African Vision and Eye Health
ISSN: (Online) 2410-1516, (Print) 2413-3183

Refractive errors among schoolchildren in the Middle East: A systematic review and meta-analysis

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Dates:
Received: 20 Apr. 2024
Accepted: 02 Sept. 2024
Published: 04 Oct. 2024

How to cite this article:
Mohamed ZD, Ismail GM, Alrasheed SH, Vankudre GS, Noushad B, Ayyappan JP. Refractive errors among schoolchildren in the Middle East: A systematic review and meta-analysis. Afr Vision Eye Health. 2024;83(1), a940. https://doi.org/10.4102/aveh.v83i1.940

Background: Refractive errors are the most prevalent ocular conditions among adolescents and children.

Aim: The purpose of this systematic review and meta-analysis is to evaluate the prevalence of refractive error (RE) among children aged 5–17 years in the Middle East Region.

Method: The research adhered to the Preferred Reporting Criteria for Systematic Reviews and Meta-Analyses (2020) in conducting the study. A comprehensive search for relevant studies was conducted on multiple databases. The analysed dataset was classified based on gender and the methods employed to estimate REs.

Results: The meta-analysis included data from 38 population-based studies in 11 countries, covering 103 053 children. The overall pooled prevalence rates of myopia, hyperopia and astigmatism were 5.74%, 5.35% and 13.16%, respectively. Females had slightly higher prevalence rates at 7.25%, 5.54% and 15.50%, compared to males at 6.09%, 5.07% and 12.20%, respectively. The prevalence of myopia, hyperopia and astigmatism was higher with cycloplegic refraction at 6.33%, 6.36% and 14.39%, respectively, compared with non-cycloplegic refraction at 4.07%, 2.73% and 9.64%, respectively. Significant heterogeneity was observed between the reviewed studies ($p < 0.0001$).

Conclusion: This meta-analysis revealed that astigmatism was the most common RE in Middle Eastern children aged 5–17 years, followed by myopia and hyperopia. There was no significant difference in the pooled prevalence of RE between genders. The findings indicated that myopia, hyperopia and astigmatism measurements varied between cycloplegic and non-cycloplegic refractions.

Contribution: These findings concur with the global trend and emphasise the need for deliberate action to address childhood REs in the Middle East.

Keywords: children; refractive errors; Middle East Region; public health; prevalence.

Introduction

Refractive error (RE) occurs when the refractive system is unable to properly refract the parallel light rays at the centre of the fovea.[1,2] They are classified as myopia, hyperopia and astigmatism.[3] Uncorrected RE is the leading cause of moderate to severe visual impairment and the second leading cause of blindness worldwide. and is classified as a serious public health concern.[4,5,6] Furthermore, the relative prevalence of uncorrected RE increases in the younger population with a higher incidence of myopia.[5] Uncorrected RE is the most common cause of vision impairment in children, and it can be avoided with timely investigation and interventions.[7,8,9]

Global estimates show that approximately 19 million children between the age of 5 and 15 years suffer from visual impairment because of uncorrected RE, and nearly 90% of them live in developing countries.[10,11] The most prevalent RE in children in China was myopia, followed by astigmatism and hyperopia.[12] A study conducted in 2020 to estimate the prevalence of RE in the Middle East population reported that astigmatism is more prevalent among children concurring with a study conducted on Indian children.[9,13] Another worldwide report in 2018 observed that among children and adolescents, astigmatism was the most prevalent RE (14.9%), followed by myopia and hyperopia. Likewise, astigmatism was the most prevalent RE in American children (27.2%).[14]

Uncorrected RE has the potential to impact the quality of life and socioeconomic status of an individual.[10,15] The consequences of uncorrected RE in children are multifaceted because the

resulting visual impairment can have a negative impact on a child's social, psychological and academic development.[15,16] Therefore, a timely intervention is crucial. A sound mechanism at the community level is important to screen children for their vision such as school eye health initiatives to identify children with visual impairment and its debilitating consequences such as amblyopia.[17,18,19,20] This early detection of RE can support mitigation of uncorrected visual impairment and improving their academic performance and quality of life.[21]

The prevalence and distribution of RE vary between countries and regions.[22] In a meta-analysis study conducted in 2020 among different age groups, the prevalence of childhood REs in the Middle Eastern region was reported without mentioning the methods of refraction assessment, such as wet or dry refraction.[13] Therefore, the present study was conducted to complement those findings, because the RE prevalence reported in our study is based on gender, cycloplegic refraction and non-cycloplegic refraction.

Methods

Search plan and quality assessment of epidemiological studies

The recommended reporting items for systematic reviews and meta-analyses framework was applied in this study as shown in the Preferred Reporting Criteria for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram in Figure 1.[23] This study covered the epidemiological studies on the prevalence of RE in the Middle East covering 19 countries including Saudi Arabia, Afghanistan, Pakistan, Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Syria, Turkey, United Arab Emirates, Yemen, Egypt, Libya and Sudan. It focussed on an organised search and review for the studies reported between January 2008 and October 2023. The quality of the studies was evaluated on an individual basis utilising the checklist that was designed by Downs and Black.[24] Each article was graded and given a score based on a 10-items as shown in Table 1.

This work limited itself to cross-sectional studies reported in English, available online in peer-eviewed publications, that addressed the prevalence of RE among children in Middle Eastern countries. The databases such as Scopus, Google Scholar, Web of Sciences, Index Medicus for the EMR, ProQuest, Medline and PubMed were searched till October 2023. A thorough search of the titles and abstract was done using the keywords with Boolean operators (OR/AND). The search terms were – prevalence OR incidence OR rate OR proportion OR frequency OR proportion OR epidemiology OR distribution AND REs in children in the Middle East region (MER).

Inclusion and exclusion criteria

For full text review, all population-based studies on the prevalence of RE in male and female school aged children 5–17 years old were considered including population and school-based studies. The studies employed an observational study design with a detailed description of the data collection approaches such as the sampling method, the RE measuring technique (whether cycloplegic or non-cycloplegic refraction) as well as subjective or objective refraction. The benchmarked criteria for categorising REs were myopia as spherical equivalent (-0.5 D SPH),[25] hyperopia (1.5 D SPH)[26] and astigmatism (0.5 D CYL).[27] Studies that lacked the inclusion criteria were omitted, studies that did not show a valid frequency or prevalence were excluded and those datasets reported outside of Middle Eastern countries were also excluded.

Data extraction

The first and second authors carefully screened and reviewed the titles of studies conducted in Middle Eastern countries among children with REs that met the inclusion criteria. Thereafter, the authors examined the abstract of each selected study, focussing on the prevalence of REs such as hyperopia, myopia and astigmatism, as well as the methods used for measuring REs, whether with or without cycloplegia. Finally, the full texts of the included studies were carefully reviewed to extract information such as sample size, gender and the number of affected children with REs, in order to calculate pooled prevalence based on overall totals, gender and refractive methods. Next, the data such as the first author's name, publication year, country, participant's characteristics (age, gender and sample size), technique employed for RE measurement (cycloplegic or non-cycloplegic refraction) and the benchmarks for defining the RE according to predefined study protocol were extracted. For addressing disagreements between authors in this review, clear standards and protocols were developed to guide the review process and build open communication to reach consensus by arguing different viewpoints and referring to established protocol.

Data analysis

The data from the inclusive studies were documented in a conditioned Microsoft Excel sheet including databases, participants age (mean ± standard deviation [s.d.]), samples size and the prevalence and frequency of myopia, hyperopia, astigmatism as well as the total RE. MedCalc-Version 19.6.1 software (MedCalc, Mariakerke, Belgium) was used for meta-analysing the prevalence of RE.

In the present study, heterogeneity among articles was checked by a Q-statistic that is allotted as Chi-square under the assumption of homogeneity of effect sizes, and I^2 index I^2 values ranged between 0% and 75%, representing none to high heterogeneity. MedCalc-Version 19.6.1 was used to build tables that showed the prevalence of RE among children, by age (mean ± s.d.), sex, refraction procedure in different studies and the weight for each article. The overall pooled prevalence of RE (myopia, hyperopia and astigmatism) was estimated using a random-effect model and its associated 95% confidence intervals (CI), p values were less than 0.05.

TABLE 1: Characteristics of studies reporting the prevalence of refractive error across the Middle East Region (2008–2023).

Authors and year of study	Country	Sample size	Range of age (years)	Age in years (mean ± s.d.)	Cycloplegic refraction	Myopic	Hyperopic	Astigmatism	Quality assessment score
Ghalib et al. 2020[28]	Sudan	400	6–15	-	Yes	24	22	49	9
Mohamed et al. 2017[29]	Sudan	822	5–15	12.41 ± 1.99	No	14	5	19	8
Alrasheed et al. 2016[30]	Sudan	1678	6–15	10.8 ± 2.8	Yes	114	32	42	10
Alsaqr et al. 2017[31]	Saudi Arabia	335	3–6	4.5 ± 0.87	Yes	14	27	67	10
Alrahili et al. 2017[32]	Saudi Arabia	1893	3–10	6.2 ± 1.9	No	13	28	473	9
Alomair et al. 2020[33]	Saudi Arabia	850	6–15	-	Yes	120	51	72	8
AlThomali et al. 2022[34]	Saudi Arabia	7356	7–18	11.8 ± 2.2	Yes	2442	1295	3688	10
Abbas et al. 2019[35]	Pakistan	2491	-	-	No	101	21	124	8
Hameed 2016[36]	Pakistan	1644	5–15	-	No	56	20	59	8
Latif et al. 2014[37]	Pakistan	533	9–18	13.9 ± 1.6	Yes	66	15	26	9
Ullah et al. 2020[38]	Pakistan	2288	5–12	8.10 ± 2.3	No	53	46	25	9
Atta 2015[39]	Pakistan	300	5–20	-	Yes	65	35	24	7
Mahjoob et al. 2016[25]	Iran	320	7–12	9.11 ± 1.62	Yes	20	186	11	10
Norouzirad et al. 2015[40]	Iran	1130	6–15	11.05 ± 2.93	Yes	168	146	509	10
Hashemi et al. 2017[41]	Iran	602	5–15	10.02 ± 3.19	Yes	16	24	NA	9
Hashemi et al. 2016[42]	Iran	4106	7	7	No	125	255	716	9
Abdelrheem et al. 2021[43]	Egypt	14 787	6–12	9.22 ± 1.64	Yes	340	754	1523	10
Farida et al. 2018[44]	Egypt	1272	11–15	13.14 ± 0.91	Yes	703	145	649	10
Elsabagh et al. 2020[45]	Egypt	1075	9–13	10.79 ± 0.92	Yes	42	34	162	9
Kandi et al. 2021[46]	UAE	733	6–10	-	Yes	38	16	50	8
Hussam et al. 2018[47]	Iraq	735	6–8	6.1 ± 0.34	Yes	144	148	54	9
Hussein et al. 2008[48]	Jordan	1647	11–17	13.2 ± 2.1	N0	256	47	85	8
Alghamdi 2020[49]	Saudi Arabia	417	6–13	9.2 ± 1.9	No	32	37	14	9
Al-Rowaily et al. 2010[50]	Saudi Arabia	1319	4–6	-	No	33	28	33	9
Yamamah et al. 2015[51]	Egypt	2070	6–17	10.7 ± 3.1	Yes	64	75	318	9
Aldebasi 2014[52]	Saudi Arabia	5176	5–15	9.5 ± 1.8	Yes	300	36	228	10
Rajavi et al. 2014[53]	Iran	2417	7–12	9.4 ± 1.7	No	118	85	546	9
Elmajri 2017[54]	Libya	920	6–11	9.53 ± 1.5	Yes	16	56	34	7
Al Wadaani et al. 2012[55]	Saudi Arabia	2002	6–15	9.4 ± 203	Yes	180	27	67	9
Gilal et al. 2022[56]	Pakistan	400	6–15	10.5	Yes	15	7	5	9
Jamali et al. 2009[57]	Iran	827	6	6	Yes	14	170	162	8
Fotouhi et al. 2011[58]	Iran	3481	8–14	10.7 ± 2.3	Yes	14	352	230	10
Caca et al. 2013[59]	Turkey	21 062	6–14	10.56 ± 3.59	Yes	674	1243	3012	8
Aydoğan et al. 2017[60]	Turkey	1729	7–14	9.43 ± 2.06	No	187	66	455	9
Abdianwall 2020[61]	Afghanistan	951	11–15	-	No	27	13	5	9
Khandekar et al. 2016[62]	Oman	286	Grade 7	-	yes	27	3	13	8
Anuradha 2015[63]	Oman	12 448	5–15	-	No	354	7	-	8
Mohamed et al.[64]	Sudan	551	5–15	12.46 ± 1.97	No	28	6	18	9
All	-	103 053	-	9.69 ± 1.75	-	8.28%	7.12%	12.6%	-

NA, not applicable; s.d., standard deviation.

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

Results

Study characteristics

Figure 1 shows 18 250 studies selected by the authors. After removing duplicates, they analysed 9240 study titles. A total of 9122 studies were removed because they did not meet the inclusion criteria. Another 83 studies were excluded because their data were inaccessible. Therefore, this meta-analysis comprised of 38 studies from 12 countries from 2008 to 2023 (Table 1). The articles sampled 103 053 children aged 5–17 years with their mean (± s.d.) age of 9.65 ± 1.8 years from 38 studies.

Prevalence of refractive error among Middle East schoolchildren (2008–2023)

The meta-analysis to estimate the prevalence of RE among Middle Eastern schoolchildren between 5 and 17 years of age was conducted as shown in Table 2. The pooled prevalence of myopia was 5.74% (95% CI: 5.59–5.89, $p < 0.001$), and about 42.85% of reviewed articles ($n = 15$) showed a considerably greater prevalence of myopia, while 57.15% ($n = 20$) reported a lower prevalence. The study conducted by Farida et al.[44] found that Egyptian children had the highest prevalence of myopia (55.35%, 95% CI: 52.57–58.10), whereas Fotouhi et al.[58] reported that Iranian children had the lowest prevalence of myopia (0.4% 95% CI: 0.22–0.67). The pooled prevalence of myopia in this review was comparable to Ghalib et al.[28] among Sudanese children (6.00%, 95% CI: 3.882–8.796).

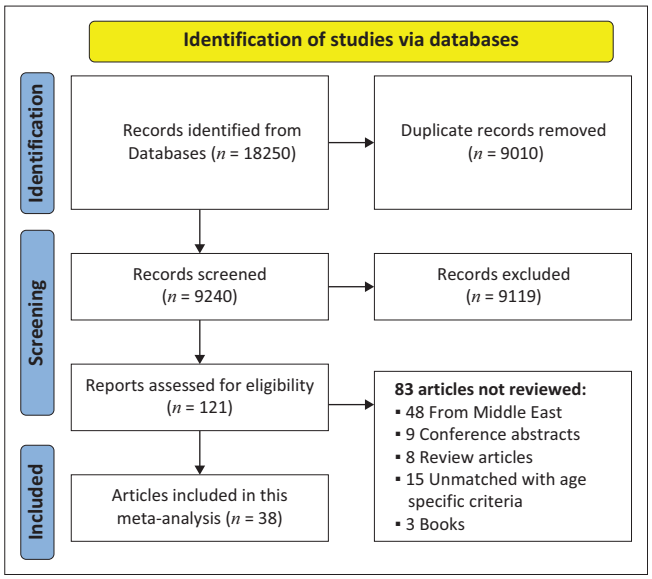

FIGURE 1: PRISMA 2020 flow diagram model for systematic reviews used in the prevalence of RE in the Middle East.

Approximately 42.85% of the reviewed articles (n = 15) reported a significantly higher estimation of hyperopia while 57.15% (n = 20) reported a lower prevalence compared with the pooled prevalence across the Middle East as shown in Table 2. The estimated overall pooled prevalence of hyperopia was (5.35%, 95% CI: 5.20–5.50, p 0.001). In a cross-sectional study, Mahjoob et al.[25] observed that the prevalence of hyperopia was highest among Iranian schoolchildren (58.13%; 95% CI: 52.51–63.59) and lowest among Omani children (0.07%; 95% confidence interval: 0.05–0.09).[62] The pooled prevalence of hyperopia in this review was comparable to that reported by Ghalib et al.[28] for Sudanese children (6.00%, 95% CI: 3.88–8.80) and Abdelrheem et al.[43] for Egyptian children (5.19% 95% CI: 4.84–5.56).

The total pooled prevalence of astigmatism was 13.16% (95% CI: 12.94–13.38, p < 0.001). Approximately 35.29% of the reviewed articles (n = 12) appeared to have a significantly higher prevalence of astigmatism while 64.71% (n = 22) reported a lower estimation in comparison to the total pooled prevalence across the Middle East as shown in Table 2. In contrast to Farida et al.,[44] who found that Egyptian schoolchildren had the highest astigmatism prevalence (50.94%; 95% CI: 48.16–53.73), Abdianwall,[61] found that Afghan schoolchildren had the lowest estimated astigmatism prevalence (0.53%; 95% CI: 0.17–1.22).

The prevalence of refractive error according to gender among Middle East schoolchildren (2008–2023)

Table 3 illustrates the prevalence of RE according to gender. Between male and female students, there were significant differences in the pooled prevalence of myopia, hyperopia and astigmatism (p < 0.001). In comparison to male students (6.09%, 95% CI: 5.83–6.37), females had a greater total pooled prevalence of myopia (7.25, 95% CI: 6.94–7.56). The presence of hyperopia was somewhat greater in females (5.54%, 95% CI: 5.27–5.82) than in males (5.07%, 95% CI: 4.82–5.32), and the prevalence of astigmatism was higher in females (15.50%, 95% CI: 15.07–15.94) than in males (11.83–12.57). T test showed no significant difference between genders considering the types of REs (myopia p = 0.941, hyperopia p = 0.896 and astigmatism p = 0.484).

Prevalence of refractive error depending on refraction technique among Middle East schoolchildren

Table 4 presents the pooled prevalence of RE among Middle East children. The results showed that studies that used cycloplegic refraction reported a higher prevalence of myopia (6.33%, 95% CI: 6.15–6.51), hyperopia (6.36%, 95% CI: 6.18–6.55) and astigmatism (14.39%, 95% CI: 14.16–14.66) among school-aged children, compared with studies that used non-cycloplegic refraction – myopia (4.07%, 95% CI: 3.81–4.34), hyperopia (2.73%, 95% CI: 2.51–2.95) and astigmatism (9.64%, 95% CI: 9.26–10.04). Meta-analysis reports a significant heterogeneity between both groups of articles that used cycloplegic and non-cycloplegic refraction (p < 0.001).

Discussion

This meta-analysis estimated the prevalence of childhood RE in the MER, considering uncorrected RE measurement approaches and gender. The standards used in this study to describe myopia, hyperopia and astigmatism are spherical equivalent (-0.5 D SPH), +1.50 D SPH, and 0.5 Cylinder, respectively. The meta-analysis revealed that myopia (5.74%), hyperopia (5.35%) and astigmatism (13.16%) were the three most common types of RE among school age children. This examination revealed substantial heterogeneity among the published studies as well as significant variances within and between Middle Eastern nations (p < 0.0001). Astigmatism is more common maybe because of a combination of genetic and environmental elements and the effect of sample size.

Children in Egypt were found to have the highest myopia estimates,[44] whereas Iranians had a much lower prevalence of myopia.[58] This study's pooled prevalence of myopia was comparable to that of Sudanese children.[28] The prevalence of hyperopia is lowest among Omani children[62] and highest among Iranians.[25] A comparable prevalence finding was observed in school-age Sudanese[28] and Egyptian students.[44] The Egyptian children had the highest prevalence of astigmatism,[44] while Afghani children showed the lowest prevalence.[61]

While Iran showed variation in the prevalence of myopia within the country (6.25%,[25] 14.87%,[40] 2.66%,[41] and 3.04%[42]), Saudi Arabia showed variation in its hypermetropia prevalence (8.06%,[31] 1.53%,[32] 6.0%,[33] 17.63%[34]). The highest prevalence of myopia (55.35%)[44] and astigmatism (50.94%)[44] was reported from Egypt, and the same for hypermetropia was from Iran (58.3%).[25] This study found significant regional

TABLE 2: The meta-analysis prevalence of childhood refractive errors in Middle East Region (2008–2023).

Authors and year of study	Country	Sample size	Myopia		Hyperopia		Astigmatism		Weight (%)
			Prevalence (%)	95% CI	Prevalence (%)	95% CI	Prevalence (%)	95% CI	
Ghalib et al. 2020[28]	Sudan	400	6.00	3.882–8.796	5.50	3.479–8.209	12.25	9.202–15.870	0.45
Mohamed et al. 2017[29]	Sudan	822	1.70	0.934–2.841	0.61	0.198–1.414	2.31	1.397–3.586	0.92
Alrasheed et al. 2016[30]	Sudan	1678	6.79	5.636–8.105	1.85	1.259–2.612	2.50	1.810–3.368	1.87
Alsaqr et al. 2017[31]	Saudi Arabia	338	4.18	2.303–6.912	8.06	5.378–11.510	20.00	15.849–24.69	0.37
Alrahili et al. 2017[32]	Saudi Arabia	1893	0.69	0.366–1.171	1.53	1.028–2.193	25.30	23.358–27.326	2.11
Alomair et al. 2020[33]	Saudi Arabia	850	14.12	11.846–16.642	6.00	4.500–7.814	8.47	6.687–10.549	0.95
AlThomali et al. 2022[34]	Saudi Arabia	7356	33.21	32.135–34.301	17.63	16.767–18.522	50.14	48.987–51.285	6.19
Abbas et al. 2019[35]	Pakistan	2491	3.97	3.242–4.818	0.84	0.523–1.286	4.62	3.826–5.516	2.77
Hameed 2016[36]	Pakistan	1644	3.29	2.477–4.264	1.28	0.792–1.946	3.65	2.796–4.673	1.83
Latif et al. 2014[37]	Pakistan	533	12.38	9.708–15.483	2.81	1.583–4.599	4.88	3.211–7.066	0.59
Ullah et al. 2020[38]	Pakistan	2288	2.23	1.664–2.920	2.05	1.513–2.722	1.09	0.708–1.609	2.55
Atta 2015[39]	Pakistan	300	21.67	17.138–26.764	11.67	8.262–15.851	8.00	5.193–11.670	0.34
Mahjoob et al. 2016[25]	Iran	320	6.25	3.859–9.488	58.13	52.509–63.589	3.44	1.728–6.067	0.36
Norouzirad et al. 2015[40]	Iran	1130	14.87	12.842–17.077	12.92	11.019–15.017	44.96	42.027–47.910	1.26
Hashemi et al. 2017[41]	Iran	602	2.66	1.527–4.280	3.99	2.571–5.874	-	-	0.67
Hashemi et al. 2016[42]	Iran	4106	3.04	2.540–3.617	6.21	5.491–6.992	17.44	16.289–18.634	2.57
Abdelrheem et al. 2021[43]	Egypt	14 787	2.88	2.617–3.163	5.19	4.835–5.557	10.30	9.814–10.801	13.15
Farida et al. 2018[44]	Egypt	1272	55.35	52.565–58.102	11.32	9.631–13.191	50.94	48.157–53.725	1.42
Elsabagh et al. 2020[45]	Egypt	1075	3.91	2.830–5.245	3.16	2.200–4.392	15.07	12.983–17.350	1.20
Kandi et al. 2021[46]	UAE	733	5.18	3.694–7.047	2.18	1.253–3.521	6.82	5.105–8.894	0.82
Hussam et al. 2018[47]	Iraq	735	19.59	16.781–22.649	20.14	17.293–23.221	7.21	5.448–9.326	0.82
Hussein et al. 2008[48]	Jordan	1647	15.54	13.826–17.385	2.85	2.104–3.777	5.16	4.143–6.342	1.84
Alghamdi 2020[49]	Saudi Arabia	417	7.67	5.308–10.661	9.11	6.529–12.293	3.12	1.670–5.272	0.47
Al-Rowaily et al. 2010[50]	Saudi Arabia	1319	2.50	1.728–3.496	2.05	1.353–2.964	2.50	1.728–3.496	1.47
Yamamah et al. 2015[51]	Egypt	2070	3.09	2.389–3.931	3.62	2.860–4.521	15.36	13.835–16.989	2.31
Aldebasi 2014[52]	Saudi Arabia	5176	5.80	5.175–6.468	0.68	0.471–0.939	4.41	3.862–5.000	5.0
Rajavi et al. 2014[53]	Iran	2417	4.88	4.057–5.818	3.52	2.819–4.330	22.59	20.936–24.310	2.69
Elmajri 2017[54]	Libya	920	1.74	0.997–2.809	6.20	4.726–7.953	3.70	2.573–5.126	1.03
Al Wadaani et al. 2012[55]	Saudi Arabia	2002	8.99	7.774–10.330	1.35	0.891–1.956	1.65	1.137–2.307	2.23
Gilal et al. 2022[56]	Pakistan	400	3.75	2.114–6.110	1.75	0.706–3.572	1.25	0.407–2.893	0.45
Jamali et al. 2009[57]	Iran	827	1.69	0.929–2.824	20.56	17.850–23.474	19.59	16.936–22.461	0.92
Fotouhi et al. 2011[58]	Iran	3481	0.40	0.220–0.674	10.11	9.130–11.162	6.61	5.804–7.484	3.88
Caca et al. 2013[59]	Turkey	21 062	3.20	2.966–3.447	5.90	5.587–6.228	14.30	13.830–14.781	21.45
Aydoğan et al. 2017[60]	Turkey	1729	10.76	9.336–12.314	3.82	2.964–4.831	26.32	24.253–28.459	1.93
Abdianwall 2020[61]	Afghanistan	951	2.84	1.879–4.104	1.37	0.730–2.326	0.53	0.171–1.223	1.06
Khandekar et al. 2016[62]	Oman	286	9.40	7.90–11.20	1.09	0.90–2.72	4.54	3.53–6.01	0.32
Anuradha 2015[63]	Oman	12 448	2.84	1.879–4.104	0.07	0.05–0.09	NA	NA	7.76
Mohamed et. al[64]	Sudan	551	5.08	4.01–6.8	1.09	1.01–2.50	3.27	2.301–4.71	0.50
Total	-	**103 053**	**5.74**	**5.589–5.894**	**5.35**	**5.204–5.500**	**13.16**	**12.937–13.382**	**100.00**

Note: p (Heterogeneity between groups) < 0.0001; I^2, Myopia 99.59%; Hyperopia 99.09%; Astigmatism 99.71%.
NA, not applicable.

TABLE 3: Childhood refractive errors prevalence by gender in Middle East Region (2008–2023).

Authors and year of study	Country	Sample size	Myopia		Hyperopia		Astigmatism		Weight (%)
			Prevalence (%)	95% CI	Prevalence (%)	95% CI	Prevalence (%)	95% CI	
Male									
Ghalib et al. 2020[28]	Sudan	284	3.52	1.701–6.380	3.52	1.701–6.380	5.99	3.525–9.411	0.93
Mohamed et al. 2017[29]	Sudan	822	1.70	0.934–2.841	0.61	0.198–1.414	2.31	1.397–3.586	2.70
Alrasheed et al. 2016[30]	Sudan	827	6.89	5.262–8.838	1.81	1.019–2.974	1.94	1.110–3.123	2.72
Alsaqr et al. 2017[31]	Saudi Arabia	162	2.78	0.908–6.363	6.67	3.492–11.356	NA	NA	0.59
Alrahili et al. 2017[32]	Saudi Arabia	947	0.53	0.172–1.228	2.32	1.461–3.496	25.13	22.397–28.022	3.11
AlThomali et al. 2022[34]	Saudi Arabia	3674	31.30	29.803–32.829	17.23	16.021–18.490	47.69	46.060–49.316	12.05
Abbas et al. 2019[35]	Pakistan	1250	3.76	2.776–4.969	0.96	0.497–1.671	4.00	2.983–5.240	4.10
Hameed 2016[36]	Pakistan	951	2.73	1.794–3.980	1.68	0.965–2.718	3.47	2.400–4.839	3.12
Ullah et al. 2020[38]	Pakistan	1746	1.83	1.257–2.578	2.18	1.545–2.975	0.92	0.525–1.484	5.73
Mahjoob et al. 2016[25]	Iran	160	8.75	4.866–14.245	63.75	55.788–71.192	5.00	2.183–9.614	0.53
Hashemi et al. 2017[41]	Iran	294	35.37	29.911–41.136	22.45	17.809–27.654	NA	NA	0.97
Hashemi et al. 2016[42]	Iran	2127	3.06	2.366–3.879	5.08	4.184–6.098	15.47	13.956–17.075	6.98
Abdelrheem et al. 2021[43]	Egypt	7450	3.03	2.656–3.449	4.85	4.369–5.358	9.96	9.289–10.662	24.44
Farida et al. 2018[44]	Egypt	460	56.52	51.853–61.106	7.83	5.541–10.670	45.22	40.604–49.893	1.51
Kandi et al. 2021[46]	UAE	411	6.08	3.975–8.849	2.92	1.518–5.045	9.25	6.626–12.469	1.35
Hussam et al. 2018[47]	Iraq	486	14.20	11.217–17.621	16.26	13.086–19.842	5.97	4.032–8.458	1.60
Alghamdi 2020[49]	Saudi Arabia	417	7.67	5.308–10.661	9.11	6.529–12.293	3.12	1.670–5.272	1.37
Aldebasi 2014[52]	Saudi Arabia	2573	4.70	3.917–5.593	0.78	0.475–1.198	10.07	8.930–11.294	8.44
Rajavi et al. 2014[53]	Iran	1238	4.52	3.435–5.834	3.88	2.872–5.108	25.20	22.804–27.718	4.06
Al Wadaani et al. 2012[55]	Saudi Arabia	966	7.25	5.692–9.067	1.45	0.795–2.420	1.35	0.718–2.290	3.17
Gilal et al. 2022[56]	Pakistan	203	0.49	0.0125–2.714	1.97	0.539–4.968	0.49	0.0125–2.714	0.67
Fotouhi et al. 2011[58]	Iran	1598	0.38	0.138–0.815	12.58	10.991–14.304	7.07	5.863–8.440	5.24
Aydoğan et al. 2017[60]	Turkey	827	9.92	7.964–12.158	4.60	3.272–6.253	27.57	24.548–30.752	2.72
Abdianwall 2020[61]	Afghanistan	574	2.27	1.211–3.842	0.70	0.190–1.775	0.17	0.00441–0.967	1.89
Total		30 465	6.09	5.827–6.367	5.07	4.822–5.318	12.20	11.828–12.572	100
Female									
Ghalib et al. 2020[28]	Sudan	116	12.07	6.758–19.420	10.35	5.461–17.373	27.59	19.695–36.657	0.43
Alrasheed et al. 2016[30]	Sudan	839	6.79	5.186–8.713	1.91	1.094–3.078	3.10	2.034–4.508	3.05
Alsaqr et al. 2017[31]	Saudi Arabia	176	5.81	2.689–10.736	9.68	5.518–15.459	NA	NA	0.57
Alrahili et al. 2017[32]	Saudi Arabia	946	0.85	0.366–1.659	0.74	0.298–1.519	25.48	22.726–28.379	3.44
AlThomali et al. 2022[34]	Saudi Arabia	3682	35.12	33.574–36.684	18.03	16.804–19.314	52.58	50.952–54.204	13.39
Abbas et al. 2019[35]	Pakistan	1241	4.19	3.145–5.459	0.73	0.332–1.372	5.24	4.065–6.628	4.52
Hameed 2016[36]	Pakistan	639	4.38	2.931–6.271	0.78	0.255–1.817	5.79	4.109–7.893	2.33
Ullah et al. 2020[38]	Pakistan	542	3.51	2.124–5.420	1.66	0.762–3.129	1.66	0.762–3.129	1.97
Mahjoob et al. 2016[25]	Iran	160	3.75	1.388–7.983	52.5	44.466–60.439	1.88	0.388–5.382	0.59
Hashemi et al. 2017[41]	Iran	308	20.78	16.386–25.744	25.97	21.167–31.250	-		1.12
Hashemi et al. 2016[42]	Iran	1979	3.03	2.321–3.886	7.43	6.311–8.673	19.56	17.829–21.373	7.20
Abdelrheem et al. 2021[43]	Egypt	7337	2.73	2.365–3.125	5.53	5.021–6.081	10.65	9.948–11.373	26.68
Farida et al. 2018[44]	Egypt	812	54.68	51.183–58.143	13.30	11.040–15.831	54.19	50.689–57.655	2.96

Table 3 continues on the next page→

TABLE 3 (Continues ...): Childhood refractive errors prevalence by gender in Middle East Region (2008–2023).

Authors and year of study	Country	Sample size	Myopia		Hyperopia		Astigmatism		Weight (%)
			Prevalence (%)	95% CI	Prevalence (%)	95% CI	Prevalence (%)	95% CI	
Kandi et al. 2021[46]	UAE	322	4.04	2.167–6.805	1.24	0.339–3.150	3.73	1.940–6.419	1.17
Hussam et al. 2018[47]	Iraq	249	30.12	24.489–36.233	27.71	22.246–33.715	9.64	6.274–14.002	0.91
Aldebasi 2014[52]	Saudi Arabia	2603	6.88	5.934–7.917	0.58	0.323–0.949	9.68	8.572–10.882	9.47
Rajavi et al. 2014[53]	Iran	1179	5.26	4.055–6.691	3.14	2.219–4.300	19.76	17.525–22.152	4.29
Al Wadaani et al. 2012[55]	Saudi Arabia	1036	0.97	0.464–1.768	1.26	0.670–2.136	1.93	1.183–2.966	3.77
Gilal et al. 2022[56]	Pakistan	177	7.91	4.392–12.915	1.70	0.351–4.873	2.26	0.619–5.685	0.65
Fotouhi et al. 2011[58]	Iran	1883	0.43	0.184–0.835	8.02	6.832–9.339	6.21	5.165–7.400	6.85
Aydoğan et al. 2017[60]	Turkey	902	11.53	9.519–13.796	3.10	2.072–4.455	25.17	22.364–28.132	3.28
Abdianwall 2020[61]	Afghanistan	377	3.71	2.045–6.152	2.39	1.097–4.483	1.06	0.290–2.694	1.37
Total		**27 484**	**7.25**	**6.942–7.559**	**5.54**	**5.271–5.815**	**15.50**	**15.069–15.935**	**100**

Note: $p < 0.0001$; I^2 (male), Myopia 99.33%; Hyperopia 98.70%; Astigmatism 99.56%; I2 (female), Myopia 99.49%; Hyperopia 98.84%; Astigmatism 99.60%.
NA, not applicable.

variations in the prevalence of REs, which is consistent with other studies.[44,65] Such differences are reported even within the same geographic area. The possible reasons for those differences might be because of the different benchmarks used for describing REs or genetic factors, or differences in the technique utilised to estimate the RE (cycloplegic or non-cycloplegic). This study investigated the pooled prevalence of all REs for studies that used cycloplegic and non-cycloplegic refraction independently.

The overall pooled prevalence of myopia among children in the Middle East is higher than that reported from Africa,[66] but lower than the figures globally, including estimations in Indian and Chinese children.[14,67,68] This might be because of the reduction of outdoor activities, and screen-related visual stress. The pooled prevalence data of hypermetropia was higher than the global finding[14,69] and slightly lower than the children from Eastern Mediterranean region.[65]

This prevalence of hyperopia in Middle Eastern children compared with the other regions may be because of the difference in the genetic tendency to hyperopia development and that most of studies used non-cycloplegic refraction that could lead to reduce the prevalence of hyperopia.

The pooled prevalence of astigmatism was higher than the estimates from Indian schoolchildren,[12] and lower than global and Chinese prevalence.[12,14] This variation could be because of differences in geographic, socioeconomic and ethnic factors. The Middle East is a geographic region that includes countries in Asia and Africa. Most of the observations in this study were from Middle Eastern Asian nations, which may indicate the results' heterogeneity and slight variations in the prevalence of myopia, hyperopia and astigmatism in children.

The prevalence of all RE in schoolchildren was not significantly different between females and males ($p > 0.05$). Most of the studies reviewed in this analysis showed no statistically significant difference between gender and REs, which agrees with previous studies conducted in Middle East and Africa.[65,66] However, a significant gender difference was reported from India in myopic and astigmatic REs.[9]

This analysis showed that the studies that used cycloplegic refraction technique reported a significantly higher prevalence of childhood myopia, hyperopia and astigmatism compared with non-cycloplegic refraction studies, which is inconsistent with Manny et al.,[69] Alrasheed et al.[65] and Castagno et al.,[70] which showed that cycloplegic refraction is the acceptable technique to diagnose REs accurately. The increase in myopia prevalence among cycloplegic studies might be because of the variations in sample sizes and RE estimation accuracy in some studies.

This systematic review and meta-analysis had some limitations, including the inherent variations within the studies considered for this review, such as sample sizes,

TABLE 4: The prevalence of refractive errors by refraction technique among Middle East schoolchildren.

Authors and year of study	Country	Myopia		Hyperopia		Astigmatism		Weight (%)
		Prevalence (%)	95% CI	Prevalence (%)	95% CI	Prevalence (%)	95% CI	
Cycloplegic refraction technique								
Ghalib et al. 2020[28]	Sudan	6.00	3.882–8.796	5.50	3.479–8.209	12.25	9.202–15.870	0.59
Alrasheed et al. 2016[30]	Sudan	6.79	5.636–8.105	1.85	1.259–2.612	2.50	1.810–3.368	2.47
Alsaqr et al. 2017[31]	Saudia Arabia	4.18	2.303–6.912	8.06	5.378–11.510	20.00	15.849–24.690	0.49
Alomair et al. 2020[33]	Saudia Arabia	14.12	11.846–16.642	6.00	4.500–7.814	8.47	6.687–10.549	1.25
Althomali et al. 2022[34]	Saudia Arabia	33.21	32.135–34.301	17.63	16.767–18.522	50.14	48.987–51.285	10.81
Latif et al. 2014[37]	Pakistan	12.38	9.708–15.483	2.81	1.583–4.599	4.88	3.211–7.066	0.78
Atta 2015[39]	Pakistan	21.67	17.138–26.764	11.67	8.262–15.851	8.00	5.193–11.670	0.44
Mahjoob et al. 2015[25]	Iran	6.25	3.859–9.488	58.13	52.509–63.589	3.44	1.728–6.067	0.47
Norouzirad et al. 2015[40]	Iran	14.87	12.842–17.077	12.92	11.019–15.017	44.96	42.027–47.910	1.66
Hashemi et al. 2017[41]	Iran	2.66	1.527–4.280	3.99	2.571–5.874	-	-	0.89
Abdelrheem et al. 2021[43]	Egypt	2.88	2.617–3.163	5.19	4.835–5.557	10.30	9.814–10.801	21.73
Farida et al. 2018[44]	Egypt	55.35	52.565–58.102	11.32	9.631–13.191	50.94	48.157–53.725	1.87
Elsabagh et al. 2020[45]	Egypt	3.91	2.830–5.245	3.16	2.200–4.392	15.07	12.983–17.350	1.58
Kandi et al. 2021[46]	UAE	5.18	3.694–7.047	2.18	1.253–3.521	6.82	5.105–8.894	1.08
Hussam et al. 2018[47]	Iraq	19.59	16.781–22.649	20.14	17.293–23.221	7.21	5.448–9.326	1.08
Yamamah et al. 2015[51]	Egypt	3.09	2.389–3.931	3.62	2.860–4.521	15.36	13.835–16.989	3.04
Aldebasi 2014[52]	Saudia Arabia	5.8	5.175–6.468	0.68	0.471–0.939	4.41	3.862–5.000	7.61
Elmajri 2017[54]	Libya	1.74	0.997–2.809	6.20	4.726–7.953	3.70	2.573–5.126	1.35
Al Wadaani et al. 2012[55]	Saudia Arabia	8.99	7.774–10.330	1.35	0.891–1.956	1.65	1.137–2.307	2.94
Gilal et al. 2022[56]	Pakistan	3.75	2.114–6.110	1.75	0.706–3.572	1.25	0.407–2.893	0.59
Jamali et al. 2009[57]	Iran	1.69	0.929–2.824	20.56	17.850–23.474	19.59	16.936–22.461	1.22
Fotouhi et al. 2011[58]	Iran	0.40	0.220–0.674	10.11	9.130–11.162	6.61	5.804–7.484	5.12
Caca et al. 2013[59]	Turkey	3.20	2.966–3.447	5.90	5.587–6.228	14.30	13.830–14.781	30.94
Total		6.33	6.147–6.514	6.36	6.181–6.550	14.39	14.125–14.656	100.00
Non-Cycloplegic Refraction Technique								
Mohamed et al. 2017[29]	Sudan	1.70	0.934–2.841	0.61	0.198–1.414	2.31	1.397–3.586	3.79
Alrahili et al. 2011[32]	Saudi Arabia	0.69	0.366–1.171	1.53	1.028–2.193	25.30	23.358–27.326	8.71
Abbas et al. 2019[35]	Pakistan	3.97	3.242–4.818	0.84	0.523–1.286	4.62	3.826–5.516	11.46
Hameed 2016[36]	Pakistan	3.29	2.477–4.264	1.28	0.792–1.946	3.65	2.796–4.673	7.57
Ullah et al. 2020[38]	Pakistan	2.23	1.664–2.920	2.05	1.513–2.722	1.09	0.708–1.609	10.53
Hashemi et al. 2016[42]	Iran	3.04	2.540–3.617	6.21	5.491–6.992	17.44	16.289–18.634	18.89
Hussein et al. 2008[48]	Jordan	15.54	13.826–17.385	2.85	2.104–3.777	5.16	4.143–6.342	7.58
Alghamdi 2020[49]	Saudi Arabia	7.67	5.308–10.661	9.11	6.529–12.293	3.12	1.670–5.272	1.92
Al-Rowaily et al. 2010[50]	Saudi Arabia	2.50	1.728–3.496	2.05	1.353–2.964	2.50	1.728–3.496	6.07
Rajavi et al. 2014[53]	Iran	4.88	4.057–5.818	3.52	2.819–4.330	22.59	20.936–24.310	11.12
Aydoğan et al. 2017[60]	Turkey	10.76	9.336–12.314	3.82	2.964–4.831	26.32	24.253–28.459	7.96
Abdianwall 2020[61]	Afghanistan	2.84	1.879–4.104	1.37	0.730–2.326	0.53	0.171–1.223	4.38
Total		**4.07**	**3.814–4.344**	**2.73**	**2.512–2.950**	**9.64**	**9.255–10.044**	**100.00**

Note: Cycloplegic Refraction Technique - $p < 0.0001$; I^2, Myopia 99.71%; Hyperopia 99.25%; Astigmatism 99.75%; Non-Cycloplegic Refraction Technique - $p < 0.0001$; I^2, Myopia 98.11%; Hyperopia 96.20%; Astigmatism 99.53%.

which could cause the prevalence of REs to be overestimated or underestimated, and some studies used cycloplegic refraction and others didn't. Additionally, some studies limited themselves to the term schoolchildren instead of mentioning the average age. Because of categorisation issues or differences in age groups, some research was eliminated from this review, causing a reduction in the number of studies that were included. Additionally, the multitude of variables influencing the prevalence of RE were not examined in this study.

Conclusion

This meta-analysis reveals that the most common RE in the Middle Eastern schoolchildren between 5 and 17 years of age was astigmatism followed by myopia and hyperopia. However, there was no significant difference between male and female in the pooled prevalence of REs. The results found that myopia, hyperopia and astigmatism estimations varied between cycloplegic and non-cycloplegic refractions. These findings, which generally concur with the global trend, call for deliberate action to tackle childhood REs.

Acknowledgements

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

The idea was created and written by Z.D.M. and S.H.A. Furthermore, Z.D.M. and S.H.A. were also involved in data gathering and data analysis. The theory and concept were developed by Z.D.M. and G.M.I. J.P.A. and B.N. conducted the data examination, and G.S.V. and B.N. verified the analytical techniques created by Z.D.M. and S.H.A. Z.D.M. was the work supervisor. Every author participated in the final article review and talked about the findings.

Funding information

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

The data that support the findings of this study are available upon request from the corresponding author, Z.D.M.

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