ORIGINAL ARTICLE

The Pakistan National Blindness and Visual Impairment Survey—Research Design, Eye Examination Methodology and Results of the Pilot Study

ABSTRACT

Purpose: To establish age- and sex-specific prevalence rates and causes of blindness and low vision in children aged 10 to 15 years and adults aged 30 years and older in Pakistan. Methods: Multi-stage, stratified (rural/urban), cluster random sampling, with probability proportional-to-size procedures, was utilised to select a cross-sectional, nationally representative sample of adults (16,600 subjects) and children (6,000 subjects). Each subject underwent: interview, visual acuity (logMAR), autorefraction and optic disc examination. Those that saw <6/12 in either eye underwent corrected visual acuity and dilated posterior segment examination. Results: The results of a pilot survey are reported in this paper. In the two rural pilot sites, 159 subjects (including 47 children) were examined; 50% were male. Thirty-seven adults (23.3%) but no children saw worse than 6/12 in either eye. Two subjects were blind (corrected visual acuity) in the better eye, and 11 were visually impaired. Refractive error was the main cause (in 22 eyes (39% of the total of 56 eyes)) of <6/12 visual acuity, followed by cataract (12 eyes), uncorrected aphakia (6 eyes) and age-related macular disease (3 eyes). Conclusions: The pilot survey demonstrated that the proposed examination process for the main survey is feasible. Particular strengths of this survey include the use of logMAR visual acuity testing and autorefraction of all subjects, a dilated posterior segment examination, and the use of a ‘less than 6/12’ threshold for further examination. This lower threshold addresses the burden of refractive error, which, with cataract, are two of the diseases specifically targeted by Vision 2020.

KEYWORDS

Blindness; low vision; cataract; Pakistan National Blindness and Visual Impairment Survey; pilot study; underdeveloped countries

INTRODUCTION

Pakistan is a developing country situated in the Eastern Mediterranean Region of the World Health Organisation (EMRO, WHO). The population of
approximately 132 million people comprises 52% males and 48% females. The overall literacy rate (of those aged 10 years or older) is 44% and approximately 67% of the national population lives in rural areas. The country is divided into six regions for administrative purposes. The four provinces are Punjab, Sindh, North-West Frontier Province (NWFP) and Baluchistan. In addition to these provinces, there is the state of Azad Jammu Kashmir and the Northern Areas region that includes Skardu and Gilgit. These regions differ widely in their geography as well as density of population. Only 0.7% of the Gross National Product is spent on health, and of this, 2% is allocated to eye care.

Until 1980, there were no data available on blindness and its causes in Pakistan. Following a report by the WHO, the Government of Pakistan instituted a national eye camp planning committee for the prevention of blindness. In 1987, an initiative was taken by the Government of Pakistan with the help of the WHO to perform a national survey of blindness. The study (1988–1990) revealed that the national prevalence of blindness for individuals of all ages was 1.78% (blindness was defined as <3/60 visual acuity in the better eye). It was found that 70% of blindness was caused by age-related cataract. The blindness prevalence in the provinces of Sindh, Baluchistan, NWFP, and Punjab were 1.14%, 2.69%, 1.00%, and 2.17%, respectively.

This study had some methodological limitations but the results served the purpose at that time. As a result of that study, a National Committee for Prevention of Blindness in Pakistan was formed in 1990. This committee produced the five-year National Plan for the Prevention of Blindness 1994–1999, a policy document that outlined the strategies that were needed to improve the eye care situation in the country. Following several years of implementing expanded eye care services in Pakistan, it was felt for a number of reasons that a more detailed survey was required. A survey with more diagnostically rigorous methodology was needed, with one which would detect diseases of the posterior segment, the importance of which has been highlighted in two recent low vision and blindness surveys in Bangladesh and India. Based on the results of the original survey, the eye services were adapted to meet the identified need for expanded cataract surgical service delivery. A more up-to-date survey would assess the impact of current eye care provision and identify diseases and populations that require targeting. Characteristics of the population, such as total number, average age and certain lifestyle factors, have altered since the original study. In addition, the structure of eye care provision in Pakistan has changed, with the establishment of a National Committee for Prevention of Blindness administered at provincial level, and an increased number of eye care centres throughout the country.

From a global perspective, there have recently been renewed efforts to obtain accurate data and identify causes of blindness (‘Vision 2020: The Right to Sight,’ the WHO’s Initiative for the Elimination of Avoidable Blindness and the Global Elimination of Trachoma (GET 2020) worldwide. The launch of Vision 2020 in Pakistan took place in February 2001.

Objectives of the Definitive Survey

1) To establish the age- and sex-specific point prevalences for blindness and low vision in a) adults aged 30 years and older and b) children aged 10 to 15 years living in enumerated households in Pakistan.

2) To identify the causes of blindness and visual impairment within the two study sample groups.

3) To evaluate cataract service delivery by measuring cataract surgical coverage (CSC) and cataract surgical rate (CSR).

4) To identify visual functioning outcomes of surgery amongst all aphakes and pseudophakes.

5) To identify the socio-economic and cultural barriers to uptake of eye care service provision amongst severely visually impaired and blind subjects.

6) To evaluate quality of life amongst the severely visually impaired and the blind, those who have undergone cataract surgery, and a sample of adults with a visual acuity of 6/12 or better in both eyes.

MATERIALS AND METHODS

Subjects

The principal inclusion criterion for the survey was age. For this survey, two separate age groups were targeted, namely adults aged 30 years and older and all young persons aged 10 to 15 years normally resident in the enumerated households. According to the official 1998 national census data, there are an estimated 44.7 million persons in the adult age group (31.6%) and 21 million persons (14.8%) aged 10 to 15 years nationally. Demographic data indicate that the majority of the population resides in rural areas (67.5%) while 32.5% live in urban zones. Examination of children under the
age of ten would have required specialist equipment and training, and it was felt that these were beyond the scope of the intended survey.

The lower age limit for adults (30 years) corresponds to other similar blindness prevalence surveys in South Asia (e.g., Bangladesh and India), which allows direct comparisons to be made between the three studies.

**Sample Size for the Definitive National Survey**

The sample size for the study was calculated for the adult group of subjects. The parameters taken into account were: an assumed prevalence of 1.8% of blindness in persons 30 years and older; random sampling error precision of 0.3%; a design effect of 2.0 with a 95% level of confidence. Based on these values, the adult sample size was 16,600, which included an additional 10% increase for potential non-response. An *a priori* sample size for children was not determined. Rather, as described below, the cohort of children examined in this survey were those who resided in the households of eligible enumerated adults.

**Sampling Strategy**

Multi-stage stratified cluster random sampling, with probability proportional-to-size (PPS) procedures, was adopted as the strategy for the selection of a cross-sectional, nationally representative sample of the population. For the purposes of this survey, a rural cluster consisted of a village while an urban cluster comprised a street block. Stratification of the sample according to rural and urban residence was incorporated into the sample selection process. Within each of the four provinces of Pakistan, a proportional number of clusters in relation to the overall national population was identified based upon official census data. A total of 221 cluster sample sites were selected by PPS, of which 112 were rural villages while the remaining 109 were urban block areas. The rural cluster areas consisted of 100 subjects, while the urban study areas consisted of 50 subjects each. The logistic advantages of this sampling strategy included efficiency in terms of time, transport and subject enumeration and subsequent examination per cluster. The distribution of clusters within the country is displayed in Figure 1.

**Sampling Frame**

Pakistan National Blindness & Low Vision Survey

![Sampling Frame](image)

**FIGURE 1** A map of Pakistan with the four provinces (North-West Frontier Province (NWFP), Punjab, Sindh, Baluchistan) marked. The various districts in which clusters were enumerated are coloured according to whether the district contained rural clusters, urban clusters or a combination of both.

*Pakistan National Blindness & Visual Impairment Survey*
Prior to the examination of subjects, enumeration of all persons who were living in households was undertaken until the target number of adults was attained, i.e. 100 adults for each rural site and 50 for each urban cluster. The sample of children included those who resided in the households of the adults who had been enumerated for the study. Recruitment of children in this manner was logistically possible. Moreover, given that persons of all ages living in the household were enumerated, it was possible to determine the response rate of participation for both adults and children. Subject identification involved the two-person enumeration teams serially assigning a number to each household and registering the names and ages of all habitual occupants until the required number of eligible subjects was attained for a given cluster. All eligible subjects were informed that they would be asked to attend for an examination in their community in the near future.

It was projected that an average of 50 subjects would be surveyed per day by each of the three survey teams taking part in data collection. Taking into account other logistic issues (travel, religious holidays), the nationwide survey was projected to have a duration of approximately twelve months.

Ethical and Official Government Approval

The Pakistan Medical Research Council (PMRC) provided written ethical approval in March 2002. Additionally, the research project was an officially agreed collaboration among the following bodies: the National Leprosy, Blindness and Tuberculosis Control Board of the Pakistan Ministry of Health; the Pakistan Institute of Community Ophthalmology; the National Coordinator and the Provincial Coordinators for the Prevention of Blindness; the International Centre for Eye Health, London School of Hygiene and Tropical Medicine, London, and the international non-governmental development organisations Sight Savers International (SSI), Christoffel Blinden Mission (CBM) and Fred Hollows Foundation (FHF).

Training of Personnel

An ophthalmologist (RB), two epidemiologists (BD and MZJ) and a specialist in ophthalmic instruments (PSL) were responsible for training survey team members with regard to enumeration, interviewing, and the ophthalmic examination process. Three separate survey teams were appointed, one each from the North-West Frontier province, the Punjab province and the Sindh province. The Punjab team was also designated to survey the sparsely-populated province of Baluchistan.

Each survey team consisted of one clinical and one community ophthalmologist, one senior ophthalmic nurse and two medical technicians (all Pakistani nationals). Other non-medical staff within each team included six enumerators, one female enumeration ‘facilitator’ and one interviewer. Four data processors were also specially trained to carry out double entry and database maintenance.

All survey team members underwent specialised training for two two-week periods. The survey interviewers were trained on the content and protocol for completing the demographic information interview schedule questionnaire (a modified WHO/PBL Version III) as well as the visual functioning (VF) and quality of life (QOL) instruments.

A detailed survey protocol manual outlining the survey activities, a guide for completing the questionnaire interview, and information about the duties and responsibilities of all survey personnel were given to each team member. The survey coordinator (MZJ) monitored and coordinated the day-to-day activities of the teams, with assistance from the collaborating epidemiologist (BD) and ophthalmologist (RB), who visited on several occasions.

PILOT STUDIES

Two pilot studies were conducted following completion of the comprehensive training sessions for all survey team personnel. The results of the pilot surveys conducted by the North-West Frontier and Punjab teams are presented in this paper.

Survey Data Collection Process

i. Prior to the Ophthalmic Examination

Oral informed consent was sought from each subject by the senior ophthalmic nurse, following explanation of the procedures to be carried out. Personal and demographic data (age, sex, height, weight, smoking history, blood pressure (model of machine), literacy status, previous school attendance, occupation, land tenure status, religious affiliation) were obtained by the interviewer for each of the enumerated subjects that attended the eye examinations. If the subject was unable
or had difficulty in responding to questions at any time, a relative was subsequently asked for clarification.

**ii. Development of a ‘Normative Database’ for Adults aged 40 Years and Older**

One out of every five subjects, aged 40 years or older, consecutively attending the survey station was recruited for a ‘normative database’ in advance of visual acuity testing. The rationale for this database lies in the fact that without it, one would only be performing a dilated ophthalmic examination and examination with other diagnostic instruments on those who failed a given visual acuity cut-off (in this case, <6/12 in either eye). The normative database would allow researchers to find individuals later who had ophthalmic disease but who were still able to see 6/12 or better in both eyes. The other purpose of the normative database is to examine the distribution of ocular variables, such as intraocular pressure and cup/disc ratio, in the ‘normal population.’ These data can then be used when judging the normality or abnormality of a given ocular finding against these reference normative values.

**iii. Definitions Used in the Ophthalmic Examination**

The WHO categories of visual impairment\(^{14}\) were used for this study. ‘Blindness’ was defined as a corrected visual acuity of less than 3/60 (20/400, 0.05) in the better eye. ‘Low vision’ was defined as corrected visual acuity of less than 6/18 (20/60, 0.3) but equal to or better than 3/60 in the better eye (comprising categories 1 and 2 in ICD-10). Category 1 is ‘moderate visual impairment’, less than 6/18 to 6/60, and category 2 ‘severe visual impairment’, less than 6/60 to 3/60. We also used the term ‘near normal’ to describe those subjects with a corrected visual acuity of less than 6/12 (20/40, 0.2) but equal to or better than 6/18 in the better eye. Subjects whose presenting visual acuity was worse than 6/12 in either eye were targeted in this study for further examination. The Snellen notation for visual acuity has been incorporated in the methods section of this paper for ease of comparison with the above definitions. Visual fields were not used in the definitions of visual impairment for the purposes of this paper because very few subjects fulfilled the criteria for visual field examination (see below). However, it merits pointing out that field constriction will be considered, along with visual acuity, in the definition of blindness when reporting on the results obtained in the main, national survey given the larger number of subjects that will be involved.

‘Cataract’ was defined as any opacity visualised with a direct ophthalmoscope through an undilated pupil. The Mehra and Minassian grading system was used for classifying lens opacities in all subjects.\(^{15}\) The LOCS III\(^{16}\) grading system was used with a slit lamp through a dilated pupil on subjects with less than 6/12 in either or both eyes, and on subjects recruited for the normal database.

‘Glaucoma.’ The 95%, 97.5%, and 99.5% percentiles for IOP will be calculated from a population-based distribution of intraocular pressure (IOP) measured with the Goldmann tonometer on the ‘normative database’ subjects (1:5 aged 40 years or older). Using the same database, the 95%, 97.5%, and 99.5% percentiles for cup/disc ratio (CDR) will be calculated. As this information would not be known until after the survey, the following 97.5th percentiles for IOP, CDR and CDR asymmetry were chosen: 21 mHg, 0.7 and 0.2, respectively. These values were obtained from published material from a population-based survey in India.\(^{19}\)

The SITA-Fast Glaucoma Hemifield Test was performed on both eyes of all subjects with an abnormal optic disc or discs. An abnormal disc was defined as one in which there was at least one of the following features: CDR ≥0.7, CDR asymmetry ≥0.2, optic disc haemorrhage(s), optic disc notch (≤0.1 CDR, between 11 and 1 o’clock or between 5 and 7 o’clock). Visual fields were also performed on all subjects recruited for the normal database, and if the IOP in either or both eyes was greater than 21 mmHg. A SITA-Fast or SITA-Standard test was judged unreliable if fixation losses exceeded 20%, false positives exceeded 33%, or false negatives exceeded 33%. A reproducible defect on a SITA-Standard visual field (VF) was defined as one in which one point of <0.5% (on the pattern deviation plot) was present in the same or adjacent location as on the previous SITA-Fast test pattern deviation. A glaucomatous SITA-Standard VF was defined as two or more contiguous points with a p < 0.01 loss or greater, or three or more contiguous points with a p < 0.05 loss or greater, compared to perimeter-defined age-matched control subjects; or a 10dB difference across the nasal horizontal midline at two or more adjacent locations. A normal visual field was taken to be one in which there were no sensitivity losses matching the criteria for glaucoma. Cases of glaucoma were
TABLE 1 The Classification of Glaucoma Used for the Survey

<table>
<thead>
<tr>
<th>Category</th>
<th>CDR</th>
<th>CDR asymmetry</th>
<th>Visual field</th>
<th>Visual acuity</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1†</td>
<td>≥97.5th percentile; NRR width ≤ 0.1 CDR*</td>
<td>≥97.5th percentile</td>
<td>≥18° × 12° &amp; ≥ 10 dB below age-specific normal. ≤ 50% FP</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2†</td>
<td>≥99.5th percentile</td>
<td>≥99.5th percentile</td>
<td>Cannot complete satisfactorily</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3i</td>
<td>Disc not seen</td>
<td></td>
<td>Impossible</td>
<td>&lt;3/60</td>
<td>Evidence of glaucoma filtering surgery</td>
</tr>
<tr>
<td>ii</td>
<td>Disc not seen</td>
<td></td>
<td>Impossible</td>
<td>&lt;3/60</td>
<td>–</td>
</tr>
</tbody>
</table>

Percentiles refer to those subjects with normal suprathreshold visual fields in both eyes; *between 11 and 1 o’clock or between 5 and 7 o’clock; †no alternative explanation for CDR findings (dysplastic disc or marked anisometropia) or the VF defect (retinal vascular disease, macular degeneration or cerebrovascular disease; FP = False Positives.

defined using the International Society of Geographical and Epidemiological Ophthalmology (ISGEO) scheme. The scheme classifies cases of glaucoma according to three levels of evidence or ‘categories’ (Table 1). Upon completion of the study, when the distribution of IOP and CDR were available, agreement was reached in a masked fashion by expert observers in categorising subjects as glaucoma cases or glaucoma suspects.

‘Diabetic retinopathy’ was subdivided into three types: non-proliferative, proliferative and maculopathy. These were not mutually exclusive, as the latter two types may, for example, co-exist. Cases of suspected diabetic retinopathy, in the absence of a history of diabetes mellitus, underwent a random blood glucose test (One Touch Basic Plus Glucometer, LifeScan Deutschland G.m.b.H., Neckargemünd, Germany) to detect hyperglycaemia (defined as >11.0 mmol/l). Subjects recruited into the normal database also underwent a random blood glucose test.

**Examination Procedures (see Figure 2)**

**Measurement of Visual Acuity**

Distance visual acuity was measured with a reduced logMAR-based tumbling ‘E’ chart, with fewer letters per line than other similar logMAR visual acuity charts. Prior to this study, the chart had been extensively validated in clinic-based and population-based studies in advance of its use in the National Blindness and Low Vision Survey of Bangladesh. The RLM chart is based on the illiterate E, a necessity in a population with only 47% adult literacy. The ‘E’ optotypes are arranged according to the logMAR scale with three letters per line, each with a different directional orientation.

The ophthalmic nurse recorded whether the subject arrived with distance spectacles, usually wore distance spectacles but had forgotten to bring them, had been prescribed distance spectacles but did not habitually wear them, or did not possess them. Visual acuity was measured with no refractive correction, for the right and then the left eye. The number of letters seen at 4 metres was recorded by the ophthalmic nurse using a hand-held tally counter. If the subject was unable to see any of the three letters of the top line of the RLM chart at 4 metres (logMAR = 1.0), he or she was moved to 1 metre and then retested. If he or she was still unable to see any of the top letters at 1 metre, the ophthalmologist was called to test the ability to count fingers, see hand movements, or perceive light. Rather than select acuity “cut-offs,” this method of counting the total letters seen at a certain distance allows measurement of the exact logMAR (and Snellen equivalent) acuity. In this manner, data could be grouped at any logMAR acuity for analysis purposes. Based on presenting visual acuity, subjects were assigned either a red card (acuity <6/12 in either eye) or a green card (equal or better than 6/12 in both eyes tested separately). This division—according to visual acuity—defined the subsequent sequence of examinations that each individual subject would undergo (see Figure 2). If the subject was assigned a red card, the binocular unaided visual acuity was also measured. In addition, if the subject was wearing their habitual distance correction,
FIGURE 2  The examination process.

the spectacle-corrected visual acuity was remeasured for each eye. The nurse also asked the subject if they wore reading spectacles.

**Measurement of Refractive Error**

All patients underwent automated refraction (Nikon Retinomax K-Plus II; Nikon, Tokyo, Japan), performed by trained medical technicians. Measurements obtained included average refractive error (based on three consecutive readings), spherical equivalent, vertex distance, and keratometry. If the autorefractor did not yield a measurement (due especially to media opacity) in a subject with <6/12 visual acuity (‘red card-holders’), the ophthalmologist attempted a manual objective and subjective refraction. During the training period, results of automated refraction were satisfactorily compared with those from manual refraction for each ophthalmologist. Subjects with <6/12 visual acuity (‘red card-holders’) were then retested for visual acuity in each eye with their autorefraction result placed in a trial frame using trial lenses. This was performed to estimate the contribution of refractive error to these subjects’ visual disability.

**Interview and Examination by the Community Ophthalmologist of all Subjects**

The ophthalmologist asked all patients whether they were diabetic. The subjects were also asked if they had been treated previously for eyelid abnormalities, cataract, glaucoma or other disorders. He also examined the patient to record entropion or ectropion if present. Lens opacity was graded according to the Mehra and Minassian system, which has been used effectively in other population-based surveys. Briefly, this grading system (consisting of six categories) is based on obscuration of the red reflex (of an undilated normal pupil) by a lens opacity.

With respect to previous cataract surgery, the time since surgery, location, and technique (couching/ intracapsular/ extracapsular) were documented. To record the technique, the ophthalmologist relied on a history from the patient and subsequent findings from the examination. The presence or absence of an intraocular lens and the use of aphakic correction were also noted. In previously diagnosed cases of glaucoma, the modality of treatment was recorded. The presence or absence of strabismus was recorded after testing using a 4-metre target.

The optic discs of subjects assigned a ‘green card’ (visual acuity 6/12 or better in both eyes) were examined by the community ophthalmologist using a direct ophthalmoscope through an undilated pupil. If the optic disc was abnormal (according to the criteria given in ‘glaucoma definitions’ above), the subject underwent a full dilated examination by the clinical
ophthalmologist, the process otherwise reserved for red card holders (<6/12 in one or both eyes) and subjects assigned to the normal database. The final examination of ‘green card’ subjects involved an undilated examination of the fundus in dim light conditions with a direct ophthalmoscope.

All subjects underwent biometry using an ultrasound A-scan (Microscan 100A+ A-scan ultrasound, Sonomed Inc., New York, USA) which measured axial length, anterior chamber depth, and lens thickness of each eye. Following ultrasound examination, ‘green card’ subjects were discharged from the survey station, with ophthalmic advice given if necessary.

**Detailed Ocular Examination of Specific Subject Groups: 1) Subjects with <6/12 in Either/Both Eyes, 2) Subjects with ≥6/12 in Both Eyes but with Abnormal Optic Discs, 3) ‘Normative Database’ Subjects**

Red card holders (<6/12 in either/both eyes), green card subjects (6/12 or better in both eyes) with abnormal optic discs and ‘normative database’ subjects all underwent a comprehensive examination using a slit-lamp (Topcon SL-7F; Tokyo, Japan). Adnexal and external disease were noted if present. The anterior chamber was examined, with measurement of the temporal limbal chamber depth according to a modified Van Herick classification system. If the limbal chamber depth was ≤15% of the corneal thickness, an applanation gonioscopy was performed (Goldmann model, Haag Streit, Bern, Switzerland) after intra-ocular pressure measurement. The angle was described as ‘occludable’ if less than 90° of the posterior (usually pigmented) trabecular meshwork could be seen without manipulation or indentation. Intra-ocular pressures were measured using Goldmann applanation tonometry (Haag Streit, Bern, Switzerland). The ophthalmologist then tested for a relative afferent pupil defect.

Subjects were then dilated with a solution containing 1% tropicamide and 1% cyclopentolate (Tropicacyl) to obtain a pupil diameter of at least 6 mm. Those with occludable angles were not dilated. All patients were warned about the symptoms of angle-closure and advised to return if such symptoms were experienced.

Following dilation of the pupils, cataract grading was performed using the Lens Opacity Classification System III (LOCS III). The ophthalmologist compared the degree of nuclear, cortical and posterior subcapsular opacity with a series of photographs. The nuclear colour and nuclear opalescence grades were amalgamated into a single grade for nuclear cataract for the purposes of this survey.

The optic disc was then examined using indirect ophthalmoscopy with a 90D (Volk Optical, Ohio, USA) lens on the slit-lamp (x10), viewing the disc through an eyepiece graticule (Haag-Streit, Bern, Germany). This allowed the examiner to measure the vertical disc diameter and vertical cup diameter accurately. The examiner also noted whether a neuroretinal rim notch (≤0.1 CDR, between 11 and 1 o’clock or between 5 and 7 o’clock) or optic disc haemorrhage was present. Following the examination, the ophthalmologist calculated the vertical cup/disc ratio and CDR asymmetry. Other retinal pathology was also recorded if present.

**Digital Photography, Visual Fields and Optic Disc Examination Using the Heidelberg Retinal Tomograph-II (HRT-II)**

Digital photographs (Nidek NM-100; Nidek, Aichi, Japan) of the optic disc and macula were taken if retinal disease was noted during the dilated fundus examination. They were also taken if the optic disc was abnormal (after confirmation using the eyepiece graticule and mydriatic examination) or if the subject had been assigned to the ‘normative database’. The photographs were coded and transferred to a database on a computer hard disk. Validation of the cause of reduced vision made by the ophthalmologist on the record sheet will be achieved by checking these photographs independently at the Moorfields Eye Hospital Reading Centre.

Visual fields (Humphrey 355 series, Carl Zeiss Meditec, Dublin, California, USA) and examination with the Heidelberg Retinal Tomograph-II (HRT-II; Heidelberg, Germany) were undertaken if one or more of the following criteria were met:

- Goldmann IOP ≥21 mmHg in either/both eyes
- Abnormal optic disc (see definition above) after confirmation with a mydriatic examination using an eyepiece graticule
- ‘Normative database’ subject (1:5 subjects aged 40 years or older)

A SITA-Fast 24/2 Glaucoma Hemifield Test was initially performed on each eye. If either or both tests were
unreliable, the SITA-Fast test was repeated in one or both eyes. If the second SITA-Fast test was also unreliable, the test was not repeated for a third time. If the final SITA-Fast test was ‘within normal limits’ in both eyes, further testing was not performed; however, if either or both eyes gave a final SITA-Fast result ‘outside normal limits’, the subject was then given a SITA-Standard Full Threshold test for both eyes. Only one SITA-Standard test attempt was permitted per eye. The ophthalmologist compared the SITA-Standard test with the final SITA-Fast test and judged whether there was a reproducible glaucomatous visual field defect.

The HRT-II, a scanning laser ophthalmoscope, was used after explanation of the instrument to the subject. This device has been used previously in a population-based study of glaucoma and has been shown to have high reproducibility and repeatability. The values for average keratometry for each eye (obtained earlier in the examination process) were inserted into the software, and following imaging, the disc topographies were computed. These were archived onto a magnetic optical disk.

**Identification of Causes of Low Vision and Blindness**

The survey ophthalmologist, epidemiologist and the three clinical ophthalmologists coordinated a systematic approach for the decision-making process for the identification of the cause(s) of low vision and/or blindness, based on the ocular examination findings. In accordance with the WHO Prevention of Blindness Proforma (Version III), allowance is made for the recording of all pathological findings, for each eye separately, which are identified at the time of the ocular examinations. The standardised WHO protocol further stipulates that the main cause of blindness or low vision for each eye must then be selected. After selecting one cause for each eye, one cause was selected for each subject with a presenting visual acuity <6/12. The selection of the cause of visual impairment for the subject was based on the WHO recommendation that the cause should be the pathology ‘most amenable to treatment or prevention.’ When more than one ocular disorder is present, one of which is secondary to the other, the ‘primary’ cause to be selected as the principal disorder is that which is ‘most readily curable’ or, if not curable, that which is ‘most easily preventable.’

**Visual Function (VF) and Quality of Life (QOL) Instruments**

The following categories of subjects were asked questions from the VF and QOL instruments after ocular examination:

- subjects with a visual acuity <6/60 in either or both eyes
- pseudo- or aphakic subjects
- 1:20 subjects with a visual acuity of 6/12 or better in both eyes

Prior to the pilot study, these instruments were translated into Urdu, Punjabi, Pashto and Sindi and were then reverse-translated back into English in order to permit refinement of the translations prior to the instruments being utilised. The survey tools were incorporated into this study in order to identify the difficulties perceived by those with visual disability and the effects on their quality of life in the Pakistani context.

**Barriers to Uptake of Eye Care**

The following groups of subjects were asked to choose from a selection of possible barriers (which were refined following responses to an open-ended question used in the pilot survey) to the uptake of eye care that included cost, lack of relatives/friends to accompany the subject, inadequate time, lack of awareness and fear (there was also an open question, should none of the options be applicable).

- subjects with a cataract grade of 2B or 3
- subjects with a visual acuity of <6/60 in either or both eyes

**Inter-observer Agreement**

The inter-observer agreement was measured for the various components of the eye examination protocol. Levels of agreement for the different ocular measurements were calculated, comparing the results of the English ophthalmologist (R. B., the ‘gold standard’) with the findings of the six Pakistani ophthalmologists. Single-measure, two-way random effect model testing was done and the intra-class correlation coefficients were calculated (Table 2). These studies took...
TABLE 2 Inter-observer Agreement Studies with Intra-class Correlation Coefficients for Various Measurements Involved in the Examination Process. These Studies Took Place on Two Occasions, First with the North-West Frontier Province (NWFP) and Punjab Teams’ Ophthalmologists and then with the Ophthalmologists from the Sindh Team. The Sindh and Punjab Teams also Examined Subjects in the Smaller Province of Baluchistan.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Observers compared with UK ophthalmologist (R.B., gold standard)</th>
<th>Number of measurements by each observer</th>
<th>Intra-class correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Cup/Disc Ratio (undilated pupil, direct ophthalmoscopy)</td>
<td>NWFP Cl.O &amp; Cm.O Punjab Cl.O &amp; Cm.O</td>
<td>54</td>
<td>0.560</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O. Sindh Cm.O.</td>
<td></td>
<td>0.753</td>
</tr>
<tr>
<td>Vertical disc diameter (slit-lamp biomicroscopy with graticule)</td>
<td>NWFP Cl.O. Punjab Cl.O.</td>
<td>12</td>
<td>0.877</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O.</td>
<td>9</td>
<td>0.689</td>
</tr>
<tr>
<td>Vertical cup diameter (slit-lamp biomicroscopy with graticule)</td>
<td>NWFP Cl.O. Punjab Cl.O.</td>
<td>12</td>
<td>0.814</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O.</td>
<td>8</td>
<td>0.946</td>
</tr>
<tr>
<td>Intraocular pressure (Goldmann applanation tonometry)</td>
<td>NWFP Cl.O. Punjab Cl.O.</td>
<td>38</td>
<td>0.862</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O.</td>
<td>18</td>
<td>0.465</td>
</tr>
<tr>
<td>Cataract grading (Mehra–Minassian15 score)</td>
<td>NWFP Cm.O. Punjab Cm.O.</td>
<td>42</td>
<td>0.767</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O. &amp; Cm.O</td>
<td>14</td>
<td>0.958</td>
</tr>
<tr>
<td>Lens Opacity [nuclear]* (LOCS III16)</td>
<td>NWFP Cl.O. Punjab Cl.O.</td>
<td>14</td>
<td>0.848</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O.</td>
<td>6</td>
<td>0.985</td>
</tr>
<tr>
<td>Lens Opacity [cortical] (LOCS III16)</td>
<td>NWFP Cl.O. Punjab Cl.O.</td>
<td>14</td>
<td>0.538</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O.</td>
<td>6</td>
<td>0.964</td>
</tr>
<tr>
<td>Lens Opacity [posterior subcapsular] (LOCS III16)</td>
<td>NWFP Cl.O. Punjab Cl.O.</td>
<td>13</td>
<td>0.893</td>
</tr>
<tr>
<td></td>
<td>Sindh Cl.O.</td>
<td>6</td>
<td>0.995</td>
</tr>
</tbody>
</table>

Cl.O. = clinical ophthalmologist; Cm.O. = community ophthalmologist; LOCS III = Lens Opacity Classification System III16; *the nuclear colour and nuclear opalescence grades were amalgamated into a single grade for nuclear cataract for the purposes of this survey.

place on two occasions, first with the North-West Frontier Province and Punjab teams’ ophthalmologists and then with the ophthalmologists from the Sindh team. The Sindh and Punjab teams also examined subjects in the smaller province of Baluchistan.

Service Component

In the main survey, all persons with low vision or who are blind will be referred (with a written referral note) to the nearest eye care facility (district or non-governmental hospital) in conjunction with the provincial Comprehensive Eye Cells (CEC) of the Pakistan National Programme for the Prevention of Blindness. Ophthalmic medications (provided at no cost by pharmaceutical companies) will be dispensed for minor ocular conditions.

Non-responders for Participation in the Study

Those enumerated subjects who did not attend the examination process following the initial verbal invitation by the postenumeration logisticians were repeatedly requested to attend if they were present in or nearby their home. If the subject was unable to attend the survey station but was prepared to be examined, a household visit took place where visual acuity, autorefracion and direct ophthalmoscopy were performed.

Persons who either refused to attend for the eye examination or were not available were listed as ‘non-responders’, with the reason for non-attendance recorded by the logistic staff. All ‘non-responders’ were recorded as ‘believed blind or not blind’ in each eye, depending on the answers given by the non-respondents themselves or by a close relative or neighbour of that individual if he or she was absent.

Data Management

A record sheet was completed for each eligible enumerated subject, even if the subject was a non-responder (see above). Two members of the staff independently entered the data into two independent databases. These two databases were later compared and mismatches investigated and corrected in order to form one final database. In addition, each record sheet of a subject with <6/12 presenting visual acuity was examined by
the collaborating survey ophthalmologist (R.B.) for errors and these were corrected on the database. Visual fields were printed and attached to the record forms, in addition to being stored electronically. Fundus images and HRT scans were stored on hard drives and magnetic optical disks.

RESULTS

Following six weeks’ training and a standardisation process, a pilot survey was carried out in two rural villages in the North-West Frontier Province and Punjab Province, prior to conducting the main, nationwide survey. This was done principally in order to assess the examination procedures described above. Two rural village communities were purposely selected and eligible adults enumerated in preparation for the examinations that would be conducted over a two-day period.

Demographics

Two hundred adults (aged 30 years and older) were enumerated and 117 adults (58.5%) attended the two pilot survey centres. Five of the enumerated subjects were subsequently discovered to be ineligible in terms of age, and were therefore not examined. Forty-seven enumerated children (aged 10–15 years) also attended. Table 3 shows the age distribution of the pilot study subjects; the mean ages were 12.5 years in those aged 10–15 years and 44.3 years in those aged 30 years and older. Of those aged 10-15 years, 55.3% were male, while of those aged 30 years and older, 47.3% were male.

Visual Acuity

As mentioned above, the visual acuity ‘cut-off’ that identified those individuals requiring further ophthalmic examination was ‘<6/12 (0.3 logMAR)’ in one or both eye(s). All 47 children saw 6/12 or better in both eyes at presentation. A total of 77 adults (68.7% of 112 adults) had a presenting visual acuity of 0.3 logMAR or less (Snellen equivalent of 6/12 or better) in both eyes tested separately. The remaining 35 persons (23.3%) were found to have an acuity >0.3 logMAR (Snellen equivalent of <6/12) in either eye, two of whom (1.8%) were blind in the better eye.

Table 4 shows the pilot survey subjects distributed according to WHO categories of visual impairment, using presenting visual acuity and corrected visual acuity in the better eye. The blindness prevalence rate among adults, based on the presenting visual acuity in the better eye, for this pilot sample was 1.8%, which is consistent with the estimated rate used in the sample-size calculation for the main survey.

Causes of Visual Impairment and Blindness

Causes per Person

Among the 18 subjects who had a presenting visual acuity <6/12 in the better eye, the main cause of impairment was refractive error in 10 subjects (55.6%), in three of whom (30.0%) this was due to uncorrected aphakia. The next most common cause was cataract (5 subjects; 27.8%), followed by one case of glaucoma and one subject with a central corneal opacity.

Of the 11 subjects with a presenting visual acuity <6/18 in the better eye, the main cause of reduced vision was refractive error in 7 subjects (63.6%), in three of whom (42.8%) this was due to uncorrected aphakia. The next most common cause was cataract (2 subjects; 18.2%), followed by one case of glaucoma and one subject with a central corneal opacity.

Pakistan National Blindness & Visual Impairment Survey
Causes per Eye

Refractive error was the main cause of reduced vision in eyes that had a visual acuity <6/12, i.e. in 22 eyes (39.3%) out of a total of 56 eyes. Cataract was the next most common cause (12 eyes), followed by uncorrected aphakia (6 eyes) and age-related macular degeneration (3 eyes). The two cases of blindness in the better eye were due to central corneal opacity and uncorrected aphakia, respectively.

DISCUSSION

This proposed national survey is the largest of its kind to take place in Pakistan and one of the largest worldwide. The two age groups involved should give a useful overview of ocular disease in the population and its impact on vision. The quality-of-life questionnaires will also address the effect of visual impairment on the daily activities of affected individuals. Particular strengths of this survey include the use of logMAR visual acuity testing and autorefraction of all subjects, a dilated posterior segment examination, and the use of a ‘less than 6/12’ threshold for further examination. This lower threshold addresses the burden of refractive error, which, with cataract, constitutes two of the diseases specifically targeted by Vision 2020. The use of visual field analysis and image capture of the retinal and optic disc findings will create an opportunity for detailed verification of diseases such as glaucoma and age-related macular degeneration after completion of the survey.

The pilot survey was of great use in verifying that the methods could be employed effectively and that the considerable burden of testing was feasible. The pilot, and other field trials that preceded it, were also of importance in gaining expertise in enumerating subjects for the study and attempting to maximise the participation of the enumerated subjects. For example, lower participation of men among adults rather than children was found to be due to the work commitments of men in these communities. As a result of this, efforts were made to accommodate this by running the fieldwork over two or more days in a given community, giving notice of the impending visit, and arranging examinations before and after working hours. The number of individuals in the pilot survey was relatively small, yet sufficient to achieve these logistic goals. This survey assigned considerably more time for testing of individuals found to have reduced visual acuity in either eye. The visual acuity findings of the pilot survey therefore enabled the coordinators of the study to predict the duration required for examinations in the main survey. The comprehensive examination of one out of every five subjects aged 40 years or older is expected to result in useful data on those individuals who have ophthalmic disease but who are still able to see 6/12 or better in both eyes, and also to create a ‘normal database’ of ocular variables in this population.

It is expected that this survey will yield important information that will be of use in assessing the current situation in Pakistan and in the planning of resource allocation in the future.

ACKNOWLEDGEMENTS

The authors of this study are grateful for the contribution made by the ‘Pakistan National Eye Survey Study Group’, which consists of the following individuals:

- Professor Shad Mohammed (Provincial Coordinator, North-West Frontier Province)
- Professor Zia Uddin Sheikh (Provincial Coordinator, Sindh)
- Professor Asad Aslam (Provincial Coordinator, Punjab)
- Professor Nasim Panazai (Provincial Coordinator, Baluchistan)
- Dr. Shabbir Mir (Provincial Coordinator, Kashmir)
- Dr. Niaz Ali (Provincial Coordinator, Northern Areas)
- Mr. Pak Sang Lee (Technical Coordinator, International Centre for Eye Health, London)
- Dr. Haroon Awan (Sight Savers International)
- Dr. Rubina Gillani (Fred Hollows Foundation)
- Dr. Babar Qureshi (Christoffel Blinden Mission)
- Dr. Mohammed Shabbir (Clinical Ophthalmologist, North-West Frontier Province team)
- Dr. Falak Naz (Community Ophthalmologist, North-West Frontier Province team)
- Dr. Abdul Ghafoor (Clinical Ophthalmologist, Punjab team)
- Dr. Kiramatullah (Community Ophthalmologist, Punjab team)
- Dr. Waheed Shaikh (Clinical Ophthalmologist, Sindh team)
- Dr. Amjad Shaikh (Community Ophthalmologist, Sindh team).
This study was supported financially by the ‘International Blindness Prevention Collaborative Group’, which consisted of:

- The Government of Pakistan
- The World Health Organisation East Mediterranean Regional Office & Pakistan Office
- Sight Savers International
- Christoffel Blinden Mission
- Fred Hollows Foundation
- The International Centre for Eye Health in London
- The Pakistan Institute of Community Ophthalmology.

Dr. Clare Gilbert read and gave valuable advice on the manuscript. Heidelberg Engineering (Heidelberg, Germany) kindly lent the survey two HRT-II instruments. In addition, two companies based in Lahore, Pakistan (‘Lateef Bros Lahore’ and ‘S. Haji Amerdin and Sons’) were also generous with their instrumental support during survey preparations. Ophthalmic medications were generously donated by the NWFP divisions of the companies Remington and Kobec.

REFERENCES