Evidence for an “Epidemic” of Myopia

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Abstract

Introduction: It has been widely suggested that the prevalence of myopia is growing worldwide, and that the increases observed in East Asia, in particular, are sufficiently severe as to warrant the term “epidemic”. Data in favour of a cohort effect in myopia prevalence are reviewed, with attention to significant shortcomings in the quality of available evidence. Additional factors contributing to myopia prevalence, including near work, genetics and socioeconomic status, are detailed. Materials and Methods: Medline search of articles regarding myopia prevalence, trends and mechanisms. Results: Age-related changes in myopia prevalence (increase during childhood, and regression in the fifth and sixth decades) are discussed as an alternative explanation for cross-sectional patterns in myopia prevalence. There have only been a handful of studies that have examined the relative contribution of longitudinal changes in refraction over life and birth cohort differences on age-specific myopia prevalence as measured in cross-sectional studies. Available data suggest that both longitudinal changes and cohort effects may be present, and that their relative contribution may differ in different racial groups. Conclusions: In view of the relatively weak evidence in favour of a large cohort effect for myopia in East Asia, and the even greater lack of evidence for increased prevalence of secondary ocular pathology, there appears to be inadequate support for large-scale interventions to prevent or delay myopia at the present time.

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Introduction

A number of authors have recently proposed that myopia is increasing at an “epidemic” rate, particularly in East Asia, and especially among populations of Chinese descent.1-3 It has been reported that the prevalence of myopia among some populations in this area has reached 90%.4-6 Some writers have suggested that this purported rapid increase in myopia may be related to changing environmental factors, in particular the demands of near work.7-12 Finally, it has been asserted that the phenomenon of rapidly increasing myopia may lead to an increase in diseases that may be associated with myopia, such as retinal detachment, glaucoma and cataract, and that the threat of such an increase requires preventive action now on the part of health policymakers.1,3,13 This review offers a critical examination of all of these assertions and the data that have been advanced to support them.

Age, Race, Environment and Myopia

The tendency for myopia to progress from birth until the early teenage years appears to be nearly universal among all races.14-20 A complementary tendency for myopia to regress during the fifth and sixth decades of life has been recognised since at least the 1950s.21-24 Significant differences exist in the prevalence of myopia between racial groups, with the Chinese reported to have particularly high rates.24 Other Asian populations appear to have myopia rates somewhat higher than those of European populations, but not as high as Chinese.16,19,21-23 Myopia rates in urban areas are often significantly higher than for rural populations in China and other Asian countries.9,16,26 It is interesting to note that myopia prevalence as high as 50% to 70% has been reported among the Chinese since at least the 1920s, depending on the definition and mode of data acquisition.27

In conjunction with their apparent higher prevalence of myopia, the Chinese13,28,29 appear to have rates of myopia progression in childhood significantly higher than those of European-derived populations,30,31 and somewhat higher than for other Asian groups.18 Saw et al29 have consistently found rates of myopia progression among Singaporean children aged 6 to 12 years as high as 0.6 D/year, compared to <0.1 D/year
in Western studies. It is clear that early refractive errors, possibly as early as in infancy, are very strong predictors of later myopia, and that socioeconomic and educational factors, parental myopia and possibly near work also play a significant role. Accurate measurement of exposure, with regards to near work, has somewhat hampered investigation in this area. For example, one study reported that reading 3 or more hours a day is predictive of myopia risk, but reading 2 or more books per week is not.

**Myopia Genetics**

A number of recent studies leave little doubt that myopia is under strong genetic influence. Classical twin studies in European-derived populations have reported high heritability of myopia, in the 90% range, with similar figures for the various biometric factors known to control refractive error, axial length, anterior chamber depth and corneal curvature. Young et al have reported candidate loci for myopia genes on chromosomes 12q21-23 region and 18p11.31, while Naiglin et al has reported a separate locus 7q36. Recently, Paluru et al have reported a new locus for autosomal dominant high myopia to 17q21-22 in a family of 22 individuals. At present, no actual genes controlling myopia are known. Evidence for a genetic effect in myopia among persons of East Asian descent is equally strong, though some have suggested that heritability of myopia is reduced in areas where myopia prevalence is changing rapidly. Rose et al and Chen et al have pointed out that the mere fact of strong genetic control of myopia does not preclude the possibility of the sort of cohort effect that might result in a myopia “epidemic”, as has been reported in East Asia. Both genetic and environmental influences may play a significant role when populations are affected by an unusually high burden of a particular disease, just as genetic propensity, poor diet and obesity appear to combine to produce the high prevalence of diabetes seen among the Pima Indians.

**Methodologic Challenges in Myopia Assessment**

Reported prevalence of myopia is highly sensitive to the definition used in a given study. As with other important ocular conditions such as cataract, defining myopia involves imposing arbitrary cutoffs on what is essentially a continuous distribution. There is no commonly accepted definition for myopia, which makes comparability between studies in different racial groups, and even between studies done in areas at different times within a given population, extremely difficult. One investigator has reported that the very small shift in cutoff from −0.50 to −0.75 D would decrease myopia prevalence by 22% in the population he was studying. The potential impact of incompatible definitions of myopia must always be borne in mind when attempting to assess time trends or population differences in myopia prevalence.

When investigators state that an “epidemic” of myopia is occurring in East Asia, they are describing a phenomenon known formally as a “cohort effect”. When a cohort effect is present, individuals born during a certain period are subject to environmental influences not present for individuals born in an earlier or later period. An example of this might be the AIDS epidemic: the life expectancy for sexually active adults in Uganda today is some 20 years less than what it was 15 years ago. The cohort effect that is most commonly postulated to explain the supposed current epidemic of myopia in East Asia is the increased demand for near work due to rising educational standards in many urbanised East Asian communities, including Singapore, Hong Kong and Japan.

Often, investigators draw inferences about cohort effects, which are inherently longitudinal, from cross-sectional data, simply because such data are more easily acquired. In fact, the vast majority of the data that has been adduced in favour of an Asian myopia epidemic is cross-sectional in nature. The problem with trying to make a case for increasing incidence of myopia from cross-sectional data is that, as noted above, myopia prevalence increases naturally with age in nearly all populations. Many investigators have noted the large increases in myopia prevalence observed cross-sectionally between the primary and secondary school years as evidence of a cohort effect, while in fact such data may simply point to an effect of ageing occurring among individuals in a single cohort. Similarly, cross-sectional studies showing lower prevalence of myopia among individuals in their 60s as compared to their 40s have frequently been interpreted as evidence that the younger cohort has been subjected to more near work demands than their less-educated parents; again, however, these cross-sectional trends may simply represent a normal effect of ageing. As noted above, the decline in myopia in the decades immediately following the onset of presbyopia is a frequently described phenomenon.

Other studies have also attempted to draw inferences about a supposed “myopia epidemic” by following a single cohort over time. Studies that demonstrate the progression of myopia in a single cohort are, by definition, unable to establish the presence of a cohort effect. This can only be demonstrated by comparing 2 or more cohorts measured at different points in time, ideally using identical techniques and definitions.

**Available Evidence for an Epidemic of Myopia**

**East Asian Populations**

However, such studies are extremely rare in East Asia. Lin and colleagues have examined refractive error distribution among very large groups of school children in Taiwan for decades now. Based on these studies, they conclude that myopia prevalence is increasing rapidly in Taiwan. Careful review of these manuscripts reveals significant uncertainties regarding such assertions. The publication, establishing the baseline myopia prevalence from which more recent comparisons have been drawn, does not provide a definition of myopia, nor does it clearly describe the methodology for measuring refractive error. More recent work by this group has chosen an unusually low cutoff for myopia (spherical...
that military recruits in Singapore do, in fact, represent a cohort to 43.3% in the later cohort. Available evidence suggests prevalence of myopia increased from 26.3% in the earlier 1974 to 1984 and 1987 to 1991. The authors conclude that the males as part of the compulsory system of military service. Tay where vision testing has been carried out for decades on all significant cohort effect in myopia comes from Singapore, association for the condition.

Perhaps the strongest available evidence supporting a significant cohort effect in myopia comes from Singapore, where vision testing has been carried out for decades on all males as part of the compulsory system of military service. Tay et al. have reported on the resulting large database of over 400,000 young men, arbitrarily dividing it into two cohorts: 1974 to 1984 and 1987 to 1991. The authors conclude that the prevalence of myopia increased from 26.3% in the earlier cohort to 43.3% in the later cohort. Available evidence suggests that military recruits in Singapore do, in fact, represent a population-based sample. It appears that the racial breakdown of the sample did not change significantly over time, which is an important issue, as the prevalence of myopia appears to be significantly higher among the Chinese relative to the other ethnic groups in Singapore. However, significant problems remain with this widely cited paper: myopia is defined as vision in the right eye without correction worse than 6/18 (while excluding persons whose vision could not be corrected to 6/18 or better with refraction). Such a definition is subjective and prone to manipulation by the subject, particularly when avoidance or reduction of compulsory military responsibilities may be at stake. Moreover, the impact of refractive errors other than myopia cannot be assessed. Methodologic description of the protocol for measuring vision is essentially nil, and thus important changes over time in measurement protocol cannot be excluded. Finally, although the authors indicate that vision examinations were carried out at a mean age of 17.5 to 17.75 years, no data are given to show whether this age changed over the study period. Given the tendency of myopia to increase with age in this young adult population, the impact of any change on the mean recruitment age cannot be excluded. It is interesting that, while the authors conclude that higher educational attainment to be the cause of increased prevalence of myopia between the two cohorts, their data show an increasing prevalence of myopia across the various educational strata as well.

**Inuit Populations**

It has been suggested that an “epidemic” of myopia is also occurring among Eskimos. Accurate data to support these assertions are even more difficult to obtain than the populations of East Asia. Many papers simply assert that such an “epidemic” is in progress, but fail to provide longitudinal or cohort data of any kind. Even the most carefully-performed studies, such as those by Alsbrink among Eskimos in Greenland, suffer from small population numbers and do not adjust for potentially important shifts in age and gender. Similar assertions regarding cohort changes towards myopia have been made for Australian aborigines, but the as-yet unpublished data (Taylor HR, Robin TA, Lansingh VC, Weih LM, Keefe JE. ARVO abstract 800; 2003) similarly fail to adjust for a very significant shift toward female preponderance between the 1978 and 2001 cohorts of 20- to 30-year olds. Myopia prevalence for young women is significantly higher in a number of populations, including Eskimos and Chinese.

**European-derived Populations**

Some investigators have concluded that myopia prevalence is also increasing in a cohort-based fashion among European-derived populations, in addition to East Asians and Eskimos. However, the conclusion that Westerners are suffering from their own “myopia epidemic” is hardly universal. Mutti and Zadnik have reviewed available evidence from the United States and conclude that these data are more consistent with increasing hyperopia in the 5th and 6th decades of life, rather
than a cohort effect. Fledelius\textsuperscript{55} similarly concludes that myopia prevalence rates among Danish medical students have not changed significantly over many decades. Once again, school-based data must be viewed with caution; it is entirely possible that confounding of the type described above, but in the reverse direction, might lead to the erroneous conclusion that myopia prevalence is stable in the population as a whole, based only on socioeconomic trends controlling school admission.

In the Framingham Offspring Eye Study,\textsuperscript{56} the prevalence of myopia was found to decrease with age in 1319 parents aged 23 to 78 years. In addition, the association of myopia between siblings was found to be weaker with increasing between-sibling age. The authors suggest that the decreasing prevalence of myopia with age, coupled with the decreasing association of myopia between sibling pairs of increasing age differences, is the result of a cohort effect, in which the younger of the two siblings were at a greater risk of myopia. The authors assume that the degree of myopia remains static after adolescence, and thus conclude that their findings point towards an increasing incidence of myopia. In fact, the results are consistent with a normal decrease in myopia with ageing over life.

The strongest direct evidence in favour of a cohort effect for myopia among Caucasians is provided by the 10-year follow-up of refractive information in the Beaver Dam Eye Study.\textsuperscript{57} These data reveal a decreasing prevalence of myopia with age as the result of longitudinal changes, consistent with previous studies. However, by treating the refractions observed at each examination of a person as independent observations and plotting those by age, a birth cohort effect was also demonstrated. The average refractions in persons 55 to 59 years were +0.20 D, –0.13 D, and –0.50 D, for those born between 1928 to 1932, 1933 to 1937, and 1938 to 1942, respectively. This difference between birth cohorts in other age ranges had a similar trend, but was not statistically significant. The study concludes that, in addition to longitudinal changes in refraction, there is also a birth cohort effect in which those persons born more recently are at a higher risk of myopia.

Conclusion

It would seem reasonable to conclude, based on the weight of available evidence, that the case for a “myopia epidemic” has not yet been entirely proven. Even if one accepts that myopia prevalence is increasing dramatically in Asia, and there are good reasons as noted above to believe that this trend has been somewhat exaggerated, the attention of health policymakers should only justifiably be directed towards this “problem” if there are data to suggest that increased myopia is anything more than an inconvenience for those affected. While it is known that myopia may be associated with increased risk for retinal detachment,\textsuperscript{58} and perhaps glaucoma\textsuperscript{59} and cataract,\textsuperscript{60,61} there is little if any data to suggest how acquired myopia from environmental factors affects the shape of the eye, and equally little data to suggest a cohort increase in retinal detachment or other eye diseases that might reasonably be attributed to an epidemic of myopia.\textsuperscript{52} While Lam et al\textsuperscript{53} have suggested that the majority of increase in axial length in acquired myopia occurs in the vitreous cavity, Zhang et al\textsuperscript{44} have suggested that the anterior segment is primarily involved. The resolution of this issue might have significant implications for future prevalence of retinal detachment, or of angle-closure glaucoma, if one accepts the myopia cohort effect hypothesis.

Recent studies\textsuperscript{65-69} have provided evidence of our ability to intervene early in life to decrease myopia progression. However, there is much uncertainty about the reality of a “myopia epidemic”, and a paucity of data to suggest any significant increase in more serious diseases, such as retinal detachment. It cannot be denied that uncorrected myopia is a potentially serious public health problem.\textsuperscript{29,70} However, it appears on the weight of the evidence that those rural areas in the developing world, which lack the resources to correct myopia with spectacles, are precisely the areas at the least risk for the problem. They are also the populations least able to afford invasive preventive measures for myopia. Just because research has potentially given us the tools to retard or prevent myopia early in life does not clearly imply that such invasive and potentially resource-intensive measures are either warranted or cost-effective.

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REFERENCES


