Review Article

Global Prevalence and Causes of Visual Impairment and Blindness in Children: A Systematic Review and Meta-Analysis

Abbasali Yekta[1], Elham Hooshmand[2], Mohammad Saatchi[3], Hadi Ostadimoghaddam[4], Amir Asharlous[5], Azadeh Taheri[6], Mehdi Khabazkhoob[7]

[1]Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran, [2]Iranian Research Center on Aging, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran, [3]Health in Emergency and Disaster Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran, [4]Refractive Errors Research Center, Mashhad University of Medical Sciences, Mashhad, Iran, [5]Rehabilitation Research Center, Department of Optometry, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran, [6]Noor Research Center for Ophthalmic Epidemiology, Noor Eye Hospital, Tehran, Iran, [7]Department of Basic Sciences, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Abstract

Purpose: To determine the global prevalence and common causes of visual impairment (VI) and blindness in children.

Methods: In this meta-analysis, a structured search strategy was applied to search electronic databases including PubMed, Scopus, and Web of Science, as well as the list of references in the selected articles to identify all population-based cross-sectional studies that concerned the prevalence of VI and blindness in populations under 20 years of age up to January 2018, regardless of the publication date and language, gender, region of residence, or race. VI was reported based on presenting visual acuity (PVA), uncorrected visual acuity (UCVA), and best corrected visual acuity (BCVA) of equal to 20/60 or worse in the better eye. Blindness was reported as visual acuity worse than 20/400 in the better eye.

Results: In the present study, 5711 articles were identified, and the final analyses were done on 80 articles including 769,720 people from twenty-eight different countries. The prevalence of VI based on UCVA was 7.26% (95% confidence interval [CI]: 4.34%–10.19%), PVA was 3.82% (95% CI: 2.06%–5.57%), BCVA was 1.67% (95% CI 0.97%–2.37%), and blindness was 0.17% (95% CI: 0.13%–0.21%). Refractive errors were the most common cause of VI in the subjects of selected articles (77.20% [95% CI: 73.40%–81.00%]). The prevalence of amblyopia was 7.60% (95% CI: 05.60%–09.10%) and congenital cataract was 0.60% (95% CI: 0.3%–0.9%).

Conclusion: Despite differences in the definition of VI and blindness, based on PVA, 3.82%, and based on BCVA, 1.67% of the examined samples suffer from VI.

Keywords: Blindness, Children, Low vision, Visual impairment

Address for correspondence: Mehdi Khabazkhoob, Department of Basic Sciences, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
E-mail: khabazkhoob@yahoo.com
Submitted: 25-Apr-2021; **Revised:** 06-Dec-2021; **Accepted:** 09-Dec-2021; **Published:** 16-Apr-2022

Introduction

Visual impairment (VI) in childhood has a negative and sometimes irreversible impact on children's psychological, educational, and social performance, which can persist into adulthood and affect individuals' quality of life.[1] Given the significant burden of VI, its causes, and visual complications, the VISION 2020 Initiative was implemented by the World Health Organization (WHO) to eliminate preventable blindness on a global level.[2,3] According to WHO estimates at the beginning of the VISION 2020 program, about 19 million children under the age of 15 years were visually impaired and 1.4 million children had irreversible blindness, and it was predicted that half of the blindness cases were preventable.[4] The reported prevalence of blindness in low and middle-income countries ranges from 0.2 to 7.8/10,000

Access this article online

Quick Response Code:

Website: www.jcurrophthalmol.org

DOI: 10.4103/joco.joco_135_21

How to cite this article: Yekta A, Hooshmand E, Saatchi M, Ostadimoghaddam H, Asharlous A, Taheri A, *et al*. Global prevalence and causes of visual impairment and blindness in children: A systematic review and meta-analysis. J Curr Ophthalmol 2022;34:1-15.

people, and in developed and industrialized countries, the annual incidence is 6/10,000 in the under-15 age group. [5,6] According to available information, the causes of VI differ by the residence location of the studied population (urban versus rural) or in different countries (developed, under developed, or developing) as well as the prevention strategies within each health system. Nevertheless, Courtright *et al*. suggest that retinal disorders, glaucoma, corneal ulcers due to vitamin A deficiency, cataract, and neural causes are the most common causes of VI in low and middle-income countries.[5] This is while neurological disorders are one of the major causes of VI in industrialized countries, and in countries such as England, 75% of blindness cases are due to unpreventable causes.[7,8] A large amount of information on VI in children has been generated from population-based and clinic-based studies, studies in schools for blind children, different age groups (3–5 years, 7-years, 3–10 years, under-15-years, 5–15 years, etc.) as well as different settings such as high-income and low-income countries, but due to the mentioned differences, it is not possible to make global policies or evaluate measures that have been taken in this regard. Given the lack of cohesive results on the prevalence of VI as well as the differences in the causes of VI in different parts of the world, it seems necessary to have an estimate of the global prevalence and causes of VI in children to inform policies, especially the Vision 2020 Initiative. Therefore, the present study aims to determine the overall prevalence and causes of VI in children in the world.

Methods

The entire process of this study was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[9] All population-based cross-sectional studies concerning the prevalence of VI and blindness in individuals under 20 years of age were reviewed regardless of publication and language, gender, region of residence, and race. The search strategy and entry terms showed in Appendix 1. Of studies conducted on the same population, the one with a higher quality was included in this review. Also, we included studies that were performed in all age groups and used the prevalence rates reported for the under-20-year age groups. We excluded articles that did not have one or more of the inclusion criteria. The outcome of interest was the prevalence of VI and blindness and the causes of VI in the population. In the selected papers, cases of VI were identified using measurements based on different units including feet, logMAR, and meters. For this reason, and to facilitate the presentation of the results, all measurements were converted to feet.

The prevalence of VI in this study was calculated based on uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), and presenting visual acuity (PVA) as reported in previous studies.[10-40] The participant's PVA was considered UCVA in participants without glasses and visual acuity with present glasses in individuals with glasses. According to previous studies, the prevalence of VI was reported based on visual acuity cut-point of 20/40 or worse and 20/60 or worse in the better eye (according to the WHO guidelines, VI based on PVA, UCVA, and BCVA was considered as visual acuity in the better eye of equal to 20/60 or worse). The prevalence of blindness was determined based on: (1) BCVA of 20/200 or worse in the better-seeing eye, and (2) BCVA of 20/400 or worse in the better-seeing eye (according to the WHO guidelines, blindness was defined as visual acuity worse than 20/400 in the better eye). We excluded the studies that specifically investigated the VI and blindness in the schools for the blind.

To ensure the correct selection of articles related to the topic of the research and in accordance with the inclusion criteria, two researchers (E.H. and M.S.) independently selected the articles; they were not blinded to the names of the authors, the journal titles, or study results. The kappa agreement index between researchers was 80.2%. Cases of controversy between the researchers were decided through discussion or by consulting a third person. The two researchers independently extracted the required data based on predefined variables. We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist[41] to perform a qualitative assessment of the selected articles in terms of methodology and report. Present key elements of study design, describe the setting, locations, and relevant dates, including periods of recruitment, give the eligibility criteria, and the sources and methods of selection of participants, clearly define all outcomes, and report numbers of outcome events or summary measures were assessed. The studies were categorized as low risk of bias if they reported all items, as moderate risk of bias if they reported all items but one, and as high risk of bias otherwise. To examine the inconsistency of the articles, the k-square test was used at a 5% confidence interval (CI). In order to quantitatively analyze the heterogeneity of the results, we used the I-square test based on the Higgins classification. According to which, an I-square more than 75% was considered as heterogeneity. The variables investigated in this study included the name of the first author, the year of publication, the country of the study, the mean age and gender distribution of study subjects, sample size, the prevalence VI (based on UCVA, PVA, and BCVA) and blindness with their 95% CI, and the prevalence of the most important causes of VI and blindness. One of the PRISMA checklist items is calculating publication bias. In our study, publication bias was not assessed because the prevalence is always a positive number between zero and one, and cannot be negative; therefore, all studies were distributed on the right side of the vertical line, and this leads to asymmetry in the funnel plot which is not related to publication bias. Data analysis was performed using Stata Software version 11 (StataCorp, College Station, TX, USA). The data was analyzed using the random-effects model at a 95% confidence level.

Results

In the present study, 5711 studies were identified; 5211 articles by searching electronic databases and 500 articles through

the lists of references of selected articles and other sources. After removing redundant articles, the title and abstract of 4381 articles were reviewed, and 4231 articles were excluded after applying the exclusion criteria, and thus, 150 papers were eligible for full-text review. After reviewing the full text of the articles, 70 articles were excluded from the study for not meeting the inclusion criteria, lack of access to the full text of the article, nonoriginal paper (letter, commentary, review), and finally, data for this study were extracted from 80 articles [Figure 1].

As shown in Table 1, the final 80 papers comprised 769,720 people from a total of 28 different countries.[10-83]

Among the selected articles, the studies by Razavi *et al*.[75] in Iran with 123 people and Beiram[84] with 127,426 people in Sudan had the smallest and the largest sample sizes, respectively.

The overall prevalence of VI was 12.72% (95% CI: 9.26%–16.19%) based on a UCVA of 20/40 or worse in the better eye, and 7.26% (95% CI: 4.34%–10.19%) based on a UCVA of 20/60 or worse in the better eye [Figure 2]. The prevalence was 7.34% (95% CI: 5.53%–9.15%) based on a PVA of 20/40 or worse in the better eye and 3.82% (95% CI: 2.06%–5.57%) with a PVA of 20/60 or worse in the better eye, and 2.91% (95% CI: 2.31%–3.51%) based on a PVA worse than 20/60 in the better eye [Figure 3]. The prevalence of VI based on a BCVA of 20/40 or worse in the better eye was 0.77% (95% CI: 0.56%–0.97%), 1.67% (95% CI 0.97%–2.37%) based on a BCVA of 20/60 or worse in the better eye, and 0.88% (95% CI: 0.63%–1.12%) based on a BCVA worse than 20/60 in the better eye [Figure 4].

Based on criteria worse than 20/200 in better eye and worse than 20/400 in the better eye, the blindness prevalence was 0.15% (95% CI: 0.06%-0.25%) and 0.17% (95% CI: 0.13%-0.21%), respectively [Figure 5]. Table 2 summarizes the prevalence of UCVA, BCVA, PVA VI, and blindness in the six regions of the WHO. The highest rate of VI based on UCVA of 20/40 or worse in the better eye was 20.10% (95% CI: 13.75%–26.45%) in the Pacific Region, and based on UCVA of <20/60 in the better eye was 15.72% (95% CI: 14.74%–16.70%) in the Americas. The highest prevalence of VI based on PVA of 20/40 or worse in the better eye, 20/60 or worse in the better eye, and worse than 20/60 in the better eye in the Pacific Region was 10.87% (95% CI: 7.26%–14.48%), 8.03% (95% CI 1.00% -20.84%) in the Americas, and 11.59 (95% CI: 10.65–12.53) in the Eastern Mediterranean Region, respectively. The highest prevalence of VI based on a BCVA of 20/40 was 0.91 (95% CI: 0.54–1.27) in the Pacific Region. The highest rates of blindness were 1.91 (95.1% CI: 1.78–5.58) in the African Region based on worse than 20/200 and 1.94 (95% CI: 0.27%–3.61%) in the Eastern Mediterranean Region with criteria worse than 20/400.

Table 3 presents the prevalence of the causes of VI and blindness. In the selected articles, refractive errors, with a prevalence of 77.20% (95% CI: 73.40%–81.00%), were the most common cause of VI. Amblyopia, retinal disorders, congenital cataract, and corneal opacities were other causes of visual impairment, and cataract, glaucoma, and refractive errors were the most common causes of blindness.

Discussion

Our study is the first to generate a more accurate estimate of the global prevalence of VI in children using credible

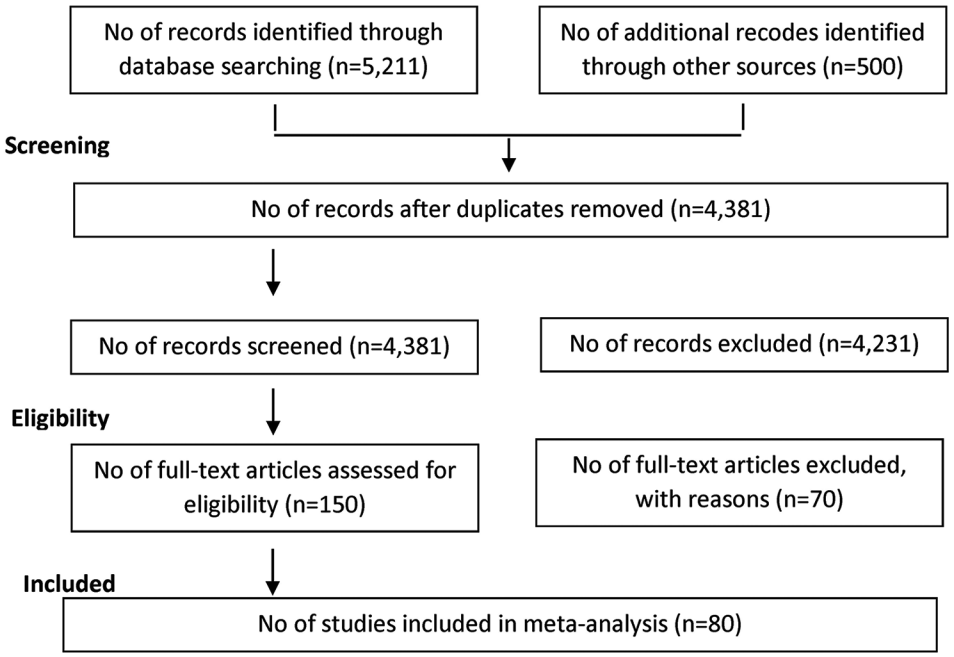

Figure 1: Flow of information through the different phases of the systematic review

Table 1: Summary of studies results

1st author	Country (city)	Gender percentage male	Age mean, range	SS	UCVA % (95% CI)
Abu-Shagra *et al*., 1991[42]	Saudi Arabia	100	10.9 (6-19)	1188	-
Adhikari *et al*., 2014[43]	Nepal	47.3	5.7±3.1 (0-10)	10,950	-
Ajaiyeoba *et al*., 2007[44]	Nigeria	44.1	11.8±3.8 (4-18)	1144	-
Akogun 1992[45]	Nigeria	54.5	9-19	1600	-
A1 Faran *et al*., 1993[46]	Saudi Arabia	49.0	0-19	1909	-
Alrasheed *et al*., 2016[47]	Sudan	-	6-15	1678	6.40 (4.90-7.90)
Beiram 1971[48]	Sudan	-	0-19	127,426	-
Bucher and Ijsselmuiden, 1988[49]	South Africa	40.5	0-19	44,977	-
Casson *et al*., 2012[50]	Asia	49.9	6-11	2899	-
Congdon *et al*., 2008[27]	China	50.2	14.7±0.8 (11.4-17.1)	1892	41.17 (38.94-43.42)
Dandona *et al*., 1999[40]	India	-	0-15	663	-
Dandona *et al*., 2001[51]	India	-	0-15	2859	-
Darge *et al*., 2017[52]	Ethiopia	50.8	11.05±2.5 (5-16)	378	-
Demissie and Solomon, 2011[53]	Ethiopia	-	0-15	58,480	-
Dorairaj *et al*., 2008[54]	India	-	3-15	13,241	-
Drews *et al*., 1992[55]	Atlanta	-	10	89,534	-
Farber 2003[56]	Israel	48.6	0-18	1161	-
Feghhi *et al*., 2009[57]	Iran	40.5	5-19	2492	-
Flanagan *et al*., 2003[58]	Ireland	-	10.5±4.8 (1-18)	47,110	-
Fotouhi *et al*., 2007[29]	Iran	52.1	7-15	5544	-
Ghosh *et al*., 2012[59]	India	45.8	6-14	2570	4.24 (3.41-5.10)
Gilbert *et al*., 2008[26]	Six countries	51.7	5-15	40,779	-
Goh *et al*., 2005[32]	Malaysia	50.8	7-15	4634	17.07 (15.99-18.18)
Hashemi *et al*., 2018[11]	Iran	-	1-15	766	-
He *et al*., 2014[17]	China	57.9	7-12	9512	13.33 (12.65-14.03)
He *et al*., 2007[28]	China	52.5	13-17	2454	27.04 (25.27-28.86)
He *et al*., 2004[33]	China	51.9	5-15	4364	22.27 (21.04-23.54)
Heijthuijsen *et al*., 2013[60]	Suriname	-	8-16	4643	-
Jamali *et al*., 2009[61]	Iran	-	6	902	3.55 (2.39-5.07)
Johnson and Minassian, 1989[62]	Africa	-	0-6	5436	-
Kaphle *et al*., 2016[63]	Malawi	54.8	0-15	635	-
Kedir and Girma, 2014[64]	Ethiopia	54.1	7-15	592	-
Kemmanu *et al*., 2016[65]	India	-	≤15	23,087	-
Khandekar *et al*., 2002[66]	Oman	52.1	0-15	6208	-
Kingo and Ndawi, 2009[67]	Tanzania	-	6-17	400	-
Kumah *et al*., 2013[19]	Ghana	46.6	12-15	2453	3.65 (2.94-4.47)
Li *et al*., 2015[68]	China	51.5	0-19	22,148	-
Limburg *et al*., 2012[20]	Vietnam	52.2	0-15	28,800	-
Lu *et al*., 2009[24]	Beijing	52.2	4.41±1.09 (0-6)	17,699	-
Ma *et al*., 2016[13]	China	54.0	3-10	8267	19.79 (18.93-20.66)
Maul *et al*., 2000[39]	Chile	50.7	5-15	5303	15.72 (14.75-16.73)
Moraes Ibrahim *et al*., 2013[18]	Brazil	51.0	12.4±1.6 (10-15)	1590	5.72 (4.63-6.98)
Moser *et al*., 2002[69]	Equatorial Guinea	47.9	0-19	812	-
Murthy *et al*., 2002[36]	India	51.9	7-15	6447	6.40 (5.79-7.05)
Naidoo *et al*., 2003[35]	South Africa	49.3	5-15	4679	1.34 (1.03-1.71)
Newland *et al*., 1992[70]	Vanuatu	-	6-19	483	-
O'Donoghue *et al*., 2010[71]	Northern Ireland	50.5	13.1±0.38 (12-13)	661	12.85 (10.40-15.65)
Pai *et al*., 2011[21]	Sydney	51.3	2-4	475	-
Pan *et al*., 2016[12]	China	53.3	4-6	713	-
Park *et al*., 2014[16]	South Korea	52.6	5-19	4394	-
Paudel *et al*., 2014[15]	Vietnam	46.1	12-15	2238	19.39 (17.77-21.09)
Pi *et al*., 2012[72]	Western China	52.4	6-15	3079	-
Pokharel *et al*., 2000[38]	Nepal	51.7	5-15	4803	2.87 (2.41-3.38)

Contd...

Table 1: Contd...

1st author	Country (city)	Gender percentage male	Age mean, range	SS	UCVA % (95% CI)
Premsenthil *et al*., 2013[73]	Malaysia	49.0	4-6	400	-
Raihan *et al*., 2005[74]	Bangladesh	50.2	5-15	28,835	-
Razavi *et al*., 2010[75]	Iran	-	6-13	123	-
Rezvan *et al*., 2012[76]	Iran	41.5	11.2±2.4 (6-17)	1547	2.20 (1.41-2.90)
Robaei *et al*., 2005[31]	Sydney	50.6	6.7 (5-9)	1738	1.32 (0.84-1.97)
Rustagi *et al*., 2012[77]	Delhi	46.8	14.25 (11-18)	1075	2.88 (1.96-4.06)
Salomão *et al*., 2009[78]	Brazil	48.2	11-14	2440	4.83 (4.01-5.76)
Sapkota *et al*., 2008[25]	Kathmandu	53.5	10-15	4282	18.63 (17.47-19.83)
Sewunet *et al*., 2014[79]	Ethiopia	43.1	7-15	420	11.66 (8.75-15.12)
Shahriari *et al*., 2007[80]	Iran	46.2	10-19	2307	-
Sharma *et al*., 2017[81]	Haryana	40.3	6-15	1265	2.68 (1.86-3.73)
Srivastava and Verma, 1978[82]	India	54.4	0-14	7822	-
Tabbara and Ross-Degnan, 1986[83]	Saudi Arabia	50.4	0-19	4467	-
Tananuvat *et al*., 2004[84]	Chiang Mai	-	6-7	3467	-
Taylor *et al*., 2010[85]	Australia	-	5-15	1694	-
Thulasiraj *et al*., 2003[34]	India	-	6-19	5342	-
Unsal *et al*., 2009[86]	Turkey	53.7	10.52±2.2 (6-17)	1606	-
Varma *et al*., 2017[87]	United States	-	3-5	-	-
Vitale *et al*., 2006[30]	United States	43.8	12-19	4564	-
Wu *et al*., 2013[88]	China	52.9	9.7±3.3 (4-18)	6026	27.09 (25.97-28.24)
Xiao *et al*., 2011[89]	China	-	<16	23,675	-
Yamamah *et al*., 2015[14]	Egypt	50.6	10.7±3.1 (5-17)	2070	29.42 (27.46-31.43)
Yekta *et al*., 2010[22]	Iran	53.5	10.9±2.2 (7-15)	1872	6.46 (4.96-7.96)
Zainal *et al*., 2002[90]	Malaysia	47.0	0-9	4690	-
Zerihun and Mabey, 1997[91]	Ethiopia	50.5	0-19	4084	-
Zhao *et al*., 2000[37]	China	48.8	5-15	5884	12.81 (11.97-13.69)
MEPEDS Group 2009[23]	African-American	-	2-6	1592	-
	Hispanic			165	

1st author	PVA % (95% CI)	BCVA % (95% CI)	Blindness	Definition of visual impairment/ blindness	Risk of bias
Abu-Shagra *et al*., 1991[42]	11.86 (10.08-13.84)	-		≤6/12 in the better eye	Medium risk
Adhikari *et al*., 2014[43]	0.1 (0.04-0.15)	-	0.07 (0.02-0.12)	VI: <6/18 in the better eye BL: PVA <6/60	Low risk
Ajaiyeoba *et al*., 2007[44]	1.32 (0.74-2.18)		0.17 (0.02-0.63)	VI: <6/18 either in one or both eyes BL: VA <3/60	Low risk
Akogun 1992[45]	8.12 (6.83-9.57)	-	3.81 (2.92-4.87)	VI: <6/18 in the better eye BL: VA <6/60 in the better eye	High risk
A1 Faran *et al*., 1993[46]	-	1.67 (1.14-2.35)	-	<6/18 in the better eye	Medium risk
Alrasheed *et al*., 2016[47]	4.40 (2.90-5.90)	1.20 (0.30-2.70)	-	≤6/12 in the better eye	Low risk
Beiram 1971[48]	-	-	0.071 (0.057-0.087)	VA ≤3/60 in the better eye	High risk
Bucher and Ijsselmuiden, 1988[49]	-	-	0.006 (0.001-0.019)	PVA <3/60 in the better eye	High risk
Casson *et al*., 2012[50]	1.90 (1.43-2.46)	-	-	<20/32 in the better eye	Low risk
Congdon *et al*., 2008[27]	19.29 (17.53-21.14)	0.47 (0.21-0.90)	-	≤6/12 in the better eye	Low risk
Dandona *et al*., 1999[40]	2.86 (1.73-4.43)	-	-	<20/40 in the better eye	Medium risk
Dandona *et al*., 2001[51]	-	-	0.17 (0.05-0.40)	PVA <6/60 in the better eye	Medium risk
Darge *et al*., 2017[52]	5.82 (3.68-8.67)	-	-	≤6/12 in the either eye	Low risk
Demissie and Solomon, 2011[53]	-	-	0.05 (0.03-0.07)	PVA <6/60 in the better eye	Low risk
Dorairaj *et al*., 2008[54]	-	-	0.11 (0.06-0.17)	BCVA <3/60 in the better eye	Low risk
Drews *et al*., 1992[55]	-	-	0.068 (0.05-0.08)	BCVA <20/200 in the better eye	High risk
Farber 2003[56]	-	-	14.41 (12.41-16.60)	VA ≤20/400 in the better eye	High risk
Feghhi *et al*., 2009[57]	-	5.09 (4.26-6.03)	-	<20/60 in the better eye	Medium risk
Flanagan *et al*., 2003[58]	-	0.057 (0.03-0.08)	-	≤6/18 in the better eye	High risk

Contd...

Table 1: Contd...

1st author	PVA % (95% CI)	BCVA % (95% CI)	Blindness	Definition of visual impairment/ blindness	Risk of bias
Fotouhi *et al*., 2007[29]	1.73 (1.40-2.11)	0.25 (0.13-0.42)	-	≤20/40 in the better eye	Low risk
Ghosh *et al*., 2012[59]	-	0.19 (0.06-0.45)	-	<6/12 in the better eye	Medium risk
Gilbert *et al*., 2008[26]	-	0.14 (0.11-0.18)	-	<6/18 in the better eye	Low risk
Goh *et al*., 2004[32]	10.08 (9.22-10.98)	1.42 (1.10-1.81)	2.033 (1.64-2.48)	VI: ≤20/40 in the better eye BL: ≤20/200 in the better eye	Low risk
Hashemi *et al*., 2017[11]	1.30 (0.63-2.38)	0.52 (0.14-1.33)	0.78 (0.28-1.69)	VI: ≤20/60 in the better eye BL: VA <20/400 in the better eye	Low risk
He *et al*., 2014[17]	11.25 (10.63-11.91)	0.63 (0.48-0.81)	-	≤20/40 in the better eye	Low risk
He *et al*., 2007[28]	16.58 (15.11-18.13)	0.45 (0.22-0.81)	-	≤20/40 in the better eye	Low risk
He *et al*., 2004[33]	10.25 (9.36-11.19)	0.61 (0.41-0.89)	-	≤20/40 in the better eye	Low risk
Heijthuijsen *et al*., 2013[60]	2.30 (1.89-2.77)	-	0.81 (0.57-1.12)	VI: <6/18 in the better eye BL: PVA <3/60 in the better eye	Medium risk
Jamali *et al*., 2009[61]	-	-	-	<6/12 in either eye	Medium risk
Johnson and Minassian, 1989[62]	-	-	0.11 (0.04-0.24)	VA<3/60 in the better eye	Medium risk
Kaphle *et al*., 2016[63]	3.60 (0.43-12.31)	-	1.78 (0.04-9.55)	VI: VA <6/18 in the better eye BL: PVA <3/60 in the better eye	Medium risk
Kedir and Girma, 2010[64]	1.75 (0.84- 3.20)	1.40 (0.61-2.74)	-	<6/18 in the better eye	Low risk
Kemmanu *et al*., 2015[65]	-	-	0.077 (0.046-0.12)	BCVA <3/60 in the better eye	Low risk
Khandekar *et al*., 2002[66]	-	-	0.08 (0.02-0.18)	PVA<3/60 in the better eye	Low risk
Kingo and Ndawi, 2009[67]	9.50 (6.81-12.80)	-	-	VI: VA<6/18 in the better eye	Medium risk
Kumah *et al*., 2013[19]	3.53 (2.83-4.34)	0.41 (0.19-0.75)	-	≤20/40 in the better eye	Low risk
Li *et al*., 2015[68]	-	0.07 (0.04-0.11)	0.02 (0.007-0.05)	VI: <6/18 in the better eye BL: BCVA <3/60 in the better eye	Low risk
Limburg *et al*., 2012[20]	-	-	0.07 (0.05-0.11)	PVA <3/60 in the better eye	Medium risk
Lu *et al*., 2009[24]	0.42 (0.33-0.53)	-	-	<6/18 in the better eye	Medium risk
Ma *et al*., 2016[13]	15.53 (14.75-16.33)	1.69 (1.42-1.99)	-	≤20/40 in the better eye	Low risk
Maul *et al*., 1999[39]	14.57 (13.63-15.55)	7.29 (6.61-8.03)	-	<20/40 in at least one eye	Low risk
Moraes Ibrahim *et al*., 2013[18]	2.83 (2.07-3.76)	0.81 (0.43-1.39)	-	≤20/40 in the better eye	Medium risk
Moser *et al*., 2002[69]	-	-	0.61 (0.20-1.43)	VA <3/60 in the better eye	Medium risk
Murthy *et al*., 2001[36]	4.85 (4.32-5.43)	0.81 (0.59-1.06)	-	<20/40 in the better eye	Low risk
Naidoo *et al*., 2003[35]	1.17 (0.88-1.52)	0.32 (0.17-0.52)	-	VA ≤20/40 in the better eye	Low risk
Newland *et al*., 1992[70]	-	-	0.21 (0.005-1.14)	VA <6/18 in the better eye	High risk
O'Donoghue *et al*., 2010[71]	3.17 (1.97-4.81)	-	-	<6/12 in the better eye	Low risk
Pai *et al*., 2011[21]	6.10 (4.12-8.65)	-	-	<20/50 in the better eye	Low risk
Pan *et al*., 2016[12]	6.59 (4.88-8.66)	-	-	<20/40 in the better eye	Low risk
Park *et al*., 2014[16]	6.12 (5.43-6.87)	-	0.25 (0.12-0.44)	VI: <20/60 in the better eye BL: VA <20/400 in the better eye	Low risk
Paudel *et al*., 2014[15]	12.19 (10.87-13.62)	-	0.26 (0.09-0.58)	VI: VA ≤6/12 in the better eye BL: PVA ≤6/120 in the better eye	Low risk
Pi *et al*., 2012[72]	7.69 (6.78-8.69)	-	-	≤20/40 in the better eye	Low risk
Pokharel *et al*., 2000[38]	2.83 (2.38-3.34)	1.35 (1.04-1.72)	-	≤20/40 in the better eye	Medium risk
Premsenthil *et al*., 2013[73]	5.0 (3.08-7.61)	-	-	≤6/12 in the better eye	Low risk
Raihan *et al*., 2005[74]	-	-	0.06 (0.04-0.11)	PVA <3/60 in the better eye	High risk
Razavi *et al*., 2010[75]	-	-	17.88 (11.56-25.81)	VA <3/60 in the better eye	Low risk
Rezvan *et al*., 2012[76]	1.0 (0.59-1.67)	0.25 (0.07-0.66)	-	≤6/12 in the better eye	Low risk
Robaei *et al*., 2005[31]	0.86 (0.48-1.41)	-	-	≤20/40 in the better eye	Low risk
Rustagi *et al*., 2012[77]	-	-	0.93 (0.44-1.70)	VI: <20/60 in the better eye BL: VA <20/200 in the better eye	Medium risk
Salomão *et al*., 2009[78]	2.70 (2.09-3.42)	0.40 (0.19-0.75)	-	≤20/40 in the better eye	Low risk
Sapkota *et al*., 2008[25]	9.08 (8.24-9.98)	0.86 (0.60- 1.18)	-	≤20/40 in the better eye	Medium risk
Sewunet *et al*., 2014[79]	-	6.42 (4.27-9.21)	-	<20/40 in the better eye	Medium risk
Shahriari *et al*., 2007[80]	-	1.51 (0.98-2.04)		<20/60 using a pinhole	Low risk

Contd...

Table 1: Contd...

1st author	PVA % (95% CI)	BCVA % (95% CI)	Blindness	Definition of visual impairment/ blindness	Risk of bias
Sharma *et al*., 2017[81]	-	-	-	≤6/18 in the better eye	High risk
Srivastava and Verma, 1978[82]	-	-	0.14 (0.07-0.25)	PVA <3/60 in the better eye	High risk
Tabbara and Ross-Degnan, 1986[83]	11.59 (10.67-12.57)	-	2.39 (1.96-2.88)	VI: <6/18 in the better eye BL: PVA <3/60 in the better eye	Low risk
Tananuvat *et al*., 2004[84]	8.68 (7.76- 9.66)	-	-	≤20/40 at least one eye	Medium risk
Taylor *et al*., 2010[85]	1.68 (1.12-2.43)	-	0.18 (0.03-0.52)	VI: <6/12 in the better eye BL: PVA<6/60 in the better eye	Low risk
Thulasiraj *et al*., 2003[34]	0.73 (0.52-0.99)	0.48 (0.32-0.72)	0.07 (0.02-0.19)	VI: <6/18 in the better eye BL: PVA<3/60 in the better eye	Low risk
Unsal *et al*., 2009[86]	1.68 (1.11-2.43)	-	-	<20/40 in the better eye	High risk
Varma *et al*., 2017[87]	1.50 (1.20-1.80)	-	-	<20/50 or 20/40 in the better eye	Low risk
Vitale *et al*., 2006[30]	9.70 (8.86-10.60)	-	-	≤20/50 in the better eye	Low risk
Wu *et al*., 2013[88]	-	0.31 (0.19-0.49)	-	≤20/40 in the better eye	Low risk
Xiao *et al*., 2011[89]	-	-	0.02 (0.006-0.049)	PVA <3/60 in the better eye	Medium risk
Yamamah *et al*., 2015[14]	-	-	-	≤6/9 in the better eye	Medium risk
Yekta *et al*., 2010[22]	1.49 (0.82-2.15)	0.90 (0.30-2.74)	-	≤6/12 in the better eye	Low risk
Zainal *et al*., 2002[90]	0.44 (0.27-0.68)	-	0.04 (0.005-0.15)	VI: <6/18 in the better eye BL: PVA <3/60 in the better eye	Low risk
Zerihun and Mabey, 1997[91]	0.18 (0.04-0.53)	-	0.07 (0.01-0.21)	VI: <6/18 in the better eye BL: PVA <3/60 in the better eye	High risk
Zhao *et al*., 2000[37]	10.92 (10.14-11.75)	1.75 (1.43-2.11)	-	≤20/40 in the better eye	Low risk
MEPEDS Group 2009[23]	2.76 (2.01-3.69)	0.78 (0.41-1.33)	-	<20/50 or 20/40 in the better eye	Low risk
	2.47 (1.77-3.35)	0.71 (0.36-1.22)			

SS: Sample size, UCVA: Uncorrected visual acuity, PVA: Presenting visual acuity, BCVA: Best corrected visual acuity, CI: Confidence interval, VI: Visual impairment, BL: Blindness, VA: Visual acuity

population-based studies. We also presented the prevalence of VI and blindness based on different definitions. Studies in the under-20 year's old groups and especially studies in the under-15 year's old groups were the most important reason for choosing 20 years-old as a cut-off. Our results indicated that the lowest prevalence of BCVA VI was 0.057% in the study by Flanagan *et al*.[58] in Ireland and the highest prevalence was 7.29% in a study by Maul *et al*. in Chile.[39] The lowest and highest prevalence of VI based on PVA was, respectively, 19.29% in the study by Adhikari *et al*.[43] and 0.1% in the study by Congdon *et al*.[27] Despite the lower prevalence of VI in children compared to adults (3.82% versus 35.8%[10]), the number of years lost due to disabilities caused by vision impairment in children imposes a large burden on societies, especially in less developed countries. In a systematic review, Köberlein *et al*.[92] reported that the direct costs of VI included hospitalization, utilization of medical services, purchase of medical products, and the recurrence of VI. They showed that in several population-based studies using representative populations in the United States, the annual cost was 12,175-14,029 dollars for a patient with moderate VI, and 14,882–24,180 dollars for a blind person.[92] The high cost of treatment and follow-up on the one hand, and the mental burden, the educational failure, and in general, the reduced quality of life for children on the other hand justify the importance of determining estimates of the trend of the prevalence of VI and its causes in children.

In addition to imposing costs, the burden of disease is an important issue. In a retrospective study, examining data from 195 countries between 1995 and 2017, the disability-adjusted life year (DALY) number of refractive errors in school children was higher than preschool and teenagers.[93]

Determining the prevalence of VI and its most important causes are necessary to apply policies and strategies to prevent and eliminate the preventable causes of VI. Our findings showed that refractive errors were the most common cause of VI in most articles reviewed in this meta-analysis, such that 29 articles described refractive errors as the cause or one of the causes of VI with rates ranging between 48.3% in the study by Zainal *et al*.[90] and 96.8% in the study by He *et al*.[28] Failure to use the protocol recommended for Refractive Error Study in Children (the RESC Protocol which suggests the use of cycloplegic refraction) in some studies has led to different estimates of the prevalence of refractive errors. In the RESC study, the following definition is defined to determine the refractive error Cycloplegic Refraction: In eyes with successful cycloplegia, refraction is performed with either an autorefractor or retinoscope. Autorefraction is carried out according to the manufacturer instruction manual, including daily calibration. Retinoscopy is carried out using a streak retinoscope in a semi-dark room, with the examiner at a distance of 0.75 meters and a +1.50 diopter lens in the trial frame. Therefore, not using the same definition in studies has led to different estimates in

Table 2: Prevalence of visual impairment and blindness in the six regions of the World Health Organization

WHO region	UCVA % (95% CI)			PVA % (95% CI)		BCVA % (95% CI)		Blindness % (95% CI)	
	≤20/40 in better eye	≤20/60 in better eye	≤20/40 in better eye	≤20/60 in better eye	<20/60 in better eye	≤20/40 in better eye	≤20/60 in better eye	<20/200 in better eye	<20/400 in better eye
Eastern Mediterranean	4.24 (1.00-8.55)	7.47 (1.00-15.43)	3.62 (1.81-5.44)	1.54 (1.04-2.04)	11.59 (10.65-12.53)	0.41 (0.12-0.71)	3.36 (1.00-9.14)	-	1.94 (0.27-3.61)
Americas	5.19 (4.34-6.04)	15.72 (14.74-16.70)	2.75 (2.25-3.25)	8.03 (1.00-20.84)	-	0.57 (0.18-0.96)	7.29 (6.59-7.99)	0.07 (0.05-0.08)	-
Africa	3.76 (1.09-6.44)	-	3.57 (1.58-5.56)	-	3.48 (1.96-5.01)	0.55 (0.19-0.91)	0.78 (0.36-1.21)	1.91 (1.78-5.58)	0.11 (0.04-0.16)
Western Pacific	20.10 (13.75-26.45)	6.10 (3.95-8.25)	10.87 (7.26-14.48)	2.90 (1.42-4.37)	2.11 (0.97-3.23)	0.91 (0.54-1.27)	-	0.17 (0.01-0.37)	0.05 (0.02-0.08)
South-east Asia	7.77 (1.15-14.39)	4.07 (2.23-5.93)	6.85 (2.29-11.42)	4.85 (4.33-5.38)	0.44 (0.01-0.99)	1.11 (0.63-1.58)	0.49 (0.1-1.096)	0.21 (0.01-0.43)	0.08 (0.06-0.09)
European	-	12.85 (10.31-15.41)	-	2.69 (2.18-3.21)	-	-	0.35 (0.28-0.98)	-	-

UCVA: Uncorrected visual acuity, PVA: Presenting visual acuity, BCVA: Best corrected visual acuity, CI: Confidence interval, WHO: World Health Organization

the reports. In studies on similar age groups in geographic regions close to each other, different definitions of refractive errors have been used, and the prevalence of refractive errors, as a cause of VI, is significantly different.[51] Another cause of the difference in the prevalence of refractive errors can be the difference between the studied age groups in the reviewed articles. In studies conducted in age groups over 7 years, the refractive errors as a cause of VI is higher than in studies where the average age of the participants is <7 years. In studies such as those by Sapkota *et al*.[25] and Paudel *et al*.[15] where the average age is 10 years and older, over 90% of VI is due to refractive errors. The age-related increase in the prevalence of myopia is one of the major causes of the high prevalence of refractive errors in studies that sampled older age groups. The meta-analysis by Rudnicka *et al*.[94] in the Middle East Region suggested a significant age-related increase in the prevalence of myopia, such that rates changed from 3.5% in the 5-year age group to more than 47% in the 18-year age group. In a trend analysis from 1990 to 2017, the prevalence of children aged 1–14 years with refractive disorders was 1.8% (95% uncertainty interval [UI]: 1.5–2.1). In school children, teenagers, and preschool children, the prevalence was 2.1% (95% uncertainty interval [UI]: 1.5–2.8), 2% (95% UI: 1.4–2.7) and 1.6% (95% UI: 1.2–2), respectively.[93] Another cause of difference in the results of these studies can be race and ethnic differences, and thus, genetic and lifestyle differences. In the meta-analysis by Rudnicka *et al*.,[94] the prevalence of myopia in the East Asian Region was more than 80% while it was <5.5% in black African children of the same age group. This racial difference has also been observed with other causes of VI such as amblyopia.

According to our findings, amblyopia is the second leading cause of VI after refractive errors in the reviewed papers. In countries where such screening programs have been in effect for a longer time, the prevalence of amblyopia, as one of the most important preventable causes of VI has been reported. In the absence of apparent strabismus, amblyopia is usually not easily identifiable in children, thus, only properly designed and implemented screening programs by trained people will be effective for the timely diagnosis of amblyopia. Otherwise, childhood amblyopia will continue until they reach adulthood and will lead to a decline in the quality of life in adolescence and older age. Findings by Høeg *et al*.[95] show that the prevalence of amblyopia in the Danish 20 to 29-year old population, who had been screened by the national screening program for children and treated in childhood was 0%, and in cohorts over 50 years of age, the rate was more than 1.5%. This significant difference clearly shows the impact of the implementation and expansion of screening program in recent years compared to previous years.

Based on our findings, the overall global prevalence of blindness in the under 20-year population was 0.17%. The definition by the WHO is based on BCVA <0.05 (20/400).

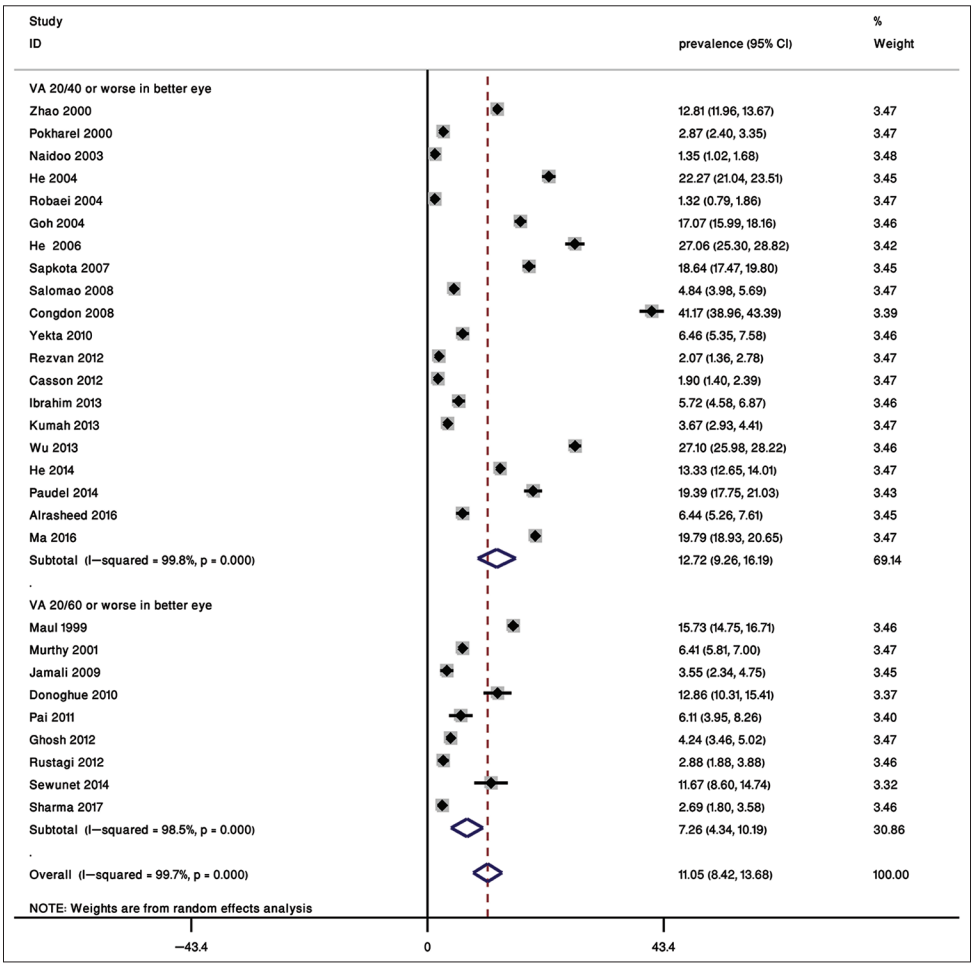

Figure 2: Overall prevalence and subgroups of uncorrected visual acuity based on uncorrected visual acuity

Table 3: The proportion (%) of causes of visual impairment and blindness in the reviewed articles

1st author	Causes visual impairment (%)						Causes of blindness (%)		
	Refractive errors	Amblyopia	Congenital cataract	Corneal opacity	Retinal disorder	Glaucoma	Refractive errors	Cataract	Glaucoma
Al Faran *et al*., 1993[46]	67.9	1.3	20.6	3.8	0.6	1.0	5.3	52.6	5.3
Ajaiyeoba *et al*., 2007[44]	66.6	-	-	-	-	-	-	-	-
Adhikari *et al*., 2014[43]	1.9						-	-	-
Alrasheed *et al*., 2016[47]	57.0	5.6	3.7	0.9	13.1	-	-	-	-
Beiram, 1971[48]	-	-	-	-	-	-	-	3.2	10.9
Darge *et al*., 2017[52]	77.3	4.5	4.5	-	-	-	-	-	-
Demissie and Solomon, 2011[53]	-	-	-	-	-	-	17.0	33.0	11.0
Dorairaj *et al*., 2008[54]	-	-	-	-	-	-	-	28.7	-
Farber, 2003[56]	-		-	-	-	-	-	4.1	2.7
Fotouhi *et al*., 2007[29]	87.3	13.2	0.5	0.8	0.5	-	-	-	-
Gilbert *et al*., 2008[26]	-	30.0	3.3	6.6	36.6	-	-	-	-
Goh *et al*., 2005[32]	89.5	2.9	0.2	0.1	0.2	-	-	-	-
He *et al*., 2007[28]	96.8	1.4	0.24	0.24	0.36	-	-	-	-
He *et al*., 2004[33]	95.6	2.8	0.1	0.1	0.2	-	-	-	-
He *et al*., 2014[17]	89.5	10.1	0.1	-	-	-	-	-	-
Ibrahim *et al*., 2013[18]	89.0	5.5	-	-	4.1	-	-	-	-
Jamali *et al*., 2009[61]	62.1	37.9	-	-	-	-	-	-	-
Kedir and Girma 2014[64]	54.0	5.4	2.7	8.1	10.8	-	-	-	-

Contd...

Table 3: Contd...

1st author	Causes visual impairment (%)						Causes of blindness (%)		
	Refractive errors	Amblyopia	Congenital cataract	Corneal opacity	Retinal disorder	Glaucoma	Refractive errors	Cataract	Glaucoma
Kingo and Ndawi, 2009[67]	31.2	-	-	-	-	-	-	-	-
Kumah *et al*., 2013[19]	88.8	4.5	1.1	2.3	2.2	-	-	-	-
Lu *et al*., 2009[24]	80.3	4.2	4.2	-	-	-	-	-	-
Maul *et al*., 2000[39]	62.1	9.0	0.72	0.48	2.5	-	-	-	-
Murthy *et al*., 2002[36]	80.9	6.4	0.37	1.3	5.1	-	-	-	-
Naidoo *et al*., 2003[35]	66.4	9.4	2.3	4.7	10.9	-	-	-	-
Paudel *et al*., 2014[15]	92.7	2.2	0.7	-	0.4	-	-	-	-
Pi *et al*., 2012[72]	86.1	9.7	0.42	-	-	-	-	-	-
Pokharel *et al*., 2000[38]	55.1	12.3	2.9	4.4	5.1	-	-	-	-
Robaei *et al*., 2005[31]	69.0	22.5	-	-	2.8	-	-	-	-
Salomão *et al*., 2009[78]	76.8	11.4	-	-	5.9	-	-	-	-
Sapkota *et al*., 2008[25]	93.3	1.77	0.10	-	1.25	-	-	-	-
Sewunet *et al*., 2014[79]	87.7	-	-	-	-	-	-	-	-
Srivastava and Verma, 1978[82]	-	-	-	-	-	-	-	32.0	25.0
Taylor *et al*., 2010[85]	56.0	-	-	-	-	-	33.0	-	-
Thulasiraj *et al*., 2003[34]	-	-	-	-	-	-	-	-	10.2
Wu *et al*., 2013[88]	96.6	2.2	-	0.05	-	-	-	-	-
Yamamah *et al*., 2015[14]	-	0.4	0.4	-	0.4	-	-	-	-
Zainal *et al*., 2002[90]	48.3	-	35.9	2.5	2.8	-	-	-	-

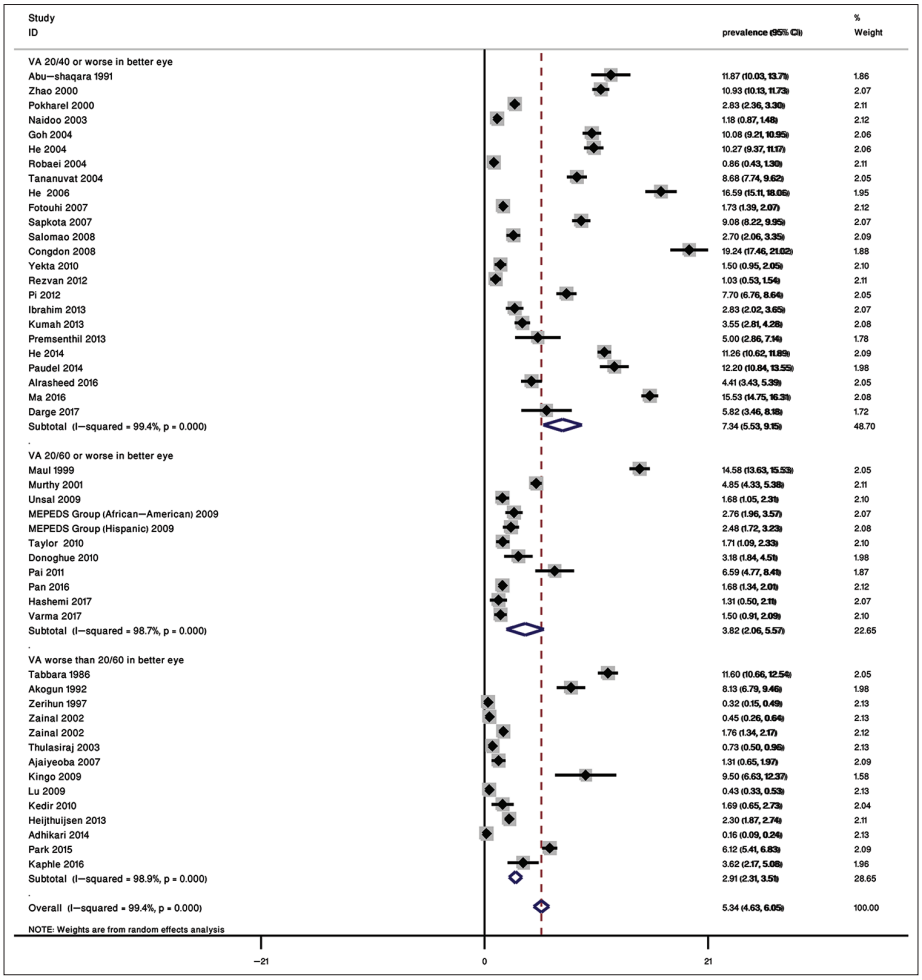

Figure 3: Overall prevalence and subgroups of presenting visual acuity (PVA) based on PVA

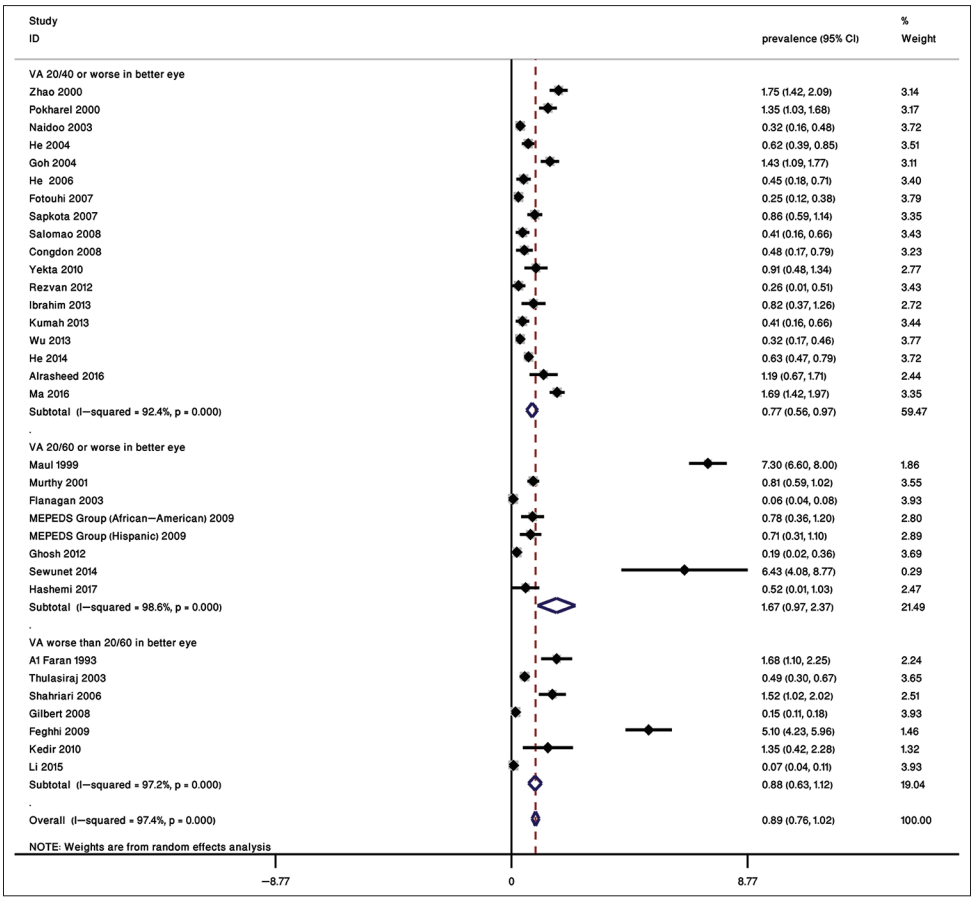

Figure 4: Overall prevalence and subgroups of best corrected visual acuity (BCVA) based on BCVA

The prevalence of blindness in the studies using this criterion was estimated at 4.5%. These definitions in different countries have always led to various estimates of blindness. For example, blindness is defined as a visual acuity of ≤0.02 (20/1000) in Germany and ≤0.05 in Israel.[56,96] Rosenberg and Klie[97] have shown that changing the definition of blindness from ≤0.1 to <0.1 can reduce the diagnosis of blindness by up 32%. Establishing national registries for the blind is very important and effective in determining the prevalence and causes of blindness. Unfortunately, few countries have established reliable registries so far, and in other countries, relevant information, such as the prevalence and causes of blindness, is generated from surveys or studies in schools for the blind, and due to methodological errors in these studies, the results are interpreted with caution. This lack of consistency in the definition and diagnosis of blindness and the lack of registries has led to overestimation or underestimation of global blindness. Despite these differences, we determined the prevalence of blindness based on different diagnostic criteria by referring to the most reliable survey articles and excluding studies performed at schools for the blind. Studies have shown that despite the reduction in age-standardized prevalence of blindness and VI over the past 20 years, based on corrected vision, cataract is still the most important cause of blindness in the world, such that in 2015, Khairallah *et al*.[98] reported that more than 33% of the world's blindness was due to cataract between 1990 and the end of 2010. In our study, cataract was the most common cause of blindness and the third most common cause of VI in the reviewed studies. Due to lack of information such as nonreporting standard error or CI, meta-analysis of other causes was not possible for the authors. In 2002, Zainal *et al*.[90] reported the highest prevalence of cataract (3.92%) in children younger than 19 years of age. In determining the cause of blindness and comparing it among different populations, the study of the economic status of the countries and the availability of public health services plays an important role. In countries where access to cataract surgery due to lack of equipment, lack of experienced specialists, and financial inability of people for access to surgery, cataract plays a major role in blindness. In light of this discussion, to reduce preventable blindness, it is necessary to conduct nationwide surveys to determine the existence and availability of surgical facilities and to give priority to raising public awareness for the utilization of healthcare services.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

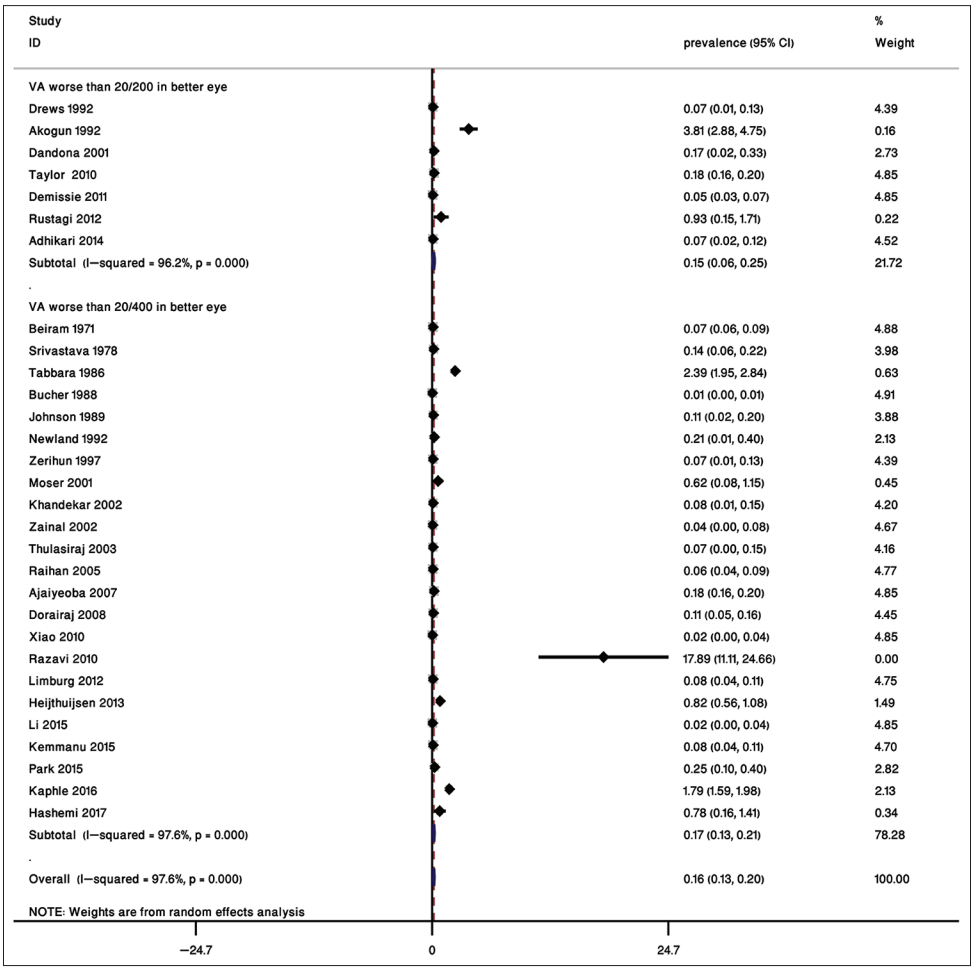

Figure 5: Overall prevalence and subgroups of blindness

References

1. Solebo AL, Teoh L, Rahi J. Epidemiology of blindness in children. Arch Dis Child 2017;102:853-7.
2. World Health Organization. (1997). Strategies for the prevention of blindness in national programmers: a primary health care approach, 2nd ed. https://apps.who.int/iris/handle/10665/41887. [Last accessed on 2022 Mar 27].
3. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, *et al.* Global data on visual impairment in the year 2002. Bull World Health Organ 2004;82:844-51.
4. Blindness and Visual Impairment; 2017. Available from: http://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. [Last accessed on 2017 Mar 05].
5. Courtright P, Hutchinson AK, Lewallen S. Visual impairment in children in middle- and lower-income countries. Arch Dis Child 2011;96:1129-34.
6. Rahi JS, Cumberland PM, Peckham CS; British Childhood Visual Impairment Interest Group. Improving detection of blindness in childhood: The British Childhood Vision Impairment study. Pediatrics 2010;126:e895-903.
7. Kong L, Fry M, Al-Samarraie M, Gilbert C, Steinkuller PG. An update on progress and the changing epidemiology of causes of childhood blindness worldwide. J AAPOS 2012;16:501-7.
8. Rahi JS, Cable N; British Childhood Visual Impairment Study Group. Severe visual impairment and blindness in children in the UK. Lancet 2003;362:1359-65.
9. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. Open Med 2009;3:e123-30.
10. GBD 2019 Blindness and Vision Impairment Collaborators; Vision Loss Expert Group of the Global Burden of Disease Study. Trends in prevalence of blindness and distance and near vision impairment over 30 years: An analysis for the Global Burden of Disease Study. Lancet Glob Health 2021;9:e130-43.
11. Hashemi H, Khabazkhoob M, Saatchi M, Ostadimoghaddam H, Yekta A. Visual impairment and blindness in a population-based study of Mashhad, Iran. J Curr Ophthalmol 2018;30:161-8.
12. Pan CW, Chen X, Gong Y, Yu J, Ding H, Bai J, *et al.* Prevalence and causes of reduced visual acuity among children aged three to six years in a metropolis in China. Ophthalmic Physiol Opt 2016;36:152-7.
13. Ma Y, Qu X, Zhu X, Xu X, Zhu J, Sankaridurg P, *et al.* Age-specific prevalence of visual impairment and refractive error in children aged 3-10 years in Shanghai, China. Invest Ophthalmol Vis Sci 2016;57:6188-96.
14. Yamamah GA, Talaat Abdel Alim AA, Mostafa YS, Ahmed RA, Mohammed AM. Prevalence of visual impairment and refractive errors in children of south Sinai, Egypt. Ophthalmic Epidemiol 2015;22:246-52.
15. Paudel P, Ramson P, Naduvilath T, Wilson D, Phuong HT, Ho SM, *et al.* Prevalence of vision impairment and refractive error in school children in Ba Ria-Vung Tau province, Vietnam. Clin Exp Ophthalmol 2014;42:217-26.
16. Park SH, Lee JS, Heo H, Suh YW, Kim SH, Lim KH, *et al.* A nationwide population-based study of low vision and blindness in South Korea. Invest Ophthalmol Vis Sci 2014;56:484-93.
17. He J, Lu L, Zou H, He X, Li Q, Wang W, *et al.* Prevalence and causes of visual impairment and rate of wearing spectacles in schools for

children of migrant workers in Shanghai, China. BMC Public Health 2014;14:1312.
18. Moraes Ibrahim F, Moraes Ibrahim M, Pomepo de Camargo JR, Veronese Rodrigues Mde L, Scott IU, Silva Paula J. Visual impairment and myopia in Brazilian children: A population-based study. Optom Vis Sci 2013;90:223-7.
19. Kumah BD, Ebri A, Abdul-Kabir M, Ahmed AS, Koomson NY, Aikins S, *et al.* Refractive error and visual impairment in private school children in Ghana. Optom Vis Sci 2013;90:1456-61.
20. Limburg H, Gilbert C, Hon DN, Dung NC, Hoang TH. Prevalence and causes of blindness in children in Vietnam. Ophthalmology 2012;119:355-61.
21. Pai AS, Wang JJ, Samarawickrama C, Burlutsky G, Rose KA, Varma R, *et al.* Prevalence and risk factors for visual impairment in preschool children the Sydney Paediatric eye disease study. Ophthalmology 2011;118:1495-500.
22. Yekta A, Fotouhi A, Hashemi H, Dehghani C, Ostadimoghaddam H, Heravian J, *et al.* Prevalence of refractive errors among schoolchildren in Shiraz, Iran. Clin Exp Ophthalmol 2010;38:242-8.
23. Multi-Ethnic Pediatric Eye Disease Study G. Prevalence and causes of visual impairment in African-American and Hispanic preschool children: The multi-ethnic pediatric eye disease study. Ophthalmology 2009;116:1990-2000.e1991.
24. Lu Q, Zheng Y, Sun B, Cui T, Congdon N, Hu A, *et al.* A population-based study of visual impairment among pre-school children in Beijing: The Beijing study of visual impairment in children. Am J Ophthalmol 2009;147:1075-81.
25. Sapkota YD, Adhikari BN, Pokharel GP, Poudyal BK, Ellwein LB. The prevalence of visual impairment in school children of upper-middle socioeconomic status in Kathmandu. Ophthalmic Epidemiol 2008;15:17-23.
26. Gilbert CE, Ellwein LB; Refractive Error Study in Children Study Group. Prevalence and causes of functional low vision in school-age children: Results from standardized population surveys in Asia, Africa, and Latin America. Invest Ophthalmol Vis Sci 2008;49:877-81.
27. Congdon N, Wang Y, Song Y, Choi K, Zhang M, Zhou Z, *et al.* Visual disability, visual function, and myopia among rural Chinese secondary school children: The Xichang Pediatric Refractive Error Study (X-PRES) – Report 1. Invest Ophthalmol Vis Sci 2008;49:2888-94.
28. He M, Huang W, Zheng Y, Huang L, Ellwein LB. Refractive error and visual impairment in school children in rural southern China. Ophthalmology 2007;114:374-82.
29. Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful, Iran. Br J Ophthalmol 2007;91:287-92.
30. Vitale S, Cotch MF, Sperduto RD. Prevalence of visual impairment in the United States. JAMA 2006;295:2158-63.
31. Robaei D, Rose K, Ojaimi E, Kifley A, Huynh S, Mitchell P. Visual acuity and the causes of visual loss in a population-based sample of 6-year-old Australian children. Ophthalmology 2005;112:1275-82.
32. Goh PP, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. Ophthalmology 2005;112:678-85.
33. He M, Zeng J, Liu Y, Xu J, Pokharel GP, Ellwein LB. Refractive error and visual impairment in urban children in southern china. Invest Ophthalmol Vis Sci 2004;45:793-9.
34. Thulasiraj RD, Nirmalan PK, Ramakrishnan R, Krishnadas R, Manimekalai TK, Baburajan NP, *et al.* Blindness and vision impairment in a rural south Indian population: The Aravind Comprehensive Eye Survey. Ophthalmology 2003;110:1491-8.
35. 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. Invest Ophthalmol Vis Sci 2003;44:3764-70.
36. Murthy GV, Gupta SK, Ellwein LB, Muñoz SR, Pokharel GP, Sanga L, *et al.* Refractive error in children in an urban population in New Delhi. Invest Ophthalmol Vis Sci 2002;43:623-31.
37. Zhao J, Pan X, Sui R, Munoz SR, Sperduto RD, Ellwein LB. Refractive error study in children: Results from Shunyi District, China. Am J Ophthalmol 2000;129:427-35.
38. Pokharel GP, Negrel AD, Munoz SR, Ellwein LB. Refractive error study in children: Results from Mechi Zone, Nepal. Am J Ophthalmol 2000;129:436-44.
39. Maul E, Barroso S, Munoz SR, Sperduto RD, Ellwein LB. Refractive error study in children: Results from La Florida, Chile. Am J Ophthalmol 2000;129:445-54.
40. Dandona L, Dandona R, Naduvilath TJ, McCarty CA, Srinivas M, Mandal P, *et al.* Burden of moderate visual impairment in an urban population in southern India. Ophthalmology 1999;106:497-504.
41. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, *et al.* The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. Prev Med 2007;45:247-51.
42. Abu-Shagra S, Kazi G, Al-Rushood A, S. Y. Prevelance and causes of visual acuity defect in male school children in Al-Khobar area. Saudi Med J 1991;12:397–402.
43. Adhikari S, Shrestha MK, Adhikari K, Maharjan N, Shrestha UD. Factors associated with childhood ocular morbidity and blindness in three ecological regions of Nepal: Nepal pediatric ocular disease study. BMC Ophthalmol 2014;14:125.
44. Ajaiyeoba AI, Isawumi MA, Adeoye AO, Oluleye TS. Pattern of eye diseases and visual impairment among students in southwestern Nigeria. Int Ophthalmol 2007;27:287-92.
45. Akogun OB. Eye lesions, blindness and visual impairment in the Taraba river valley, Nigeria and their relation to onchocercal microfilariae in skin. Acta Trop 1992;51:143-9.
46. Al Faran MF, Al-Rajhi AA, Al-Omar OM, Al-Ghamdi SA, Jabak M. Prevalence and causes of visual impairment and blindness in the south western region of Saudi Arabia. Int Ophthalmol 1993;17:161-5.
47. Alrasheed SH, Naidoo KS, Clarke-Farr PC. Prevalence of visual impairment and refractive error in school-aged children in South Darfur State of Sudan. Afr Vision Eye Health 2016;75:1-9.
48. Beiram MM. Blindness in the Sudan: Prevalence and causes in Blue Nile Province. Bull World Health Organ 1971;45:511-5.
49. Bucher PJ, Ijsselmuiden CB. Prevalence and causes of blindness in the northern Transvaal. Br J Ophthalmol 1988;72:721-6.
50. 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;119:2021-7.
51. Dandona L, Dandona R, Srinivas M, Giridhar P, Vilas K, Prasad MN, *et al.* Blindness in the Indian state of Andhra Pradesh. Invest Ophthalmol Vis Sci 2001;42:908-16.
52. Darge HF, Shibru G, Mulugeta A, Dagnachew YM. The prevalence of visual acuity impairment among school children at Arada Subcity Primary Schools in Addis Ababa, Ethiopia. J Ophthalmol 2017;2017:9326108.
53. Demissie BS, Solomon AW. Magnitude and causes of childhood blindness and severe visual impairment in Sekoru District, Southwest Ethiopia: A survey using the key informant method. Trans R Soc Trop Med Hyg 2011;105:507-11.
54. Dorairaj SK, Bandrakalli P, Shetty C, Vathsala R, Misquith D, Ritch R. Childhood blindness in a rural population of southern India: Prevalence and etiology. Ophthalmic Epidemiol 2008;15:176-82.
55. Drews CD, Yeargin-Allsopp M, Murphy CC, Decoufle P. Legal blindness among 10-year-old children in Metropolitan Atlanta: Prevalence, 1985 to 1987. Am J Public Health 1992;82:1377-9.
56. Farber MD. National registry for the blind in Israel: Estimation of prevalence and incidence rates and causes of blindness. Ophthalmic Epidemiol 2003;10:267-77.
57. Feghhi M, Khataminia G, Ziaei H, Latifi M. Prevalence and causes of blindness and low vision in Khuzestan province, Iran. J Ophthalmic Vis Res 2009;4:29-34.
58. Flanagan NM, Jackson AJ, Hill AE. Visual impairment in childhood: Insights from a community-based survey. Child Care Health Dev 2003;29:493-9.
59. Ghosh S, Mukhopadhyay U, Maji D, Bhaduri G. Visual impairment in urban school children of low-income families in Kolkata, India. Indian J Public Health 2012;56:163-7.
60. Heijthuijsen AA, Beunders VA, Jiawan D, de Mesquita-Voigt AM, Pawiroredjo J, Mourits M, *et al.* Causes of severe visual impairment and blindness in children in the Republic of Suriname. Br J Ophthalmol

2013;97:812-5.
61. Jamali P, Fotouhi A, Hashemi H, Younesian M, Jafari A. Refractive errors and amblyopia in children entering school: Shahrood, Iran. Optom Vis Sci 2009;86:364-9.
62. Johnson GJ, Minassian DC. Prevalence of blindness and eye disease: Discussion paper. J R Soc Med 1989;82:351-4.
63. Kaphle D, Gyawali R, Kandel H, Reading A, Msosa JM. Vision impairment and ocular morbidity in a refugee population in Malawi. Optom Vis Sci 2016;93:188-93.
64. Kedir J, Girma A. Prevalence of refractive error and visual impairment among rural school-age children of Goro District, Gurage Zone, Ethiopia. Ethiop J Health Sci 2014;24:353-8.
65. Kemmanu V, Hegde K, Giliyar SK, Shetty BK, Kumaramanickavel G, McCarty CA. Prevalence of childhood blindness and ocular morbidity in a rural pediatric population in southern India: The Pavagada pediatric eye disease study-1. Ophthalmic Epidemiol 2016;23:185-92.
66. Khandekar R, Mohammed AJ, Negrel AD, Riyami AA. The prevalence and causes of blindness in the Sultanate of Oman: The Oman Eye Study (OES). Br J Ophthalmol 2002;86:957-62.
67. Kingo AU, Ndawi BT. Prevalence and causes of low vision among schoolchildren in Kibaha District, Tanzania. Tanzan J Health Res 2009;11:111-5.
68. Li T, Du L, Du L. Prevalence and causes of visual impairment and blindness in Shanxi province, China. Ophthalmic Epidemiol 2015;22:239-45.
69. Moser CL, Martín-Baranera M, Vega F, Draper V, Gutiérrez J, Mas J. Survey of blindness and visual impairment in Bioko, Equatorial Guinea. Br J Ophthalmol 2002;86:257-60.
70. Newland HS, Harris MF, Walland M, McKnight D, Galbraith JE, Iwasaki W, *et al.* Epidemiology of blindness and visual impairment in Vanuatu. Bull World Health Organ 1992;70:369-72.
71. O'Donoghue L, McClelland JF, Logan NS, Rudnicka AR, Owen CG, Saunders KJ. Refractive error and visual impairment in school children in Northern Ireland. Br J Ophthalmol 2010;94:1155-9.
72. Pi LH, Chen L, Liu Q, Ke N, Fang J, Zhang S, *et al.* Prevalence of eye diseases and causes of visual impairment in school-aged children in Western China. J Epidemiol 2012;22:37-44.
73. Premsenthil M, Manju R, Thanaraj A, Rahman SA, Kah TA. The screening of visual impairment among preschool children in an urban population in Malaysia; the Kuching pediatric eye study: A cross sectional study. BMC Ophthalmol 2013;13:16.
74. Raihan A, Rahmatullah S, Arefin MH, Banu T. Prevalence of significant refractive error, low vision and blindness among children in Bangladesh. In: International Congress Series 1282. London, UK. Elsevier; 2005. p. 433-7.
75. Razavi H, Kuper H, Rezvan F, Amelie K, Mahboobi-Pur H, Oladi MR, *et al.* Prevalence and causes of severe visual impairment and blindness among children in the lorestan province of Iran, using the key informant method. Ophthalmic Epidemiol 2010;17:95-102.
76. 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 Physiol Opt 2012;32:25-30.
77. Rustagi N, Uppal Y, Taneja DK. Screening for visual impairment: Outcome among schoolchildren in a rural area of Delhi. Indian J Ophthalmol 2012;60:203-6.
78. Salomão SR, Mitsuhiro MR, Belfort R Jr. Visual impairment and blindness: An overview of prevalence and causes in Brazil. An Acad Bras Cienc 2009;81:539-49.
79. Sewunet SA, Aredo KK, Gedefew M. Uncorrected refractive error and associated factors among primary school children in Debre Markos District, Northwest Ethiopia. BMC Ophthalmol 2014;14:95.
80. Shahriari HA, Izadi S, Rouhani MR, Ghasemzadeh F, Maleki AR. Prevalence and causes of visual impairment and blindness in Sistan-va-Baluchestan Province, Iran: Zahedan Eye Study. Br J Ophthalmol 2007;91:579-84.
81. Sharma A, Maitreya A, Semwal J, Bahadur H. Ocular morbidity among school children in Uttarakhand: Himalayan State of India. Southeast Asian J Trop Med 2017;10:149-53.
82. Srivastava RN, Verma BL. An epidemiological study of blindness in an Indian rural community. J Epidemiol Community Health (1978) 1978;32:131-5.
83. Tabbara KF, Ross-Degnan D. Blindness in Saudi Arabia. JAMA 1986;255:3378-84.
84. Tananuvat N, Manassakorn A, Worapong A, Kupat J, Chuwuttayakorn J, Wattananikorn S. Vision screening in schoolchildren: Two years results. J Med Assoc Thai 2004;87:679-84.
85. Taylor HR, Xie J, Fox S, Dunn RA, Arnold AL, Keeffe JE. The prevalence and causes of vision loss in Indigenous Australians: The National Indigenous Eye Health Survey. Med J Aust 2010;192:312-8.
86. Unsal A, Ayranci U, Tozun M. Vision screening among children in primary schools in a district of western Turkey: An epidemiological study. Pak J Med Sci 2009;25:976-81.
87. Varma R, Tarczy-Hornoch K, Jiang X. Visual impairment in preschool children in the United States: Demographic and geographic variations from 2015 to 2060. JAMA Ophthalmol 2017;135:610-6.
88. 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:e82763.
89. Xiao B, Fan J, Deng Y, Ding Y, Muhit M, Kuper H. Using key informant method to assess the prevalence and causes of childhood blindness in Xiu'shui County, Jiangxi Province, Southeast China. Ophthalmic Epidemiol 2011;18:30-5.
90. Zainal M, Ismail SM, Ropilah AR, Elias H, Arumugam G, Alias D, *et al.* Prevalence of blindness and low vision in Malaysian population: Results from the National Eye Survey 1996. Br J Ophthalmol 2002;86:951-6.
91. Zerihun N, Mabey D. Blindness and low vision in Jimma Zone, Ethopia: Results of a population-based survey. Ophthalmic Epidemiol 1997;4:19-26.
92. Köberlein J, Beifus K, Schaffert C, Finger RP. The economic burden of visual impairment and blindness: A systematic review. BMJ Open 2013;3:e003471.
93. Abdolalizadeh P, Chaibakhsh S, Falavarjani KG. Global burden of paediatric vision impairment: A trend analysis from 1990 to 2017. Eye (Lond) 2021;35:2136-45.
94. Rudnicka AR, Kapetanakis VV, Wathern AK, Logan NS, Gilmartin B, Whincup PH, *et al.* Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: Implications for aetiology and early prevention. Br J Ophthalmol 2016;100:882-90.
95. Høeg TB, Moldow B, Ellervik C, Klemp K, Erngaard D, La Cour M, *et al.* Danish Rural Eye Study: The association of preschool vision screening with the prevalence of amblyopia. Acta Ophthalmol 2015;93:322-9.
96. Finger RP, Bertram B, Wolfram C, Holz FG. Blindness and visual impairment in Germany: A slight fall in prevalence. Dtsch Arztebl Int 2012;109:484-9.
97. Rosenberg T, Klie F. Current trends in newly registered blindness in Denmark. Acta Ophthalmol Scand 1996;74:395-8.
98. Khairallah M, Kahloun R, Bourne R, Limburg H, Flaxman SR, Jonas JB, *et al.* Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010. Invest Ophthalmol Vis Sci 2015;56:6762-9.

Appendix

Appendix 1: Search methods

The search strategy was created using the following phrase

(Vision impairment or Low Vision or Visual Disorders or Visual Disorder or Visual Impairments or Vision Disability or Visual disability or Vision Disabilities or Day Blindness or Reduced Vision or Subnormal Vision or Diminished Vision or vision impaired or Visual defect or Visual loss or Visually impaired or Visually impaired persons or blindness or Acquired Blindness or Complete Blindness) and (prevalence or epidemiology or cross-sectional stud* or observational stud* or survey). Three international databases including Scopus, Web of Science, and PubMed were searched for publications indexed up to January 2018. To access more articles and to ensure the correctness of the search strategy in the databases, we also reviewed the reference lists of the selected articles as well as Google Scholar.