CONDITIONS

CATARACT

Age-related cataract is the leading cause of preventable blindness in the world. Despite the numerous efforts of Governments and non-Governmental organizations, it still remains a major challenge to blindness prevention efforts worldwide, both in the developing and developed countries.

Age-related cataracts consist of three major types:

- Anterior cortical cataracts
- Nuclear sclerosis
- Posterior subcapsular cataract

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

These cataracts are classified based upon the location and severity of the lens opacity. Studies have revealed that, generally among whites, nuclear sclerosis is the most common, followed by cortical cataracts. The least prevalent form of cataract in nearly all studies and populations surveyed has been posterior sub-capsular cataract. Cortical cataracts are more common among blacks than whites.

According to early WHO estimates (1998), there were approximately 20 million bilaterally blind due to cataract. However, the more recent estimates by Johnson and Foster (2003) estimate that there are approximately 50 million blind worldwide with 25 million blind from cataract. Many estimates now quantify cataract blindness as 50% or more of blindness. Using data for 2002 Resnikoff *et al* (2004) estimated that there are 18 million cataract blinds in the world and 3–4 million are in Africa.

The proportion of blindness due to cataract among all eye diseases ranges from 5% in Western Europe, North America and the more affluent countries in the Western Pacific Region to 50% or more in poorer regions.

The 1981 Nepal National Blindness Survey revealed that among those aged 45 years and older bilateral blindness (<3/60); was 3.77% Brilliant, 1985). It was estimated that 80% of this blindness is either curable or preventable. The major cause of blindness was cataract: 83% in those >45 years (65.4% in all ages).

Recently in a population-based prevalence survey, in both urban and rural areas in Beijing China 4439 people were examined (Xu *et al*, 2006). For those with blindness and low vision, the most frequent cause of low vision and blindness was cataract at 36.7% and 38.5% respectively.The prevalence of blindness due to cataract in Africa is higher than the Beijing study probably reflecting the poor access to cataract surgery.The prevalence of bilateral blinding cataract in Africa is estimated at 0.5%.

The proportion of blindness due to cataract in Sub-Saharan Africa has ranged from 21.7% in Tanzania to 85.0% in Cameroon with great variation evident between countries and regions within countries (Loewenthal *et al* (1990), Whitfield *et al* (1990). These figures are influenced by the prevalence of other significant blinding conditions such as onchocerciasis and trachoma which decrease the relative contribution of cataract to blindness. Furthermore, there is significant variation within countries. Within a given country the prevalence depends on the geography, for example, the prevalence of blindness as a result of onchocerciasis and, hence, the proportion attributable to other causes varies widely from region to region in Togo.

A series of population based studies in Africa have revealed that cataract contributes approximately 50% or more to blindness (Moll, 1994).A population-based survey on the prevalence of major blinding disorders in the Wenchi district in central Ghana estimated the prevalence of blindness among those 30 years and older to be 1.7%with cataract (62.5%) the most common cause of blindness in individuals aged 30 years and older.

In Nigeria, surveys have in the South Western and Eastern parts have shown that the prevalence of blindness due to cataract is (48.1%) and 70.6% respectively (Adeoye, 1996; Ezepue, 1997)).

The Cape Verde Blindness and low vision national survey found that 57.7 % of blindness was due to cataracts Schemann *et al*, 2006). In the rural districts of Segou in Mali, cataract was reported to be the most common cause of visual loss and was most prevalent among those 50 years of age and older. In the Central African Republic, cataract (51%) was found to be the main cause of blindness, followed by glaucoma (12.7%) and onchocerciasis (8.1%).

In South Africa, population based studies conducted in 1985 (Bucher and Ijesselmuiden, 1988) and subsequently in 1991 (Cook *et al*, 1993) have found prevalence rates of 55.1% and 55% respectively. In the first in the then Northern Transvaal (Limpopo currently), there were 14 aphakic blind persons who did not have aphakia glasses (43% of all persons operated on for cataract). These studies were not confined to specific health districts and, as a result, the effect of key concentrated areas of the population can affect the results e.g. major towns or cities, whereas health districts generally encompass a good cross-section of the area under study. Women were 1.6 times less likely to have undergone cataract surgery than men.

Rapid Assessment of Cataract Surgical Studies (RACSS)

The cost of implementing population based studies has led to alternative approaches being sought and developed to estimate blindness prevalence and the causes thereof. The rapid assessment of cataract services is a quick inexpensive way to determine the prevalence of blindness due to cataracts compared to population based studies. The prevalence is an indicator of the disease burden and service load.

Cook *et al* (2007) conducted a RACSS study at pension pay points in South Africa. The subjects were thus > 60 years in women and > 65 years in men. 1000 pensioners were screened (681 women and 319 men). 17.2% of pensioners had operable cataract (visual acuity <6/60); 95% CI -3.4% to 3.4%); 15.6% of pensioners were blind due to cataract (95% CI -3.1% to 3.4%); and 5.6% of pensioners had had previous cataract surgery, 55.4% with intraocular lens implant and 44.6% without intraocular lens implant.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

In much of the developing world cataract and eye care services are under enormous strain with most resources being deployed to deal with the HIV, TB and Malaria pandemic. There is often a shortage of cataract surgeons in the public sector and this is significantly affecting the prevalence rates.

GLAUCOMA

Quigley (1996) indicates that an estimated 33.2 million worldwide have open angle glaucoma of which 10% have profound vision impairment. Further he estimated that in this group there are 6.7 million are blind due to glaucoma. Prevalence estimates in predominantly white populations range from 1.1% to 3.0% and in back populations range from 4.2% to 8.8%. More recently, the WHO has estimated that 4.5 million people are blind due to glaucoma.

Published projections indicate that 4.5 million people will be blind due to open-angle glaucoma and 3.9 million due to primary angle closure glaucoma in 2010. Furthermore, about 60.5 million people will have glaucoma by the year 2010 (44.7 million with open-angle glaucoma and 15.7 million with angle-closure glaucoma). Given the ageing of the world's population, this number may increase to almost 80 million by 2020. Published projections also indicate that nearly half of the bilateral blindness attributable to glaucoma by 2020 will be caused by angle-closure glaucoma (11.2 million people).

In terms of regional variation Leske (2007) conducted a comprehensive review of epidemiological studies that quantify the prevalence of glaucoma. In persons 40 years and older, Leske states that studies report prevalence estimates of around 1–3% in Europe, 1–4% in Asia, and 2–3% in Australia. Rates are much higher in Africa, with prevalence estimates varying between approximately 1% in Nigeria to over 8% in Ghana, attesting to the heterogeneity of glaucoma frequency across African populations. High prevalence of 7–9% was found in African-Caribbeans, who originate mainly from West Africa, an area where rates are elevated. In the United States, prevalence reports vary according to the main ancestry of the subgroups included in specific studies, with 1–2% found in persons of European origin, 4% in African-Americans, and 2–5% in Mexican-Americans.

In a population of 3,654 patients of 49 years and older in Australia (Blue Mountains Study) open angle glaucoma was found in 3.0% of the population with an exponential rise in prevalence with increasing age Mitchell *et al*, 1996). Ocular hypertension, which was defined as an IOP in either eye of greater than 21 mmHg without matching field and disc changes, was present in 3.7% of the population. The prevalence of glaucoma was higher in women after adjusting for age but there were no sex differences in the age-adjusted prevalence of ocular hypertension. Weih *et al*. (2001) found 1.2% of possible, 0.7% of probable and 1.8% of definite cases of open angle glaucoma in a study conducted in Melbourne.

The risk factors associated with Primary Open Angle Glaucoma (POAG) include age, race, sex, high intraocular pressure (IOP), genetic factors, high refractive error (myopia and hyperopia), exposure to corticosteroids, ocular damage diabetes, hypertension, cataract, myopia, and lifestyle factors including smoking, alcohol consumption and exposure to sunlight. Among Barbadian's it was found that leaner body mass is also associated with POAG. However, other studies have not found this to be related to POAG.

Given the racial profile of Africa, race as a contributor to the overall prevalence is important. Estimates from population based studies of glaucoma prevalence have indicated that prevalence among blacks was 4 times higher than among whites, leading to the conclusion that glaucoma is undertreated in blacks.

Two glaucoma studies conducted in Africa estimated the prevalence to be 3.1% of POAG (Buhmann *et al*, 2000)

and 2.7% (Rotchford &Johnson, 2002) in South Africa. Both studies included patients over 40 years. However, when compared to studies among individuals of African origin, the prevalence differs significantly e.g. in Jamaica (1.4%), St. Lucia (8.8%), Baltimore (4.74%) and Barbados (7.1%). This variation indicates that genetics alone cannot be a predictor of risk for POAG.

In South Africa, a clinic-based study found the rate of PACG (gonioscopically verified closure of the angle with raised IOP) was equal among the black and white populations of Johannesburg. Among the white population, 66% of cases were symptomatic, whereas only 31.5% of the black patients reported symptoms (Luntz, 1973; Foster, 2001).

The data from the studies described above indicate that race is a major factor in glaucoma with higher prevalence being found among Africans. The South African, population like the rest of Africa, is at higher risk of glaucoma given the racial profile of South Africa. Furthermore the lack of primary eye care services in South Africa in the public sector severely hampers efforts to identify and refer patients with glaucoma in the early stages.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

TRACHOMA

While trachoma has been eliminated in the developed world, it is still a public health problem in significant sections of the developing world affecting the poorest sections of society. Despite the efforts of NGDOs and Governments, trachoma remains a major cause of blindness.

Trachoma is an infection which, despite it being preventable, it has been previously estimated that it affects an estimated 300 million to 500 million people, of whom 5.8 million are blind. The estimated number of affected people has fallen from 360 million in 1985 to about 80 million today. Comparing early 1990s and 2002 data, trachoma has slipped from the second leading cause of blindness to the seventh.

The 'SAFE' Strategy (Surgery, Antibiotics, Face washing and Environmental changes) advocated by the WHO has been very successful in preventing blindness from trachoma when applied correctly. The approach includes Surgery for the trichiasis, Antibiotics to treat the infection, Face washing to prevent transmission and Environmental modification to prevent transmission from flies.

South Africa has been fortunate as improvement in access to running water has created hygienic conditions that prevent the transmission of the disease. As such South Africa has been declared a trachoma-free country. However, the situation in other parts of Africa differs remarkably with population-based studies revealing prevalence rates of active disease, scars and trichiasis respectively of:

- Zambia (Luapala Valley) - 18%, 7% and 0.6% 68
- Tanzania (Dodoma Region) - 3%, 8% and 3.5%
- Ethiopía (Dalocha)- 51%, 25% and 5.5%

A recent population based study in Southern Sudan the prevalence of trachoma (TT) was 9.6% in a study sample of 3567 persons (Ngodi, 2007). Furthermore 1 in 20 people of the entire population suffered low vision or blindness. Indicating that despite the progress being made with international efforts there are still focal areas were Trachoma is a major public health challenge.

ONCHOCERCIASIS

Onchocerciasis, or river blindness, is an insect-borne disease caused by a nematode worm (Onchocerca volvulus), and transmitted by blackflies of the genus Simulium. It is endemic over much of Sub-Saharan tropical Africa, as well as in localised parts of the Arabian Peninsula and in six countries in Latin America.

The disease is endemic in:

- Thirty (30) African countries (Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Togo, Uganda and the United Republic of Tanzania)
- Thirteen (13) foci scattered in six Latin American countries (Brazil, Colombia, Ecuador, Guatemala, Mexico and Venezuela); and
- Yemen (although Ivermectin is being distributed in a few communities, technical assistance is needed to determine the current epidemiological status of the disease so that it can be controlled)

Currently, about 300 000 people are blind from onchocerciasis. Control measures entail larvicide spraying of blackfly breeding sites and treatment of endemic communities with the microfilaricide Mectizan® (Ivermectin).

The World Bank estimates that onchocerciasis is annually responsible for about one million disability-adjusted life-years. Despite the devastating effects of onchocerciasis in affected communities, vector control and drug therapy (Ivermectin) have proven to be highly effective in countries and regions when applied appropriately.

Given the focal nature of the disease in that specific areas only are affected it is better suited to a rapid assessment study as a profile of a specific area is sought and there is no need to extrapolate the data to the particular country.A broad assessment of endemic areas can be made through the rapid epidemiological mapping of onchocerciasis (REMO), which is based on a selection of survey communities that is optimally biased towards those at highest risk, given the ecology and behaviour of the Simulium vectors.

In Africa, the greatest numbers of persons infected are in Nigeria.While neighbouring Mozambique has affected areas, South Africa is one of the countries in Africa that is unaffected by onchocerciasis.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

CHILDHOOD BLINDNESS

Childhood ocular conditions causing vision loss if not treated early can lead to permanent visual loss. Furthermore, while the prevalence rates may not be as high as in some of the adult blindness conditions, the number of years one lives with the disability makes childhood blindness a priority issue. This, therefore, highlights the importance of appropriate and timely intervention in conditions causing childhood blindness and visual impairment, particularly those that are treatable. The reality, however, is that in much of the developing world poor public health resources results in many childhood ocular conditions being left untreated, resulting in amblyopia and blindness.

It is estimated that there are 1.4 million children who are blind, only 6.5% of who live in the more affluent regions of the world. According to Gilbert and Awan (2003) the following summarises the key issues related to magnitude and causes of childhood blindness:

- The epidemiology of blindness in children reflects socio-economic development
- The prevalence and magnitude ranges from about 3/10,000 children in affluent societies (60 blind children per million total population) to 15/10,000 in the poorest communities (600 blind children per million total population)
- 75% of the world's blind children live in developing countries
- Some 500,000 children become blind each year, most in developing countries
- Blind children have a high death rate - the prevalence therefore markedly underestimates the burden

The main causes of childhood blindness differ according to the income level of societies:

- **Low income societies:** Vitamin A deficiency, harmful traditional eye remedies, or cerebral malaria, measles, congenital rubella and ophthalmia neonatorum
- **Middle income societies:** The pattern of causes is mixed, with retinopathy of prematurity emerging as an important cause
- **High income societies:** Currently unavoidable causes (the biggest group in affluent countries) include hereditary retinal dystrophies, disorders of the central nervous system, and congenital anomalies
- **In all regions:** Uncorrected refractive error is a common cause of visual impairment and blindness

Studies in Africa in schools for the blind have outlined the causes of blindness among children.

Ezegwui *et al* (2003) conducted a study in south eastern Nigeria among the three schools for blind pupils. Of 162 pupils, 142 were examined and two were excluded from the study because they were not blind. The rest were either blind (136 pupils) or had severe visual impairment (4). Six functionally blind pupils had significant vision when supplied with appropriate lenses. The most common cause of blindness was cataract (33, 24%), thirty pupils (21%) had disease of the whole globe, and 13 had anophthalmos, microphthalmos, or disorganised globe. 30 pupils (21%)had corneal scarring, 13 (9%) had glaucoma or buphthalmoswhile (7%) were thought to have been the result of using traditional eye medications. For 54 pupils (39%) their blindness had resulted from factors active in childhood, 21 (15%) were considered hereditary, 11 (8%) from intrauterine causes, and for 54 (39%) the timing of the insult was unknown. In all, 91 pupils (65%) were blind from causes considered preventable (such as measles) or treatable (such as cataract).

A cross-sectional survey, undertaken at 15 of the 16 schools for the blind in South Africa, revealed that in children less than 16 years, 30.4% of children were blind (< 3/60), 12.6% had severe visual impairment (< 6/60-3/60), 42.3% were visually impaired (< 6/18-6/60), and 12.0% had no impairment (6/18 or better) (Oduntan, 2001). The anatomical sites of severe visual impairment/Blind (SVI/BL) in 564 children were: retina 38.5%; optic nerve 15.2%; cornea/phthisis bulbi 11.0% and glaucoma 6.7%. Aetiological categories of SVI/BL were: hereditary diseases 33.0%; intra-uterine factors 0.9%; perinatal conditions 13.1%; acquired conditions of childhood 11.5%. In 41.5% the underlying cause could not be determined.In 38.8% of children with SVI/BL the cause was avoidable, i.e. preventable or treatable.

As indicated by the data from studies in Africa, a high prevalence of treatable (cataract) and preventable (measles, corneal scar) conditions occurs. Unlike many of the countries in Africa, South Africa will have a higher percentage of hereditary conditions as the aetiologies normally associated with low income societies are not as common. This is due to the better access to health care facilities and eye care services compared to other African countries.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

REFRACTIVE ERROR

Uncorrected refractive errors remained a neglected aspect of Vision 2020 in the early years of the campaign. However, the establishment of the WHO Refractive Error Working Group, the inclusion on the task force of Vision 2020 of NGDOs and professional bodies focusing on refractive errors, and a series of population-based studies on refractive error in children, has catapulted refractive errors to the centre stage of blindness prevention. While many refractive error studies have been conducted, the lack of consistency in defining and measuring refractive errors has often made comparison across populations difficult. Furthermore many studies have been clinic-based rather than population-based.

The prevalence of refractive error exhibits significant variation across geographic, racial, age and ethnic boundaries. This variation has enormous impact on the strategies one utilizes in addressing uncorrected refractive error. This is especially so in a climate of limited resources whereby one has to target specific groups who are most affected. Furthermore limited research especially among the adult population has made the planning and implementation of interventions difficult especially in underserved communities.

Resnikoff *et al* (2004) reviewed a series of published and unpublished surveys on uncorrected refractive error as of 2004. While in the past the emphasis in the presentation of refractive error data was on best corrected vision, Resnikoff and co-workers addressed the category of presenting vision. This is a more accurate indicator of the relevance and challenge of refractive error as a public health problem globally and accurately quantifies the need for services. Many individuals who can be corrected to have normal vision often do not get access to spectacles due to affordability and accessibility of services.

The estimates were based on the prevalence of visual acuity of less than 6/18 in the better eye with the currently available refractive correction that could be improved to equal to or better than 6/18 by refraction or pinhole. People aged 5 and over were considered for the estimates. Previous estimates based on the best corrected vision resulted in the 2002 projections of visual impairment being estimated to affect 161 million people globally, of whom 37 million were blind.

The exclusion of uncorrected refractive error underestimated the number of people visually impaired globally. The estimates released by the WHO in 2006, based on the review of surveys as of 2004 by Resnikoff *et al* (2004), indicated that a total of 153 million people are estimated to be visually impaired from uncorrected refractive errors, of whom eight million are blind. Combined with the 161 million people visually impaired estimated in 2002 according to best-corrected vision, 314 million people are visually impaired from all causes with uncorrected refractive errors the main cause of low vision and the second cause of blindness.

The following criteria were used in the estimation of the prevalence of visual impairment from uncorrected refractive errors:

Age group from 5 to 15 years:

The prevalence is estimated by the difference between the prevalence of presenting and best-corrected visual acuity of less than 6/18 with refraction under cycloplegia: this difference corresponds to the prevalence of presenting visual acuity that could be improved to equal to or better than 6/18 by appropriate correction. In the case of studies reporting only the prevalence of presenting visual acuity, the prevalence of visual impairment due to refractive error was determined from the distribution of causes determined in the surveys.

Age group 16–39 years:

Same criteria used as that for those aged 5–15 years, on the assumption that from the ages of 16 years to 39 years, the refractive status generally does not undergo changes that require further correction.

Age group 40–49 years:

It is either estimated from the results of surveys that reported age-specific data for this age group or calculated by a linear fit between the prevalence at age 39 and 55 years.

Age group 50 years and older:

The prevalence was estimated from the difference between visual acuity of less than 6/18 with the available correction and visual acuity of less than 6/18 with best correction determined using refraction or pinhole, assuming that pinhole approximates complete refraction.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

REFRACTIVE ERROR PREVALENCE AND STRATEGIES IN SPECIFIC GROUPS

Infants

The early determination of the refractive error of infants is an important consideration because myopia may result from an ocular defect that prevents the formation of a sharp retinal image. The risk of amblyopia and tropias makes the need for detection a priority, especially in unilateral ametropia.

Kuo (2003) reviewed records of all children from birth to 5 years of age seen at the Tennessee Lions Eye Center at Vanderbilt Children's Hospital with a billing diagnosis of nasolacrimal duct obstruction and no co-morbid ocular diagnoses except for refractive error. The review revealed that, of the 130 patients, the mean age was 15.5 ± 9.9 months (range, 2 days to 66 months). The mean refractive error (spherical equivalent) was +1.4 D ± 1.1 D. Cumulative Probability Distribution (CPD) plot analysis showed 95% of hyperopia to be < +3.25 D. Two children had myopia ≤ -1.00 D. The mean astigmatism was +0.2 D ± 0.4 D, and 74% of patients had no astigmatism. Seven (7) children had astigmatism > +1.00 D in one eye. CPD plot analysis showed 95% of astigmatism to be < +1.50 D and 95% of meridional anisometropia to be < 1.50 D. Six (6) children had anisometropia ≥ 1.50 D, and three children had anisometropia > 3.00 D.

Furthermore, photorefraction on a sample of children less than 1 year old revealed the error distribution in Table 5.6. It has been noted that the high percentage of astigmatic children decreases rapidly between 12 to 18 months.

Table 5-6: *Photorefraction on a sample of < 1yr old*

Error Type	Percentage
Hypermetropia	5.0
Myopia	4.5
Astigmatism	70.0
Anisometropia	1.3
Emmetropes	19.2

A significant proportion of infants show hyperopia of more than +3.5 D. Using the criterion of at least one meridian of +3.5 D or greater, 89% of infants deemed to have hyperopia at screening.

However infants generally develop gradually toward emmetropia during the first years of life as they are initially usually hyperopic making a confirmation of refractive error as a permanent factor very difficult.

The U.S. Preventive Services Task Force (USPSTF) recommendation on screening for visual impairment in children younger than five years published a set of recommendations in 2004.The USPSTF stated that it found no direct evidence that screening for visual impairment, compared with no screening, leads to improved visual acuity.

However, the USPSTF found fair evidence that screening tests have reasonable accuracy in identifying strabismus, amblyopia, and refractive error in children with these conditions; that more intensive screening compared with usual screening leads to improved visual acuity; and that treatment of strabismus and amblyopia can improve visual acuity and reduce long-term amblyopia. The USPSTF found no evidence of harms for screening, judged the potential for harms to be small, and concluded that the benefits of screening are likely to outweigh any potential harms.

The above, together with the low prevalence of refractive error among infants, establishes a strong case for less emphasis on screening and the development of specific refractive error programs aimed at infants. This approach is particularly important in the developing world where places in Africa, Asia and other continents lack the human resources to provide services for the groups most affected and even poorer infrastructure and human resources to cater for the examination and management of infants. The focus should be on the development of comprehensive eye care services which have the capacity to manage infants appropriately when presenting for services.

Preschoolers

In the United States visual impairment caused by refractive error, amblyopia, strabismus, and astigmatism is a common condition among young children, affecting 5 to 10 percent of all preschoolers. Amblyopia is present in 1 to 4 percent of preschool-aged children; an estimated 5 to 7 percent of preschool-aged children have refractive errors.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

Given the implications of amblyopia and undetected refractive error i.e. poor school performance, poor self image and the risk of permanent blindness in the affected eye, the importance of visual screening in preschoolers and the appropriate screening strategy has been investigated extensively.

In the Canadian provinces ofNewfoundland and Labrador, the prevalence of eye and vision disorders among young children who participated in a vision screening program in the day care settings, 946 children (mean age 4.2 years) were screened with the latest tests of optics and functional vision. From the results of these examinations, prevalence rates were estimated for several categories of vision disorders. 14.0% of the children possessed significant vision disorders, the most prevalent of which were hyperopia, amblyopia, and strabismus (4.8%, 4.7%, and 4.3%, respectively). Myopia and anisometropia, on the other hand, were relatively rare (1.1% and 1.4%, respectively) (Harrad and McKee, 1999).

The Seoul Metropolitan Preschool Screening Study involved the screening of 36 973 kindergarten children aged 3–5 years (Lim *et al*, 2004). Of those screened, 7116 (19.2%) children did not pass and 2058 (28.9%) out of the 7116 were referred. Refractive errors were found in 608 (1.6%) children. Astigmatism was associated in 78.2% of ametropes. Amblyopia was discovered in 149 (0.4%) children and refractive error was the major aetiology with a predominant rate (82.5%). Manifest strabismus was detected in 52 children.

In the United Kingdom, a systematic review by Harrad & McKee (1997) from the NHS Centre for Reviews and Dissemination summarised the available clinical evidence and emphasised that there was no evidence from methodologically sound studies to suggest that preschool screening was effective in reducing the population burden of amblyopia.

The review recommended that “providers currently offering screening programmes should consider discontinuing them.” Williams *et al* (2003) conducted a study to determine if there were differences in amblyopia outcomes after preschool screening versus school entry screening. Of 6081 children, 24.9% had been offered preschool screening and 16.7% had attended. The prevalence of amblyopia was approximately 45% lower in the children who received preschool screening than in those who did not (1.1% v 2.0%, p = 0.05). The mean acuity in the worse seeing eyes after patching treatment was better for amblyopic children who received preschool screening than for those who did not; 0.14 v 0.20 logMAR (p <0.001). These effects did not persist in an intention to screen analysis.

The researchers concluded that preschool screening at 37 months was associated with an improved treatment outcome for individuals with amblyopia. However, the improvement was clinically small and disappeared when considering all children offered screening rather than only those who received it. They indicated that further research is needed into improving the effectiveness of vision screening for preschool children.

The Vision in Preschoolers Study Group (2005) designed a research study to evaluate vision screening tests for identifying preschool children who would benefit from a comprehensive eye examination. Conditions targeted for identification are amblyopia, strabismus, significant refractive error, and reduced visual acuity (VA) in the absence of amblyogenic conditions.

Phase I of the VIP Study provided a comparison of 11 screening tests administered by optometrists and ophthalmologists experienced in assessment of preschool-aged children.The 11 screening tests included VA tests (crowded Linear Lea Symbols VA test [Precision Vision, Inc., La Salle, IL, or Good- Lite, Inc., Steamwood, IL], crowded Linear HOTV VA test [Precision Vision, Inc.]), stereoacuity tests (Random Dot E and Stereo Smile II [Stereo Optical, Inc., Chicago, IL]), autorefractors (Retinomax Autorefractor [Right Manufacturing, Virginia Beach, VA], SureSight Vision Screener [Welch Allyn, Inc., Skaneateles Falls, NY]), instruments based on photorefractive technology (iScreen Photoscreener, MTI Photoscreener, Power Refractor II), and two procedures frequently used by eye care professionals (noncycloplegic retinoscopy [NCR] and the cover–uncover test). Tests were conducted in specially equipped VIP vans that provided a standard environment with minimal distractions.

Phase II of the VIP Study compared nurse and lay screeners’ performances in administering selected screening tests from phase I. Three of the four best-performing tests in phase I (Retinomax Autorefractor, SureSight Vision Screener, and crowded Linear Lea Symbols VA test) were selected for phase II. The fourth test, NCR, was not selected because its use necessitates a high degree of training, skill, and clinical knowledge. A test of stereoacuity, the Stereo Smile II test, was selected because it was one of the most effective tests for detection of strabismus in phase I and may, when used in combination with another screening test, provide better screening results than a single test.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

RESULTS OF THE VIP STUDIES

Phase 1:

The performance of the screening tests varied widely in phase I. At high levels of specificity (0.90 and 0.94; i.e., over-referral rates for normal children of 10% and 6%, respectively), the sensitivity of the best four tests (NCR, Retinomax Autorefractor, SureSight Vision Screener, and crowded Linear Lea Symbols VA) for detecting children with one or more targeted conditions was similar.

With 90% specificity, the best tests detected only two thirds of children having > or =1 targeted conditions, but nearly 90% of children with the most important conditions. The 2 tests that use static photorefractive technology were less accurate than 3 tests that assess refractive error in other ways.

Phase II

Two of the best-performing tools for vision screening of preschool children (Retinomax Autorefractor and SureSight Vision Screener) are as effective when used by nurse screeners and by lay screeners as they are when used by optometrists and ophthalmologists. A third tool (Linear Lea Symbols VA screening) that was one of the most effective screening tools when used by optometrists and ophthalmologists was much less effective when used by nurse screeners and lay screeners. However, there was a marked improvement in the performance of lay screeners when the test distance was reduced from 10 to 5 ft and the test format was modified from linear presentation to single, crowded symbols. Although these results are promising and support the use of autorefraction and some types of VA testing as screening tools for preschool children, a broad recommendation cannot be made, because the data were collected within the context of a research protocol specifically designed to compare tests and screening personnel in a selected group of children.

Unfortunately, there is lack of studies conducted in Africa among preschool children. However, in extrapolating from the experiences in the United Kingdom and United States, the following is evident:

- The prevalence of refractive errors is relatively low
- The screening methodologies best suited for this population involves automated testing and thus expensive equipment
- The more successful screening tools are not easily available in the developing world either through lack of access to the products or the equipment is prohibitively expensive

It is therefore appropriate to only target this group when an abundance of resources exist in a particular country or community. However in a relatively well resourced country such as South Africa (in comparison to other African countries) such equipment is expensive and not available to public sector health care workers and school screening programs.

Children

Beginning in 1998, a series of population-based surveys (Table 5.7) of refractive error and visual impairment in school-age children were conducted – all using the same protocol. These Refractive Error Study in Children surveys were carried out in populations with different ethnic origins and cultural settings: a rural district in eastern Nepal (Pokharel *et al*, 2000), a semi-urban county outside of Beijing, China (Zhao *et al*, 2000), an urban area of Santiago, Chile (Maul *et al*, 2000), a rural district near Hyderabad, India (Dandona *et al*, 2002), an urban area of New Delhi, India (Murthy *et al*, 2002), and a semi-urban district in Durban, South Africa (Naidoo *et al*, 2003), an urban area of Guangzhou, China and the urban Gombak district in Kuala Lampur, Malaysia (He *et al*, 2004; Goh *et al*, 2005).

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

The prevalence of myopia and hyperopia when evaluated with a handheld Retinomax K-Plus autorefractor and defined as myopia ≤ -0.5D and Hyperopia ≥ +2.00 D, was as follows (Table 5.7):

Table 5-7: *Prevalence of myopia and hyperopia with cycloplegic autorefraction in a multi-country study*

COUNTRY	MYOPIA	HYPEROPIA
India (Hyderabad)	4.1	0.8
Nepal	1.2	2.1
India (Delhi)	7.4	7.7
Malaysia	20.7	1.6
China (urban)	38.1	4.6
China (rural)	42.4	1.20
South Africa	4.0	2.6
Chile	19.3	7.3

In South Africa, a total of 5,599 children living in 2,712 households were enumerated, and 4,890 (87.3%) were examined. The prevalence of uncorrected, presenting, and best-corrected VA of ≤ 20/40 in the better eye was 1.4%, 1.2%, and 0.32%. Refractive error was the cause in 63.6% of the 191 eyes with reduced vision, amblyopia in 7.3%, retinal disorders in 9.9%, corneal opacity in 3.7%, other causes in 3.1%, with unexplained causes in the remaining 12.0%. Myopia (≤ -0.50 D) in one or both eyes was present in 2.9% of children when measured with retinoscopy and in 4.0% with autorefraction. Beginning with an upward trend at age 14, myopia prevalence with autorefraction reached 9.6% at age 15. Myopia was also associated with increased parental education. Hyperopia (≥ +2.00 D) in at least one eye was present in 1.8% of children when measured with retinoscopy and in 2.6% with autorefraction, with no significant predictors of hyperopia risk. The data reveals that the prevalence of refractive error in children in South Africa is not as high in Asian countries, however, the lack of services in South Africa and, thus, the high prevalence of uncorrected refractive error poses an immense challenge.

It is evident from the prevalence figures in Table 5.7 that China and Malaysia pose the biggest challenge in terms of the correction of myopia from a prevalence perspective while the other developing countries have a low prevalence of myopia. The prevalence of hyperopia is low in all countries. However given the backlog of services as well as the lack of human resources and infrastructure to provide refractive services myopia and hyperopia still pose a major public health problem in all study countries and many other developing countries in a similar situation.

Adults

A comparison of adult refractive error studies poses a huge challenge as researchers have used different criteria for determining myopia and hyperopia and data is often not presented with different cut off points for myopia and hyperopia.

Bourne *et al* (2004) examined 12,782 adults 30 years of age and older as part of a National Blindness and Low Vision study in Bangladesh. Six thousand four hundred and twelve subjects (6,412; 57.3%) were emmetropic, 2,469 (22.1%) were myopic (< -0.5 D), and 2,308 (20.6%) were hypermetropic (> +0.5 D). Two hundred and six subjects (206; 1.8%) were highly myopic (< -5 D). Myopia was more common in men (26.3%) than in women (21.0%), whereas hyperopia was more common in women (27.4%) than in men (15.8%). Overall, myopia increased with age (17.5% of those aged 30-39 years were myopic, compared with 65.5% of those age 70 years and older).

The refractive error analysis of the Blue Mountain Eye Study in Australia (Mitchel *et al*, 1996), which sampled older adults (3,654 residents, aged 49-97) revealed prevalence rates for myopia of 15%, hyperopia 57% and emmetropia 28%. Hyperopia prevalence was age-related, increasing from 36% in persons aged < 60 years to 71% of persons aged > or = 80 (P < 0.0001), whereas myopia prevalence decreased with age, from 21% in persons aged < 60 years to 10% of persons aged > or = 80 years (P < 0.0001).

Aine (1994), in researching a Danish population of 5-80 years age range found an increase in myopia from 6% in childhood to approximately 35% in early adulthood, after which it decreased, with hypermetropia gaining a greater share.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

In subjects > 15 years of age, age-gender-adjusted prevalence of myopia was 19.39%, hyperopia 9.83% and astigmatism 12.94% as compared to the < 15 years old group which had prevalence of myopia of 4.44%, hyperopia 59.37% and astigmatism 6.93%. The adult studies refer to trends whereby myopia increases till early adulthood, and then decreases, while hyperopia tends to increase in late adulthood.

A population-based survey of visual impairment and blindness among non-institutionalized Mexican Americans aged 40 years and more living in Pima and Santa Cruz counties of southern Arizona revealed that 8.2% of the population had visual acuity worse than 20/40 while uncorrected visual acuity accounted for 73% of the impaired acuity (Munoz *et al*, 2002). Uncorrected refractive error showed a strong correlation with age, less than 13 years of education, lack of insurance coverage and not having seen an eye-care provider in the past two years. The prevalence of best corrected acuity worse than 20/40 increased from 0.3% in those aged 40-49 yrs to 18% in those aged 80 years or more. It is evident from the above data that the prevalence of uncorrected refractive error is influenced by strong socio-economic factors.

The population based studies conducted in Africa often quantified refractive errors in relation to the impact on blindness and visual impairment but not the prevalence of myopia, hyperopia and presbyopia. This remains a major deficit in the epidemiological data for refractive errors in Africa. A series of regional eye surveys were conducted in Kenya as part of the Kenya Rural Blindness Prevention Project (Whitfield *et al*, 1990). Refractive errors were found to be a leading cause of visual impairment after cataracts with 4.5 per 1000 individuals affected.

Resnikoff *et al* (2004), in estimating the prevalence of uncorrected refractive error worldwide, utilised the following criteria to include data from studies:

The prevalence of best-corrected and presenting visual acuity of less than 6/18 had to be reported or, alternatively, the distribution of causes of presenting visual impairment. In children, refractive diagnostics had to be determined by objective refraction under cycloplegia plus subjective refraction.

The studies had to be population based, representative of the area sampled, with definitions of visual impairment clearly stated.

Studies with inadequate sample sizes and response rate were not included.

Data reported only for eyes or for the worse eye could not be included in the estimates calculated for people and the better eye. Only three studies in Africa met this criterion and were included in the estimates Naidoo *et al* (2003) (South Africa), Ceccon (2002) (Mali) and Ahmedou (2001) (Mauritania).

The prevalence of uncorrected refractive errors in Sub Saharan Africa (Table 5-8) was projected as almost 6.4 million. The highest prevalence was in the >50 years old age group with the lowest being in the 5-39 age groups. Adults therefore have a higher prevalence visual impairment due to uncorrected refractive error.

Table 5-8: *Number of individuals with uncorrected refractive errors in sub-Saharan Africa for the different age groups (adapted from Resnikoff et. al. 2004))*

AGE 5–15 YEARS	AGE 16–39 YEARS	AGE 40–49 YEARS	AGE >50 YEARS	TOTAL (5 TO >50 YEARS)	
No. in millions (prevalence %)	No. in millions (prevalence %)	No. in millions (prevalence %)	No. in millions (prevalence %)	Population in millions	No. in millions (prevalence %)
0.534 (0.24)	0.683 (0.24)	0.647 (1.13)	4.529 (5.94)	640.4	6.393 (1.00)

More recently the rapid assessment of blindness studies conducted in Africa provide additional information as to the impact of uncorrected refractive error on visual impairment.Mathenge *et al* (2007b) conducted a rapid assessment of blindness study in post conflict Rwanda. A sample of 2206 subjects was examined. The prevalence of visual impairment in the population was 5.3%. Refractive error contributed to 29.9% of visual impairment.

The rapid assessment of avoidable blindness study in Nakuru District, Kenya quantified the contribution of refractive error to visual impairment and blindness (Mathenge *et al*, 2007b). Refractive error made up almost a third of cases of bilateral visual impairment (31.5%) but only 4.3% of cases of blindness.Eighty-six people in the sample wore spectacles, compared with 219 people who needed spectacles for distance correction (people with spectacles people with uncorrected refractive errors), giving a coverage of 39.3%.

The early population based studies in South Africa did not quantify refractive error as a cause of blindness and visual impairment. However among post cataract patients the lack of refractive services was identified by the fact that uncorrected aphakia (9%), was a cause of blindness.

PREVALENCE OF MAIN OCULAR CONDITIONS(CONT.)

Cook *et al* (1993) in a survey of the prevalence of blindness and low vision in the Ingwavuma district of KwaZulu (N = 6,090) found that the prevalence of blindness was 1.0% (95% confidence interval 0,7-1,2%), and the prevalence of impaired vision was 1,4% (95% confidence interval 1,1-1,7%). Refractive error (10,0%) was one ofthe main causes of impaired vision. The study encompassed a screening of patients and subsequent referral to an Ophthalmologist. The refractive error was not further quantified into myopia, hyperopia or presbyopia.

PRESBYOPIA

Presbyopia refers to a refractive error affecting the near vision of older people. Presbyopia is caused by age-related elasticity changes in the crystalline lens and its capsule. Despite the often made clinical assumption that presbyopia affects almost 100% of the population over 40 years it has been one of the most neglected aspects of refractive error both from a research and service perspective. The high prevalence is often coupled by the lack of spectacles and the personnel to provide eye exams. Even in situations where reading glasses are available to the population affordability limits access. Recent efforts by the WHO to develop a series of studies to quantify presbyopia as well as determine the impact on the quality of life of individuals, has brought an increased focus on this aspect of refractive error.

Holden *et al* (2008) recommend the following criteria for the exclusion of the results of presbyopia studies in the generation of reliable estimates:

1. Participating sample size of less than 1000
2. Unspecified number of eligible participants or participation rate (as this limits generalization of the data);
3. Inclusion of only very specific age groups (e.g. if a study was restricted to 70 – 75 years, which excludes most people with presbyopia because the age of onset is generally much younger); and
4. Data from a specific population which could not be generalized to the population as a whole (e.g. institutionalized nursing home population, or only women who have given birth)

Holden *et al* (2008) suggest that four studies on presbyopia provide valuable input on the prevalence of presbyopia:

In Brazil, Duarte *et al* (2003) found a prevalence of 10.7% among subjects 30-39 years, 47.8% among subjects 40-49 years, 86.3% in subjects 50-69 years, 92.9% in subjects 65+ years. The overall prevalence of presbyopia in the study population 30 years and older was 54.7%.

Nirmalan *et al* (2006) conducted a survey in India and found a prevalence of 22.9% among subjects 30-39 years, 92.6% among subjects 40-49 years, 94.9% and 88.4 % among subjects 50-69 years. The overall prevalence of presbyopia in the study population 30 years and older was 69.9%.

Ramke *et al* (2007) in a rapid assessment study in East Timor determined that presbyopia was prevalent in 43.5% of individuals 40-49 years, 48.1% in individuals 50-69 years and 32.6% of the individuals in the 70+ group. The prevalence for all age groups combined was 43.8%. Burke *et al*. (2006) conducted a cross sectional evaluation of presbyopia in Tanzania and found a prevalence of 61.7% among the subjects 40 years and older. The prevalence in the 40-49 year old group was 50.4%, the 50-64% age group was 68.7% and 72.4% in the 65+ age group. Laviers conducted a study on presbyopia in Zanzibar. A nationally representative sample of 400 people aged 40–50 years with distance visual acuity >6/18 was selected from a RAAB survey. Near visual acuity (defined as the ability to read N8 at 40 cm using a logMar E chart) was assessed with and without distance correction. The overall prevalence of presbyopia was 89.2%. Of those who needed correction, only 17.7% had spectacles. Barriers to accessing services included ‘not considered a priority’ (33%) and ‘lack of money’ (30.6%).

It is evident from the data that there is a wide variation in prevalence of presbyopia among the different groups. However this data has to be cautiously analysed because of the differences in age groups studied, the measurement methodology utilised as well as the study design with one study utilising a rapid assessment method and the others a cross sectional design. Current efforts by the World Health Organisation to establish a standardised protocol for the measurement of presbyopia and the conduction of studies based on this protocol in various parts of the world, will assist in ensuring standardisation of procedure and validity of the results.

Holden *et al* (2008) estimated from population based surveys that there were 1.04 billion people globally with presbyopia in 2005, 517 million of whom had no spectacles or inadequate spectacles. Furthermore, 410 million were prevented from performing near tasks in the way they required. These estimates based on population based studies currently available but which did not all use the same protocol should be further evaluated when the standardised population based studies being conducted are published.

SELECTED READING/REFERENCES

- Adeoye A, 1996. **Survey of blindness in the rural communities of South West Nigeria**. Tropical Medicine and Internal Health 1:672-676
- Ahmedou SE, 2001. **Results of rapid assessment of cataract surgical services in urban Nouackchott, Mauritania.** Service Ophthalmologie, MOH, Nouackchott, Mauritania
- Aine E, 1994. **Refractive errors in a Finnish rural population.** Acta Ophthalmol 62(6):944-54
- Bourne RR, B.P.Dineen, Ali SM, et al. 2004.**Prevalence of refractive error in Bangladeshi adults: results of the National Blindness and Low Vision Survey of Bangladesh.** Ophthalmology 111(6):1150-60
- Brilliant et al, 1985.**Epidemiology of blindness in Nepal.**Bulletin of the World Health Organisation 63(2):375-386
- Bucher PJM, Ijesselmuiden CB, 1988. **Prevalence and causes of blindness in the Northern Transvaal.** British Journal of Ophthalmology 72:721-6
- Buhrmann RR, Quigley HA, Barron Y, 2000. **Prevalence of glaucoma in a rural East African population.** Investigative Ophthalmology and Visual Science 41:40-8
- Burke AG, Patel I, Munoz B, Kayongoya A, McHiwa W, Schwarzwalder AW, West SK, 2006. **Population-Based Study of Presbyopia in Rural Tanzania.** Ophthalmology 113(5):723-7
- Ceccon JF, 2002.**Results of rapid assessment of cataract surgical services in Koulikouro**, Mali. Institute of African Tropical Ophthalmology
- Cook C, Kluever H, Mabena L, Limburg H, 2007. **Rapid assessment of cataract at pension pay points in South Africa.** British Journal of Ophthalmology 91:867-8
- Cook CD, Knight SE, Crofton-Briggs I, 1993. **Prevalence and causes of low vision and blindness in northern KwaZulu.** South African Medical Journal 83:590-3
- Cook CD, Stulting AA, 1995. **Prevalence and incidence of blindness due to age-related cataract in the rural areas of South Africa.** South African Medical Journal 85:26–27
- Dandona et al, 2001.**Blindness in the Indian state of Andhra Pradesh.**Investigative Ophthalmology and Visual Science 42(5):908-9016
- Dandona R, Dandona L, Srinivas M, et al, 2002. **Refractive error in children in a rural population in India.** Investigative Ophthalmology and Visual Science 43:615–22
- Dineen et al, 2003.**Prevalence and causes of blindness and visual impairment in Bangladeshi adults: Results of the National Blindness and Low Vision Survey of Bangladesh.**British Journal of Ophthalmology 87:820-828
- Duarte WR, Barros AJD, Dias-da-Costa JS, Cattan JM, 2003. **Prevalence of near vision deficiency and related factors: a population-based study in Brazil.** Cadernos de Saúde Pública 19:551-9
- Ezegwui IR,Umeh RE,Ezepue UF, 2003. **Causes of childhood blindness: results from schools for the blind in south eastern Nigeria.** British Journal of Ophthalmology 87:20–23
- Ezepue UF,1997. **Magnitude and causes of blindness in Anambra state of Nigeria.** Public Health 111:305-309
- Faal H, Minassian DC, Dolin PJ, 2000. **Evaluation of a national eye care programme: re-survey after 10 years.** British Journal of Ophthalmology 84:948-51
- Faal H, Minassian DC, Sowa S, Foster A, 1989. **A National Survey of blindness and Low Vision in the Gambia: results.** British Journal of Ophthalmology 73:82-7
- Foster PJ, 2001.**Advances in the understanding of primary angle-closure as a cause of glaucomatous optic neuropathy.** Journal of Community Eye Health,14(39):37-39
- Gilbert C, Awan H, 2003. **Blindness in Children.** British Medical Journal 327:760-1
- Goh P, Abqariyah Y, Pokharel GP, et al, 2005. **Refractive Error and Visual Impairment in School-Age Children in Gombak District, Malaysia.** Ophthalmology 112:678–85
- Harrad RA, McKee SP, 1999. **Preschool vision screening: results of a systematic review.** Survey of Ophthalmology 43:374–6
- He M, Zeng J, Liu Y, Xu J, et al, 2004. **Refractive error and visual impairment in urban children in southern China.** Investigative Ophthalmology and Visual Science 45:793–9

SELECTED READING/REFERENCES(CONT.)

- Holden BA, Fricke TR, Ho SM, Wong R, Schlenther G, Cronjé S, Burnett A, Papas E, Naidoo KS , Frick KD, 2008. **Global Vision Impairment Due To Uncorrected Presbyopia.** Archives of Ophthalmology 126(12):1731-1639
- Hyman L, Wu SY, Connell AM, Schachat A, Nemesure B, Hennis A, Leske MC, 2001.**Prevalence and causes of visual impairment in The Barbados Eye Study.** Ophthalmology 108(10):1751-6
- Jadoonet al, 2006.**Prevalence of Blindness and Visual Impairment in Pakistan: The Pakistan National Blindness and Visual Impairment Survey.**Investigative Ophthalmology and Visual Science 47(11):4749-4755
- Johnson JG, Foster A, 2003. **Prevalence, incidence and distribution of visual impairment.** Epidemiology of Eye Disease. 2nd Edition.Edward Arnold: London
- Kahn et al, 1977.**The Framingham Eye Study: Outline and major prevalence findings.**American Journal of Epidemiology 106(1):17-32
- KatzJ, Tielsch JM and Sommev A, 1997.**Prevalence and Risk Factors for Refractive Errors in an adult inner city population.**Investigative Ophthalmology and Visual Science 38(2): 334-340
- Kuo A, Sinatra R, Donahue S. **Distribution of refractive error in healthy infants.** Journal of the American Association for Pediatric Ophthalmology and Strabismus 2003;3:174-7
- Laviers H, Burhan I, Omar F, Jecha H, Gilbert C. 2011.**Evaluation of distribution of presbyopic correction through primary healthcare centres in Zanzibar, East Africa.** British Journal of Ophthalmology 95(6):783-787
- Leske CM, 2007. **Open Agnle Glaucoma-An Epidemiological Over.** Ophthalmic Epidemiology 14(4): 166-172
- Limburg H, Barria von-Bischhoffshausen F, Gomez P, Silva JC and Foster A, 2008. **Review of recent surveys on blindness and visual impairment in Latin America.** British Journal of Ophthalmology 92:315–319
- Loewenthal R, Pe'er J, 1990. **A prevalence survey of ophthalmic diseases among the Turkana tribe in north-west Kenya.** British Journal of Ophthalmology 74:84–8
- Luntz MH, 1973. **Primary angle-closure glaucoma in urbanized South African Caucasoid and Negroid communities.** British Journal of Ophthalmology 57:445-56
- Mathenge,W, Kuper H,LimburgHPolack S, Onyango O, Nyaga G & Foster A, 2007a. **Rapid Assessment of Avoidable Blindness in Nakuru District, Kenya.** Ophthalmology 114:599–605
- Mathenge W, Nkurikiye J, Limburg H, et al, 2007b. **Rapid assessment of avoidable blindness in western Rwanda: blindness in a post-conflict setting.** PLoS Med 4:e217
- Maul E, Barroso S, Munoz SR, et al, 2000. **Refractive error study in children: results from La Florida, Chile.** American Journal of Ophthalmology 29:445–54
- Mitchell P, Smith W, Attebo K, Healey P, 1996. **Prevalence of open-angle glaucoma in Australia.** The Blue Mountains Eye Study. Ophthalmology 103(10):1661-9
- Moll AC, van der Linden AJ, Hogeweg M, Schader WE, Hermans J, de Keizer RJ, 1994. **Prevalence of blindness and low vision of people over 30 years in the Wenchi district, Ghana in relation to eye care programmes.**British Journal of Ophthalmology 78 275-278
- Mun˜oz B, West SK, Rodriguez J, Sanchez R, Broman AT, Snyder R and Klein R, 2002. **Blindness, Visual Impairment and the Problem of Uncorrected Refractive Error in a Mexican-American Population: Proyecto VER.** Investigative Ophthalmology and Visual Science 43:608–614)
- Murthy GV, Gupta SK, Ellwein LB, et al, 2002. **Refractive error in children in an urban population in New Delhi.** Investigative Ophthalmology and Visual Science 43:623–31
- Naidoo KS, Raghunandan A, Mashige KP, et al, 2003. **Refractive Error and Visual Impairment in African Children in South Africa.** Investigative Ophthalmology and Visual Science 44:3764–70
- Department of Health, 2002.**National guideline: Prevention of blindness in South Africa**
- Ngondi J, Reacher M, Matthews F, Ole-Sempele F, Onsarigo A, Matende I, Baba S, Brayne C, Emerson P, 2007. **The epidemiology of low vision and blindness associated with trichiasis in southern Sudan.**BMC Ophthalmology 7:12
- Nirmalan PK, Krishnaiah S, Shamanna BR, Rao GN, Thomas R, 2006. **A Population-Based Assessment of Presbyopia in the State of Andhra Pradesh, South India: The Andhra Pradesh Eye Disease Study.** Investigative Ophthalmology and Visual Science 47(6):2324-8

SELECTED READING/REFERENCES(CONT.)

- Oduntan AO, 2001. **Causes of low vision and blindness in Black South African children attending special education schools in the Northern Province of South Africa.** South African Optometrist 60:120-123
- Pokharel GP, Negrel AD, Munoz SR, et al, 2000. **Refractive error study in children: results from Mechi Zone, Nepal.** American Journal of Ophthalmology 129:436–44
- Quigley HA, 1996. **The number of people with Glaucoma worldwide.** British Journal of Ophthalmology 80:389-93
- Ramke J, du Toit R, Palagyi A, Brian G, Naduvilath T, 2007. **Correction of refractive error and presbyopia in Timor-Leste.** British Journal of Ophthalmology 91(7):860-6
- Ramke J, Palagyi A, Naduvilath T, du Toit R, Brian G, 2007. **Prevalence and causes of blindness and low vision in Timor-Leste.** British Journal of Ophthalmology 91(9):1117-21
- Resnikoff S , Pascolini D, Mariottia SP & Pokharel GP, 2008. **Global magnitude of visual impairment caused by uncorrected refractive errors in 2004.** Bulletin of the World Health Organisation 86:63–70
- Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel G, Mariotti SP, 2004. **Global data on visual impairment in the year 2002.** Bulletin of the World Health Organisation, 82 844-851
- Rotchford A, Johnson G, 2002. **Glaucoma in Zulus. A population based cross sectional survey in a rural district in South Africa.** Archives of Ophthalmology 120:471-8
- Schémann JF, Inocencio F, de Lourdes Monteiro M, Andrade J, Auzemery A, Guelfi Y, 2006. **Blindness and low vision in Cape Verde Islands: results of a national eye survey.** Ophthalmic Epidemiology. 13(4):219-26
- The Vision in Preschoolers Study Group, 2005. **Preschool Vision Screening Tests Administered by Nurse Screeners Compared with Lay Screeners in the Vision in Preschoolers Study.** Investigative Ophthalmology and Visual Science 46:2639–2648
- Weih L, Nanjan M, McCarty C, Taylor H, 2001. **Prevalence and Predictors of Open-Angle Glaucoma: Results from the visual impairment project.** Ophthalmol 108(11):1966-72
- Whitfield R, Schwab L, Ross-Degnan D, Steinkuller P and Swartwood J, 1990.**Blindness and eye disease in Kenya: Ocular status survey results from the Kenya rural Blindness Prevention Project.** British Journal of Ophthalmology 74:333-340
- WHO Study Group on the Prevention of Blindness, 1973. **WHO Technical Report Series No. 518.** World Health Organisation, Geneva
- WHO, 1998.**World Health Organisation Informal Consultation on Analysis of Blindness Prevention Outcomes.** WHO/PBL/98.68 Geneva: World Health Organisation
- Williams C, Northstone K, Harrad RA, Sparrow JM and Harvey I, 2003. **Amblyopia treatment outcomes after preschool screening v school entry screening: observational data from a prospective cohort study.** British Journal of Ophthalmology 87;988-99
- World Health Organisation, 2011.**International Statistical Classification of Diseases and Related Health Problems: ICD10.**10th Revision.WHO Publications, Geneva
- World Health Organization. **Sight test and glasses could dramatically improve the lives of 150 million people with poor vision.** Press release, 11 October 2006. http://www.who.int/mediacentre/news/releases/2006/pr55/en/index.html
- Xu L, Wang Y, Li Y, Wang Y, Cui T, Li J, Jonas JB, 2006. **Causes of blindness and visual impairment in urban and rural areas in Beijing: the Beijing Eye Study.**Ophthalmology 113(7):1134.e1-11
- Zainul et al, 2002.**Prevalence of blindness and low vision in Malaysian population: results from the National Eye Survey 1996.**British Journal of Ophthalmology 86(9):951-6
- Zhao J, Pan X, Sui R, et al 2000. **Refractive error study in children: results from Shunyi District, China.** American Journal of Opthalmology 129:427–35