Factors Influencing Prevalence of Vision and Ocular Abnormalities among Jewish and Arab Israeli Schoolchildren

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ABSTRACT: **Background:** The detection and correction of refractive errors is one of the priorities of the World Health Organization Initiative Vision 2020.

Objectives: To determine the factors related to ocular abnormalities (poor vision, refractive error or other abnormality) among schoolchildren in northern Israel.

Methods: A cross-sectional population-based study was conducted among 2113 students aged 6–7 and 13–14 years old in 70 schools in northern Israel. Medical examination included vision history, clinical eye examination and vision testing. If a parent's informed consent was available, eye drops (cycloplegia) were delivered for fundus and retinoscopy testing. An ophthalmologist was asked to determine the need for the child's referral for further diagnostic procedures, treatment and/or follow-up. Multivariate analysis was limited to 1708 children, using data pertaining to the ophthalmologist's decision regarding referral, as well as vision and retinoscopy results.

Results: Vision and/or ocular abnormality was prevalent in 21.5% (95% confidence interval 17.4–26.6%), predominantly among 13–14 year olds and Jewish children. Abnormal clinical findings were found in 5.7% of the students. Retinoscopy showed a higher prevalence of hypermetropia among 6–7 year olds and a higher prevalence of myopia and astigmatism among the 13–14 year olds. The multivariate analysis suggests an independent effect of retinoscopy abnormality (odds ratio = 3.85), vision abnormality (OR = 2.42), Jewish ethnicity (OR = 1.62) and 13–14 year old age group (OR = 1.26) on the ophthalmologist's referral decision.

Conclusions: Vision and/or ocular abnormality is an important health problem among schoolchildren in northern Israel. The independent effect of ethnicity and age on the ophthalmologist's referral decision should be further explored.

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KEY WORDS: vision screening, refractive errors, schoolchildren, Jews, Arabs, Israel

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OR = odds ratio

Given the high prevalence of visual impairment due to uncorrected refractive errors in children, and the simplicity of treatment, the detection and correction of refractive errors is one of the priorities of the World Health Organization Initiative Vision 2020 [1]. Presenting signs and symptoms of significant refractive errors include complaints of blurred vision, ocular fatigue, and headaches. Diagnosis is made by objective and subjective refraction [1,2].

Various published studies have documented the prevalence of vision abnormalities and refractive errors among schoolchildren [3-17]. Population-based studies in children aged 5–15 years in the Far East, South America and southern African countries show that 0.9–9% of children would benefit from spectacles [1]. Risk factors for vision problems, such as family history, gender, age, ethnicity and education, were mentioned.

The policy of the Public Health Services of Israel's Ministry of Health is to screen all 6–7 year old schoolchildren (first-graders), except for those tested at age 5 prior to school entry, and 13–14 year old schoolchildren (8th graders). The screening would be performed at school by PHS nurses [18]. In 2002 we launched a Northern District vision screening project. Details of its aims, design and initial results were previously published [19]. The present report focuses on the factors related to prevalence of vision and/or ocular abnormalities, as determined by medical eye examination.

SUBJECTS AND METHODS

POPULATION

As detailed in a previous report [19], the intended population included 70 of 541 (13%) Northern District schools (regular education), each represented by a single class: 1st grade or 8th grade randomly pre-selected. The intended sample size was 2113 (0.78% of the total number of Northern District students and 4.5% of all 1st and 8th graders). The school managers, parents and children's response rates were 93.3%, 68.3% and 93.5%, respectively [19].

PHS = Public Health Services

We tried to achieve a high participation rate by conducting all the examinations in schools and by being accessible to parents. The students who did not attend school on the study day, or those who refused the eye drops, despite their parents' approval, were considered non-compliant and were not given an alternative examination date.

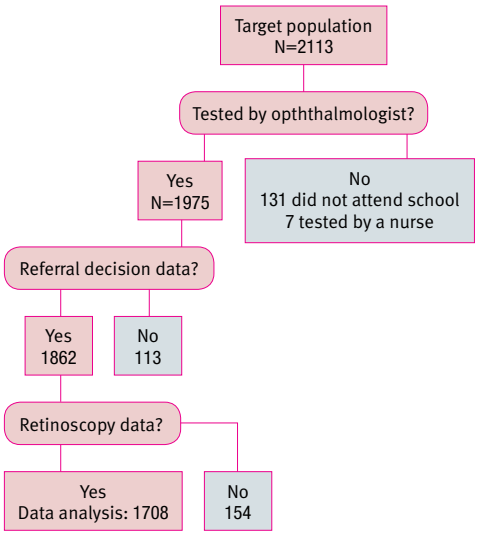
MEASUREMENTS

A training program for ophthalmologists focused on study procedures and research forms. The medical examination included vision history, a clinical eye examination, vision testing from a distance of 5 m using the illiterate E-chart, and retinoscopy. For students using spectacles, the corrected vision was recorded. If parents' signed informed consent was available, the testing proceeded with the delivery of cycloplegic drops (midramide) for fundus and retinoscopy 30–45 minutes later. As stated in our previous publication [19], 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. Students without parental approval and/or those afraid of eye drops were examined without pupil dilation. The findings and the ophthalmologist's decision regarding referral for further diagnostic procedures, treatment and/or follow-up were recorded.

DATA ANALYSIS

The present analysis refers to 1708 of 1862 students (91.7%) who had data pertaining to the ophthalmologist's decision regarding whether the student needs further referral, and the retinoscopy results [Figure 1].

Figure 1. Study scheme



OUTCOME VARIABLES

- *Clinical data*: Prevalence rates of the main clinical pathologies (strabismus, abnormal findings in either anterior segment, fundus and/or eye movements), and prevalence rate of any clinical abnormality were calculated.

- *Vision data*: The prevalence of abnormal vision test was calculated, using two definitions: a) the current PHS definition of a positive test: vision worse than 6/6 in at least one eye (each eye tested separately), or b) vision equal to or worse than 6/12 in both eyes (each eye tested separately).

- *Retinoscopy data:* Refractive error types were classified as mild, moderate or high myopia, hypermetropia and/or astigmatism [19].

- *Prevalence of vision and/or ocular abnormality:* All students referred by an ophthalmologist for further evaluation, therapy or follow-up were considered prevalent cases of vision and/or ocular abnormality.

STATISTICAL ANALYSIS

The prevalence rates of vision and/or ocular abnormality by students' demographic, clinical, vision and retinoscopic characteristics, as well as by ophthalmologists' seniority level were calculated. Log-binomial regression models were fitted for the total population and for each ethnicity, age group, and each combination of ethnicity and age, with prevalence of vision and/or ocular abnormality used as the dependent variable. The explanatory variables were physicians' seniority level; student's demographic, clinical, vision and retinoscopic characteristics; and an interaction term between student's ethnicity and age group.

To account for the cluster sampling of schools and examinations carried out by 67 nurses and 10 physicians, estimations and comparisons of clinical (physical eye examination), vision and retinoscopy results, as well as prevalence of vision and/or ocular abnormality were performed using log-binomial regression models adjusted for correlated data (SAS® GENMOD procedure with REPEATED statement). Compound symmetry (exchangeable) structure was assumed for the correlation among the students checked at the same school (class) by the same physician. This analytic approach implements the GEE methodology for correlated data [20,21]. Prevalence ratio and 95% confidence interval were estimated by introducing a LOG link and a binomial distribution into the GENMOD procedure. Data analysis was performed using SPSS 14.0 (SPSS Inc. Chicago, IL, USA 2004) and SAS 9.1.3 (SAS Institute Inc. Cary, NC, 2002-2003).

RESULTS

Of the 2113 sampled students, 1975 (93.5%) were tested. Of them, 1862 (94.3%) had a physician's decision as to whether the student

needs further referral. The current analysis included 1708 students (91.7% of 1862) [Figure 1]. About half of them (48.0%) were 6–7 years old, about half (52.8%) were males and about two-thirds (69.1%) were Arab. A comparison of these 1708 students with Northern District eligible subjects revealed a slight over-representation of 13–14 year old students (52.0% vs. 46.8% respectively).

CLINICAL ABNORMALITY

Any clinical abnormality was prevalent in 5.7% of students, with no differences by age. Borderline higher rates were noted among Jews as compared to Arabs (7.5% vs. 4.9%, $P < 0.07$). No differences by age or ethnicity were observed in strabismus or anterior segment abnormality. Negligible (< 0.8%) fundus and eye movement abnormalities were observed.

VISION ABNORMALITY

Vision abnormality, defined as vision equal to or worse than 6/12 in both eyes, was prevalent in 22.6% of students. Stratification by age and ethnicity revealed 1.85 times higher rates of abnormal vision among 6–7 year old Arab students as compared to Jewish students of the same age (29.1% vs. 15.7% respectively, $P < 0.02$). On the other hand, 13–14 year old Jewish students had 1.67 times higher rates of vision abnormality as compared to Arab students of similar age (27.8% vs. 16.6%, $P < 0.002$).

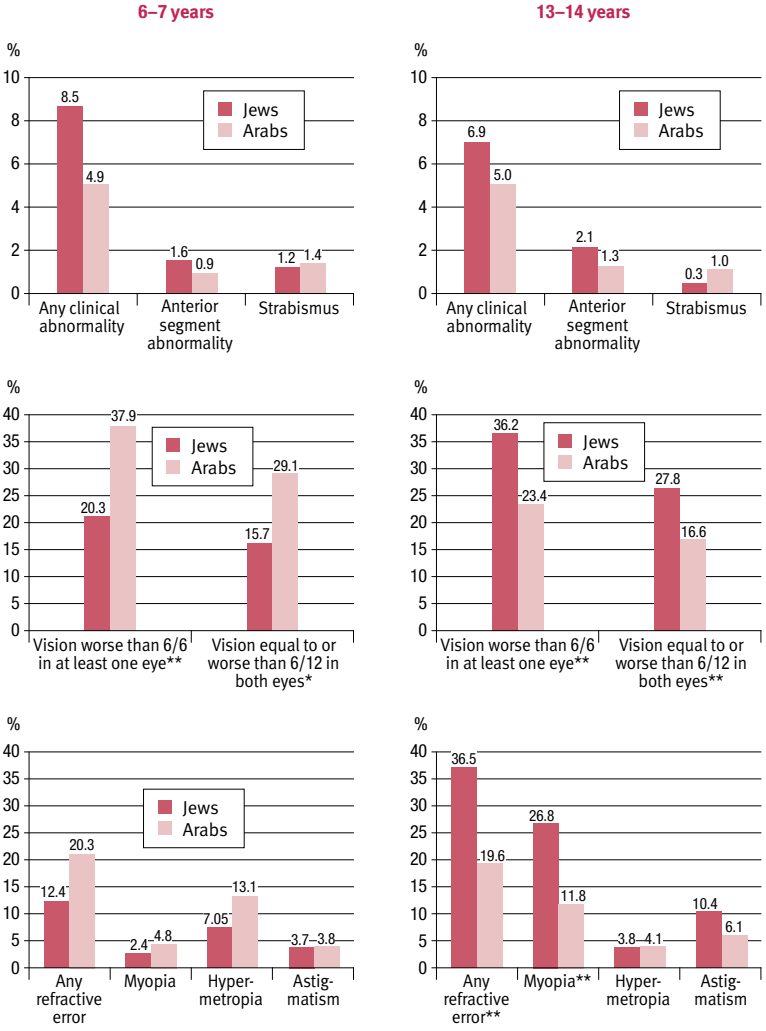
REFRACTIVE ERRORS

Refractive error of any type was prevalent in 21.2% of students, myopia being the most prevalent abnormality (10.3%), followed by hypermetropia (8.3%) and astigmatism (4.7%). Myopia and astigmatism were 5.5 times and 1.76 times, respectively, more prevalent among 13–14 year old students; hypermetropia was 3.28 times more prevalent among 6–7 year old students. Data stratification by age and ethnicity revealed that myopia was almost twice as prevalent among Jews (15.7% vs. 8.3%, $P < 0.003$) and hypermetropia 1.5 times higher among Arabs (8.5% vs. 5.3%, $P < 0.02$). Opposite associations between ethnicity and prevalence of any refractive error were seen in the two age groups: a higher rate among 6–7 year old Arab students than among 6–7 year old Jewish students (20.3% vs. 12.4% respectively, $P < 0.03$), whereas a lower rate was noted in Arabs in the older age group (19.6% vs. 36.5% respectively, $P < 0.002$). Myopia was detected 2.27 times more among 13–14 years old Jews as compared to Arabs of similar age (26.8% vs. 11.8% respectively, $P < 0.0001$). A summary graph of the prevalence of clinical, vision and refractive abnormality among Northern District Israeli students, by abnormality type, ethnicity and age groups is presented in Figure 2.

PREVALENCE OF VISION AND/OR OCULAR ABNORMALITY

Vision and/or ocular abnormality was prevalent in 21.5% of all students (95%CI 174.–26.6%) [Table 1]. As seen, this abnormality was almost twice as high among 13–14 year old students as compared to the 6–7 year olds, and almost twice as high among Jews than Arabs. It was also more prevalent among students who reported a history of vision follow-up and regular use of spectacles, as well as among students with clinical abnormalities, vision abnormality and refractive errors (data not shown). For each variable studied, a higher prevalence was noted among Jews. Physician's seniority was related to prevalence of vision and/or ocular abnormality in the total population only (24.6% vs. 17.2%, $P < 0.03$ among senior and resident ophthalmologists, respectively). The results of the log binomial models to predict prevalence of vision and/or ocular abnormality as determined by the

Figure 2. Adjusted prevalence (%) of clinical, vision and refractive abnormality among Northern District Israeli students, by abnormality type, ethnicity and age group



Adjusted prevalence for cluster sampling (school nurse and physician)
*P value < 0.05
**P value < 0.01

CI = confidence interval

Table 1. Prevalence of vision and/or ocular abnormality, by student's and physician's characteristics and by ethnicity (n=1708)

Characteristic	Total		Jews		Arabs	
	Total examined	Prevalence %* (95%CI)	Total examined	Prevalence %* (95%CI)	Total examined	Prevalence %* (95%CI)
Total**	1708	21.5 (17.4-26.6)	528	32.2 (26.5-39.0)	1180	16.7 (12.0-23.3)
***Age group						
6-7 yr	820	14.7 (12.2-17.8)	241	20.7 (16.5-26.0)	579	12.6 (8.6-17.3)
13-14 yr	888	27.8 (21.3-36.1)	287	41.8 (35.4-49.3)	601	21.1 (14.0-31.8)
Gender**						
Male	902	19.7 (14.9-26.0)	297	28.9 (23.2-36.1)	605	15.2 (10.4-22.1)
Female	806	23.5 (19.4-28.5)	231	36.3 (29.2-45.1)	575	18.4 (13.7-24.7)
History of vision follow-up***						
No	1373	18.9 (14.2-25.2)	359	28.6 (22.7-36.1)	1014	15.4 (10.7-22.2)
Yes	103	60.1 (46.6-77.6)	55	67.2 (53.6-84.3)	48	52 (33.7-80.3)
***regular spectacles Use						
No	1377	18.2 (13.9-23.8)	357	27.1 (22.2-33.2)	1020	15 (10.7-21.1)
Yes	98	73.4 (60.9-88.5)	55	80 (68.9-92.8)	43	65.1 (47.3-89.5)
Ophthalmologist**						
Resident	709	17.2 (13.0-22.6)	183	28.4 (19.3-41.6)	526	13.3 (8.4-21.0)
Specialist	999	24.6 (20.3-29.7)	345	34.2 (29.2-39.9)	654	19.5 (14.0-27.1)

* Adjusted prevalence for cluster sampling (school nurse and physician)
***P* value ‹ 0.05, *** *P* value ‹ 0.0001

Table 2. Results of log binomial models in total population and by ethnicity to predict prevalence of vision and ocular abnormality as determined by field ophthalmologists (n=1708)

Variables	Reference group	Total	Jews	Arabs
		(N=1708)	(N=528)	(N=1180)
		PR*	PR*	PR*
		(95%CI)	(95%CI)	(95%CI)
		P value	*P* value	*P* value
Abnormal retinoscopy	Normal retinoscopy	3.85	2.58	5
		(3.12-4.76)	(1.83-3.64)	(3.84-6.65)
		‹ 0.0001	‹ 0.0001	‹ 0.0001
Abnormal vision**	Normal vision***	2.42	2.32	2.57
		(2.01-2.92)	(1.68-3.186)	(2.04-3.24)
		‹ 0.0001	‹ 0.0001	‹ 0.0001
Jews	Arabs	1.62		
		(1.29-2.02)	Not relevant	Not relevant
		‹ 0.0001		
Age 13–14 yr	Age 6–7 yr	1.26	1.09	1.4
		(1.07-1.47)	(0.9-1.32)	(1.15-1.69)
		0.0041	0.371	0.0006

* Adjusted prevalence ratio for cluster sampling (school nurse and physician)
** Abnormal vision = vision equal to or worse than 6/12 in both eyes
***Normal vision = vision 6/6, 6/6 or 6/6, 6/12
CI = confidence interval

field physicians are presented in Table 2. The five components retained in the final model were Retinoscopy (PR 3.85, 95%CI 3.12–4.76, $P < 0.0001$), Vision (PR 2.42, 95%CI 2.01–2.92, $P < 0.0001$), Ethnicity (PR 1.62, 95%CI 1.29–2.02, $P < 0.0001$), Age (PR 1.26, 95%CI 1.07–1.47, $P < 0.004$), and an interaction term between Age and Ethnicity ($P < 0.0003$).

DISCUSSION

In this large study, the first of its kind in Israel, a high prevalence of vision and/or ocular abnormality (22%) was observed, as reflected by the physician's recommendation to refer the student for further diagnosis, treatment or follow-up. This finding is consistent with the increase in incidence of myopia reported in many countries, including Israel.

Some may argue that our true prevalence is even higher, since our results are based on weak cycloplegic drops and are therefore false-negative. Our choice, however, could not bias the comparison between groups, as all children were evaluated using the same cycloplegic drops. The opposite could also be argued, namely, that our true prevalence is lower, since the assumption that referral by an ophthalmologist to further evaluation is equal to a vision or ocular abnormality is incorrect.

A comparison of prevalence data with published reports is generally not simple because of the non-uniform methodology and definitions used, as well as inconsistent reporting [7]. Using the ICD-10, Resnikoff et al. [22] reported that the world prevalence rate of blindness is 0.57% and low vision 2%. Adopting the WHO definition, there were no blind students in the regular school system in our region. In order to give some idea of our students' visual acuity severity, two definitions of low vision were given: a) vision equal to or worse than 6/18 in at least one eye [prevalent in 103 students (5.1%), 95%CI

PR = prevalence ratio

WHO = World Health Organization

3.89–6.72%], and b) vision of both eyes equal to or worse than 6/18 [prevalent in 53 (2.7%) 95%CI 1.83–3.95%].

Students aged 6–7 years old, as compared to 13–14, had a lower prevalence of vision and/or ocular abnormality (14.7% vs. 27.8%, respectively). It may be argued that the lower value among the former does not reflect lower rates in the younger age group, but may be the result of young students having already been treated prior to school entry. Our data do not support this notion: only 3.3% of 631 first-graders, as compared to 9.7% of 845 eighth graders ($P < 0.0001$), reported a history of vision follow-up. Another possible explanation for the different prevalence rates by age group is that ocular abnormalities are acquired, at least partially. Increasing vision pathology by age was also reported by others. The finding of no differences between genders is consistent with several reports [3] and contradicts others [5,6,10,23]. The higher prevalence noted among 13–14 year old students and among Jews was reflected in the multivariate analysis by an independent effect of age (PR = 1.26) and ethnicity (PR = 1.62) on the physician's referral decision. This outcome is surprising since the multivariate results are controlled for vision and retinoscopy findings. As far as age is concerned, it could be argued that physicians referred 6–7 year old students with amblyopia for further treatment, and not older students with the same pathology, since therapy is effective only in the younger age group. However, such an age-dependent decision would create results opposite to those observed. It might be possible that field physicians tended to attribute some of the abnormal vision test findings among 6–7 year old students to students' immature behavior and therefore ignored it.

The reasons for the higher rates of Jewish students' referrals are even more obscure, disturbing and deserve further research. A possible explanation suggests that physicians may differentially judge Jewish and Arab parents and students with regard to compliance, assuming higher compliance among Jews due to their higher socioeconomic status. The higher socioeconomic status was also most likely manifested by higher exposure of Jews to TV programs, computers and reading, factors associated with increased risk of vision abnormality [11].

We used two definitions of abnormal vision test. According to the current PHS cutoff point, abnormal vision was found in 30.1% of 1708 students. According to the alternative definition, this proportion was 22.6%. The latter is similar to the 22.3% reported in China [6]. The present study revealed that our students rank higher than other pediatric populations [3,7-9].

Vision screening programs for undetected correctable vision deficits inevitably identify some children with reduced vision due to causes other than refractive errors. Indeed, we had 12 students with abnormal vision, normal retinoscopy and abnormal clinical findings (cataract, amblyopia, corneal opacities, congenital glaucoma, fundus pathology). Eye pathologies in the physical examination were not frequent and, as expected in schoolchildren, they were more frequent in the anterior segment (mainly corneal and lental opacity) than the posterior segment.

A comparison of our results with the vision tests done by the nurses of the "regular" school health services revealed higher VA abnormality rates (about a third vs. about 10%). Regarding external validity, as mentioned in our previous publication [19, p.81, 82], "the comparison of study population to Northern District eligible subjects revealed a slight over-representation of eighth-graders (51.5% vs.46.8%). Taking into account the over-sampling of eighth-graders, the total district prevalence of vision and/or ocular abnormality was 22.4%."

We believe that data obtained from our population-based study can reliably be used to plan eye-care for Northern District children because schoolchildren in Israel represent Israeli children at large. This is unlike poor countries, where a significant proportion of school-age children do not attend school [3], and in studies conducted in populations of limited representativeness, for example in convenience samples or in samples defined on the basis of failing a vision screen. Although not all Northern District students were included in the sampling frame (those aged 8–12 and students in special education were excluded), we believe no significant bias has been introduced: children in special education comprise only 2.6% of the total number of district schoolchildren, and the prevalence of vision abnormality increases with age. Thus, the average prevalence of vision abnormality in 1st and 8th graders reflects the prevalence in all age groups. Our weighted estimate of about 22% is therefore a good estimate of the average prevalence in northern Israel.

The 6.2% of students (131 of 2113) who did not attend school on the study day (compared to 4% reported in Oman) [4], or those who refused the eye drops despite parents' approval (1% of students) were considered, as stated, non-compliant and were not given an alternative examination date. This is unlike another study conducted in India [3]. The compliance of school directors was high compared to compliance reported elsewhere (93.0% vs. 78.9% respectively) [5].

Students' response rate to ophthalmologic examination (1975 of 2113) was 93.5%. This is similar to the participation rate in India [3] and higher than reported in China [6]. Differences were noted between ethnic groups: a lower rate among Jews (89.6%) as compared with Arabs (95.6%). Similar differences were noticed in our region, also in relation to compliance with other health care activities, such as vaccination. The lower response rate among Jews may offset the higher prevalence of vision abnormality observed in that population, introducing some underestimation of the Northern District prevalence.

Data reported by field ophthalmologists were incomplete in several important parameters, such as decision about students' referral (5.7% of 1975), fundus findings (7.6%) and retinoscopy results (10.3%). Since the proportion of missing values was low, we believe it introduced minor inaccuracies, if at all.

VA = visual acuity

LIMITATIONS

Despite efforts to achieve high parental compliance rates, only 68.3% gave approval. This is lower than the parental consent (78.9%) reported by Huynh et al. [16]. In China, providing post-midriasis sunglasses and reading glasses without cost helped alleviate hesitancy to participate [6]. The relatively low proportion of parental agreement might be due to the formidable official wording of the approval letter dictated by the Ministry of Education. It might have had some negative effect on the quality of our findings as 26.5% of 1975 retinoscopies and 28.4% of 1975 fundus examinations were carried out without cycloplegia. However, all children with available fundus and retinoscopy data were analyzed, regardless of whether they had been tested with or without pupillary dilation. A comparison between students tested with or without cycloplegia revealed only insignificant differences: abnormal fundus 0.8% vs. 0.6%, $P > 0.77$; abnormal retinoscopy 20.7% vs. 22.6%, $P > 0.40$. Some studies included all children in refractive error analysis, while others included only children with cycloplegic dilation in both eyes [3]. The lack of significant differences in the prevalence of abnormal fundus or retinoscopy when eye examination was performed with or without pupillary dilation raised the question as to whether cycloplegic drops in this age group was really mandatory.

SUMMARY AND CONCLUSIONS

The prevalence of vision and/or ocular abnormality among schoolchildren in northern Israel is approximately 22%, occurring predominantly among 13–14 year old students and Jews. The main refractive error is myopia. Further research is needed regarding:

- the validity of referral decisions of field ophthalmologists
- the factors influencing the nurse screening results (the reliability [24] and performance measures [25] of the illiterate E-chart, as performed by Northern District PHS nurses have been already published)
- the generalizability of the data to Israeli children, as the Northern District has unique demographic characteristics
- the follow-up evaluation of our project including data on the proportion of children screened who needed spectacles, the number prescribed glasses who actually wear them, and the number of children whose vision has been improved as a result of the project. The students' parents received a letter with summary results and recommendations for further care. In other studies more immediate care was given [5].

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