Prevalence of Myopia in the United States

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• Data from the 1971 to 1972 National Health and Nutrition Examination Survey were used to estimate myopia prevalence rates for persons in the United States between the ages of 12 and 54 years. When persons were classified by the refractive status of their right eye, 25% were myopic. Significantly lower prevalence rates were found for male subjects than for female subjects and for blacks than for whites. Myopia prevalence rose with family income and educational level. The importance of income and educational level may result from their association with near work, a factor that has been implicated in the pathogenesis of myopia.

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Little is known about the distribution of myopia in the population of the United States. Most surveys of refractive error have dealt with select populations, such as students, army recruits, and eye clinic patients. As a result, knowledge of how the prevalence of myopia varies with sex, race, and age, for example, is incomplete.

Such prevalence data could be helpful in health care planning. In recent years, there has been growing interest in radial keratotomy, a surgical procedure aimed at correcting myopia.

To evaluate the potential medical and economic importance of this procedure, better prevalence data are required.

Prevalence data are also useful in searching for etiologic mechanisms. Are early eye use habits of any importance? Information about the distribution of myopia in the population seems a useful place to start formulating an answer to this question.

We have used data from a general population study, the National Health and Nutrition Examination Survey (HANES), to report the prevalence of myopia for persons between the ages of 12 and 54 years in the United States. Rates are presented separately by age, sex, race, family income, and education.

SUBJECTS AND METHODS

As part of the HANES conducted by the National Center for Health Statistics in 1971 to 1972, a national probability sample of 14,147 persons, aged 1 through 74 years, was selected to represent the 192.7 million persons in the civilian noninstitutionalized population of that age at the time of the survey.[1] The probability that any person was included in the sample varied by race, age, and economic status. Weights that compensated for this oversampling and undersampling were assigned to each person sampled and permitted construction of valid estimates of population rates.

Between April 1971 and October 1972, eye examinations were performed on 9,882 (69.9%) of the 14,147 persons by 91 ophthalmologists in 35 geographic areas of the United States. A standardized eye examination included the following: determination of monocular distance visual acuity with current distance correction, if any, and with a pinhole test to measure correctability for eyes with visual acuity worse than 20/20; measurement of prescription in current correction; and detailed retinoscopy or spherical refraction for eyes with visual acuity worse than 20/40 (not including pinhole acuity).[2]

We classified eyes as nonmyopic or myopic and determined the degree of myopia. Nonmyopic eyes were not further classified. Refractive status was determined as follows:

For eyes with 20/20 visual acuity, a spherical equivalent was calculated from the current distance correction. If no correction was worn, the eye was classified as nonmyopic.

For eyes with 20/25 to 20/40 visual acuity, a group not refracted, a spherical equivalent was calculated from the current correction. If the spherical equivalent was negative and acuity improved with pinhole testing, the amount of myopia was adjusted according to the method described by Sloan.[3]

If no correction was worn and acuity improved with pinhole testing, the eye was excluded from the analysis because insufficient data were available for classification of refractive status. If no correction was worn and acuity did not improve with pinhole testing, the eye was classified as nonmyopic.

For eyes with visual acuity of less than 20/40 (not including pinhole acuity), a spherical equivalent was calculated from retinoscopy or spherical equivalent refraction.

We used these data to obtain national prevalence estimates of myopia for persons aged 12 to 54 years. The national probability sample included 7,401 persons within this age range. Although oversampling was used in certain population groups, rates were computed so as to provide representative national estimates. Of the 5,282 (71.4%) persons examined, insufficient data were available to classify the refractive status of 846 right eyes (16.0%) and 778 left eyes (14.7%).

Tables were prepared that allowed comparisons of national prevalence estimates according to age, sex, race, family income, and education. Income data were not available for 242 persons and educational level data were not available for 41 persons. In testing for differences between population proportions, we used SEs that took account of the complex sampling design used in the survey.

RESULTS

The prevalence of any degree of myopia among eyes of persons between 12 and 54 years was 25.0% and 24.3% for right and left eyes, respectively (Table 1). For all ages combined, prevalence rates were significantly less for men than for women ($P < .05$), but this difference in rates was not present after the age of 35 years (Table 1). Whites had substantially high-

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Table 1.—Estimated Prevalence of Myopia by Age, Race, and Sex in the United States From 1971 to 1972

Race and Sex	All Ages %	All Ages SE	Aged 12-17 yr %	Aged 12-17 yr SE	Aged 18-24 yr %	Aged 18-24 yr SE	Aged 25-34 yr %	Aged 25-34 yr SE	Aged 35-44 yr %	Aged 35-44 yr SE	Aged 45-54 yr %	Aged 45-54 yr SE
All races												
Both sexes												
OD	25.0	1.1	24.0	1.6	27.7	2.1	24.2	1.6	24.5	2.0	24.8	2.2
OS	24.3	1.0	23.7	1.6	27.3	2.2	23.2	1.6	23.3	2.0	23.7	2.0
Men												
OD	22.8	1.5	21.7	2.1	22.5	2.6	20.2	2.2	26.1	3.7	24.4	2.6
OS	22.0	1.2	21.2	2.2	23.1	2.8	19.0	2.0	23.6	2.5	24.1	2.3
Women												
OD	27.1	1.2	26.4	2.8	32.5	3.1	27.8	2.4	23.2	1.6	25.1	2.2
OS	26.4	1.2	26.5	2.9	31.2	2.9	27.3	2.4	23.1	2.0	23.2	2.5
Whites, both sexes												
OD	26.3	1.2	25.8	1.8	29.7	2.6	25.6	1.8	24.9	2.3	25.5	2.3
OS	25.6	1.0	25.6	1.7	29.7	2.6	24.4	1.9	23.9	2.2	24.4	2.1
Blacks, both sexes												
OD	13.0	1.8	12.0	2.7	10.4	2.5	12.3*	3.5	14.8*	3.8	17.3*	7.1
OS	12.2	1.9	11.4	2.7	8.5*	2.6	13.4*	3.7	12.6*	3.5	16.8*	7.3

*Coefficient of variation is greater than 25%.

Table 2.—Estimated Prevalence (%) of Specific Levels of Myopia by Age in the United States From 1971 to 1972

Myopia, Diopters	All Ages	Aged 12-17 yr	Aged 18-24 yr	Aged 25-34 yr	Aged 35-44 yr	Aged 45-54 yr
<2						
OD	13.4	11.1	11.7	13.1	15.9	15.8
OS	13.2	11.0	11.6	13.4	14.9	15.4
2-7.9						
OD	11.4	12.5	15.8	10.7	8.4	8.9
OS	10.7	12.4	15.0	9.7	7.8	8.3
≥7.9						
OD	0.2	0.4	0.3	0.3	0.2	0
OS	0.4	0.4	0.7	0.2	0.7	0

Table 3.—Estimated Prevalence of Myopia by Age and Family Income in the United States From 1971 to 1972

Income	All Ages %	All Ages SE	Aged 12-17 yr %	Aged 12-17 yr SE	Aged 18-24 yr %	Aged 18-24 yr SE	Aged 25-34 yr %	Aged 25-34 yr SE	Aged 35-44 yr %	Aged 35-44 yr SE	Aged 45-54 yr %	Aged 45-54 yr SE
<$5,000												
OD	17.3	2.1	12.1	2.9	26.6	4.3	15.7	3.8	15.9*	5.2	10.0*	4.4
OS	17.1	2.2	13.1*	3.5	24.1	4.1	15.3	3.8	16.4*	5.5	12.1*	5.2
$5,000-10,000												
OD	23.2	1.1	24.2	2.3	28.4	3.1	22.7	2.1	17.0	2.8	20.4	4.5
OS	22.2	0.9	21.9	2.1	27.9	3.0	21.3	1.8	16.4	2.7	19.8	3.8
>10,000												
OD	28.9	1.6	27.9	2.2	27.6	4.1	28.2	3.3	29.9	2.8	30.3	3.1
OS	27.8	1.4	28.0	2.2	28.0	4.2	27.5	3.2	27.7	2.3	27.8	2.8

*Coefficient of variation is greater than 25%.

er rates than blacks ($P < .01$). For whites and blacks, respectively, rates were 26.3% and 13.0% for right eyes and 25.6% and 12.2% for left eyes.

Although there was little variation in the overall rates with age, there was a progressive increase with age in the proportion of persons with less than 2 diopters of myopia and a corresponding decrease in those with 2 D or more of myopia (Table 2).

The prevalence of myopia increased as family income rose (Table 3). For the total poulation the rates increased from 17.3%, to 23.2%, to 28.9% for right eyes as family income increased from less than $5,000, to $5,000 to 10,000, to greater than $10,000 per year. Corresponding rates for left eyes were 17.1%, 22.2%, and 27.8%.

Myopia prevalence increased markedly for all age groups as the number of years of school completed rose from less than five years to greater than 12 years, another trend that was highly significant ($P < .01$) (Table 4).

The increase with age in the proportion of persons with less than 2 D of myopia and the corresponding decrease in those with 2 D or more of myopia persisted after standardization separately for income and education.

COMMENT

Most previous studies have dealt with select populations, making comparisons of prevalence estimates difficult. Our rates (about 25%) are higher than those in most published reports. Among British army recruits between 18 and 22 years of age, Sorsby et al[4] found an 11% myopia prevalence rate, whereas Goldschmidt[5] found a 14.5% rate for Swedish army recruits. In a population study of communal settlements in Israel, Hyams et al[6] noted myopia in 18.4% of eyes in subjects 40 years of age or older. Leibowitz and associates[7] found myopia to be present in 17.7% of eyes in the Framingham (Mass) Eye Study population, where age ranged from 52 to 85 years.

There were two important reasons for missing data in our analysis, but it seems unlikely that they explain the higher rates that we found. More than one quarter of the national probability sample was not examined. On the basis of the reasons given for nonparticipation and an analysis of the medical histories that were available for most of those not examined, the National Center for Health Statistics concluded that no sizable bias was introduced by these nonrespondents.[8] Furthermore, one of the components of the weight assigned to an examined person was an adjustment for nonresponse. Though the analysis of the characteristics of those not examined is reassuring, the sizable proportion of nonexamined remains a potential source of bias in our estimates.

The inability to determine the refractive status of approximately 15% of examined eyes was a second source of missing data. This factor resulted from a failure of the examiner to record essential information or our inability to determine the refractive status of eyes with 20/25 to 20/40 visual acuity that had no correction but improved with pinhole testing. This group of eyes with missing data was known to be enriched with eyes that required glasses for distance or had decreased acuity. Tabulations were made available to us of the rates of missing data among those exam-

Table 4.—Estimated Prevalence of Myopia by Age and Highest Grade Level Completed in the United States From 1971 to 1972

Highest Grade Level Completed, yr	Aged 18-24 yr %	Aged 18-24 yr SE	Aged 25-34 yr %	Aged 25-34 yr SE	Aged 35-44 yr %	Aged 35-44 yr SE	Aged 45-54 yr %	Aged 45-54 yr SE
<5								
OD	3.1*	7.8	3.9*	8.3	5.5*	7.5	2.7*	2.3
OS	3.1*	7.8	4.0*	9.1	5.5*	8.1	2.8*	2.1
5-8								
OD	3.0*	2.7	13.2*	3.7	12.8*	5.4	10.2*	3.7
OS	2.9*	3.1	13.5*	3.5	10.1*	4.8	8.2*	3.6
9-12								
OD	28.0	2.4	22.0	1.9	20.3	1.9	24.2	3.0
OS	27.1	2.3	20.8	2.0	19.1	1.6	23.0	2.7
>12								
OD	31.4	3.3	32.3	4.4	39.3	4.7	39.5	5.0
OS	32.2	3.7	31.7	4.4	38.3	4.7	39.2	5.2

*Coefficient of variation is greater than 25%.

ined separately by age, by sex, and by race. Making some simple assumptions about the distribution of refractive errors among these, we concluded that the prevalence of myopia was likely to be underestimated by about 1% and that observations about major patterns were unaffected. We had no information on the proportion missing by income and education. As with the problem of the unexamined, although we were reassured by our analyses of potential bias from missing data, there is no substitute for complete ascertainment.

In our tests of significance, we used SEs that took into account the complex sample design of the survey.[1,8] This step was necessary because we were interested in general population estimates, and oversampling of certain population groups was used in the survey.

Myopia prevalence remained remarkably constant from the ages of 12 to 54 years. However, there were progressively more low myopes and, correspondingly, fewer moderate-high myopes, with advancing age. In 1950, Slataper[9] reported a slight but steady trend toward more positive (hypermetropic) mean refractive errors from the third to the seventh decades. Richler and Bear[10] also noted this trend toward decreasing mean refractive error among persons between the ages of 20 and 59 years in a population study in three communities in Newfoundland. Duke-Elder and Abrams[11(p232)] suggested that this is not the apparent increase in hypermetropia due to progressive failure of accommodation. Possible explanations for this trend toward hypermetropia include factors that decrease the power of the aging lens, such as a decreasing curvature of its surface as it grows throughout life or an increasing optical density of the cortex that makes the lens more uniformly refractive.[11(p238)] Alternately, this trend toward less severe myopia with advancing age in cross-sectional studies such as ours may be a cohort effect indicating that more recent birth cohorts are at a greater risk of the development of more severe myopia.

Duke-Elder and Abrams cited no sex difference in prevalence rates for refractive error. In a study of schoolchildren, Goldschmidt[5] found a higher frequency of myopia in girls than in boys. Angle and Wissmann,[12] using data from the 1966 National Health Examinations Survey of 12- to 17-year-olds, reported a 35.0% rate for girls and 27.4% for boys. Our data showed higher rates for female subjects than for male subjects between 12 and 35 years, but thereafter the rates for the two sexes were similar. In a 15- to 29-year age group, the Newfoundland study[10] found that the shift to negative refraction occurred at an earlier age and was somewhat greater for women than men.

The association of myopia with both income and educational level has been noted in several previous reports. Among a US national probability sample of 12- to 17-year-olds, Angle and Wissmann[12] showed the frequency of myopia to increase from 16.8% to 35.1% as family income rose from less than $500 to more than $15,000 per year. Goldschmidt[5] found a higher frequency of myopia among more educated Danish recruits, and British investigators[13] reported that myopia was more common in British children of nonmanual than manual workers.

The association with income and educational level may result from an association with near work. Angle and Wissmann[12] have shown that most of the variance in myopia explained by income level is eliminated when adjustments are made for near work. Educational status has been shown to be closely related to near work[10] and is sometimes used as an indicator of near work in epidemiologic analyses. These observations can be used in support of the use-abuse theory of myopia, which postulates that accommodative effort in the developing eye causes the optic axis to elongate and the eye to become myopic. However, Goldschmidt[5] has cautioned that genetic heterogeneity along social class lines may confound these observations.

Further analyses are needed to explore how the various factors, age, race, sex, education and income, relate to one another and how the association of myopia with one factor may be "explained" by another.

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