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Elimination of avoidable visual disability due to refractive errors

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Report of an informal planning meeting

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World Health Organization

Prevention of Blindness and Deafness

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Preamble

Significant visually disabling refractive error affects a large proportion of the world's population, affecting both genders and all age and ethnic groups. Many have permanent low vision (less than 6/18 binocularly) that requires rehabilitation services. Refractive error can be simply diagnosed, measured and corrected with spectacles. Their provision (distance spectacles for myopia and near spectacles for presbyopia) is extremely cost-effective.

The lack of refraction and spectacle provision in eye care services in underserved communities has important negative consequences in terms of lost educational and employment opportunities, which result in impaired quality of life and lost economy for the individual, the family and society.

The participants recognized that the provision of low vision services is a separate although closely related subject. Previous reports have addressed the issue of low vision services, and the group therefore focused its attention on correctable visually disabling refractive error.

Summary

There are currently a number of barriers to the effective correction of refractive error. In many areas, the eye care personnel and/or the equipment needed to perform refraction are unavailable. Services, or the spectacles needed to correct vision, may be inaccessible or unaffordable to the community in need. There may be a lack of public awareness of the importance of eye care and the availability of vision correction. In some countries, there are cultural barriers to the use of spectacles.

In the delivery of effective refractive services, all of these barriers must be removed and long-term sustainable solutions and infrastructure put in place. The aim of programmes for correction of refractive error should be the delivery of equitable affordable eye care, so that all those who can benefit from refractive services get the correction and support they need.

The refractive error situation varies greatly throughout the world. However, it is clear that all countries, including those in the developed world, require improvement in refractive services. Stratified guidelines on priority-setting (based on the prevalence and pattern of refractive error) are needed in order to allow each region to target resources optimally. A number of activities, for example under the direction of eye care NGDOs, are already under way. Future programmes can both learn from these experiences and be integrated with them.

In technology, research is still needed to determine and develop the best method for refractive assessment for mass populations in a range of locations. Development of new equipment which is easy to use, reliable, affordable and durable will determine the effectiveness of service delivery. A number of models are available for the production and delivery of low-cost spectacles, and these will need to be developed on a national or regional basis.

Human resources are crucial to the establishment of long-term refractive services. Training will be required to produce refractionists and other eye care personnel. "Training the trainers" and developing educational materials will be an important part of strategies to build lasting eye care infrastructure. Ongoing support and career opportunities for eye care personnel will help to ensure the retention of trained personnel in the field. Models for the numbers of eye care personnel and the structure of services have been developed. Again, these will need to be adopted and implemented on a national or regional basis.

Cooperation and networking between programmes and organizations will be important for the most effective use of resources. Integration, both vertically within the eye care team and horizontally with other health care and community development efforts, will also be important for planning and effective delivery of eye care.

Research is still needed in a number of areas, including epidemiology, delivery of services, and technology. Monitoring of outcomes will also be an important check on any programmes implemented and will be needed to ensure continued support from governments and other supporters.

The elimination of uncorrected refractive error will be a significant improvement in the worldwide standards of eye care, health and quality of life.

General conclusions and recommendations

1. The participants endorsed the inclusion of the correction of visually disabling refractive errors as a component of the Global Initiative for the Elimination of Avoidable Blindness – *Vision 2020: The Right to Sight*.
2. The participants emphasized the need to deliver refraction services as an integral part of general health care systems and comprehensive eye care.
3. Priority needs to be given to the identification of communities with visual disability due to uncorrected refractive errors. Service provision to these underserved communities will improve the quality of vision; create greater acceptance of eye care by the population; and be used to identify individuals with other treatable causes of poor vision.
4. The lack of epidemiological data on the magnitude of uncorrected visually disabling refractive error was noted. A small number of population-based studies have revealed a wide variation in magnitude of refractive error across age, gender and ethnicity. It was recommended that future epidemiological studies use agreed definitions and methodologies (as discussed in the report) in ascertaining the magnitude of the problem and the need for refractive services.
5. The first priority in an underserved society is the provision of refractive services for the individual. These clinical refractive services will normally be delivered at the secondary level of health care. Spectacles need to be readily available, affordable, and of acceptable quality, appearance and comfort.
6. Once clinical refractive services have been established at the secondary level of health care, these services can be used to support the development of community-/primary-level services.
7. At the community/primary level, the priority groups for provision of refractive services are children aged 11-15 years with myopia and people over the age of 40-45 years who require spectacles for near vision.
8. It is important that the outcome of providing refractive services be monitored through appropriate indicators and that operational research be utilized to evaluate the most cost-effective interventions.

Specific conclusions and recommendations

Refractive error in children

1. In the adult population, the level of significant visual impairment is less than 6/18; however, it is recommended that, for children, binocular vision of less than 6/12 be considered significant.
2. Screening of children for significant visual impairment should only occur when there are appropriate resources for follow-up refraction and delivery of spectacles.
3. Visual acuity screening of children can be performed at community level by suitably trained teachers, health care workers, etc. Where possible, screening of children should be integrated within the school health programmes. Teachers should be provided with appropriate educational materials, and information on the programme should be provided to parents.
4. It is recommended that priority for screening programmes be given to children aged 11-15 years and that a binocular vision of less than 6/12 be used to identify children needing referral for clinical refraction. The frequency of screening will depend on available resources and magnitude of the problem. In countries where evidence indicates that the prevalence of significant refractive error is high in younger age groups, screening of these children should be considered.

Refraction technique in children

5. Refraction examination of children should be carried out only by eye care personnel (ECP) with the appropriate skills in objective and subjective refraction, ocular motility, basic eye examination, ability to detect potentially blinding diseases, and communication skills. The examination should be carried out preferably at the screening site to facilitate patient compliance, if the appropriately skilled personnel and facilities are available.
6. It is recommended that the minimum standard refractive diagnostic examination for children be retinoscopy plus subjective refraction, with cycloplegia for young children as needed. Autorefractometry, plus subjective refraction with cycloplegia where necessary, is an alternative. Objective refraction by itself is not considered an appropriate basis on which to prescribe spectacles as a routine.

People over the age of 45 years

7. It is recommended that affordable ready-made spherical spectacles for near vision be made available at the community level in underserved societies. Health workers can be trained to test the vision of people over the age of 45 who present with near vision problems. If the distance visual acuity is 6/18 or better in each eye, near spectacles can be offered. If the visual acuity is less than 6/18 in either eye, the individual should be referred to the secondary-level centre for a full eye examination.

Aphakic/ pseudophakic patients

8. It is recommended that community health workers be made aware that post-cataract patients usually require spectacles and that if they are not available the patient should be referred to a secondary-level centre.

The provision of spectacles

9. Affordable or fully subsidized spectacles should be provided to those in need, preferably at the site of the screening/refraction. The spectacles should be of acceptable optical and safety quality (conforming to ISO standards), be of good/acceptable appearance and be well fitted and comfortable to encourage use. Ready-mades are considered acceptable if the anisometropia is less than 0.50D and the astigmatism in both eyes is less than 0.75D. The acceptable limit for prism is considered to be 0.50D.

10. Low-cost spherical ready-made spectacles can be imported in some countries which may meet up to 70% of the community's need. However, there may be a role for low-cost spectacle workshops in the manufacturing of prescription spectacles and the distribution of ready-made spectacles. Before establishing such a workshop, careful consideration should be given to the available "market", the cost-effectiveness of the workshop and the long-term financial sustainability of the programme.

11. Although the collection and recycling of used spectacles is a well-intentioned voluntary activity, experience has shown that the redistribution of recycled spectacles is not a cost-effective strategy for correcting uncorrected refractive error, and the participants do not recommend it.

Human resources for refractive services

12. The group recognized the need for trained and equipped personnel to implement refractive services at the community level, mid-level and specialist level of health care. Possible cadres for each level include the following:

    - Community level: community worker, schoolteacher, primary health care worker
    - Mid-level: ophthalmic nurses, ophthalmic and optometric technicians, dispensing opticians
    - Specialist level: Optometrists, ophthalmologists, managers

    As well as receiving training, eye care workers should be provided with an appropriate kit for their work, and professional support to optimize their services.

13. It is recommended that the minimum target for second-level personnel be 1:50 000 population, although it is acknowledged that this target will vary between countries depending on available resources. In order to train mid-level personnel in refraction, existing national training programmes should be strengthened and, if not available, regional programmes should be implemented.

Coordination and collaboration

14. The group recognized that the private sector is an important provider of refraction services. The group encouraged coordination and collaboration between governmental, nongovernmental and private sectors in the development of refractive services for underserved communities.

Operational research and programme implementation

15. There is a need for operational research into various aspects of assessment, cost-effectiveness of interventions, and outcome measurement. It is recommended that a working group be established to develop an action plan for the programme, including aspects of operational research.

1. INTRODUCTION

Uncorrected refractive errors are a significant cause of avoidable visual disability, especially in developing countries. Lack of awareness and recognition of this correctable cause of visual disability, compounded by the non-availability of affordable services for testing and the provision of corrective lenses, has been highlighted in population surveys of blindness and visual impairment worldwide. In addition, cultural factors in some countries lead to non-compliance in the use of optical correction, especially spectacles.

The correction of refractive errors to eliminate this form of avoidable disability has been included as a priority component within the planned areas of action under *Vision 2020: The Right to Sight*, the Global Initiative for the Elimination of Avoidable Blindness.

There is a need to define clearly the scope and extent of the problem and to outline the various measures that need to be adopted to introduce vision screening, refraction and the provision of refractive correction, as an integral part of the delivery of eye care and of the health care system that is accessible and affordable to the majority of the population.

An Informal Planning Meeting on the Elimination of Avoidable Visual Disability due to Refractive Errors was held from 3 to 5 July 2000 in the headquarters of the World Health Organization in Geneva. Twenty-three attendees, representing 14 organizations, participated in the meeting (*see Annex 1*).

The purpose of the meeting was:

- to define the scope of the problem in terms of both operational definition and visual disability burden;
- to discuss the known barriers to the availability/acceptance of refractive correction;
- to outline the various elements such as eye health promotion, human resources and training needs, technology options and distribution strategies for refractive services as an integral part of eye care services;
- to prepare a framework for implementation of action as a collaborative effort of Member States, WHO and the network of interested international nongovernmental organizations and institutions;
- to identify available resources and future resource mobilization for this component of *Vision 2020: The Right to Sight;*
- to identify research needs in the area of refractive services provision.

In his opening remarks, Dr Derek Yach, Executive Director, Noncommunicable Diseases and Mental Health, World Health Organization, stressed the importance of uncorrected refractive error and its effects on all aspects of daily life, particularly education and employment.

He commented on recent studies in a number of countries indicating that, on average, about 10% of children would benefit from using spectacles, noting that this is the equivalent of saying that the investment made in one school out of 10 is not fully utilized if corrective lenses are not provided.

Dr Yach also pointed to the development of several strategies for the elimination of uncorrected refractive error, focusing on creating awareness and a demand for refractive error

services through community-based activities; improving access to refractive services with a special emphasis on gender and disadvantaged populations; and ensuring that optical services become part of an essential package of services in all countries.

Professor Brien Holden was elected Chairperson of the meeting and Dr Hannah Faal Vice-Chairperson. Drs Kovin Naidoo and G.P. Pokharel were elected Rapporteurs. The draft agenda was adopted (*see Annex 2*).

2. REFRACTIVE ERRORS AS A CAUSE OF VISUAL DISABILITY

2.1 Epidemiology

Increasingly, refractive error is being recognized as an important cause of visual impairment in both children and adults. The type and magnitude of refractive error clearly change with advancing age and also appear to be changing over time, with recent cohorts having a higher prevalence than earlier ones. Although such differences in refractive error prevalence along with variations associated with geographical and ethnic differences are apparent, detailed and definitive comparisons from reports in the literature are generally not possible because of non-uniform measurement methods and definitions. Instead of direct measurement, for example with retinoscopy, autorefraction or subjective refraction, some estimate the prevalence of refractive error indirectly on the basis of improvement in visual acuity after refractive correction. Even if direct measurement is used, however, findings will be influenced by the measurement method and by whether or not cycloplegia is used.

Inconsistent thresholds in defining the degree of refractive error associated with the diagnosis of myopia or hyperopia also make it nearly impossible to compare findings from one study to another. Adding to this inconsistency is that some use only the spherical measurement on one principal meridian, while others use a mean of the two principal meridian measurements (spherical equivalent). Reporting is also not consistent, with some using data from a particular eye (e.g. the right eye) and others using measurements from both eyes in reporting findings at the person level (e.g. the worse eye). It is likely that some data may also be affected by lack of study control, such as through a learning effect between eyes, or by patients squinting.

Further, studies are frequently conducted in populations of limited representativeness, for example in convenience samples drawn from hospital clinics and schools, or in study samples defined on the basis of failing a visual acuity screen. Even in representative population-based samples, biases of unknown magnitude can be introduced when data are unavailable for a significant percentage of the targeted study population.

Finally, because refractive error is frequently gender- as well as age-dependent, comparisons across study populations are possible only if the underlying age and gender demographics are comparable.

Table 1, summarizing prevalence of refractive error findings from published studies from the different WHO regions, shows widely varying estimates and illustrates the difficulty in making meaningful comparisons. Although measurement methods are not identified in the table, either autorefraction or retinoscopy, frequently with cycloplegia for younger ages, was commonly used. Occasionally, improvement in visual acuity, at a specific level, with refractive correction was used in indirect measurement. Data generally pertain to measurements in the right eye. Considering myopia and hyperopia together, nearly 100% of some age groups were affected by refractive error in a few of the studies.

Table 1: Prevalence of refractive errors

Country	Author	Year	Age range	Myopia		Hyperopia	
				Definition	Prevalence %	Definition	Prevalence %
AFRICAN REGION							
Madagascar	Auzemery	1995	8-14	≤6/9	0.9	≤6/9	1.1
Malawi	Lewallen	1995	18-30	≤-0.50	4.3	n.a.	n.a.
AMERICAS							
Barbados	Wu	1999	40-84	<-0.50	21.9	>0.50	46.9
Canada	Robinson	1999	6	<-0.25	6.4	n.a.	n.a.
Chile	Maul	2000	5-15	≤-0.50	5.8	≥2.00	14.5
Puerto Rico	Gordon	1990	5-81	≤-0.50	25.4	≥0.50	47.1
USA 1	Hirsch	1952	5-6	≤-0.25	6.8	n.a.	n.a.
USA 2	Hirsch	1962	12	≤-0.50	12	n.a.	n.a.
USA 3	Angle	1980	12-17	<20/20	31.8	n.a.	n.a.
USA 4, Alaska	van Rens	1991	≥4	≤-0.25	44.9	>0.25	11.3
USA 5	Wang	1994	43-84	<-0.50	42.9-14.4	>0.50	22.1-68.5
USA 6	Preslan	1996	4-7	<-0.50	3.1	>4.00	0.9
USA 7	Katz	1997	>39	<-0.50	36-12.5	>0.50	15-62
USA 8	Zadnik	1999	5-13	≤-0.75	4.4-17.3	n.a.	n.a.
EASTERN MEDITERRANEAN REGION							
Oman	Lithander	1999	6-12	≤-1.00	0.6-5.2	n.a.	n.a.
EUROPEAN REGION							
Denmark	Fledelias	1986	5-10	<-0.00	6	n.a.	n.a.
Iceland	Gudmunds-dottir	1999	28-14	n.a.	50-80	n.a.	n.a.
Norway	Kinge	1994	~20	n.a.	46.9	n.a.	29.5
Russia	Aleksandrov	2000	20	n.a.	66	n.a.	n.a.
Sweden	Kohler	1978	7	<-1.00	1.8	n.a.	n.a.
Turkey	Turacli	1995	4-12	n.a.	3.5	n.a.	2.3
United Kingdom	Cunnings	1996	8-10	≤6/9	24.4	≤6/9	0.6
SOUTH-EAST ASIA REGION							
India 1	Kalikivayi	1997	3-18	n.a.	8.6	n.a	22.6
India 2	Dandona	1999	1.<16 2. 16-39 3. >39	< -0.50	Gr1: 5.0 Gr2: 14.6 Gr3: 28.2	>0.50	1: 5.84 2: 2.7 3: 27.4
Nepal 1 (Tibetan)	Garner	1999	7-18	≤-0.50	21.7	n.a.	n.a.
Nepal 2 (Sherpa)	Garner	1999	7-18	≤-0.50	2.9	n.a.	n.a.
Nepal 3	Pokharel	2000	5-15	≤-0.50	0.3	≥2.00	1.1

Country	Author	Year	Age range	Myopia		Hyperopia	
				Definition	Prevalence %	Definition	Prevalence %
WESTERN PACIFIC REGION							
Australia 1	Attebo	1999	≥49	<-0.50	15.5	>0.50	56.6
Australia 2	Windsor	1999	≥40	<-0.50	17	n.a.	n.a.
China	Zhao	2000	5-15	≤-0.50	21.6	≥2.00	2.7
Hong Kong	Edwards	1997	7-12	≤-0.50	11-57	n.a.	n.a.
Japan	Matsumura	1999	17	≤-0.50	65.6	n.a.	n.a.
Malaysia	Garner	1990	6-17	≤-0.50	4.2-25.6	n.a.	n.a.
Singapore 1	Au Eong	1993	15-25	≤6/18	44.2	n.a.	n.a.
Singapore 2	Wong	2000	40-81	<-0.50	38.7	>0.50	28.4
Taiwan 1	Lin	1988	13-16	n.a.	49.6	>2.00	0.6
Taiwan 2	Lin	1999	7-18	<-0.25	12-84	n.a.	n.a.
Vanuatu	Grosvenor	1988	6-19	≤-0.50	2.9	≥1.25	0.3

Because of the lack of uniformity in measurement and definitions across regions or within countries, it is generally very difficult to draw general conclusions regarding prevalence patterns. An exception is the childhood refractive error studies conducted in China, Nepal and Chile by Zhao, Pokharel and Maul, where a common protocol was used. The standardized protocol used in these population-based studies was developed in a collaboration between WHO and the United States National Eye Institute, National Institutes of Health.

However, in whatever way myopic and hyperopic refractive errors are measured and defined, it should be recognized that the immediate public health question pertains not to the prevalence of refractive error *per se*, but to the prevalence of *visually disabling refractive error* and the extent to which it remains uncorrected in the community.

2.2 Delivery of effective vision correction

The existence of refractive error and the feasibility of providing refractive correction are not necessarily the best indication for correction to be provided. It is more important to think in terms of *an unmet need*. While there is a clear relationship between refractive error and vision, it is also necessary to think of the relationship between vision and the activities and lifestyle of the person.

In the framework of Vision 2020, it is important to recognize that there may be a need to have stratified guidelines. The degree and type of refractive error requiring correction will vary between countries, and not all countries have the resources to treat the whole problem. It is important also to recognize that improvement in refractive error services is needed in both developing and developed countries, as there may still be populations within developed countries who are not receiving adequate refractive services. Data should be presented showing the range of refractive error, to assist health authorities in developing targets and priorities.

Guidelines should be provided not only to understand the magnitude of the problem, but also to monitor and evaluate refractive and corrective services.

One possible indicator is the proportion of patients still using spectacles six months after receiving them. It should be recognized that in some areas, barriers to use – such as cultural acceptability – may need to be specifically addressed. Spending time educating people about their new spectacles may directly influence their use of the devices and may be a valuable investment in the long-term effectiveness of any programme.

2.2.1 *Refractive error in children*

It is initially recommended that:

- myopia be defined as ≤-0.50D;
- hyperopia be defined as ≥2.00D, particularly in children.

"Significant refractive error" could also be functionally defined simply as refractive error, in that if the patient is given the correct spectacles, he/she will wear them – but this will vary widely due to cultural and educational environment. Refractive correction in the adult population is considered high priority for adults with less than 6/18 binocularly, moderate priority for less than 6/12, and low priority for less than 6/9. For children, less than 6/12 binocularly is recommended as the criterion for a full refraction and correction.

The *International Classification of Diseases,* Tenth Revision, Vol. 1 (World Health Organization, 1992) categorizes visual acuity as follows:

Category of visual impairment	**Visual acuity with best possible correction**	
	Maximum less than:	Minimum equal to or better than:
1	6/18 3/10 (0.3) 20/70	6/60 1/10 (0.1) 20/200
2	6/60 1/10 (0.1) 20/200	3/60 1/20 (0.05) 20/400
3	3/60 1/20 (0.05) 20/400	1/60 (finger counting at 1 metre) 1/50 (0.02) 5/300
4	1/60 (finger counting at 1 metre) 1/50 (0.02) 5/300	Light perception
5	No light perception	
9	Undetermined or unspecified	

As vision is vitally important in education, screening of children as they enter primary school (age 5-6 years) and secondary school (age 11-12 years) is to be recommended. However, this will need to be assessed on a regional basis, depending on available resources and age-specific prevalence of refractive error. In general, as the incidence of myopia is higher in the 11-15 age group, this is the highest priority, although in countries where there is evidence that younger children have a high prevalence of refractive error and resources are available, these children should also be screened.

It is also important to recognize that schooling levels must be taken into account when designing programmes. Low levels of schooling, or different attendance levels between different ethnic groups or between genders, will require additional or alternative methods to reach effectively all of the targeted age cohort.

On a country or regional basis, assessment of the refractive error will determine the priorities for resource concentration. However, this will be dependent on the definitions used:

Priority	**<6/12**	**<6/18**
High	5%	3%

Moderate	2-5%	1-3%
Low	<2%	<1%

For children, less than 6/12 is set as the standard, and for adults, less than 6/18.

The involvement of other personnel in the system, such as teachers, nurse assistants, or local health workers, can be a valuable way to improve the efficiency of the system. With training, these personnel can carry out basic screening with tools which are culturally appropriate for the group. "Pre-screening" of patients could be done by these personnel in readiness for patients to be seen by a trained refractionist in a primary or secondary eye care setting. Educational materials provided to these personnel will also be communicated to the patients to raise awareness of the importance of eye care.

The frequency of screening must be considered in the long-term provision and management of refractive services. Initial screenings in a region should cover all school-age children and each year subsequently should concentrate on 11-year-olds. It will also be necessary to re-evaluate regularly those who have previously been given spectacles, to ensure that they continue to have the right correction. Personnel at the community level could perform annual screenings.

2.2.2 *Refractive technique in children*

Visual acuity is the most appropriate screening test to identify individuals with visual impairment due to uncorrected refractive error. It is suggested that visual acuity be measured and recorded for both eyes separately and binocularly.

The method of measurement of refractive error is dependent on the availability of equipment and trained practitioners. Retinoscopy and autorefraction under cycloplegia can produce similar results; however, retinoscopy requires trained personnel, and autorefractors are currently expensive. Categorization of refractive error can be on sphere only, meridian with least or greatest refractive error, or spherical equivalent. Ideally, the full refractive error should be recorded, i.e. sphere/cylinder and axis for both eyes and interpupillary distance. Again, the decision to correct or not must be based on *visually disabling refractive error* and *unmet need*. Retinoscopy is recommended as the standard objective method, with autorefractor as a back-up and cycloplegia as needed. Autorefractor plus subjective refraction is also an alternative; however, subjective refraction alone is not recommended. Though cycloplegia is preferred for younger children, problems with its use include the need for parental permission, reluctance of the children and the use of diagnostic drug by non-licensed ophthalmic personnel.

2.2.3 *Presbyopia*

The need for near spectacles for close work after the age of 45 years is almost universal although the onset of presbyopia is earlier in countries nearer the equator. The availability of reading spectacles can be assessed to give an estimate of population coverage. For example, in assessing 100 people aged 45 years and above:

- if less than one-third have near spectacles, the population would be ranked high priority;
- if one to two-thirds have spectacles, this would be moderate priority;
- if more than two-thirds have spectacles, this would be low priority.

This assessment will allow communities to be ranked for priority action, depending on country priorities and resources. All people over the age of 45 years should be screened. Ready-made readers should be available at the primary eye care level and can be part of an income-generating model.

It is also important to recognize that refractive services for presbyopia also act as a valuable gateway to general eye care for this age group. Failing near sight can bring patients to primary eye care sites, where assessment for other conditions such as cataract, glaucoma and diabetes can take place.

3. SITUATIONAL ANALYSIS OF EXISTING SERVICES FOR PROVISION OF REFRACTIVE SERVICES

3.1 Country situations

3.1.1 *Nepal*

The estimated population of Nepal is about 22 million. In 1981, a blindness survey was conducted in Nepal. Among 39 887 persons of all ages who were examined, 2.7% had uncorrected visual acuity worse than 6/18 in the better eye, 1.3% worse than 6/60. Refractive error was identified as a primary ocular disorder in 1.3% of those examined. In 1998, a population-based study was conducted in school-age children in Eastern Nepal, of whom 2.9% of those examined had visual acuity of 6/12 or worse in one or both eyes without correction, which is quite low if compared to China (12.8%) and Chile (15.8%). Compared to other countries, refractive error prevalence is lower in Nepal. In noting this lower prevalence of refractive error, it is therefore important to target those sections of the population who would be most helped by refractive error correction. As previously noted, guidelines which will be useful for a range of countries will be needed.

Refraction

- Refractive services are provided by postgraduate ophthalmologists, who are usually trained for three years after graduation. This type of service is provided in about 50 privately run eye clinics.
- The bulk of refractive services is provided by 200 ophthalmic assistants through 35 eye hospital/district eye centres. They are trained for three years in basic ophthalmology followed by six months' training in refraction. About 20 ophthalmic assistants are trained annually.
- In 1999, a graduate course on optometry was started by Tribhuvan University with an intake of four candidates every year since 1982.
- A combination of private opticians and hospital-/clinic-based opticians (few of them) provide refractive services also.
- There are some refractive error programmes involving school screenings; however, school education is not compulsory. There are differences in school attendance between males and females, and in some areas schooling is limited by geographical considerations. Future programmes will need to take these issues into account to ensure that all those in need are reached.

Diagnostic

- Retinoscopy: All basic refraction is performed using a streak retinoscope. All ophthalmic assistants providing refraction services are experienced in the use of a retinoscope.
- Keratometry: Although private clinics usually do not have a keratometer, all 16 hospitals which provide surgical facilities have one.
- Autorefractor: Few centres (five) have an autorefractor, and even in these centres usage is minimal.

Spectacle correction

- The average cost could be as low as US$ 2 for presbyopic glasses using glass lenses to US$ 50 for plastic lenses. Frames and lenses are imported, mainly from India and Korea. There is no subsidy on glasses, but aphakic (+10 and +11) glasses are provided free of charge to those who cannot afford to pay. There is no revolving fund for spectacles. Sometimes donated frames and lenses are used on an *ad hoc* basis.
- There is no low-cost production facility and probably no need for one.

Contact lenses

- Only three clinics (two of them private) provide contact lens services. The average cost is from US$ 10 to US$ 75.

Refractive surgery

- There is no refractive service facility in Nepal. A very few go to India for such services. In India, LASIK for each eye costs from US$ 150 to US$ 300.

Presbyopia

- Over-the-counter presbyopic correction is available in optical shops. There could be anywhere between 200 to 400 such optical shops in Nepal.
- More than half of the work of refractive services in the 35 centres is on presbyopics, and the service is expanding as more women who have to do the needlework and housework are wearing glasses.

3.1.2 *China*

China has a population of 1.27 billion. Clinical evidence suggests that refractive error is a common problem, particularly in children. In response to growing concerns, the Chinese Government has established a special unit within the Ministry of Education to deal with refractive error.

A refractive error study in children aged 5-15 years in the Shunyi district of Beijing was conducted in 1998 in order to assess the prevalence of refractive error and visual impairment. Myopia $\leq$-0.50D was found in 36.7% of males and 55% of females by age 15. The females were also more hyperopic, 19.6% being +2D at the age of 5, with 8.8% of males. The prevalence of refractive error in adults was also recognized in another study which showed myopia in 22% of people aged over 45. Some data showed that there was a significant increase in myopia after the "cultural revolution", due to increased schooling. There are currently 0.3 billion people in China with refractive error. More than 85% of refractive error in children of 15 years was uncorrected. In most cases, cost and availability are not an issue for spectacle correction; there may therefore be cultural barriers to the acceptance of spectacles. In some cases this could be based on cosmesis, and in some cases there is a belief that wearing spectacles worsens vision.

Refraction

- In general, ophthalmologists, optometrists and opticians perform refraction.
- Refraction is a part of the resident training in ophthalmology in China, which is a three- to five-year training course including refraction training and practice. The training sites are usually in hospitals. There are about 400 new residents in ophthalmology per year in China. They usually perform the refraction in eye hospitals, or in hospital departments of ophthalmology.
- Since 1988, there are two kinds of optometry school for training the optometrists for refraction

in China. The first is affiliated to the medical school, where students receive five-year training, including optometry and ophthalmology. The training sites are usually in medical schools and affiliated hospitals. There are about 250 new students in this kind of optometry school per year. The second is affiliated to the general college, where students get three years' training in optometry. The training sites are usually in the college and related hospitals. There are about 100 new students in this kind of optometry school per year. The optometrists usually perform the refraction in eye hospitals, departments of ophthalmology or large-scale spectacle shops.

- There are some technical schools providing a three-year course on refraction training and practice for training opticians in China. The training sites are usually in these schools and the related hospitals. There are about 300-400 new students per year. The opticians usually perform the refraction in medium- or small-scale spectacle shops.
- Retinoscopy, keratometry, automated refraction, subjective refraction and cycloplegic refraction are all used for refraction in China. Retinoscopy is mainly used in eye hospitals and in departments of ophthalmololgy, especially for children. Keratometry is used in eye hospitals, in departments of ophthalmology and in large-scale spectacle shops. Automated refraction is used in the spectacle shops, spectacle markets and eye hospitals and in departments of ophthalmology. Subjective refraction is usually used in spectacle shops. Cycloplegic refraction is usually used in eye hospitals and in departments of ophthalmology and is used mainly for children.
- About 80% of children and adolescent patients with refractive error undergo refraction in the eye hospitals and in departments of ophthalmology.
- Most adult patients with refractive error undergo refraction in spectacle shops.
- Some patients who are elderly, or whose spectacles are lost or damaged, obtain spectacles over the counter without refraction.

Spectacle correction

- About 50% of refractive error patients are corrected by spectacles.
- Spectacles are dispensed by hospital-/clinic-based government or private opticians, or dealers.
- The cost of spectacles varies in different spectacle shops according to the location, service facility, etc. The average cost of spectacles is from US$ 36 to US$ 48.
- In general, frames are locally made in Guangchow, Shenzhen, Beijing, Shanghai and Hong Kong. Some are imported from Japan. Expensive frames are imported from Korea, Japan, France, Italy, Germany and USA.
- Most resin lenses are imported, although manufacturing facilities have started to be established locally. Most glass lenses are made locally.
- Some spectacle shops have subsidy schemes, especially for children and the elderly, perhaps on Children's Day or National Eyecare Day. There is no revolving fund for spectacles, and there are no programmes involving the use of recycled spectacles.
- There are no low-cost production facilities for spectacles, and this is probably an area of need. It is estimated that spectacles could be produced for around US$ 6 to US$ 12.

Contact lenses

- About 2-3% of refractive errors are corrected by contact lenses.
- Lenses are dispensed by hospital-/clinic-based government opticians, or private opticians.
- The average cost of lenses is from US$ 10 to US$ 14.

Refractive surgery

- There are more than 200 excimer lasers in China. About 300 000 patients with refractive error receive refractive surgery (RK, PRK, LASIK) per year. This is less than 1% of the total number of patients with refractive error.

- Refractive surgery is performed by the hospital-/clinic-based government sector. The average cost of refractive surgery is from US$ 240 to US$ 300 per eye.

3.1.3 *India*

The population of India is 1 billion, with at least 10 million blind and perhaps 19 million visually impaired. Refractive error occurs at a rate of 1 in 25 (4.0%). Current barriers to the correction of refractive error include the availability and accessibility of trained personnel and refractive services; a lack of public awareness of the need for and availability of refractive error correction; and the affordability of services and spectacles. The annual per capita income is around US$ 350; however, the poorer 50% of the population earn only US$ 50 per annum, which has significant implications for the delivery of affordable eye care.

Refraction

- Refraction is performed by ophthalmologists (about 10 000), optometrists (about 5000), ophthalmic technicians/assistants (about 2000), and also opticians and others.
- Refraction is performed in eye hospitals; in out-reach clinics; and by opticians and optometrists and in ophthalmic clinics.
- Ophthalmologist training is through residency, at medical school departments or eye institutes, over three years. Over 100 ophthalmologists are produced per year. There are more ophthalmologists than other categories of people in eye care. This weighting, with higher-level practitioners, is reflected throughout the medical sector.
- Optometrist training is through optometry training programmes or schools, over two to four years. About 50 optometrists are produced per year.
- Ophthalmic technician/assistant training is done through teaching and non-teaching hospitals, over one to two years. The number produced is unknown.
- A lack of career advancement opportunities for mid-level personnel is a possible reason for the shortage in these areas. There is no structure through which they can advance, so many do not enter the area, or exit rapidly to other fields.
- Some training programmes exist for opticians; however, information is scanty. There is currently no registration or organization of this sector.
- Others performing refraction are a few general practitioners, or unqualified people. There are thousands of "optical shops" with unqualified people providing refractive services. There is no actual accreditation process for any health or medical care facility in India.

Diagnostic

- Retinoscopy is most popular, keratometry is rare, and autorefractor is also rare, usually seen only in urban practices.

Spectacle correction

- Spectacle correction is the most common method of correction of refractive error, usually dispensed by hospital-/clinic-based government or private opticians.
- The average cost of spectacles ranges from US$ 3 to US$ 150.
- Spectacle frames and lenses are both manufactured locally (90%) and imported.
- Subsidy schemes for indigent populations are run by the Government and by local and international NGDOs. There are revolving funds for spectacles run by some voluntary institutes. In some places, recycled spectacles are used. Low-cost production facilities exist and are a valuable part of the Indian refractive error system.

Contact lenses

- Contact lenses are worn by around 1 million people.
- Lenses are dispensed by opticians, optometrists and ophthalmologists.
- The average cost of lenses is from US$ 15 to US$ 50.

Refractive surgery

- Around 100 000 refractive surgeries are performed each year.
- They are performed almost entirely by the private sector, and the average cost per eye is from US$ 250 to US$ 1000.

Presbyopia

- Over-the-counter presbyopic correction is not available.
- Low-cost spectacle distribution is low in India, despite the opportunity for business to cater for 200 to 300 million presbyopes. This is due to lack of awareness, particularly in the rural population, of the need for or availability of good near vision for the elderly.

3.1.4 *Viet Nam*

There are fragmentary data regarding refractive errors among schoolchildren in Viet Nam. However, in primary schools, refractive errors are known to be around 10%-20%. The number increases in secondary school. Urban figures are said to be higher; however, a new study needs to be undertaken. There are almost 1 million children aged three who will be targeted in the future plan of vision screening, once there is a strengthened refraction care system with a sufficient number of mid-level personnel in eye care. Approximately 30% of the population over 40 years of age may have reading problems.

The Third Intercountry Workshop of the Region, held in Hanoi in March 2000, placed refraction services development as the major topic of the discussions. The plan of refraction services development and cooperation which was developed includes:

- manpower development, emphasizing the necessity of mid-level personnel in eye care (MLP/EC);
- appropriate technology from research and development;
- adequate investment in physical facilities and equipment instalment;
- collaboration with existing professional groups;
- inventory of affordable ophthalmic lenses and frames and new pricing policy.

According to the Hanoi Workshop, the service targets of refractive care were designed as follows:

- Primary target groups
  - Preschool-age children (3-6 years old)
  - Schoolchildren (6-14 years old)
  - The elderly
- Special target groups
  - Labour force, in relation to occupational health care and prevention of injury
  - Partially sighted population in relation to low vision care.

Refraction

- Two groups of professional staff share eye care services, including refraction services: those at blindness prevention stations and those at general hospital eye units at the provincial level.
- A total of 700 ophthalmologists work in the above two lines of administration. Blindness prevention is mainly the responsibility of the staff of stations administered by the Institute of Ophthalmology, Hanoi, while provincial hospitals belong to the curative sector of the Ministry of Health. Currently, these are merging at the operational level. Some stations are being upgraded to form independent eye centres.
- Blindness prevention efforts in the past have been confined to the interventions of cataract, blinding malnutrition and trachoma. As a result, refraction services were almost overlooked.

Spectacle correction

- Local production of ophthalmic lenses is always in short supply. There are two factories in Hanoi and Ho Chi Minh City producing 250 000 pairs of lenses annually. The rest are mainly imported from China. Frames also come mainly from China through the border trade.
- Optical shops exist in large cities, and unqualified opticians carry out refractive check-ups. Only a small number of ophthalmologists supervise in the shops. The price for spectacles is around US$ 7 to US$ 8. To the average citizen, this amount is approximately equivalent to one week's income.

Contact lenses

- Contact lens practice is still unpopular. Two clinics are attached to the eye facilities in Hanoi and Ho Chi Minh City. In general, soft lenses are handled by unqualified personnel at the approximate price of from US$ 40 to US$ 50.

Refractive surgery

- The country is now facing an aggressive approach from different overseas dealers importing machines.
- The Hanoi Institute plans to upgrade its refractive surgery unit and to install an excimer laser. The present radial keratotomy charges are US$ 700.

Presbyopia

- Reading spectacles of low quality are available in local vendors' shops at an approximate price of US$ 1.

3.1.5 *Australia*

In Australia, despite 3500 eye care practitioners providing refractive services as part of a government-funded health care programme and low- or no-cost supply systems available to those in need, the levels of visual impairment due to uncorrected refractive error are disappointingly high. Uncorrected refractive error accounts for 27% of blindness and 53% of impaired vision. Major issues include lack of awareness of services; poor distribution of services, particularly to rural areas; and lowered expectations of the aged. Around 20% of the population have their eyes examined each year. The Federal Government has also identified eye care as a specific problem in rural and remote Australia. Aboriginal people in Australia suffer up to 10 times the level of blindness from preventable eye disease than non-Aboriginal people. In 1998, the Review of Eye Health Services for Aboriginal Communities in NSW found that Aboriginal people present to eye specialists in disproportionately small numbers. Some of the barriers to effective eye care were

identified as lack of eye health awareness, lack of support and follow-up, and social and economic conditions.

Refraction

- Registered optometrists and ophthalmologists undertake refractive services. There are 2800 practising optometrists, 98.4% working in the private sector. The average optometrist-to-population ratio is 15 per 100 000 population, although three States have a lower ratio (South Australia, Northern Territory, Western Australia).
- 61% of optometrists in Australia work from 35 to 48 hours per week, providing an average number of services of around 1402 per year.
- There are approximately 650 ophthalmologists in private practice in Australia, providing 0.6 million consultations per year. Twenty-five ophthalmologists graduate each year.
- Government-funded hospital eye clinics are serviced by ophthalmologists and some optometrists. University-located eye clinics, which are staffed by academic registered optometrists, provide clinical training and experience for final-year optometry students.
- Services are also provided by visits to private homes/nursing homes/hospitals, domestically for housebound or bedridden patients and through institutions and private and government-funded medical centres.
- On average, there have been around 100 optometry graduates each year and the number of students commencing the courses has remained fairly constant. There are 4.8 commencing students per 100 000 population. The optometry course in Australia is a four-year university degree for a Bachelor of Optometry.

Diagnostic

- Equipment used includes retinoscope (high), keratometer (mid-low) and autorefractor (low); phoropters are used for subjective refraction.

Spectacle correction

- Optometrists provide services to 3.9 million (21%) people per year and 0.6 million people are seen by ophthalmologists.
- The population wearing spectacles or contact lenses is around 9 million people (approximately 50%).
- Prescription spectacles are dispensed by optometrists and optical dispensers, operating from 2196 locations in capital cities and 840 locations elsewhere.
- The average cost of supply for spectacles is approximately US$ 115 to US$ 130. Those members of the community who qualify for government-funded low-cost spectacle programmes may pay between US$ 0 and US$ 25, depending on the State.
- Spectacle frames and lenses are supplied by both local and overseas companies.
- Low-cost production facilities in Australia do exist; however it is only low-cost in comparison to Australia (US$ 3 per pair of glasses) and is still relatively high compared to overseas.
- Ready-made spectacles are available through a range of retail outlets. The manufacturers of these appliances are required by law to carry a tag that purchasers should treat the ready-made as an emergency replacement spectacle. The spectacle by law must carry a printed statement to the effect that the purchaser should undertake a regular eye examination by either an optometrist or an ophthalmologist. The retail price ranges from US$ 3 to US$ 20.
- 98.7% of eye examination fees were paid by Medicare Benefits provided by the Government.
- State/Territory low-cost or free government-funded eye care programmes provide low-cost or free eyewear for low-income earners. The administration and guidelines for conducting each programme vary from State to State, with some programmes requiring a modest patient-to-pay contribution. Spectacles are provided to the needy once every two years, unless there is a reason such as loss of or damage to the spectacles, or a change in refraction. In NSW, up to

100 000 applications are processed annually, with approximately 85% being approved for benefits at a total cost of almost US$ 2 million per annum to the Government. The Department of Veteran Affairs also provides government-funded eye care and spectacles to veterans.
- Private insurance companies reimburse towards the cost of spectacles if the client takes out appropriate insurance.

Contact lenses

- The number in the population wearing contact lenses is around 400,000.
- Cost to patient for various contact lenses: frequent replacement disposables (one-year supply), an average of US$ 75 per year; soft spherical and soft toric, an average of US$ 100 per pair; RGP, an average of US$ 60 per pair. These figures exclude additional costs for eye examinations and lens care (cleaner, saline, soaking solutions, etc.).

Refractive surgery

- This is a relatively new procedure in Australia and only a small percentage of the population has elected to undergo laser surgery to date. The cost to the patient is approximately US$ 1050 per eye.

3.1.6 *Gambia (and West Africa)*

Gambia has a population of around 1 million people. There is a great demand for refractive services, with presbyopia accounting for 31% of the demand in the hospitals and 55%-60% in eye camps, myopia for 19% in the hospitals and 12% in eye camps, and astigmatism for 16%. As in much of Africa, eye care services are concentrated in the private sector.

Refraction

- Refractive services are provided by ophthalmologists, opticians and ophthalmic assistants.
- Gambia has two dispensing opticians (trained in the United Kingdom), working through the main hospital.
- Senior ophthalmic medical assistants are trained in refraction and provide subjective refraction and presbyopia correction.
- In most of the French-speaking countries of Africa, the profession of optometrist is not recognized. Even the very few opticians who exist are not allowed to prescribe glasses according to the law, although they do this in practice. The rationale behind this is that refractive screening must include ophthalmic examination. Refraction is done in fact by nurses, but it must be done under the supervision of an ophthalmologist.
- For other parts of Africa: In Ghana, there are over 1000 trained optometrists and two training centres offering a six-year Doctor of Optometry degree. In Ghana, a postgraduate training programme offers BSc graduates a two-year course in optometry. To date, 10 optometrists have been trained. In Liberia and Sierra Leone, there are no optometric services and no training. In Nigeria, there are over 1000 trained optometrists, who are concentrated in the urban areas and the teaching hospitals and are primarily in private practice.

Diagnostic

- The main diagnostic test used is retinoscopy.

Spectacle correction

- Spectacle correction is provided by the ophthalmologists, opticians and ophthalmic assistants through the hospitals and through one optician in private practice.

- The average cost of spectacles ranges from US$ 4 (subsidized) to US$ 100 (private sector).
- Spectacles are imported from the United Kingdom and India.
- In some areas, "optical shops" have a range of ready-made spectacles, and "patients" simply come and choose a pair. This service is used mostly by the presbyopes.
- A revolving cost-recovery scheme has been established at the hospital; however, this does not always work efficiently. Accessing the money can be difficult, delaying orders. External support is also provided by NGDOs. Recycled spectacles are donated and used for patients who cannot afford correction.
- There are no low-cost production facilities.

Contact lenses

- There is no contact lens service.

Refractive surgery

- There is no refractive surgery service.

3.1.7 *South Africa*

The population of South Africa is 40-41 million. Optometry is essentially a private practice profession in the country; however, only 20% of the population has access to medical insurance or can afford private care. A National Prevention of Blindness Committee has been established.

Refraction

- Refraction is performed by optometrists, ophthalmologists and ophthalmic nurses.
- For optometrists, training is conducted at four optometric institutions which offer a four-year undergraduate programme. Each institution produces 40-45 graduates per annum. There are 2000 optometrists in the country but only 15 in the public sector, mainly in the Northern Province and, in a part-time capacity, in KwaZulu Natal. Two optometrists are employed through the Red Cross Flying Doctors to visit outlying areas and conduct outreach clinics.
- Refraction is performed by optometrists in district, regional and provincial hospitals in the Northern Province and on a sessional basis in KwaZulu Natal regional hospitals and in Eastern Cape. Also, in Northern Cape, a private group has been contracted to provide services in the outlying areas as well as in the main city.
- Seven institutions produce a total of 15 ophthalmology graduates per annum, in a four-year postgraduate programme. Ophthalmologists generally conduct refractions only in selected circumstances, for example post-cataract patients. In the private sector, ophthalmologists perform refractions and refer the patient to an optician or an optometrist.
- Ophthalmic nurses are the mainstay of public sector eye care. A one-year training programme is available at Edendale Hospital, Elim Hospital and St John's Hospital. These are nurses identified for training by the respective health departments and deployed to outlying hospitals. Nurses are employed in district hospitals as well as in regional and provincial hospitals and clinics. They work either with or without ophthalmologists and, in refraction, perform mainly basic refractions and issue ready-mades for reading and distance.
- Refractive services are also delivered by the Bureau for the Prevention of Blindness – Bureau tours for cataracts to outlying areas include optometrists who provide refractions – and the Eye Care Train (Phelophepa) which travels to rural areas and is staffed by optometry and dispensing students.

Diagnostic

- Retinoscopy is performed by ophthalmologists and optometrists, rarely by ophthalmic nurses.

- Keratometry is only available in larger hospitals and is rarely used as part of the refraction routine.
- Autorefractor is available in a few large hospitals, for example Edendale.

Spectacle correction

- Ophthalmic nurses dispense ready-made spectacles within the hospital setting. A national tender exists for ready-mades and these are available at hospitals, depending on the budget of each hospital and the existence of an ophthalmic nurse. Some hospital patients are refracted and referred to the nearest optometrist with a prescription.
- Dispensing arrangements vary depending on region. In the Northern Province, optometrists dispense the spectacles and these are supplied by a private company which has won the tender. In KwaZulu Natal, ophthalmic nurses provide ready-mades for distance and near. The Red Cross Flying Doctors service provides readers and made-to-order spectacles which are dispensed by the optometrists. In Northern Cape, the optometrist dispenses the spectacles.
- In general, the ophthalmic nurse or optometrist does the dispensing. Opticians function within the private sector and not the public sector.
- The average cost of spectacles within the public sector is from US$ 7 to US$ 8 for ready-mades – single vision readers or distance spectacles; and for made-to-order spectacles, from US$ 11 to US$ 13 for single vision, from US$ 23 to US$ 25 for plastic bifocals, and from US$ 44 to US$ 47 for metals.
- In the private sector, single vision readers/distance ready-mades are available for from US$ 7 to US$ 13; made-to-order single vision are from US$ 32 to US$ 46, plastic bifocals are from US$ 46 to US$ 65, and metals are >US$ 65. These prices quoted are at the lower end – there is great variability in prices based on quality, etc.
- Spectacle frames and lenses are fully imported.
- The Gauteng Ministry provides a subsidy for children. Other provincial governments that used to do so have terminated this due to the lack of funds. A Red Cross project subsidizes those who cannot afford spectacles. However, this subsidy is provided per case and is not a blanket subsidy for indigent or poor patients. There is no revolving fund for spectacles. Lions International provides recycled glasses for indigent patients; however, this programme is not widely used.
- There are no low-cost production facilities in South Africa, but labour costs in South Africa make importing a more attractive option. A previous attempt to manufacture low-cost spectacle frames failed. However, it must be noted that the mark-up in spectacles is very high, and there may be scope for distribution of imported spectacles more cheaply.

Contact lenses

- Patients from hospitals are referred to private optometrists, who dispense the lenses. The average cost is from US$ 92 to US$ 131 for rigid lenses and from US$ 79 to US$ 105 per annum for soft lenses.

Refractive surgery

- Refractive surgery is available only through the private sector, in all of the larger cities. The number of refractive surgery procedures as well as the number of sites performing refractive surgery are increasing. The average cost per eye is US$ 525.

Presbyopia

- Chain stores sell reading glasses, usually of a very poor quality, which range from US$ 5 to US$ 13.

3.2 The role of nongovernmental development organizations in the provision of refractive services

3.2.1 *Helen Keller Worldwide*

Aim

Helen Keller Worldwide, an 85-year-old United States non-profit organization, is dedicated to eliminating preventable blindness.

Current activities

The ChildSight® model was developed in Brazil in 1993. The success of the programme led to its implementation in the United States, Mexico, Morocco and Philippines.

- **United States**

The mission of ChildSight® is to improve the vision and educational performance of junior high-school students living in urban and rural poverty. ChildSight® is a unique, school-based programme that provides vision screening and prescription eyeglasses, when needed, to students aged 11-14 years, at no cost. ChildSight® was initiated in New York City in 1994 as a small pilot project in cooperation with Columbia school-based health clinics. This project determined that in a given population (ages 11-14) up to 25% of adolescents will fail standard visual acuity screening.

At the invitation of local school districts, communities and funders, ChildSight® brings an efficient and cost-effective programme to schools. The programme's headquarters staff provides technical assistance in the areas of training, programme management, continuous quality improvement, inventory management and certification of best practices. ChildSight® has trained 86 community-based workers, 12 local optometrists, 11 ophthalmologists, two opticians and 14 project coordinators, hundreds of school nurses and teachers and members of five local ChildSight® Community Boards (CCBs).

Due to economies of scale, the initial pilot costs decrease as the programme serves more students. In 1998/1999, the New York City programme expanded dramatically and developed the maximum model to meet the needs of large school populations. This model enabled the programme to serve over 20 000 students in one year.

Pilot	Maximum
5000 students screened 1250 provided with spectacles Cost per child screened – US$ 10 Cost per child with spectacles – US$ 38	20 000 students screened 5000 provided with spectacles Cost per child screened – US$ 9 Cost per child with spectacles – US$ 19

As of 10 June 2000, ChildSight® has worked in 212 schools, screened 131 807 students and distributed 21 045 pairs of prescription eyeglasses. ChildSight® has demonstrated that providing a pair of brand-new, prescription eyeglasses will increase the opportunity for children to learn. An important part of the programme is that children are supplied with spectacles on the spot, as referral or vouchers for spectacles are generally unsuccessful. Also, time is spent encouraging and teaching the children about their new spectacles, resulting in a retention rate of 81%.

In Newark, 91% of students participate more in class; in Baltimore, 85% of students state their eyeglasses help them to see better; in Los Angeles, 82% of students participate more in class; and in Cleveland, 80% of students still have their eyeglasses after six months.

Table 2. US Childsight® 1994-2000 (ages 11-14 and 200% of US poverty)

Site	Years	Screened	Received spectacles	Notes
New York	5	47 286	9 223 (20%)	Maximum model
New Jersey	4	28 664	5 157 (18%)	Maximum model
Maryland	3	29 157	3 718 (13%)	Parental permission required
Ohio	0	4 676	551 (12%)	Pilot programme
California	1	22 024	2 396 (11%)	Parental permission required
Total		**131 807**	**21 045 (16%)**	

- **Brazil**

The pilot programme *Projeto Criança de Saude Ocular*, launched in 1993, provides spectacles to children in need. Refinements in the programme now include the complementary services of education about vitamin A, personal hygiene, domestic violence and the care of the household water supply.

Table 3. *Projeto Criança de Saude Ocular* 1998-1999 (ages 8-14)

City	Examinations	Spectacles	Other pathologies	Surgeries	Children served
Iguaba	199	99	11	n.a.	2 500
Araras	317	130	22	106	3 600
Cruz Alta	491	177	39	126	9 000
Jatai	664	348	44	256	12 000
Total	**1671**	**754**	**116**	**488**	**27 100**

- **Mexico**

Vision en la Niñez started in 1994 with private and USAID funding for activities in the State of Chihuahua. The programme provides vision screening and, when needed, brand-new prescription spectacles to students who cannot afford them. Retention rate is more than 90%. Partners include two Mexican health and social service agencies, *Instituto para los Chihuahenses de Salud*, *ICHISAL* and *Desarollo Infantil y Familia DIF.*

The programme has now been turned over to the Mexican Government's programme *Ver Bien Para Aprender Mejor.* The impact on students has been so substantial in Mexico that the Governor of Chihuahua has made a commitment to sustain the programme financially through government funds.

Table 4. *Vision en La Niñez* 1995-2000 (ages 11-14 and social worker tests income need)

City	Screening	Passed screening	Failed screening	Examined with retinoscope	Referred to hospital	Received spectacles

State of Chihuahua	124 786	102 349	19 566	17 914	450	4113 (11.3%)

3.2.2 *Sight Savers International*

Aim

Sight Savers International (SSI) has identified the provision of good-quality refraction services as a key element of its "Comprehensive Eye Services" (CES) model. This model, which targets a defined population, embraces the concept of an integrated approach to establishing a service network that covers all aspects of eye care from prevention, treatment and restoration, through to rehabilitation and education of people who are irreversibly blind or visually impaired.

Current activities

Although it is SSI's intention to support an all-inclusive service for those with refractive errors, for programme purposes its current policy on the provision of refraction services identifies three main target groups:

- Children
- Presbyopia
- Aphakia

Service level	Identification method	Diagnostic equipment	Action	Personnel
• **Children** (5 to 15 years old)				
Primary	Community/school screening	Vision chart, pinhole	Referral	PHC workers, schoolteachers
Secondary	Referral, OPD, community screening	+ Trial set & frame, retinoscope	Prescription glasses (spherical)	Refractionists, ophthalmic paramedic
Tertiary	Referral, OPD	+ Streak retinoscope, lensometer	Prescription glasses (cylindrical)	Optometrists, opticians ophthalmologists, etc.
• **Presbyopia** (over 40 years)				
Primary	Community screening	Vision chart, pinhole	Referral	PHC workers, community social workers
Secondary	Referral, OPD, community screening	+ Trial set & frame	Prescription glasses (spherical)	Refractionist, ophthalmic paramedic

- **Aphakia**

Although SSI increasingly supports extracapsular cataract extraction (ECCE) with IOL implant, there are occasions when intracapsular cataract extraction (ICCE) with aphakic correction is the preferred option. In these cases, SSI seeks to provide a follow-up service that ensures best possible refractive correction.

When integrating refraction services into a CES programme, SSI's strategy seeks to address the following key factors:

- *Awareness:* The need for refraction services is very often far greater than the demand, simply because people are either unaware that they have a sight problem or, if a problem is recognized, they are unaware that anything can be done about it. Raising awareness at community level is an essential strategy to bringing demand in line with need. SSI believes that this can be most effectively achieved through basic primary eye care training of primary health care workers, community workers, schoolteachers, etc., which includes the skills of simple vision testing using an E or C chart and pinhole.
- *Availability:* Raising awareness of the need will inevitably raise the demand for service. It is therefore critical to the programme's effectiveness and credibility that it have the capacity to deal with the cases that are referred up from the primary level. The establishment of a secondary-level service, which has the capacity to test and prescribe refractive correction accurately, is essential. This requires the presence of at least an ophthalmic paramedic who is trained in the techniques of simple spherical refraction and equipped with a trial set. Although this should service at least 85% of refraction cases, there will be a need for an ophthalmologist to handle the more complex referrals.
- *Accessibility:* Inaccessibility is one of the major barriers to service uptake. It is therefore important to ensure that refraction becomes an integral service component of community eye care screening programmes. In areas that are either remote or where transport is difficult, these programmes will need to provide more than just identification and referral, as the cost of having to travel to a referral centre may mitigate against patients taking up the service. In these circumstances, the organizers of community screening camps should carry a stock of optical spectacles for purchase, to save patients the additional expense of unnecessary travel.
- *Affordability:* The cost of optical glasses is often a major prohibitive factor in people's accessing refraction services and it is therefore essential that the service make available prescription spectacles at an affordable cost. These might be sourced from a local market or produced locally by a low-cost optical workshop. Alternatively, they may be imported. Even if the spectacles are offered at low cost, it is still very unlikely that they will be affordable to all and it may be necessary to introduce a cross-pricing policy whereby, in a given product range, the cost of some spectacles is subsidized by the profits gained on others.

3.2.3 *Christoffel-Blindenmission*

Aim

To reduce visual loss from refractive errors in underserved communities of the world through the provision of affordable spectacles.

Current activities

- Support and provision of equipment to optical workshops which manufacture (surface and/or edge) and dispense spectacles.
- Provision of lenses, frames, ready-made spectacles and low vision devices.
- Training courses for ophthalmologists and ophthalmic assistants/technicians and nurses in refraction.
- Production of manuals:
  - surfacing workshops
  - edging workshops
  - refraction
  - low vision services
- Personnel for the development of training courses and service provision for refractive errors and low vision.

- 350 partner projects in 48 countries providing optical services.
- 38 optical workshops in 13 countries with 57 optical technicians.
- 185 274 spectacles were made.
- 589 national personnel performing refraction.
- 525 584 spectacles were dispensed.
- 1.09 million EURO were spent on optical equipment and supplies.

Future priorities

- To emphasize identification and treatment of school-age children with "significant refractive errors". It is planned that this can be incorporated into a school health education programme about Vision 2020.
- To use the provision of reading spectacles in people over 50 years as a means of identifying patients with visual loss due to cataract and glaucoma.
- To promote low vision services for children with less than 6/18 corrected bilateral vision.
- To provide good spherical correction for post-cataract patients.

3.2.4 *International Centre for Eyecare Education*

Aim

ICEE's primary aim is to help eliminate refractive blindness and impaired vision in countries and areas in need. This is being achieved through the development of self-sustaining systems for the delivery of quality and affordable eye care including:

- supplying teachers, materials and courses for the training of:
  - the teachers of "refractionists";
  - "refractionists";
- systems to make available and deliver rapidly good-quality, affordable spectacles for all those in need, particularly children;
- liaising with eye care professionals, NGDOs, governments, institutions and industry to increase refractive and other primary eye care services to those in need.

Current activities

- **Human resources**

The most important of human resources concerned with eliminating refractive visual impairment are refractionists. ICEE has sought to avoid issues such as demarcation of professional responsibilities by simply teaching the skills and knowledge needed to those who are available to carry out refractive care in areas of need, in cooperation with relevant NGDOs, institutions or government departments. For example, in most of Africa, ICEE is providing training of local primary eye care workers such as ophthalmic assistants and nurses to provide refractive services. While in other countries (for example Tanzania), a widespread optometric infrastructure exists and resources are better spent in assisting the development of the Eye Hospital's School of Optometry.

Thus ICEE provides training of local primary eye care personnel such as ophthalmic assistants and nurses to provide refractive services and "train-the-trainer" programmes to provide the educators of future eye care personnel.

ICEE has initiated refraction training programmes for ophthalmic technicians, assistant nurses and their teachers in Africa (Malawi, South Africa, Botswana, Tanzania, Swaziland, Namibia, Zimbabwe and Kenya) and Asia (India and China). ICEE is also assisting in the

development of optometry schools in Africa (Tanzania and Ghana) and Asia (India and Thailand) and ophthalmology training programmes in India and China.

- **Service delivery**

In the Western Pacific, ICEE both provides services to those in need and trains key personnel. For example, ICEE has appointed community optometrists to work with ophthalmological colleagues in the Northern Territory of Australia and East Timor, and in New South Wales in Australia on improving eye care services through the Aboriginal Medical Service. Two optometric academics and project teams are working in association with colleagues in ophthalmology at the Prince of Wales Hospital in Sydney to develop eye care clinics at seven Aboriginal Medical Service centres in New South Wales and training programmes for Aboriginal eye health coordinators. ICEE is also starting indigenous children screening programmes in New South Wales, the Northern Territory and East Timor and is developing a programme to develop sustainable eye care services in East Timor, including the education of teachers and nurses.

- **Spectacles**

While spectacles may be readily available in urban areas, the system must ensure that they are also available for patients living in rural and remote areas. ICEE is currently reviewing models and systems for spectacle supply and distribution, which would deliver low-cost spectacles to communities and provide profits to be used for education and supply to those in need. Various delivery models have already been devised for the delivery of eye care and vision correction, including a "franchise" model. The franchise guidelines could include the standard of care, the minimum number of eye examinations to be provided in schools and villages, guidelines for service to various communities and the profitability of sale of low-cost spectacles.

ICEE is currently providing ANSI-quality, attractive, durable low-cost ready-made spectacles in pilot projects to Eritrea, East Timor, Papua New Guinea, South Africa (for distribution in Africa), India and China. For stock-lens prescription spectacles ICEE is developing a "kit" consisting of conventional lens-edging and fitting equipment. However, ICEE is investigating a simpler, less expensive modular approach. Unfortunately, grind-lens spectacles require traditional laboratory methods of production.

- **Equipment**

To support existing and newly produced refractionists, low-cost, simple and effective equipment and methods for rapid and accurate refraction are required. Retinoscopy, mobile phoropters, hand-held autorefractors and refractometers are all possible. At this stage, ICEE supplies refraction "kits" consisting of trial lenses, frames and retinoscopes. Better and simpler ways are being researched.

Future priorities

Overall, ICEE is keen to work together with any other NGDOs to identify the best methods and systems to eliminate unnecessary blindness and impaired vision due to refractive error.

ICEE is also establishing continuing professional support systems including continuing education and follow-up logistical support for all the refractionists it has trained. This is a most important part of retaining professionals and enabling a career path for the new practitioners. Through university affiliations, ICEE intends to provide accreditation, certification, qualifications and professional development and career progression for all the personnel it trains.

4. TECHNOLOGY

4.1 Core requirements

Programmes that aim to alleviate uncorrected refractive error must use simple and versatile methods of screening and refraction as well as efficient mechanisms for the provision of spectacles. Efficient screening and refraction can be difficult in countries with inadequate numbers of skilled practitioners for the population. Moreover, in many areas of the world, spectacles are either not available or are too expensive. Methods for refraction and mechanisms for spectacle delivery must be in place before any vision screening can begin.

4.1.1 *Eye examination for refractive error*

- **Protocols**

Screening involves the rapid assessment of a large number of people for visual impairment. Refractive error should be detected and immediately followed by delivery of spectacles for those in need. Screening is usually carried out using subjective methods, and refraction is a combination of subjective and objective (instrumental) methods.

Refraction of paediatric and preschool-age children needs to take into account their high level of accommodation and should be as objective as possible to overcome problems with communication and cooperation. Cycloplegic retinoscopy and refraction are the traditional methods used for measuring refractive error in school-age children (5-15 years) to prevent underestimation of hyperopia or overestimation of myopia. Ideally, a simpler objective method should be developed.

- **Instrumentation**

"Instrumentation" (in the broadest sense) for determining refractive error and prescribing of spectacles should be versatile, accurate and widely applicable. Measurement of refractive error should not require a patient's response so that a broad range of people with varying ages and language skills can be examined. The ideal instrument should be mobile, lightweight, easy to use by low-skilled operators, affordable, durable and easily maintained. It is essential that the instrumentation be usable within the resource constraints of the target region. Unfortunately, the ideal equipment is not yet available.

Factors to be considered when choosing the most appropriate instrumentation include:

- technical skill of the proposed operator;
- reliability and accuracy of the measurement;
- characteristics of the population (age, ethnicity, literacy, verbal communication);
- resource constraints of the target region (for example power source, access to maintenance facilities, etc.) and cost.

A technique that can be used to screen and/or to measure refractive error accurately without cycloplegia in children of less than five years, and especially less than three years, has yet to be developed. The value of using commercially available autorefraction instruments for children less than two years over conventional vision screening in an older child is currently under investigation.

4.1.2 *Methods of determining refractive error*

- *Retinoscopy* is a rapid, objective method that is used in general clinical practice. However, the technique requires a skilled operator and can suffer from operator bias and inter-operator variation. Retinoscopy is versatile and mobile but requires intensive training. Batteries are required for its use and measurement is dependent on the use of trial lenses and frames.

- *Autorefractors* provide an objective measure of refraction that can be successfully used as a preliminary screen on patients of school age (five years) or older. Prescriptions cannot always be implemented using autorefraction results, as instruments can make errors of up to 1.00D or more. There is also much variation in performance between autorefractors from different manufacturers and even between models from the same manufacturer. Therefore the chosen instrument should be carefully validated before use. The major drawbacks with conventional autorefractors are that they are expensive, are bench-top equipment and are relatively immobile.

- *Portable autorefractors* or hand-held autorefractors have the potential to be an excellent tool for large-scale vision screening. Several attempts have been made to validate the Nikon Retinomax K+ autorefractor, particularly for use in children. The Retinomax autorefractor is reported to be highly reliable and accurate with adults and with preschool and schoolchildren when used with cycloplegia. Preliminary results suggest that the Welch Allyn SureSight autorefractor is also reliable for use with adults. However, both these instruments can underestimate hyperopia by as much as 2.00D in children without cycloplegia. The main advantages of portable autorefractors are that they require little technical skill and are mobile and versatile. Disadvantages are that they are expensive and require mains power supply.

- *Infrared photorefractors* objectively measure refraction by analysis of the emergent light reflected off the fundus and are designed specifically for use with young children. This technology is still being developed and, when used without cycloplegia, can underestimate hypermetropic and astigmatic refractive error in children less than eight years old. However, as a large-scale screening device it is reliable and is only slightly less sensitive than the Retinomax autorefractor. A disadvantage with this technique is that this instrument has been tested on predominantly white populations and the effects that a heavily pigmented eye will have on measurement are unknown.

- *Photoscreeners* are camera-based instruments that give an indication of the refractive state of the eye as opposed to measuring refractive error. These instruments were designed for rapid screening of large numbers of children and do not have high sensitivity or specificity compared to other methods. Analysis usually requires the operator to assess the refractive state of the patient by observing a photographic image. New photoscreeners are available that use digital technology and computerized image analysis to assess the refractive state. Advantages are that this technique is mobile and easy to use but it requires further referral for an accurate prescription, a supply of Polaroid film and batteries and is relatively expensive.

- *Focometers* are less expensive instruments for measuring spherical and astigmatic monocular refractive error in rural, remote or economically disadvantaged populations. This is a subjective technique, as it relies on patient interpretation of when an image is focused. Focometry is reported to be reliable, and measurements range within 0.5D when compared with autorefraction and retinoscopy. This method is relatively inexpensive, simple to use, can be administered by a trained unskilled assistant, does not require a power source and is hand-held. However, as this method is subjective, it can result in over-prescription, especially in children or where communication is difficult.

- *Variable focus spectacles* with fluid-filled lenses that have adjustable power have been suggested for self-refraction, but little has been published on their use in this way. For children, such self-testing is difficult and it would be especially challenging for young children to understand the task. They are also not very attractive, which will limit their acceptance as a method of vision correction.

- *New technology: Hartman-Shack wavefront sensing* can rapidly and accurately measure refraction over a broad range of refractive errors (+16.00D to –12.00D of sphere and up to 5.00D of cylinder). This technology is based on different principles from current autorefractive techniques and is still being developed for clinical use. Adaptation of this technology to hand-held refraction might overcome many of the problems with current techniques. Cost will be an issue for some time.

  For the future, new equipment needed includes:

  - low-cost hand-held refractometer;
  - automatic vertometer;
  - low-cost mobile phoropter.

The development of these items would significantly improve the ease and accuracy of vision screening.

4.1.3 *Spectacle dispensing*

The provision of affordable vision correction devices is vital to effective refractive services. In many areas of the world, spectacles are either not available or are too expensive. The issues in the provision of spectacles are the following:

- **Quality:** The spectacles need to be of the highest possible quality:

  - Lenses: ISO standards (power, prism, power variation)
  - Comfort: Lightweight lenses
  - Frames: Easily fitted, sturdy (especially for children), with a metal hinge, and attractive. A minimum but acceptable variety of well-designed plastic and metal frames in different shapes and colours is essential.

Research has shown that even where spectacles are supplied at very low cost, acceptability and continued use depend on physical and visual comfort, appearance and quality of the vision obtained. Good-quality, attractive, effective and comfortable spectacles (that conform to international standards) are essential to avoid waste from non-use or failure. In recent studies in India of spectacle wearers, comfort and attractiveness were significant factors in determining wearing patterns. Particularly for school-age children, attractiveness may relate directly to the acceptability of a product. In the USA ChildSight® programme, the retention rate improved from 50% to 81% when smaller, more attractive frames were used. The programme needs to be focused on the outcome, i.e. improvement in vision, rather than the distribution of a certain number of devices.

Efficient delivery of spectacles requires a manageable inventory system, whether it be for ready-mades or separate stock lenses and frames. Issues include storage, availability, distribution and re-supply.

- **Supply** (ready-made or prescription)

In providing spectacles to patients, there is a choice between ready-made and prescription devices. Ready-mades are convenient for the refractionist and patient; however, there are issues of:

- cost
- availability
- quality
- re-supply
- applicability

Prescription spectacles will be needed for approximately 30%-50% of the patient population where:

- anisometropia $\geq$ 0.50DS
- astigmatism $\geq$ 0.75DC
- bifocals

Wherever possible, direct dispensing of spectacles following refraction would be preferred. There is a significant loss in "capture" due to the non-appearance rate if patients are required to attend the clinic again, or to go to a secondary source for spectacles.

In general, spectacle supply must provide affordable devices, and the supply must be sustainable. Importantly, the income generation provided by spectacle dispensing can underwrite other areas of eye care, or can provide income for refractionists.

Schemes involving the use of recycled spectacles are in place in a number of countries. However, while the aims of the schemes are laudable, there are quality control problems, with patients not necessarily receiving devices which are correct for their refractive error. Recycled spectacles are not helpful in developing a sustainable process, as they perpetuate dependency of the community on outside resources. The establishment of sustainable systems for the delivery of spectacles is an important part of the integrated refractive eye care system.

- **Distribution**

- While spectacles may be readily available in some urban areas, the system must ensure that vision correction devices are affordable and are also available for people living in rural and remote areas. It is therefore necessary to look at every level of distribution:

  - Regional
  - District
  - Community

Ready-made spectacles can be made available at the community level, while prescription lenses would require a dispensing laboratory within the district, to grind lenses, and a technician within the community to fit lenses to frames. Manufacture and delivery systems need to be developed on a regional basis.

Low-cost spectacle manufacture options are:

- to import complete spectacles from a country already producing low-cost spectacles;
- to import finished lenses and finished frames, then cut lenses to shape for assembly into frames;

- to produce lenses from imported blanks and insert into imported finished frames;
- to import or source raw materials and make lenses and frames.

Local industry opportunities (can they tolerate expansion and growth without reduction in reliability and standards?) or training opportunities (are there appropriate personnel who can be trained in manufacturing skills, are there effective education avenues?) will need to be assessed for:

- frame manufacture;
- lens production (glass and/or plastic);
- assembly and edging.

Ready-made spectacles are low-cost and easy to stock but are only practical if both lenses are of nearly equal spherical power. The key issue is the number of people who have neither significant differences in refraction between their eyes nor significant astigmatism. Between 30% and 70% of people could use ready-mades depending on the limits of differences allowed, but the proportion needs to be accurately estimated for the target population.

Globalization is rapidly affecting the spectacle industry. Ready-mades can be imported at very low cost. Frames and simple prescription lenses can be made relatively inexpensively at a district/regional level or imported at relatively low cost. A key issue is the establishment of self-sustaining infrastructure to provide consistency of supply and employment at the local level. Grind lenses require a higher level of investment and greater subsidy initially for areas in need.

For the establishment of sustainable, local low-cost facilities, the size of the market and ability to pay must be determined and good management control systems established.

The supply of prescription spectacles takes two forms: stock-lens spectacles that require lens cutting, edging and fitting to frames; and grind-lens spectacles that require lens blanks to be ground. All spectacle lenses need to conform to ANSI standards for optical quality and be made from "safety acceptable" materials.

The modular approach (involving an assembly kit) to supplying prescription spectacles holds great promise for providing a cost-effective system. Such spectacles are easy to assemble and are versatile in suiting the requirements of the wearer. The kit could include:

- metal or plastic bridges in two or three sizes;
- metal sides/temples in two lengths;
- right and left side mounts;
- lenses of two sizes (and a distribution curve by lens power).

Materials could be supplied in more than one colour and fasteners could involve snapclips, screws or glues.

Stock-based spectacle dispensing requires lens cutting, edging and frame-fitting equipment. Ideally, this should be available at the local level (per 50 000 people). One way to approach this is to start a simple laboratory with a lens-edging facility and an inventory of a limited range of stock lenses purchased from low-cost sources or second-hand. Stock lenses and frames should be made regionally (per 1-5 million people), but could be imported. A full laboratory facility can be set up at district, national or regional levels to cater for prescriptions requiring grind lenses.

The manufacture of spectacle lens manufacturing equipment requires significant investment but many countries already have such facilities on a regional basis, although they may need help in upgrading.

4.1.4 *Repair and maintenance*

Repair, maintenance and supply of parts are essential for all equipment. Costly equipment that requires lengthy periods of downtime for service or repair is not practical. Equipment should be durable and be able to withstand a high degree of mistreatment, especially if it is to be constantly moved. If necessary, operators should be able to access a service centre or person with appropriate expertise for advice. Simple guidelines on how to solve a list of common problems should be provided.

4.1.5 *Technology transfer*

There is a great need to recruit (a) optometric educators to facilitate rapid teaching of basic refractive techniques to a large number of "refractionists", (b) dispensing educators to teach and implement spectacle services and (c) optical engineers to ensure supply and maintenance of equipment. An integrated teaching programme that includes workshops and videos can be used to help train practitioners and to facilitate rapid dissemination of knowledge related to technology and techniques.

4.2 Role of contact lenses in correcting refractive error and their feasibility in developing countries

Contact lens usage has grown rapidly over the past 30 years: 2 million contact lens wearers worldwide in 1970, 25 million in 1986 and, today, 90 million. This considerable growth has been in response to the research and developments in lens materials, design, manufacturing and practitioner education. Today, 84% of contact lens wearers use soft contact lenses, 15% use rigid gas permeables and less than 1% polymethylmethacrylate (PMMA) lenses. Conventional soft contact lenses are used by 18%, soft extended wear is used by 15%, disposable daily wear lenses 35%, soft toric lenses 15% and bifocals 1%. There are approximately 34 million wearers in North America (11% of the population), 21.5 million in Asia (0.6% of the population), 18 million in Europe (3% of the population), 8 million in Latin America (0.8% of the population), 3 million in Africa and the Middle East (0.1% of the population) and 0.6 million in Australia and New Zealand (3% of the population).

4.2.1 *Types of lenses*

- *Polymethylmethacrylate (PMMA):* These were the first commercially available contact lenses, available in both full eye size, i.e. 26 mm in diameter, covering both the cornea and the sclera (haptic form), and corneal lenses 8.5-10.0 mm in diameter. PMMA has virtually been phased out due to lack of oxygen permeability; however, PMMA has the advantage of being a very inert and biocompatible material, hence its use in intraocular lenses for many years.

- *Rigid gas permeables (RGPs):* Rigid gas permeable lenses were introduced to combat the oxygen impermeability of PMMA. They have diameters between 8.0 and 10.0 mm, can be used for daily or extended wear (high oxygen permeability lenses only) and require some period of adjustment for wear to be comfortable. With proper care, one pair of lenses can be used for a year or more. Although their popularity is falling due to initial discomfort, in many ways RGP lenses are the lenses of choice for developing countries. RGP lenses offer various levels of oxygen permeability, and excellent tear exchange, limited corneal coverage, minimal spoliation and easy care make them a "safe" vision correction option. With current materials, good lens design and fitting, annual lens replacement and compliance with the care system, there are minimal ocular complications. They are also essential for some conditions such as keratoconus, corneal irregularities and aphakia.

- *Soft contact lenses (SCLs):* Soft contact lenses are made of hydrophilic polymers and may be of high, medium or low water content. SCLs have diameters between 12.5 and 16.0 mm, most commonly around 14 mm, covering the cornea and limbus. Soft lenses are immediately comfortable to the wearer but should be used only for daily wear (removed nightly and cleaned, and reinserted the next day), as their oxygen permeability is not high enough for overnight wear. Nevertheless a substantial number of wearers do sleep with their lenses, risking microbial keratitis. Serious complications with these lenses are rare if used properly.

- *Disposable lenses:* Lens replacement is used to address the issue of lens contamination and bacterial colonization. Mass production systems were developed that enabled the cost of soft lenses to decrease, making frequent replacement practical. In the developed world, two-weekly and monthly replacement of mid-water-content lenses, with rinsing and disinfectant storage overnight, is the most common modality.

- *Daily disposables (DDs):* In 1994, production costs dropped to the point where daily replacement of soft lenses was feasible. It has rapidly become a popular alternative to regular lens cleaning in some countries, for example Japan and the United Kingdom. These lenses allow the simplest form of daily wear and the cost is gradually moving toward US$ 1 per day to the patient.

- *Silicone hydrogels:* Patients want to sleep with lenses so that they can see clearly all the time and not have the daily routine of lens removal, cleaning, disinfection and reinsertion. The first barrier to extended (seven days and nights with lenses) or continuous wear (30 days and nights of continuous wear) has been oxygen permeability (Dk). In the 1980s, it was established that contact lenses must have an oxygen transmissibility (Dk/t) of at least 87 Barrers to avoid overnight corneal swelling, which can lead to adverse corneal effects and susceptibility to ocular infection. Silicone hydrogel contact lenses have an oxygen transmissibility (Dk/t) of 110 to 175, up to twice the requirement and six many times the oxygen transmissibility of currently available lenses. Though high-Dk soft lenses can be worn for up to 30 days and nights continuously before replacement, without hypoxic side-effects, mechanical and inflammatory adverse events still occur with these lenses.

4.2.2 *Contact lens use in developing countries*

While contact lenses can be an effective and safe form of vision correction, offering the wearer optical advantages over spectacles, there are a number of considerations which render them unsuitable for general use to solve uncorrected refractive error.

In one contact lens utilization model, the most influential factors in contact lens usage are the number of trained practitioners, the purchasing power of the population and public awareness regarding contact lenses. Accordingly, at present, contact lenses have limited application for refractive error correction for the general population in developing countries, but they are being increasingly used by the more affluent members of these societies. China and India, for example, have the fastest growth rates in contact lens use in the world.

- *Practitioner availability and skill:* The major non-economic factor in the level of use of contact lenses within a region is the number of skilled and knowledgeable practitioners serving that area. Contact lenses should be considered as an ocular device, needing to be fitted properly and monitored. Practitioners should be able to select suitable patients, perform quality eye examinations, understand the signs and symptoms of potential complications of contact lenses and educate patients thoroughly in the proper use of this form of correction. Many developing countries still have very few contact lens teaching institutions and trained contact lens educators.

- *Cost:* Cost is another major barrier. The annual cost of contact lenses and the solutions, etc., needed for their care averages approximately US$ 140 per year globally. While this cost is not an insurmountable barrier to their increasing use in the developed world, it is clearly prohibitive for the less affluent. The annual cost of spectacles and their delivery, by contrast, can be as low as US$ 3 per year (it averages approximately US$ 30 per year globally). However, the cost of contact lenses can be a factor in the economic viability of clinics. By providing the wealthier patients with lenses, it is possible to subsidize the operations of the clinic in providing care to poorer patients.

- *Availability of lenses:* Increasing contact lens use in the urban areas of some developing countries has meant that the availability of these products is increasing. However, there is still little or no availability in rural areas.

- *Equipment:* In order to fit contact lenses properly and conduct good follow-up care, a slit lamp and keratometer are essential. These are not always available in developing countries and are reasonably expensive to purchase and maintain.

- *Environment:* Hygiene is an extremely important component of maintaining eye health with all types of contact lens wear. Unfortunately, in developing countries, the environment is challenging. In particular, limited availability of clean water and/or high levels of dust and other contaminants make the maintenance of high levels of lens and facial cleanliness difficult. This can compromise the safety of contact lenses as a vision correction option.

- *Follow-up:* A further compromise to lens safety is lack of availability of follow-up services. Lens wearers should monitor their eyes daily and promptly contact their practitioner if signs of inflammation or infection occur. In developing countries, particularly in rural areas, there may be no practitioner readily available. Inflammation and infection may therefore go untreated, threatening ocular health and even sight.

- *Patient education:* Education is also important for contact lens wearers. They must be trained in lens insertion and removal, lens cleaning and storage, and monitoring of eye health.

Conclusion

Clearly, none of these barriers to contact lens wear in developing countries is insurmountable. Lower-cost lens options could be found and distribution systems established. Education of practitioners and educators has already been shown to be highly effective in increasing the numbers and availability of contact lens trained practitioners, thus increasing the use of contact lenses. Disposable income and environmental conditions are gradually improving in many areas. However, overall, contact lenses are a far more complex and costly option for correcting uncorrected refractive error. At present, spectacles are the better answer. Specialty contact lens service should be considered at the tertiary level of eye care for those in need.

4.3 Role of refractive surgery in correcting refractive error and its feasibility in developing countries

It is estimated that nearly 2 million LASIK procedures will be performed in the year 2000 and the procedure has been performed in at least 90 countries around the globe. Large-scale refractive surgery delivery businesses have sprung up around the world, and laser and instrumentation manufacturers have set a rapid pace of technological development. For most LASIK patients, the correction is simple, quick, without significant discomfort, and is permanent. Re-treatments are needed for some patients and a minority have significant visual complications. The long-term effects of the surgery are still unknown and, due to cost and availability, refractive surgery is only applicable for a small percentage of patients at present.

Refractive surgery removes the necessity for the delivery of vision correction devices such as spectacles or contact lenses. It is also a "permanent" correction for the pre-presbyope. However, obvious concerns in developing an effective delivery system of refractive surgery in developing countries include the following:

- *Cost of equipment:* LASIK machines cost between US$ 400 000 and US$ 500 000, although in some areas manufacturers may be willing to donate equipment. Long-term maintenance of the "high-tech" equipment is also of concern in developing countries.
- *Training of technical staff, screening personnel, surgeons and postoperative care-givers:* The primary factor in successful refractive surgery is the skill of the surgeon. In developing countries, the training needed to deliver high-quality surgery is likely to be prohibitive in terms of cost and time.
- *Quality control:* In developing countries, there is a high danger of cost-cutting measures such as the re-use of equipment, rapid turnover of patients and poor patient screening. All of these have negative implications for the outcome of the surgery.
- *Limited application:* Refractive surgery is presently not considered appropriate for paediatric age groups, for high degrees of myopia, or for presbyopia. Some patients may still need some spectacle correction following surgery, thus refractive services will still need to be in place.

Overall, it is concluded that refractive surgery does not have a role in correcting refractive errors in developing countries at this time, but that developments in this field should be closely watched.

5. RESOURCES

5.1 Human resource requirements

Refractive services and dispensing need to be accessible at different levels and different locations, from remote rural areas to urban environments all over the world.

The aim of the programme is:

- to make refraction services of good quality available, accessible and affordable to all;
- to develop appropriate human resources cost-effectively;
- to generate local employment, where possible.

5.1.1 *Situational analysis of existing refractive services*

Region	Service delivery		Infrastructure
	Government	Non-government (private)	Education
Western Pacific	*	***	****
South-East Asia	**	**	**
Eastern Mediterranean	*	***	*
Africa	*	***	*
Europe	*	***	****
The Americas	*	***	****

Scale used (group rating based on participants knowledge): *Not adequate – ****Very good

5.1.2 *Personnel*

There are a number of categories and levels of personnel involved in refractive service delivery:

- *Professional (responsible for refraction, referral, dispensing, management, and teaching)*
    - Optometrists (three- to four-year training post-high school except in North America and Nigeria, where it is post-degree)
    - Ophthalmologists (three to four years' residency post-medical school)
- *Mid-level (responsible for refraction, referral, dispensing and some management)*
    - Ophthalmic nurses (one year post-nursing, minimum six months)
    - Ophthalmic technicians (one to three years)
    - Vision technicians (one year)
    - Dispensing opticians (one to two years)

  Staff at this level who are conducting basic eye examinations and binocular refraction should be able to detect and refer potentially damaging eye disease.
- *Community (responsible for health education, basic screening, referral and some dispensing)*
    - Community workers
    - Schoolteachers
    - Primary eye care workers
    - Primary health care

  An important role of this level of personnel is the creation of public awareness of eye care and vision correction. Even in developed countries such as Australia, groups such as the elderly, remote and rural populations may not realize that their vision could be improved by refractive correction. By raising awareness of the need for eye care, these communities in general become more involved with eye care efforts and support the sustainability of any programmes.
- *Other personnel (responsible for management)*
    - Administrators
    - Public health specialists
    - Accounting/Finance
    - Managers

While the target number of personnel will depend on needs and will be specific to each country, the following are the requirements in general:

- There should be at least one nurse in each clinic who has received training in primary eye care. There should be one clinic nurse trained in primary eye care for every 10 000 population.
- There should be a minimum of one mid-level personnel such as an ophthalmic nurse who refracts for every 200 000 population, improving to 1 per 100 000, then to 1 per 50 000.
- There should be at least one optometrist in each health care region, improving to 1 per 250 000 population, then to 1 per 100 000. While there are many "official" professional definitions of optometrist, for the purposes of Vision 2020 an "optometrist" is defined as a person who can provide refractive services, determine and provide appropriate optical

correction, conduct eye examinations and identify eye conditions requiring appropriate referral.

- There should be one ophthalmologist per million population, increasing to 1 per 500 000.

Vision 2020 human resource targets (minimum figures for Africa) are as follows:

	Target per population		
	2000	**2010**	**2020**
Ophthalmologists	1:500 000	1:400 000	1:250 000
Ophthalmic nurses	1:400 000	1:200 000	1:100 000
Refractionists	1:250 000	1:100 000	1:50 000

It is also important that there be an integration both vertically, within the eye care team, and horizontally, with other health providers and organizations. While in some countries, particularly in the developed world, there can be rivalry or tension between different professional groups, such as between ophthalmology and optometry, this can be a barrier to the delivery of refractive services and general eye care. Regular contact between all groups will assist in planning and effective targeting of priorities and resources.

MODEL 1

During the launch of *Vision 2020: The Right to Sight*, a generic four-tier structure has been considered for delivery of eye care that is suitable to most parts of the world, with appropriate local modifications.

Tier 1: Primary eye care

Local vision centres to deliver community eye health services and to refer patients for further treatment.

Population unit 50 000 people

Functions
Refraction and dispensing
Screening of eye problems
Referral to secondary service centres
Linkage with primary health network.

Staff 1 eye care/vision mid-level personnel

Tier 2: Service centre

Secondary eye care, based in hospitals, district hospitals or private clinics.

Population unit 500 000 to 1 million

Staff
1 ophthalmologist
2 optometrists
2 ophthalmic technicians
Mid-level eye care personnel

Tier 3: Training centres

Where all medical and paramedical training is conducted, including departments of ophthalmology, medical colleges, optometry schools, etc.

Functions	Teaching Service Clinical research
Staff	Ophthalmologists (all functions) Optometrists (all functions) Ophthalmic technicians (service only) Mid-level eye care personnel

Tier 4: Centres of excellence

Providing resource mobilization, planning and administration for the entire pyramid, education including masters and doctoral programmes, and research.

Functions	Teaching Service Research
Staff	Ophthalmologists (all functions) Optometrists (all functions) Ophthalmic technicians (service only) Mid-level eye care personnel

MODEL 2

Eye care practitioners should not be allocated for refractive services exclusively. Particularly in developing or poorer nations, the eye care practitioner has to be responsible for general eye care. Furthermore, limited resources dictate that any strategy devised should be in accordance with the human resource strategy of the country. Creating models that suggest new personnel may result in limited support and involvement from the authorities and thus prevent the success of any refractive services strategy. Therefore the following approach should be considered as an alternative.

Community level

Functions	Screening is integral to early detection and management. Screenings need to be conducted at schools and other community settings. Provision of readers for presbyopic patients Other eye care tasks such as treatment of conjunctivitis and the detection of ocular disease
Staff	Eye care nurse or community health worker
Training	Many clinics have nurses involved in basic eye care from an ocular disease perspective. Additional training in eye care will include assessing visual acuity, screening techniques and dispensing of readers.

Larger clinics or community health centres

Functions	Refraction in the context of a "primary eye care examination" Dispensing of single vision ready-mades for distance and near Ocular disease management Low vision
Staff	Same as for clinics or, if resources permit, mid-level eye care personnel/ophthalmic nurses

District hospitals

Functions	Refraction in the context of a full eye examination Dispensing of ready-made spectacles Dispensing of custom-made spectacles
Staff	Ophthalmic nurses Optometrists/refractionists Mid-level eye care personnel

Regional hospitals

Functions	Refraction in the context of a full eye examination Dispensing of spectacles Fitting and dispensing of contact lenses Cycloplegic refraction Low vision Binocular vision Optometrists should be utilized in the training of other personnel in refractive error and basic low vision skills so that the tasks outlined for the clinics and district hospitals become a reality.
Staff	Ophthalmologists Optometrists/refractionists Ophthalmic nurses Mid-level eye care personnel

Provincial or tertiary-level hospitals

Functions	Minimal routine refraction should be done at this level (preferably none). Most refraction should be in relation to postoperative and preoperative management. Cycloplegic refraction for paediatric patients with squints and who may need to be evaluated for surgery
Staff	Ophthalmologists Optometrists/refractionists Ophthalmic nurses Mid-level eye care personnel

5.1.3 *Personnel issues*

- *Distribution:* In many developing countries, trained eye care personnel are concentrated in urban areas. One way to combat this maldistribution may be to recruit people from local communities, in the hope that they return to these communities following training. However, it is important to recognize that isolation in the situations to which they return induces some personnel to seek opportunities elsewhere. Ongoing professional support and continuing education are important components of keeping people motivated. Initiatives such as annual reviews, planning meetings with other members of the four tiers, ongoing contact with organizations and professionals, and regular visits from service centre staff are all valuable methods of retaining personnel and maintaining momentum in the delivery of eye care.

- *Career advancement:* Similarly, lack of professional advancement opportunities leads mid-level personnel to seek placement in other fields. Career opportunities and advancement are therefore an important aspect of developing and retaining trained eye care staff. Career paths and certification should be developed to allow personnel to improve their training and level of responsibility.

5.1.4 *Role of NGDOs*

Ideally, there should be coordination of the activities of NGDOs and other philanthropic organizations to ensure that the outreach activities, distribution of free spectacles, etc., are conducted within the overall needs of a country. These initiatives could be useful in alleviating backlogs and serving those parts of the country where there may be a shortage of skills. Short-term visits of NGDO clinics to countries and areas in need should be complemented by training of local personnel to ensure sustainability.

The development of effective models for the delivery of refractive services as part of eye care services is an important part of the improvement process.

NGDOs will play an important role, not only in advocacy, but also in developing models for the delivery of some of the infrastructure and refractive services. In particular, NGDOs can contribute significantly to and assist in the education and training of personnel, and support the establishment of administrative systems for eye care delivery. However, it will be important for any model to build in sustainability which does not necessitate the ongoing contribution of NGDOs. *Vision 2020: The Right to Sight* will play an important role in advocating the issue of eye care to governments and other relevant groups, in order to have eye care placed on the health agenda.

5.1.5 *Indicators for monitoring and evaluation of human resource development for refraction services*

- *At a national, provincial (State) and regional level:*

  - community health workers/nurses trained in primary eye care each year
  - practising ophthalmic nurses per indigent population
  - opticians per population
  - optometrists per population
  - cataract surgeons per population
  - ophthalmologists per population

- *Specific refraction indicators:*

    - refractions per personnel per annum
    - ready-made spectacles dispensed per annum
    - made-to-order spectacles dispensed
    - cycloplegic refractions conducted per annum
    - eye care personnel trained in refraction

5.2 Other resource requirements

In addition to human resources and the technologies for refraction and vision correction covered earlier, there are a number of other resources and activities that are needed in order to enable and/or maximize the delivery of refractive services.

Many of these resources already exist and require only mobilization and coordination. The mobilization process needs to take place on a country/regional/district basis, to ensure the effectiveness of any activities and programmes. It also needs to build on existing facilities and programmes in order to maximize existing resources. The regional process includes the following:

- Identifying existing resources, their effectiveness and their interaction with each other and with other systems.
- Determining what is needed to improve the effectiveness of their activities. For example:
  – epidemiological research to understand the demand
  – market research to understand and develop the appropriate delivery model
  – business research to understand what systems are available and how best to work with and integrate them
- Identifying organizations and groups with which to work, to "piggyback" on established health services/resources:
    - hospitals and medical centres
    - visiting health care services
    - international health care services/agencies
    - government agencies
    - local and nearby eye care professionals
- Identifying and developing methods to mobilize each resource, i.e.:
    - build on "knowns"
    - critically analyse methods and performance
    - develop effective models
    - recommend alternatives to maintain efficiencies

5.2.1 *Advocacy*

Communication, publicity and public relations will be an important part of gaining the support of governments and the interest and cooperation of the public in preventing avoidable blindness and impaired vision due to refractive error. NGDOs, professional organizations and individuals need to publicize the need for refractive services and the human and economic consequences of ignoring blindness and impaired vision due to refractive error. The community-at-large, institutions, governmental and nongovernmental agencies need to be made aware of and help support initiatives to deliver quality eye care to all. *Vision 2020: The Right to Sight* is the lynchpin of achieving this advocacy worldwide. An important part of advocacy will be data on the impact of programmes.

5.2.2 *Related personnel*

As well as "refractionists", other personnel can and should be involved in providing and coordinating services, such as schoolteachers, volunteers and private professionals. Actions could include the following:

- Schoolteachers: to provide teacher guidelines to good eyesight, and/or provide educational modules on the importance of eye care and eye screening.
- Volunteers, for example retired educators from within or outside the country: to teach or set up programmes.
- Private sector professionals: to participate in a referral system or conduct regular visits to districts in need, for example monthly to assist the vision screening workers.
- The community, and personnel who work closely with the communities, should be involved in the policy development and decision-making.

5.2.3 *Infrastructure*

Wherever possible, existing infrastructure should be employed, with additional support or services developed in order to create an integrated and self-sustaining system.

- Use existing health care systems, for example hospitals, to provide refractive services.
- Use existing community health centres and programmes to deliver refractive services, "piggyback" refractive programmes to maximize resources.
- Get private practice to participate, for example where practitioners are funded by the government to provide low-cost spectacles to low-income earners (the VisionCare NSW Model).
- Health care systems and programmes for those in need should, ideally, be provided by government or national insurance systems. By default, they may need to be NGDO-sponsored until advocacy and community action achieve national eye care systems.

5.2.4 *Delivery*

Of particular concern in the area of infrastructure is the issue of delivery, of:

- patients (transport, access)
- refractionists (transport, access)
- equipment (transport, maintenance)
- spectacles (distribution, storage, security)

Delivery systems will need to be assessed for effectiveness and the capacity to accommodate increased demands. Accessibility also needs to be assessed to ensure that patients can access eye care services. This assessment will help make decisions on the placement of services.

5.2.5 *Community*

- Public education programmes should include courses on the importance of eye health and eye screening. Programmes and materials should be developed to suit national audiences and can include talks, plays, posters, videos and other publicity materials.
- Local government and leaders involved in the community should be sourced to assist in targeting and marketing the programmes.
- Target groups, for example school-age children, parents, workers.
- Necessary accommodation for the servicing of patients can be arranged by the community.

Community partnerships have great potential, especially in association with NGDOs, and can be resourceful, efficient and effective. They can provide support for the servicing of patients, including helping with costs, organizing screening and delivery programmes and arranging public education.

5.2.6 *Government*

- Relevant government subsidies need to be identified and targeted. If necessary, negotiations can be made with governments to broaden or introduce subsidies to support refractive schemes.
- Proposals should be presented to introduce equity programmes.
- Insurance schemes can be instituted on a community basis.

5.2.7 *Finance*

Financial arrangements are very important for the long-term sustainability of refractive services. Regardless of the type of service offered, to build a successful activity its value will be established by the quality of the service and the reputation it develops. The keys to self-sufficiency are as follows:

- To ensure:
  - the quality of skills and knowledge of the staff
  - that the most appropriate and reliable equipment is used
  - the efficient use of resources – time, equipment
  - accurate recording of statistics

- To establish:
  - a management team and a process for becoming self-sufficient
  - a philosophy of service delivery
  - local management structures

- To plan:
  - current and future cost of services
  - for financial independence to suit regional circumstances
  - guidelines and targets for cost-recovery schemes
  - local management structures leading to a self-sustaining programme

Perhaps the most simple of possible systems to be implemented is a cost-recovery scheme, whereby practitioners charge those people who can afford it and provide free service for those who cannot. This is done, for example, in the LV Prasad Eye Institute where, in 1998-1999, the Eye Hospital treated a total of 161 612 outpatients, 52 656 (around 30%) of whom were non-paying.

6. PARTNERSHIPS AND NETWORKING IN DEVELOPMENT OF REFRACTIVE SERVICES AS AN INTEGRAL PART OF EYE CARE SERVICES

6.1 Partners

The possible partners involved in the provision of services for refractive errors are as follows:

- Professional groups
  - technicians/manufacturers
  - optometrists and opticians
  - paramedical eye workers
  - ophthalmologists
- Ministries of health
- World Health Organization
- Nongovernmental organizations (international and local)
- Corporate sector

Each has an important role to play.

6.2 Networking

Networking may take place at the global, regional, national and district levels.

At the global level, the IAPB Task Force for Vision 2020 provides a forum for advocacy, resource mobilization, coordination and overall planning of the Vision 2020 initiative of which the elimination of visual disability due to refractive errors is an integral part. At the regional level, the six Vision 2020 regional working groups can facilitate networking between the different partners.

National prevention of blindness (eye care) committees should bring together representatives of all those involved in eye care provision within the country; and at the district level, governmental and nongovernmental providers of eye care, school health and adult literacy programmes should collaborate and coordinate their activities in implementing services.

6.3 Integration

There are opportunities to integrate services for significant refractive errors in various eye care, health and education programmes. These include the following:

- Screening children for refractive errors with the school health services and ministries of education (for example, in Brazil and Sri Lanka the Ministry of Education is providing spectacles for indigent schoolchildren as part of Vision 2020).
- The provision of reading spectacles to the over-45-years population provides an opportunity to screen for loss of vision due to cataract, and possibly glaucoma, and thus to integrate with health services for these conditions.
- Adult literacy programmes, which may be run by the ministry of education or NGDOs, require the provision of reading spectacles as an important component.
- Many children with severe visual loss in schools for the blind or integrated education programmes can be assisted to read print through the provision of spectacles and/or low vision devices.

Conclusion

A challenge which faces the programme for the prevention of blindness is to ensure cooperation and coordination between the different partners/players. This will require:

- a common goal;
- agreed priorities and a defined strategy;
- dialogue between partners at all levels of advocacy, planning and implementation.

7. RESEARCH NEEDS

While there is a wealth of information in the area of eye care, there is little information on the prevalence of refractive error in various population groups. This is important and pertinent information to the development of effective programmes for the correction of uncorrected refractive error. For best effect, programmes should be evidence-based. The priorities of research encompass a number of areas.

7.1 Epidemiology

- Epidemiological studies will be essential to the planning and targeting of resources.
- Following on from the childhood refractive error studies conducted in China, Nepal and Chile by Zhao, Pokharel and Maul, two more studies in India using the same protocol are now planned. In addition, a similar study in Alaska is possible, and there may be a re-examination of the studied population in Nepal.
- The continuation of these and similar epidemiological studies for different ages, ethnic groups and geographical areas is important in order to assess the needs of the population.
- In addition, "rapid assessment" studies may be needed in order quickly to assess the priority to be attached to a region or population: for example, the rapid assessment of 100 schoolchildren to determine the levels of refractive error.

7.2 Delivery of effective vision correction

- In order to ensure the delivery of optimum refractive services, comparison of different methods of determining refractive error should be made, taking into account the accuracy of assessment, the ease of use, the skill and knowledge required for operation, whether it effectively picks up other eye problems, etc.
- It is recognized that there are barriers to the use of spectacles in some cultures and by some groups; however, there are few data on the nature of these barriers and on what possible methods may be used to counteract this cultural influence.
- It may be helpful to examine commercial marketing models, to see how spectacles are successfully "sold".

7.3 Technology

- Investigations are needed both into the technical aspects of the manufacture of low-cost spectacles and into the business plans associated with such units. The relationship between price and demand, and the methods of cost-containment and income generation, will be valuable to the development of business models which are applicable to a number of regions.
- In addition, the research and development of new technologies – such as a low-cost hand-held vertometer, automatic vertometer and low-cost mobile phoropter – would significantly improve the ease of provision of refractive services.

7.4 Human resources

- It will be useful to know both the numbers and types of personnel available and the activities of each level of personnel. This will allow effective planning for the placement of personnel and the distribution of work. It will also help with future planning for the education of additional personnel, by identifying those areas under most pressure.

7.5 Outcomes

- Monitoring and evaluation will be an important part of any programme. It will check that the activities are effective and will provide valuable feedback for possible improvements. Knowledge of programme outcomes will also be needed in order to ensure continued support from governments, those organizations involved and other supporters and donors.

- Possible outcome measurements include:
  – the usage and retention of spectacles (satisfaction with services and products);
  – school performance data.

- Other data which may assist in assessing the impact of refractive service provision will be an understanding of the economic cost of uncorrected refractive error, for example in Disability-Adjusted Life Years (DALYs) and the relative cost per DALY saved.

ANNEX 1

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ANNEX 2

AGENDA

1. Scope of refractive errors as a cause of visual disability (Dr A.-D. Négrel and Dr L. Ellwein)

   - Operational definitions
   - Burden of visual disability from uncorrected refractive errors, including global/regional epidemiological aspects

2. Situational analysis of existing services for provision of refractive services

   - Country situations
     - Nepal (Dr G. P. Pokharel)
     - China (Professor J. Zhao)
     - India (Dr G. N. Rao)
     - Viet Nam (Dr K. Konyama)
     - Australia (Mr B. MacNamara)
     - Gambia (Dr H. Faal)
     - South Africa (Dr K. Naidoo)

   - NGDOs' role in provision of refractive services
     - Helen Keller Worldwide (Ms M. Tilp)
     - Sight Savers International (Mr M. Kyndt)
     - Christoffel-Blindenmission (Dr A. Foster)
     - International Centre for Eyecare Education (Ms S. Sulaiman/Professor B. Holden)

3. Technology

   3.1 Core requirements (Professor B. Holden)
   - Examination
   - Dispensing
   - Repair/maintenance
   - Technology transfer – affordable cost

   3.2 Role of contact lenses in refractive errors and their feasibility in developing countries (Professor B. Holden)

   3.3 Role of refractive surgery in refractive errors and its feasibility in developing countries (Dr J. B. Robin)

4. Resources

   4.1 Human resource requirements (Dr K. Naidoo and Dr G. N. Rao)
   - Range of personnel
   - Training needs

   4.2 Other resource requirements (Mr B. MacNamara)
   - Currently identifiable
   - Mobilization

5. Partnerships and networking in development of refractive services as an integral part of eye care services (Dr A. Foster)

6. Research needs (discussion facilitated by Dr A.-D. Négrel and Dr L. Ellwein)

ANNEX 3

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