

# Vision Screening among Northern Israeli Jewish and Arab Schoolchildren

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**ABSTRACT:** **Background:** Uncorrected refractive error is the leading cause of visual impairment in children. In 2002 a screening project was launched in Israel to provide data on the effectiveness of the illiterate E-chart in identifying Jewish and Arab schoolchildren in need of a comprehensive eye examination.

**Objectives:** To present the aims, design and initial results of the visual screening project and the prevalence of vision abnormality in the study population.

**Methods:** A cross-sectional population-based study was conducted during 2002–2003 among first- and eighth-graders in 70 schools in northern Israel. The nurse's test included use of the illiterate E-chart to measure visual acuity. The medical examination included vision history, clinical eye examination, VA and retinoscopy. The ophthalmologist's evaluation as to whether a child needed a referral for diagnostic procedures, treatment and/or follow-up was recorded and compared with explicit referral criteria formulated after data collection.

**Results:** Of 1975 schoolchildren, 31% had abnormal VA, defined as VA worse than 6/6 in at least one eye, and a quarter had VA equal or worse than 6/12 in both eyes. The prevalence of vision abnormality among the children was 22.4% when based on the evaluation of the field ophthalmologist and 26.1% when based on two sets of explicit severity scores and referral criteria.

**Conclusions:** Vision abnormality is a significant health problem among northern Israeli schoolchildren. This project is unique in scope and importance, providing evidence to assist policy making with regard to vision screening for schoolchildren (including data on test reliability and validity) and optimal VA cutoff level, and confirming the need for clinical guidelines regarding referral criteria.

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**KEY WORDS:** vision screening, schoolchildren, vision abnormality, E-chart

in rural and urban China, rural Nepal, urban Chile, and South Africa show that 0.9–9% of the children would benefit from spectacles. Even in countries with well-resourced health systems like the United States, uncorrected refractive error in children can be a major cause of visual impairment [1]. Given the high prevalence of uncorrected refractive error and the simplicity of treatment, the detection and correction of this problem has been made one of the priorities of the World Health Organization Initiative Vision 2020 [1,2].

Screening programs for vision abnormality vary in terms of the screening tool and who is carrying out the testing, the threshold for failure, and the setting. The most common method to test visual acuity is the standard Snellen chart [3]. Different screening techniques are likely to differ in sensitivity and specificity [1]. The policy of the Israeli Public Health Services of the Ministry of Health mandates that all first- and eighth-graders be screened for VA at school by PHS nurses. The underlying assumption is that early detection of vision abnormality may lead to early intervention followed by optimal function [4].

In 2002–2003 we launched the Northern District Israeli Vision Screening Project. Its main goal was to provide data on the effectiveness of the illiterate E-chart as used by northern district PHS school nurses in identifying children in need of a comprehensive eye examination. This report presents the project's aims, design and initial results and the prevalence of vision abnormality in the study population. The aims of the project were to assess: a) the prevalence and characteristics of schoolchildren with abnormal vision results as determined by PHS nurses; b) the prevalence of vision and ocular abnormalities as determined by a medical eye examination; c) the reliability of vision screening; d) the validity of the screening test (the illiterate E-chart performance measures); and e) the validity of the decision made by the ophthalmologist to refer the child for diagnosis, therapy or follow-up.

## SUBJECTS AND METHODS

The project included several components: a) estimating the prevalence of vision abnormality and the validity of

Uncorrected refractive errors (myopia, hypermetropia and astigmatism) were recently identified as the leading cause of visual impairment in children [1]. Several population-based cross-sectional studies in 5–15 year old children

VA = visual acuity

PHS = Public Health Services

the screening test (first and second years), b) assessing the reliability of the screening test among PHS nurses (second year), and c) follow-up of the findings (second and third year).

#### **SAMPLE SELECTION**

The northern district, the largest Ministry of Health region in the country, has a population of 1.1 million in five subdistricts (Acre, Yizre'el, Nazareth, Kinneret, Safed) and includes, according to the Ministry of Education, 266,712 school-age children. About 61% of these children are Arab, many live in rural areas of low socioeconomic status, and 39% are Jewish.

The population chosen for the cross-sectional part of the project (first two components) included first-graders (age 6–7) and eighth-graders (age 13–14) attending the regular northern district education system. A cluster sampling of 75 schools representing 15% of 541 eligible northern district schools (elementary and middle schools) was used. Each school was represented by all students in one class (first grade or eighth grade) randomly preselected. This strategy was in line with the intention to recruit 2000 schoolchildren (1000 in each age group). Assumptions underlying the determination of sample size included 10% prevalence of vision abnormality (based on VA results of the previous year), and 40% sensitivity of the screening test. The intention was to point-estimate the above sensitivity with an error that would not exceed 10%. This meant a required sample size of 100 children with vision abnormality in each age group.

#### **FIELD OPERATIONS**

##### **PREPARATION PHASE**

The following was obtained: a) approval of the budget by the Ministry of Health's Chief Scientist; b) permit from the Ministry of Education and from each school principal to conduct the study in the school; c) approval of the study protocol by the institutional review board of HaEmek Medical Center; and d) permit from the Ministry of Justice's database registrar for electronic research data entry. Other pre-study activities included obtaining the cooperation of the eye department of HaEmek Medical Center and of subdistrict managements, and conducting training of medical teams and PHS nursing staff.

##### **INFORMATION LEAFLET AND PARENTS' INFORMED CONSENT**

Leaflets were distributed to parents in three languages (Hebrew, Arabic, Russian). They contained information on PHS policy and procedures regarding vision screening and stated that a survey was about to be launched in northern district schools aimed at assessing the prevalence of vision

abnormality among schoolchildren and the quality (reliability and validity) of the screening test. Information was also provided about elements of the study – e.g., tests performed during school hours by the school nurse and an ophthalmologist, and that the examination includes the use of eye drops that widen the pupils for about 3 hours during which vision might be blurred. It emphasized that in rare cases some allergic reaction might occur but without long-term consequences. Parents were also informed that a written report of findings would be provided, and they were invited to accompany the child during the examination or call the participating ophthalmologist for further clarifications. Assurance of the confidentiality of data and the anonymous publication of the results was given. Education Ministry officials provided a consent form for parents to sign. An appendix was attached and parents were asked whether their child wears spectacles or contact lenses (in which case he or she was requested to bring them to class), and whether the child underwent ophthalmic follow-up.

##### **TRAINING OF NURSE SCREENERS AND OPHTHALMOLOGISTS**

A training program of several half-day sessions was delivered by the study team. These sessions were held for nurse screeners either at the study center (Health Ministry-Northern District) or in the subdistricts. Training was also carried out for ophthalmologists at the eye department of HaEmek Medical Center. It focused on issues such as strategies to obtain parents' agreement, study procedures, and forms. Discussions on parents' cooperation were held as the study team was concerned about low compliance due to the rigid style of the Education Ministry's informed consent form.

##### **PROJECT INTRODUCTION TO SCHOOL PRINCIPALS**

The project was introduced at each school by the project's head (L.O.) and project coordinator, in the presence of the school nurse, and if possible also her supervisor. Also present was the school principal, usually accompanied by a staff member. The rationale of the project and its goals were explained, the written Education Ministry approval was presented, as were the information leaflet and informed consent forms, followed by discussion of the school's suggestions for obtaining parents' cooperation, and scheduling a study day once the principal had given his/her approval. The meeting was then followed by an inspection of the nurse's room and a decision was made regarding the most appropriate location and logistics for medical eye examinations (room size and light conditions). A list of the relevant students was provided to the study coordinator and consent forms, individually named for these students, were then sent to the school nurse who distributed them to the assigned students to obtain their parents' signature.

Most schools preferred that the study be introduced to the students by the school nurse about a week before the study day, and that an information leaflet and informed consent forms be sent to parents via their children. Other schools chose to schedule a meeting where parents were collectively introduced to the study and were asked for individual signed permission. All signed consent forms were collected by the school nurse.

#### STUDY DAY

Participating in the project were 67 PHS nurses and 10 ophthalmologists from HaEmek Medical Center (5 eye specialists and 5 residents who had completed at least 3 years of residency training). Each study day was planned to last about 4–5 hours during which all students (about 30) were expected to be examined, starting with those who had their parents' permission for cycloplegia. The study team comprised a research coordinator, a school nurse and an ophthalmologist. Each child was examined first by the nurse, followed by a two-part medical eye examination by the ophthalmologist. The study coordinator assisted with logistics and coordination as well as supervising students awaiting the second part of the ophthalmologic test after midriasis.

#### THE NURSE'S EXAMINATION

The nurse's examination was carried out using the illiterate E-chart (Sarel, Ministry of Health, Israel). The chart has a large "E" at the top (denoting vision of 6/60) and six additional horizontal lines of letters, decreasing in size from top to bottom. The bottom line denotes vision of 6/6. All children were always measured at 5 meters. No alternative distance was adopted for those with very poor vision. Nurse activities, according to standard PHS procedures, included asking the student to cover each eye in turn, and to specify the direction of the letter "E" shown by the nurse. There were some exceptions to the usual PHS routine: a) children with spectacles or contact lenses were also tested (in the usual routine they were not considered candidates for vision screening); b) all first-graders were examined (not only those who missed the vision screening test at age 5, prior to school entry); c) at the end of each examination a report of vision results (or VA for those wearing eyeglasses) of each eye and a statement regarding whether the student passed (or failed) the test was handed to the study coordinator; d) a letter to the parents reporting the screening results was not sent by the nurse but by the ophthalmologist.

The vision screening test was considered negative (successful) if the child, when tested for each eye separately, correctly identified with each eye four of the nine E letters in the bottom (seventh) row of the chart, in which case he or she was recorded as having vision (or VA) of 6/6 (= 5/5).

#### THE MEDICAL (OPHTHALMOLOGIST) EXAMINATION

Examination was carried out in a different classroom after the nurse's examination. It included vision history, a clinical eye examination, and vision testing using the illiterate E-chart. For students with spectacles, the corrected VA was recorded. If signed informed consent was available the testing proceeded 30–45 minutes later with instillation of midramide eye drops for fundus and retinoscopy. The use of midramide (less effective than cyclopentolate for complete cycloplegia) was preferred since the purpose of the test was screening, and those found positive were referred for further evaluation where cyclopentolate was administered. Children without their parents' agreement and/or those afraid of eye drops were examined without cycloplegia. Physicians documented the findings and their clinical judgment regarding further diagnostic procedures, treatment and/or follow-up. If positive, the reason for referral and the recommended professional/clinic were stated. Indicated reasons were at least one of the following: a) myopia (retinoscopy > 1, absolute value); b) hypermetropia (retinoscopy > 2); c) cylinder (astigmatism, retinoscopy > 1); d) corneal pathology; e) lental pathology; f) retinal pathology; and g) other. At the end of the study day, the ophthalmologist received the nurse's reports to which he had been blinded until that moment. Letters were prepared and sent to parents; these letters were also copied for the students' health and research files.

#### SEVERITY SCORE AND REFERRAL CRITERIA

In order to validate the field ophthalmologist's decision, a post factum study referral decision tool [Appendix A] was formulated by the study ophthalmologist and consultant (H.G.), who was blinded to the findings and referral decisions made by the field ophthalmologists. The decision tool was based on two sets of explicit criteria for vision severity designed for this study: The first was a 33 item list of potential retinoscopy results (23 items) and physical examination findings (10 items). Vision severity score was based on the student's worst eye results. The second was a set of four items related to vision findings.

#### STATISTICAL DATA ANALYSIS

Data analysis was performed using SPSS 13.0 (SPSS Inc. Chicago, IL, USA, 2004) and SAS 9.1.3 (SAS Institute Inc. Cary, NC, 2002-2003) software. Data analyses were stratified by age group. Emphasis was given to the following:

- **Cluster sampling:** To account for the cluster sampling of schools, estimations and comparisons of data (vision, prevalence of abnormal vision, validity measures, and prevalence of follow-up data) were performed using log-binomial regression models adjusted for correlated data (SAS' GENMOD procedure with REPEATED statement). Compound symmetry structure was assumed for the

correlation among the students examined by the same nurse (= same school) and ophthalmologist. This analytic approach uses the GEE methodology for correlated data [5,6]. Adjusted prevalence ratios and 95% confidence intervals were calculated using log-binomial regression.

- **Vision:** Students' vision results were analyzed separately for ophthalmologist and nurse reports. Two different definitions of vision abnormality were used: a) the current PHS definition of a positive screening test: vision worse than 5/5 (= 6/6) in at least one eye; and b) vision equal or worse than 5/10 (= 6/12) in both eyes, tested separately. The prevalence of vision abnormality by the children's demographic characteristics and by professionals' seniority was calculated.

- **Physical examination:** Prevalence of strabismus, abnormality in eye movements, anterior segment and fundus were calculated, and associations with vision abnormality were tested.

- **Retinoscopy:** Refractive error types were classified as mild, moderate or high myopia, hypermetropia and/or astigmatism [Appendix B] and associations with students' demographic characteristics were evaluated, using chi-square test.

- **Prevalence of vision or ocular abnormality:** Students referred for further evaluation, therapy or follow-up were considered "prevalent cases" of vision or ocular abnormality. Associations between referral and children's demographic characteristics, as well as ophthalmologists' seniority were calculated.

- **Severity scores:** Referring to the first set of vision severity scores, Mann-Whitney and Kruskal-Wallis tests were used to determine differences by children's and ophthalmologists' characteristics. Spearman correlation coefficient was calculated for determining association between vision severity score and vision results.

- **Screening test performance measures:** The validity of the vision screening test was determined using the ophthalmologist's decision regarding the need for referring the student as the gold standard. The detection rate (sensitivity), false positive rate (1 - specificity), positive predictive value, and negative predictive value, including 95% CI were estimated overall and by students' demographic characteristics [7].

- **Reliability of screening test:** Inter-observer variation regarding vision results (nurse vs. ophthalmologist) was calculated overall and by children's characteristics, using % of total agreement and Kappa values [8].

- **Follow-up:** The prevalence of school-documented follow-up data on referred students was calculated.

- **Log-binomial regression models:** Based on the univariate vision results, separate log-binomial regression models were fit for predicting vision abnormality, as determined by the nurse using vision abnormality as the dependent variable,

and the student's and nurse's characteristics as the explanatory variables. Similarly, log-binomial regression models were fit for predicting the prevalence of vision abnormality, as determined by the ophthalmologist. Adjusted prevalence ratios and 95% CI were calculated.

## RESULTS

The study population comprised a sample of 2113 schoolchildren in 70 regular education, northern district schools. The compliance among school principals was 93.3% (70 of 75), among parents - 68.3% (1444 of 2113), and among schoolchildren (to the examination by both the nurse and the ophthalmologist) 93.5% (1975 of 2113). Of 1398 children who attended school on the study day and had a parent's permission, 22 (1.6%) refused to have their eyes dilated. About half of the children were first-graders, the proportion of males was slightly higher than that of females, and Arab children comprised about two-thirds of the participants. The comparison of the study population to northern district eligible subjects revealed a slight over-representation of eighth-graders (51.5% vs. 46.8%).

The nurses tested 1982 students (93.8% of the intended population). The ophthalmologists examined 1975 students. Reasons for not being examined included school absence (131 students) or leaving the school before the medical examination (7 students). About half of the 1975 children (48.1%) were first-graders, 53.2% were males and 65.5% were Arab. Most of the children were from Acre and Yizre'el subdistricts (39.0% and 20.9% respectively).

### PREVALENCE OF ABNORMAL VISION (NURSE/OPHTHALMOLOGIST)

Of 1975 children tested by ophthalmologists, a third (31%) had abnormal vision according to the current PHS definition of abnormality [Figure 1]. The proportion was slightly higher among nurses. According to the second definition of vision abnormality, abnormal vision was reported for about a quarter of the children (by ophthalmologists 23%, by nurses 25%).

### PREVALENCE OF VISION AND/OR OCULAR ABNORMALITY

Data on the referral decision (yes/no) was available for 1862 (94.3%) of 1975 students, of whom 420 (22.5%) were considered "prevalent cases" of vision and/or ocular abnormality. Taking into account the over-sampling of eighth-graders, the total district prevalence of vision and/or ocular abnormality was 22.4%. Vision and/or ocular abnormality based on the two sets of explicit severity scores and referral criteria was found in 26.1% of 1708 children.

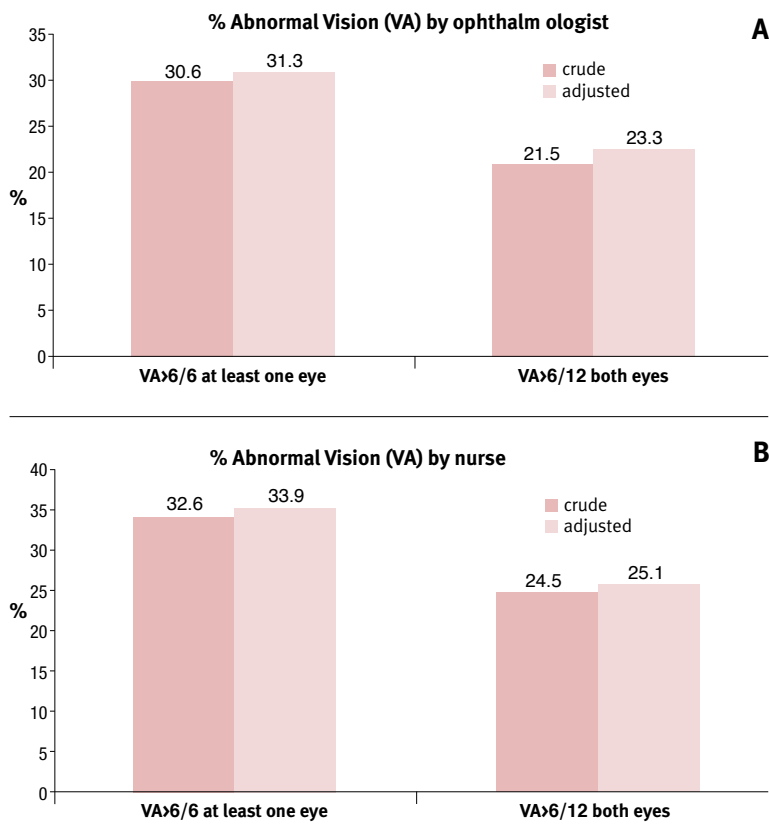
### PERFORMANCE MEASURES ON THE ILLITERATE E-CHART TEST

Using the current PHS definition of a positive screening test, the test was found to be 71.9% sensitive (95%CI 65.8-78.7%;

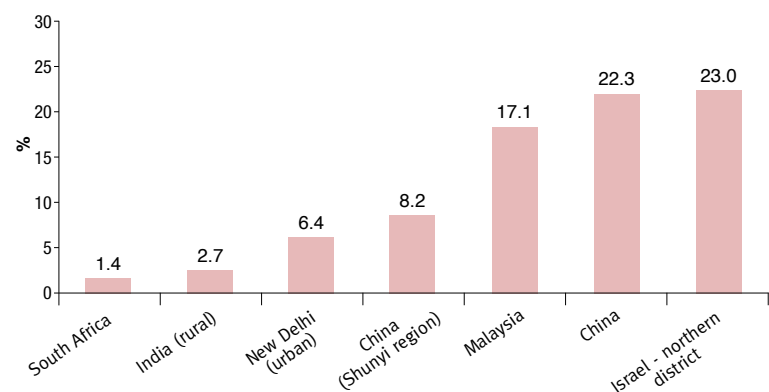
<sup>2</sup> CI = confidence interval

false negative rate 28.1%) and 77.2% specific (95% CI 82.1–71.1%; false positive rate 22.8%). Detailed data on the test's performance were published elsewhere [7].

**Figure 1.** Crude and adjusted prevalence (%) of abnormal vision (VA) by definition of vision abnormality and professional type (N=1975). **[A]** ophthalmologist, **[B]** nurse



**Figure 2.** International comparisons of prevalence of abnormal vision among children (vision > 6/12 in both eyes)\*



\*References 10-15

## DISCUSSION

The study was undertaken to provide prevalence data of vision abnormality among northern district Israeli schoolchildren. These data are necessary for determining the subdistricts, population groups and age cohorts (first-graders vs. eighth-graders) most in need of intervention, and for providing the basis for future evaluation. To the best of our knowledge this is the largest cross-sectional study to provide data on the prevalence of vision abnormality among Israeli schoolchildren. A lack of epidemiological data on the magnitude of uncorrected visually disabling refractive errors was also reported worldwide, with prevalence variations in different geographic areas and ethnic groups [9]. Compared to international studies [10-15], the prevalence of vision (and VA) abnormality in northern district Israeli students was highest, occurring in about a quarter of the children [Figure 2].

This project is unique in its scope and importance, providing evidence to assist policy making – local, national and global – regarding the screening of schoolchildren. Emphasis is given to information on the prevalence of vision abnormality, data about reliability and validity of the test (including false positive, false negative, positive predictive and negative predictive measures) [7], optimal vision cutoff level for referral, as well as confirming the need for clinical guidelines regarding referral criteria.

The current paper introduces the project as a whole, its aims and design, as well as initial results. In order to share detailed information and to ensure clarity and comprehensiveness, the projects' results will be presented in separate reports, dedicated to different aspects of vision screening of schoolchildren.

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**APPENDIX B.** Definition of refractive error types (retinoscopy and cylinder values)

Refractive error type	Retinoscopy value
<b>Myopia</b>	
Mild myopia	(-0.75) – (-2.75)
Moderate myopia	(5.75-) – (3-)
High myopia	(-6)+
<b>Normal</b>	<b>(0.75+) – (0.5-)</b>
<b>Hypermetropia</b>	
Mild hypermetropia	(2.75+) – (1+)
Moderate hypermetropia	(4.75+) – (3+)
High hypermetropia	(5+)+
<b>Cylinder (astigmatism)</b>	*Cylinder:
Mild cylinder	(2) – (0.75)
Moderate cylinder	(3.75) – (2.25)
High cylinder	(4)+

\* Absolute values

**APPENDIX C.**

**Executive committee:** Liora Ore (MD, MPH), Hanna J. Garzosi (MD), Ada Tamir (DSc), Michal Cohen Dar (MD, MPH). **Advisory committee:** Gil Sartani (MD), Shihab Shihab (MD, MPH), Sonia Habib (MD, MPH), Olga Vinizky (MD, MPH), Avshalom Strulov (MD, MPH), Amos Mor (MD, MPH), Rachel Maoz (RN), Ben-Chay Koznizky (LLB). **Administrative assistant:** Terez Tukan, Michal Shneiderman. **Project coordinator (PC):** Validity and reliability studies – Sara Kidron, Follow-up study – Michal Shneiderman. **Principal investigator (PI):** Liora Ore (MD, MPH). **Programmer (PR):** Irina Merimson. **Data entry:** Inessa Zvagelsky (BA), Michal Shneiderman. **Statistical analysis:** Ada Tamir (DSc), Inessa Zvagelsky (BA), Nili Stein (MPH), Naama Schwartz (BA).

**APPENDIX A.** Severity scores and referral criteria for vision abnormality

Severity level	Score	Vision status	Referred
<b>A. Retinoscopy and physical examination results</b>			
<b>Normal</b>	0	Normal	No
<b>Mild</b>	1	Mild hypermetropia	No
	2	Mild myopia	No
	3	Mild astigmatism	No
<b>Moderate</b>	4	Moderate hypermetropia	Yes
	5	Moderate myopia	Yes
	6	Mild hypermetropia with mild astigmatism	Yes
	7	Mild myopia with mild astigmatism	Yes
	8	Moderate astigmatism	Yes
	<b>Severe</b>	9	Moderate hypermetropia with mild astigmatism
10		Moderate myopia with mild astigmatism	Yes
11		High hypermetropia	Yes
12		High myopia	Yes
13		High hypermetropia with mild astigmatism	Yes
14		High myopia with mild astigmatism	Yes
15		Moderate hypermetropia with moderate astigmatism	Yes
16		Moderate myopia with moderate astigmatism	Yes
17		High astigmatism	Yes
18		Mild hypermetropia with high astigmatism	Yes
19		Mild myopia with high astigmatism	Yes
20		Moderate hypermetropia with high astigmatism	Yes
21		Moderate myopia with high astigmatism	Yes
22		High hypermetropia with high astigmatism	Yes
23		High myopia with high astigmatism	Yes
24		Isolated eye movement disorders (including nystagmus)	Yes
25		Strabismus	Yes
26		Anterior segment pathology	Yes
27		Fundus pathology	Yes
28		Any refractive error with pathology in ant. Segment	Yes
29		Any refractive error with strabismus	Yes
30		Any refractive error with nystagmus	Yes
31		Any refractive error with fundus pathology	Yes
32		Fundus pathology with strabismus	Yes
33		Any refractive error with fundus pathology and strabismus	Yes

<b>B. Vision results:</b>	Normal	0	6/6, 6/6	No
<b>Mild</b>	1	6/6, 6/12	No	
<b>Moderate</b>	2	6/12, 6/12	Yes	
<b>Severe</b>	3	6/18+ one/both eyes	Yes	