International Journal of General Medicine

Dovepress
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ORIGINAL RESEARCH

The Impact of School Education on High Myopia in Children and Adolescents

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Purpose: To investigate the effect of school education on the prevalence of high myopia.

Patients and Methods: This prospective cross-sectional study, conducted in schools across Hubei Province, included 1,017,622 students from 103 county-level administrative regions between October 2021 and November 2023. Refractive measurements and basic demographic data were collected for all participants. The prevalence of high myopia and the differences in prevalence across grade levels were calculated. Regression discontinuity was used to assess the effects of age and education on high myopia prevalence.

Results: A total of 1,017,622 students participated, with 540,860 (53.15%) boys, and an average age of 11.93 ± 3.06 years. Over three years, the average prevalence of high myopia was 4.75%. Prevalence increased with grade level, with the largest difference observed between grades 9 and 10. Age showed no significant effect on high myopia prevalence. Each additional year of education led to an increase in prevalence by 1.26% (95% CI: −1.87, −0.65, P=0.000) in 2021, 1.20% (95% CI: −1.88, −0.52, P=0.001) in 2022, and 1.26% (95% CI: −2.49, −0.04, P=0.04) in 2023.

Conclusion: Increased grade, rather than age, is the key factor driving the rise in high myopia prevalence. Interventions targeting myopia risk factors during schooling could potentially reduce the growing prevalence of high myopia.

Keywords: high myopia, education, school, regression discontinuity

Introduction

The global prevalence of myopia is increasing rapidly, particularly in East and Southeast Asia, where over 80% of high school graduates are affected.[1,2] Myopia typically develops around the age of 8, with progression continuing over the subsequent 10 to 15 years, and stabilization commonly occurring by approximately age 17 or in early adulthood.[3] An earlier age of onset is associated with a longer duration of progression, thereby increasing the risk of developing high myopia. This rising prevalence, along with earlier onset, is driving an increase in high myopia cases.[4,5] By 2050, the global prevalence of high myopia is projected to reach 10%.[6] The rapid growth of high myopia and its associated complications place a significant burden on eye health systems.[7,8] About 50% of individuals with high myopia may develop pathologic myopia, which can result in serious conditions such as posterior staphyloma, myopic choroidal atrophy, and myopic traction maculopathy.[9,10] Pathological myopia is a leading cause of vision impairment globally.[11] Since refractive correction alone cannot prevent pathologic changes in individuals with high myopia, preventing the onset of high myopia is especially critical.[12]

The factors influencing high myopia remain unclear, as both genetic and environmental factors play a role.[13] Molecular genetic studies, familial aggregation research, and twin studies suggest a significant genetic predisposition to high myopia, with genes like SCO2, ZNF644, and CCDC111 implicated in high myopia.[14,15] However, genetic factors alone cannot explain the rapid increase in high myopia prevalence in a short period.[16] Twin studies have shown that variations in reading habits and educational attainment can result in differences in refractive status between twins.[17] Modern lifestyle changes, such as earlier onset of myopia, reduced outdoor activity, prolonged near-work tasks, increased screen time, and heightened educational and occupational pressures, have contributed to this trend.[18,19]

Received: 27 April 2025
Accepted: 26 August 2025
Published: 31 August 2025

Both myopia and high myopia tend to increase with age. The prevalence of high myopia at a given age or grade reflects cumulative exposure, influenced not only by factors encountered in that grade but also by those in all preceding grades. In China, the prevalence of high myopia is under 1% in children younger than seven but rises to about 15% by the ages of 16 to 18.[20,21] As age increases, so does the level of education. Previous studies have shown that advancing educational grade, rather than age, is the main factor driving myopia development.[22] However, few studies have explored whether the annual progression of high myopia is more influenced by age or education. In this study, we used regression discontinuity analysis to compare high myopia prevalence among students born in the same year, examining differences by birth month and educational grade to evaluate the impact of age and education on high myopia prevalence.

Methods

Participants

All procedures in this study adhered to the Declaration of Helsinki and were approved by the Ethics Committee of Renmin Hospital of Wuhan University. Before the study commenced, research objectives and examination procedures were thoroughly explained to students and their parents or legal guardians. Written informed consent was obtained from at least one parent, and verbal consent was secured from each participating student during the examination.This study was a school-based prospective cross-sectional survey initiated in 2021. It included students from kindergartens, primary schools, middle schools, and high schools across 103 county-level administrative districts in Hubei Province. Each year, stratified cluster sampling was performed by school, grade, and class. The minimum sampling requirement was two kindergartens, two primary schools, two middle schools, and two high schools per district, with at least 80 students selected from each grade. The survey was conducted annually from October to November, with three provincial-wide surveys completed to date. The initial dataset comprised 1,084,477 entries from primary, middle, and high school students collected over the three surveys. After excluding 5,283 students who were not aged 6–18 years, 32,586 students without comparison data, 10,566 students who did not start school at age 6, 11,652 students without refractive data, and 6,768 students with incorrect personal information, the final analysis included data from 408 primary schools (559,171 students), 392 middle schools (263,368 students), and 378 high schools (195,083 students), totaling 1,178 schools and 1,017,622 students.

Examinations

Non-cycloplegic refractive examinations were performed by uniformly trained optometrists or ophthalmologists using the desk-top auto-refractor (RM-800; Topcon Optical Company, Tokyo, Japan). Each eye was measured three times, with the average value automatically calculated by the computer. If the spherical or cylindrical power measurements varied by ≥0.50D between any two of the three readings for a single eye, additional measurements were conducted until data stabilization, and then the average value was recorded. The equivalent spherical power was defined as the spherical power plus half of the cylindrical power. High myopia was defined as a spherical equivalent (SE) ≤ −6.00D in either eye.[23]

Statistical Methods

Statistical analysis was conducted using R version 4.2.2. High myopia and gender were presented as counts and percentages, while age was described using the mean and standard deviation. A regression discontinuity (RD) analysis was employed to analyze the impact of age and education on high myopia prevalence.

RD leverages changes at a specific threshold in a continuous variable to approximate random assignment, thereby estimating treatment effects.[24] In accordance with China's Compulsory Education Law, children who turn six years old are required to start school. As the academic year in China begins on September 1st, children born before this date start school in the year they turn six, while those born on or after September 1st start school the following year. Consequently, children born between January and August receive one more year of education than those born between September and December. To evaluate the effects of age and education on high myopia prevalence, we used April 30th and August 31st as cutoff points. We compared high myopia prevalence among children born between January and April with those born between May and August, and between May and August with those born between September and December.

Results

The study included 1,017,622 students aged 6 to 18 years, with an average age of 11.93 ± 3.06 years; 540,860 (53.15%) were boys. The average prevalence of high myopia from 2021 to 2023 was 4.75%. Prevalence rates varied by birth month: 5.08% for students born between January and April, 5.17% for those born between May and August, and 3.95% for those born between September and December, indicating a lower prevalence in this group. Annual prevalence rates were 5.00% in 2021, 4.64% in 2022, and 4.59% in 2023, indicating a declining trend. During the screening periods of 2021, 2022, and 2023, students born between October and December consistently showed lower prevalence rates of high myopia. Detailed prevalence rates by year and birth month are provided in Table 1.

Figure 1 illustrated that as educational grade increases, the prevalence of high myopia also rose. Prevalence remained below 2% before grade 5 but showed a marked increase from grade 6 onwards. In 2021, high myopia prevalence rose from 0.29% in grade 1 to 16.12% in grade 12. In 2022, it increased from 0.17% to 15.59%, and in 2023, from 0.18% to 14.04%. Across the three screening periods, the prevalence difference of high myopia between adjacent grades generally showed an upward trend with increasing grade level, peaking between grades 9 and 10, followed by a slight decline (See Figure 2).

Table 1 indicated that within the same year, the prevalence of high myopia among students born between January and April and those born between May and August was similar and higher compared to students born between September and December. Regression discontinuity analysis showed no significant discontinuity in high myopia prevalence between students born from January to April and those born from May to August each year: in 2021 ($\beta = -0.25$, 95% CI = (−0.94, 0.44), $P = 0.477$), in 2022 ($\beta = 0.091$, 95% CI = (−0.80, 0.98), $P = 0.842$), and in 2023 ($\beta = 0.304$, 95% CI = (−0.298, 0.907), $P = 0.322$). See Figure 3. This suggested that age did not significantly impact the prevalence of high myopia.

In contrast, there was a significant discontinuity in the prevalence of high myopia between students born from May to August and those born from September to December each year, indicating an association with education. In the 2021 survey, each additional year of education was associated with a 1.26% increase in high myopia prevalence ($\beta = -1.26$, 95% CI = (−1.87, −0.65), $P = 0.000$). In 2022, each additional year of education increased the prevalence by 1.20% ($\beta = -1.20$, 95% CI = (−1.88, −0.52), $P = 0.001$). In 2023, each additional year of education increased the prevalence by 1.26% ($\beta = -1.26$, 95% CI = (−2.49, −0.04), $P = 0.043$). See Figure 3.

Table 1 Distribution of High Myopia Rates Across Different Birth months

	Overall	Jan to Apr	May to Aug	Sep to Dec
Three years				
Sample size (N)	1017622	341,114	349,595	326913
Male [N (%)]	540,860 (53.15%)	183,036 (53.66%)	183,614 (52.52%)	174,210 (53.29%)
Age [Mean (SD)]	11.93 (3.06)	12.28 (3.03)	11.94 (3.06)	11.54 (3.05)
High myopia rate [N (%)]	48,339 (4.75%)	17,329 (5.08%)	18,086 (5.17%)	12,924 (3.95%)
Year 2021				
Sample size (N)	353299	118,232	122,789	112278
Male [N (%)]	187,917 (53.19%)	63,703 (53.88%)	64,280 (52.35%)	59,934 (53.38%)
Age [Mean (SD)]	11.93 (3.07)	12.29 (3.05)	11.94 (3.07)	11.53 (3.06)
High myopia rate [N (%)]	17,666 (5.00%)	6396 (5.41%)	6667 (5.43%)	4603 (4.10%)
Year 2022				
Sample size (N)	341291	113,947	116,987	110357
Male [N (%)]	182,630 (53.51%)	61,303 (53.80%)	61,734 (52.77%)	59,593 (54.00%)
Age [Mean (SD)]	11.83 (3.03)	12.17 (3.01)	11.88 (3.03)	11.42 (3.00)
High myopia rate [N (%)]	15,836 (4.64%)	5617 (4.93%)	5882 (5.03%)	4337 (3.93%)
Year 2023				
Sample size (N)	323032	108,935	109,819	104278
Male [N (%)]	170,313 (52.72%)	58,030 (53.27%)	57,600 (52.45%)	54,683 (52.44%)
Age [Mean (SD)]	12.04 (3.07)	12.38 (3.04)	12.03 (3.08)	11.69 (3.06)
High myopia rate [N (%)]	14,834 (4.59%)	5316 (4.88%)	5534 (5.04%)	3984 (3.82%)

Abbreviation: SD, standard deviation.

 https://doi.org/10.2147/IJGM.S537179

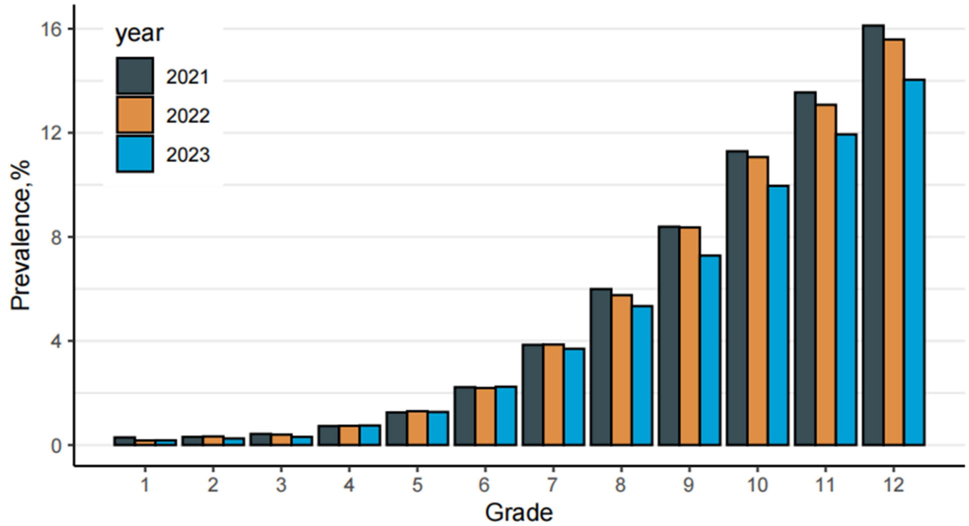

Figure 1 Grade distribution of high myopia rate. 1–6 represents primary school grades 1–6; 7–9 represents junior high school grades 1–3; 10–12 represents senior high school grades 1–3.

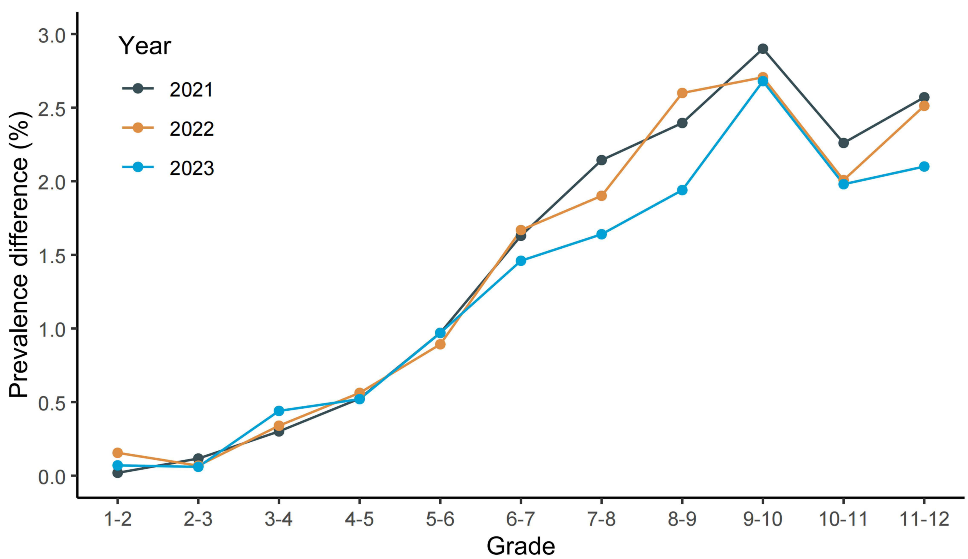

Figure 2 Difference in high myopia prevalence between adjacent grades. Points represent the difference of high myopia compared to the previous grade. "1–2" represents the difference in high myopia prevalence between grades 2 and 1; "2–3" and subsequent labels follow the same pattern.

Discussion

This study analyzed data from a three-year cross-sectional survey of students in Hubei Province to evaluate the effects of age and education on high myopia. The average prevalence of high myopia from 2021 to 2023 was 4.75%. The data revealed that the prevalence of high myopia increased with educational grade, and the difference between adjacent grades also widened, peaking between grades 9 and 10. Regression discontinuity analysis showed no significant discontinuity in high myopia prevalence between students born from January to April and those born from May to August. However, students born between September and December had a significantly lower prevalence compared to those born between May and August. This suggests that the increase in educational grade, rather than age, is the primary driver of rising high myopia prevalence.

Consistent with other surveys in China, our study found that the prevalence of high myopia gradually increases with educational grade.[25] Preschool children rarely exhibit high myopia, but its prevalence rises slowly during elementary school from under 1% to around 3%. In middle and high school, the increase accelerates, with first-year middle school

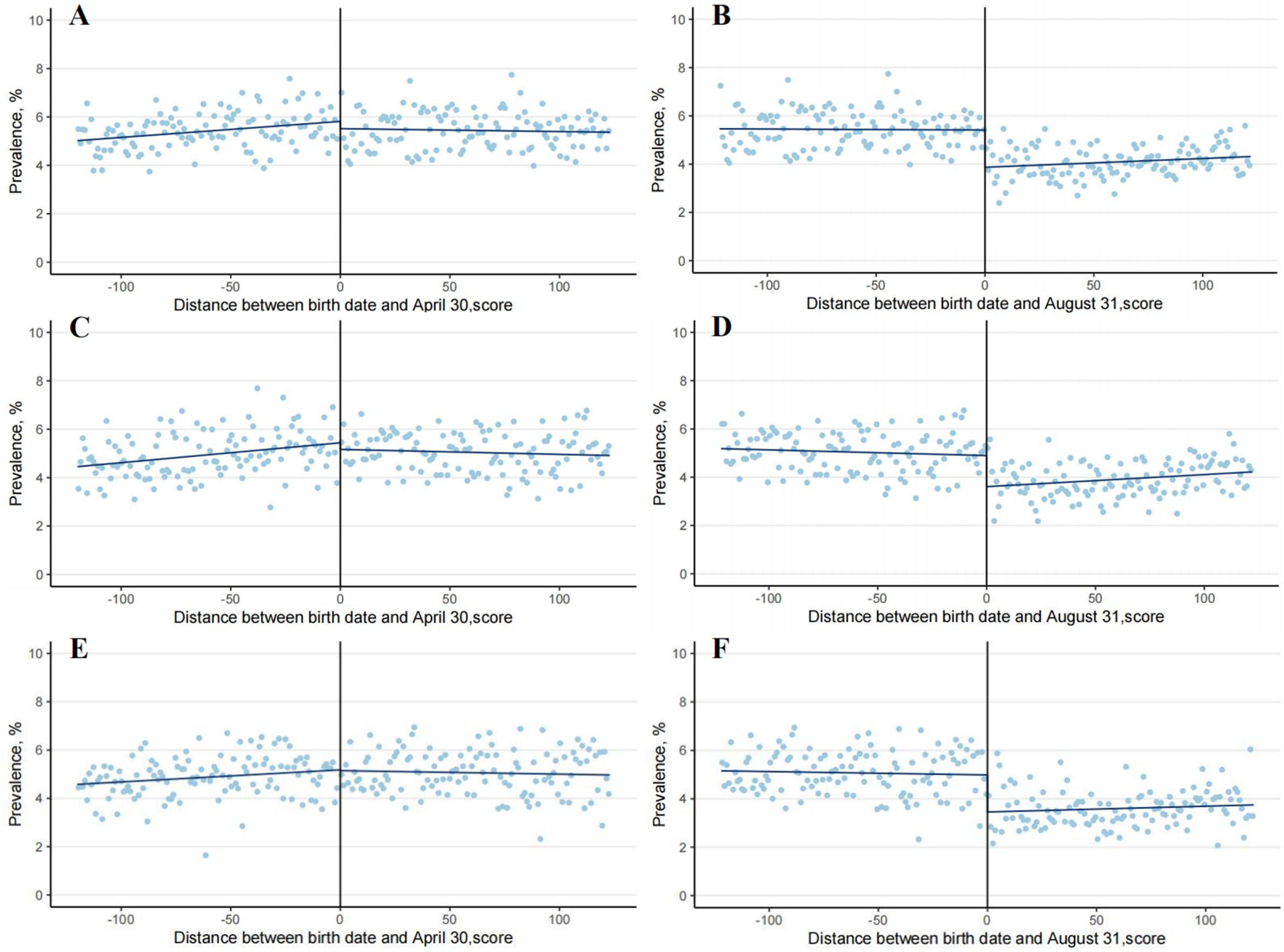

Figure 3 The casual analysis of the education on high myopia rates by using regression discontinuity analysis. Solid line, local regression line by different blocks; Solid vertical line, the cut-off; Dots denote observed bins. Students born after April 30 and August 31 are at the right. (**A** and **B**) represent the year 2021; (**C** and **D**) represent the year 2022; (**E** and **F**) represent the year 2023.

students showing a prevalence between 4% and 7%, and third-year middle school students approaching 14.5%. Nearly 20% of high school graduates are affected by high myopia.[21,26,27] This trend aligns with our findings. High myopia prevalence in East Asian countries are notably higher than in Western countries. For instance, in Tokyo, Japan, the prevalence among elementary and middle school students is 4.0% and 11.3%, respectively.[28] In South Korea, the prevalence is 6.9% among elementary and middle school students.[29] In contrast, in the United States, 2.7% of school-aged children have high myopia, while in France, the prevalence among adolescents aged 10–19 is 1.8%, and in Norway, it is only 0.5% among those aged.16−19[30,31]

Our study highlighted that education was a primary factor influencing the prevalence of high myopia. Previous research has similarly used regression discontinuity analysis to investigate the impact of education on myopia. For instance, a study led by Professor Jia Qu's team, which included approximately 4 million preschool children and adolescents in Wenzhou, used August 31 as a cutoff to compare myopia between students born on or before this date and those born after.[22] Their findings indicated that each additional year of education was associated with an average decrease of 0.17D in mean spherical equivalent (MSE) and a 0.03 decrease in uncorrected vision, which accounted for 66.4% and 85.9% of the annual changes in spherical equivalent and vision, respectively. Another study from Sun Yat-sen University included first- and second-grade students and divided the year into three segments based on birth months. It found no significant differences in spherical equivalent among students born in different months within the same educational grade. However, within the same birth year, second-grade students had significantly lower spherical equivalents compared to first-grade students.[32] Research conducted in Shanghai on children and adolescents aged 4–14 demonstrated that the breakpoint effect of an additional year of education emerged at age 6, with a spherical equivalent change of approximately 0.5D by age 13 and 0.67D by age 14.[33] Additionally, a European meta-analysis assessing the impact of educational level on adult myopia found that the prevalence of myopia was 25.4% among adults with primary education, 29.1% with middle school education, and 36.6% with high school education.[34] This indicates a clear association between higher educational attainment and increased prevalence of myopia.

The impact of education on myopia and high myopia may be mediated by several factors, including exam preparation, competitive pressure, increased near work, and reduced outdoor activity.[35,36] Research from Shanghai showed that as educational grade increases, students' daily reading and homework time rose from 48 minutes in preschool to 159.6 minutes by grade 9, while daily outdoor time decreased from 82.5 minutes in preschool to 56.8 minutes by grade 9. The higher prevalence of high myopia in East Asia compared to Europe is likely related to the increased educational pressure and competition in the region.[37] Additionally, increased screen time could also contribute to the rising prevalence of high myopia associated with education.[38]

This study's strengths included its extensive coverage of data over three years across Hubei Province, involving over one million students from elementary through high school. The use of regression discontinuity analysis to assess the impact of age and education on high myopia was particularly noteworthy. The strict school entry age regulations in China provided a natural experimental design, which was a rarity in educational policy research. This study has several limitations. As a large-scale, school-based screening, it did not employ cycloplegic refraction, which may affect the accuracy of refractive measurements. However, the findings of this study are primarily based on comparative data analysis; therefore, the potential overestimation of high myopia prevalence due to non-cycloplegic refraction has a limited impact on the results. Additionally, the study did not investigate the mediating factors that could influence the relationship between school education and the prevalence of high myopia. This study focused only on the prevalence of high myopia among students of different grade levels born in the same year. Future research could further investigate the prevalence among students in the same grade but born in different years.

Conclusion

This study indicates that the prevalence of high myopia increases with grade level, and the difference between adjacent grades also widens. Education, rather than age, is the key factor driving the increase in high myopia among children and adolescents. Our findings suggest investigating the mediating factors through which education influences high myopia, focusing on grades with rapid growth in prevalence, and implementing measures to reduce the prevalence of high myopia.

Acknowledgments

The authors are grateful for the support from the government of Hubei Province for helping organize the survey.

Funding

This work was supported by the Key Research and Development Program of Hubei Province (2022BCA044); The Key Scientific Research Program of Health commission of Hubei Province (WJ2023Z006); the Interdisciplinary Innovative Talent Program of Renmin Hospital of Wuhan University (JCRCGW-2022-007).

Disclosure

The authors report no conflicts of interest in this work.

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