An overview of the myopia problem in China

It is now generally accepted that several locations in East and Southeast Asia, specifically the Republic of Korea, Japan, Singapore, mainland China, Hong Kong and Taiwan, have a high prevalence of myopia and potentially pathological high myopia (1-3). In fact, around 70–90% of students completing secondary schooling in these locations are now myopic (4-11), requiring some form of correction for good distance viewing. In many places, over half of the students are myopic and need correction by the end of primary school. In most of these locations, there has been a progressive development of education systems since the end of the Second World War, resulting in highly competitive systems, which produce educational outcomes that top the world in international surveys such as PISA and TIMSS (12). The data which illustrate these trends were published in recent review (2) and used as a figure in an influential news report in Nature on The Myopia Boom (1).

The pattern of development was somewhat different in mainland China. Here, the prevalence of myopia remained relatively low until the end of the Cultural Revolution in 1976 (2). This was followed by restoration of the competitive university entrance examination, commonly known as the gaokao, with several subsequent waves of expansion of further educational opportunities, including at the university level. The prevalence of myopia appears to have rapidly increased in mainland China since this time to reach levels typical of the economically more developed countries in the region.

It appears that changes in myopia in mainland China were taking place before then. In 1963, China commissioned the development of a series of eye exercises based on traditional Chinese medicine. These have since then been widely practiced by Chinese school-children and are still part of the standard school day for most students. The stimulus for preventive action appears to have been a survey carried out by the Beijing Student Health Bureau, which found that around 30% of senior high school students were myopic. It is now closer to 70–90%, and thus, whatever the benefits of the eye exercise program, which are still not clear (13-16), it is obvious that eye exercises are inadequate to prevent myopia in the face of the current environmental pressures.

There was little published contemporaneous data on the prevalence of myopia until the late 1990s, apart from one study which has unfortunately been interpreted as showing that the prevalence of myopia was already high in China in the 1930s (17). It was presented in Curtin's classical book, The Myopias, as evidence for a much earlier high prevalence of myopia, but closer reading indicates that the report was of a high prevalence of spectacles for myopia in westernized hospitals in China. As such, it does not establish the population prevalence of myopia.

The first papers that gave a solid scientific basis to the high prevalence of myopia in mainland China were two studies from the Refractive Error Studies in Children (RESC) series, one carried out in Shunyi, a semi-rural area close to Beijing (18), and another in the southern city of Guangzhou (8). These studies used a solid sampling frame based on enumeration of a defined site, and measured refractive status using cycloplegia. They were followed by a large number of studies on both children and adults, which collectively show that the prevalence of myopia is now high in the younger generation in many parts of mainland China, but low in others. It is unfortunate that some of these studies have neglected the need for cycloplegia to obtain accurate measures—a need which extends well beyond childhood and adolescence, and indeed up to the age of around 40–50, until accommodative power is lost (19-22).

One of the limitations of most studies, including the RESC series, is that they may give an accurate picture of the situation at one site, but that site is unlikely to be representative of the whole of China. In fact, these studies are predominantly on urban areas on the eastern part of China, where the prevalence of myopia is generally high. There is a general tendency for studies on rural areas to show lower prevalence of myopia (8,9,18), and a few studies from much less developed regions show a much lower prevalence of myopia (23,24), confirming that Chinese populations are not genetically or intrinsically more myopic than others, but respond in the same way as other populations to environmental risk factors. Recent genetic analysis supports the same conclusion by showing that there are at most only small differences in myopia-associated SNPs between Caucasian (European ancestry) and East Asian ethnic groups (25).

There is not sufficient information to pull together a comprehensive picture of the prevalence of myopia in China overall, but it is clear that the more developed parts of China have a severe myopia problem comparable to that in other parts of East and Southeast Asia. Results from the Chinese National Surveys of the Constitution and Health of Students indicate that the prevalence of reduced visual acuity, a good proxy for myopia in children, is already quite high in most provinces in China (26,27). In the future, the Chinese population will become more urbanized, and access to services, particularly education, will expand in rural areas. Therefore, the situation in the more advanced urban areas, around 80–90% myopia at the end of 12 years of school, with a prevalence of high, potentially pathological myopia ranging from 10–20% will become universal, defining the future for China. Holden et al. (28) projected that by 2050, the prevalence of myopia in East Asia will be 65.3%, but extrapolation of the existing data, taking account of natural population demographics, suggests that the situation may be even worse. China is thus faced with a continuing problem of providing the corrections needed to ensure good distance vision. There is good evidence that more effective correction will improve educational outcomes in less developed areas (29,30), but unless preventive measures are adopted in parallel, this will also increase the prevalence of myopia.

To the extent that a reasonably accurate estimate of the national prevalence of myopia is required, it can come from a broader series of site-specific studies, using gold standard techniques. Alternatively, nation-wide sampling frames can be used, but these generally do not use gold standard measurement techniques. The Chinese National Survey on the Constitution and Health of Students uses visual acuity as a proxy measure for myopia. It is a reasonably accurate proxy for children, adolescents and young adults (27,31). It is thus highly suitable for monitoring trends in school-children, which are of crucial interest in the current epidemics of myopia. More consideration needs to be given to the use of other proxy measures such as the AL/CR ratio, since it correlates more highly with spherical equivalent refraction than does axial length and can be accurately measured without cycloplegia (32). This should make high participation rates easier to obtain ensure.

With the evidence that has been accumulated, there is no doubt that mainland China has a major myopia problem. Further economic and social development, particularly in rural areas, and population turnover will ensure that the current levels of myopia and high myopia seen in urban children will become the adult norm. In the future, some priority needs to be given to studies from less developed regions in China compared to more studies simply providing further documentation of high prevalence in urban areas. This will be primarily important for risk factor analysis. In this context, recent progress in the development of objective measures of nearwork and time outdoors, which appear to be the primary determinants of the prevalence of myopia, and use of these devices is likely to become an important, if not obligatory, part of major future studies.

Risk factor analysis is in many ways crucial, because it is modifiable risk factors that are the key to prevention. We already have strong evidence that the major drivers of the epidemics of myopia are intensive education from an early age combined with a life-style characterised by limited time outdoors. Genetic change at the population level is too slow to explain the rapid changes in prevalence that has taken place. It may be possible to turn around the myopia epidemics by slowing the onset of myopia through increasing the time that children spend outdoors, as has been demonstrated in school-based trials in both Guangzhou (33) and Taiwan (34). In the foreseeable future, considerable onset of myopia in the early school years is likely to continue, leading to predictable increases in the prevalence of high, potentially pathological myopia through myopic progression. The development of high myopia can be minimized by the use of a range of techniques for slowing progression, such as low-dose atropine (35), orthokeratology (36-38), and other promising optical approaches (39-41). It thus seems feasible to reduce both the prevalence of myopia and of high myopia with current techniques, but more research on prevention is required. There is very little data of this kind from China, and we hope that this will become a major area for future research.

A long-term solution requires also addressing the organization of schooling, since schools appear to be the major generators of myopia. The systems that have produced high prevalence of myopia and high myopia are characterised by early competition for places in academically high performing schools (12), leading to excessive pressures on children from an early age, early-onset myopia and ultimately high, potentially pathological myopia. If these pressures could be delayed until the high school years by limiting homework in the pre-school and primary school years, emphasizing enrolment in local schools, eliminating selective enrolment in key schools, and promoting more time outdoors, so that the onset of myopia becomes more common in the late primary and early high school years, progression to high myopia would be markedly reduced. It is important to recognize that many of the recent proposals in China to reform schooling are consistent with these directions and would probably have a major impact on the current epidemic of myopia, as well as contributing to reductions in childhood obesity, increases in fitness, and reductions in student stress. Currently consultation is underway on specific proposals for myopia control in students. Myopia appears to be a remarkably sensitive indicator of educational pressures, and success in controlling myopia is likely to be an important indicator of success in other areas of children's health. And it is clearly now on the national agenda.

In conclusion, we would like to express our gratitude to the authors of the papers in this special issue. We invited authors associated with major studies on the prevalence of myopia in China, and experts from outside China with relevant expertise. In August 2018, Chinese President Jinping Xi called for increased efforts to protect the eyesight of children in China, given the increasing prevalence of myopia. We hope that this special issue of *Annals of Eye Science* will help to focus research on important areas related to the prevention of myopia in the future, providing a solid evidence base for the initiatives which will flow from these important developments. They indicate that the problem of myopia is now being given priority at the highest levels in China.

Acknowledgements

None.

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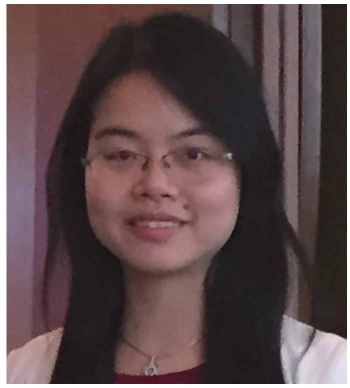
Ian G. Morgan

Xiaohu Ding



Xinxing Guo

Ian G. Morgan, BSc, PhD
Research School of Biology, Australian National University, Canberra, Australia. (*Email: Ian.Morgan@anu.edu.au*)
Xiaohu Ding, MD
State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou 510275, China. (*Email: xiaohuding@163.com*)
Xinxing Guo, PhD
Dana Center for Preventive Ophthalmology, Johns Hopkins Medical School, Baltimore, USA. (*Email: xguo11@jhu.edu*)
doi: 10.21037/aes.2018.09.03
Conflicts of Interest: The authors have no conflicts of interest to declare.
View this article at: http://dx.doi.org/10.21037/aes.2018.09.03

doi: 10.21037/aes.2018.09.03
Cite this article as: Morgan IG, Ding X, Guo X. An overview of the myopia problem in China. Ann Eye Sci 2018;3:49.

