

# Self-reported myopia in Taiwan: 2005 Taiwan National Health Interview Survey

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## Abstract

**Purpose** To determine the prevalence of self-reported myopia nationwide in Taiwan and its association with degrees of urbanization and education levels.

**Methods** Data were obtained from the 2005 Taiwan National Health Interview Survey, a nationwide survey using multistage stratified systematic sampling. The presence of myopia, current residential areas, and education levels were ascertained by a structured questionnaire in participants  $\geq 12$  years of age.

**Results** A total of 20 609 eligible persons were included in this study. The overall weighted prevalence of myopia in Taiwan was 46.7% (95% confidence interval: 45.9, 47.5%). The prevalence of myopia for persons aged 12–19, 20–39, 40–64, and  $\geq 65$  years was 70.3%, 65.4%, 30.4%, and 5.6%, respectively. Women had significantly higher rates of myopia than men for persons younger than 40 years of age ( $P < 0.001$ ). Myopia was significantly associated with both higher degrees of urbanization of current residential areas and higher education levels (both  $P < 0.001$ ). In young adult and adult groups, the effect of education levels on myopia was stronger than that of degrees of urbanization. **Conclusion** The study provides a nationwide prevalence data on myopia in Taiwan. Both degrees of urbanization and education levels are risk factors for myopia.

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**Keywords:** myopia; self-reported; 2005 Taiwan National Health Interview Survey; epidemiology; prevalence

## Introduction

Myopia is the cause of a significant proportion of visual impairment. It decreases visual

function and thus influences daily activity performance. Eye care services to myopes who use or need optical correction, such as spectacles and contact lens, or refractive surgery involve considerable expense and impose a substantial economic burden.<sup>1</sup> Moreover, high myopia is a risk factor for several visually impaired ocular diseases such as rhegmatogenous retinal detachment, open-angle glaucoma, or myopic maculopathy.<sup>2</sup>

Myopia is highly prevalent worldwide, in particular in developing and developed Asian countries. In Taiwan, both prevalence and severity of myopia increased rapidly over the past two decades in young generations.<sup>3</sup> Nationwide surveys in schoolchildren aged 6–18 years in Taiwan reported a myopia prevalence of more than 80% by 18 years of age.<sup>4,5</sup> In the elderly ( $\geq 65$  years of age) Taiwanese, about 19% were myopic.<sup>6</sup> Prevalence data on other age groups, such as young adult and adult populations, in Taiwan are limited. To draw a general picture of current myopia prevalence in Taiwan across all age groups, we used data from the 2005 Taiwan National Health Interview Survey (NHIS) to estimate the prevalence of self-reported myopia in the population aged  $\geq 12$  years. In addition, we determined the association of self-reported myopia with the degree of urbanization of the current residential area and education levels.

## Materials and methods

### Study population

The Taiwan NHIS is a nationwide cross-sectional health survey that was conducted to study the general health of the resident civilian non-institutionalized population in Taiwan.<sup>7</sup> Details of the study design and sampling can be

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found elsewhere.<sup>8</sup> In brief, the NHIS was conducted from April to August 2005 in residents in Taiwan, using a multistage stratified systematic sampling scheme. The whole sample drawn was nationally representative.<sup>9</sup> A total of 359 townships/districts in Taiwan were divided into seven strata according to their geographical location and degree of urbanization.<sup>10</sup> Townships or districts in each stratum were selected with a selection probability proportional to size (PPS). In each selected township/district, *lins* (the smallest administrative unit) were again selected with PPS. Four households were selected randomly from each selected *lin*. Each member of these households was interviewed by trained interviewers using a structured questionnaire.

The selected households included a total of 30 680 residents; of them, 24 726 (80.6%) participated in the home interview. We excluded subjects aged below 12 years ( $n=3900$ ) and subjects with missing data on education levels ( $n=16$ ) or current residential places ( $n=201$ ), leaving us 20 609 subjects with complete data for the current analysis.

The study was approved by the ethics committee of the National Health Research Institutes and Bureau of Health Promotion, Taiwan, and performed in accordance with the tenets of the World Medical Association's Declaration of Helsinki.

### Data collection

Myopia status was self-reported by the survey participants and was ascertained by the question 'Did a doctor ever tell you that you have myopia? (yes/no/not sure/never examined)'. If the participants answered 'yes' to this question, they were then asked 'Is the myopia present in one or both eyes?' For the present analysis, myopia was defined if the participants answered 'yes' to the first question (ie, presence of myopia in one or both eyes), while non-myopia was defined if the participants answered 'no', 'not sure', or 'never examined'. Information on participants' education level and degree of urbanization of the current residential area was also collected using the questionnaire. Education levels were classified into four categories: elementary school and below (including illiterate), junior high school, senior high school, and college or above. Degrees of urbanization of current residential area were grouped into seven categories: village, agriculture town, aged town, general town, developing town, moderate urbanization, and high urbanization.<sup>10,11</sup> The degrees of urbanization were measured based on groupings of demographic characteristics, industrialization, and distribution of medical resource.<sup>10</sup>

### Statistical analysis

Analyses were performed by the following four age groups: 12–19, 20–39, 40–64, and  $\geq 65$  years of age. The prevalence of myopia was determined with appropriate sampling weighting to account for the complex sampling design, so that the estimates of prevalence would be representative of the whole non-institutionalized Taiwanese population. The association of myopia with degree of urbanization of current residential area and education levels was further analyzed with multivariate logistic regression models after adjustment for each other, age, and sex. In the age group of 12–19 years, we did not include education levels as independent variables in the multivariate regression models, because of the collinearity of age and education levels ( $\rho=0.88$ ,  $P<0.001$ ) in school-aged children and adolescents. All statistical analyses were performed using STATA statistical software (Version 10.0, StataCorp LP, College Station, TX, USA).

### Results

The characteristics of 20 609 participants included in the study by four age groups are summarized in Table 1. About one half (49.2%) of the participants lived in areas of moderate or high urbanization. The distribution of educational levels was different among the four groups. In participants aged  $\geq 20$  years, older persons generally had lower education levels than younger ones ( $P<0.05$ ).

The weighted prevalence of myopia by age groups and sex are presented in Table 2. The overall prevalence of self-reported myopia in Taiwan across all age groups was 46.7% (95% confidence interval: 45.9, 47.5%). The rate was the highest (70.3%) in participants aged 12–19 years, and decreased to 5.6% in those aged  $\geq 65$  years. The weighted prevalences of myopia by sex and age in 5-year intervals are shown in Figure 1. The highest prevalence was observed in the age group of 15–19 years. Women tended to have significantly higher rates of myopia than men before 40 years of age ( $P<0.001$ ), but there was no gender difference thereafter.

Table 2 also presents weighted prevalence by degrees of urbanization and education levels. The prevalence was significantly higher in residential areas with higher degree of urbanization ( $P<0.001$ ), and such a trend was consistent across all age groups. Persons with higher education levels were more likely to have myopia than those with lower education levels ( $P<0.001$ ) in all age groups.

Table 3 shows the association of myopia with degrees of urbanization and education levels, after adjustment

**Table 1** Characteristics of participants by age groups

Characteristics	Age group (years)			
	12–19 (N = 2978)	20–39 (N = 7453)	40–64 (N = 7480)	≥ 65 (N = 2698)
<i>Sex</i>				
Male	1569 (52.7)	3873 (52.0)	3743 (50.0)	1335 (49.5)
Female	1409 (47.3)	3580 (48.0)	3737 (50.0)	1363 (50.5)
<i>Degrees of urbanization</i>				
Village	65 (2.2)	189 (2.5)	240 (3.2)	144 (5.3)
Agriculture town	207 (7.0)	462 (6.2)	551 (7.4)	324 (12.0)
Aged town	44 (1.5)	96 (1.3)	145 (1.9)	102 (3.8)
General town	481 (16.2)	995 (13.4)	1122 (15.0)	491 (18.2)
Developing town	716 (24.0)	1772 (23.8)	1648 (22.0)	475 (17.6)
Moderate urbanization	997 (33.5)	2583 (34.7)	2509 (33.5)	778 (28.8)
High urbanization	468 (15.7)	1356 (18.2)	1265 (16.9)	384 (14.2)
<i>Education levels</i>				
Elementary school or below	300 (10.1)	139 (1.9)	2662 (35.6)	2147 (79.6)
Junior high school	1220 (41.0)	899 (12.1)	1474 (19.7)	211 (7.8)
Senior high school	1156 (38.8)	2768 (37.1)	1989 (26.6)	166 (6.2)
College or above	302 (10.1)	3647 (48.9)	1355 (18.1)	174 (6.4)

Data are presented as number (%).

**Table 2** Prevalence of self-reported myopia by sex, education level, and degree of urbanization by age groups

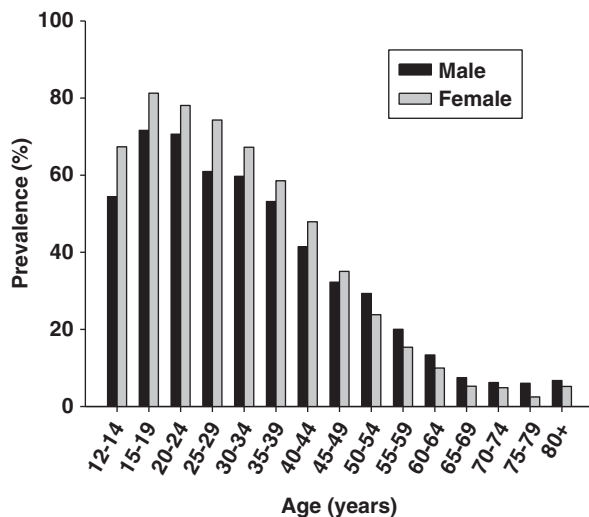
Characteristics	Prevalence, % (95% confidence intervals) (years)			
	12–19	20–39	40–64	≥ 65
Overall	70.3 (68.5–72.0)	65.4 (64.2–66.5)	30.4 (29.2–31.6)	5.6 (4.5–6.6)
<i>Sex</i>				
Male	65.0 (62.4–67.6)	61.2 (59.5–62.9)	30.4 (28.7–32.1)	6.6 (5.0–8.3)
Female	75.8 (73.4–78.2)	69.7 (68.0–71.3)	30.4 (28.7–32.0)	4.6 (3.2–5.9)
	$P < 0.001$	$P < 0.001$	$P = 0.585$	$P = 0.699$
<i>Degrees of urbanization</i>				
Village	60.9 (48.0–73.9)	51.8 (43.9–59.6)	10.5 (6.4–14.7)	0.7 (–0.7–2.1)
Agriculture town	64.3 (57.1–71.6)	50.5 (45.6–55.3)	16.1 (12.8–19.4)	3.1 (0.7–5.5)
Aged town	62.0 (44.6–79.3)	52.8 (40.8–64.7)	25.9 (17.0–34.7)	5.6 (–0.8–12.0)
General town	60.1 (55.3–64.9)	56.8 (53.4–60.2)	19.8 (17.1–22.6)	3.3 (1.5–5.2)
Developing town	67.3 (63.6–71.0)	63.7 (61.3–66.1)	25.2 (22.9–27.5)	2.6 (1.0–4.2)
Moderate urbanization	72.9 (69.8–76.0)	66.9 (64.9–68.9)	35.0 (32.9–37.2)	6.1 (4.1–8.1)
High urbanization	78.3 (74.5–82.1)	73.7 (71.3–76.1)	40.2 (37.4–43.1)	11.4 (8.0–14.8)
	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
<i>Education levels</i>				
Elementary school or below	49.1 (42.8–55.4)	15.9 (9.3–22.6)	8.9 (7.6–10.1)	3.2 (2.3–4.1)
Junior high school	65.0 (62.1–67.9)	34.8 (31.3–38.3)	22.2 (19.8–24.6)	8.1 (3.7–12.5)
Senior high school	76.3 (73.6–79.0)	54.9 (52.9–56.9)	39.7 (37.3–42.1)	12.8 (6.7–18.8)
College or above	85.6 (81.4–89.8)	81.2 (79.9–82.6)	61.1 (58.3–64.0)	20.0 (13.4–26.5)
	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

for each other, age, and sex. The effect of education levels on myopia was stronger than that of degrees of urbanization in the age groups of 20–39 and 40–64 years. Compared with participants whose education levels were elementary school or below, those

whose education levels were college or above had a 20.4-fold increased risk of myopia in the age group of 12–19 years, a 11.7-fold increased risk in the age group of 20–39 years, and a 5.9-fold higher risk in the elderly group.

## Discussion

The 2005 NHIS survey provided the first large-scale, population-based, cross-sectional data on the prevalence of myopia in Taiwanese aged  $\geq 12$ . Our results showed an overall myopic prevalence of 46.7% in Taiwan. The prevalence of myopia reached the peak at the age of 15–19 years and gradually decreased after puberty. We acknowledge that one of the major limitations with the present study was that the presence of myopia was self-reported and not clinically verified. However, with a sample size of more than 20 000 participants spanning over a wide range of age groups, we were able to demonstrate the age-specific gradients of myopia.



**Figure 1** Weighted prevalence of self-reported myopia by age groups and sex in the 2005 Taiwan National Health Interview Survey.

Previous nationwide surveys of myopia in Taiwanese schoolchildren reported that the myopic rates were 61% at the age of 12 years, 81% at the age of 15 years, and 84% from the age of 16 to 18 years in 2000.<sup>3</sup> In the elderly group ( $\geq 65$  years), the Shihpai Eye Study in Taipei, Taiwan, reported that the prevalence of myopia was 19.4%. We noted that the corresponding rates of myopia in the present study were 53.8% at the age of 12 years, 72.3% at the age of 15 years, 77.7% from the age of 16 to 18 years, and 5.6% at the age of  $\geq 65$  years. Compared with the previous surveys where myopia was clinically measured, the prevalence estimates from the present study were relatively lower. At least two reasons may account for this difference. First, very mild myopia may not cause visual disturbance and thus could be easily ignored by schoolchildren or the elderly, leading to under-reporting of myopia. Second, nuclear cataract is known to cause a myopia shift in refraction in the elderly,<sup>12–14</sup> but they might not be aware of this change. Therefore, the prevalence of myopia was likely to be underestimated in the present study owing to information bias.

Education levels have been known to be associated with myopia.<sup>3,12,14</sup> In the Visual Impairment Project in Australia,<sup>14</sup> prevalence of myopia was significantly higher in participants with higher education levels. In the Tanjong Pagar Study in Singapore,<sup>12</sup> increasing education levels were significantly associated with higher rates of myopia in adult Chinese, after adjustment for age and sex. An analysis including five large-scale, population-based surveys of schoolchildren between 7 and 18 years of age in Taiwan also indicated that the prevalence of myopia was associated with education levels.<sup>3</sup> Our results confirmed previous studies that education levels were strongly associated with myopia.

**Table 3** Association of myopia, education levels, and degrees of urbanization by age groups

	Odds ratio (95% confidence intervals) (years)			
	12–19	20–39	40–64	$\geq 65$
<i>Degrees of urbanization</i>				
Village	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Agriculture town	1.04 (0.57–1.90)	0.88 (0.58–1.31)	1.34 (0.81–2.21)	4.33 (0.51–36.54)
Aged town	0.90 (0.38–2.09)	1.09 (0.57–2.08)	3.17 (1.63–6.17) <sup>a</sup>	9.65 (0.94–98.51)
General town	0.88 (0.51–1.52)	1.03 (0.71–1.51)	1.60 (1.00–2.55) <sup>a</sup>	4.70 (0.60–36.71)
Developing town	1.61 (0.94–2.75)	1.30 (0.90–1.88)	2.03 (1.30–3.19) <sup>a</sup>	3.31 (0.41–26.53)
Moderate urbanization	1.21 (0.71–2.08)	2.44 (1.57–3.80) <sup>b</sup>	2.44 (1.57–3.80) <sup>b</sup>	6.07 (0.81–45.78)
High urbanization	2.16 (1.23–3.79) <sup>b</sup>	1.62 (1.11–2.35) <sup>a</sup>	2.97 (1.89–4.65) <sup>b</sup>	10.47 (1.38–79.31) <sup>b</sup>
<i>Education levels</i>				
Elementary school or below	—	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Junior high school	—	3.03 (1.78–5.18) <sup>b</sup>	2.23 (1.79–2.78) <sup>b</sup>	2.32 (1.12–4.81) <sup>b</sup>
Senior high school	—	6.17 (3.67–10.36) <sup>b</sup>	4.91 (4.04–5.97) <sup>b</sup>	3.60 (1.83–7.09) <sup>a</sup>
College or above	—	20.37 (12.10–34.31) <sup>b</sup>	11.73 (9.49–14.49) <sup>b</sup>	5.90 (3.16–11.02) <sup>a</sup>

Data are odds ratios of myopia, adjusted for age, sex, and degrees of urbanization or education levels.

<sup>a</sup> $P < 0.05$ .

<sup>b</sup> $P < 0.001$ .

Recent studies reported that in Asia myopia rates varied widely between urban and rural populations.<sup>15,16</sup> In Taiwan, compared with schoolchildren living in towns or villages, those living in cities had much higher myopic refraction.<sup>3</sup> Consistently, our study showed that degrees of urbanization were strongly associated with myopia, particularly in the age groups of 20–39 and 40–64 years. This suggests that in recent cohorts, crowded living environments account for the observed increase in myopia prevalence in part. The housing type of apartment residence, which is more common in cities, may contribute to the high rates of myopia in areas of higher degrees of urbanization.<sup>17</sup>

We found that prevalence of myopia was higher in females than in males, particularly in persons aged 12–39 years. Similarly, myopia was more prevalent and severe in girls than in boys in prior surveys in Taiwan.<sup>3</sup> Data from the 1999–2004 National Health and Nutrition Examination Survey in the United States also supported this gender difference.<sup>18</sup> The reasons for such a gender difference are not exactly known. There are possible gender differences in emmetropization mechanisms in young children.<sup>19</sup> Girls reach puberty at earlier ages than do boys, and the pubertal growth spurt may contribute to excess myopia in girls.<sup>19</sup>

In summary, the present study provides the first large-scale data on the prevalence of self-reported myopia across all age groups in Taiwan. The rates of myopia reached the peak at the age of 15–19 years and then gradually decreased with age. Findings from this survey confirm previous reports of higher myopia prevalence in persons with higher levels of education or living in areas with higher degrees of urbanization. Further research is needed to characterize which specific aspects of urban living environments contribute to myopia.

## Summary

### What was known before

- In Taiwan, both prevalence and severity of myopia increased rapidly over the past two decades in young generations. Nationwide surveys in schoolchildren aged 6–18 years in Taiwan reported a myopia prevalence of more than 80% by 18 years of age. In the elderly ( $\geq 65$  years of age) Taiwanese, about 19% were myopic.

### What this study adds

- This study provides the first large-scale data on the prevalence rates of self-reported myopia across all age groups in Taiwan. We observed that the rates of myopia reached the peak at the age of 15–19 years and then gradually decreased with age. Findings from this survey confirm previous reports of higher myopia prevalence in persons with higher levels of education or living in areas with higher degree of urbanization.

## Conflict of interest

The authors declare no conflict of interest.

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