

Prevalence and Risk Factors of Myopia in Victoria, Australia

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Objective: To determine the prevalence and risk factors of myopia in urban and rural Victoria, Australia.

Participants and Methods: The Visual Impairment Project is a population-based prevalence study of eye disease in which both urban and rural adult populations were examined. Refractive data on the participants were collected using logMAR visual acuity, corrective lens measurement, and subjective refraction. All refractive error data were converted into spherical equivalent and myopia was defined at 2 levels: worse than -0.5 diopters (D) and worse than -1.00 D.

Results: A total of 3271 (83%) urban and 1473 (91%) rural residents were examined. The overall prevalence of myopia worse than -0.50 D in the population was 17% (95% confidence limit = 15.8%, 18.0%). Prevalence of myopia decreased from 24% in those aged 40 to 49 years to

12% in those aged 70 to 79 years, and then increased to 17% in people older than 80 years. The younger age groups also had higher usage of myopic corrective lenses throughout their lives than the older age groups, indicating an increased use of myopic corrective lenses in recent times. Myopia was found to be significantly higher in people with higher education levels ($\chi^2 = 119.20$, $P < .001$), in clerks and professionals ($\chi^2 = 132.53$, $P < .001$), in people born in southeast Asia ($\chi^2 = 77.62$, $P < .001$), and in people with higher degrees of nuclear opacity ($\chi^2 = 55.26$, $P < .001$).

Conclusion: Myopia rates in the Visual Impairment Project generally decrease with age and use of myopic correction has increased in recent times. Myopia was significantly related to education level, occupation, country of birth, and nuclear opacity.

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MYOPIA IS CAUSED by an incongruity between the power of the optical elements of the eye and the axial length so that corrective lenses or other refractive treatment is required to produce a clear image.

Several studies of myopia have been conducted, but most have been on selected subgroups and have not been population based, and often they have used different definitions of myopia, making it difficult to compare results. Definitions of myopia have ranged from any spherical equivalent refractive error as myopic to only those with a refractive error worse than -0.5 diopters (D) or worse than -1 D.

Myopia rates with these different definitions of myopia have ranged from 12% to 28% in adult¹⁻⁵ and mixed-age populations,^{6,7} while the rates are higher in adolescents.⁸ Racial differences in myopia rates are well documented. Prevalence of myopia has been shown to be as low as 2% to 5% in Australian Aborigines³ and Solo-

mon Islanders.⁹ Rates of myopia were also lower in urban African American subjects compared with white subjects in the same sample population.¹ However, various studies conducted in Asia have shown that prevalence of myopia is very high, ranging from more than 40% in the general population^{10,11} to between 50% and 80% in the student populations.^{12,13}

Several investigations in Denmark, Iceland, Japan, and North America in aboriginal populations have indicated that myopia is increasing in prevalence and may be a growing problem in the future.^{7,12,14-18} In Iceland, the rate of myopia increased from 4% in 1935 to 20% in 1975.⁷

Two population-based studies have shown that myopia rates decrease with age for people aged 40 years or older.^{1,2}

The causes of myopia are unclear, although evidence supports both genetic and environmental components, including links to higher amounts of "near work," or working at a close distance, (the "use-abuse" theory),¹⁹⁻²² years of education,^{1,2,23-27} and intelligence.²⁸⁻³²

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PARTICIPANTS AND METHODS

Data were collected as part of the Visual Impairment Project (VIP). This is a population-based prevalence study that has been conducted in Victoria, Australia. The methods have been described previously.³³ Victoria is a state in south-east Australia with a population of approximately 4.5 million (about one quarter of the Australian population), about 3.2 million of whom live in its capital city of Melbourne.³⁴

The first stage of the VIP was conducted in Melbourne on residents from 9 pairs of randomly selected 1986 Australian Bureau of Statistics Census Collector Districts. The second stage was conducted in 4 randomly selected pairs of Census Collector Districts in rural Victoria. To be eligible for inclusion, residents had to be living at their current address for at least 6 months and had to be 40 years of age or older, or be turning 40 in the current calendar year.

Participants were contacted through a household census by field interviewers who completed a questionnaire on demographic details and health service use, and then invited the eligible residents to a local screening center for an eye examination.

As part of the standardized examination, each participant had their visual acuity tested on the Early Treatment of Diabetic Retinopathy Study logMAR chart.³⁵ Vision was tested one eye at a time with presenting correction and the resulting level of vision was converted to the number of letters read. A logMAR E chart was used if the participant was illiterate or had problems reciting the English alphabet.

If the participant was unable to read at least 53 letters (20/20 minus 2 letters), a refraction was performed, starting with an initial automatic objective refraction (Humphrey 590 Automatic Refractor; Humphrey Systems, Dublin, Calif). The result was used as a starting point for the subsequent manual subjective refraction. After the best-corrected visual acuity was found, both the derived prescription and the number of letters read were recorded. Because of the age of the study population, cycloplegia was not used.

Subjective refraction was not performed for those who could read 53 letters with their present correction and the power of this correction was measured and used in these analyses. Refractive error was assumed to be 0 D for participants who did not wear eyeglasses and who did not undergo refraction because their uncorrected visual acuity was 20/20 or better. Data for people with no glasses who did

not have a refraction and had an uncorrected visual acuity of worse than 20/20 were excluded because of insufficient data for an accurate estimation of refractive error. All refractive errors were converted to the spherical equivalent for analysis. The spherical equivalent is derived by adding the spherical component of a refraction to half of the cylindrical component.

Two definitions of myopia were used. Myopia was defined as a refractive error of worse than -0.5 D or worse than -1.00 D. The former level was chosen because it only includes myopia to a significant functional degree and also will concur with definitions of the Baltimore Eye Survey¹ and the Beaver Dam Eye Study² groups, 2 other major studies with similarly aged study populations. Hypermetropia was defined as a refractive error of greater than $+0.5$ D and emmetropia was defined as a refractive error between $+0.5$ D and -0.5 D.

Nuclear cataract was graded from slitlamp photographs using the Wilmer scale,³⁶ which grades nuclear opacity in severity on a continuous scale from 0.1 to 4.9. For data analysis, the score was converted into 5 groups (1.0, 1.1-2.0, 2.1-3.0, 3.1-4.0, and >4.0).

Excluded from the data analyses were those who were aphakic or pseudophakic and those with eye conditions that could alter or interfere with accurate refraction such as keratoconus, corneal grafts, and visually impairing opaque media. Those with media opacities were only excluded if they had visual acuity reduced to worse than 20/60.

All analyses were performed with commercial statistical software (SAS version 6.10; The SAS Institute, Cary, NC). The distribution of spherical equivalent did not conform to the normal gaussian curve, as it consisted of a large number of data clustered around emmetropia and a myopic tail, which is well known to be the case in refractive error distributions.³⁷⁻³⁹ Data were transformed using the square root of the spherical equivalent, which eliminated the skewness but not the peak. Statistical tests comparing means such as *t* tests, general linear models, the Bonferroni statistic, and the χ^2 test were used, as they rely on the symmetry of a distribution rather than the shape. One myopic outlier was present that altered the data somewhat. It was decided that all analyses would be done twice, 1 including and 1 excluding this outlier. If the conclusions of the analyses were unaltered, this outlier was then excluded, and the more normal distribution to fit the parametric analyses was used. $P = .05$ was considered significant.

The aim of this study is to ascertain the prevalence and risk factors of myopia in a population-based group in Victoria, Australia.

RESULTS

A total of 4744 people (86%) underwent the eye examination, 3271 (83%) from the urban group and 1473 (92%) from the rural group. There was no difference between participants and nonparticipants other than the fact that non-English-speaking people were slightly less likely to attend.⁴⁰ The participation rate of people who spoke a language other than English at home was 79% compared with 87% of those who spoke English at home ($\chi^2 = 44.05$, $P < .001$).

The study population consisted of 2211 men (47%) and 2530 women (52%) between 40 and 98 years of age, with a mean age of 59 years.

The correlation between the right and left eyes for spherical equivalent was high ($\rho = 0.89$); in the following analyses, only the results from the right eye were used.

There were 13 people (0.27%) with refractive data missing, leaving 4731 right eyes available for analysis. Of these, 67 (1.4%) had uncorrected visual acuities worse than 20/20 for analysis, were not refracted, had no glasses, and therefore, were excluded. Also excluded were 124 people (2.6%) who had undergone cataract surgery in their right eyes, 1 with a corneal graft, 3 with corneal opacities, 3 with vitreous opacities, and 1 who had undergone radial keratotomy. This left 4532 subjects for the

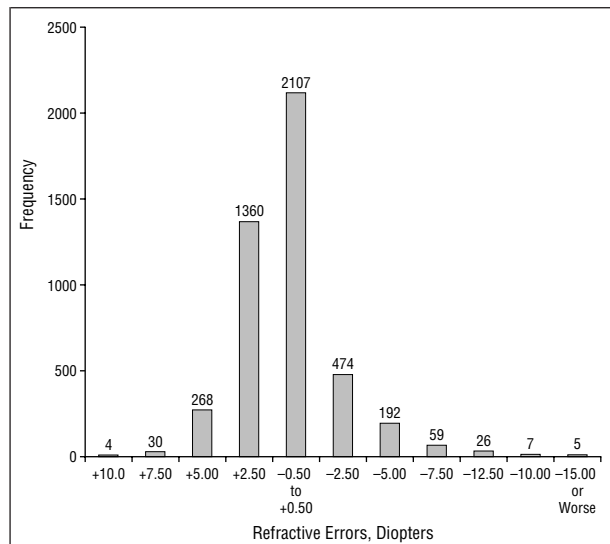


Figure 1. Frequency distribution of spherical equivalent refractive errors.

Age Group, y	Sample Size	Myopia, No. (%) [95% Confidence Limit]	
		<-0.5 Diopters	<-1 Diopters
40-49	1236	295 (23.6) [21.3, 26.0]	230 (18.4) [16.3, 20.6]
50-59	1307	214 (16.3) [14.3, 18.3]	153 (11.6) [9.9, 13.4]
60-69	1141	148 (12.4) [10.5, 14.4]	115 (10.1) [8.3, 11.8]
70-79	649	77 (11.9) [9.4, 14.3]	55 (8.5) [6.3, 10.6]
≥80	173	29 (16.8) [11.2, 22.4]	23 (13.3) [8.2, 18.4]

final analyses. Of these, 1514 (33%) were assumed to have no refractive error, that is, 0 D spherical equivalent, because they had no refraction, wore no optical correction, and had a visual acuity of 20/20 or better.

A total of 763 people (17%) had myopia worse than -0.5 D, 576 (13%) had myopia worse than -1 D, 1662 (37%) were hypermetropic, and 2081 (46%) were emmetropic. There was no significant difference in myopia rates between urban and rural populations ($P > .05$).

Of the people who were defined as having myopia at the -0.5 D level, 666 (87%) had low myopia (> -0.5 D and ≤ -5 D), 85 (11%) had high myopia (> 5 D but ≤ 10 D), and 12 (1.6%) were regarded as having extreme myopia (> 10 D) (Figure 1).

The prevalence of myopia was shown to be significantly related to age group ($\chi^2 = 65.33$, $P < .001$). Prevalence of myopia significantly decreased with age up to age 80 years ($P < .001$), but then increased in those aged 80 years or older (Table 1). A general shift in the "plus" direction in spherical equivalent (ie, less myopic) was also found in older age groups ($F = 84.72$, $P < .0001$), except in the 70- to 79-year-old age group and the 80 years and older age group. This relationship only explained 8.4% of the variance in spherical equivalent ($R^2 = 0.084$).

The prevalence of hypermetropia also changed with age. Levels of hypermetropia increased significantly in older age groups. Hypermetropia was defined as refractive error either greater than +0.50 D ($\chi^2 = 933.4$, $P < .001$) or greater than +1.00 D ($\chi^2 = 731.9$, $P < .001$).

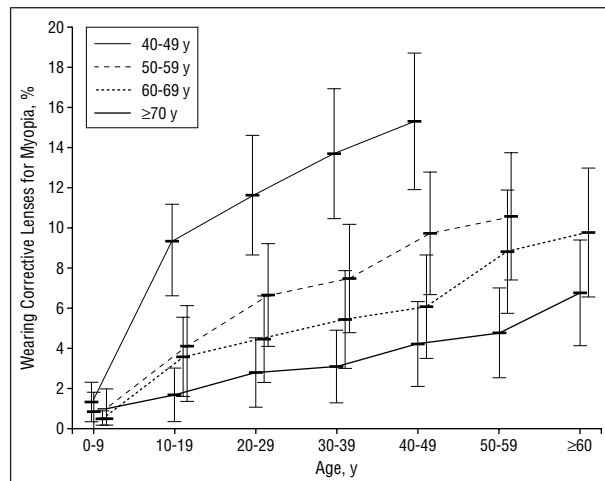


Figure 2. Lifetime use of myopic correction by age group.

Also examined, using data from the rural group, was the proportion of people wearing myopic correction at each stage of their lives. Younger age groups had higher proportions of people wearing myopic correction at all stages of life than did the older groups (Figure 2). For example, the 40- to 49-year-old group had significantly higher levels of myopic correction between ages 10 and 19 years than all other groups. To examine trends in these data, the analyses were restricted to use of myopic corrective lenses when each subject in the study population was 40 years old. There was a significant linear trend for increased use of myopic correction at age 40 years in the 40- to 49-year-old group compared with the 70 years and older group ($\chi^2 = 31.52$, $P < .001$). This trend became more significant after controlling for education and occupation ($\chi^2 = 23.38$, $P < .0001$).

Overall, sex was not significantly related to myopia ($\chi^2 = 0.006$, $P = .94$). However, when controlling for age group, women had slightly more positive spherical equivalent refractive errors than men ($F = 4.44$, $P = .04$). This result has limited clinical value, as the difference in mean spherical equivalent refractive error between men (+0.127 D) and women (+0.219 D) was small.

A significant relationship between myopia and educational level was also found ($\chi^2 = 119.20$, $P < .001$) with prevalence of myopia increasing with higher degrees of education ($P < .001$) (Table 2). More negative overall spherical equivalent was also associated with higher degrees of education ($F = 34.99$, $P < .001$), a relationship which describes 3% of variation ($R^2 = 0.03$). The Bonferroni t test for differences between means revealed that those who had completed a university or college education had significantly more myopia than all other groups. The relationship between educational level and spherical equivalent was not as strong in the rural group ($F = 3.59$, $P < .07$), but the overall relationship was still significant when controlling for geographical area (ie, rural vs urban).

Prevalence of myopia was also significantly related to the major occupation that each person had for most of their lives ($\chi^2 = 132.53$, $P < .001$). Professionals and clerks were found to have a significantly higher prevalence of myopia than all other occupational groups

Table 2. Prevalence of Myopia by Level of Education Attained

Level of Education Attained	Sample Size	Myopia, No. (%) [95% Confidence Limit]
Secondary school not completed	2074	255 (12.3) [10.9, 13.7]
Trade completed	470	51 (10.9) [8.0, 13.7]
Secondary school completed	972	201 (20.7) [18.1, 23.2]
Some university or other higher education	396	87 (22.0) [17.9, 26.1]
Completed university or other higher education	515	152 (29.5) [25.6, 33.5]

(**Table 3**). Overall spherical equivalent was also significantly different between groups ($F = 11.80, P < .001$), with professionals and clerks having significantly more negative spherical equivalents than all other groups.

Spherical equivalent was examined in a multivariate model that controlled for age group, education level, and occupation. All of these variables remained significant with spherical equivalent at the $P < .001$ level.

Information on gross household income was only gathered in the rural study, therefore analyses using this variable are only done on the rural data. Income was found not to be significantly related to myopia ($\chi^2 = 6.72, P = .08$). Spherical equivalent, though, was significantly more positive in people belonging to the lowest income level compared with all of the others ($F = 9.65, P < .001$). This relationship was not significant when controlling for education level, occupation, and age group.

The prevalence of myopia varied significantly with country of birth ($\chi^2 = 77.62, P < .001$). People who were born in southeast Asia had significantly higher rates of myopia than any other geographical area other than those with a small representation in the sample (**Table 4**). Spherical equivalent also had a significant relationship to country of birth controlling for age group and education level ($F = 34.03, P < .001$) and the spherical equivalents of those with a southeast Asian origin were again significantly more myopic than most other geographical areas.

The prevalence of myopia was also significantly related to the level of nuclear opacity that was present ($\chi^2 = 55.26, P < .001$). The prevalence of myopia was significantly higher in people with nuclear opacity greater than 3.0. Significance in difference between groups and trend remained after controlling for age group. Spherical equivalent refractive error was also significant, controlling for age ($F = 97.32, P < .001$). The Bonferroni *t* test, which has the inability to control for other variables such as age, revealed that people with the most advanced nuclear opacity had significantly more negative refractive errors than all other groups.

The analyses regarding age group, urban vs rural residence, sex, education level, occupation, country of birth, income, and nuclear opacity were also tested using a more strict definition of myopia, that is, a spherical equivalent of worse than -1 D. The results did not change markedly using this alternate definition. Finally, a multiple logistic regression using all variables was performed (**Table 5**). It showed that age, nuclear opacity, country of birth, education level, and occupation all remained significantly re-

Table 3. Prevalence of Myopia by Occupation

Occupation	Sample Size	Myopia, No. (%) [95% Confidence Limit]
Professionals	446	135 (30.3) [26.0, 34.5]
Clerks	452	125 (27.7) [23.5, 31.8]
Managers and administrators	664	112 (16.9) [14.0, 19.8]
Salespeople and personal service workers	261	42 (16.1) [11.7, 20.6]
Home workers	1203	172 (14.3) [12.3, 16.3]
Paraprofessionals	211	29 (13.7) [9.1, 18.4]
Laborers, farmers, and related workers	431	57 (13.2) [10.0, 16.4]
Plant and machine operators/drivers	322	37 (11.5) [8.0, 15]
Tradespeople	489	46 (9.4) [6.8, 12.0]

Table 4. Prevalence of Myopia by Country of Birth

Country of Birth	Sample Size	Myopia No. (%) [95% Confidence Limit]
Australia/New Zealand	2963	487 (16.4) [15.1, 17.8]
Southeast Asia	81	36 (44.4) [35.3, 53.6]
Pacific Islands	7	1 (14.3) [0, 42.3]
British Isles	393	60 (15.3) [11.7, 18.8]
Other Europe	922	135 (14.6) [12.4, 16.9]
Middle East and North Africa	69	13 (18.8) [9.6, 28.1]
Indian subcontinent	33	7 (21.2) [7.1, 35.4]
North and South America	19	6 (31.6) [10.1, 53.1]
Africa (except for North Africa)	34	15 (44.1) [27.2, 61.1]

lated to myopia prevalence (worse than -0.50 D). Only sex and geographical area (ie, urban vs rural) were no longer significant. This analysis was repeated using a higher definition of myopia (worse than -4 D). This level was chosen to discover if the variables remained significant at higher levels of myopia, and -4 D was the highest level that could be used for the analysis to remain valid owing to low numbers in the high myopia category (Table 5).

A multivariate general linear model was also examined for the degree of spherical equivalent. Again, age, nuclear opacity, country of birth, education level, and occupation were all significantly related to spherical equivalent refractive error ($P < .001$), whereas sex and geographical area were not.

COMMENT

The VIP provides one of the few population-based prevalence estimates of myopia in an adult population and is unique in that it includes an urban and a rural sample population. The overall prevalence of myopia (-0.50 D or more) in the urban and rural VIP combined in right eyes was 17% (95% confidence limit = 15.8%, 18.0%). This is lower in general compared with many other studies (**Table 6**).

It was assumed that the group of participants who wore no corrective lenses and who had a visual acuity of 20/20 or better did not have a refractive error and did not undergo refraction. This limitation was imposed by field conditions. This should not affect the myopia rate,

Table 5. Prevalence of Myopia in Multivariate Logistic Regression*

Risk Factor	Odds Ratio (95% Confidence Limit)	
	-0.5 Diopters	-4 Diopters
Age, y	0.97 (0.96, 0.98)	0.94 (0.92, 0.97)
Nuclear opacity†	3.03 (2.04, 4.51)	6.31 (2.73, 14.58)
Country of birth		
Australia/New Zealand	1.00 (NA)	NA (NA)
Southeast Asia	2.55 (1.60, 4.06)	5.00 (2.69, 9.27)
Africa (except North Africa)	2.56 (1.26, 5.19)	NA (NA)
Europe	NA (NA)	1.73 (1.15, 2.60)
Educational level attained		
High school not completed	1.00 (NA)	NA (NA)
High school completed	1.53 (1.24, 1.88)	NA (NA)
Some university/advanced education	1.57 (1.19, 2.09)	NA (NA)
University/advanced education completed	1.89 (1.42, 2.53)	2.30 (1.41, 3.75)
Occupation		
Laborers, farmers, etc	1.00 (NA)	NA (NA)
Tradespersons	0.68 (0.49, 0.94)	NA (NA)
Clerks	1.89 (1.49, 2.40)	3.19 (2.07, 4.92)
Professionals	1.63 (1.23, 2.16)	1.90 (1.11, 3.25)

*NA indicates not applicable.

†Continuous Wilmer grading scale.³⁶

although this assumption would underestimate the prevalence of hypermetropia in the sample. A number of the subjects labeled emmetropic in this study would be younger participants with low hypermetropia who had enough reserve accommodative power to overcome their small refractive error. This may also account for some of the increase in hypermetropia with age because of declining accommodative power.

In all of the univariate analyses, both the prevalence of myopia and the level of spherical equivalent were examined. The degree of spherical equivalent refractive error was examined to reflect degrees of myopia and myopic shifts. This is important because if a particular variable acts on a person's refractive state and causes a myopic shift, the person's baseline refractive error becomes important. If, for example, a person starts off at baseline as being hypermetropic and an environmental variable contributes to a myopic shift, the person does not necessarily become myopic, they may simply become less hypermetropic, ie, more myopic. Thus, if the presence of myopia was simply examined, this previously mentioned effect would be hidden.

Myopia prevalence was found to decrease significantly with age until about age 80 years. In persons older than this, there is an increase in the prevalence of myopia, although it not statistically significant. This concurs with other studies of similarly aged populations.^{1,2,4,39} Numerous other studies that have included much younger age groups have shown that the prevalence of myopia increases with age.^{13,19,41-45} Both of these trends are reflected in an extensive study by Slataper,³⁹ which shows a myopic shift between the ages of 8 to 30 years, a hypermetropic shift between the ages of 31 and 64 years, and finally a myopic shift between the ages of 65 and 87 years. The myopic shift seen in people in the upper age groups has been as-

Table 6. Prevalence of Myopia in Selected Studies

Study	Age Group, y	Myopia Definition	Myopia, % (95% Confidence Limit)
Visual Impairment Project	≥40	Worse than -0.5 D	16.9 (15.8, 18.0)
		Negative refraction	22.1 (20.9, 23.3)
		Worse than -0.25 D	19.6 (18.4, 20.8)
		Worse than -0.75 D	14.7 (13.7, 15.7)
Baltimore Eye Survey ¹	≥40	Worse than -1.00 D	12.8 (11.8, 13.8)
		Worse than -0.5 D	22.7 (21.5, 23.9)
Beaver Dam Eye Study ²	≥43	Worse than -0.5 D	26.2 (24.9, 27.5)
HANES ⁶	12-54	Negative refraction	25.0 (23.7, 26.3)
HES ¹⁹			
Men	12-17	Negative refraction	28.4 (NA)
Women	12-17	Negative refraction	35.0 (NA)
Iceland ⁷	1-99	Worse than -0.25 D	20.51 (NA)
Central Australia ³			
Aborigines	20-30	Worse than -0.75 D	4.8 (15, 8.1)
Whites	20-30	Worse than -0.75 D	13.5 (8.1, 19.0)
Israel ⁵	≥40	Worse than -1.0 D	11.6 (10.6, 12.6)
		Negative refraction	18.4 (17.2, 19.6)

sociated with age-related changes to the lens.^{39,46,47} The VIP data supports this theory, showing that not only does overall spherical equivalent refractive error become more negative with increasing amounts of nuclear opacity, but also the prevalence of myopia increases. This increase of myopia in the upper age groups also occurs in black persons in the Baltimore Eye Survey¹ and men in the Beaver Dam Eye Study,² although the effect may be somewhat dampened in the latter study because of the exclusion of participants with visual acuities worse than 20/40.

Not only does the prevalence of myopia decrease with age, there is also an overall shift in the hypermetropic direction of refractive error resulting in a corresponding increase in the prevalence of hypermetropia.

There are 2 possible explanations for this trend. First, it could be that myopia actually does improve with age, or second, that the incidence of myopia has increased in the younger cohorts other than can be explained by the variables controlled for in the multivariate analysis such as possible higher education levels.

It was also found in the rural component that, when examining the use of myopic correction during different life periods of each person, the younger groups, especially persons aged 40 to 49 years, wore myopic corrective lenses more often at all stages of their lives than the older age groups. This indicates that the use of myopic correction has increased in recent times. There are several possible explanations for this trend. This may suggest that the prevalence of myopia is increasing, a view that has been put forth by several investigators.^{7,12,14} It might also reflect greater use of health care services in more recent years, which may have been influenced by the introduction of the national government-subsidized health care (Medicare) in the 1970s, which includes a subsidy for glasses. The result may also simply reflect potential recollection bias of the older groups.

Myopia was found to increase significantly in frequency and overall refractive error to become more myopic with higher levels of education, as has been reported

previously.^{1,2,4,6} The relationship still held while controlling for geographical area (ie, urban vs rural), although when examining rural data separately, the relationship was significant but weaker, probably owing to the smaller number of university graduates in rural areas (5%) compared with urban areas (14%). The level of education can be used as a crude measure of the amount of near work that a person has done in their younger days, and the link between this measure and myopia has been used to support the use-abuse theory of myopia.¹⁹

Another indication of near work is occupation. Professionals (30% myopic) and clerks (28% myopic) had significantly higher rates of myopia compared with other occupations even after controlling for educational level and age group. This could also support the use-abuse theory of myopia or may simply suggest that people with myopia tend to be attracted to professional and clerical occupations, which involve large amounts of near work.

Those who were born in southeast Asia had significantly higher levels of myopia than those born elsewhere. This concurs with several other studies that report large prevalence of myopia in Asian countries.¹⁰⁻¹³ In the multivariate logistic regression, those born in Africa (except north Africa) had an increased risk of myopia. This group is somewhat anomalous, as it consisted almost exclusively of white South Africans. Previous reports have shown that myopia is uncommon in indigenous African groups.²⁶ The myopia rates relating to country of birth may be influenced somewhat by the likelihood that immigrants who are let into the country probably have higher education levels, although this has been controlled for in the multivariate analysis.

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REFERENCES

- Katz J, Tielsch JM, Sommer A. Prevalence and risk factors for refractive errors in an adult inner city population. *Invest Ophthalmol Vis Sci*. 1997;38:334-340.
- Wang Q, Klein BE, Klein R, Moss SE. Refractive status in the Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci*. 1994;35:4344-4347.
- Taylor HR. Racial variations in vision. *Am J Epidemiol*. 1981;113:62-80.
- The Framingham Offspring Eye Study Group. Familial aggregation and prevalence of myopia in the Framingham Offspring Eye Study. *Arch Ophthalmol*. 1996;114:326-332.
- Hyams SW, Pokotilo E, Shkurko G. Prevalence of refractive errors in adults over 40: a survey of 8102 eyes. *Br J Ophthalmol*. 1977;61:428-432.
- Sperduto RD, Seigel D, Roberts J, Rowland M. Prevalence of myopia in the United States. *Arch Ophthalmol*. 1983;101:405-407.
- Sveinsson K. The refraction of Icelanders. *Acta Ophthalmol (Copenh)*. 1982;60:779-787.
- Cumming RG, Mitchell P. Hormone replacement therapy, reproductive factors, and cataract: the Blue Mountains Eye Study. *Am J Epidemiol*. 1997;145:242-249.
- Verlee DL. Ophthalmic survey in the Solomon Islands. *Am J Ophthalmol*. 1968;66:304-319.
- Rasmussen OD. Incidence of myopia in China. *Br J Ophthalmol*. 1936;20:350-360.
- Van Newkirk MR. The Hong Kong Vision Study: a pilot assessment of visual impairment in adults. *Trans Am Ophthalmol Soc*. 1997;95:715-749.
- Hosaka A. Population studies: myopia experience in Japan. *Acta Ophthalmol Suppl*. 1988;185:37-40.
- Lin LL, Chen CJ, Hung PT, Ko LS. Nation-wide survey of myopia among school-children in Taiwan, 1986. *Acta Ophthalmol Suppl*. 1988;185:29-33.
- Fledelius HC. Is myopia getting more frequent? a cross-sectional study of 1416 Danes aged 16 years+. *Acta Ophthalmol (Copenh)*. 1983;61:545-559.
- Morgan RW, Munro M. Refractive problems in northern natives. *Can J Ophthalmol*. 1973;8:226-228.
- Boniuk V. Refractive problems in native peoples (the Sioux Lookout Project). *Can J Ophthalmol*. 1973;8:229-233.
- Johnson GJ, Green JS, Paterson GD, Perkins ES. Survey of ophthalmic conditions in a Labrador community, II. *Can J Ophthalmol*. 1984;19:224-233.
- van Rens GH, Arkell SM. Refractive errors and axial length among Alaskan Eskimos. *Acta Ophthalmol (Copenh)*. 1991;69:27-32.
- Angle J, Wissmann DA. The epidemiology of myopia. *Am J Epidemiol*. 1980;111:220-228.
- Adams DW, McBrien NA. Prevalence of myopia and myopic progression in a population of clinical microscopists. *Optom Vis Sci*. 1992;69:467-473.
- Richler A, Bear JC. Refraction, nearwork and education: a population study in Newfoundland. *Acta Ophthalmol (Copenh)*. 1980;58:468-478.
- Wong L. Education, reading and familial tendency as risk factors for myopia in Hong Kong fishermen. *J Epidemiol Community Health*. 1993;47:50-53.
- Paritsis N, Sarafidou E, Koliopoulos J, Trichopoulos D. Epidemiologic research on the role of studying and urban environment in the development of myopia during school-age years. *Ann Ophthalmol*. 1983;15:1061-1065.
- Teasdale TW, Goldschmidt E. Myopia and its relationship to education, intelligence and height: preliminary results from an on-going study of Danish draft-ees. *Acta Ophthalmol Suppl*. 1988;185:41-43.
- Angle J, Wissmann DA. Age, reading, and myopia. *Am J Optom Physiol Opt*. 1978;55:302-308.
- Lewallen S, Lowdon R, Courtright P, Mehl GL. A population-based survey of the prevalence of refractive error in Malawi. *Ophthalmic Epidemiol*. 1995;2:145-149.
- Mordechai R, Belkin MA. Intelligence, education, and myopia in males. *Arch Ophthalmol*. 1987;105:1508-1511.
- Karlsson JL. Genetics of myopia and associated mental traits. *Hereditas*. 1986;105:205-208.
- Karlsson JL. Influence of the myopia gene on brain development. *Clin Genet*. 1975;8:314-318.
- Teasdale TW, Fuchs J, Goldschmidt E. Degree of myopia in relation to intelligence and educational level. *Lancet*. 1988;2:1351-1354.
- Cohn SJ, Cohn CMG, Jensen AR. Myopia and intelligence: a pleiotropic relationship? *Hum Genet*. 1988;80:53-58.
- Karlsson JL. Genetic relationship between giftedness and myopia. *Hereditas*. 1973;73:85-88.
- Livingston PM, Carson CA, Stanislavsky YL, Lee SE, Guest CS, Taylor HR. Methods for a population-based study of eye disease: the Melbourne Visual Impairment Project. *Ophthalmic Epidemiol*. 1994;1:139-148.
- Australian Bureau of Statistics. *Basic Community Profile*. Canberra, Australia: AGPS: 1993.
- Ferris FL, Kassoff, Bresnick GH, Bailey. New visual acuity charts for clinical research. *Am J Ophthalmol*. 1982;94:91-96.
- Taylor HR, West SK. The clinical grading of lens opacities. *Aust N Z J Ophthalmol*. 1989;17:81-86.
- Rubin ML. *Optics for Clinicians*. 2nd ed. Gainesville, Fla: Triad Publishing Co; 1974.
- McGhee CN, Taylor HR, Gartry DS, Trokel SL. *Excimer Lasers in Ophthalmology: Principles and Practice*. London, England: Martin Dunitz; 1997.
- Slataper FJ. Age norms of refraction and vision. *Arch Ophthalmol*. 1950;43:466-481.
- Livingston PM, Lee SE, McCarty CA, Taylor HR. A comparison of participants and non-participants in a population-based epidemiologic study: the Melbourne Visual Impairment Project. *Ophthalmic Epidemiol*. 1997;4:73-81.
- Goss DA, Cox VD. Trends in the change of clinical refractive error in myopes. *J Am Optom Assoc*. 1985;56:608-613.
- Mantylarvi M. Incidence of myopia in a population of Finnish school children. *Acta Ophthalmol (Copenh)*. 1983;61:417-423.
- Laatikainen L, Erkkila H. Refractive errors and other ocular findings in school children. *Acta Ophthalmol Suppl*. 1980;58:129-136.
- Garner LF, Kinnear RF, Klinger JD, McKellar MJ. Prevalence of myopia in school children in Vanuatu. *Acta Ophthalmol (Copenh)*. 1985;63:323-326.
- Pendse GS, Bhave LS, Dandekar VM. Refraction in relation to age and sex. *Arch Ophthalmol*. 1954;52:404-412.
- Duke-Elder S, Abrams D. *Ophthalmic Optics and Refraction*. London, England: Henry Kimpton; 1970.
- Curtin BJ. *The Myopias: Basic Science and Clinical Management*. Philadelphia, Pa: Harper & Row Publishers; 1985.