Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention

Alicja R Rudnicka, Venediktos V Kapetanakis, Andrea K Wathern, Nicola S Logan, Bernard Gilmartin, Peter H Whincup, Derek G Cook, Christopher G Owen

ABSTRACT
The aim of this review was to quantify the global variation in childhood myopia prevalence over time taking account of demographic and study design factors. A systematic review identified population-based surveys with estimates of childhood myopia prevalence published by February 2015. Multilevel binomial logistic regression of log odds of myopia was used to examine the association with age, gender, urban versus rural setting and survey year, among populations of different ethnic origins, adjusting for study design factors. 143 published articles (42 countries, 374 349 subjects aged 1–18 years, 74 847 myopia cases) were included. Increase in myopia prevalence with age varied by ethnicity. East Asians showed the highest prevalence, reaching 69% (95% credible intervals (CrI) 61% to 77%) at 15 years of age (86% among Singaporean-Chinese). Blacks in Africa had the lowest prevalence; 5.5% at 15 years (95% CrI 3% to 9%). Time trends in myopia prevalence over the last decade were small in whites, increased by 2.3% in East Asians, with a weaker increase among South Asians. Children from urban environments have 2.6 times the odds of myopia compared with those from rural environments. In whites and East Asians sex differences emerge at about 9 years of age; by late adolescence girls are twice as likely as boys to be myopic. Marked ethnic differences in age-specific prevalence of myopia exist. Rapid increases in myopia prevalence over time, particularly in East Asians, combined with a universally higher risk of myopia in urban settings, suggest that environmental factors play an important role in myopia development, which may offer scope for prevention.

INTRODUCTION
Myopia is the most common cause of correctable visual impairment in the developed world in adults and children2–5 and is a leading cause of preventable blindness in developing countries.6 Approximately one in six of the world’s population is myopic.7 This represents a substantial burden worldwide with an appreciable unmet need for visual correction especially in poorer countries.8 Myopia begins in early life and increases in frequency and severity through childhood and adolescence into adulthood. High myopia affects up to 20% of secondary school children in East Asia, and is associated with sight-threatening pathologies that are irreversible.9 In white European populations the prevalence of myopia is relatively low affecting approximately 3–5% of 10-year-olds10–12 and up to 20% aged 12–13 years.13–15 In contrast, studies from Asian populations suggest rapid increases in the prevalence of childhood myopia (in terms of prevalence and absolute levels of myopia), affecting 80–90% of school-leavers in East Asia.9, 16–19 However, not all Asian populations appear to be undergoing this myopic transition.12–20–23 There are marked ethnic and geographical differences in myopia prevalence, which seem to have changed over time. There is a need to bring together the evidence to quantify population differences in myopia prevalence over time. However, quantifying the degree of ethnic differences in myopia is often hampered by interstudy differences in methodology, where different age groups, sampling methods and definitions of myopia are used. Hence, we undertook a systematic review of geographical and ethnic variations in myopia prevalence in childhood over an extended time period using a quantitative Bayesian meta-regression of studies that reported myopia prevalence. We provide estimates of myopia prevalence by age, ethnicity and sex, and examine trends over time. The influence of interstudy differences in study design on estimates of myopia prevalence was investigated as well as gender differences, and living in urban versus rural environments.

METHODS
The systematic review followed the Meta-analysis Of Observational Studies in Epidemiology guidelines for the conduct of systematic reviews and meta-analysis of observational studies.24 A combination of text words for myopia (short$sight$/myop$/myope$/refractive error$/ocular refraction), childhood (child/childhood/children/adolescent/adolescence/teenage) and epidemiological terms (incident/incidence/prevalen$7/population$/survey$) were combined with the related medical subject headings in MEDLINE (1950 to February 2015), and subject headings EMBASE (1980 to February 2015) and Web of Science (1970 to February 2015) databases (full search strategy is available in the online supplementary material). Validity of the search strategy was verified by its ability to identify all studies known to the investigators and those identified in recent qualitative reviews of myopia.9, 25–26

Inclusion and exclusion criteria
Studies were included if they provided quantitative estimates of myopia prevalence in populations with...
a clearly defined sampling strategy. Surveys or audits of hospital
eye departments or clinics were excluded. Studies that did not report ethnicity of the participants were excluded. Review articles were excluded to avoid duplication of data from individual studies, but were used to check that relevant studies were identified. Studies inviting non-specific volunteers, that relied on self-reported myopia or carried out refractive assessment in a subset, that is, only in those with reduced vision, were excluded.

**Studies identified and data extraction**

All data extraction was carried out independently by three reviewers (ARR, VVK and CGO), with independent extraction in a subset. Disagreements in data extraction were resolved by discussion.

Data were extracted on a number of key indicators of study quality, identified a priori. These included methods of assessment (including subjective refraction/retinoscopy and open or closed field autorefraction and use of cycloplegia) and case definition of myopia. In the presence of multiple definitions for myopia within a study, the definition with spherical equivalent refraction/sphere refraction closest to ‘−0.5 D or less’ was used. Some studies reported prevalence based on subjective refraction separately from those on autorefraction. In these situations we included only data from the autorefractor measurements to avoid double counting data from the same study. When prevalence was reported with and without the use of cycloplegia, estimates obtained after the use of cycloplegia were used preferentially.

Data were also extracted on study response rates, habitation type (urban, rural or mixed) and year of survey (midpoint when a study period was reported), geographical location (region/city and country), number of children examined, number with myopia, estimates of myopia prevalence by gender and ethnic/racial group where available. For longitudinal studies, prevalence estimates from follow-up visits were not included in the analyses as our analyses are based on myopia prevalence not incidence.

Among studies that reported ethnicity, most studies were conducted on indigenous population groups (migrant populations were classified according to the reported ethnicity). Ethnicity was classified into the groups listed below, broadly following definitions of the United Nations (UN) and WHO:

I. **Whites**: individuals of white European ancestry residing in Europe, America, Australia and New Zealand

II. **East Asian**: (eg, Chinese, Japanese, Mongolian, Taiwanese, and Chinese children in Hong Kong and Singapore)

III. **South Asian**: (eg, Indian, Pakistani, Bangladeshi and Nepalese)

IV. **South-East Asian**: (eg, Malaysian, Thai, Cambodian, Lao)

V. **Blacks in Africa**: (eg, children from Burkina Faso, Madagascar, South Africa and Tanganika)

VI. **Blacks not in Africa**: (eg, blacks in UK or America)

VII. **Middle Eastern or North African**: (eg, Iranian, Israeli, North African and Tunisian)

VIII. **Hispanic or Latino**: (eg, Chilean, Colombian, Mexican, Puerto Rican and Ecuadorian)

IX. **Native Hawaiian or other Pacific Islander**: (eg, Aborigines and children from Vanuatu)

X. **American Indian or Alaska native**

Ethnic specific estimates of prevalence were extracted if available; otherwise the reported prevalence of myopia was linked to the predominant ethnicity of the study population.

**Statistical analysis**

All statistical analyses were carried out using OpenBUGS (V.3.2.2) and R (V.3.1.1). We used Bayesian multilevel binomial logistic regression to investigate the associations between the log odds of myopia in either eye and potentially modifying factors, including age, gender, ethnicity, year of survey, and study design factors such as methods of assessment and habitation type.

Associations with age were non-linear and varied by ethnicity therefore the model allowed for a quadratic association with age that differed by ethnic group by including an interaction term in the models. Note, quadratic associations on the log odds scale translate into flexible non-linear associations on the prevalence scale, which encompass exponential associations with an asymptote. Ethnic specific time trends in reported myopia prevalence were investigated using year of survey.

Missing data on survey year were imputed for studies by subtracting 3 years from the year that the article was published (based on the median time to publication, in studies with available data). There were sufficient data to analyse time trends in whites, East Asians and South Asians only. We estimate ORs for rural versus urban and rural versus mixed habitation settings assuming a common OR across ethnicity; however we present sensitivity analyses by ethnicity.

We allowed for potential systematic differences between studies using different methods of refractive assessment by including study level covariates for the use of cycloplegia or not and whether refraction was based on (1) subjective refraction/retinoscopy (this included studies that performed autorefract and subjective refraction/retinoscopy) or (2) open field autorefraction or (3) closed field autorefraction. This investigation was performed on a subset of studies with available data adjusting for ethnic specific associations with age and survey year, as well as habitation type. Additional analyses investigated an interaction between age and use of cycloplegia.

The difference in myopia prevalence between boys and girls was estimated from a separate model using the subset of studies that reported data separately for boys and girls, adjusting for study design factors and ethnic specific associations with age. All analyses took into account the hierarchical data structure arising from repeated measures of prevalence within the same study population by fitting ‘study population’ as a ‘level’ in all our models. A study population was defined as the same ethnicity examined at the same point in time in the same geographical location. A full description of the model appears in the online supplementary statistical appendix. We present median prevalence estimates and ORs with 95% credible intervals (95% CrI), which represent the range of values within which the true value of an estimate is expected to lie with 95% probability.

Modelling age and ethnic specific prevalence estimates were standardised to urban populations and applied to UN demographic data for 2015 and 2025. We selected the dominant ethnic group for the following UN defined regions (1) Black—Africa and the Caribbean, (2) White—Europe, North America, Western Asia, Australia and New Zealand, (3) Hispanic—Central and Southern America, (4) Other/mixed—Melanesia, Micronesia and Polynesia. More detailed ethnic division was possible for Asia where (5) East Asian was used to represent Eastern and Central Asia, (6) South Asian—Southern Asia, and (7) South-East Asian—Southeast Asia. Using UN population data by 5-year intervals (from 0 year to 19 years) the mid age band prevalence estimates at ages 2 years, 7 years, 12 years and 17 years were applied to the corresponding population data, to obtain population numbers with myopia, overall and by region, with associated 95% CrIs as described previously. A description of the statistical model is available online (see online supplementary statistical appendix).
RESULTS

The article selection process is outlined in figure 1. In total 143 articles reported age-specific prevalence of myopia in 164 separate study populations (374 349 participants, 74 847 cases of myopia) from cross-sectional surveys published between 1958 and 2015 in 42 different countries. Online supplementary table S1 summarises the key features of the articles contributing to this review along with the citation. Table 1 summarises the numbers of subjects and cases of myopia by ethnicity contributing to the analysis. Data extracted on myopia prevalence by ethnicity showed stark differences overall (figure 2) and a non-linear increase in myopia prevalence with age. We therefore modelled ethnic specific quadratic associations with age. There were sufficient data to estimate trends over time in myopia prevalence in whites, East Asians and South Asians only. Estimated over an extended time period there appears to have been a marginal decline in the odds of myopia in white children and adolescents after adjustment for age and environmental setting (estimates per decade in table 2). However, the 95% CrI for this result is wide and compatible with stable myopia prevalence over time. In contrast, evidence suggests a 23% increase in myopia prevalence over time. In addition, among East Asians time trends were not linear. In addition, among East Asians time trends did not appear to vary by geographical location.

Table 3 provides estimates of myopia prevalence by age and ethnicity standardised to children residing in urban environments. For whites, East Asians and South Asians estimates are also standardised to 2005. For other ethnic groups there were insufficient data to model time trends and therefore estimates are indicative of data available for the ‘average’ survey year given in tables 1. East Asians have the highest prevalence of myopia reaching 80% by 18 years of age. In contrast, the lowest myopia prevalence in late adolescence is in black children in Africa (5.5% of 15 year olds).

Children living in predominantly urban environments have 2.6 times the risk of myopia compared with children living in rural environments (table 2, OR 2.61, 95% CrI 1.79 to 3.86). Studies that reported prevalence for a mixed (urban+rural) population are a very heterogeneous group and the estimate should be interpreted with caution. There was no evidence of heterogeneity in the OR of urban versus rural environment by ethnicity. For all ethnic groups, except whites, an urban environment is associated with an increased risk of myopia, especially in blacks in Africa, South Asians and South-East Asians (figure 3). However, exclusion of one outlying study in western Newfoundland whites[31] residing in a rural community weakened the OR for urban versus rural in whites to 0.99 (95% CrI 0.26 to 5.01).

Studies that did not use cycloplegia reported double the odds of myopia than those that did use cycloplegia (after allowing for age, ethnicity, survey year and environmental setting, table 2). We examined an interaction between use of cycloplegia and age and found that the OR for ‘no cycloplegia’ versus cycloplegia was stronger at younger ages than at older ages (see online supplementary table S2). Method of measurement of refraction was also associated with myopia prevalence. Studies defining myopia based on autorefraction reported a higher prevalence of myopia (especially closed autorefraction) than studies using retinoscopy or subjective refraction (either exclusively or in addition to autorefraction).

The meta-regression comparing boys and girls is based on 64 study populations with 146 996 participants and 36 958 cases of myopia. We examined differences between boys and girls for each ethnic group separately. At about age 9 years gender differences begin to emerge in whites and East Asians and become more pronounced with age showing a higher prevalence of myopia in girls than in boys (see online supplementary table S3). By 18 years of age white girls are approximately twice as likely as white boys to be myopic (OR 2.03 95% CrI 1.40 to 2.93). A similar picture emerged for East Asians (OR 2.30 95% CrI 2.01 to 2.61). There was no clear evidence of gender differences in South Asians or in Hispanic/Latinos and there was insufficient data in the other ethnic groups to estimate gender differences by age.

There were sufficient data to investigate geographical variations in age-specific myopia prevalence in whites, East Asians and South Asians. In whites there was no clear evidence of differences in myopia prevalence in studies from Europe, USA and Oceania. Among East Asians the highest prevalence of myopia is among those residing in Singapore (86% of 13 year olds, table 4). Rates are very similar in Hong Kong and Taiwan (~80% of 15 year olds), lower in China (~59% of 15 year olds) and Australia (41% of 15 year olds). Rates are lowest in a rural population of Mongolia (table 4). Estimates in Japan are based on data from the 1990s and may not be representative of contemporary Japanese children. South Asian children residing in Australia, England or Singapore are approximately five times more likely to be myopic than their counterparts living in Nepal or India (table 4). At 15 years of age approximately 40% of migrant South Asians are myopic compared with 9% of indigenous South Asians.

Figure 1 Summary of article selection process from MEDLINE, EMBASE and Web of Science.
### Table 1  Summary of the number of study populations with data on myopia prevalence by ethnic group

| Ethnicity                        | No. study populations | Published articles | K   | N   | x          | Range         | Mean*         |
|---------------------------------|-----------------------|--------------------|-----|-----|------------|---------------|---------------|
| White                           | 34                    | 34                 | 87  | 54  | 324        | 1958 to 2011  | 1994          |
| East Asian                      | 65                    | 55                 | 310 | 157 | 60895      | 1983 to 2013  | 2000          |
| South Asian                     | 23                    | 20                 | 72  | 46  | 2648       | 1992 to 2014  | 2002          |
| South-East Asian                | 9                     | 7                  | 18  | 19  | 1344       | 1987 to 2010  | 2006          |
| Black in Africa                 | 10                    | 5                  | 24  | 8491| 262       | 1961 to 2009  | 1993          |
| Black not in Africa             | 5                     | 5                  | 15  | 5038| 371       | 1997 to 2008  | 2006          |
| Middle Eastern or North African | 16                    | 16                 | 67  | 41  | 2679       | 1990 to 2011  | 2008          |
| Hispanic or Latino              | 10                    | 10                 | 26  | 33  | 1503       | 1976 to 2007  | 1995          |
| Native Hawaiian or other Pacific Islander | 6                  | 6                  | 15  | 5794| 529       | 1967 to 2008  | 1987          |
| American Indian or Alaska native | 4                    | 4                  | 9   | 2457| 440       | 1967 to 2002  | 1985          |
| Unknown/other/mixed             | 3                     | 3                  | 3   | 323 | 42        | 2001 to 2008  | 2004          |

K, total number of available estimates of prevalence.  
N, total number of participants (published or estimated).  
X, total number of cases of myopia using definition closest to ‘spherical equivalent refraction/sphere refraction of −0.50 D or more myopia’  
*Mean survey year weighted by study population size.

### Figure 2  Prevalence (%) of myopia for boys and girls combined by age and ethnic group.

Data extracted on the age-specific prevalence (as a percentage) of myopia for all study populations are plotted against age for girls and boys combined, by ethnic group. The vertical axis is plotted on the logit scale. Data points from the same study population are joined by a straight line. The size of each symbol is inversely proportional to the SE of the estimate of prevalence.
Estimates of the global myopia prevalence and number of cases by region were attained by applying modelled age and ethnic specific prevalence estimates to UN defined population data for calendar years 2015 and 2025 and ages 0 year to <19 years (see online supplementary table S4). Global estimates suggest a burden of 312 million myopic cases in 2015 (95% CrI 265 million to 369 million), rising to 324 million (95% CrI 276 million to 382 million) in 2025. Population prevalence of myopia in childhood (0 year to <19 years) is highest in East Asia (35%) with nearly 80% of cases in Asia. The global share of myopia cases will remain high in Asia in 2025 with a marginal increase in Africa due to more rapid expansion of this age group in Africa than in other regions.

**DISCUSSION**

This is the first systematic review and quantitative meta-analysis of the worldwide prevalence of myopia in childhood and adolescence. We have quantified the striking ethnic differences in myopia prevalence that become more marked with age. In particular, East Asians show the highest prevalence with over 90% of East Asians living in Singapore and 72% of East Asians living in China aged 18 years exhibiting myopia (defined as at least −0.5 D of myopia). Overall South Asians had much lower rates with limited evidence of trends over time. However, there were marked differences between those living in South Asia compared with migrant South Asian populations. There was no strong evidence of time trends in myopia prevalence among white populations. Non-linear associations between age and the log odds of myopia captured a large proportion of the ethnic variation in myopia prevalence. Some ethnic groups show a rapid increase with age in the early years that flattens (East Asians, whites, South Asians), suggesting that levels of myopia may have plateaued, reaching saturated levels. In others the increase in myopia prevalence was almost linear with age (South-East Asian, American Indian or Alaska Native, Native Hawaiian Pacific Islanders). In other groups the increase with age did not emerge until after about 8 years of age (Hispanics, blacks (in and outside of African) and Middle Eastern or North Africans).

We have shown that living in an urban rather than rural environment is associated with almost a tripling in the risk of myopia and this pattern is seen among all ethnic groups. As expected, studies that did not use cycloplegia reported higher myopia prevalence (especially at younger ages) as did studies that relied

### Table 2 ORs for trends over time, environmental setting and methods of refractive assessment

| Factor                        | Number of study populations | Adjusted odds ratio* (95% credible interval) |
|-------------------------------|----------------------------|---------------------------------------------|
| Calendar Time                 |                            |                                             |
| Per decade in whites          | 34                         | 0.85 (0.69, 1.05)                           |
| Per decade in East Asians     | 65                         | 1.23 (1.00, 1.55)                           |
| Per decade in South Asians    | 23                         | 1.05 (0.45, 2.63)                           |
| Environmental setting         |                            |                                             |
| Rural                         | 37                         | 1.00                                        |
| Urban                         | 115                        | 2.61 (1.79, 3.86)                           |
| Mixed†                        | 12                         | 2.71 (1.63, 4.68)                           |
| Study design characteristics  |                            |                                             |
| Cycloplegia—yes               | 109                        | 1.00                                        |
| Cycloplegia—no                | 43                         | 2.12 (1.76, 2.52)                           |
| Subjective refraction/retinoscopy| 85                    | 1.00                                        |
| Closed field autorefraction   | 54                         | 2.18 (1.79, 2.73)                           |
| Open field autorefraction     | 12                         | 1.30 (0.89, 1.85)                           |

*ORs are the medians (95% credible intervals in parenthesis) of the posterior distributions from the Bayesian multilevel binomial logistic regression of the log odds of myopia adjusting for ethnic specific associations with age, ethnic specific associations with survey year (for white, East Asian and South Asian children, only) and environmental setting. The multilevel model took into account that some study populations provide only one age-specific estimate whereas others contribute data for several age groups. ORs for the study design characteristics are based on a subset of studies that specifically reported whether cycloplegia was used. ORs for environmental setting and study design characteristics were assumed to be common across ethnicities. †Mixed refers to studies that reported myopia prevalence for urban and rural groups combined.

### Table 3 Estimated prevalence of myopia by age and ethnicity in boys and girls combined

| Ethnicity                     | Prevalence (%) of myopia by age | Year       |
|-------------------------------|---------------------------------|------------|
|                               | 5 years            | 10 years     | 15 years     | 18 years     |
| White                         | 1.6 (1.0, 2.5)      | 6.7 (4.1, 10.3) | 16.7 (10.6, 24.5) | 22.8 (14.6, 32.7) | 2005* |
| East Asian                    | 6.3 (4.4, 9.2)      | 34.5 (26.7, 44.0) | 69.0 (60.6, 76.8) | 79.6 (73.0, 85.4) | 2005* |
| South Asian                   | 5.3 (2.9, 9.6)      | 9.2 (5.2, 15.7)  | 13.0 (7.4, 21.6) | 13.9 (7.7, 23.5) | 2005* |
| South-East Asian              | 6.7 (2.9, 14.4)†    | 11.5 (5.3, 23.3) | 23.7 (11.7, 41.8) | 28.0 (13.8, 48.2)† | 2006§ |
| Black in Africa               | 2.8 (1.5, 5.0)      | 1.8 (1.1, 2.7)  | 5.5 (3.1, 9.0)   |              | 1993§ |
| Black not in Africa           | 4.8 (4.0, 5.7)      | 8.2 (6.8, 9.8)  | 19.9 (14.3, 26.5)† |              | 2006§ |
| Middle Eastern or North African| 3.5 (2.0, 5.7)      | 5.5 (3.4, 8.8)  | 19.6 (12.6, 28.6) | 47.1 (34.2, 60.4) | 2008§ |
| Hispanic or Latino            | 5.0 (1.9, 11.6)†    | 4.7 (1.8, 11.0) | 14.3 (5.8, 29.8) |              | 1995§ |
| Native Hawaiian or other Pacific Islander | 2.6 (0.5, 11.6)† | 5.5 (1.4, 20.3) | 23.0 (6.9, 57.6) |              | 1987§ |
| American Indian or Alaska native**| 11.3 (3.3, 31.4) | 20.2 (6.0, 49.9) | 29.8 (10.7, 59.7)† |              | 1985§ |

Prevalence estimates are medians (95% credible intervals in parenthesis) of the posterior distributions for predicted prevalence from the Bayesian multilevel binomial logistic regression of the log odds of myopia adjusting for ethnic specific associations with age, ethnic specific associations with survey year (for white, East Asian and South Asian children, only) and environmental setting. The multilevel model takes into account that some study populations provide only one age-specific estimate whereas others contribute data for several age groups. Estimates correspond to urban populations.

*Survey year fitted in the model.
†Estimate at age 16.5 years (upper limit of available data).
‡Estimate at age 7 years (lower limit of available data).
§Mean survey year weighted by study population size.
††Estimate at age 12.5 years (upper limit of available data).
**Estimates correspond to rural populations as there were no data in an urban setting for this ethnic group.
††Estimate at age 14.5 years (upper limit of available data).
on autorefractor findings, particularly closed field instruments. We also showed that sex difference in the age-specific prevalence of myopia exist in whites and East Asians, emerge at about 9 years of age and become more marked through adolescence showing double the odds of myopia in girls compared with boys.

The increase in myopia prevalence seen in urban compared with rural populations agrees with others that have explicitly examined this in children with the same ethnic ancestry.20 21 33–46 Although there was no formal evidence of a difference in urban-rural differences across ethnic groups, some populations showed marginally larger ORs compared with others. Stronger urban-rural differences in South Asians and South-East Asians may reflect greater disparity in living conditions compared with high-income countries. These findings are consistent with the results of studies in population groups that migrate from rural to urban settings, which tend to adopt myopia rates of the host population, for example, Pacific Islanders that migrated to Taiwan;47 South Asian children living in the UK have higher rates of myopia12 than South Asian children residing in predominantly rural communities in India;21 39 Indians in Singapore have prevalence rates more similar to Singaporean Chinese than to Indians in India.48 49 The apparent decreased risk of myopia associated with urban environment in whites was explained by inclusion of western Newfoundland whites residing in a rural community with shared genetic ancestry, who showed an unusually high prevalence of myopia.31 Removal of this single

Figure 3 ORs for urban versus rural setting are from a Bayesian multilevel binomial logistic regression stratified by ethnicity, adjusting for the quadratic association with age and year of survey (for white, East Asian and South Asian children, only). The common OR is from a Bayesian multilevel binomial logistic regression model using all the data from all ethnic groups combined that adjusts for the ethnic specific quadratic association with age, ethnic specific associations with survey year (for white, East Asian and South Asian children, only) and environmental setting, assuming common OR for urban versus rural settings across ethnicities (as presented in table 2).

Table 4 Estimated prevalence of myopia by age in boys and girls combined (1) stratified by country for East Asians, and (2) stratified by continent for South Asians

| Prevalence (%) of myopia by age | 5 years | 10 years | 15 years | 18 years | Year |
|--------------------------------|--------|---------|---------|--------|------|
| **East Asians by country**    |        |         |         |        |      |
| Australia                      | 1.9 (0.8, 4.2)* | 13.6 (6.2, 26.5) | 40.6 (22.3, 60.9)* | –      | 2005† |
| China                          | 3.9 (2.9, 5.9)  | 24.9 (19.8, 34.3) | 59.0 (51.7, 69.3) | 71.9 (65.4, 80.0)* | 2005† |
| Hong Kong                      | 9.2 (5.4, 15.7) | 45.3 (31.8, 60.7) | 78.2 (66.8, 87.1) | 86.4 (78.2, 92.2)* | 2005† |
| Japan                          | 1.7 (0.7, 3.8)  | 12.2 (5.8, 24.3)  | 37.6 (21.1, 58.2) | 51.7 (32.1, 71.2)* | 1990† |
| Malaysia                       | 4.6 (1.4, 14.5)*| 28.4 (10.4, 58.1) | 63.2 (33.5, 85.7) | 75.3 (47.2, 91.4) | 1990† |
| Mongolia                       | 0.3 (0.1, 0.9)  | 2.7 (0.8, 7.2)§   | 10.8 (3.5, 25.0)§ | 17.7 (5.9, 37.2)*§ | 2003† |
| Singapore                      | 14.9 (9.9, 22.4) | 59.0 (47.2, 70.2) | 86.2 (79.4, 91.1) | 91.7 (87.2, 94.8)* | 2005† |
| Taiwan                         | 10.1 (5.9, 19.8)* | 48.0 (34.0, 67.4) § | 80.0 (69.0, 90.0)*§ | 87.6 (79.9, 94.0)*§ | 2005† |
| USA                            | 4.9 (1.9, 12.0) | –       | –       | –      | 2005† |
| **South Asians by continent** |        |         |         |        |      |
| Living in South Asia           | 3.6 (2.2, 5.7)  | 6.4 (4.0, 9.7)    | 9.1 (5.7, 13.7)   | 10.3 (5.8, 17.0)* | 2005† |
| Not living in South Asia       | 20.4 (10.6, 36.0)* | 31.6 (17.8, 50.1) | 40.5 (24.1, 59.5) | 43.8 (25.2, 63.9)* | 2005† |

Numbers express medians and 95% credible intervals in parenthesis. Estimates correspond to urban populations standardised where possible to 2005. For Japan and Malaysia, estimates are indicative of 1990 and for Mongolia estimates are for a rural population in 2003.

*Estimate obtained by extrapolation.
†Survey year as fitted in the model.
‡Mean survey year weighted by study population size.
§Estimates correspond to rural populations.
¶Estimates correspond to mixed populations in terms of urban/rural environmental setting.
population reduced the OR for urban versus rural in whites towards the null.

Potential explanations have been suggested for the higher rates of myopia in children residing in urban settings compared with children from the same ethnic groups living in more rural settings including a more congested environment and greater emphasis on education and hence near vision activities. Several studies have shown a link between increased near vision activities and myopia, but this is not a universal finding. Years of education have also been related to myopia and introduction of formal education at younger ages in some East Asian countries. There may be a contributing factor. In Singapore, children from as young as 3 years and as young as 2 years in Hong Kong actively participate in additional education classes before formal schooling education begins. In contrast, the prevalence of myopia is low in African populations where literacy rates are low, and formal education does not start for most children until the ages of 6–8 years. It is possible that the younger age of initial exposure to formal education patterns levels of myopia through childhood.

Further evidence is provided by the reported independent associations of population density on myopia prevalence, which may suggest a contribution from a collection of risk factors associated with urban living environment. Time spent outdoors will differ between urban and rural communities and has been examined in relation to myopia. Children who become myopic are less likely to participate in sports/ outdoor activities. In a 2-year prospective study there was a suggestion that longer durations spent outdoors were associated with slower axial elongation in non-myopic teenagers but not in pre-existing myopes. A recent systematic review and meta-analysis showed a 2% reduction in the odds of myopia for every additional hour per week spent outdoors. Biological mechanisms for an association include low accommodative difficulty with an individual data approach, that is, omitting studies with imperfect study methods, would result in loss of power and would not allow study design differences to be quantified. We took account of study level factors including environmental setting, year of survey and survey methods used to define cases of myopia, particularly use of cycloplegia. The increased numbers allowed us to quantify the marked differences in the age-specific prevalence of myopia between ethnic groups, between urban and rural environments as well as gender differences. Limitations of this study include the omission of study response rates in the analysis as reliable data were not routinely reported. Our analysis is based on summaries from published data rather than data from individuals, which may lack the granularity to determine associations. A meta-analysis based on individual data would have yielded more precise results for the age-specific prevalence and could adjust for individual factors. Such an approach would be preferable if these data could be obtained for all relevant studies. However, the difficulty with an individual data meta-analysis is that it may represent a subset, biased towards well resourced studies, which are not representative of studies as a whole. Future work could examine trends in myopia incidence over time by meta-analysing estimates of incidence from longitudinal studies. This review did not examine within-person changes in spherical refractive error over time which is likely to show different myopic refraction progression rates by ethnicity over time.

In summary, this meta-analysis provides the most comprehensive and current evidence on myopia prevalence in childhood and adolescence. It seems that populations that have experienced rapid economic transition (East and South Asians) have undergone the most rapid myopic transition. It will be important to monitor trends in myopia over time especially in relation to populations undergoing rapid transitions in myopia and to identify factors of the urban environment that are responsible. Understanding the aetiology of childhood myopia will give clues to prevention, potentially offering strategies to limit the economic impact of refractive error.

Collaborators All authors contributed substantially to the conception and design of this paper. ARR, VVK, AKW and CGO conducted the literature searches and extracted the data from published papers. ARR, VVK and CGO drafted the paper and carried out statistical analysis. All authors contributed to revising the manuscript and all authors approved the final version. ARR and CGO will act as guarantors. The guarantors accept full responsibility for the integrity of the work as a whole. All authors had access to the data, and approved the final version to be published.

Funding This work was supported by a grant from the BUPA Foundation (TBF-M10-034).

Disclaimer All researchers acted independently of study funders. The study funders played no role in study design and the collection, analysis, and interpretation of data and the writing of the article and the decision to submit it for publication. None of the funders influenced data analysis or interpretation of results. The comments made in this paper are those of the authors and not necessarily those of any funders.

Competing interests None declared.
REFERENCES

1 Junghans B, Kiely PM, Cwethor DP, et al. Referral rates for a functional vision screening among a large cosmopolitan sample of Australian children. Ophthalmic Physiol Opt 2002;22:120–25.

2 Kleinert RN, Jones LA, Hublet S, et al. Refractive error and ethnicity in children. Arch Ophthalmol 2003;121:1141–7.

3 Lam CS, Goldschmidt E, Edwards MH. Prevalence of myopia in local and international schools in Hong Kong. Optom Vis Sci 2004;81:317–22.

4 Cumberland PM, Peckham CS, Rahi JS. Inferior myopia over the lifetime from uncorrected distance visual acuity in childhood. Br J Ophthalmol 2007;91:151–3.

5 Fotheringham PI, Jiang X. Refractive error. Eye (Lond) 2014;28:202–8.

6 Congdon NG, Friedman DS, Lietman T. Important causes of visual impairment in the world today. JAMA 2003;290:2057–60.

7 Gilmartin B. Myopia: precedents for research in the twenty-first century. Clin Experiment Ophthalmol 2004;32:305–24.

8 Kempen JH, Mitchell P, Lee KE, et al. The prevalence of refractive errors among adults in the United States, Western Europe, and Australia. Arch Ophthalmol 2004;122:495–506.

9 Morgan IG, Ohno-Matsui K, Saw SM. Myopia. Lancet 2002;359:1739–48.

10 Rudnicka AR, Owen CG, Richards M, et al. Effect of breastfeeding and sociodemographic factors on visual outcome in childhood and adolescence. Am J Clin Nutr 2008;87:1392–9.

11 Williams C, Miller L, Gazzard G, et al. A comparison of measures of reading and intelligence as risk factors for the development of myopia in a UK cohort of children. Br J Ophthalmol 2008;92:1117–21.

12 Rudnicka AR, Owen CG, Nightingale CM, et al. Ethnic differences in the prevalence of myopia and ocular biometry in 10- and 11-year-old children: The child heart and health study in england (CHASE). Invest Ophthalmol Vis Sci 2010;51:6270–6.

13 O’Donoghue I, McClelland J, Logan NS, et al. Refractive error and visual impairment in school children in Northern Ireland. Br J Ophthalmol 2010;94:1155–9.

14 Ip JM, Huyhn SC, Rabiad D, et al. Ethnic differences in refraction and ocular biometry in a population-based sample of 11–15-year-old Australian children. Eye 2008;22:649–56.

15 Logan NS, Shah P, Rudnicka AR, et al. Childhood ethnic differences in ametropia and ocular biometry: the Aston Eye Study. Ophthalmic Physiol Opt 2011;31:550–8.

16 Saw SM. A synopsis of the prevalence rates and environmental risk factors for myopia. Clin Exp Optom 2003;86:289–94.

17 Saw SM, Goh PP, Cheng A, et al. Ethnicity-specific prevalences of refractive errors vary in Asian children in neighbouring Malaysia and Singapore. Br J Ophthalmol 2006;90:1230–5.

18 Fan DSP, Lam DSC, Lam RF, et al. Prevalence, incidence, and progression of myopia of school children in Hong Kong. Invest Ophthalmol Vis Sci 2004;45:1071–5.

19 Quek TPL, Chuang CC, Chong CS, et al. Prevalence of refractive errors in teenage high school students in Singapore. Ophthalmic Physiol Opt 2004;24:47–55.

20 Dandona R, Dandona L, Naduvilath TI, et al. Refractive errors in an urban population in southern India. The Andhra Pradesh Eye Disease Study. Invest Ophthalmol Vis Sci 2001;42:511–8.

21 Dandona R, Dandona L, Sindhwai V, et al. Refractive error in children in a rural population in India. Invest Ophthalmol Vis Sci 2002;43:615–22.

22 Kalikivayi V, Naduvilath TI, Bansal AK, et al. Visual impairment in school children in Southern India. Indian J Ophthalmol 1997;45:129–34.

23 Murthy GVS, Gupta SK, Ellwein LB, et al. Refractive error in children in an urban population in new Delhi, India. Br J Ophthalmol 2004;88:623–31.

24 Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-Analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000;283:2008–12.

25 Morgan I, Rose K. How genetic is school myopia? Prog Retin Eye Res 2005;24:1–38.

26 Fan CW, Ramamurthy D, Saw SM. Worldwide prevalence and risk factors for myopia. Ophthalmic Physiol Opt 2012;32:3–16.

27 Lunn D, Spiegelhalter D, Thomas A, et al. The BUGS project: evolution, critique and future directions. Stat Med 2009;28:3049–67.

28 R Core Team. R: A Language and Environment for Statistical Computing.R Foundation for Statistical Computing. Vienna, Austria. 2014. 21–4.2015.

29 United Nations. World Population Prospects: The 2012 Revision. 2012 http://esa.un.org/wpp/panel_indicator.html (accessed Sep 2014).

30 Kapetanakis VV, Chan MP, Foster PJ, et al. Global variations and trend in the prevalence of primary open angle glaucoma (POAG): a systematic review and meta-analysis. Br J Ophthalmol 2016.
Review

63 Saw SM, Shankar A, Tan SB, et al. A cohort study of incident myopia in Singaporean children. *Invest Ophthalmol Vis Sci* 2006;47:1839–44.

64 Jones LA, Sinnott LF, Mutti DO, et al. Parental history of myopia, sports and outdoor activities, and future myopia. *Invest Ophthalmol Vis Sci* 2007;48:3524–32.

65 Dinani M, Tong L, Gazzard G, et al. Outdoor activity and myopia in Singapore teenage children. *Br J Ophthalmol* 2009;93:997–1000.

66 Wu P-C, Tsai C-L, Hu C-H, et al. Effects of outdoor activities on Myopia among rural school children in Taiwan. *Ophthalmic Epidemiol* 2010;17:338–42.

67 Guggenheim JA, Northstone K, McMahon G, et al. Time outdoors and physical activity as predictors of incident myopia in childhood: a prospective cohort study. *Invest Ophthalmol Vis Sci* 2012;53:2856–65.

68 Jones-Jordan LA, Mitchell GL, Cotter SA, et al. Visual activity before and after the onset of juvenile myopia. *Invest Ophthalmol Vis Sci* 2011;52:1841–50.

69 Li SM, Li H, Li SY, et al. Time outdoors and myopia progression over 2 years in Chinese children: the anyang childhood eye study. *Invest Ophthalmol Vis Sci* 2015;56:4734–40.

70 Shenwin JC, Reacher MH, Keogh RH, et al. The association between time spent outdoors and myopia in children and adolescents: a systematic review and meta-analysis. *Ophthalmology* 2012;119:2141–51.

71 Deere K, Williams C, Leary S, et al. Myopia and later physical activity in adolescence: a prospective study. *Br J Sports Med* 2009;43:542–4.

72 Rose KA, Morgan IG, Ip J, et al. Outdoor activity reduces the prevalence of myopia in children. *Ophthalmology* 2008;115:1279–85.

73 Lin LLK, Shih YF, Tsai CB, et al. Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. *Optom Vis Sci* 1999;76:275–81.

74 Zadnik K, Manny RE, Yu JA, et al. Ocular component data in schoolchildren as a function of age and gender. *Optom Vis Sci* 2003;80:226–36.

75 He M, Xu J, Yin Q, et al. Need and challenges of refractive correction in urban Chinese school children. *Optom Vis Sci* 2005;82:229–34.

76 He MG, Huang WY, Zheng YF, et al. Refractive error and visual impairment in school children in rural southern China. *Ophthalmology* 2007;114:374–82.

77 Goh P-P, Abqariyah Y, Pokharel GP, et al. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. *Ophthalmology* 2005;112:678–85.

78 Zhang M, Gazzard G, Fu Z, et al. Validating the accuracy of a model to predict the onset of myopia in children. *Invest Ophthalmol Vis Sci* 2011;52:5836–41.

79 Pokharel GP, Negrel AD, Munoz SR, et al. Refractive error study in children: results from Mechi Zone, Nepal. *Am J Ophthalmol* 2000;129:436–44.

80 Maul E, Barroso S, Munoz SR, et al. Refractive error study in children: results from La Florida, Chile. *Am J Ophthalmol* 2000;129:445–54.

81 Naidoo KS, Raghunandan A, Mashige KP, et al. Refractive error and visual impairment in African children in South Africa. *Invest Ophthalmol Vis Sci* 2003;44:3764–70.

82 Rahi JS, Cumberland PM, Peckham CS. Myopia over the lifecourse: prevalence and early life influences in the 1958 British birth cohort. *Ophthalmology* 2011;118:797–804.

83 Wong TY, Foster PJ, Hee J, et al. Prevalence and risk factors for refractive errors in adult Chinese in Singapore. *Invest Ophthalmol Vis Sci* 2000;41:2486–94.

84 Farhood QK. Cycloplegic refraction in children with cyclopentolate versus atropine. *J Clin Exp Ophthalmol* 2012;3:239.

85 Williams C, Miller L, Northstone K, et al. The use of non-cycloplegic autorefraction data in general studies of children’s development. *Br J Ophthalmol* 2008;92:723–4.

86 Zhao J, Mao J, Luo R, et al. Accuracy of non-cycloplegic autorefraction in school-age children in China. *Optom Vis Sci* 2004;81:49–55.

87 Choong YF, Chen AH, Goh PP. A comparison of autorefraction and subjective refraction with and without cycloplegia in primary school children. *Am J Ophthalmol* 2006;142:68–74.
Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention

Alicja R Rudnicka¹, Venediktos V Kapetanakis¹, Andrea K Wathern¹, Nicola S Logan², Bernard Gilmartin², Peter H Whincup¹, Derek G Cook¹, Christopher G Owen¹

1. Population Health Research Institute, St George’s, University of London, Cranmer Terrace, London, UK SW17 0RE
2. School of Life and Health Sciences, Aston University, Aston Triangle, Birmingham, UK B4 7ET

Address for correspondence
Dr Alicja R Rudnicka, Population Health Research Institute, St George’s, University of London, Cranmer Terrace, London, UK SW17 0RE
tel: +44 (0)20 87252799, fax: +44 (0)20 87253584, e-mail: arudnick@sgul.ac.uk

Key words: systematic review, meta-analysis, myopia, prevalence, childhood

Manuscript word count: 3911
MATERIAL FOR ONLINE SUPPLEMENT

Supplemental Table S1. Articles contributing to the meta-analysis and accompanying reference list

Supplemental Table S2. Odds ratios for not using cycloplegia vs using cycloplegia by age

Supplemental Table S3: Odds ratio for girls versus boys by ethnic group and age

Supplemental Table S4. Global myopia estimates: age, gender and ethnic specific prevalence estimates applied to UN defined population data for age below 19 years for 2010, 2015 and 2020

Appendix. Prevalence of myopia in childhood search strategy

Statistical Appendix. The underlying fitted model
**APPENDIX: Prevalence of myopia in childhood search strategy**

**MEDLINE and EMBASE databases**

**Textwords**

```plaintext
(((Short$sight*) OR (Myopi?) OR (Myope$) OR (Refractive error$) OR (Ocular Refraction)).tw)
AND (((Incident) OR (Incidence) OR (Prevalen*) OR (Population$) OR (Survey$)).tw)
AND (((Child) OR (Childhood) OR (Children) OR (Adolescent) OR (Adolescence) OR (Teenage*)).tw)
```

**MESH headings (Medline)**

```plaintext
(Myopia/) OR (Refraction, ocular/) OR (Refractive errors/)
AND ((Incidence/) OR (Prevalence/) OR (Population/))
AND ((CHILD/) OR (ADOLESCENT/))
```

**Subject headings (Embase)**

```plaintext
((Myopia/) OR (High myopia/) OR (Refractive error/))
AND ((Incidence/) OR (Prevalence/) OR (Population/) OR (Health survey/))
AND ((CHILD/) OR (ADOLESCENT/))
```

Combine Textword, MESH and Subject headings search within Medline and Embase

**Web of Science database**

```plaintext
Topic Search TS= ((Myopia) OR (Myopic) OR (Short$sight*) OR (Refractive error$) OR (Ocular refraction))
AND ((Incident) OR (Incidence) OR (Prevalen$) OR (Population) OR (Survey))
AND ((Child) OR (Childhood) OR (Children) OR (Adolescent) OR (Adolescence) OR (Teenage$))
```
| Authors                        | N    | Gender  | Age range | Ethnicity | Urbanicity | Country   | Survey year | Cycloplegia | Method of refraction | Field |
|-------------------------------|------|---------|-----------|-----------|------------|-----------|-------------|-------------|----------------------|--------|
| Abdi S et al, 2008[89]        | 216  | B       | 6 to 16   | W         | U          | Sweden    | 2001        | Yes         | A                    | NA     |
| Adlergrinberg D, 1986[90]     | 788  | B       | 0 to 16   | AIAN      | R          | USA       | 1980        | No          | NA                   | NA     |
| Aine E, 1984[91]              | 145  | B,M,F   | 6 to 20   | W         | R          | Finland   | NA          | Yes         | H                    | O      |
| Aldeebasi YH, 2014[92]        | 5176 | B       | 6 to 13   | MENA      | U          | Saudi Arabia | 2011     | Yes         | A                    | C      |
| Almeder LM et al, 1990[93]    | 326  | B       | 3.2 to 8.1| W         | U          | USA       | NA          | No          | H                    | O      |
| Anera RG et al, 2006[61]      | 388  | B,M,F   | 5 to 16   | BA        | R          | Burkina Faso | 2005     | No          | H                    | O      |
| Anera RG et al, 2009[94]      | 545  | B,M,F   | 6 to 16   | MENA      | U          | Morocco   | 2007        | Yes         | A                    | O      |
| Auzemery A et al, 1995[95]    | 1081 | B       | 8 to 14   | BA        | U          | Madagascar | 1994     | Yes         | H                    | O      |
| Awasthi S et al, 2010[96]     | 1165 | B       | 5 to 19   | SA        | R          | Nepal     | 2008        | NA          | H                    | O      |
| Ayed T et al, 2002[97]        | 708  | B       | 6 to 20   | MENA      | U          | Tunisia   | 2000        | Yes         | A                    | NA     |
| Azizoglu S et al, 2011[98]    | 353  | B,M,F   | 10 to 11  | MENA      | U          | Australia | NA          | No          | A                    | O      |
| Boniuk V, 1973[99]            | 502  | B       | 3 to 19   | AIAN      | R          | Canada    | NA          | Yes         | H                    | O      |
| Brody BL et al, 2007[100]     | 507  | B       | 3 to 5    | HL        | U          | USA       | 2003        | Yes         | H                    | O      |
| Buchner TF et al, 2003[101]   | 216  | B       | 3.5 to 4.5| W         | U          | Germany   | NA          | Yes         | A                    | C      |
| Caca I et al, 2013[102]       | 21062| B       | 6 to 14   | MENA      | R          | Turkey    | NA          | Yes         | A                    | C      |
| Casson RJ et al, 2012[103]    | 2842 | B       | 6 to 11   | SEA       | R          | Laos      | 2010        | Yes         | H                    | O      |
| Chan OY et al, 1993[104]      | 570  | B       | 3 to 5.5  | EA        | U          | Hong Kong | 1991        | No          | H                    | O      |
| Chang F et al, 2014[105]      | 403  | B,M,F   | 7 to 15   | NHOPI     | R          | Taiwan    | 2009        | No          | H                    | O      |
| Cheng CY et al, 2013[106]     | 1894 | B       | 6 to 11   | EA        | U          | Taiwan    | 2010        | No          | M                    | O      |
| Cheng HM et al, 2012[107]     | 694  | B       | 6 to 12   | EA        | R          | Taiwan    | NA          | No          | A                    | C      |
| Chung KM et al, 1996[108]     | 1873 | B,M,F   | 6 to 18   | EA        | U          | Malaysia  | 1990        | No          | H                    | O      |
| Congdon N et al, 2008[109]    | 1892 | B,M,F   | 11.4 to 17.1| EA     | R          | China     | 2007        | Yes         | A                    | C      |
| Czepita D et al, 2007[42]     | 4422 | B       | 6 to 18   | W         | M          | Poland    | 2001        | Yes         | H                    | O      |
| Dandona R et al, 1999[21]     | 599  | B       | 0 to 15   | SA        | U          | India     | 1997        | Yes         | H                    | O      |
| Dandona R et al, 2002[22]     | 4074 | B       | 7 to 15   | SA        | R          | India     | 2001        | Yes         | H                    | O      |
| Dirani M et al, 2010[60]      | 2639 | B       | 0.5 to 6  | EA        | U          | Singapore | 2008        | Yes         | A                    | C      |
| Authors | N  | x  | Gender | Age range | Ethnicity | Urbanicity | Country | Survey year | Cycloplegia | Method of refraction | Field |
|---------|----|----|--------|-----------|-----------|------------|---------|-------------|-------------|----------------------|-------|
| Dobson V et al, 2007[110] | 963 | 95 | B      | 3 to 4    | AIAN      | R          | USA     | 2002        | Yes         | A                    | C     |
| Edwards MH, 1999[111]   | 123 | 13 | B      | 7 to 12   | EA        | U          | Hong Kong| 1991        | No          | H                    | O     |
| Fan DS et al, 2011[112] | 1424 | 66 | B      | 2 to 6    | EA        | U          | Hong Kong| 1997, 2007  | Yes         | A                    | C     |
| Fan DSP et al, 2004[113] | 108 | 5  | B      | 2 to 6    | EA        | U          | Hong Kong| 1995        | Yes         | A                    | C     |
| Fan DSP et al, 2004[19]  | 7560 | 2988 | B,M,F  | 5 to 16   | EA        | U          | Hong Kong| 1999        | Yes         | A                    | C     |
| Fischbach LA et al, 1993[114] | 854 | 12 | B,M,F  | 6 to 7    | W, HL     | U          | USA     | 1990        | No          | H                    | O     |
| Fotouhi A et al, 2007[41] | 4293 | 398 | B,M,F  | 7 to 18   | MENA      | M          | Iran    | 2005        | Yes         | A                    | C     |
| Gao TY et al, 2014[115]  | 837 | 197 | B, M, F| 6 to 18   | EA        | R          | China   | 2010        | Yes         | M                    | O     |
| Gao Z et al, 2012[116]   | 5527 | 322 | B      | 12 to 14  | SEA       | U, R      | Cambodia| 2010        | Yes         | H                    | O     |
| Garner LF et al, 1985[117] | 977 | 8  | B      | 6 to 17   | NHOPI     | R          | Vanuatu | 1983        | No          | H                    | O     |
| Garner LF et al, 1990[118] | 1657 | 160 | B,M,F  | 7 to 17   | SEA, NHOPI| U, R      | Malaysia| 1987, 1986  | No          | H                    | O     |
| Garner LF et al, 1995[119] | 404 | 16 | B      | 6 to 16   | SA        | U          | Nepal   | 1992        | Yes         | H                    | O     |
| Garner LF et al, 1999[36] | 825 | 128 | B      | 7 to 18   | SA        | U, R      | Nepal   | 1998        | Yes         | A                    | C     |
| Giordano L et al, 2009[120] | 2121 | 97  | B      | 1 to 6    | W, BNA    | U          | USA     | 2006        | Yes         | A                    | C     |
| Goh P et al, 2005[78] | 4634 | 942 | B,M,F  | 7 to 15   | SEA       | U          | Malaysia| 2003        | Yes         | A                    | C     |
| Goh WSH et al, 1993[121] | 2569 | 1247 | B,M,F  | 6 to 17   | EA        | U          | Hong Kong| NA          | No         | A                    | C     |
| Goldschmidt E et al, 2001[122] | 130 | 6  | B,M,F  | 6 to 18   | EA        | U          | Hong Kong| 1993        | Yes         | A                    | O     |
| Gordon A, 1990[123] | 366 | 48 | B      | 0 to 20   | HL        | R          | Puerto Rico| NA          | No         | H                    | O     |
| Gronlund MA et al, 2006[124] | 143 | 9  | B      | 4 to 15   | W         | U          | Sweden  | NA          | Yes         | A                    | C     |
| Grosvenor T, 1970[125] | 973 | 135 | B      | 12 to 19  | W, NHOPI  | U          | New Zealand| NA          | NA         | H                    | O     |
| Guggenheim JA et al, 2012[68] | 7520 | 188 | B      | 7.5       | W         | U          | England | NA          | No         | A                    | C     |
| Guo K et al, 2015[126] | 1565 | 939 | B      | 6 to 21   | EA        | R          | China   | 2012        | Yes         | A                    | C     |
| Guo Y et al, 2013[127] | 681 | 194 | B,M,F  | 5 to 13   | EA        | U, R      | China   | NA          | No         | A                    | C     |
| Gursoy H et al, 2013[128] | 709 | 160 | B      | 7 to 8    | MENA      | U          | Turkey  | 2010        | Yes         | A                    | C     |
| Hashemi H et al, 2004[129] | 809 | 58  | B,M,F  | 5 to 15   | MENA      | U          | Iran    | 2002        | Yes         | H                    | O     |
| Hashemi H et al, 2014[130] | 434 | 128 | B, M, F| 14 to 18  | MENA      | U          | Iran    | 2011        | No         | M                    | O     |
| He MG et al, 2004[51] | 4364 | 1659 | B      | 5 to 15   | EA        | U          | China   | 2003        | Yes         | A                    | O     |
| Authors                  | N     | x    | Gender   | Age range | Ethnicity | Urbanicity | Country | Survey year | Cycloplegia | Method of refraction | Field |
|-------------------------|-------|------|----------|-----------|-----------|------------|---------|-------------|-------------|-----------------------|-------|
| He MG et al, 2007[77]   | 2229  | 944  | B,M,F    | 13 to 17  | EA        | R          | China   | 2005        | Yes         | A                     | O     |
| Hendricks TJW et al, 2007[131] | 487  | 72   | B        | 11 to 13  | W         | U          | Netherlands | 2003       | No                    | A C   |
| Ho CSD et al, 2006[132] | 629   | 441  | B        | 12 to 16  | EA        | U          | Singapore | 2005        | No                     | A C   |
| Hsu SL et al, 2008[133] | 371   | 62   | B,M,F    | 7 to 13   | NHOPI     | R          | Taiwan   | 2006        | Yes                     | M O   |
| Ingram RM et al, 1979[134] | 148  | 12   | B        | 3.5       | W         | U          | England  | NA          | Yes                     | H O   |
| Ip JM et al, 2008[15]   | 2041  | 252  | B,M,F    | 11.1 to 14.4 | W, EA, MENA, SA | U          | Australia | NA          | Yes                     | A C   |
| Jamali P et al, 2009[135] | 815  | 14   | B        | 6         | MENA      | U          | Iran     | 2005        | Yes                     | H O   |
| Jimenez R et al, 2012[62] | 315  | 8    | B        | 6 to 16   | BA        | U          | Burkina Faso | NA        | No                    | H O   |
| Johnstone WW et al, 1963[136] | 1817 | 45   | B        | 8 to 14   | BA        | U          | Tanganyika | 1961       | Yes                    | H O   |
| Junghans B et al, 2002[1] | 2697 | 143  | B        | 3 to 12   | W         | U          | Australia | 1992        | No                     | H O   |
| Junghans BM et al, 2005[137] | 1936 | 162  | B,M,F    | 4 to 12   | W         | U          | Australia | 2001        | No                     | H O   |
| Kalikivayi V et al, 1997[23] | 3987 | 341  | B,M,F    | 3 to 18   | SA        | U          | India    | 1993        | Yes                    | H O   |
| Kalogjera T, 1979[138]  | 583   | 14   | B,M,F    | 3 to 7    | W         | U          | Yugoslavia | NA          | Yes                    | H O   |
| Khan AA et al, 2005[40]  | 1062  | 214  | B,M,F    | 6 to 16   | SA        | U, R      | India    | NA          | Yes                    | H O   |
| Kleinstein RN et al, 2003[11] | 2523 | 264  | B        | 5 to 17   | W, EA, HL, BNA | U          | USA      | 1998        | Yes                    | A C   |
| Laatikainen L et al, 1980[139] | 822  | 81   | B        | 7 to 15   | W         | U          | Finland  | NA          | Yes                    | H O   |
| Lai YH et al, 2009[140]  | 584   | 32   | B,M,F    | 3 to 6    | EA        | U          | Taiwan   | 2005        | Yes                    | H O   |
| Lam C et al, 1991[141]   | 773   | 417  | B,M,F    | 6 to 17   | EA        | U          | Hong Kong | NA          | No                     | H O   |
| Lam C et al, 2012[33]    | 2653  | 1240 | B        | 6 to 12   | EA        | U          | Hong Kong | 2008        | No                     | A O   |
| Lan W et al, 2013[142]   | 2478  | 24   | B, M, F  | 3 to 6    | EA        | M          | China    | 2009        | Yes                    | A O   |
| Li S et al, 2013[143]    | 4861  | 1528 | B        | 5 to 16   | EA        | U          | China    | 2011        | Yes                    | A C   |
| Li Z et at, 2014[144]    | 1675  | 84   | B, M, F  | 5 to 18   | EA        | R          | China    | 2008.5      | Yes                    | M O   |
| Liang BS et al, 1991[145] | 5458 | 740  | B,M,F    | 7 to 17   | EA        | R          | China    | 1988        | Yes                    | H O   |
| Liang YB et al, 2013[146] | 395  | 264  | B        | 6 to 17   | EA        | U          | China    | NA          | Yes                    | H O   |
| Liao CC et al, 2014[147] | 687   | 557  | B        | 12 to 14  | EA        | U          | Taiwan   | 2010        | Yes                    | A C   |
| Lin LL et al, 1988 (a)[148] | 17411 | 6436 | B,M,F    | 6 to 18   | EA        | U, R, M   | Taiwan   | 1986        | Yes                    | H, A O C |
| Authors                        | N   | x    | Gender | Age range | Ethnicity | Urbanicity | Country | Survey year | Cycloplegia | Method of refraction | Field |
|-------------------------------|-----|------|--------|-----------|-----------|------------|---------|-------------|-------------|----------------------|-------|
| Lin LL et al, 1988 (b)[48]    | 3000| 386  | B,M,F  | 13 to 16  | NHOPI     | R          | Taiwan  | 1985        | Yes         | H                    | O     |
| Lin LLK et al, 1999[74]       | 11178| 5914 | B,M,F  | 7 to 18   | EA        | M          | Taiwan  | 1995        | Yes         | M                    | O     |
| Lin LLK et al, 2001[38]       | 10878| 6421 | B,M,F  | 7 to 18   | EA        | M          | Taiwan  | 2000        | Yes         | M                    | O     |
| Lin LLK et al, 2004[149]      | 12792| 5699 | B      | 7 to 18   | EA        | M          | Taiwan  | 1983, 1990  | Yes         | A                    | C     |
| Logan NS et al, 2011[150]     | 596 | 106  | B      | 6 to 13   | W, BNA, SA| U          | England | NA          | Yes         | A                    | O     |
| Ma Q et al, 2014[151]         | 1219| 5    | B, M, F| 0 to 3    | EA        | U          | China   | 2013        | No          | A                    | O     |
| Macfarlane DJ et al, 1987[152]| 877 | 114  | B      | 6 to 11   | W         | U          | Australia| NA          | Yes         | H                    | O     |
| Marasini S et al, 2010[153]   | 1802| 39   | B      | 3 to 22   | SA        | U          | Nepal   | NA          | NA          | H                    | O     |
| Martinez J et al, 1997[154]   | 1179| 43   | B      | 3 to 6    | W         | U          | Spain   | NA          | Yes         | M                    | O     |
| Matsumura H et al, 1999[155]  | 2664| 860  | B      | 3 to 17   | EA        | U          | Japan   | 1984, 1996  | NA          | A                    | O     |
| Maul E et al, 2000[81]        | 5303| 362  | B,M,F  | 5 to 15   | HL        | U          | Chile   | 1998        | Yes         | H                    | O     |
| Montes-Mico R et al, 2000[156]| 1711| 287  | B      | 3 to 19   | W         | U          | Spain   | NA          | No          | H                    | O     |
| Morgan A et al, 2006[157]     | 1057| 61   | B,M,F  | 7 to 17   | EA        | R          | Mongolia| 2003        | No          | H                    | O     |
| Multi-ethnic pediatric eye    | 6030| 309  | B      | 0.5 to 6  | BNA, HL   | U          | USA     | NA          | Yes         | A                    | C     |
| disease study group, 2010[158]|     |      |        |           |           |            |         |             |             |                      |       |
| Murthy GVS et al, 2002[24]    | 5696| 420  | B      | 5 to 15   | SA        | U          | India   | 2000        | Yes         | H                    | O     |
| Naidoo KS et al, 2003[82]     | 4890| 197  | B      | 5 to 15   | BA        | U          | South Africa| 2002       | Yes         | A                    | C     |
| Nanthavisit U et al, 2008[159]| 2658| 313  | B      | 9 to 20   | SEA       | R          | Thailand| 2006        | NA          | H                    | O     |
| Nepal BP et al, 2003[160]     | 1100| 47   | B,M,F  | 5 to 16   | SA        | U          | Nepal   | NA          | Yes         | H                    | O     |
| O'Donoghue L et al, 2010[14]  | 1053| 128  | B      | 6 to 13   | W         | U          | Northern Ireland| 2007       | Yes         | A                    | O     |
| Ogielska E et al, 1967[161]   | 2368| 232  | B,M,F  | 8 to 19   | W         | U          | Poland  | 1962        | NA          | H                    | O     |
| Ojaimi E et al, 2005[162]     | 1724| 26   | B,M,F  | 5 to 8.4  | W, EA     | U          | Australia| 2004        | Yes         | M                    | C     |
| Ore L et al, 2014[163]        | 1708| 181  | B      | 6 to 14   | MENA      | U          | Israel  | 2002.5      | Yes         | H                    | O     |
| Oscar A et al, 2014[164]      | 2054| 61   | B, M, F| 6 to 12   | W         | U          | Bulgaria| 2014        | No          | H                    | O     |
| Ostadimoghaddam H et al, 2011[165]| 765| 39   | B      | 0 to 15   | MENA      | U          | Iran    | 2008        | Yes         | M                    | O     |
| Padhye AS et al, 2009[44]     | 12422| 268  | B      | 6 to 15   | SA        | U, R     | India   | 2005        | Yes         | H                    | O     |
| Pant M et al, 2014[166]       | 569 | 43   | B, M, F| 6 to 18   | SA        | U          | Nepal   | 2014        | No          | H                    | O     |
| Authors                          | N   | x  | Gender | Age range | Ethnicity | Urbanicity | Country | Survey year | Cycloplegia | Method of refraction | Field |
|---------------------------------|-----|----|--------|-----------|-----------|------------|---------|-------------|-------------|-----------------------|--------|
| Pi L et al, 2010[167]           | 3070| 422| B      | 6 to 15   | EA        | U          | China   | 2007        | Yes         | H                     | O      |
| Pokharel GP et al, 2000[80]     | 5067| 60 | B,M,F  | 5 to 15   | SA        | R          | Nepal   | 1998        | Yes         | H                     | O      |
| Quek TPL et al, 2004[20]        | 946 | 699| B,M,F  | 15 to 19  | EA,SA,SEA | U          | Singapore| 2002        | No          | A                     | C      |
| Resvan F et al, 2012[168]       | 1548| 64 | B      | 6 to 16   | MENA      | U          | Iran    | 2010        | Yes         | A                     | O      |
| Richler A et al, 1980[32]       | 448 | 179| B,M,F  | 15 to 19  | W         | R          | Canada  | 1974        | NA          | H                     | O      |
| Rodriguez MA et al, 1995[169]   | 17697| 257| B      | 5 to 14   | HL        | U          | Colombia| 1994        | NA          | NA                    | NA     |
| Rose KA et al, 2008[59]         | 752 | 187| B      | 6 to 7    | EA        | U          | Australia, Singapore | NA   | Yes   | A                     | C      |
| Rudnicka AR et al, 2010[13]     | 755 | 100| B,M,F  | 10 to 11  | W, BNA, SA| U          | England | 2008        | No          | A                     | O      |
| Saw SM et al, 2001[170]         | 127 | 11 | B,M,F  | 3 to 7    | EA        | U          | Singapore| 1998        | Yes         | A                     | C      |
| Saw SM et al, 2006[18]          | 1962| 712| B,M,F  | 7 to 9    | EA        | U          | Singapore| 2000        | Yes         | A                     | C      |
| Saw SM et al, 2007[171]         | 740 | 460| B      | 10 to 12  | EA        | U          | Singapore| 1999        | Yes         | A                     | C      |
| Shrestha RK et al, 2006[172]    | 1816| 183| B      | 5 to 16   | SA        | U          | Nepal   | NA          | Yes         | H                     | O      |
| Shrestha RK et al, 2012[173]    | 4228| 405| B      | 12.3      | SA        | U          | Nepal   | NA          | Yes         | H                     | O      |
| Shrestha GS et al, 2013[174]    | 366 | 24 | B, M, F| 0 to 16   | SA        | U          | Nepal   | 2010        | Yes         | H                     | O      |
| Sorsby A et al, 1961[175]       | 386 | 24 | B,M,F  | 3 to 15   | W         | U          | England | NA          | Yes         | H                     | O      |
| Tan G et al, 2000[176]          | 414 | 119| B      | 3 to 6    | EA        | U          | Singapore| 1999        | No          | A                     | C      |
| Villamar Roldan E, 1980 [177]   | 2853| 134| B      | 6 to 14   | HL        | U          | Mexico   | 1976        | NA          | H                     | O      |
| Villarreal GM et al, 2003[178]  | 1035| 455| B,M,F  | 13        | HL        | U          | Mexico   | 1999        | Yes         | H                     | O      |
| Villarreal MG et al, 2000[179]  | 1045| 519| B      | 12 to 13  | W         | U          | Sweden   | 1997        | Yes         | H                     | O      |
| Virgili G;Angi M et al, 2007[180]| 1591| 46 | B      | 5 to 6    | HL        | M          | Ecuador  | NA          | No          | A                     | C      |
| Wang X et al, 2014[181]         | 2255| 20 | B      | 2 to 7    | EA        | U          | China    | 2011        | Yes         | H                     | O      |
| Watanabe S et al, 1999[182]     | 350 | 1  | B      | 6         | EA        | U          | Japan    | 1989        | Yes         | A                     | O      |
| Wen G et al, 2013[183]          | 3008| 78 | B      | 0.5 to 6  | W, EA     | U          | USA      | 2010        | Yes         | A                     | C      |
| Williams C et al, 2008[12]      | 7554| 113| B      | 7         | W         | U          | England  | 1999        | No          | A                     | C      |
| Williams SM et al, 1988[184]    | 503 | 23 | B,M,F  | 11        | W         | U          | New Zealand| 1983        | NA          | H                     | O      |
| Woodruff ME, 1986[185]          | 8085| 97 | B      | 6         | W         | U          | Canada   | 1982        | NA          | H                     | O      |
| Authors                     | N   | x    | Gender | Age range | Ethnicity | Urbanicity | Country   | Survey year | Cycloplegia | Method of refraction | Field |
|-----------------------------|-----|------|--------|-----------|-----------|------------|-----------|-------------|-------------|----------------------|--------|
| Wu JF et al, 2013[47]      | 6025| 2221 | B, M, F| 4 to 18   | EA        | M          | China     | 2013        | Yes         | A                    | C      |
| Wu P et al, 2010[67]       | 144 | 45   | B, M, F| 7 to 12   | EA        | R          | Taiwan    | 2007        | Yes         | A                    | C      |
| Xiang F et al, 2012[186]   | 3631| 1311 | B      | 5 to 15   | EA        | U          | China     | 2002        | Yes         | A                    | C      |
| Yekta A et al, 2010[187]   | 1854| 92   | B, M, F| 5 to 15   | MENA      | U          | Iran      | 2009        | Yes         | H                    | O      |
| Yingyong P, 2010[188]      | 2340| 175  | B      | 6 to 12   | SEA       | U, R       | Thailand  | 2009        | Yes         | M                    | O      |
| Yoon K-C et al, 2011[189]  | 2989| 1906 | B      | 8 to 15   | EA        | M          | South Korea| 2008        | Yes         | A                    | C      |
| You QS et al, 2012[190]    | 15066| 8588 | B      | 7 to 18   | EA        | M          | China     | NA          | No         | A                    | C      |
| Young FA et al, 1970[191]  | 204 | 54   | B, M, F| 9 to 12   | AIAN      | R          | USA       | NA          | Yes        | H                    | O      |
| Zhang M et al, 2011[79]    | 1979| 621  | B      | 7 to 11   | EA        | U          | Singapore | 1999        | Yes         | A                    | C      |
| Zhang MZ et al, 2000[37]   | 382 | 34   | B      | 6 to 7    | EA        | U, R       | China, Singapore | 1998        | Yes         | A                    | C      |
| Zhao J et al, 2000[192]    | 5884| 958  | B, M, F| 5 to 15   | EA        | R          | China     | 1998        | Yes         | H                    | O      |
| Zylbermann R et al, 1993[193] | 870 | 377  | B      | 14 to 18  | MENA      | U          | Israel    | NA          | No         | H                    | O      |

N: Total number of participants (published or estimated).
x: Total number of cases of myopia -0.50D or less. When more than one definition were reported the one with spherical equivalent refraction /sphere refraction closest to -0.50D was used.
Gender: B=Both genders combined, M=Male, F=Female.
Ethnicity: W=White, EA=East Asian, SA=South Asian, SEA=Southeast Asian, BA=Black in Africa, BNA=Black not in Africa, MENA=Middle Eastern or North African, HL=Hispanic or Latino, NHOPI=Native Hawaiian or other Pacific Islander. AIAN=American Indian or Alaska native.
Urbanicity: U=Urban or semi-rural, R=Rural, M=Mixed.
Cycloplegia: NAI=No available information.
Method: A=Automatic refraction, H=Human assessment (retinoscopy and/or subjective refraction), M= Mixture of automatic refraction and human assessment. NA=Not available.
Field: refers to whether method of refraction was classified as O=Open, C=Closed, NA=Not available.
Table S2. Odds ratios for not using cycloplegia vs using cycloplegia by age

| Age | OR (95% CrI)       |
|-----|--------------------|
| 5   | 4.21 (3.18, 5.65)  |
| 6   | 3.90 (2.98, 5.17)  |
| 7   | 3.62 (2.79, 4.74)  |
| 8   | 3.35 (2.61, 4.34)  |
| 9   | 3.10 (2.45, 3.99)  |
| 10  | 2.87 (2.29, 3.66)  |
| 11  | 2.66 (2.14, 3.37)  |
| 12  | 2.47 (2.00, 3.10)  |
| 13  | 2.29 (1.86, 2.86)  |
| 14  | 2.12 (1.73, 2.63)  |
| 15  | 1.96 (1.61, 2.43)  |
| 16  | 1.82 (1.49, 2.25)  |
| 17  | 1.69 (1.39, 2.09)  |
| 18  | 1.56 (1.28, 1.94)  |

Numbers correspond to median odds ratio of myopia for no cycloplegia use vs cycloplegia use (95% CrI) by age after adjusting for urbanicity of living environment (all ethnic groups, except for native Hawaiian or other Pacific Islanders) and year of survey (White, East Asian, and South Asian children, only).
**Table S3.** Odds ratios for girls versus boys by ethnic group and age

| Age | White          | East Asian | South Asian | Hispanic or Latino |
|-----|----------------|------------|-------------|--------------------|
| 5   | 0.99 (0.59, 1.61) | 0.97 (0.86, 1.09) | 0.23 (0.09, 0.66) | 0.69 (0.38, 1.25) |
| 6   | 1.05 (0.72, 1.50) | 1.00 (0.91, 1.09) | 0.37 (0.18, 0.74) | 0.93 (0.61, 1.42) |
| 7   | 1.12 (0.85, 1.43) | 1.04 (0.97, 1.11) | 0.54 (0.35, 0.84) | 1.18 (0.85, 1.64) |
| 8   | 1.19 (0.97, 1.41) | 1.09 (1.04, 1.14) | 0.75 (0.57, 0.97) | 1.40 (1.03, 1.90) |
| 9   | 1.26 (1.06, 1.45) | 1.14 (1.10, 1.19) | 0.98 (0.81, 1.16) | 1.57 (1.16, 2.12) |
| 10  | 1.34 (1.13, 1.56) | 1.21 (1.16, 1.25) | 1.19 (0.99, 1.44) | 1.65 (1.23, 2.22) |
| 11  | 1.41 (1.19, 1.68) | 1.28 (1.24, 1.33) | 1.37 (1.10, 1.70) | 1.63 (1.25, 2.13) |
| 12  | 1.48 (1.24, 1.80) | 1.37 (1.32, 1.43) | 1.48 (1.16, 1.86) | 1.51 (1.22, 1.89) |
| 13  | 1.56 (1.31, 1.90) | 1.47 (1.41, 1.54) | 1.49 (1.16, 1.92) | 1.32 (1.10, 1.59) |
| 14  | 1.65 (1.38, 2.00) | 1.59 (1.52, 1.67) | 1.42 (1.05, 1.94) | 1.08 (0.85, 1.38) |
| 15  | 1.74 (1.45, 2.11) | 1.73 (1.64, 1.83) | 1.27 (0.82, 1.95) | 0.84 (0.55, 1.26) |
| 16  | 1.84 (1.48, 2.27) | 1.89 (1.76, 2.03) | 1.07 (0.57, 2.00) | 0.61 (0.31, 1.16) |
| 17  | 1.93 (1.46, 2.53) | 2.08 (1.88, 2.29) | 0.84 (0.34, 2.06) | 0.42 (0.16, 1.06) |
| 18  | 2.03 (1.40, 2.93) | 2.30 (2.01, 2.61) | 0.62 (0.18, 2.13) | 0.27 (0.07, 0.95) |

Numbers correspond to median odds ratio of myopia for girls as compared with boys (95% CrI) by age after adjusting for environmental setting (urban, rural or mixed) and year of survey (White, East Asian, and South Asian children, only).

*a:* Estimate obtained by extrapolation.
Table S4. Global myopia trends: age, gender and ethnic specific prevalence estimates applied to UN defined population data for age below 19 years for 2015 and 2025

| UN population | Total population (≤19 years) | Myopia cases (95% CrI) | Population prevalence (%) | % of global prevalence |
|---------------|-----------------------------|------------------------|---------------------------|------------------------|
|               | 2015 | 2025 | 2015 | 2025 | 2015 | 2025 | 2015 | 2025 |
| Europe        | 155.1 | 157.2 | 13.2 (8.4, 19.4) | 14.0 (8.9, 20.5) | 8.5 | 8.9 | 4.2 | 4.3 |
| Africa        | 593.9 | 719.3 | 18.1 (10.7, 28.0) | 22.1 (13.1, 34.1) | 3.0 | 3.1 | 5.8 | 6.8 |
| Asia          | 1,418.9 | 1,410.4 | 248.4 (206.5, 301.5) | 256.3 (213.7, 309.8) | 17.5 | 18.2 | 79.6 | 79.1 |
|               |       |       | 139.8 (114.6, 154.9) | 139.8 (119.5, 161.9) | 34.9 | 36.8 | 42.9 | 43.1 |
| Western Asia  | 96.9 | 101.8 | 11.9 (8.1, 17.0) | 12.9 (8.7, 18.4) | 12.3 | 12.7 | 3.8 | 4.0 |
| Central Asia  | 24.9 | 26.9 | 8.3 (7.1, 9.6) | 9.5 (8.1, 11.0) | 33.2 | 35.3 | 2.7 | 2.9 |
| Eastern Asia  | 384.2 | 379.9 | 133.9 (114.6, 154.9) | 139.8 (119.5, 161.9) | 34.9 | 36.8 | 42.9 | 43.1 |
| Southern Asia | 690.4 | 683.7 | 60.3 (33.8, 102.4) | 60.1 (33.7, 102.0) | 8.7 | 8.8 | 19.3 | 18.5 |
| South-Eastern Asia | 222.4 | 218.1 | 31.6 (15.3, 58.6) | 31.6 (15.3, 58.4) | 14.2 | 14.5 | 10.1 | 9.7 |
| Northern America | 92.7 | 97.5 | 8.1 (5.2, 11.9) | 8.4 (5.4, 12.4) | 8.8 | 8.7 | 2.6 | 2.6 |
| Latin America and the Caribbean | 220.4 | 211.6 | 20.7 (9.4, 42.4) | 19.8 (9.0, 40.6) | 9.4 | 9.4 | 6.6 | 6.1 |
| Central America | 66.6 | 64.8 | 6.1 (2.5, 13.1) | 5.9 (2.4, 12.8) | 9.2 | 9.2 | 2.0 | 1.8 |
| Southern America | 139.4 | 133.0 | 12.9 (5.2, 27.6) | 12.2 (5.0, 26.3) | 9.2 | 9.2 | 4.1 | 3.8 |
| Caribbean      | 14.4 | 13.8 | 1.7 (1.4, 2.1) | 1.6 (1.3, 2.0) | 11.8 | 11.8 | 0.5 | 0.5 |
| Australia and New Zealand | 7.3 | 8.2 | 0.6 (0.4, 0.9) | 0.7 (0.5, 1.0) | 8.5 | 8.7 | 0.2 | 0.2 |
| Melanesia     | 4.5 | 4.9 | 0.4 (0.1, 1.2) | 0.5 (0.1, 1.4) | 9.7 | 10.1 | 0.1 | 0.2 |
| Micronesia    | 0.2 | 0.2 | 0.02 (0.01, 0.06) | 0.02 (0.01, 0.06) | 10.6 | 10.0 | 0.01 | 0.01 |
| Polynesia     | 0.3 | 0.3 | 0.03 (0.01, 0.08) | 0.03 (0.01, 0.07) | 9.3 | 9.0 | 0.01 | 0.01 |
| Global        | 2,493 | 2,610 | 312 (265, 369) | 324 (276, 382) | 12.5 | 12.4 | 100.0 | 100.0 |

Total population and numbers of myopia cases are reported in millions.
In Europe and North America the predominant ethnicity was assumed to be White.
In Africa the predominant ethnicity was assumed to be Black in Africa.
Asia includes Western Asia (Middle Eastern or North African), Central Asia (East Asian), Eastern Asia (East Asian), Southern Asia (South Asian) and South-Eastern Asia (South-East Asian).
Latin America and the Caribbean include the Caribbean (Black not in Africa), Central America (Hispanic or Latino) and South America (Hispanic or Latino).
Oceania includes Australia and New Zealand (White), Melanesia (Native Hawaiian or other Pacific Islander), Micronesia (Native Hawaiian or other Pacific Islander) and Polynesia (Native Hawaiian or other Pacific Islander).
Statistical Appendix: Bayesian models for the estimation of myopia prevalence

Prevalence of myopia for both genders combined, adjusted for multiple risk factors

Let \( K \) be the total number of estimates of myopia prevalence identified in the literature review, refined by the exclusion criteria described in the statistical analysis Section. For each \( k = 1, \ldots, K \), let \( p_k \) and \( n_k \) denote the prevalence of myopia and the number of myopic children within a population of size \( N_k \), respectively. Let \( C_W, C_{EA}, C_{SA}, C_{SEA}, C_{BA}, C_{BNA}, C_{MENA}, C_{HL}, C_{NHOP1}, C_{ALIAN} \) be the subset of indexes \( k \in \{1, \ldots, K\} \) corresponding to white, East Asian, South Asian, South-East Asian, black living in Africa, black living not in Africa, Middle Eastern or North African, Hispanic or Latino, native Hawaiian or other Pacific Islander, and American Indian or Alaska native children, respectively. Note that \( C_W \cup C_{EA} \cup C_{SA} \cup C_{SEA} \cup C_{BA} \cup C_{BNA} \cup C_{MENA} \cup C_{HL} \cup C_{NHOP1} \cup C_{ALIAN} = \{1, \ldots, K\} \) and \( C_W, C_{EA}, C_{SA}, C_{SEA}, C_{BA}, C_{BNA}, C_{MENA}, C_{HL}, C_{NHOP1}, C_{ALIAN} \) are mutually exclusive. Let \( i \) denote a distinct study population group defined by its ethnicity, examined at a fixed point in time and specific geographical location. Furthermore, let \( I_W, I_{EA}, I_{SA}, I_{SEA}, I_{BA}, I_{BNA}, I_{MENA}, I_{HL}, I_{NHOP1}, I_{ALIAN} \) be the total number of clusters defined in white, East Asian, South Asian, South-East Asian, black living in Africa, black living not in Africa, Middle Eastern or North African, Hispanic or Latino, native Hawaiian or other Pacific Islander, and American Indian or Alaska native children, respectively. The fitted model is described by the following formulas:

\[
n_k \sim Bin(p_k, N_k) \quad \text{for } k = 1, \ldots, K,
\]

where,
logit(\(p_k\)) = \(\beta_0^W + \beta_A^W A + \beta_A^{W2} A^2 + \beta_{R_1} R_1 + \beta_{R_2} R_2 + \beta_Y^{W} Y + U_{iw}^W\) if \(k \in C_W\),

logit(\(p_k\)) = \(\beta_0^{EA} + \beta_A^{EA} A + \beta_A^{EA2} A^2 + \beta_{R_1} R_1 + \beta_{R_2} R_2 + \beta_Y^{EA} Y + U_{iEA}^{EA}\) if \(k \in C_{EA}\),

logit(\(p_k\)) = \(\beta_0^{SA} + \beta_A^{SA} A + \beta_A^{SA2} A^2 + \beta_{R_1} R_1 + \beta_Y^{SA} Y + U_{iSA}^{SA}\) if \(k \in C_{SA}\),

logit(\(p_k\)) = \(\beta_0^{SEA} + \beta_A^{SEA} A + \beta_A^{SEA2} A^2 + \beta_{R_1} R_1 + U_{iSEA}^{SEA}\) if \(k \in C_{SEA}\),

logit(\(p_k\)) = \(\beta_0^{BA} + \beta_A^{BA} A + \beta_A^{BA2} A^2 + \beta_{R_1} R_1 + U_{iBA}^{BA}\) if \(k \in C_{BA}\),

logit(\(p_k\)) = \(\beta_0^{BNA} + \beta_A^{BNA} A + \beta_A^{BNA2} A^2 + U_{iBNA}^{BNA}\) if \(k \in C_{BNA}\),

logit(\(p_k\)) = \(\beta_0^{MENA} + \beta_A^{MENA} A + \beta_A^{MENA2} A^2 + \beta_{R_1} R_1 + \beta_{R_2} R_2 + U_{iMENA}^{MENA}\) if \(k \in C_{MENA}\),

logit(\(p_k\)) = \(\beta_0^{HL} + \beta_A^{HL} A + \beta_A^{HL2} A^2 + \beta_{R_1} R_1 + \beta_{R_2} R_2 + U_{iHL}^{HL}\) if \(k \in C_{HL}\),

logit(\(p_k\)) = \(\beta_0^{NHOP}\) \(p_k\) = \(\beta_0^{NHOP} + \beta_A^{NHOP} A + \beta_A^{NHOP2} A^2 + \beta_{R_1} R_1 + U_{iNHOP}^{NHOP}\) if \(k \in C_{NHOP}\),

logit(\(p_k\)) = \(\beta_0^{AIAN} + \beta_A^{AIAN} A + \beta_A^{AIAN2} A^2 + U_{iAIAN}^{AIAN}\) if \(k \in C_{AIAN}\),

\(U_{iw}^W \sim N(0, \sigma_{iw}^2)\) for \(i \in \{1, \ldots, I_W\}\),

\(U_{iEA}^{EA} \sim N(0, \sigma_{iEA}^2)\) for \(i \in \{1, \ldots, I_{EA}\}\),

\(U_{iSA}^{SA} \sim N(0, \sigma_{iSA}^2)\) for \(i \in \{1, \ldots, I_{SA}\}\),

\(U_{iSEA}^{SEA} \sim N(0, \sigma_{iSEA}^2)\) for \(i \in \{1, \ldots, I_{SEA}\}\),

\(U_{iBA}^{BA} \sim N(0, \sigma_{iBA}^2)\) for \(i \in \{1, \ldots, I_{BA}\}\).
\[ U_{i_BNA}^{BNA} \sim N(0, \sigma_{BNA}^2) \]
\[ U_{i_MENA}^{MENA} \sim N(0, \sigma_{MENA}^2) \]
\[ U_{i_HL}^{HL} \sim N(0, \sigma_{HL}^2) \]
\[ U_{i_NHOPI}^{NHOPI} \sim N(0, \sigma_{NHOPI}^2) \]
\[ U_{i_AIAN}^{AIAN} \sim N(0, \sigma_{AIAN}^2) \]

for \( i_{BNA} \in \{1, ..., I_{BNA}\} \),

for \( i_{MENA} \in \{1, ..., I_{MENA}\} \),

for \( i_{HL} \in \{1, ..., I_{HL}\} \),

for \( i_{NHOPI} \in \{1, ..., I_{NHOPI}\} \),

for \( i_{AIAN} \in \{1, ..., I_{AIAN}\} \)

where the \( U_i \) take account of the hierarchical structure of the data according to which estimates of prevalence are nested within a study population group, and where \( A \) is age; \( R_1 \) and \( R_2 \) are indicator variables for a rural and a mixed environment (as compared with urban), respectively; and \( Y \) is year of survey. Non-informative normal priors were for log odds and log odds ratios, and non-informative Gamma priors for the corresponding variances.

The model allows a different quadratic association between age and prevalence of myopia by ethnicity. The association with an urban living environment is assumed to be equal across the ethnic groups and it is estimated when data are available (e.g. there were no estimates of prevalence on mixed urbanity environments for South Asians, and all estimates of prevalence were from rural environments for American Indians or Alaska natives). Finally, a linear association between year of survey and prevalence of myopia is estimated for white, East Asian, and South Asian populations allowing a different trend over time for each of these three ethnic groups.
Reference List (including additional references in Suppl Table 1)

1. Junghans B, Kiely PM, Crewther DP, Crewther SG. Referral rates for a functional vision screening among a large cosmopolitan sample of Australian children. Ophthalmic and Physiological Optics 2002; 22(1):10-25.

2. Kleinstein RN, Jones LA, Hullett S, Kwon S, Lee RJ, Friedman NE et al. Refractive error and ethnicity in children. Archives of Ophthalmology 2003; 121(8):1141-1147.

3. Lam CS, Goldschmidt E, Edwards MH. Prevalence of myopia in local and international schools in Hong Kong. Optom Vis Sci 2004; 81(5):317-322.

4. Cumberland PM, Peckham CS, Rahi JS. Inferring myopia over the lifecourse from uncorrected distance visual acuity in childhood. Br J Ophthalmol 2007; 91(2):151-153.

5. Foster PJ, Jiang Y. Epidemiology of myopia. Eye (Lond) 2014; 28(2):202-208.

6. Congdon NG, Friedman DS, Lieman T. Important causes of visual impairment in the world today. JAMA 2003; 290(15):2057-2060.

7. Gilmartin B. Myopia: precedents for research in the twenty-first century. Clin Experiment Ophthalmol 2004; 32(3):305-324.

8. Kempen JH, Mitchell P, Lee KE, Tielsch JM, Broman AT, Taylor HR et al. The prevalence of refractive errors among adults in the United States, Western Europe, and Australia. Arch Ophthalmol 2004; 122(4):495-505.

9. Morgan IG, Ohno-Matsui K, Saw SM. Myopia. Lancet 2012; 379(9827):1739-1748.

10. Rudnicka AR, Owen CG, Richards M, Wadsworth ME, Strachan DP. Effect of breastfeeding and sociodemographic factors on visual outcome in childhood and adolescence. Am J Clin Nutr 2008; 87(5):1392-1399.

11. Kleinstein RN, Jones LA, Hullett S, Kwon S, Lee RJ, Friedman NE et al. Refractive error and ethnicity in children. Archives of Ophthalmology 2003; 121(8):1141-1147.

12. Williams C, Miller LL, Gazzard G, Saw SM. A comparison of measures of reading and intelligence as risk factors for the development of myopia in a UK cohort of children. British Journal of Ophthalmology 2008; 92(8):1117-1121.

13. Rudnicka AR, Owen CG, Nightingale CM, Cook DG, Whincup PH. Ethnic differences in the prevalence of myopia and ocular biometry in 10- and 11-year-old children: The child heart and health study in England (CHASE). Invest Ophthalmol Vis Sci 2010; 51(12):6270-6276.

14. O'Donoghue L, McClelland JF, Logan NS, Rudnicka AR, Owen CG, Saunders KJ. Refractive error and visual impairment in school children in Northern Ireland. British Journal of Ophthalmology 2010; 94(9):1155-1159.

15. Ip JM, Huynh SC, Robaei D, Kifley A, Rose KA, Morgan IG et al. Ethnic differences in refraction and ocular biometry in a population-based sample of 11-15-year-old Australian children. Eye 2008; 22(5):649-656.
16. Logan NS, Shah P, Rudnicka AR, Gilmore B, Owen CG. Childhood ethnic differences in ametropia and ocular biometry: the Aston Eye Study. Ophthalmic & Physiological Optics 2011; 31(5):550-558.

17. Saw SM. A synopsis of the prevalence rates and environmental risk factors for myopia. Clin Exp Optom 2003; 86(5):289-294.

18. Saw SM, Goh PP, Cheng A, Shankar A, Tan DTH, Ellwein LB. Ethnicity-specific prevalences of refractive errors vary in Asian children in neighbouring Malaysia and Singapore. British Journal of Ophthalmology 2006; 90(10):1230-1235.

19. Fan DSP, Lam DSC, Lam RF, Lau JTF, Chong KS, Cheung EYY et al. Prevalence, incidence, and progression of myopia of school children in Hong Kong. Investigative Ophthalmology & Visual Science 2004; 45(4):1071-1075.

20. Quek TPL, Chua CG, Chong CS, Chong JH, Hey HW, Lee J et al. Prevalence of refractive errors in teenage high school students in Singapore. Ophthalmic and Physiological Optics 2004; 24(1):47-55.

21. Dandona R, Dandona L, Naduvilath TJ, Srinivas M, McCarty CA, Rao GN. Refractive errors in an urban population in southern India: The Andhra Pradesh Eye Disease Study. Investigative Ophthalmology & Visual Science 1999; 40(12):2810-2818.

22. Dandona R, Dandona L, Srinivas M, Sahare P, Narsaiah S, Munoz SR et al. Refractive error in children in a rural population in India. Investigative Ophthalmology & Visual Science 2002; 43(3):615-622.

23. Kalikivayi V, Naduvilath TJ, Bansal AK, Dandona L. Visual impairment in school children in Southern India. Indian Journal of Ophthalmology 1997; 45(2):129-134.

24. Murthy GVS, Gupta SK, Ellwein LB, Munoz SR, Pokharel GP, Sanga L et al. Refractive error in children in an urban population in New Delhi. Investigative Ophthalmology and Visual Science 2002; 43(3):623-631.

25. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000; 283(15):2008-2012.

26. Morgan I, Rose K. How genetic is school myopia? Prog Retin Eye Res 2005; 24(1):1-38.

27. Pan CW, Ramamurthy D, Saw SM. Worldwide prevalence and risk factors for myopia. Ophthalmic Physiol Opt 2012; 32(1):3-16.

28. Lunn D, Spiegelhalter D, Thomas A, Best N. The BUGS project: Evolution, critique and future directions. Stat Med 2009; 28(25):3049-3067.

29. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. Vienna, Austria. 2014. 21-4-2015.

30. United Nations. World Population Prospects: The 2012 Revision. [Accessed September 2014] Available from: URL:http://esa.un.org/wpp/unpp/panel_indicators.htm
31. Kapetanakis VV, Chan MP, Foster PJ, Cook DG, Owen CG, Rudnicka AR. Global variations and time trends in the prevalence of primary open angle glaucoma (POAG): a systematic review and meta-analysis. Br J Ophthalmol 2015.

32. Richler A, Bear JC. The distribution of refraction in 3 isolated communities in Western Newfoundland. American Journal of Optometry and Physiological Optics 1980; 57(11):861-871.

33. Lam CS, Lam CH, Cheng SC, Chan LY. Prevalence of myopia among Hong Kong Chinese schoolchildren: changes over two decades. Ophthalmic & Physiological Optics 2012; 32(1):17-24.

34. Ip JM, Rose KA, Morgan IG, Burlutsky G, Mitchell P. Myopia and the urban environment: findings in a sample of 12-year-old Australian school children. Invest Ophthalmol Vis Sci 2008; 49(9):3858-3863.

35. Yingyong P. Refractive errors survey in primary school children (6-12 year old) in 2 provinces: Bangkok and Nakhonpathom (one year result). J Med Assoc Thai 2010; 93(10):1205-1210.

36. Garner LF, Owens H, Kinnear RF, Frith MJ. Prevalence of myopia in Sherpa and Tibetan children in Nepal. Optometry & Vision Science 1999; 76(5):282-285.

37. Zhang MZ, Saw SM, Hong RZ, Fu ZF, Yang H, Shui YB et al. Refractive errors in Singapore and Xiamen, China: a comparative study in school children aged 6 to 7 years. Optometry & Vision Science 2000; 77(6):302-308.

38. Lin LLK, Shih YF, Hsiao CK, Chen CJ, Lee LA, Hung PT. Epidemiologic study of the prevalence and severity of myopia among school children in Taiwan in 2000. Journal of the Formosan Medical Association 2001; 100(10):684-691.

39. Saw SM, Hong RZ, Zhang MZ, Fu ZF, Ye M, Tan D et al. Near-work activity and myopia in rural and urban schoolchildren in China. J Pediatr Ophthalmol Strabismus 2001; 38(3):149-155.

40. Khan AA, Nasti AR, Ayoub DM, Lone SA. Prevalence of refractive errors in school children. JK Practitioner 2005; 12(3):156-159.

41. Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful, Iran. British Journal of Ophthalmology 2007; 91(3):287-292.

42. Czepita D, Zejmo M, Mojsa A. Prevalence of myopia and hyperopia in a population of Polish schoolchildren. Ophthalmic and Physiological Optics 2007; 27(1):60-65.

43. Uzma N, Kumar BS, Khaja Mohinuddin Salar BM, Zafar MA, Reddy VD. A comparative clinical survey of the prevalence of refractive errors and eye diseases in urban and rural school children. Canadian Journal of Ophthalmology 2009; 44(3):328-333.

44. Padhye AS, Khandekar R, Dharmadhikari S, Dole K, Gogate P, Deshpande M. Prevalence of uncorrected refractive error and other eye problems among urban and rural school children. Middle East Afr J Ophthalmol 2009; 16(2):69-74.
45. Zhang M, Li L, Chen L, Lee J, Wu J, Yang A et al. Population density and refractive error among Chinese children. Invest Ophthalmo Vis Sci 2010; 51(10):4969-4976.

46. Gao Z, Meng N, Muecke J, Chan Wo, Piseth H, Kong A et al. Refractive error in school children in an urban and rural setting in Cambodia. Ophthalmo Epidemiology 2012; 19(1):16-22.

47. Wu JF, Bi HS, Wang SM, Hu YY, Wu H, Sun W et al. Refractive error, visual acuity and causes of vision loss in children in Shandong, China. The Shandong children eye study. PloS one 2013; 8(12):e82763.

48. Lin LLJ, Hung P-T, Ko L-S, Hou P-K. Study of myopia among aboriginal school children in Taiwan. Acta Ophthalmologica 1988; 66(Suppl 185):34-36.

49. Au Eong KG, Tay TH, Lim MK. Race, culture and Myopia in 110,236 young Singaporean males. Singapore Med J 1993; 34(1):29-32.

50. Wu HM, See B, Yap EP, Saw SM, Lim TH, Chia KS. Does education explain ethnic differences in myopia prevalence? A population-based study of young adult males in Singapore. Optom Vis Sci 2001; 78(4):234-239.

51. He MG, Zeng JW, Liu YZ, Xu JJ, Pokharel GP, Ellwein LB. Refractive error and visual impairment in urban children in southern China. Investigative Ophthalmology & Visual Science 2004; 45(3):793-799.

52. Shih YF, Chiang TH, Hsiao CK, Chen CJ, Hung PT, Lin LL. Comparing myopic progression of urban and rural Taiwanese schoolchildren. Jpn J Ophthalmol 2010; 54(5):446-451.

53. Tay MT, Au Eong KG, Ng CY, Lim MK. Myopia and educational attainment in 421,116 young Singaporean males. Ann Acad Med Singapore 1992; 21(6):785-791.

54. Williams K M, Bertelsen G, Cumberland P, Wolfram C, Verhoeven VJ, Anastasopoulos E et al. Increasing Prevalence of Myopia in Europe and the Impact of Education. Ophthalmology 2015; 122(7):1489-1497.

55. Saw SM, Chua WH, Hong CY, Wu HM, Chan WY, Chia KS et al. Nearwork in early-onset myopia. Invest Ophthalmo Vis Sci 2002; 43(2):332-339.

56. Mutti DO, Mitchell GL, Moeschberger ML, Jones LA, Zadnik K. Parental myopia, near work, school achievement, and children's refractive error. Invest Ophthalmo Vis Sci 2002; 43(12):3633-3640.

57. Ip JM, Saw SM, Rose KA, Morgan IG, Kifley A, Wang JJ et al. Role of near work in myopia: findings in a sample of Australian school children. Invest Ophthalmo Vis Sci 2008; 49(7):2903-2910.

58. Lu B, Congdon N, Liu XJ, Choi K, Lam DSC, Zhang MZ et al. Associations Between Near Work, Outdoor Activity, and Myopia Among Adolescent Students in Rural China The Xichang Pediatric Refractive Error Study Report No. 2. Archives of Ophthalmology 2009; 127(6):769-775.
59. Rose KA, Morgan IG, Smith W, Burlutsky G, Mitchell P, Saw SM. Myopia, lifestyle, and schooling in students of Chinese ethnicity in Singapore and Sydney. Archives of Ophthalmology 2008; 126(4):527-530.

60. Dirani M, Chan Y-H, Gazzard G, Hornbeak DM, Leo S-W, Selvaraj P et al. Prevalence of refractive error in Singaporean Chinese children: The Strabismus, Amblyopia, and Refractive Error in young Singaporean Children (STARS) study. Investigative Ophthalmology and Visual Science 2010; 51(3):1348-1355.

61. Anera RG, Jimenez JR, Soler M, Perez MA, Jimenez R, Cardona JC. Prevalence of refractive errors in school-age children in Burkina Faso. Japanese Journal of Ophthalmology 2006; 50(5):483-484.

62. Jimenez R, Soler M, Anera RG, Castro JJ, Perez MA, Salas C. Ametropias in school-age children in Fada N’Gourma (Burkina Faso, Africa). Optometry & Vision Science 2012; 89(1):33-37.

63. Khader YS, Batayha WQ, Abdul-Aziz SM, Shiekh-Khalil MI. Prevalence and risk indicators of myopia among schoolchildren in Amman, Jordan. East Mediterr Health J 2006; 12(3-4):434-439.

64. Saw SM, Shankar A, Tan SB, Taylor H, Tan DT, Stone RA et al. A cohort study of incident myopia in Singaporean children. Invest Ophthalmol Vis Sci 2006; 47(5):1839-1844.

65. Jones LA, Sinnott LT, Mutti DO, Mitchell GL, Moeschberger ML, Zadnik K. Parental history of myopia, sports and outdoor activities, and future myopia. Invest Ophthalmol Vis Sci 2007; 48(8):3524-3532.

66. Dirani M, Tong L, Gazzard G, Zhang X, Chia A, Young TL et al. Outdoor activity and myopia in Singapore teenage children. British Journal of Ophthalmology 2009; 93(8):997-1000.

67. Wu P-C, Tsai C-L, Hu C-H, Yang Y-H. Effects of outdoor activities on Myopia among rural school children in Taiwan. Ophthalmic Epidemiology 2010; 17(5):338-342.

68. Guggenheim JA, Northstone K, McMahon G, Ness AR, Deere K, Mattocks C et al. Time outdoors and physical activity as predictors of incident myopia in childhood: a prospective cohort study. Investigative Ophthalmology & Visual Science 2012; 53(6):2856-2865.

69. Jones-Jordan LA, Mitchell GL, Cotter SA, Kleinstein RN, Manny RE, Mutti DO et al. Visual activity before and after the onset of juvenile myopia. Invest Ophthalmol Vis Sci 2011; 52(3):1841-1850.

70. Li SM, Li H, Li SY, Liu LR, Kang MT, Wang YP et al. Time Outdoors and Myopia Progression Over 2 Years in Chinese Children: The Anyang Childhood Eye Study. Invest Ophthalmol Vis Sci 2015; 56(8):4734-4740.

71. Sherwin JC, Reacher MH, Keogh RH, Khawaja AP, Mackey DA, Foster PJ. The association between time spent outdoors and myopia in children and adolescents: a systematic review and meta-analysis. Ophthalmology 2012; 119(10):2141-2151.

72. Deere K, Williams C, Leary S, Mattocks C, Ness A, Blair SN et al. Myopia and later physical activity in adolescence: a prospective study. Br J Sports Med 2009; 43(7):542-544.
73. Rose KA, Morgan IG, Ip J, Kifley A, Huynh S, Smith W et al. Outdoor activity reduces the prevalence of myopia in children. Ophthalmology 2008; 115(8):1279-1285.

74. Lin LLK, Shih YF, Tsai CB, Chen CJ, Lee LA, Hung PT et al. Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. Optometry and Vision Science 1999; 76(5):275-281.

75. Zadnik K, Manny RE, Yu JA, Mitchell GL, Cotter SA, Quiralte JC et al. Ocular component data in schoolchildren as a function of age and gender. Optom Vis Sci 2003; 80(3):226-236.

76. He M, Xu J, Yin Q, Ellwein LB. Need and challenges of refractive correction in urban Chinese school children. Optometry and Vision Science 2005; 82(4):229-234.

77. He MG, Huang WY, Zheng YF, Huang L, Ellwein LB. Refractive error and visual impairment in school children in rural southern China. Ophthalmology 2007; 114(2):374-382.

78. Goh P-P, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. Ophthalmology 2005; 112(4):678-685.

79. Zhang M, Gazzard G, Fu Z, Li L, Chen B, Saw SM et al. Validating the accuracy of a model to predict the onset of myopia in children. Investigative Ophthalmology & Visual Science 2011; 52(8):5836-5841.

80. Pokharel GP, Negrel AD, Munoz SR, Ellwein LB. Refractive error study in children: results from Mechi Zone, Nepal. American Journal of Ophthalmology 2000; 129(4):436-444.

81. Maul E, Barroso S, Munoz SR, Sperduto RD, Ellwein LB. Refractive error study in children: results from La Florida, Chile. American Journal of Ophthalmology 2000; 129(4):445-454.

82. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden BA, Pokharel GP et al. Refractive error and visual impairment in African children in South Africa. Investigative Ophthalmology & Visual Science 2003; 44(9):3764-3770.

83. Rahi JS, Cumberland PM, Peckham CS. Myopia over the lifecourse: prevalence and early life influences in the 1958 British birth cohort. Ophthalmology 2011; 118(5):797-804.

84. Wong TY, Foster PJ, Hee J, Ng TP, Tielsch JM, Chew SJ et al. Prevalence and risk factors for refractive errors in adult Chinese in Singapore. Invest Ophthalmol Vis Sci 2000; 41(9):2486-2494.

85. Farhood QK. Cycloplegic refraction in children with cyclopentolate versus atropine. J Clin Exp Ophthalmol 2012; 3(7):239.

86. Williams C, Miller L, Northstone K, Sparrow JM. The use of non-cycloplegic autorefraction data in general studies of children's development. Br J Ophthalmol 2008; 92(5):723-724.

87. Zhao J, Mao J, Luo R, Li F, Pokharel GP, Ellwein LB. Accuracy of noncycloplegic autorefraction in school-age children in China. Optom Vis Sci 2004; 81(1):49-55.

88. Choong YF, Chen AH, Goh PP. A comparison of autorefracton and subjective refraction with and without cycloplegia in primary school children. Am J Ophthalmol 2006; 142(1):68-74.
89. Abdi S, Lennerstrand G, Pansell T, Rydberg A. Orthoptic findings and asthenopia in a population of Swedish schoolchildren aged 6 to 16 years. Strabismus 2008; 16(2):47-55.

90. Adlergrinberg D. Need for Eye and Vision Care in An Underserved Population - Refractive Errors and Other Ocular Anomalies in the Sioux. American Journal of Optometry and Physiological Optics 1986; 63(7):553-558.

91. Aine E. Refractive Errors in A Finnish Rural-Population. Acta Ophthalmologica 1984; 62(6):944-954.

92. Aldebasi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. Journal of optometry 2014; 7(3):168-176.

93. Almeder LM, Peck LB, Howland HC. Prevalence of anisometropia in volunteer laboratory and school screening populations. Investigative Ophthalmology and Visual Science 1990; 31(11):2448-2455.

94. Anera RG, Soler M, de la Cruz CJ, Salas C, Ortiz C. Prevalence of refractive errors in school-age children in Morocco. Clinical & Experimental Ophthalmology 2009; 37(2):191-196.

95. Auzemery A, Andriamanamihaja R, Boisier P. A survey of the prevalence and causes of eye disorders in primary school children in Antananarivo. Sante 1995; 5(3):163-166.

96. Awasthi S, Pant BP, Dhakal HP. Reduced vision and refractive errors, results from a school vision screening program in Kanchanpur district of far western Nepal. Kathmandu University Medical Journal 2010; 8(32):October-December.

97. Ayed T, Sokkah M, Charfi O, El Matri L. Epidemiologic study of refractive errors in schoolchildren in socioeconomically deprived regions in Tunisia. Journal Francais D Ophtalmologie 2002; 25(7):712-717.

98. Azizoglu S, Junghans BM, Barutchu A, Crewther SG. Refractive errors in students from Middle Eastern backgrounds living and undertaking schooling in Australia. Clinical & Experimental Optometry 2011; 94(1):67-75.

99. Boniuk V. Refractive problems in native peoples (the Sioux Lookout Project). Can J Ophthalmol 1973; 8(2):229-233.

100. Brody BL, Roch-Levecq AC, Klonoff-Cohen HS, Brown SI. Refractive errors in low-income preschoolers. Ophthalmic Epidemiology 2007; 14(4):223-229.

101. Buchner TF, Schnorbus U, Grenzebach UH, Stupp T, Busse H. Examination of preschool children for refractive errors. First experiences using a handheld autorefractor. Ophthalmologe 2003; 100(11):971-978.

102. Caca I, Cingu AK, Sahin A, Ari S, Dursun ME, Dag U et al. Amblyopia and refractive errors among school-aged children with low socioeconomic status in southeastern Turkey. Journal of Pediatric Ophthalmology & Strabismus 2013; 50(1):37-43.

103. Casson RJ, Kahawita S, Kong A, Muecke J, Sisaleumsak S, Visonnavong V. Exceptionally low prevalence of refractive error and visual impairment in schoolchildren from Lao People's Democratic Republic. Ophthalmology 2012; 119(10):2021-2027.
104. Chan OY, Edwards M. Refractive errors in Hong Kong Chinese pre-school children. Optometry & Vision Science 1993; 70(6):501-505.

105. Chang F-L, Lee Y-C, Chen N, Hsieh H-P, Li Y-H, Yang Y-Y et al. The prevalence of ocular diseases in primary and junior high school students on Orchid Island. Tzu Chi Medical Journal 2014; 26(4):166-169.

106. Cheng CY, Huang W, Su KC, Peng ML, Sun HY, Cheng HM. Myopization factors affecting urban elementary school students in Taiwan. Optometry and vision science : official publication of the American Academy of Optometry 2013; 90(4):400-406.

107. Cheng HM, Sun HY, Lin DPC, Chang HH, Chen ST, Yeh SM et al. Characterising visual deficits in children of an urban elementary school in Taiwan. Clinical and Experimental Optometry 2012; 95(5):531-537.

108. Chung KM, Mohidin N, Yeow PT, Tan LL, O'Leary D. Prevalence of visual disorders in Chinese schoolchildren. Optom Vis Sci 1996; 73(11):695-700.

109. Congdon N, Wang YF, Song Y, Choi K, Zhang MZ, Zhou ZX et al. Visual disability, visual function, and myopia among rural Chinese secondary school children: The Xichang Pediatric Refractive Error Study (X-PRES) - Report 1. Investigative Ophthalmology & Visual Science 2008; 49(7):2888-2894.

110. Dobson V, Harvey EM, Miller JM. Spherical equivalent refractive error in preschool children from a population with a high prevalence of astigmatism. Optometry and Vision Science 2007; 84(2):124-130.

111. Edwards MH. The development of myopia in Hong Kong children between the ages of 7 and 12 years: a five-year longitudinal study. Ophthalmic and Physiological Optics 1999; 19(4):286-294.

112. Fan DS, Lai C, Lau HH, Cheung EY, Lam DS. Change in vision disorders among Hong Kong preschoolers in 10 years. Clinical & Experimental Ophthalmology 2011; 39(5):398-403.

113. Fan DSP, Cheung EYY, Lai RYK, Kwok AKH, Lam DSC. Myopia progression among preschool Chinese children in Hong Kong. Annals Academy of Medicine Singapore 2004; 33(1):39-43.

114. Fischbach LA, Lee DA, Englehardt RF, Wheeler N. The prevalence of ocular disorders among Hispanic and Caucasian children screened by the UCLA Mobile Eye Clinic. Journal of Community Health 1993; 18(4):201-211.

115. Gao TY, Zhang P, Li L, Lin Z, Jhanji V, Peng Y et al. Rationale, Design, and Demographic Characteristics of the Handan Offspring Myopia Study. Ophthalmic Epidemiology 2014; 21(2):124-132.

116. Gao Z, Meng N, Muecke J, Chan WO, Piseth H, Kong A et al. Refractive error in school children in an urban and rural setting in Cambodia. Ophthalmic Epidemiology 2012; 19(1):16-22.

117. Garner LF, Kinnear RF, Klinger JD, McKellar MJ. Prevalence of myopia in school children in Vanuatu. Acta Ophthalmologica 1985; 63(3):323-326.
118. Garner LF, Meng CK, Grosvenor TP, Mohidin N. Ocular dimensions and refractive power in Malay and Melanesian children. Ophthalmic & Physiological Optics 1990; 10(3):234-238.

119. Garner LF, Yap MK, Kinnear RF, Frith MJ. Ocular dimensions and refraction in Tibetan children. Optometry & Vision Science 1995; 72(4):266-271.

120. Giordano L, Friedman DS, Repka MX, Katz J, Ibironke J, Hawes P et al. Prevalence of refractive error among preschool children in an urban population: the Baltimore Pediatric Eye Disease Study. Ophthalmology 746; 116(4):739-746.

121. Goh WS, Lam CS. A visual survey of school children in Hong Kong. Clinical and Experimental Optometry 1993; 76(3):101-108.

122. Goldschmidt E, Lam CS, Opper S. The development of myopia in Hong Kong children. Acta Ophthalmologica Scandinavica 2001; 79(3):228-232.

123. Gordon A. Refractive error in a Puerto Rican rural population. J Am Optom Assoc 1990; 61(11):870-874.

124. Gronlund MA, Andersson S, Aring E, Hard AL, Hellstrom A. Ophthalmological findings in a sample of Swedish children aged 4-15 years. Acta Ophthalmologica Scandinavica 2006; 84(2):169-176.

125. Grosvenor T. Refractive error distribution in New Zealand's Polynesian and European children. Am J Optom Arch Am Acad Optom 1970; 47(9):673-679.

126. Guo K, Yang dY, Wang Y, Yang XR, Jing XX, Guo YY et al. Prevalence of myopia in schoolchildren in ejina: the gobi desert children eye study. Invest Ophthalmol Vis Sci 2015; 56(3):1769-1774.

127. Guo Y, Liu LJ, Xu L, Lv YY, Tang P, Feng Y et al. Outdoor activity and myopia among primary students in rural and urban regions of Beijing. Ophthalmology 2013; 120(2):277-283.

128. Gursoy H, Basmak H, Yaz Y, Colak E. Vision screening in children entering school: Eskisehir, Turkey. Ophthicmic Epidemiology 2013; 20(4):232-238.

129. Hashemi H, Fotouhi A, Mohammad K. The age- and gender-specific prevalences of refractive errors in Tehran: the Tehran Eye Study. Ophthalmic Epidemiology 2004; 11(3):213-225.

130. Hashemi H, Rezvan F, Beiranvand A, Papi OA, Hoseini Yazdi H, Ostadimoghaddam H et al. Prevalence of Refractive Errors among High School Students in Western Iran. Journal of ophthalmic & vision research 2014; 9(2):232-239.

131. Hendricks TJW, De Brabander J, Van der Horst FG, Hendrikse F, Knottnerus JA. Relationship between habitual refractive errors and headache complaints in schoolchildren. Optometry and Vision Science 2007; 84(2):137-143.

132. Ho CSD, Ng CBC, Chan E, Ngeow A, Wijaya R, Ashok V et al. Uncorrected refractive error in Singapore teenagers. British Journal of Ophthalmology 2006; 90(2):202-207.
133. Hsu SL, Chang C-H, Lai YH, Wen M-H, Cheng KC, Ho CK. Refractive status of mountain aborigine schoolchildren in southern Taiwan. Kaohsiung Journal of Medical Sciences 2008; 24(3):120-125.

134. Ingram RM, Barr A. Changes in Refraction Between the Ages of 1 and 3-1/2 Years. British Journal of Ophthalmology 1979; 63(5):339-342.

135. Jamali P, Fotouhi A, Hashemi H, Younesian M, Jafari A. Refractive errors and amblyopia in children entering school: Shahrood, Iran. Optometry and Vision Science 2009; 86(4):364-369.

136. Johnstone WW, McLaren DS. Refraction anomalies in Tanganyikan children. British Journal of Ophthalmology 1963; 47:95-108.

137. Junghans BM, Crewther SG. Little evidence for an epidemic of myopia in Australian primary school children over the last 30 years. BMC Ophthalmol 2005; 5:1.

138. Kalogjera T. Refractive error in Yugoslav urban children aged between 3 and 7 years. Child Care Health Dev 1979; 5(6):439-445.

139. Laatikainen L, Erkkila H. Refractive errors and other ocular findings in school children. Acta Ophthalmol (Copenh) 1980; 58(1):129-136.

140. Lai YH, Hsu HT, Wang HZ, Chang SJ, Wu WC. The visual status of children ages 3 to 6 years in the vision screening program in Taiwan. Journal of Aapos: American Association for Pediatric Ophthalmology & Strabismus 2009; 13(1):58-62.

141. Lam C, Goh W. The incidence of refractive errors among school children in Hong Kong and its relationship with the optical components. Clinical and Experimental Optometry 1991; 74(3):97-103.

142. Lan W, Zhao F, Lin L, Li Z, Zeng J, Yang Z et al. Refractive errors in 3-6 year-old Chinese children: a very low prevalence of myopia? PloS one 2013; 8(10):e78003.

143. Li S-M, Liu L-R, Li S-Y, Ji Y-Z, Fu J, Wang Y et al. Design, methodology and baseline data of a school-based cohort study in central China: The Anyang childhood eye study. Ophthalmic Epidemiology 2013; 20(6):348-359.

144. Li Z, Xu K, Wu S, Lv J, Jin D, Song Z et al. Population-based survey of refractive error among school-aged children in rural northern China: The Heilongjiang eye study. Clinical and Experimental Ophthalmology 2014; 42(4):379-384.

145. Liang BS, Et AL. The measurement of visual refraction of pupils. Zhonghua Yufang Yixue Zazhi 1991; 25(2):99-101.

146. Liang YB, Lin Z, Vasudevan B, Jhanji V, Young A, Gao TY et al. Generational difference of refractive error in the baseline study of the Beijing Myopia Progression Study. British Journal of Ophthalmology 2013; 97(6):765-769.

147. Liao CC, Chen LJ, Yu JH, Lin JC. Refractive error change and its association with ocular and general parameters in junior high school students in Taiwan. Japanese Journal of Ophthalmology 2014; 58(4):375-380.
148. Lin LL, Chen CJ, Hung PT, Ko LS. Nation-wide survey of myopia among schoolchildren in Taiwan, 1986. Acta Ophthalmol 1988; 185(Suppl):29-33.

149. Lin LLK, Shih YF, Hsiao CK, Chen CJ. Prevalence of myopia in Taiwanese schoolchildren: 1983 to 2000. Annals Academy of Medicine Singapore 2004; 33(1):27-33.

150. Logan NS, Shah P, Rudnicka AR, Gilmartin B, Owen CG. Childhood ethnic differences in ametropia and ocular biometry: the Aston Eye Study. Ophthalmic & Physiological Optics 2011; 31(5):550-558.

151. Ma Q, Xu W, Zhou X, Cui C, Pan C-W. The relationship of season of birth with refractive error in very young children in eastern China. PLoS one 2014; 9(6):e100472.

152. Macfarlane DJ, Fitzgerald WJ, Stark DJ. The prevalence of ocular disorders in 1000 Queensland primary schoolchildren. Australian & New Zealand Journal of Ophthalmology 1987; 15(3):161-174.

153. Marasini S, Sharma R, Sthapit PR, Sharma D, Koju U, Thapa G et al. Refractive errors and visual anomalies in schoolchildren in the Kavrepalanchowk District. Kathmandu University Medical Journal 2010; 8(32):October-December.

154. Martinez J, Canamares S, Saornil MA, Almaraz A, Pastor JC. Prevalence of amblyogenic diseases in a preschool population sample of Valladolid, Spain. Strabismus 1997; 5(2):73-80.

155. Matsumura H, Hirai H. Prevalence of myopia and refractive changes in students from 3 to 17 years of age. Survey of Ophthalmology 1999; 44:S109-S115.

156. Montes-Mico R, Ferrer-Blasco T. Distribution of refractive errors in Spain. Documenta Ophthalmologica 2000; 101(1):25-33.

157. Morgan A, Young R, Narankhand B, Chen S, Cottriall C, Hosking S. Prevalence rate of myopia in schoolchildren in rural Mongolia. Optometry and Vision Science 2006; 83(1):53-56.

158. Prevalence of Myopia and Hyperopia in 6- to 72-Month-Old African American and Hispanic Children: The Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology 2010; 117(1):140-147 e3.

159. Nanthavisit U, Sornchai J, Jenchitr W. Survey of refractive errors among Buddhist scripture, Dhamma-Bali and regular school of Buddhist novices in the Bangkok metropolitan area. J Med Assoc Thai 2008; 91(Suppl 1):S24-S29.

160. Nepal BP, Koirala S, Adhikary S, Sharma AK. Ocular morbidity in schoolchildren in Kathmandu. British Journal of Ophthalmology 2003; 87(5):531-534.

161. Ogieska E, Czerek-Jaguczanska H, Pacynska J. [Problem of refraction anomalies in school children and students]. Klin Oczna 1967; 37(5):721-728.

162. Ojaimi E, Rose KA, Morgan IG, Smith W, Martin FJ, Kifley A et al. Distribution of ocular biometric parameters and refraction in a population-based study of Australian children. Investigative Ophthalmology & Visual Science 2005; 46(8):2748-2754.
163. Ore L, Garzozi HJ, Schwartz N, Cohen-Dar M. Factors Influencing Prevalence of Vision and Ocular Abnormalities among Jewish and Arab Israeli Schoolchildren. Israel Medical Association Journal 2014; 16(9):553-558.

164. Oscar A, Cherninkova S, Haykin V, Aroyo A, Levi A, Marinov N et al. Amblyopia Screening in Bulgaria. Journal of Pediatric Ophthalmology & Strabismus 2014; 51(5):284-288.

165. Ostadimoghaddam H, Fotouhi A, Hashemi H, Yekta A, Heravian J, Rezvan F et al. Prevalence of the refractive errors by age and gender: the Mashhad eye study of Iran. Clinical & Experimental Ophthalmology 2011; 39(8):743-751.

166. Pant M, Shrestha GS, Joshi ND. Ocular Morbidity among Street Children in Kathmandu Valley. Ophthalmic Epidemiology 2014; 21(6):356-361.

167. Pi L-H, Chen L, Liu Q, Ke N, Fang J, Zhang S et al. Refractive status and prevalence of refractive errors in suburban school-age children. International Journal of Medical Sciences 2010; 7(6):342-353.

168. Rezvan F, Khabazkhoob M, Fotouhi A, Hashemi H, Ostadimoghaddam H, Heravian J et al. Prevalence of refractive errors among school children in Northeastern Iran. Ophthalmic & Physiological Optics 2012; 32(1):25-30.

169. Rodriguez MA, Castro Gonzalez M. Visual health of schoolchildren in Medellin, Antioquia, Colombia. Bol Oficina Sanit Panam 1995; 119(1):11-14.

170. Saw SM, Chan B, Seenyen L, Yap M, Tan D, Chew SJ. Myopia in Singapore kindergarten children. Optometry 2001; 72(5):286-291.

171. Saw SM, Cheng A, Fong A, Gazzard G, Tan DT, Morgan I. School grades and myopia. Ophthalmic Physiol Opt 2007; 27(2):126-129.

172. Shrestha RK, Joshi MR, Ghising R, Pradhan P, Shakya S, Rizyal A. Ocular morbidity among children studying in private schools of Kathmandu valley: A prospective cross sectional study. Nepal Medical College Journal: NMCJ 2006; 8(1):43-46.

173. Shrestha RK, Joshi MR, Ghising R, Rizyal A. Ocular morbidity among children attending government and private schools of Kathmandu valley. Journal of the Nepal Medical Association 2012; 51(4):October-December.

174. Shrestha GS, Manandhar S, Joshi ND, Shrestha JK. Ocular morbidity among the children of squatter settlements in Kathmandu. Optom Vis Sci 2013; 90(9):1012-1018.

175. Sorsby A, Benjamin B, Sheridan M, Stone J, Leary GA. Refraction and its components during the growth of the eye from the age of three. Memo Med Res Counc 1961; 301(Special):1-67.

176. Tan G, Ng Y, Lim Y, Ong P, Snodgrass A, Saw S. Cross-sectional study of near-work and myopia in kindergarten children in Singapore. Annals Academy of Medicine Singapore 2000; 29(6):740-744.

177. Villamor RE. Study of refraction in schoolchildren in Guadalajara. Rev Sanid Hig Publica (Madr) 1980; 54(5-6):547-554.
178. Villarreal GM, Ohlsson J, Cavazos H, Abrahamsson M, Mohamed JH. Prevalence of myopia among 12- to 13-year-old schoolchildren in Northern Mexico. Optometry and Vision Science 2003; 80(5):369-373.

179. Villarreal MG, Ohlsson J, Abrahamsson M, Sjostrom A, Sjostrand J. Myopisation: The refractive tendency in teenagers. Prevalence of myopia among young teenagers in Sweden. Acta Ophthalmologica Scandinavica 2000; 78(2):177-181.

180. Virgili G, Angi M, Heede S, Rodriguez D, Bottega E, Molinari A. PowerRefractor versus Canon R-50 autorefraction to assess refractive error in children: A community-based study in Ecuador. Optometry and Vision Science 2007; 84(2):144-148.

181. Wang X, Liu D, Feng R, Zhao H, Wang Q. Refractive error among urban preschool children in Xuzhou, China. International Journal of Clinical and Experimental Pathology 2014; 7(12):8922-8928.

182. Watanabe S, Yamashita T, Ohba N. A longitudinal study of cycloplegic refraction in a cohort of 350 Japanese schoolchildren. Cycloplegic refraction. Ophthalmic Physiol Opt 1999; 19(1):22-29.

183. Wen G, Tarczy-Hornoch K, McKeen-Cowdin R, Cotter SA, Borchert M, Lin J et al. Prevalence of myopia, hyperopia, and astigmatism in non-hispanic white and Asian children: Multi-ethnic pediatric eye disease study. Ophthalmology 2013; 120(10):2109-2116.

184. Williams SM, Sanderson GF, Share DL, Silva PA. Refractive error, IQ and reading ability; a longitudinal study from age seven to 11. Developmental Medicine and Child Neurology 1988; 30(6):735-742.

185. Woodruff ME. Vision and refractive status among grade-1 children of the province of New-Brunswick. American Journal of Optometry and Physiological Optics 1986; 63(7):545-552.

186. Xiang F, He M, Morgan IG. The impact of parental myopia on myopia in Chinese children: population-based evidence. Optometry & Vision Science 2012; 89(10):1487-1496.

187. Yekta A, Fotouhi A, Hashemi H, Dehghani C, Ostadimoghaddam H, Heravian J et al. Prevalence of refractive errors among schoolchildren in Shiraz, Iran. Clinical and Experimental Ophthalmology 2010; 38(3):242-248.

188. Yingyong P. Refractive errors survey in primary school children (6-12 year old) in 2 provinces: Bangkok and Nakhonpathom (one year result). J Med Assoc Thai 2010; 93(10):1205-1210.

189. Yoon KC, Mun GH, Kim SD, Kim SH, Kim CY, Park KH et al. Prevalence of eye diseases in South Korea: data from the Korea National Health and Nutrition Examination Survey 2008-2009. Korean J Ophthalmol 2011; 25(6):421-433.

190. You QS, Wu LJ, Duan JL, Luo YX, Liu LJ, Li X et al. Factors associated with myopia in school children in China: the Beijing childhood eye study. PLoS ONE [Electronic Resource] 2012; 7(12):e52668.

191. Young FA, Leary GA, Baldwin WR, West DC, Box RA, Goo FJ et al. Refractive errors, reading performance, and school achievement among Eskimo children. Am J Optom Arch Am Acad Optom 1970; 47(5):384-390.
192. Zhao J, Pan X, Sui R, Munoz SR, Sperduto RD, Ellwein LB. Refractive error study in children: Results from Shunyi District, China. American Journal of Ophthalmology 2000; 129(4):427-435.

193. Zylbermann R, Landau D, Berson D. The influence of study habits on myopia in Jewish teenagers. Journal of Pediatric Ophthalmology and Strabismus 1993; 30(5):319-322.