

Twenty-five-year trends in adolescent myopia: are we approaching a plateau? Real-world evidence from 1.46 million Israeli adolescents

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Abstract

Background/Objectives:

To characterise 25-year trends in adolescent myopia and examine whether myopia prevalence and temporal trends differed according to educational characteristics.

Subjects/Methods:

This nationwide repeated cross-sectional study included 1,462,999 adolescents aged 16 to 20 years, born between 1976 and 2000, using data from the Israel Defense Forces conscription registry. Myopia was defined as spherical equivalent ≤ -0.5 D. Temporal trends were assessed across 5-year birth cohorts and according to educational level and educational system. Associations were evaluated using multivariable logistic regression.

Results

Myopia prevalence increased from 27.0% in the 1976–1980 birth cohort to 33.0% in the 1996–2000 cohort ($P < 0.001$), with most of the increase occurring between the first two birth cohorts and relative stability thereafter. Prevalence was higher with greater educational attainment, and participants with at least 12 years of education had higher adjusted odds of myopia than those with 9 years or less (OR 1.88, 95% CI 1.81 to 1.95; $P < 0.001$). Participants educated in the religious system also had higher adjusted odds of myopia than those educated in the secular system (OR 2.16, 95% CI 2.14 to 2.18; $P < 0.001$). The relative increase across the study period was smaller in the religious than in the secular system (+ 7.3% vs + 23.4%).

Conclusions

Myopia prevalence increased across successive Israeli birth cohorts, with findings suggesting a relative plateau after the early study period, particularly among adolescents educated in the religious system. Marked differences in prevalence and temporal trends across educational groups suggest that population-specific characteristics should be considered when interpreting long-term myopia trends.

Introduction

Myopia is a common refractive disorder and an increasing global public health concern over the past few decades, affecting approximately 23% of the world's population.^{1, 2} Myopia, and especially high myopia, is associated with serious ocular complications such as glaucoma, macular degeneration, retinal detachment, and cataract,³ which can have deleterious consequences on visual function and quality of life.

Recent studies have addressed the topic of myopia prevalence and specifically the projected increase in prevalence in the upcoming decades.^{4–8} These projections were mainly achieved by mathematical

models based on historical data of increasing worldwide prevalence in recent decades.⁹

Although essential environmental factors such as educational exposure, near-work activities, and lack of outdoor exposure are established as significant contributors to the development of myopia,^{10–12} the influence of additional factors on the mounting global prevalence over the past few decades remains uncertain. Large population-based datasets enable the examination of myopia prevalence across diverse subgroups and may help identify potentially modifiable risk factors relevant to the onset and progression of myopia.

Israel provides a unique setting for population-based ophthalmic research through its mandatory military conscription system, which includes standardised medical screening and routinely collected refractive, sociodemographic, and educational data. The presence of distinct educational systems in Israel, each characterised by different educational and behavioural environments, enables the comparison of diverse subpopulations. The objective of this study was to characterise 25-year trends in adolescent myopia and examine whether myopia prevalence and temporal trends differed according to educational characteristics.

Methods

In Israel, military service is mandatory for most of the Jewish population according to the law. Upon reaching the age of 17 years,¹³ Israeli conscripts are required to undergo a standardised draft board assessment, which includes a comprehensive medical evaluation, leading to a medical profiling and suitable occupational classification. Visual acuity and refractive data are assessed as part of this medical evaluation process, along with the recording of socio-demographic and educational data.

Study design and population

A nationwide repeated cross-sectional population-based study was conducted using data from the Israel Defense Forces (IDF) conscription registry, covering adolescents born between 1976 and 2000. Notably, individuals who attended ultra-orthodox educational systems are exempted from military service and therefore were not included in the study population.¹³ Individuals with pre-existing ocular conditions or who had previous refractive surgery were excluded from the study (N = 29,595; 1.7%).

Our population consisted solely of adolescents who underwent a medical assessment, and had complete data on educational level, educational system, socioeconomic status, ethnic origin and valid refractive data (overall missing data = 12.3%). Our study population encompasses all Israeli-Jewish ethnic groups, spanning Western (Europe and America), North-African, Asian, Former Union of Soviet Socialist Republics (USSR), Ethiopian, and Israeli native populations (residing in Israel for four generations).

Our study adhered to the tenets of the Declaration of Helsinki and was conducted under the approval of the Institutional Ethics Committee of the IDF Medical Corps (Approval No. 1669–2016). Informed

consent was waived by the Institutional Ethics Committee due to the retrospective nature of our study.

Vision assessment and myopia definitions

As previously detailed,¹⁴ visual acuity was assessed by a qualified technician using a Snellen chart. Participants with uncorrected visual acuity of 6/6 meters were assumed to be non-myopic and required no further refractive assessment. Participants with uncorrected visual acuity worse than 6/6 meters underwent a non-cycloplegic refraction using autorefractometers (KR-8000, KR7000S, and earlier models, Topcon, Tokyo, Japan; Speedy K, Nikon Corporation, Tokyo, Japan),¹⁵ which was validated by a complementary subjective refraction. If best-corrected visual acuity of 6/6 could not be achieved after refraction, the participant was referred for examination by a board-certified ophthalmologist.

Spherical equivalent (SE) was calculated separately for each eye according to the following formula¹⁰:
$$SE = \text{sphere power} + \frac{\text{cylinder power}}{2}$$
. High correlation between SE of the right and left eyes was found (Pearson correlation coefficient of 0.925, $P < 0.001$), and the more myopic eye was used for analyses.¹⁶
¹⁷ Myopia was defined as $SE \leq -0.5$ diopters (D) and categorised as mild ($-0.5 \geq SE > -3.0$ D), moderate ($-3.0 \geq SE > -6.0$ D), and high ($SE \leq -6.0$ D).

Study covariates

As part of the draft board intake process, socio-demographic and educational information was collected. Participants were grouped into five 5-year birth cohorts according to year of birth: 1976–1980, 1981–1985, 1986–1990, 1991–1995, 1996–2000. Educational level was categorised according to years of formal schooling as 9 years or less, 10 to 11 years, or 12 years or more, including higher and academic education. Educational system was classified as secular or religious according to the school attended and the official classification of the Israeli Ministry of Education.¹³ The religious educational system comprises non-ultra-Orthodox religious schools and is distinct from the ultra-Orthodox educational system, whose students were not represented in the study population. Socioeconomic status (SES) was determined by place of residence according to the classification of the Israeli Ministry of Interior, and categorised as low (scores 1–4), medium (scores 5–7), or high (scores 8–10).¹⁸ Ethnic origin was determined by the birthplace of the father or grandfather (if the father was born in Israel) and categorised as Western (Europe and America), North-African, Asian, Former USSR, Ethiopian, or Israeli natives.

Statistical analysis

Prevalence of myopia was calculated as the proportion of population who had myopia in each birth-cohort. Myopia temporal trends across birth cohorts were evaluated using the Cochran–Armitage test

for trend, followed by Tukey's honestly significant difference (HSD) post-hoc test for multiple pairwise comparisons.

We conducted various sensitivity analyses; Firstly, we stratified myopia temporal trends by gender to investigate any gender-specific effects on the trend. Secondly, to mitigate potential overestimation of myopia resulting from non-cycloplegic refraction, we conducted temporal trend analyses using a more stringent myopic threshold of $SE \leq -0.75$ D.

We assessed the associations between myopia, treated as a binary outcome variable, and study variables using univariable logistic regression models. Variables that were statistically significant in the univariable analyses and considered potential confounders, including age, birth year, sex, ethnic origin, socioeconomic status, educational level, and educational system, were subsequently included as appropriate in the multivariable logistic regression models. These models were used to examine the associations of educational level and educational system with myopia. Separate logistic regression models were fitted for overall myopia as a binary outcome and for each myopia severity category. Results of the regression models were presented as odds ratios (OR) with corresponding 95% confidence intervals (95% CI). Statistical significance was defined as $P < 0.05$. Analyses were performed using SPSS statistics for Windows version 24 (IBM, Armonk, NY, USA) and Excel for Windows (Microsoft corporation, Redmond, WA, USA).

Results

Study Population and Characteristics

The total study population included 1,462,999 adolescents (54.8% males) born between 1976 and 2000. Reasons for exclusion from the study cohort can be seen in the flow chart of **Figure S1**. Mean (SD) age at the draft board examination was 17.2 (0.5) years (median 17.1 years; range 16 to 20 years). Most of the study population (93.8%) had at least 12 years of formal education, and 88.1% attended a secular educational system.

Among participants with myopia, mean refractive error (SD) was -2.7 (2.0) D [median -2.1 D], compared with 0.1 (0.5) D (median 0.0 D) among non-myopic participants ($P < 0.001$). Further demographic and educational characteristics of the study population are described in Table 1. Overall prevalence of myopia ($SE \leq -0.5$ D) and high myopia ($SE \leq -6.0$ D) were 31.0% and 2.3%, respectively. Both myopia and high myopia were more prevalent in females than males (34.0% vs. 28.5%, $P < 0.001$ and 2.4% vs. 2.2%, $P < 0.001$, respectively).

Table 1
Characteristics of Study Population and Myopia and High Myopia Prevalence

Variable		Sample Size		Myopia		High Myopia	
		N; Prevalence (%)		N; Prevalence (%)		N; Prevalence (%)	
Gender	Female	660 647	45.2	224 607	34.0	15 993	2.4
	Male	802 352	54.8	228 656	28.5	17 376	2.2
	P-value		< 0.001		< 0.001		
Ethnic Origin	Western	354 008	24.2	113 958	32.2	3 904	2.6
	North-African	292 505	20.0	85 193	29.1	6 037	2.1
	Asia	277 274	19.0	93 717	33.8	7 552	2.7
	Former USSR	252 341	17.2	71 773	28.4	4 550	1.8
	Ethiopia	38 318	2.6	7 709	20.1	339	0.9
	Israel	248 553	17.0	80 913	32.6	5 587	2.2
	P-value		< 0.001		< 0.001		
Socioeconomic Status	Low	342 237	23.4	110 428	32.3	8 466	2.5
	Medium	795 875	54.4	238 597	30.3	17 095	2.1
	High	324 887	22.2	104 238	32.1	7 808	2.4
	P-value		< 0.001		< 0.001		
Educational Level	≤ 9 years	17 286	1.2	3 238	18.7	192	1.1
	10–11 years	74 059	5.1	16 127	21.8	1 128	1.5
	≥ 12 years	1 371 654	93.8	433 898	31.6	32 049	2.3
	P-value		< 0.001		< 0.001		
Myopia defined as Spherical Equivalent (SE) ≤ -0.5 Diopters (D). High myopia defined as SE ≤ -6.0 D. USSR = Union of Soviet Socialist Republics; Western = North America and Western Europe							

Variable		Sample Size		Myopia		High Myopia	
		N; Prevalence (%)		N; Prevalence (%)		N; Prevalence (%)	
Type of Educational System	Secular	1 289 531	88.1	375 450	29.1	24 927	1.9
	Religious	173 468	11.9	77 813	44.9	8 442	4.9
	P-value			< 0.001		< 0.001	
Total		1 462 999	100	453 263	31.0	33 369	2.3
Myopia defined as Spherical Equivalent (SE) $\leq$ -0.5 Diopters (D). High myopia defined as SE $\leq$ -6.0 D. USSR = Union of Soviet Socialist Republics; Western = North America and Western Europe							

Temporal Trends of Myopia

Over the span of 25 years, the prevalence of myopia increased, rising from 27.0% among adolescents born between 1976 and 1980 to 33.0% among those born between 1996 and 2000 (+ 22% change, $P < 0.001$). Most of this increase occurred between the 1976–1980 and 1981–1985 birth cohorts, with prevalence remaining relatively stable across subsequent cohorts (Fig. 1). In sex-stratified analyses, myopia prevalence increased across the study period in both females and males, with relative increases of 24% and 20%, respectively (**Figure S2**). Sensitivity analysis using a more stringent myopia threshold ($SE \leq -0.75$ D) yielded a similar temporal pattern, with prevalence increasing from 25.5% in the 1976–1980 birth cohort to 31.2% in the 1996–2000 cohort (+ 22% change; $P < 0.001$). Across all birth cohorts, prevalence estimates using the conventional $SE \leq -0.5$ D threshold were less than 2 percentage points higher than those obtained using the stricter threshold.

Association of Educational Level with Myopia and Temporal Trends

Myopia prevalence was higher with increasing educational attainment, rising from 18.7% among individuals with 9 years of education or less, to 21.8% among those with 10 to 11 years, and 31.6% among those with 12 years of education or more ($P < 0.001$; Table 1).

Over the 25-year study period, educational attainment also increased, with 91.5% of participants in the 1976–1980 birth cohort having completed at least 12 years of education compared with 96.1% in the 1996–2000 cohort (**Figure S3**).

Despite the overall increase in educational attainment, myopia prevalence increased within each educational stratum across successive birth cohorts (Fig. 2). Prevalence rose from 13.9% to 23.7% among participants with 9 years of education or less (+ 71% change, $P < 0.001$), from 17.5% to 29.8%

among those with 10 to 11 years (+ 70% change, $P < 0.001$), and from 28.0% to 33.1% among those with at least 12 years (+ 19% change, $P < 0.001$). Thus, the relative increase was smallest in the highest educational stratum, despite this group having the highest absolute myopia prevalence.

Educational level was associated with myopia in univariable logistic regression analyses (**Table S1**), and this association remained significant after adjustment for age, birth year, sex, ethnic origin, SES, and educational system (**Table S2**). Compared to individuals with 9 years of education or less, those with 10 to 11 years had higher adjusted odds of myopia (OR 1.19, 95% CI, 1.14 to 1.24; $P < 0.001$), while those with at least 12 had substantially higher adjusted odds (OR 1.88, 95% CI, 1.81 to 1.95; $P < 0.001$).

The association was also observed across myopia severity categories. Compared with participants with 9 years of education or less, those with at least 12 years had higher odds of mild myopia (OR 1.63, 95% CI 1.56 to 1.70), moderate myopia (OR 2.60, 95% CI 2.41 to 2.81), and high myopia (OR 2.54, 95% CI 2.20 to 2.93; all $P < 0.001$)

Association of Educational System with Myopia and Temporal Trends

Myopia prevalence differed according to educational system, with a higher prevalence among participants educated in the religious system than among those educated in the secular system (44.9% vs. 29.1%, $P < 0.001$; Table 1). Across birth cohorts, myopia prevalence increased in both educational systems, but the relative increase was smaller in the religious system, from 41.4% to 44.4% (+ 7.3% change, $P = 0.008$), than in the secular system, from 25.2% to 31.1% (+ 23.4% change, $P < 0.001$) (Fig. 3). Thus, despite its higher absolute prevalence, the religious educational group showed substantially less temporal change in myopia prevalence.

Educational system remained independently associated with myopia after multivariable adjustment. Participants educated in the religious system had higher adjusted odds of myopia than those educated in the secular system (OR 2.16, 95% CI, 2.14 to 2.18; $P < 0.001$).

The magnitude of this association increased with myopia severity (religious vs secular educational system; **Table S3**), with adjusted ORs of 1.70 for mild myopia (95% CI, 1.68 to 1.72), 2.94 for moderate myopia (95% CI, 2.89 to 2.98), and 3.61 for high myopia (95% CI, 3.52 to 3.71; all $P < 0.001$).

Discussion

In this nationwide repeated cross-sectional study of 1.46 million Israeli adolescents born between 1976 and 2000, myopia prevalence increased over 25-year study period. Interestingly, most of the increase occurred between the earliest birth cohorts and prevalence remained relatively stable thereafter. Importantly, temporal patterns differed substantially across educational subgroups. Participants with at least 12 years of education had the highest absolute myopia prevalence but the smallest relative increase over time, while those educated in the religious system had markedly higher prevalence than

those in the secular system but showed substantially less temporal change. Together, these findings suggest that long-term trends in myopia prevalence may not progress uniformly across population subgroups and may approach relative stabilisation in groups with higher baseline prevalence.

We observed a 22% relative increase in myopia prevalence, from 27.0% among individuals born in 1976–1980 to 33.0% among those born in 1996–2000. Similar increases have been reported in North America and Europe.^{1, 19} By contrast, a study of young adults in Singapore over a broadly similar period (1996–2010) reported consistently high myopia prevalence, ranging from 79.2% to 81.6%, suggesting a plateau in that population.²⁰

The observed trend should be considered in the context of the global rise in myopia, often referred to as the “myopia boom”,²¹ which has emerged as a major public health concern over the past few decades.^{2, 22} This trend has prompted several attempts to project future prevalence, although uncertainty remains. Holden et al. estimated that approximately 50% of the global population could be myopic by 2050, with nearly one billion individuals affected by high myopia.⁴ However, more recently, Liang et al. projected lower global prevalences of 36.59% in 2040 and 39.80% in 2050.⁶ In our cohort, myopia prevalence remained relatively stable at 31.6% to 33.0% among individuals born between 1981 and 2000, with smaller relative increase among those with at least 12 years of education (+ 19%) and among those educated in the religious system (+ 7.3%). These findings suggest that increases in myopia prevalence may not continue uniformly across all populations and that subgroup-specific temporal patterns should be considered when interpreting long-term projections.

Myopia is a multifactorial condition associated with both genetic and environmental factors.^{11, 12, 23–25} Despite increasing exposure to recognised environmental risk factors, myopia prevalence varies substantially between populations. Recent studies have reported prevalence estimates of approximately 35–40% in many Caucasian populations, compared with rates as high as 94.9% in Japan.^{6, 8, 26, 27} Lifestyle patterns characterised by intensive near-work have also been associated with high myopia prevalence, as observed in the ultra-Orthodox population in Israel, in which prevalence reached 82.2% in one adolescent cohort.¹³ These marked differences between populations support the importance of population-specific environmental and behavioural characteristics when interpreting myopia prevalence and temporal trends.

In our population-based study, higher educational attainment remained independently associated with myopia after adjustment for age, birth year, sex, ethnic origin, socioeconomic status, and educational system. Similar associations have previously been reported by Yang et al. (2020)²⁸, Williams et al. (2016)¹, and Shapira et al. (2019)²⁹. The latter also studied the Israeli population and attributed the increasing prevalence of myopia among Israeli adolescents partly to higher educational attainment. However, our findings suggest that higher educational attainment alone does not explain the entire rise in prevalence. Although myopia prevalence was highest among participants with at least 12 years of education, this group showed the smallest relative increase over time. Likewise, prevalence increased in

adolescents educated in both the secular and religious systems, but the increase was more pronounced in the secular group. The relative plateau observed in the religious group may reflect educational and behavioural differences between the populations. The religious educational system includes substantial religious studies which involve prolonged reading and other near-work activities. This educational pattern differs from that of the secular system and may partly explain the higher baseline prevalence of myopia observed in the religious group. In contrast, near-work exposure in the secular population may have changed more substantially over time with the increasing use and popularity of handheld digital devices.^{30 31} These lifestyle differences may have contributed to the observed temporal patterns. In addition, because myopia prevalence was already higher in the religious population at baseline, this group may have been closer to a plateau in prevalence, limiting the magnitude of further increase over time.

This study has several limitations. First, the repeated cross-sectional design precludes causal inference regarding the association between educational characteristics and myopia. Second, the use of non-cycloplegic refraction may have led to some overestimation of myopia prevalence, particularly in younger participants. Nevertheless, this method is widely acknowledged and well-accepted in large-scale epidemiological database studies.²⁸ Furthermore, sensitivity analysis using a more stringent threshold of $SE \leq -0.75$ D showed a similar 22% relative increase over the study period, and prevalence estimates differed by less than 2 percentage points across birth cohorts compared with the conventional $SE \leq -0.5$ D threshold. The long study period also encompassed the use of different autorefractometer models, and although the screening protocol was standardised, measurement differences between devices cannot be entirely excluded. Third, educational level and educational system served as proxies for educational and behavioural exposures and did not directly capture individual near-work intensity, study patterns, screen use, or outdoor activity. The dataset also lacked several other potential confounders, including familial myopia. The data were collected before the COVID-19 pandemic and therefore do not capture potential pandemic-related changes in myopia prevalence. Finally, generalisability is primarily limited to Israeli Jewish adolescents undergoing mandatory military assessment. Other population groups, including ultra-Orthodox adolescents and other religious groups in Israel, were not represented in this cohort.

In summary, myopia prevalence increased among Israeli adolescents across successive birth cohorts, with most of the increase occurring early in the study period and relative stabilisation thereafter. Temporal trends differed substantially across educational subgroups, with smaller relative increases among participants with at least 12 years of education and among those educated in the religious system. These findings suggest that myopia prevalence may be approaching a plateau in some populations and highlight the importance of accounting for population-specific educational and behavioural characteristics when interpreting long-term trends. Given the continuing burden of myopia, prevention strategies should remain a public health priority, including school-based approaches aimed at increasing outdoor exposure and reducing potentially modifiable environmental risk factors.^{32, 33}

Declarations

Conflict of Interest: The authors declare no conflict of interest.

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Author Contributions

JM, HL, and AB conceived and designed the study. JM, IN, and DB were responsible for data acquisition. JM performed the statistical analyses. JM, IN, DB, MB, HL, and AB interpreted the results. JM, HL, EB, and AS drafted the manuscript. HL, AB, MB, IN, EB, and AS critically revised the manuscript. HL and AB supervised the study. All authors approved the final version of the manuscript.

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Data Availability Statement

The data that support the findings of this study are derived from the Israel Defense Forces conscription registry and are not publicly available because of privacy, security, and institutional restrictions. JM, as a researcher in the IDF Medical Corps, had full access to the data used in the study.

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34. Titles and legends to figures

Figures

Figure 1.

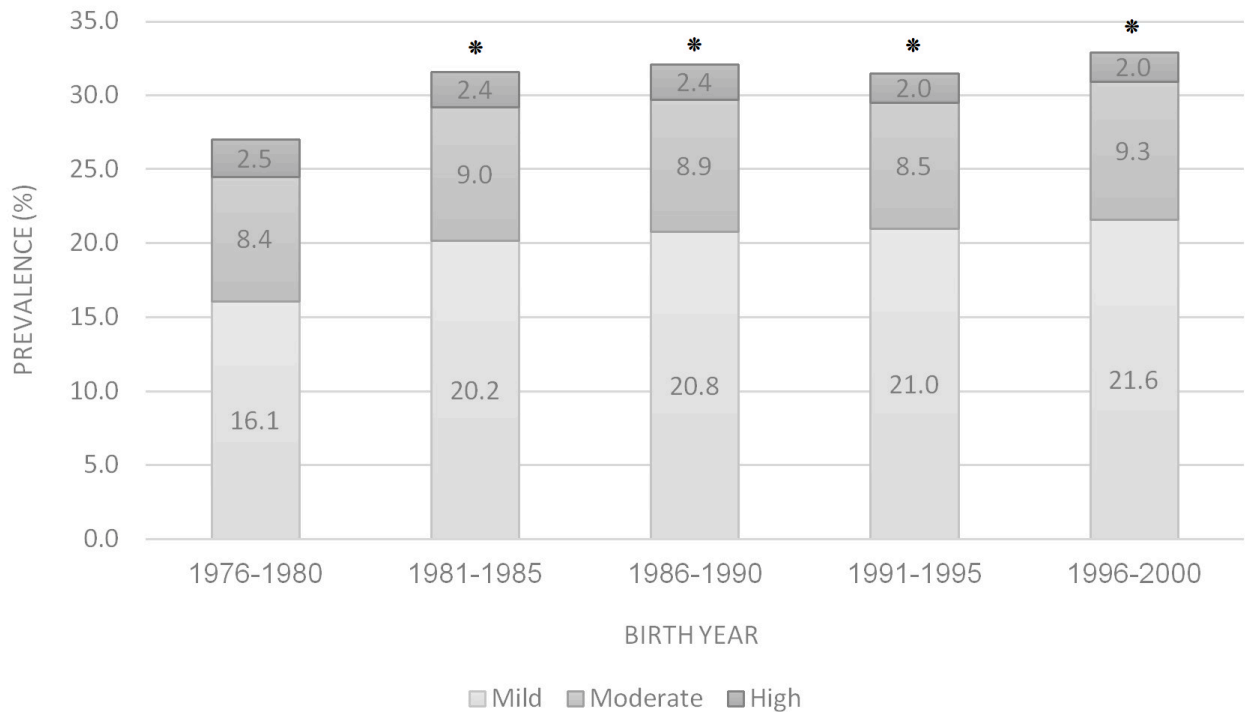


Figure 1

Prevalence of myopia by birth cohort and myopia severity

Mild myopia was defined as $-0.5 \leq \text{Spherical Equivalent (SE)} < -3.0$ D, moderate myopia as $-3.0 \leq \text{SE} < -6.0$ D, and high myopia as $\text{SE} \leq -6.0$ D. $P < 0.001$ for overall myopia prevalence in each birth cohort compared with the 1976-1980 birth cohort.

Figure 2.

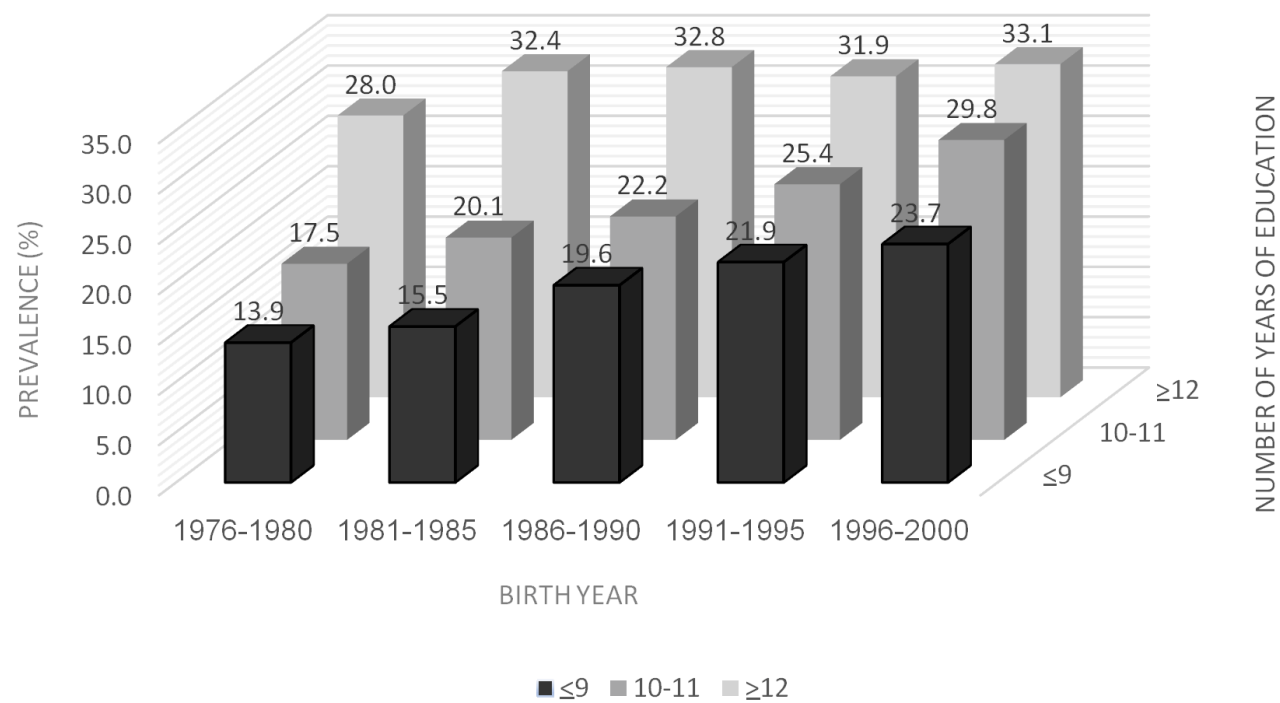


Figure 2

Prevalence of myopia by birth cohort and educational level

Educational level was categorised according to years of formal education as ≤9, 10-11, and ≥12 years; the ≥12-year category included higher and academic education.

Figure 3.

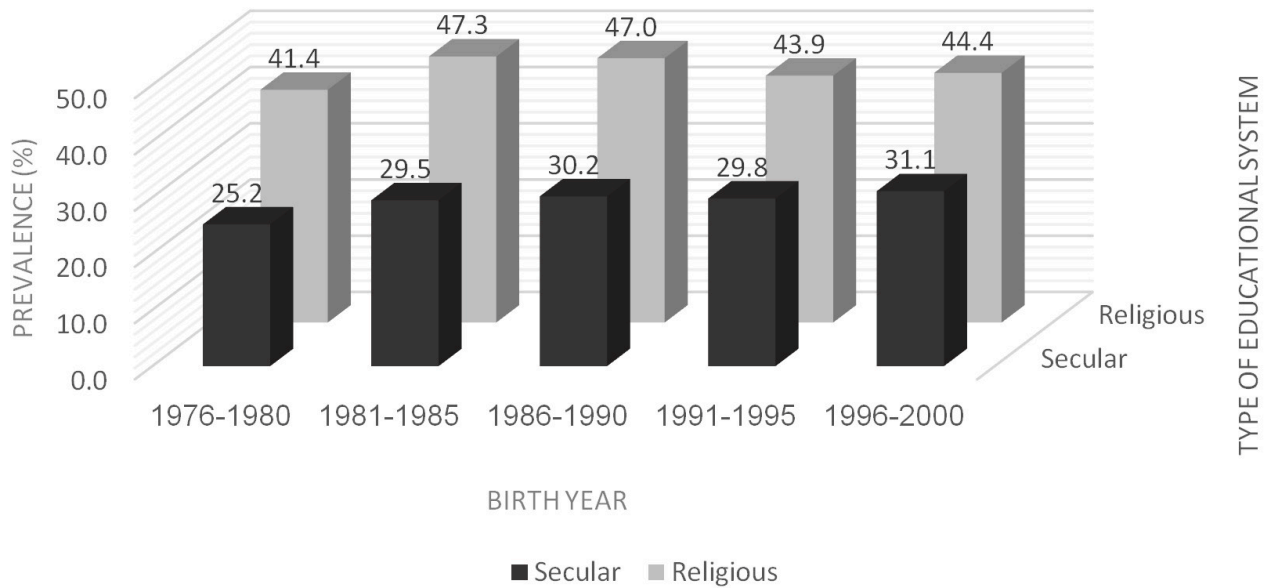


Figure 3

Prevalence of myopia by birth cohort and educational System

Temporal trends were significant in both educational systems (secular, $P < 0.001$; religious, $P = 0.008$).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [TableS2.pdf](#)
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- [FigureS1.pdf](#)
- [TableS3.pdf](#)
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