Myopia and high myopia trends in Chinese children and adolescents over 25 years: a nationwide study with projections to 2050

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Summary

Background **The global rise in myopia, particularly in Asia, presents significant public health challenges. Analyzing trends and forecasting impacts are critical for developing strategies to mitigate this burden.**

Methods **We conducted the largest study to date on myopia and high myopia prevalence in Chinese children and adolescents aged 7–18 years, analyzing data from 5,095,256 individuals across 119 studies from 1998 to 2022. Data variability between cycloplegia and non-cycloplegia measurements was addressed using a distance-based model**

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averaging calibration. Aggregated prevalence and age-specific urban-rural trends were estimated using thin plate spline regression, with projections to 2050 derived from time series modeling.

Findings Myopia prevalence plateaued in 2006 in urban areas and in 2013 in rural areas, with the urban-rural prevalence gap narrowing since 2015 (urban/rural ratio below 1.3 for all ages). By 2050, myopia prevalence is projected to stabilize at 27.1% (95% CI: 10.0–44.4%) for ages 7–9 and 81.5% (74.7–88.3%) for ages 16–18 in urban areas, and at 20.1% (8.6–31.7%) and 74.1% (63.2–84.8%), respectively, in rural areas. High myopia prevalence among adolescents aged 16–18 is expected to rise from 7.3% in 2001 to 22.1% by 2050. Prevalence correlated significantly with the Human Development Index ($P < 0.001$).

Interpretation Despite stabilization in overall myopia prevalence, the continued rise in high myopia underscores the need for targeted control measures. Projections emphasize the importance of addressing regional disparities and prioritizing public health interventions.

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Keywords: Myopia prevalence; High myopia; Children and adolescents; Urban-rural disparities

Research in context

Evidence before this study

We reviewed studies on myopia and high myopia prevalence among Chinese children and adolescents aged 7–18 years, published between 1998 and 2023 in English and Chinese. Data from 119 studies involving over 5 million participants were included, using standardized definitions and calibration to align cycloplegic and non-cycloplegic measurements. Previous research highlighted socioeconomic influences but lacked large-scale nationwide analysis, detailed urban-rural disparities, and future projections.

Added value of this study

This study is the most comprehensive investigation of myopia and high myopia prevalence in Chinese children and adolescents to date, encompassing data from 1998 to 2022. It identifies stabilization of overall myopia prevalence in urban areas since 2006 and rural areas since 2013, with a narrowing urban-rural gap. However, high myopia prevalence continues to rise with a later plateau anticipated around 2030. Our analysis highlights a strong association between myopia prevalence and socioeconomic factors, providing insights into the impact of urbanization, educational access, and lifestyle changes. This comprehensive approach offers a roadmap for understanding myopia dynamics not only in China but also in other rapidly urbanizing regions.

Implications of all the available evidence

Our study provides detailed insights into the prevalence, trends and projection of myopia in children and adolescents in China, highlighting its growing burden, and underscores the need for targeted interventions, such as increased outdoor activity. Addressing rural disparities and evaluating myopia control programs will be crucial for mitigating the long-term burden of myopia-related complications.

Introduction

Myopia has been a major health concern worldwide.[1–3] Global estimates indicate that myopia-affected individuals could rise from 1.4 billion in 2000 to 4.8 billion by 2050, potentially affecting approximately 50% of the global population.[4] East and Southeast Asia are experiencing a particularly pronounced surge in myopia prevalence, reaching approximately 80% of young adults in some regions.[5] Furthermore, the general increase in the myopia prevalence is accompanied by a rise in high myopia and associated vision impairments, such as myopic macular degeneration and high myopia-related optic neuropathies, including glaucoma and non-glaucomatous optic nerve atrophy.[5] Myopic maculopathy accounts for 12.1%–21.3% of vision impairment (including blindness), becoming the leading cause of vision impairment in China, Japan, and Singapore.[6–9]

In China, myopia has led to substantial public health and economic burdens, with recent estimates indicating that in urban areas alone, the economic cost reached has achieved $26.3 billion, or 0.23% of the gross domestic product.[10] Unlike other East Asian countries where myopia gradually increased during the sixties, China experienced this increase around 10 years later, yet the subsequent rise was steep, aligning China with other East Asia countries within one generation.[11–15] Unveiling the myopia trend in China in the past two decades provides insights into the disease not only for Asia, but also the rest of the world.

Although the sharp rise in myopia prevalence has coincided with China's economic boom since early 1980s,[16] many aspects of the increase in myopia prevalence and its associated parameters in China have remained unclear so far. Addressing several major gaps is demanding. First, it is uncertain whether myopia prevalence rates have reached a plateau or will continue to rise in the coming decades, necessitating a comprehensive, nationwide analysis to compare temporal trends and forecast the future myopia prevalence. Second, data on the trend of high myopia in adolescents are scarce but crucial for predicting the future burden of vision impairment related to high myopia. Additionally, substantial regional and urban-rural disparities persist, influenced by socioeconomic factors such as economic performance, educational access, and lifestyle diversity,[17] but the impact of these disparities on myopia remains poorly understood. Another key gap is the lack of standardization in previous data, which has led to discrepancies in findings and hindered accurate comparisons. Addressing these questions could provide a roadmap to evaluate the effectiveness of myopia prevention strategies in China, and also globally.

To bridge these gaps, we established the China Eye Epidemiology Consortium (CEEC), bringing together a range of myopia-related epidemiological studies conducted across China. A systematic literature review was additionally performed to include information provided by investigations which were not part of the CEEC. Our study aims to analyze the prevalence of myopia and high myopia in children and adolescents aged 7–18 years, including temporal trends, subregional distribution, and correlations with socioeconomic factors. We employed advanced statistical methods, including Bayesian calibration and time series modeling, to harmonize diverse data sources and provide robust prevalence estimates and projections. Additionally, we provide projections for myopia and high myopia prevalence up to 2050.

Methods

Data identification and study design

Data were first sourced from the CEEC. The CEEC brings together principal investigators from various ophthalmic studies across China, who contribute original datasets to facilitate large-scale analyses of myopia trends. This network promotes standardized methodologies, ensuring consistency in data collection and enhancing comparability across different studies. The CEEC dataset incorporates 27 myopia-related population-based studies performed across China, encompassing both cross-sectional and longitudinal investigations with individual data. Notably, 19 of these studies provided comprehensive data on a whole city-wide or region-wide basis. The CEEC dataset spans across 15 provinces (including municipalities and autonomous regions) in China over the period from 2002 to 2022. In the second step, we applied an extensive review of all published literature on the prevalence of myopia among schoolchildren and adolescents. This review included studies in both English and Chinese, from databases including PubMed, Cochrane, Embase, Web of Science, Google Scholar, CBM, CNKI, and Wanfang, covering research conducted from January 1998 to June 2023. The quality of the publications was independently evaluated by two investigators (ZP, ZW). The methodology of the search strategy, including inclusion and exclusion criteria, and the process for data identification and extraction, have been detailed in Appendix 1. The study resulted in inclusion of data collected from 119 sources, representing different locations and time points. Records for 5,095,256 children and adolescents from primary to middle high school from 1998 to 2022 were encompassed. Data sources are detailed in Appendix 2.

Definition of outcomes

Myopia was defined as a refractive error of a spherical equivalent of −0.5 diopter (D) or less in 91.8% of the studies, −0.75 D or less in 4.1% of the studies, and −1.0 D or less in 4.1% of studies. A subgroup analysis was performed with an interaction test for heterogeneity in the myopia definition, which suggested that these disparity does not significantly impact the overall results of the study ($P = 0.42$). High myopia was defined as a spherical equivalent of −6.0 D or less. Four age groups were separated, aligning with distinct educational stages: grade 1–3 (approximately 7–9 years), representing lower primary; grade 4–6 (10–12 years), representing upper primary; grade 7–9 (13–15 years), corresponding to junior high school; and grade 10–12 (16–18 years), representing senior high school.

Estimation of myopia prevalence

An age-specific prevalence of myopia in children and adolescents from four age groups was estimated from 1998 to 2022, at the national level, separated by urban and rural areas, and by each province.

The prevalence of myopia measured with cycloplegia offers greater accuracy compared to non-cycloplegia methods. However, to provide the most comprehensive dataset, we included all relevant studies regardless of whether cycloplegic refraction was utilized. Non-cycloplegia studies remain valuable for understanding overall trends in myopia prevalence, especially given the limited representation of cycloplegic data. In urban areas, cycloplegic studies accounted for 42.7% of the total studies, while in rural areas, they accounted for 55.6% of the studies. To address these discrepancies and ensure consistent analysis, we employed a well-established distance-based model averaging calibration[18,19] method to align data from 58 cycloplegia studies and 64 non-cycloplegia studies. The method gave greater weight to cycloplegia data when significant difference between the two approaches was detected. The adjusted prevalence was calculated combining both cycloplegia and non-cycloplegia prevalences, as follows:

$$\omega y_{cycloplegia} + (1-\omega) y_{noncycloplegiia}$$

where:

$y_{cycloplegia}$ represents the prevalence obtained from cycloplegic data;

$y_{noncycloplegia}$ represents the prevalence obtained from non-cycloplegic data; and ω is a weighting factor calculated as:

$$\omega = \frac{2|y_{cycloplegia} - y_{noncycloplegia}|}{y_{cycloplegia} + y_{noncycloplegia}}$$

Based on above calibration, we estimated the myopia prevalences at the national level, stratified by four age groups (Grade 1–3, Grade 4–6, Grade 7–9, and Grade 10–12) and further divided by urban and rural subgroups. These estimations were obtained using the "aggregated final model", which incorporates thin plate spline regression.[20] This method allows for interpolation and completion of data in regions and time periods with sparse myopia data, ensuring a comprehensive and robust analytical framework. The smoothing parameter and the number of knots is chosen by generalized cross-validation, and prevalence was transformed into logit form during modeling process.

We also evaluated the regional distribution of myopia prevalence in 31 provinces by urban and rural region of inhabitation for all age groups, using pooled provincial data calculated as a weighted average based on the population proportion in each age group.

The average annual growth rates (AAGR) of myopia prevalence were estimated as:

$$AAGR = (P_{end}/P_{start})^{1/T} - 1$$

where P_{end} and P_{start} represent the myopia prevalence at the final and initial time points respectively, and T is the number of years over which the change was measured.

Projection of myopia prevalence by 2050

The myopia prevalence was forecasted until 2050 based on a Bayesian vector autoregression (VAR) model to build a time series forecasting framework,[21] with the residuals from the beforementioned thin plate spline regression used in the forecasting procedure. Recognizing the potential bias due to the COVID-19 pandemic between 2020 and 2022, we only included estimation data points from 1998 to 2019 for future forecasts to enhance the reliability of our projections. We used a rolling forecasting process to obtain the one-step-ahead conditional probabilistic forecast. In this process, historical information served as the observed data for the next year's projection. We repeated this step to re-estimate the model and obtain the forecast for the following year until we reached the forecast horizon. During the estimation of the hierarchical Bayesian model, we controlled the acceptance rate between 0.2 and 0.7 to achieve better convergence. A total of 20,000 Markov Chain Monte Carlo simulations were conducted during the modeling stage, with the first 5000 runs set as the burn-in.

We also reported the predicted number of myopic individuals for the corresponding years by applying the projected prevalence rates to population estimates for the corresponding age groups from the United Nations World Population Prospects 2022 (https://population.un.org/wpp/). Detailed steps of the above modeling are shown in the Appendix 3.

Estimation and projection of high myopia prevalence

The prevalence of high myopia in adolescents aged 16–18 years (Grades 10–12), which can represent the status in adults, was estimated and forecasted over the same time frame. Due to a significant lack of data from rural areas, we mainly relied on data generated in urban regions. Similar to the estimation and projection of myopia prevalence, we used the aforementioned thin plate spline model. Given the even more limited number of study cases in the forecasting process, we also incorporated an autoregressive integrated moving average model, which was automatically configured to select the optimal number of autoregressive and moving average lags, ensuring accurate projections of both mean levels and variance, and providing a comprehensive view of high myopia's future trajectory.

Socioeconomic influence on myopia prevalence and trends

The socioeconomic influence, specifically the Human Development Index (HDI), on both the prevalence and trends of myopia was analyzed. The HDI is a comprehensive measure that reflects average achievements in key dimensions of human development. For this study, we sourced the Chinese provincial HDI data from the China National Human Development Report Special Edition,[22] using figures from the year 2010, which represent the average data during the study period. HDI was categorized into three groups based on tertiles: ten provinces were classified in the high HDI group (>0.701), ten provinces in the medium HDI group (0.663–0.701), and eleven provinces in the low HDI group (<0.663). We analyzed and compared the pooled prevalence of myopia across all age for each HDI level, as well as the trends of myopia across different HDI regions. The variation in myopia prevalence across different HDI groups was assessed using a mixed effect linear model with time included as a covariate. The model equation is given as follows:

$$\text{rate}_{ij} = \beta_0 + \beta_1 \cdot \text{HDI}_{ij} + u_j + \epsilon_{ij}$$

where:

rate_{ij} represents the myopia prevalence for observation i in year j;

β_0 is the intercept;

β_1 represents the fixed effect of HDI at the province level (HDI_{ij}); u_j represents the random effect for year, allowing for variations across years;

ϵ_{ij} is the error term.

The statistical analyses were conducted using Python 3.10 (Python Software Foundation, https://www.python.org/) and R software version 4.3.0. All P values were two-sided but not adjusted for multiple analyses. Code for reproducing the results is available at the coauthor's GitHub repository https://github.com/feng-li/myopia.

Role of the funding source

The funding source had no role in the study design, data collection, data analysis, data interpretation, writing of the report, or decision to submit the paper for publication.

Ethics approval

This study was conducted under the Declaration of Helsinki. Each study was conducted with the approval of its own local ethics committee and written informed consent was obtained from all participants. This project was approved by the ethics committee of Tsinghua University (THU01-20230145). With the ethics committees' approval, informed consent of the patient was waived in this study.

Results

Prevalence of myopia in urban and rural China from 1998 to 2022

The myopia prevalence was calculated in four approaches: cycloplegia-only, non-cycloplegia-only, adjusted prevalence combining both cycloplegia and non-cycloplegia data, and the aggregated final model, stratified by age groups and urban/rural regions (Fig. 1A and B). In urban areas, no significant differences in myopia prevalence across four age groups were observed between our final approach and data from cycloplegic studies. In rural areas, the prevalence of myopia was consistently lower in cycloplegic studies compared to the final approach across all four age groups (Table 1, P < 0.05).

Adopting the aggregated final, we observed a significant increase in the prevalence of myopia among schoolchildren and adolescents across different age groups from 1998 to 2019 (Table 2, Fig. 1). In urban areas, the prevalence increased from 16.7% to 27.3% in grades 1–3, from 26.3% to 55.8% in grades 4–6, from 54.1% to 66.5% in grades 7–9, and from 73.1% to 80.8% in grades 10–12. Rural regions experienced similar trends, with increases from 10.2% to 18.8% among students in grades 1–3, from 17.2% to 48.6% in grades 4–6, from 40.2% to 59.3% in grade 7–9, and from 51.5% to 76.0% in grades 10–12.

The AAGR of myopia prevalence in urban and rural regions were analyzed and compared (Table 2). In urban areas, the prevalence of myopia began to plateau in 2006, with significant difference in AAGR before and after 2006 (1.8% per year vs. 0.9% per year, P < 0.001). Similarly, in rural regions, myopia prevalence began to plateau in 2013 (3.1% per year vs. 0.3% per year, P < 0.001), indicating a later changing point compared to urban areas. During the COVID-19 pandemic period (2020–2022), there was an observed increase in the prevalence of myopia in grades 4–6 for urban and rural areas (P values < 0.001, respectively) (Table 2).

The increase in prevalence over time was more pronounced in rural regions as compared to urban areas (overall AAGR 2.1% per year vs. 1.1% per year, *P* < 0.001). Consequently, the urban-rural gap in myopia prevalence has narrowed, with the ratio of urban to rural myopia prevalence decreasing from 1.63 to 1.34 in grades 1–3, from 1.53 to 1.16 in grades 4–6, from 1.35 to 1.12 in grades 7–9, and from 1.42 to 1.09 in grades 10–12 from 1998 to 2022. The gap between urban and rural prevalence has narrowed, with an urban-rural ratio below 1.3 for all grades since 2015. For grades 10–12, the ratio has dropped below 1.2 since 2015 (Table 2, Fig. 2).

Projection of myopia prevalence by 2050

The myopia prevalence is expected to remain relatively stable across all age groups through 2050 (Fig. 1 and Table 3). In urban areas, the projected prevalence for 2050 is 27% (95% CI: 10–44%) for grades 1–3, 57% (39–75%) for grades 4–6, 68% (55–81%) for grades 7–9, and 82% (75–88%) for grades 10–12. In rural areas, the rates are expected to be 20% (9–32%) for grades 1–3, 49% (38–60%) for grades 4–6, 61% (51–71%) for grades 7–9, and 74% (63–85%) for grades 10–12.

Estimation and projection of high myopia prevalence

The prevalence of high myopia among young adults (grades 10–12) in urban areas increased from 7.3% (0–14.9%) in 2001 to 18.2% (12.0–25.1%) in 2022. It is projected to reach 22.1% (12.8%–31.2%) by 2050 (Fig. 3). Unlike the stable trends observed for overall myopia, high myopia continued to rise and is expected to stabilize at around 21–22% after a later plateau in 2030 (Fig. 3).

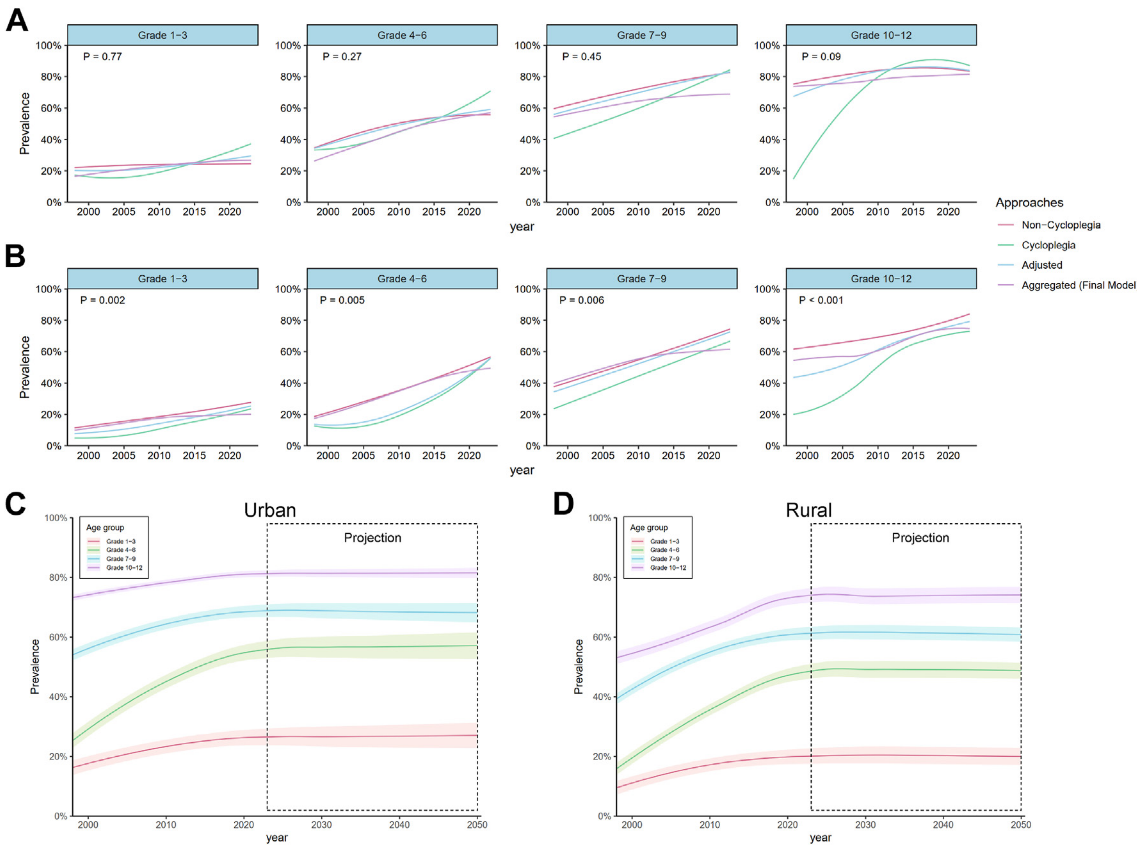


Fig. 1: **Detailed trends of myopia prevalence among schoolchildren and adolescents in urban and rural China from 1998 to 2022 and the projection till 2050**. (A, B) Trends of myopia prevalence in urban (A) and rural (B) China across the four age groups differentiated by cycloplegia-only, non-cycloplegia-only, adjusted (combining cycloplegia and non-cycloplegia data), and aggregated (final model) approaches. (C) Aggregated trends and projection of myopia prevalence in urban China. (D) Aggregated trends and projection of myopia prevalence in rural China. Aggregated data were presented with 95% CIs calculated using one-fourth of the standard error. Statistical significance between cycloplegic-only measurements and the final aggregated approach (P values in A and B) was assessed using t-tests.

Regional myopia prevalence and association with social development level

Myopia prevalence and trends were presented at the provincial level, including overall provincial prevalence and specific data for urban and rural regions in 1998 and 2022 (Figs. 4 and 5).

The pooled prevalence and trends were also analyzed in provinces with high, medium, and low HDI levels (Appendix 4). A significant positive relationship was observed: regions with higher HDI levels showed higher prevalence (50.4% in high HDI group vs. 47.3% in medium HDI group vs. 45.5% in low HDI group, Linear mixed-effect model P < 0.001, Fig. 5F), also, regions with lower HDI levels experienced a more rapid increase in myopia prevalence (AAGR: 1.87%, 1.76%, 1.52% in low, medium and high HDI group, respectively. P < 0.001). This demonstrates a significant impact of socioeconomic factors on myopia.

Region	Grade	Estimated mean difference (95% CI)	T statistic	P value
Urban	Grade 1–3	−0.004 (−0.04, 0.03)	−0.29	0.77
	Grade 4–6	0.03 (−0.03, 0.09)	1.12	0.27
	Grade 7–9	−0.02 (−0.08, 0.04)	−0.77	0.45
	Grade 10–12	−0.08 (−0.18, 0.01)	−1.70	0.09
Rural	Grade 1–3	−0.04 (−0.07, −0.02)	−3.23	0.002
	Grade 4–6	−0.10 (−0.17, −0.03)	−2.91	0.005
	Grade 7–9	−0.08 (−0.14, −0.03)	−2.88	0.006
	Grade 10–12	−0.15 (−0.23, −0.07)	−3.61	<0.001

Estimated difference indicate differences of myopia prevalence between cycloplegic-only measurements and the final aggregated approach. T statistic and P values are reported for statistical comparisons. Statistically significant differences (P < 0.05) are observed in rural regions across all grade levels.

Table 1: **Comparison of myopia prevalence between cycloplegic-only measurements and the final aggregated approach.**

Discussion

This study provides a comprehensive analysis of the trends and projections of myopia prevalence, as defined in this study, among schoolchildren and adolescents in rural and urban China, highlighting the regional and

Year	All	Grade 1–3	Grade 4–6	Grade 7–9	Grade 10–12	All	Grade 1–3	Grade 4–6	Grade 7–9	Grade 10–12	All	Grade 1–3	Grade 4–6	Grade 7–9	Grade 10–12
	AAGR (% per year), urban area					**AAGR (% per year), rural area**					–	–	–	–	–
	1.09	**2.02**	**3.25**	**0.99**	**0.45**	**2.05**	**2.87**	**4.43**	**1.77**	**1.54**	–	–	–	–	–
	Myopia Prevalence (%), urban area					Myopia Prevalence (%), rural area					Urban-rural ratio				
1998	45.9 (40.2, 51.6)	16.7 (7.2, 26.1)	26.3 (16.9, 35.8)	54.1 (47.0, 61.3)	73.1 (69.2, 77.0)	30.1 (22.5, 37.6)	10.2 (1.5, 19.0)	17.2 (9.4, 24.9)	40.2 (33.3, 47.2)	51.5 (43.3, 59.8)	1.53	1.63	1.53	1.35	1.42
1999	46.8 (41.1, 52.5)	17.1 (7.6, 26.5)	27.7 (18.3, 37.2)	55.6 (48.4, 62.7)	74.2 (70.3, 78.1)	31.0 (23.4, 38.5)	10.3 (1.6, 19.1)	19.0 (11.3, 26.8)	40.8 (33.9, 47.8)	56.2 (47.9, 64.4)	1.51	1.65	1.46	1.36	1.32
2000	47.7 (42.0, 53.4)	17.6 (8.1, 27.0)	29.0 (19.5, 38.4)	56.7 (49.6, 63.9)	74.5 (70.6, 78.4)	31.7 (24.2, 39.2)	10.9 (2.2, 19.7)	20.3 (12.5, 28.0)	42.3 (35.3, 49.2)	56.8 (48.6, 65.1)	1.51	1.60	1.43	1.34	1.31
2001	48.6 (42.9, 54.3)	18.5 (9.1, 28.0)	31.6 (22.2, 41.0)	56.8 (49.7, 64.0)	75.4 (71.5, 79.3)	32.3 (24.8, 39.9)	11.8 (3.0, 20.6)	21.0 (13.3, 28.8)	44.3 (37.3, 51.2)	56.9 (48.7, 65.2)	1.50	1.58	1.50	1.28	1.32
2002	49.5 (43.8, 55.2)	18.9 (9.5, 28.3)	32.1 (22.7, 41.6)	58.2 (51.1, 65.4)	75.0 (71.1, 78.9)	33.1 (25.5, 40.6)	12.2 (3.4, 21.0)	22.7 (15.0, 30.5)	45.2 (38.2, 52.1)	58.1 (49.8, 66.3)	1.50	1.55	1.41	1.29	1.29
2003	50.4 (44.7, 56.1)	19.8 (10.4, 29.2)	34.9 (25.5, 44.4)	58.0 (50.9, 65.2)	75.1 (71.2, 79.0)	33.9 (26.4, 41.5)	12.8 (4.1, 21.6)	24.2 (16.4, 31.9)	46.4 (39.5, 53.4)	57.9 (49.6, 66.1)	1.49	1.54	1.44	1.25	1.30
2004	51.3 (45.6, 57.0)	20.1 (10.7, 29.6)	35.6 (26.1, 45.0)	59.7 (52.6, 66.9)	75.6 (71.7, 79.5)	35.1 (27.5, 42.6)	13.8 (5.0, 22.6)	25.4 (17.7, 33.2)	47.9 (41.0, 54.9)	55.0 (46.8, 63.3)	1.46	1.46	1.40	1.25	1.37
2005	52.1 (46.5, 57.8)	20.7 (11.3, 30.1)	37.0 (27.6, 46.4)	60.7 (53.5, 67.8)	75.9 (72.0, 79.8)	36.4 (28.8, 43.9)	14.1 (5.4, 22.9)	27.3 (19.5, 35.0)	49.0 (42.1, 56.0)	59.0 (50.7, 67.2)	1.43	1.46	1.36	1.24	1.29
2006	53.0 (47.3, 58.7)	21.0 (11.5, 30.4)	39.2 (29.7, 48.6)	61.7 (54.5, 68.8)	76.7 (72.8, 80.6)	37.7 (30.1, 45.2)	15.1 (6.4, 23.9)	28.4 (20.6, 36.1)	50.7 (43.7, 57.6)	57.1 (48.8, 65.3)	1.41	1.39	1.38	1.22	1.34
2007	53.8 (48.1, 59.5)	22.2 (12.7, 31.6)	39.8 (30.4, 49.3)	61.8 (54.7, 69.0)	75.6 (71.7, 79.5)	39.2 (31.7, 46.8)	16.0 (7.2, 24.7)	29.6 (21.9, 37.4)	52.3 (45.3, 59.2)	57.4 (49.1, 65.6)	1.37	1.39	1.34	1.18	1.32
2008	54.6 (48.9, 60.3)	22.2 (12.8, 31.6)	41.4 (32.0, 50.9)	63.3 (56.1, 70.4)	76.9 (73.0, 80.8)	40.8 (33.3, 48.4)	16.6 (7.8, 25.3)	31.8 (24.0, 39.6)	53.2 (46.2, 60.1)	57.9 (49.7, 66.2)	1.34	1.34	1.30	1.19	1.33
2009	55.3 (49.6, 61.0)	23.0 (13.6, 32.4)	43.7 (34.3, 53.1)	63.4 (56.2, 70.5)	77.0 (73.1, 80.9)	42.6 (35.1, 50.2)	17.5 (8.7, 26.2)	33.6 (25.8, 41.3)	54.2 (47.3, 61.2)	55.4 (47.1, 63.6)	1.30	1.32	1.30	1.17	1.39
2010	56.0 (50.3, 61.7)	23.3 (13.9, 32.7)	44.7 (35.3, 54.1)	64.5 (57.4, 71.7)	77.9 (74.0, 81.8)	44.3 (36.8, 51.9)	17.7 (9.0, 26.5)	34.8 (27.1, 42.6)	55.5 (48.6, 62.5)	60.4 (52.2, 68.7)	1.26	1.31	1.28	1.16	1.29
2011	56.6 (50.9, 62.3)	23.0 (13.6, 32.4)	46.1 (36.6, 55.5)	65.9 (58.8, 73.1)	79.8 (75.9, 83.7)	45.7 (38.1, 53.2)	18.1 (9.3, 26.9)	36.3 (28.5, 44.0)	56.5 (49.6, 63.5)	62.9 (54.7, 71.2)	1.24	1.27	1.27	1.17	1.27
2012	57.1 (51.4, 62.8)	24.2 (14.8, 33.7)	48.1 (38.7, 57.6)	65.5 (58.4, 72.7)	79.2 (75.3, 83.1)	46.7 (39.2, 54.3)	18.5 (9.7, 27.2)	38.3 (30.5, 46.0)	57.1 (50.2, 64.1)	64.3 (56.0, 72.5)	1.22	1.31	1.26	1.15	1.23
2013	57.5 (51.8, 63.2)	25.0 (15.5, 34.4)	50.4 (41.0, 59.9)	65.6 (58.4, 72.7)	80.2 (76.3, 84.1)	47.6 (40.0, 55.1)	18.2 (9.4, 27.0)	40.2 (32.5, 48.0)	57.5 (50.5, 64.4)	69.4 (61.2, 77.7)	1.21	1.37	1.25	1.14	1.16
2014	57.9 (52.2, 63.6)	25.0 (15.6, 34.4)	49.8 (40.4, 59.2)	66.9 (59.7, 74.0)	79.8 (75.9, 83.7)	48.0 (40.5, 55.6)	19.0 (10.2, 27.8)	41.0 (33.3, 48.8)	58.5 (51.6, 65.5)	67.5 (59.2, 75.7)	1.21	1.31	1.21	1.14	1.18
2015	58.2 (52.5, 63.9)	25.0 (15.5, 34.4)	50.4 (41.0, 59.9)	67.1 (60.0, 74.3)	79.3 (75.4, 83.2)	48.2 (40.6, 55.7)	20.3 (11.5, 29.1)	40.3 (32.5, 48.0)	60.6 (53.6, 67.5)	66.0 (57.8, 74.3)	1.21	1.23	1.25	1.11	1.20
2016	58.4 (52.8, 64.1)	25.9 (16.4, 35.3)	52.2 (42.8, 61.6)	67.1 (60.0, 74.3)	80.1 (76.2, 84.0)	48.2 (40.6, 55.7)	19.0 (10.2, 27.8)	44.4 (36.7, 52.2)	58.9 (51.9, 65.8)	70.6 (62.4, 78.9)	1.21	1.36	1.17	1.14	1.13
2017	58.7 (53.0, 64.4)	25.9 (16.5, 35.4)	53.1 (43.7, 62.5)	67.5 (60.4, 74.7)	80.4 (76.5, 84.3)	48.1 (40.6, 55.7)	18.7 (9.9, 27.5)	46.3 (38.6, 54.1)	58.6 (51.6, 65.5)	72.6 (64.4, 80.9)	1.22	1.39	1.15	1.15	1.11
2018	58.9 (53.2, 64.6)	25.6 (16.2, 35.1)	51.1 (41.6, 60.5)	69.2 (62.0, 76.3)	80.8 (76.9, 84.7)	48.2 (40.7, 55.8)	19.4 (10.6, 28.1)	45.8 (38.0, 53.6)	60.3 (53.3, 67.2)	74.7 (66.5, 83.0)	1.22	1.32	1.11	1.15	1.08
2019	59.1 (53.4, 64.7)	27.3 (17.9, 36.8)	55.8 (46.3, 65.2)	66.5 (59.4, 73.7)	80.8 (76.9, 84.7)	48.4 (40.9, 56.0)	18.8 (10.0, 27.6)	48.6 (40.8, 56.3)	59.2 (52.3, 66.2)	76.0 (67.8, 84.3)	1.22	1.46	1.15	1.12	1.06
2020	59.2 (53.5, 64.9)	25.4 (16.0, 34.8)	53.6 (44.2, 63.1)	71.0 (63.8, 78.1)	81.3 (77.4, 85.2)	48.6 (41.1, 56.2)	19.9 (11.1, 28.7)	46.5 (38.8, 54.3)	61.1 (54.2, 68.1)	74.7 (66.4, 82.9)	1.22	1.28	1.15	1.16	1.09
2021	59.4 (53.7, 65.1)	27.4 (17.9, 36.8)	56.6 (47.2, 66.1)	67.6 (60.4, 74.7)	81.2 (77.3, 85.1)	48.8 (41.3, 56.4)	20.0 (11.2, 28.8)	48.1 (40.3, 55.9)	61.1 (54.1, 68.0)	75.0 (66.7, 83.2)	1.22	1.37	1.18	1.11	1.08
2022	59.6 (53.9, 65.3)	27.0 (17.6, 36.5)	56.6 (47.2, 66.1)	68.6 (61.5, 75.8)	81.4 (77.5, 85.3)	49.0 (41.4, 56.5)	20.1 (11.4, 28.9)	48.7 (40.9, 56.5)	61.2 (54.2, 68.1)	74.4 (66.2, 82.7)	1.22	1.34	1.16	1.12	1.09

Values represent the average annual growth rate (AAGR) of myopia prevalence and the estimated myopia prevalence (%) with 95% CI for schoolchildren and adolescents in urban and rural areas from 1998 to 2022, stratified by grade level (Grades 1–3, Grades 4–6, Grades 7–9, and Grades 10–12). The urban-rural ratio indicates the relative prevalence of myopia between urban and rural areas for each year and grade level. In urban areas, a significant difference in AAGR before and after 2006 (1.8% per year vs. 0.9% per year, $P < 0.001$) was observed. In rural regions, myopia prevalence plateaued in 2013, with a significant reduction in AAGR (3.1% per year vs. 0.3% per year, $P < 0.001$). Prevalence was calculated using the aggregated final model. AAGR, the average annual growth rate.

Table 2: **Myopia prevalence in schoolchildren and adolescents across age groups, 1998–2022.**

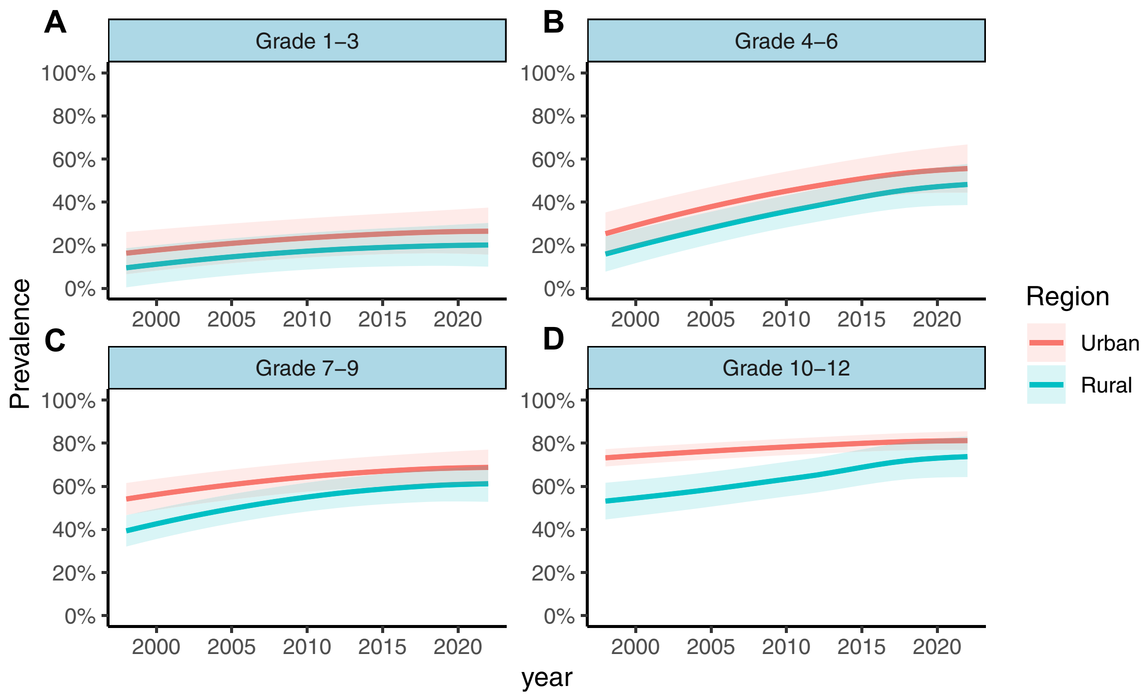


Fig. 2: **Comparison of the myopia prevalence gap between urban and rural region of schoolchildren and adolescents in China from 1998 to 2022**. Myopia prevalence of Grade 1–3 (A), Grade 4–6 (B), Grade 7–9 (C), and Grade 10–12 (D) in urban and rural China. Data were presented with 95% CIs.

age-related variations. Our findings reveal a substantial increase in myopia prevalence from 1998 to 2022, and with the highest rates observed in urban areas and among students in Grade 10–12, and with an increase in myopia prevalence most pronounced in rural regions, originally starting from a lower level as compared to the urban regions. In urban areas, the myopia prevalence across all grades has shown a trend towards stabilization since around 2006, with the prevalence beginning to plateau since 2013 in rural areas. The myopia prevalence was significantly associated with HDI level in the regions. Furthermore, the urban-rural gap in myopia prevalence has narrowed over time, reaching an urban-rural ratio less than 1.3 since 2015 across all age groups, suggesting a potential equalization of risk factors across different geographical regions. High myopia prevalence for urban adolescents (grades 10–12) increased from 2001 to 2022, and projections up to 2050 suggest that although myopia prevalence across various age groups is expected to stabilize, the prevalence of high myopia among adolescents in urban area is projected to increase slightly.

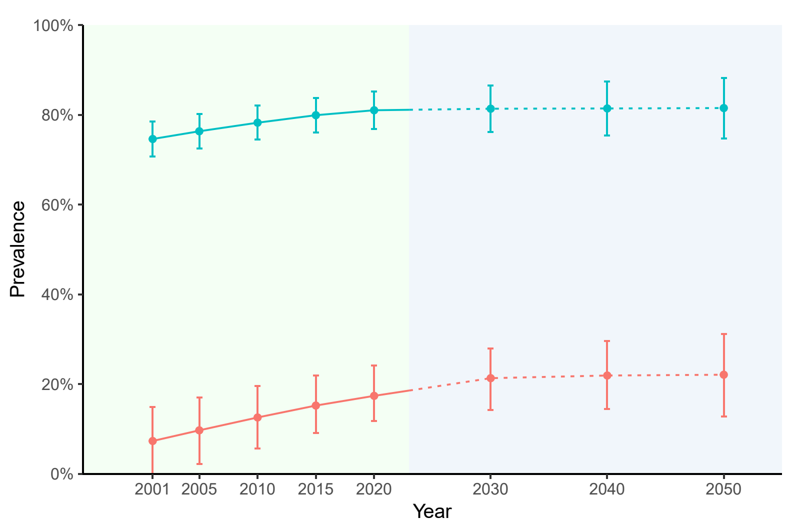
The prevalence of myopia in this study appears comparable to those reported in Singapore[23,24] and Taiwan, China.[25,26] In the 2005 Third Korea National Health and Nutrition Examination Survey (KNHANES III), the myopia prevalence increased from 1.1% in children aged 1 year–6 years, to 23.1% in the age group of 7 years–12 years, to 40.7% in the age group of 13 years–15 years, and to 45.7% in the age group of 16 years–18 years,[27] which are lower than those found in China. It is in agreement with the finding that the greatest burden of myopia focused in Southeast Asia and East Asia, particularly in China.[28–33] The interethnic and intercountry differences in myopia prevalence may be attributed to variations in lifestyle, socioeconomic background, level of education, urbanization rate, and environmental and genetic factors.[32,34–36]

Parallel to the higher prevalence of myopia, the prevalence increased with the development of the economy and the process of urbanization, and the association between myopia prevalence and the HDI further highlights the role of socioeconomic factors in the epidemiology of myopia. Consistent with previous studies,[37,38] we found a higher myopia prevalence in urban areas in all age groups, which is related to the urban lifestyle: less outdoor time and more indoor activities.[39] This study also found a sharper increase in myopia prevalence in the rural regions, especially in the older age groups. As indicated in previous studies,[40,41] education is an important factor in myopia prevalence. In 2006 China enacted and implemented a new compulsory education law, which put a special emphasis on providing nine-year compulsory education (grade 1 to grade 9) for rural regions. A substantial rise in middle school (grade 7 to grade 9) enrollment rate

Year	Projected myopia prevalence (%), urban area				Projected myopia prevalence (%), rural area			
	Grade 1–3	Grade 4–6	Grade 7–9	Grade 10–12	Grade 1–3	Grade 4–6	Grade 7–9	Grade 10–12
2023	26.4 (14.1, 38.8)	56.8 (43.7, 69.8)	69.1 (59.6, 78.4)	81.4 (76.7, 86.2)	20.3 (8.7, 32.3)	49.8 (38.0, 61.6)	61.6 (51.4, 71.7)	74.1 (63.1, 84.7)
2024	26.3 (13.9, 38.9)	56.6 (43.4, 69.6)	69.0 (59.5, 78.4)	81.4 (76.6, 86.1)	20.3 (8.7, 32.3)	49.4 (37.7, 61.2)	61.6 (51.4, 71.8)	73.1 (62.1, 83.9)
2025	26.4 (13.9, 39.1)	56.4 (43.1, 69.6)	69.0 (59.4, 78.5)	81.3 (76.4, 86.2)	20.5 (8.9, 32.5)	49.1 (37.4, 60.9)	61.7 (51.6, 71.7)	72.5 (61.5, 83.2)
2026	26.4 (13.8, 39.2)	56.2 (42.8, 69.6)	68.9 (59.2, 78.6)	81.3 (76.3, 86.2)	20.5 (9.1, 32.4)	48.8 (37.3, 60.3)	61.7 (51.7, 71.7)	72.3 (61.5, 83.1)
2027	26.6 (13.8, 39.5)	56.2 (42.7, 69.7)	68.9 (59.2, 78.7)	81.2 (76.2, 86.2)	20.6 (9.3, 32.3)	48.6 (37.3, 60.0)	61.7 (51.9, 71.5)	72.6 (61.9, 83.2)
2028	26.6 (13.6, 39.7)	56.2 (42.6, 69.8)	68.9 (59.0, 78.7)	81.3 (76.2, 86.3)	20.6 (9.3, 32.2)	48.7 (37.4, 59.8)	61.7 (52.1, 71.3)	73.1 (62.5, 83.6)
2029	26.7 (13.6, 39.9)	56.2 (42.5, 70.0)	68.9 (58.9, 78.8)	81.3 (76.2, 86.4)	20.6 (9.4, 32.0)	48.8 (37.8, 59.8)	61.7 (52.1, 71.1)	73.6 (63.1, 84.0)
2030	26.7 (13.5, 40.0)	56.4 (42.4, 70.2)	68.8 (58.8, 78.9)	81.3 (76.1, 86.5)	20.5 (9.4, 31.9)	48.9 (38.0, 59.9)	61.6 (52.2, 71.0)	74.0 (63.6, 84.3)
2031	26.7 (13.3, 40.2)	56.4 (42.4, 70.4)	68.8 (58.6, 78.9)	81.3 (76.1, 86.5)	20.5 (9.4, 31.8)	49.0 (38.1, 59.9)	61.6 (52.2, 70.9)	74.2 (63.8, 84.5)
2032	26.7 (13.2, 40.4)	56.5 (42.3, 70.6)	68.7 (58.5, 79.0)	81.3 (76.0, 86.6)	20.4 (9.4, 31.7)	49.0 (38.2, 59.8)	61.5 (52.1, 70.8)	74.2 (63.8, 84.5)
2033	26.7 (13.0, 40.5)	56.5 (42.2, 70.8)	68.6 (58.2, 79.0)	81.3 (76.0, 86.7)	20.4 (9.2, 31.6)	49.1 (38.3, 59.8)	61.4 (52.0, 70.7)	74.1 (63.7, 84.4)
2034	26.8 (12.9, 40.8)	56.6 (42.1, 71.1)	68.6 (58.1, 79.1)	81.4 (75.9, 86.8)	20.4 (9.3, 31.7)	49.1 (38.3, 60.0)	61.4 (52.1, 70.7)	74.1 (63.6, 84.4)
2035	26.8 (12.6, 40.9)	56.6 (41.9, 71.4)	68.6 (57.9, 79.2)	81.4 (75.8, 86.9)	20.4 (9.2, 31.6)	49.1 (38.3, 59.9)	61.4 (52.0, 70.7)	73.9 (63.5, 84.3)
2036	26.7 (12.4, 41.1)	56.6 (41.6, 71.6)	68.5 (57.7, 79.3)	81.4 (75.8, 87.0)	20.4 (9.2, 31.7)	49.1 (38.3, 59.9)	61.4 (52.0, 70.7)	73.9 (63.4, 84.3)
2037	26.8 (12.3, 41.4)	56.7 (41.5, 71.7)	68.4 (57.5, 79.4)	81.4 (75.7, 87.1)	20.3 (9.1, 31.6)	49.1 (38.3, 59.9)	61.3 (52.0, 70.7)	73.8 (63.4, 84.2)
2038	26.8 (12.1, 41.6)	56.7 (41.3, 72.0)	68.4 (57.3, 79.6)	81.4 (75.6, 87.2)	20.3 (9.2, 31.6)	49.0 (38.3, 59.8)	61.3 (51.9, 70.6)	73.9 (63.4, 84.3)
2039	26.8 (11.9, 41.8)	56.7 (41.2, 72.3)	68.4 (57.1, 79.7)	81.4 (75.5, 87.3)	20.3 (9.1, 31.7)	49.0 (38.2, 59.9)	61.3 (51.9, 70.7)	73.9 (63.4, 84.4)
2040	26.8 (11.7, 42.0)	56.7 (40.9, 72.5)	68.4 (56.9, 79.8)	81.4 (75.5, 87.4)	20.3 (9.1, 31.6)	49.0 (38.2, 59.8)	61.3 (51.9, 70.7)	74.0 (63.4, 84.4)
2041	26.8 (11.5, 42.2)	56.8 (40.8, 72.8)	68.3 (56.7, 79.9)	81.4 (75.4, 87.4)	20.3 (9.1, 31.7)	49.0 (38.2, 59.9)	61.2 (51.8, 70.6)	74.0 (63.4, 84.5)
2042	26.9 (11.3, 42.5)	56.8 (40.6, 73.0)	68.3 (56.5, 80.0)	81.4 (75.3, 87.5)	20.2 (9.0, 31.7)	49.0 (38.1, 59.9)	61.2 (51.7, 70.6)	74.0 (63.4, 84.5)
2043	26.8 (11.1, 42.7)	56.8 (40.4, 73.2)	68.3 (56.4, 80.2)	81.4 (75.2, 87.6)	20.2 (8.9, 31.6)	48.9 (38.1, 59.8)	61.1 (51.7, 70.6)	74.0 (63.4, 84.5)
2044	26.9 (11.0, 42.9)	56.9 (40.3, 73.5)	68.3 (56.2, 80.4)	81.5 (75.2, 87.7)	20.2 (8.9, 31.6)	49.0 (38.0, 59.8)	61.1 (51.7, 70.5)	74.0 (63.4, 84.6)
2045	26.9 (10.8, 43.2)	56.9 (40.1, 73.8)	68.3 (56.0, 80.5)	81.4 (75.1, 87.8)	20.2 (8.8, 31.6)	48.9 (38.0, 59.8)	61.1 (51.6, 70.6)	74.0 (63.4, 84.6)
2046	26.9 (10.6, 43.4)	57.0 (39.9, 74.0)	68.3 (55.9, 80.7)	81.5 (75.0, 87.9)	20.2 (8.8, 31.6)	48.9 (38.0, 59.8)	61.0 (51.6, 70.5)	74.0 (63.4, 84.6)
2047	27.0 (10.5, 43.6)	57.1 (39.9, 74.3)	68.3 (55.7, 80.9)	81.5 (74.9, 88.0)	20.1 (8.8, 31.7)	48.9 (37.9, 59.8)	61.0 (51.5, 70.5)	74.0 (63.3, 84.7)
2048	27.0 (10.3, 43.8)	57.1 (39.7, 74.6)	68.3 (55.6, 81.0)	81.5 (74.9, 88.1)	20.1 (8.8, 31.7)	48.9 (37.9, 59.8)	61.0 (51.5, 70.5)	74.0 (63.3, 84.7)
2049	27.1 (10.0, 44.1)	57.2 (39.5, 74.8)	68.3 (55.3, 81.2)	81.5 (74.8, 88.2)	20.1 (8.7, 31.7)	48.9 (37.8, 59.8)	61.0 (51.4, 70.6)	74.1 (63.3, 84.8)
2050	27.1 (10.0, 44.4)	57.2 (39.4, 75.1)	68.3 (55.3, 81.4)	81.5 (74.7, 88.3)	20.1 (8.6, 31.7)	48.8 (37.8, 59.8)	61.0 (51.4, 70.5)	74.1 (63.2, 84.8)

Values represent the projected myopia prevalence (%) with 95% CI for schoolchildren and adolescents in urban and rural areas from 2023 to 2050, stratified by grade level (Grades 1–3, Grades 4–6, Grades 7–9, and Grades 10–12). The projections are based on historical trends and time series modeling.

Table 3: **Future projection of myopia prevalence in schoolchildren and adolescents in China to 2050.**



Year	High myopia prevalence (%), Grade 10-12, with 95% CI
2005	9.7 (2.2, 17.0)
2010	12.6 (5.6, 19.5)
2015	15.2 (9.1, 21.9)
2020	17.4 (11.8, 24.1)
2025	19.6 (12.7, 27.1)
2030	21.3 (14.3, 27.9)
2035	21.8 (15.3, 28.7)
2040	21.9 (14.4, 29.6)
2045	22.0 (13.6, 30.4)
2050	22.1 (12.8, 31.2)

Fig. 3: **Prevalence and projection of myopia and high myopia in adolescents aged 16–18 years (Grade 10–12) from 1998 to 2050**. Data are presented as mean prevalence with 95% CI.

		Prevalence (%), 1998					Prevalence (%), 2022				
		Grade 1-3	Grade 4-6	Grade 7-9	Grade 10-12	All	Grade 1-3	Grade 4-6	Grade 7-9	Grade 10-12	All
Anhui	Urban	18.1	31.1	63.5	79.4	49.7	27.0	59.7	73.4	86.3	61.2
	Rural	5.4	14.3	36.0	64.1	27.1	20.1	50.4	62.8	79.1	49.7
Beijing	Urban	17.9	26.6	53.6	74.7	50.6	30.7	62.0	68.6	80.6	57.4
	Rural	/	/	/	/	/	/	/	/	/	/
Chongqing	Urban	17.9	26.5	53.9	69.5	43.8	26.8	55.9	66.0	79.7	57.8
	Rural	5.4	14.3	36.0	54.1	24.5	22.4	52.1	58.6	74.7	51.6
Fujian	Urban	17.9	29.0	61.3	76.7	50.2	25.9	55.8	68.4	84.0	56.2
	Rural	7.6	14.3	36.0	61.3	29.5	18.7	49.0	61.5	79.9	47.6
Gansu	Urban	17.9	29.1	55.9	73.6	46.2	27.8	56.0	65.5	80.6	57.0
	Rural	7.6	23.3	47.8	58.2	32.6	23.3	52.4	58.1	76.8	49.9
Guangdong	Urban	17.9	20.7	46.6	69.8	43.1	26.0	52.1	64.1	76.5	53.3
	Rural	7.6	14.9	38.5	54.4	27.7	18.8	45.7	57.6	73.0	45.1
Guangxi	Urban	11.7	19.4	45.4	68.0	39.1	21.6	51.7	74.6	72.2	54.2
	Rural	6.1	13.6	37.3	52.5	27.8	12.8	46.0	66.7	67.0	45.1
Guizhou	Urban	12.4	23.6	51.5	71.7	40.1	24.9	52.4	64.7	77.8	54.6
	Rural	6.5	16.7	41.8	56.3	28.6	17.9	43.6	57.4	73.7	45.4
Hainan	Urban	11.8	20.0	46.2	68.5	38.3	27.1	53.0	64.5	75.6	53.9
	Rural	6.1	14.0	37.9	53.1	27.5	19.9	46.3	57.4	71.5	46.7
Hebei	Urban	19.4	26.6	53.6	74.7	48.6	30.7	62.0	68.6	80.6	59.9
	Rural	12.7	19.5	39.2	55.7	32.6	25.5	54.9	61.1	76.8	50.8
Heilongjiang	Urban	15.7	22.6	44.9	71.5	40.8	31.2	58.9	65.9	83.0	61.4
	Rural	9.1	15.4	30.5	52.5	27.5	24.0	51.8	58.4	76.0	54.1
Henan	Urban	15.7	28.6	55.7	76.4	45.9	32.7	62.8	69.8	81.3	61.9
	Rural	12.6	22.5	46.3	60.2	35.1	25.3	56.8	62.0	76.6	51.8
Hubei	Urban	16.9	26.9	59.3	76.0	47.8	26.3	55.9	66.7	84.2	58.0
	Rural	12.5	18.9	47.4	60.5	34.2	19.1	48.2	58.7	79.2	46.4
Hunan	Urban	16.9	24.1	54.6	73.5	45.8	24.9	53.5	64.7	81.8	56.3
	Rural	11.5	17.9	45.9	58.1	34.0	18.2	46.1	57.3	77.9	46.5
Inner Mongolia	Urban	16.8	26.3	52.4	74.6	44.9	31.2	61.4	69.1	81.1	59.9
	Rural	10.2	19.2	38.0	55.6	31.6	24.7	54.6	62.1	78.1	53.3
Jiangsu	Urban	17.2	33.8	64.1	79.3	51.6	28.1	60.7	74.5	86.8	61.0
	Rural	12.9	25.8	52.2	63.9	38.2	20.7	52.2	64.4	79.3	51.0
Jiangxi	Urban	18.8	26.9	58.3	75.3	46.7	25.5	54.8	66.1	83.3	58.2
	Rural	13.4	19.4	47.1	59.9	34.1	18.9	47.4	58.7	79.3	48.3
Jilin	Urban	16.6	20.6	40.7	68.7	38.8	30.5	57.2	65.2	82.8	59.7
	Rural	13.4	14.5	31.4	52.5	27.6	24.7	51.1	57.4	74.9	52.5
Liaoning	Urban	17.9	22.0	46.0	70.1	41.4	28.5	56.5	64.7	81.9	57.9
	Rural	11.8	15.1	32.4	51.6	27.0	23.1	49.5	57.2	75.2	51.4
Ningxia	Urban	16.3	27.6	55.3	74.5	44.6	29.0	55.9	64.3	81.4	57.4
	Rural	10.7	21.8	47.2	59.0	34.0	23.2	52.2	57.0	77.3	50.5
Qinghai	Urban	16.7	26.8	52.5	74.0	43.0	25.1	53.6	62.1	80.1	55.0
	Rural	11.1	21.0	44.5	58.5	32.7	22.6	46.7	54.7	75.6	47.2
Shaanxi	Urban	16.2	27.9	55.4	74.5	45.9	29.5	56.6	65.4	81.6	56.9
	Rural	10.9	22.1	47.2	59.0	34.2	23.6	52.8	58.0	77.2	49.3
Shandong	Urban	19.4	26.6	53.6	74.7	47.3	30.7	62.0	68.6	80.6	59.5
	Rural	12.7	19.5	39.2	55.7	32.4	25.5	54.9	61.1	76.8	52.5
Shanghai	Urban	17.2	33.8	64.1	79.3	54.9	28.1	60.7	74.5	86.8	59.7
	Rural	/	/	/	/	/	/	/	/	/	/
Shanxi	Urban	16.8	27.2	54.4	75.4	44.4	31.3	60.9	69.0	81.1	60.4
	Rural	10.6	20.3	40.8	56.8	30.9	24.1	54.0	61.5	76.9	52.6
Sichuan	Urban	18.2	27.6	54.3	71.4	45.6	26.1	54.9	66.4	79.1	57.0
	Rural	10.8	20.7	44.6	56.0	31.1	21.2	48.6	59.4	75.0	49.8
Tianjin	Urban	19.4	26.6	53.6	74.7	49.3	30.7	62.0	68.6	80.6	60.1
	Rural	12.7	19.5	39.2	55.7	31.1	25.5	54.9	61.1	76.8	52.5
Tibet	Urban	17.2	27.5	54.2	74.8	45.7	22.0	53.5	63.6	79.1	55.1
	Rural	13.5	21.5	45.9	59.4	34.8	20.1	43.7	55.9	75.3	45.6
Xinjiang	Urban	17.0	26.6	53.1	76.2	44.7	22.9	52.8	61.9	79.6	52.8
	Rural	11.6	20.8	45.0	60.8	34.3	21.1	44.2	54.2	73.2	42.3
Yunnan	Urban	12.4	23.6	51.5	71.7	42.6	24.9	52.4	64.7	77.8	56.5
	Rural	6.5	16.7	41.8	56.3	29.8	17.9	43.6	57.4	73.7	46.1
Zhejiang	Urban	17.2	33.8	64.1	79.3	52.9	28.1	60.7	74.5	84.4	61.5
	Rural	12.9	25.8	52.2	63.9	38.4	20.7	52.2	64.4	79.1	52.0

0 100%

Fig. 4: **Myopia prevalence in different provinces in China in 1998 and 2022**. Values represent the estimated myopia prevalence (%) with 95% CI for schoolchildren and adolescents in urban and rural areas from 1998 to 2022.

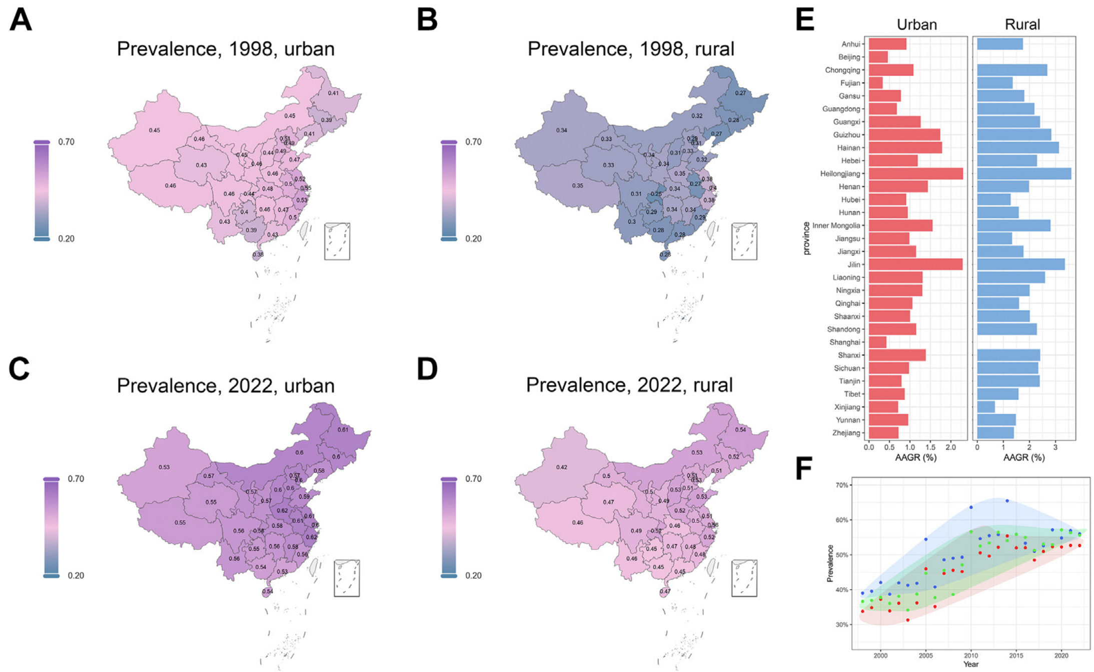


Fig. 5: **Spatial distribution of myopia prevalence among schoolchildren and adolescents in urban and rural China in 1998 and 2022.** Map displaying myopia prevalence of schoolchildren and adolescents in 1998 (A and B) and 2022 (C and D) in rural and urban China. (A) Myopia prevalence in urban China, 1998. (B) Myopia prevalence in rural China, 1998. (C) Myopia prevalence in urban China, 2022. (D) Myopia prevalence in rural China, 2022. (E) The AAGR of myopia prevalence in urban and rural China from 1998 to 2001 to 2019–2022. (F) Myopia prevalence among schoolchildren and adolescents in China at different HDI levels (Linear mixed-effect model, P < 0.001). AAGR, average annual growth rate.

was seen around that time period (https://data.stats.gov.cn/). This is consistent with a major increase in rural myopia prevalence between the following time period and a higher level of school is associated with more myopic refraction.[42] This may partially explain the increase in rural myopia, especially in older age groups who have experienced an increase in average years of schooling during the past 25 years. Environmental exposures, particularly those related to near work and limited outdoor activities, have been identified as critical factors contributing to the rising prevalence of myopia among school-aged children.[14,43] Schools emerge as pivotal environments for implementing strategies aimed at myopia control. One of the most effective interventions is increasing outdoor time for students, which has been shown to mitigate the risk of developing myopia. A systematic review indicated that for every additional hour spent outdoors per week, the odds of developing myopia decreased by approximately 2%,[43] suggesting that structured outdoor activities during school hours could significantly reduce myopia incidence.

Apart from education, lifestyle changes following the development of technology were also related to the rural myopia shift. According to a previous study, smart device exposure was related to myopia risk. Specifically, smart device screen time alone (Odds Ratio, OR 1.26 [95% CI 1.00–1.60]; I^2 = 77%) or in combination with computer use (OR 1.77 [1.28–2.45]; I^2 = 87%) was significantly associated with myopia.[44] In 2008 the Internet penetration rate was only 11.5% in rural regions and 35.8% in urban regions; by 2022 the rate increased to 61.9% in rural regions and 83.1% in urban regions (https://www.cnnic.net.cn). Increased internet penetration meant increased screen time in the rural population which was associated with a more "urban" lifestyle: more near work and less outdoor activities. Thus, causing an increase in rural myopia prevalence and narrows the rural-urban difference.

The projections suggest that the prevalence of myopia is expected to remain relatively stable across all age groups. However, effective myopia control strategies to mitigate the long-term impact on visual health are still needed. Notably, the slight projected decrease in myopia prevalence among younger children (Grade 1–3) in urban areas may reflect the early impact of recent public health interventions aimed at reducing myopia risk factors, such as increasing outdoor activities and limiting screen time. In response to the serious issue of myopia among schoolchildren and adolescents, the Chinese government formulated a plan in 2018 to address and prevent the condition. The implementation plan outlines targets to reduce myopia prevalence by 2030: approximately 3% in children aged 6 years, below 38% in primary school students, under 60% in junior high school students, and less than 70% in senior high school students. However, due to limited public health education, many parents lack sufficient knowledge about protecting their children's vision, and visual health education in schools is often ineffective. The successful prevention and treatment of myopia in preschools and schools depend on substantial support from professional ophthalmology institutions. It is crucial to convey the scientific evidence supporting the importance of eye health and to encourage early screening and correction of refractive errors in adolescents.[45] Furthermore, establishing visual health documentation could be essential in enhancing the overall visual health of adolescents in China.[46]

One of the major parts of the information provided in this study is that the prevalence of high myopia, defined by a refractive error of –6 D or less, markedly increased during the study period and will continue to increase and is expected to stabilize at around 21–22% after a later plateau in 2030. While moderate myopia offers substantial advantages, such as a relative protection against age-related macular degeneration, diabetic retinopathy and angle-closure glaucoma (and potentially amblyopia, if myopia occurs in early life), high myopia has increased risks of myopic macular degeneration and high myopia-associated, glaucomatous and non-glaucomatous, optic neuropathies. These risks increase non-linearly with longer axial length, beyond a turning point of an axial length of approximately 26.0–26.5 mm.[47–50]

The strengths of our study include a comprehensive collection of studies encompassing all regions of mainland China, the inclusion of research articles written in Chinese, a detailed examination of myopia across various age groups and in both rural and urban settings over time, a clear definition of myopia, standardized data processing, and projections for future changes in myopia prevalence. Also, a statistical method to assign weights to cycloplegia and non-cycloplegia studies was used, aligning the data between these two types as much as possible, which is particularly important in myopia research. However, our study also has some limitations that warrant discussion. First, there is a lack of data for multiple time periods, particularly for earlier periods and rural areas. Ideally, there would be annual survey data for each province conducted by the same research group, but such data do not exist in reality. In our analysis, we extrapolated the sparse data to similar regions and adjacent time periods to address the data sparsity, which may introduce some uncertainty into our findings. These data characteristics limited our ability to perform more thorough or detailed subgroup or sensitivity analyses, and did not include measures such as average outdoor time or academic load at the provincial or municipal level, which could have enabled more nuanced interpretations of regional differences. Second, we combined all available data from both cycloplegic and non-cycloplegic studies. In urban areas, our final model showed no significant difference when compared to results derived solely from cycloplegic data. However, in rural areas, discrepancies were observed between our final model and results derived solely from cycloplegic studies. This inconsistency may be attributed to that the quality of non-cycloplegic data in rural regions may be lower due to measurement conditions, equipment quality, or examiner experience, leading to greater discrepancies compared to cycloplegic data. Also, the overall severity of myopia tends to be lower in rural students, making non-cycloplegic measurements more prone to over- or under-estimation, while the higher myopia levels in urban areas might reduce such discrepancies. Third, as most Chinese high schools are located in urban areas, rural students often attend boarding schools in nearby cities for their high school education, leading them to adopt a lifestyle similar to that of urban students. Another potential limitation of this study relates to data representativeness, particularly given the long timeframe of our analysis, which might vary over time. Last, we could not fully estimate the potential effect of methods recently developed such as more time spending outdoors, orthokeratology, Defocus Incorporated Multiple Segments glasses or other similar glasses, and contact lenses with concentrically progressively increasing refractive power, which are increasingly recognized as critical interventions for reducing the prevalence of myopia and high myopia. These interventions have demonstrated substantial efficacy in controlled settings. However, current evidence is largely derived from case–control studies and RCTs, with real-world data being relatively limited. Future research efforts should prioritize large-scale, real-world studies to assess the effectiveness, adherence, and feasibility of these interventions in diverse populations and practical settings. Also, since 2018, the Chinese government has significantly increased its investment in myopia prevention and control, alongside growing public awareness and intervention measures. However, the long-term impact of these initiatives on myopia prevalence remains unclear, and our projection models do not incorporate potential behavioral or policy-driven changes. Future research should evaluate the effectiveness of these interventions and their influence on myopia trends.

In summary, this study utilized the most comprehensive dataset to date on myopia prevalence in children and adolescents in China currently available, offering a detailed analysis of the trends, urban-rural disparities, regional variations, and associations with socioeconomic development of myopia among children and adolescents in China from 1998 to 2022. Additionally, the present study provides projections of myopia prevalence through 2050. The research also includes an analysis and forecast of the prevalence of high myopia among urban adolescents in grades 10–12. There is a need for targeted interventions and comprehensive strategies to manage myopia and its complications, particularly in light of the increasing prevalence of high myopia. Future studies might aim at elucidating the underlying mechanisms contributing to the rise in both myopia and high myopia, and assess the efficacy of preventive strategies.

Contributors
ZP, HCX and FL analyzed the data. ZP, HCX, ZYW, and FL wrote the initial draft of the manuscript, which was reviewed and edited by YXW, FL and TYW. Concept and design: YXW and TYW; Paper revision: ZHL, YH, WQL, YML, JYW, HCC, YLW, YYX, GYW, YZ, LFH, JPZ, FXZ, XHQ, XHZ, LHZ, YQF, LL, XGH, XX, JY, XYZ, DZ, CWP, MA, SMS, YFZ, MGH, JBJ, NMB, CYC, YCT, CZ, YXW, and TYW. All authors accessed and verified the data and have final responsibility for the decision to submit for publication.

Data sharing statement
All code is available on GitHub (https://github.com/feng-li/myopia), and data can be provided upon reasonable request to the corresponding author.

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Declaration of interests
The authors declare no conflict of interest.

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Appendix A. Supplementary data
Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2025.101577.

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