· Meta analysis ·

Prevalence of myopia among primary school students in mainland China: a Meta-analysis

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中国大陆地区小学生近视患病率 Meta 分析

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摘要

目的:评价 1980/2013 年中国大陆地区小学生近视患病率。中国大陆人群尤其是儿童的近视眼患病率高,近视已然成为突出的公共卫生问题,而至今国内仍缺乏基于全国人群的小学生近视眼患病率的研究。

方法:系统检索万方数据库、中国(CNKI)学术文献总库和 PubMed 数据库相关文献,检索时间截止 2013 年 12 月 31 日;两名评阅者提取纳入文献的相关信息,Meta 分析采用 Meta-Analyst 3.13 软件。

结果:共纳入符合条件发表于 1980/2013 年间的文献 37 篇,总调查人数 245 248 人。纳入人群的近视眼患病率为 26.5%(95%*CI*:21.8% ~31.7%);近视眼患病率随年龄增长而上升(6~8 岁 8.4% 到 12~14 岁 57.4%)。

结论:中国大陆地区小学生近视眼患病率明显高于西方国家和地区,年龄增加近视眼患病率上升。该研究可能对大陆地区小学生近视眼防治具有参考价值。

关键词:近视眼;患病率;Meta 分析;小学生;中国

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Abstract

• AIM: To estimate the pooled prevalence of myopia among primary school students in mainland China during 1980-2013. Myopia had become a growing public health issue, with high prevalence rates in mainland China, particularly among children. However, we still had no population-based nationwide studies of the prevalence of myopia among primary school students in recent years.

• METHODS: Wanfang, Chinese National Knowledge Infrastructure and PubMed databases were searched independently until Dec. 31, 2013 to identify relevant articles. Data from the eligible articles were extracted by two reviewers. All of the data analyses were conducted using Meta-Analyst software (version 3.13, USA).

• RESULTS: Thirty - seven eligible studies published between 1980 and 2013 were selected with a total of 245248 individuals. The pooled prevalence of myopia among the included individuals was 26.5% (95% CI: 21.8%-31.7%). The prevalence of myopia increased with age (from 8.4% at 6-8y to 57.4% at 12-14y).

• CONCLUSION: The pooled prevalence of myopia among primary school students in mainland China was much higher than that of western countries or regions. The prevalence of myopia increased with age among primary school students. This study should be valuable for myopia prevention and treatment in mainland China.

• KEYWORDS: myopia; prevalence; Meta - analysis; primary school students; China
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INTRODUCTION

Myopia is the leading cause of visual impairment among refractive errors, and its prevalence has been increasing globally[1-3]. It has been reported that myopia rates in East Asia, particularly among the Japanese and Chinese populations, are much higher than in European populations[4].

Myopia has become a growing public health issue with high prevalence rates in mainland China, particularly in children. For instance, according to a report on physical fitness and health research regarding Chinese school students, the prevalence of visual impairment among primary school students between 7 and 12y was 40.9% in 2010 (48.8% in urban and 33.0% in rural areas), which increased by 9.2 percentage points compared with that in 2005[5].

Meta-analysis is a useful statistical tool for pooling data from individual studies and thereby increasing the statistical power and the precision of effect estimates. However, there have been no studies analyzing the prevalence of myopia in the Chinese population using Meta-analysis. The objective of this study was to summarize the prevalence of myopia among primary school students in mainland China and to inform broader initiatives.

SUBJECTS AND METHODS

Literature and Search Strategy The Wanfang, Chinese National Knowledge Infrastructure (CNKI) and PubMed databases were searched for relevant articles published between Jan. 1st, 1980 and Dec. 31st, 2013. Combinations of keywords and medical subject headings "myopia OR shortsightedness OR near-sightedness OR visual impairment OR refractive errors", "student OR students", "prevalence OR incidence" and "China" were used to search for potentially relevant studies. English and Chinese language restrictions were applied. No attempts were made to retrieve unpublished studies.

Inclusion and Exclusion Criteria To meet the analysis requirements and to reduce deviations, the studies included in the Meta-analysis had to meet the following inclusion criteria: 1) population-based studies; 2) focusing on primary school students aged between 6 and 14y; 3) studying prevalence of myopia; 4) conducted in mainland China; 5) having clear diagnostic criteria for myopia; 6) consisting of original research; 7) containing a sample size more than 500. The exclusion criteria were reviews and studies with insufficient information on the prevalence of myopia.

Data Extraction Data from eligible studies were extracted independently by two reviewers (Xu XQ and Wei J). The following information was extracted from each study: first author and year of publication; study site and period; sample size; myopia criteria; and prevelance of myopia. Disagreements between the two reviewers during data extraction were reconciled by a third investigator (Li SP). The data from all of the included studies were clearly tabulated, and deviations were considered and identified during the whole process.

Data Analysis Meta-analyses were conducted using Meta-Analyst software (version 3.13, National Center for Research Resources, Agency for Healthcare Research and Quality, Tufts Medical Center, Boston, MA, USA) to calculate the pooled prevalence of myopia among primary school students from all of the eligible studies. A summary of prevalence estimates was obtained using fixed-effects Meta-analysis or random-effects Meta-analysis, which was determined by I^2. Statistical heterogeneity was assessed by I^2 and its values of 25%, 50% and 75%, which represented low, moderate and high heterogeneity, respectively[6]. In this study, the type of Meta-analysis chosen was based on the rate (I^2). Subgroup analyses, including age, region and published year(s) and criteria, were also conducted. Additionally, sensitivity analysis was applied to compare the overall prevalence

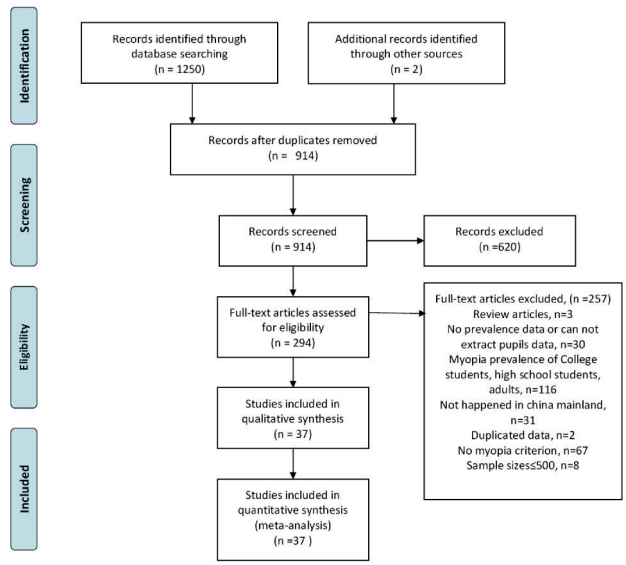

Figure 1 Flow diagram.

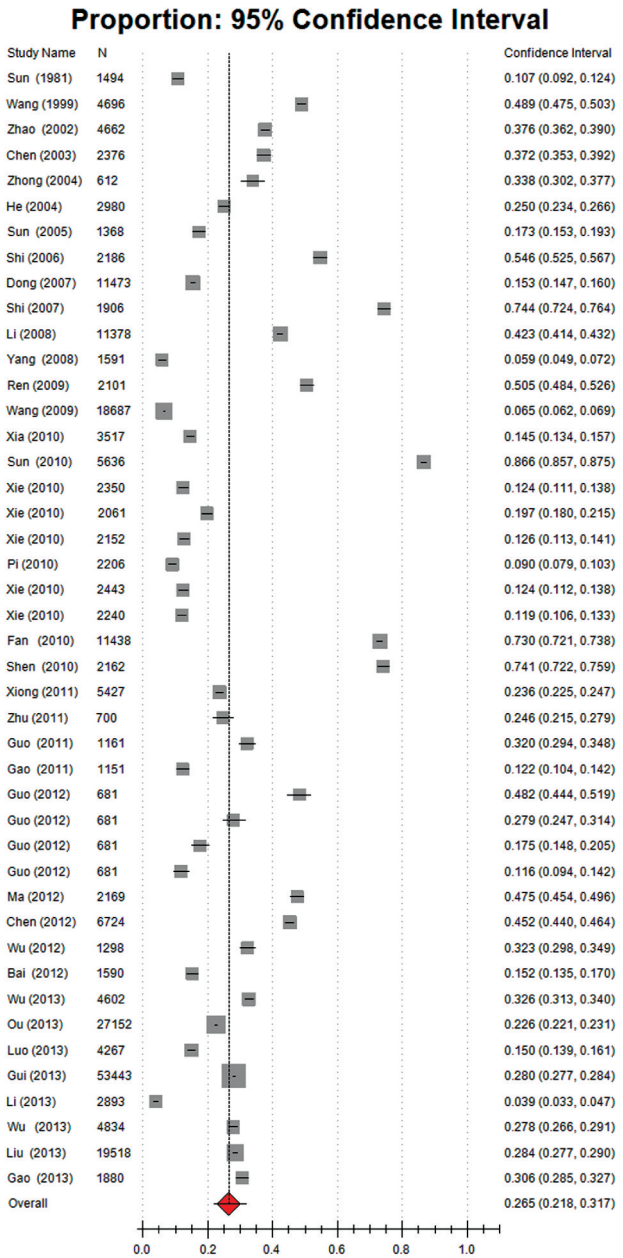

Figure 2 Forest plot of the prevalence studies of myopia among primary school students in mainland China.

Table 1 Characteristics of studies included in the Meta-analysis

First author(a)	Source or database	Year of data collection	*N*	Age criterion for study entry(a)	City, state, or region	Myopia diagnostic criteria	Prevalence (*n*/*N*)
Sun *et al*[7](1981)	CNKI	1981	7024	8-13(Grade 1-5)	Yishui	SE≤-0.25D	160/1494
Wang *et al*[8](1999)	Wanfang & CNKI	1995-1996	4696	6-13(Grade 1-6)	Wenzhou	SE≤-3.00D	2296/4696
Zhao *et al*[9](2002)	PubMed	1998	4662	5-13	Shunyi	SE≤-0.50D	1753/4662
Chen *et al*[10](2003)	Wanfang & CNKI	2001	2376	6-13	Shenzhen	SE≤-0.250D	885/2376
Zhong *et al*[11](2004)	Wanfang & CNKI	2004	612	8-12(Grade 2-6)	Jinan	SE≤-0.50D	207/612
He *et al*[12](2004)	PubMed	2002-2003	5053	6-13	Guangzhou	SE≤-0.50D	744/2980
Sun *et al*[13](2005)	Wanfang & CNKI	2004	1368	6-14(Grade 1-6)	Changshandao	SE≤-0.25D	236/1368
Shi *et al*[14](2006)	Wanfang & CNKI	2004	2186	7-9(Grade 1-3)	Xi'an	SE<-0.50D	1194/2186
Dong *et al*[15](2007)	Wanfang & CNKI	2002-2005	35944	7, 13	Tongliao	SE≤-0.50D	1759/11473
Shi *et al*[16](2007)	Wanfang & CNKI	2004	1906	9-13(Grade 4-6)	Xi'an	SE<-0.50D	1419/1906
Li *et al*[17](2008)	Wanfang	2007	18000	6-11	Dongguan	SE≤-0.50D	4814/11378
Ren *et al*[18](2008)	Wanfang	2007	4202	6-13	Zhongshan	SE≤-0.75D	1061/2101
Yang *et al*[19](2008)	Wanfang & CNKI	2005-2007	2984	7-10	Yichun	SE≤-0.50D	94/1591
Wang[20](2009)	Wanfang & CNKI	2007	18687	6-13	Fu'an	SE≤-0.50D	1215/18687
Xia *et al*[21](2010)	Wanfang & CNKI	2009	3517	6-13	Qingpu	SE<-0.50D	511/3517
Fan *et al*[22](2010)	Wanfang & CNKI	2005-2007	19866	6-13	Gansu	SE≤-3.00D	8346/11438
Shen[23](2010)	Wanfang & CNKI	2009	3322	7-14(Grade 1-5)	Luwan	SE≤-0.50D	1602/2162
Sun[24](2010)	Wanfang & CNKI	2008	6531	6-13(Grade 1-6)	Shanghai	SE<0D	4882/5636
Pi *et al*[25](2010)	PubMed	2006-2007	3469	6-12	Yongchuan	SE≤-0.50D	199/2206
Xie *et al*[26](2010)	Zhonghuayixuezazhi	2008-2009	11246	6-13(Grade 1-6)	5 Provinces[b]	SE<-0.50D	291/2350; 303/2443; 406/2061; 267/2240; 271/2152
Xiong[27](2011)	Wanfang & CNKI	2010	9937	6-12	Shanghai	SE≤-0.75 D	1297/5427
Guo[28](2011)	Wanfang & CNKI	2011	2628	Grade 1-6	Jinan	SE≤-0.75 D	372/1161
Gao *et al*[29](2011)	Wanfang & CNKI	2009	2480	Grade 1-6	Lianyungang	SE≤-0.50D	140/1151
Zhu *et al*[30](2011)	Wanfang & CNKI	2006	1464	6-13	Chengdu	SE≤-0.50D	172/700
Guo et al[31](2012)[a]	Wanfang & CNKI	-	681	6-7,9-10(Grade1,4)	Beijing	SE≤-0.50D	328/681; 190/681; 119/681; 79/681
Ma[32](2012)	Wanfang & CNKI	2011	3097	6-13	Hangzhou	SE≤-0.50D	1031/2169
Chen[33](2012)	Wanfang & CNKI	2011	9086	6~12	Shanghai	SE≤-0.75 D	3040/6724
Wu[34](2012)	Wanfang	2011-2012	1922	6-13	Kara may	SE≤-0.50D	419/1298
Bai *et al*[35](2012)	Wanfang & CNKI	2009	1590	Grade1-6	Nanjing	SE≤-0.50D	241/1590
Ou[36](2013)	CNKI	-	52536	6-13	Chenzhou	SE≤-0.50D	6128/27152
Luo *et al*[37](2013)	Wanfang & CNKI	2009-2012	4276	7-12	Baotou	SE≤-0.50D	638/4267
Gui *et al*[38](2013)	Wanfang & CNKI	2011-2013	94963	6-13(Grade1-6)	Wuhu	SE≤-0.75D	14983/53443
Wu *et al*[39](2013)	Wanfang & CNKI	2011-2012	4834	7 and 12	Liuzhou	SE≤-0.50D	1345/4834
Liu *et al*[40](2013)	Wanfang & CNKI	2011-2012	37700	Grade 1-6	Cixian	SE≤-0.25D	5534/19518
Gao[41](2013)	Wanfang & CNKI	2011	1880	Grade 1-6	Chongqing	SE≤-0.50D	575/1880
Li *et al*[42](2013)	PubMed	2011-2012	2893	7.1(5.7-9.3)	Anyang	SE≤-0.50D	113/2893
Wu *et al*[43](2013)	PloS one	2011-2012	6364	4-18(6-13)	Guanxian	SE≤-0.50D	1501/4602

SE: Spherical equivalent; *n*: number of events (myopia); *N*: Total number of primary school students from the included studies; [a]In this study, the criteria were used: SE≤-0.50D, SE≤-1.00D, SE≤-1.50D, SE≤-2.00D; [b]5 Provinces included Zhejiang, Yunnan, Shandong, Qinghai, and Shanghai.

of myopia among primary school students by excluding the included studies one by one.

RESULTS

Characteristics of the Studies A total of 1 252 potentially relevant articles were identified. Of these, 958 were excluded after reading the titles and abstracts because of duplications (338 articles) and obvious irrelevance (620 articles). Three review articles and 2 articles with data duplication were excluded. Thirty articles were excluded because of the study sites, 8 articles were excluded for small sample sizes, and 116 articles were excluded because the study populations were not primary school students. In addition, 30 articles were excluded because they did not provide information on the prevalence of myopia or it was not possible to extract information on primary school students. There were 37 articles remaining after the quality assessment (Figure 1). Table 1 shows the characteristics of 37 articles, which covered 21 provinces in mainland China. The prevalence of myopia and

Table 2 Stratified Meta-analyses of myopia prevalence among primary school student in mainland China

Subgroup		Prevalence of myopia (%)	*n*/*N*	No. of studies	Heterogeneitytest		
					Q	I^2(%)	*P*
Region	Western China	32.2(15.4,53.3)	12894/26297	8	1.0	50.0	<0.001
	Central China	12.8(9.4,17.3)	23715/100819	6	1.0	49.9	<0.001
	Eastern China	28.5(22.4,35.5)	36533/118132	24	1.0	50.0	<0.001
	Overall	26.5(21.8,31.7)	73142/245248	37[a]	1.0	50.0	<0.001
Grade	Grade 1(6-8)	8.4(5.0,13.8)	2709/16708	18	1.0	49.8	<0.001
	Grade 2(8-9)	16.8(10.1,26.8)	2811/9639	17	1.0	49.8	<0.001
	Grade 3(9-10)	26.2(17.1,37.9)	3387/9159	17	1.0	49.8	<0.001
	Grade 4(10-11)	35.0(25.8,45.4)	5456/12003	18	1.0	49.8	<0.001
	Grade 5(11-12)	44.5(33.1,56.5)	4901/9728	17	1.0	49.8	<0.001
	Grade 6(12-14)	57.4(45.5,68.6)	9700/14406	16	1.0	49.8	<0.001
	Overall	27.5(23.2,32.3)	28964/71643	20[b]	1.0	49.8	<0.001
Published year	Before 2005	28.3(20.4,37.8)	6281/18188	7	1.0	49.9	<0.001
	2006-2010	28.6(16.7,44.4)	28634/85527	13	1.0	50.0	<0.001
	2011-2013	24.3(21.3,27.6)	38227/141533	17	1.0	49.9	<0.001
	Overall	26.5 (21.8,31.7)	73142/245248	37	1.0	50.0	<0.001
Criteria	SE≤-0.25D	21.8(14.7,31.1)	6815/24756	4	1.0	49.8	<0.001
	SE<-0.50D	22.8(11.1,41.1)	4662/18855	4	1.0	50.0	<0.001
	SE≤-0.50D	23.0(17.4,29.7)	25018/108968	21	1.0	49.9	<0.001
	SE≤-0.75D	35.2(26.3,45.3)	20735/68856	5	1.0	49.9	<0.001
	Other[c]	43.0(24.5,63.8)	15912/23813	4	1.0	50.0	<0.001
	Overall	26.5 (21.8,31.7)	73142/245248	38[d]	1.0	50.0	<0.001

[a]One study cover 5 provinces, including Zhejiang, Shandong, Shanghai (Eastern China), and Qinghai, Yunnan (Western China); [b]Not all studies give the information of all grades; [c]The other criteria included SE≤-1.00D, SE≤-1.50D, SE≤-2.00D, SE≤-3.00D, SE<0D; [d]In one study the myopia criteria included SE≤-0.50D and other criteria, including SE≤-1.00 D, SE≤-1.50D,SE≤-2.00D.

95% CIs among primary school students were calculated separately for each study, and the sample sizes and published years were also presented (Figure 2).

Meta-analysis Results The prevalence of myopia and 95% CIs of all included studies are shown in Figure 2. The provinces and geographic regions of the studies included: 2 studies in Beijing municipality, 1 study in Fujian Province, 4 studies in Guangdong Province, 1 study in Hebei Province, 2 studies in Jiangsu Province, 5 studies in Shanghai, 3 studies in Zhejiang Province, 1 study in Guangxi Province and 5 studies in Shandong Province in eastern China; 1 study in Anhui Province, 2 studies in Inner Mongolia Autonomous Region, 1 study in Henan Province, 1 study in Hunan Province and 1 study in Jiangxi Province in central China; 2 studies in Chongqing, 1 study in Qinghai Province, 2 studies in Shanxi Province, 1 study in Sichuan Province, 1 study in Gansu Province, 1 study in Xinjiang Uygur Autonomous Region and 1 study in Yunnan Province in western China. According to the forest plot, the 95% confidence interval line for all included studies does not intersect the invalid line (horizontal axis is 0), all included studies were statistically significant.

The pooled prevalence among primary school students was 26.5% (95% CI: 21.8%-31.7%). The pooled prevalence was 32.2% (15.4%-53.3%) in western China, 12.8% (9.4%-17.3%) in central China and 28.5% (22.4%-35.5%) in eastern China, respectively (Table 2).

Table 2 demonstrates the subgroup analysis of pooled prevalence of myopia among different subgroups. The pooled prevalence with 95% CI increased from 8.4% (5.0%-13.8%) in Grade 1 to 57.4% (45.5%-68.6%) in Grade 6. The pooled prevalence in studies conducted before 2005 was 28.3% (20.4%-37.8%), 28.6% (16.7%-44.4%) in 2006-2010, and 24.3% (21.3%-27.6%) in 2011-2013. Table 2 also demonstrates the prevalence of myopia with different diagnostic criteria. The pooled prevalence was 21.8% (14.7%-31.1%) with SE≤-0.25D, 22.8% (11.1%-41.1%) with SE<-0.50D, 23.0% (17.4%-29.7%) with SE≤-0.50D, 35.2% (26.3%-45.3%) with SE≤-0.75D, 43.0% (24.5%-63.8%) based on other criteria.

Sensitivity analyses were performed by excluding studies one by one to estimate the pooled prevalence of myopia among primary school students in mainland China (Figure 3). The pooled prevalence showed similar results with no statistically significant differences. Figure 4 shows that the included studies are roughly funnel-shaped distribution, suggesting that publication bias can be ignored.

DISCUSSION

To the best of our knowledge, this is the first Meta-analysis to estimate the pooled prevalence of myopia among primary school students in mainland China. In this Meta-analysis, the prevalence of myopia among primary school students in mainland China reported in studies over the last three decades

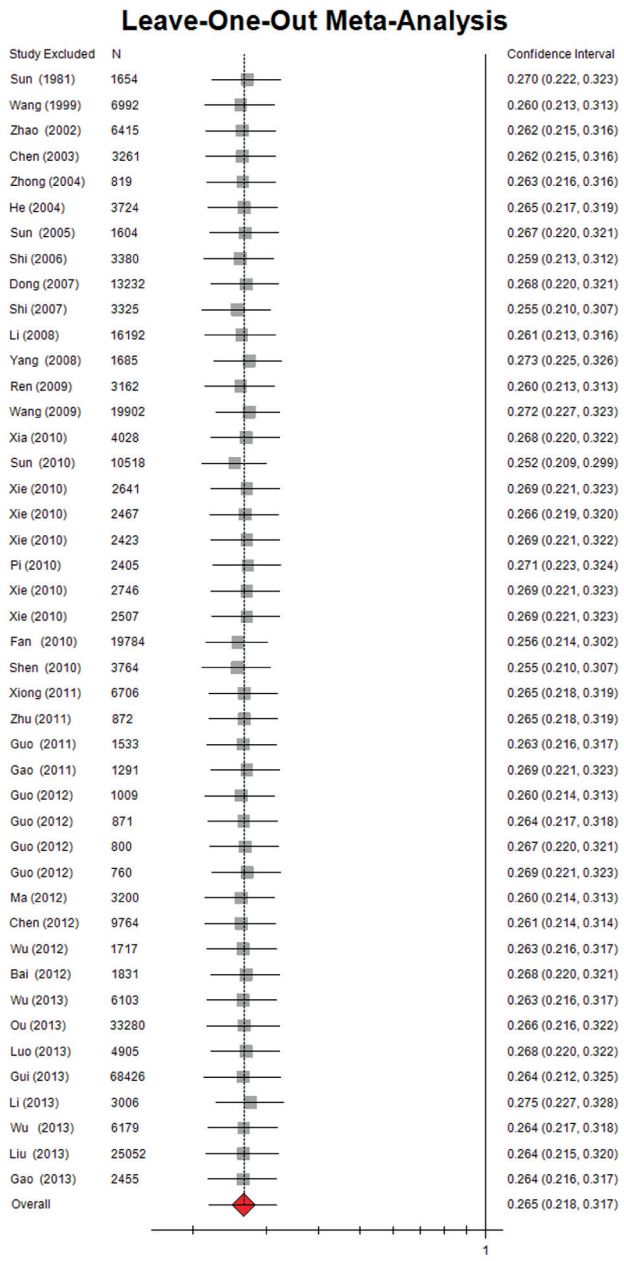

Figure 3 Sensitivity analysis of the included studies.

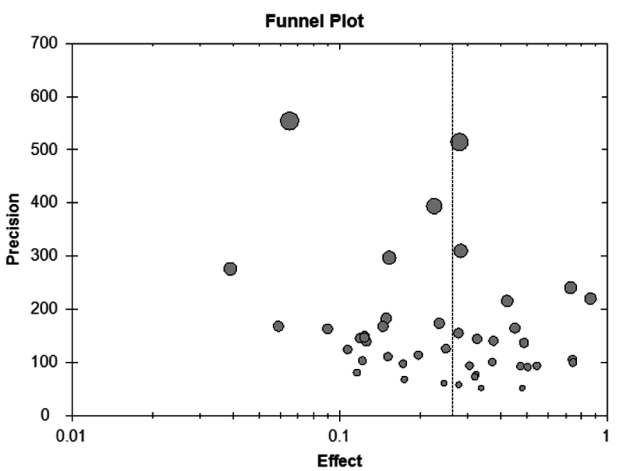

Figure 4 The funnel plot of the 37 included studies.

was pooled. A total of 37 studies with more than 240 000 individuals were included, and the pooled prevalence of myopia was 26.5% (95% CI: 21.8% – 31.7%). The evidence indicates an increasing trend in the prevalence of myopia with grades among primary school students.

The prevalence of myopia is increasing yearly worldwide[44]. Many studies have shown a higher prevalence of myopia among primary school students, particularly in Asia[45-46]. The prevalence of myopia among primary school students in mainland China was similar with that reported in the literature, which were conducted in Asia[47-49]. However, the prevalence of myopia in our study was much higher than that in western countries, such as the United Kingdom, Australia and South Africa[50-52] (see Table 3 for details). In the USA, Asians have been found to have a higher prevalence of myopia than Hispanics, Caucasian and African Americans, suggesting that ethnicity is a factor influencing the prevalence of myopia[51]. Some studies have indicated that the more intensive schooling systems in Asia might also be an independent risk factor for myopia[53-55].

Stratified analyses were used in this study in terms of regions, age, published years of studies and diagnostic criteria. Most of the individuals came from eastern or central China. However, the prevalence of myopia was highest in western China and lowest in central China. The difference might be explained by the following considerations: the limited number of studies in western and central China, the different study facilities and life customs, the limited sample size in western China, and inconsistent diagnostic criteria. For instance, the bad learning environment in western China and heavy academic burden in eastern China might be contributable to this difference[56-57]. Therefore, further research should be conducted to investigate these potential associations. The prevalence of myopia is increasing with age among primary school students, and this finding is consistent with results in other countries, and the natural history of myopia[45,51]. The prevalence of myopia among children in Grade 6 (12-14y) was 7 times greater than that among children in Grade 1 (6-8y). This finding might be related to the growing academic burden, increased use of electronic devices and insufficient outdoor activities[58-59]. The prevalence of myopia based on the SE≤-0.25D and SE<-0.50D criteria in the included studies was obviously lower than that based on other criteria. In addition, various measurements for adolescent myopia prevention have been taken recently by governments, relevant agencies and schools. For instance, *Opinion of the Central Committee of the Communist Party of China and State Council on strengthening the physical education of teenagers*, a policy of China, has been implemented in 2007 and one of its primary objectives is to significantly decrease the incidence of myopia among adolescents. In fact, the prevalence of myopia for adolescents between 2011 and 2013 was lower than before.

It is important to consider to what extent the results of studies are consistent. A statistic (I^2) was used to quantify inconsistency in this study and $I^2 \leq 50.0\%$ which indicates that the heterogeneity of the analysis was moderate[60]. Therefore, the random-effects analysis was selected to estimate

Table 3 Prevalence of myopia among primary school students in other countries

Author(a)	Study site	Myopia diagnostic criteria	Prevalence of myopia
Dirani *et al*[49](2010)	Singapore	SE≤-0.50D	7a: 29.0%; 8a: 34.7%; 9a: 53.1%
Fan *et al*[47](2003)	Hong Kong	SE≤-0.50D	7a: 28.9%; 8a: 37.5%; 9a: 43.1%; 10a 48.2%; ≥11a: 53.1%
Lin *et al*[48](2004)	Taiwan	SE≤-0.25D	7a: 20.0%; 12a: 61.0%
Ip *et al*[51](2008)	Australia	SE≤-0.50D	6a: 1.4%; 12a: 11.9%
Logan *et al*[52](2011)	England	SE≤-0.50D	6-7a: 2.8%; 12-13a: 17.7%
Naidoo *et al*[50](2003)	South Africa	SE≤-0.50D	6a: 4.6%; 7a: 2.5%; 8a: 2.9%; 9a: 3.1%; 10a: 1.9%; 11a: 4.4%; 12a: 4.4%; 13a: 3.4%

the pooled prevalence. More than 240 000 individuals were included in this Meta-analysis, and the statistical power was greatly improved. However, Meta - regression was not performed because of the study design of only reporting the pooled prevalence.

The results of this study should be interpreted in light of some limitations. First, subgroup analysis by gender was not performed because of insufficient information among the included studies. Second, although strict inclusion and exclusion criteria were used to identify studies in the literature, measurement errors was inevitable among included and excluded studies, which could affect the pooled prevalence. Third, there were great disparities in research resources among eastern, central and western China, so the investigation bias may affect the Meta-analysis results.

In conclusion, the pooled prevalence of myopia was 26.5% among primary school students in mainland China, and it was much higher than that of western countries or regions. The prevalence of myopia increased with age among primary school students, and more studies should be conducted in mainland China to investigate causative factors. Our results should be valuable to clinicians, researchers and policy - makers for myopia prevention and treatment in mainland China.

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