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A Systematic Review of Meta-Analysis for Refractive Errors

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Abstract

Refractive errors make for 43% of vision impairments worldwide, consequently being the most common eye disorders. With a focus on the public health consequences, this work attempts to conduct a comprehensive investigation and systematic review of the overall incidence of astigmatism, hyperopia, and myopia. A comprehensive search for original English-language research published between 2008 and 2024 was carried out using PubMed, Google Scholar, and Research Gate. Studies with human participants and published averages and standard deviations (SDs) of refractive errors were included in the inclusion criteria. Reviews, non-English publications, and case reports were not accepted. Of the 47 publications found, 26 satisfied the criteria, examining568,560 eyes. The Meta analysis revealed a high prevalence of refractive errors, particularly myopia, which is more common in children and younger populations. Astigmatism also emerged as a significant concern. While hyperopia decreases with age, myopia increases with inconsistent gender differences in prevalence. The findings highlight a troubling in refractive errors, especially myopia and astigmatism among children and adolescents. To mitigate their impact on visual health and quality of life, regular vision screenings, awareness campaigns and improved access to eye care services are crucial.

Key Words: Refractive errors, Myopia, Hyperopia, Astigmatism, Meta-analysis, Confidence Interval

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1 Introduction

Across all age categories, the most prevalent eye issue is refractive errors. Refractive errors are considered to be a health issue since, as per recent studies and statistics from the WHO, they account for 43 percent of all eye diseases and are the primary cause of blurred vision and sight loss globally. (1). This epidemiological change affects the majority of the main aetiology of vision impairment, such as cataracts and under corrected refractive errors, which have substantial personal and societal consequences (2). Due to the numerous ocular disorders linked to refractive errors, refractive errors continue to pose a serious issue as the primary cause of vision loss in nations with adequate access to eyecare (3). The continued rise in incidence figures for myopia in recent years throughout the world makes it a particularly concerning condition (4). People who have high prescription strengths are more susceptible to developing cataracts, primary open angle glaucoma, detachable retina and shortsighted retinal degeneration (5). Ocular health may also be impacted by other refractive problems. Hyperopia can affect angle closure, age-related macular degeneration, amblyopia, and strabismus (6,7). Research indicates that refractive errors are influenced by both environmental and human variables. Based on the information now available, taller individuals have a higher chance of developing myopia because of their longer axial length, longer vitreous chambers, and deeper anterior chambers. However heavy subjects have a greater sphere and shorter vitreous chambers, which increases their risk of hyperopia (8, 9, and 10). Although recent studies show an increase in the prevalence of myopia due to lifestyle changes, terminologies for errors in vision. (11). There is Changes in the error of refractive pattern probability among nations. The majority of earlier studies have consistently found that East Asian nations have a high frequency of myopia. On the other hand, there are various disagreements about hyperopia. Even though some research has indicated that hyperopia is highly prevalent in Europe and other western nations, it is challenging to draw any firm conclusions from this data because the majority of these studies used older participants, and lens changes are often the cause of the greater frequency of hyperopia (12). This research used a systematic examination and a meta-analysis to evaluate the worldwide incidence of refractive errors in myopia, hypermetropia, and astigmatism. After carefully reading the pertinent literature, we used the data we had acquired to run a met analysis.

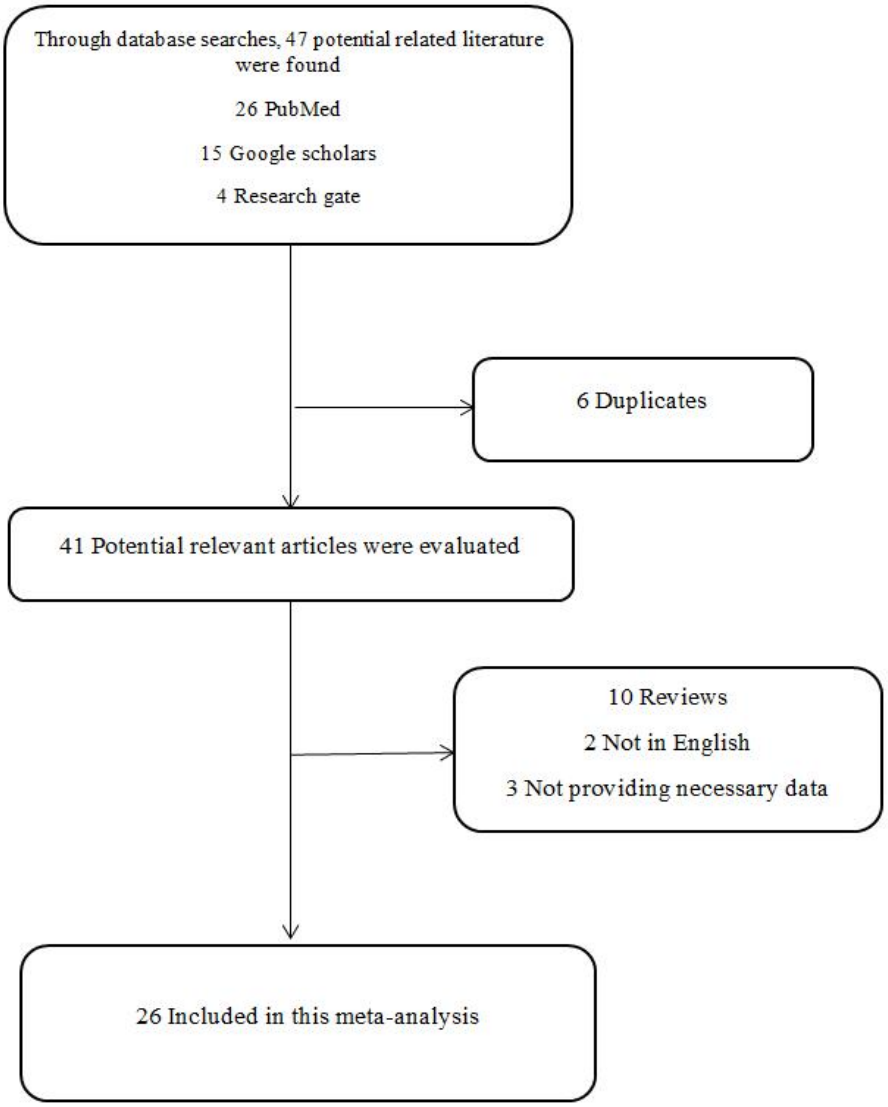

Figure 1: Schematic diagram of Search flow

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Table 1: Features of thirty research projects on Refractive errors in humans

S.NO	AUTHOR NAME	YEAR	STUDY TYPE	SAMPLE SIZE	MYOPIA		HYPERMETROPIA		ATIGMATISM	
					MEAN	SD	MEAN	SD	MEAN	SD
1	Cakmak, H. B.,	2010	Retrospective study	412	6.33	0.8	5.7	1.01	6	0.79
2	Santiago HC,	2023	Cross-sectional study	2867	45.5	21	6.84	2.79	23	8.19
3	Isabel Signes-Soler,	2017	Cross-sectional study	1466	-1.4	1.4	3.4	1.3	-3.4	1.7
4	Rai, S. K., et al	2012	Retrospective study	133	15.2	10	6.5	4.9	21	16.5
5	Salomão, S. R., et al	2008	Cross-sectional study	2441	66.5	19	25	4.2	51	1.41
6	Dirani, M., et al	2010	Pilot study	3009	25.1	12	17.2	6.01	18	11.09
7	Ferraz FH et al	2015	Population based cross sectional study	7654	1.93	2.4	1.61	1.27	1.1	0.92
8	Mehari ZA, et al	2013	Cross-sectional study	5,470	101	93	5.6	5.22	18	19.26
9	G O Ovenseri-Ogbomo.	2010	Cross-sectional study	604	5	2.8	15	1.41	20	9.19
10	Gauri Shankar Shrestha .	2011	Cross-sectional	2236	28.7	18	19.5	9.19	34	10.6
11	Shrestha, S.,	2010	Retrospective study	15,410	54	58	47.2	47	0.6	0.78
12	Pokharel, A.,	2010	Multi-stage randomization technique.	440	26	16	13.5	9.19	4	5.65
13	Adhikari, S.,	2013	Descriptive study	2000	36.8	38	11	1.41	30	23.33
14	Yoo, Y.,	2013	Cross sectional study	637	24.1	11	15.2	17.3	70	17.6
15	Eun Chul Kim	2013	Cross sectional study	23392	253	269	350	395	2517	2473
16	Pan, C. W, et al	2011	Cross sectional study	4497	54	16	574	12	141	21.2
17	Yuxia You	2022	Population-based cross-sectional study	43,105	204	222	989	1087	834	995.3
18	Fahd Al Wadaani	2012	Cross sectional study	2246	90	28	13.5	0.7	17	4.94
19	Yingyong P.	2010	Cross sectional study	2340	87.5	49	15.5	0.7	2.5	0.7
20	Mohammad A	2010	Cross sectional study	1319	11	12	9	12.2	20	18.38

21	Pi LH,	2010	Cross sectional study	3469	3.31	3.1	13.9	10.2	3.8	1.06
22	Wen-Jun Zhou et al	2016	Cross sectional study	3070	89	111	18.6	1.52	617	976.5
23	Farhad Rezvan, et al	2012	Cross sectional study	2020	4.1	0.7	5.25	1.2	11	0.9
24	Longwill, S., et al	2022	Retrospective cross sectional cohort study	153598	-2.43	2.1	1.82	1.44	1.4	0.895
25	Rajabpour, M., et al	2024	Cross-sectional study	200	-3.12	1.3	-3.5	1	-4	0.9
26	lili asma ismail, et al	2022	Cross-sectional study,	245	-1.78	2.5	1.13	1.88	-1	2.605

Methods

2.1 Search strategy

This study used the PubMed Google Scholar and Research Gate databases to find original papers from databases. Only full-text English-language publications were used in the research for this study. Explore Google Scholar to find relevant material that helped compile a list of relevant variables. The key information source for this study was articles published between 2008 and 2024. The research terminology utilized was as follows: Refractive errors, Astigmatism, Hypermetropia, and Myopia.

2.2 Literature selection criteria

Articles that met each of the following criteria for inclusion were listed: (1) Subjects with or without refractive errors were included. (2) Research using only on humans were taken (3) the reported means and standard deviations (SDs) or enough information regarding refractive problems and the frequency of hypermetropia, myopia,astigmatism were considered to calculate its mean and SDs; (4) Articles which issued in full text edition in English and has featured. Excluded from consideration were case reports, expert comments, letters, reviews, abstracts, editor's opinions, and articles involving animal research.

2.3 Data Extraction

Titles, abstracts, and keywords were used to refine the publications that were located in databases. An existing and consistent data extraction was carried out in order to methodically gather pertinent data from each study. This contained details regarding the study's design, sample compilation, year of publication, refractive errors, and the risk of developing of astigmatism, hypermetropia, and myopia among other related conditions. It also revealed whoever the first author was. After the pertinent articles were assessed, data extraction was done from the qualifying ones. After being gathered, the data had been retained in Microsoft Excel.

3. Results

3.1 Study selection

Figure 1 displays a flowchart with pertinent research articles categorized. 47 articles were found using Google Scholar and PubMed's electronic databases, according to the search strategy. Following the removal of duplicates (n = 6), reviewers went through the titles and abstracts and chose 41 papers. Of the 41 articles, 15 were disqualified due to the following reasons: Ten reviews; Three lacks the required information and two is not in English. Consequently, the eligibility of 30 complete papers was evaluated.

3.2 Study characteristics

A total of thirty publications were deemed suitable for inclusion in the meta-analysis. Twenty-six research papers examined 568560 human's eyes were examined.

3.3 Synthesis of results

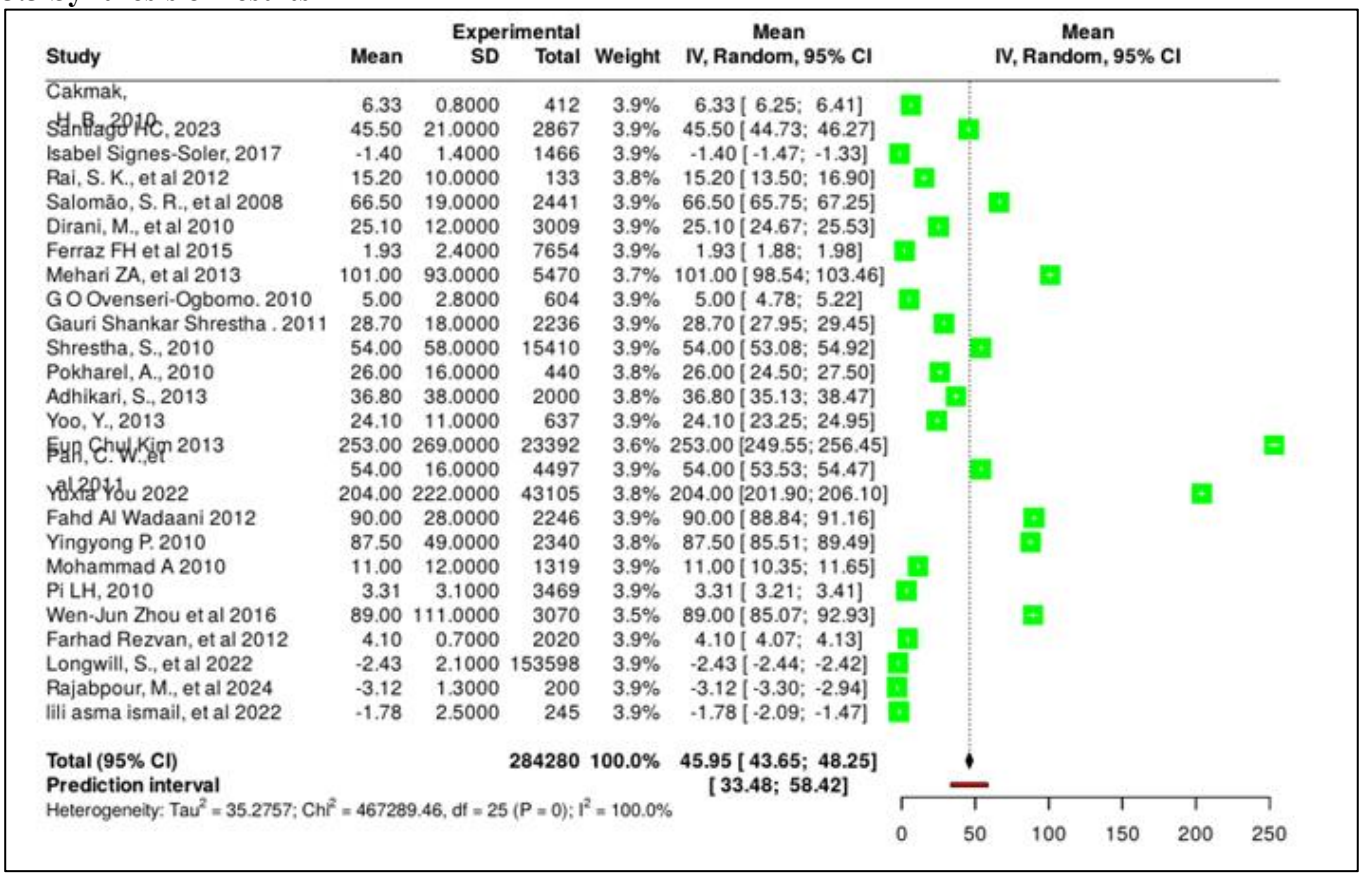

Figure 1: Forest plot of Myopia

The results of a meta-analysis of the mean values and confidence intervals (CIs) from several myopia studies are displayed visually in a forest plot. (Figure 1). A point estimate (mean) and a horizontal line showing the confidence interval are used to illustrate each study, giving information on the accuracy and variability of the estimates. The mean values range widely between investigations, with some studies suggesting positive mean values is based on the analysis performed using random effects model with inverse variance method, the summarized

raw means (MRAW) is 45.95 with a 95% confidence interval of 43.65 - 48.25. A significant heterogeneity was detected (p<0.01), suggesting inconsistent effects in magnitude and/or direction. The I2 value indicates that 100% of the variability among studies arises from heterogeneity rather than random chance.

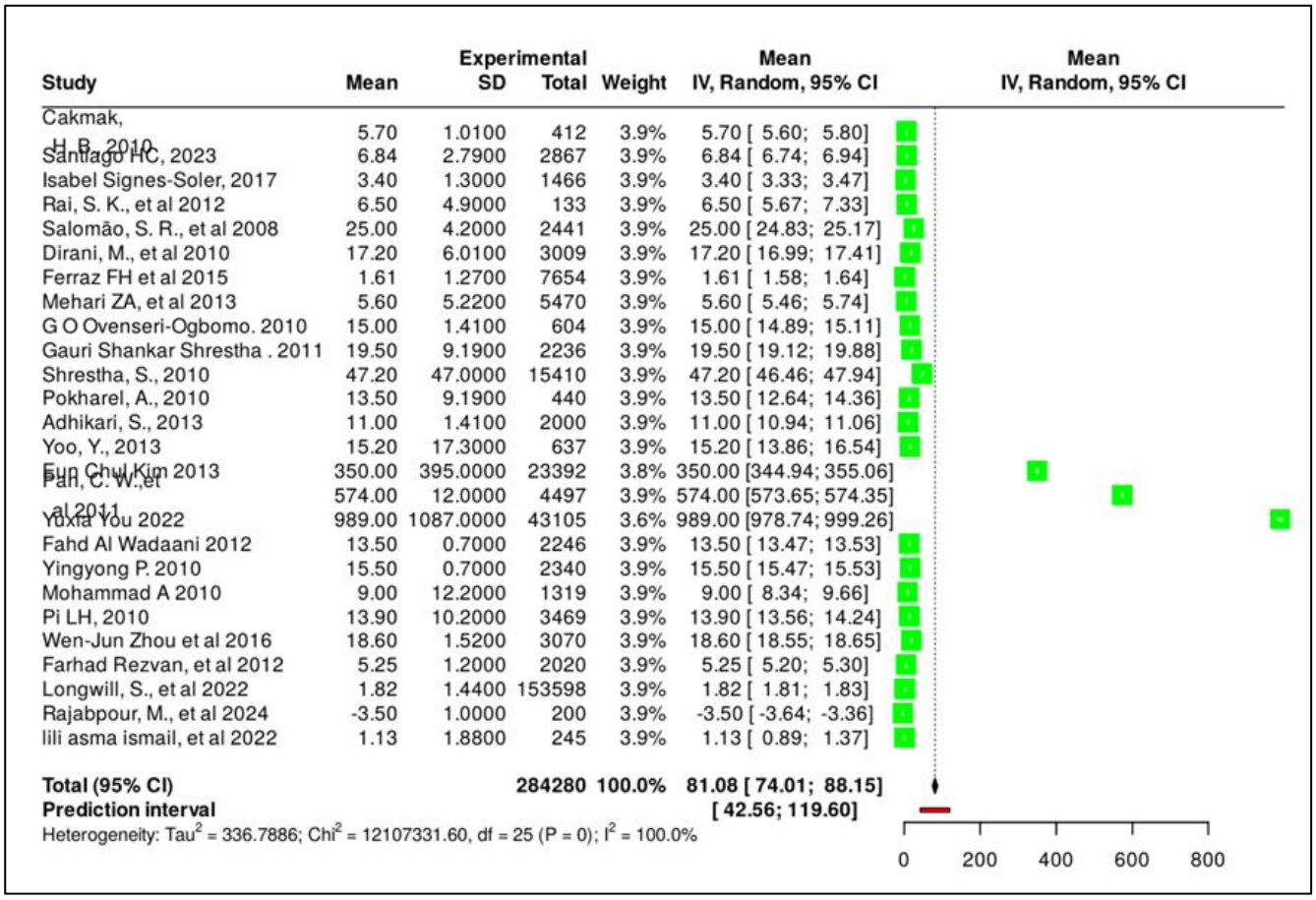

Figure 2: Forest plot of Hypermetropia

The results of a meta-analysis of several studies looking at the mean values and confidence intervals (CIs) associated with hypermetropia are displayed in a forest plot. A point estimate (mean) and a horizontal line (the confidence interval) are used to depict each study, making it possible to evaluate the accuracy and variability of the mean estimates. The mean values range widely between investigations, with some studies suggesting positive mean values is based on the analysis performed using random effects model with inverse variance method, the summarized raw means (MRAW) is 81.08 with a 95% confidence interval of 74.01 to 88.15. A significant heterogeneity was detected (p<0.01), suggesting inconsistent effects in magnitude and/or direction. The I2 value indicates that 100% of the variability among studies arises from heterogeneity rather than random chance. The large range of averages and the variety of confidence intervals show whether hypermetropia prevalence and measurement vary amongst various situations and demographics. This variation highlights the necessity for additional investigation to elucidate the variables impacting the results of hypermetropia. The forest plot, which displays the mean values and the associated confidence intervals across multiple studies, succinctly highlights the meta-analysis results for hypermetropia.

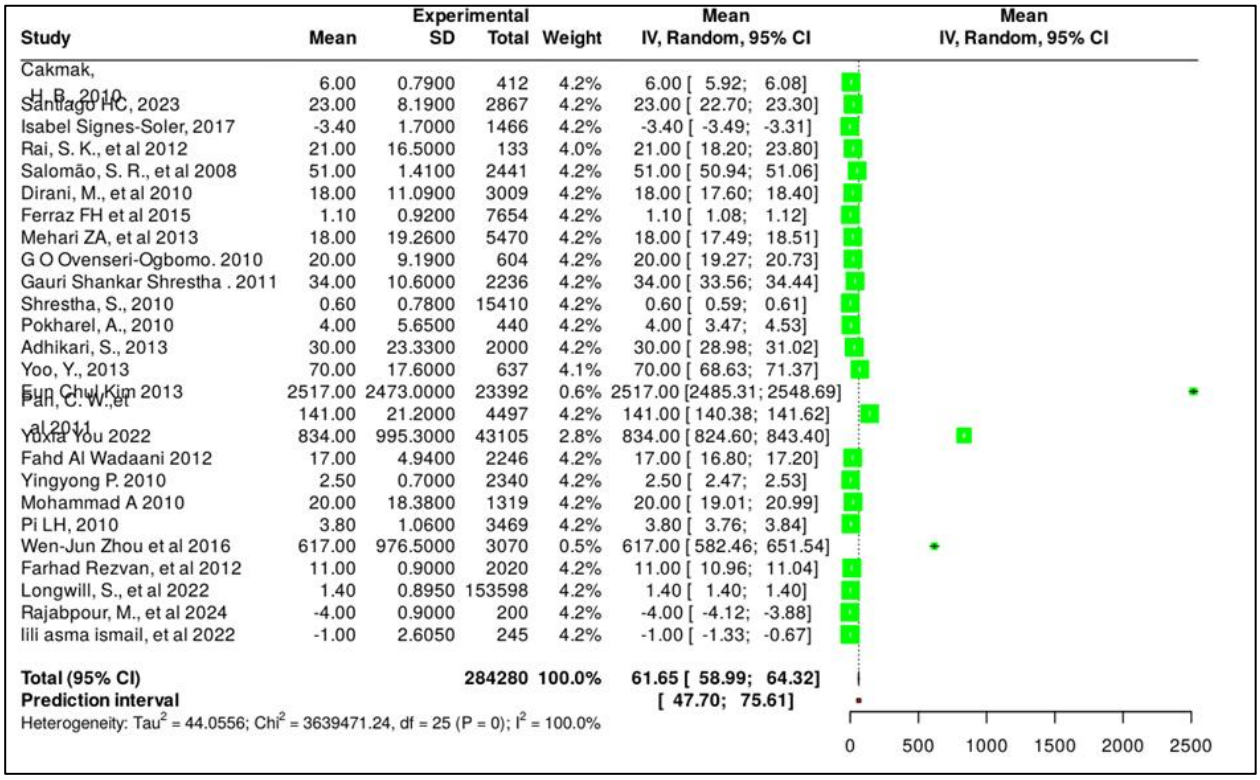

Figure 3: Forest plot of Astigmatism

The mean values and confidence intervals (CIs) pertaining to astigmatism from a meta-analysis of multiple studies are displayed in a forest plot. Based on the analysis performed using random effects model with inverse variance method, the summarized raw means (MRAW) is 61.65 with a 95% confidence interval of 58.99 - 64.32. A significant heterogeneity was detected ($p<0.01$), suggesting inconsistent effects in magnitude and/or direction. The I2 value indicates that 100% of the variability among studies arises from heterogeneity rather than random chance.

for example, are examples of extreme values that increase the likelihood of outliers affecting the analysis. These anomalies have the potential to distort the findings, thus more research is necessary to determine how they may affect the meta-analysis's overall conclusions. Variability and Implications: The range of confidence intervals and the variability in mean values show how different astigmatism prevalence and measurement methods are among different research. This heterogeneity highlights the need for more studies to investigate the variables influencing the results of astigmatism and enhance the uniformity of assessment techniques. To summarise, the forest plot provides a clear summary of the astigmatism meta-analysis results by presenting the mean values and the corresponding confidence intervals from several studies. The results show a considerable degree of diversity. This thorough analysis highlights the difficulty in measuring astigmatism and the need for more research to identify the variables influencing its prevalence.

4. Discussion

As we pointed out earlier, among eye conditions, refractive errors are most significantly prominent. in all age groups (1). The most important determinants of mesopic pupil size,

according to a retrospective study by Cakmak, H. B. (2010) (13), are age and the amount of visual impairments. Similarly, the study was done by Linke, S. J. (2012)(14), and their analysis proved the aforementioned age and state of refractivity are the key determinants of mesopic pupil size. According to Santiago, H. C. (2023) (15), Among youngsters of the same age worldwide, the distribution of myopia is among the highest., surpassing even astigmatism and hypermetropia. This study found that the prevalence rate was 20.7% . According to Signes-Soler, I. (2017) (16), In this remote area of Paraguay, myopia is more common than hyperopia, and refractive error is not as widespread. Based on a study done on children by Caca, I. (2013) (17), Myopia was linked to higher parental education, women, and older age. The inverse relationship between age and hyperopia was observed. For youngsters of school age, visual impairment is a prevalent disorder. The research investigation carried out by Rai S. (2012) (18) found that among children aged 5 to 15, The usuall type of refractive error is astigmatism, followed by myopia and hypermetropia. Many children with refractive defect never receive the necessary correction .The study, done by Salomão SR in 2008, found a marginally significant correlation between female sex and myopic vision error, but no association with ageing. Age, gender, or grade level did not correlate with hyperopic vision impairment (+2.00 D or more) (19). In the opinion of Dirani M. (2010), hyperopia is less common in young Singaporean Chinese children, although myopia and astigmatism are more common. For every category of refractive error, age effects were noted; however, gender. The disparities did not reach any statistical significance. Age-related variations in the prevalence of myopia may be caused by factors related to ocular development, testability, and/or environment. (20). However, Gomez-Salazar, F. (2017) finds that Myopia is a particularly common type of refractive error in the group under study, and males were more likely than women to have any clinically significant refractive error. (21). Ferraz FH (2015) carried out study involving 7654 participants and found that astigmatism was more common than hyperopia and myopia. Additionally, it was discovered that astigmatism increased gradually with aging (22). Nevertheless, Mehari ZA (2013) found that myopia accounts for 6.0% of all refractive errors, with compound mixed astigmatism coming in second at 0.26 percent and hyperopia at 0.33 percent (23). The study was centered in schools was carried out by G O Ovenseri-Ogbomo (2010), and the results showed because a refractive error that cannot be corrected frequently causes children in the community to have vision impairments (24). The cross-sectional study by Gauri Shankar Shrestha (2011) demonstrates that the refractive error of children in Jhapa was a severe issue. The most prevalent refractive error has become myopia. (25). The study, conducted by Shrestha, S. (2010), revealed that myopia was the common refractive defect, followed by hypermetropia. It also found that the hyperopic shift in young adults' refractive errors should be taken into consideration when planning refractive surgery for younger myopic patients (26). In 2010, Pokharel, A., concluded his research on the risk of developing in kids of children. The most common refractive impairment in the students was myopia, closely followed by hypermetropia and astigmatism. (27). In comparison to other conditions, myopia was shown to be more prevalent in the study by Adhikari S. (2013), which was a descriptive study carried out in schools (28). The study 2013 by Yoo, Y., Adult Koreans living in rural areas had a comparable frequency of myopia and hyperopia as adult Chinese living in rural areas. In comparison to other East Asian groups, the Korean sample had a reduced prevalence of extreme myopia, with astigmatism being the most common refractive defect (29). In accordance with a study done in 2013 by Eun Chul Kim, astigmatism and hyperopia are the most common conditions after myopia (30). According to research done in 2011 by Pan, C. W., et al., finds that Myopia is the most common refractive defect among Singapore's Indian community. Younger age, greater educational achievement, and an increase in near-work activities are important risk variables linked to refractive errors (31). Similarly,

According to research done in 2013 by Pan, C. W., Conversely with older adults, who have lower rates of myopia, younger generations have a greater incidence of the condition. The average axial length and astigmatism have increased significantly in the Chinese population during the past 12 years. According to Yuxia You et al.'s study from 2022, They investigated the risk of developing of astigmatism, hyperopia, and myopia in preschoolers between the ages of one and six in their population. In the younger group, the refractive error distribution was more distributed, but in the older group, it gradually became more centralized. Like hyperopia, the prevalence of myopia decreased with age in preschoolers under the age of five and then somewhat increased in those five to six years old. This may be a warning indication of myopia in school-age children. They suggest that youngsters at this age should receive extra attention as a result (33). According to a study done by Al Wadaani, F. A., et al. (2012) (34). A significant proportion of elementary school students in Al Hassa, Saudi Arabia, have uncorrected refractive defects. The students in primary school, particularly the older, female, and rural ones, are considered to be at a higher risk of refractive errors, a condition for which the included youngsters were not aware. The study, done by Yingyong P. (2010), found that Bangkok and the central region of Thailand have relatively high rates of uncorrected refractive error (35). On the flip side, the study conducted by Mohammad A. Al-Rowaily, MD (2010) (36) reveals that although in this population is generally low and does not significantly differ between boys and girls, certain conditions such as astigmatism and myopia are the most prevalent. These results emphasize the necessity of routine pediatric eye exams in order to guarantee the early identification and treatment of refractive problems, which can affect quality of life and visual development. Pi, L. H. (2010) (37) carried out the investigation. In conclusion, the data reveal a significant change in refractive error prevalence as children get older, particularly the growth in myopia. Moreover, the correlation between scholastic stress and elevated risks of myopia and astigmatism emphasizes the significance of keeping a check on children's eye health, particularly those in rigorous learning settings. The results show a clear increase in refractive errors with age, as reported by Rezvan, F. (2012) (38), emphasizing the rise in myopia and astigmatism prevalence and the fall in hyperopia. Regular vision screenings and suitable therapies are essential to properly manage these refractive disorders in children, especially as they get older, given the implications for children's visual health and development. Moreover S. Longwill et al. (2022) (39) The study concludes that there are gender-related variations in refractive status as well as a notable burden of refractive errors, especially myopia, among younger adults. Similarly, Mahdavi, M., et al. (2024) (40) The results highlight refractive mistakes' effects on life quality related to vision, underscoring the necessity of efficient techniques for vision correction and maintenance, especially for myopic people. Very low myopes have a marked difference in quality of life (QOL), which emphasizes the significance of treating non-correction in this population to improve visual health and everyday functioning. The study was carried out by Lili Asma Ismail in 2022 (41), and its conclusions shows that there would be significant prevalence of refractive errors, especially myopia, among elementary school students. The lack of discernible gender disparities implies that the effects are equivalent for boys and girls. Identically, According to Giordano, L., et al. (2009) (42), the study's conclusion emphasizes the notable ethnic differences in children's prevalence of refractive errors, especially with regard to myopia and hyperopia.

5. Conclusion

This meta-analysis highlights high frequency of refractive errors, particularly myopia, in children and young people across various research and geographical areas. According to the findings, refractive errors are the usual eye impairments, affecting people of all ages. Myopia

is the most common type of refractive error, with astigmatism then hyperopia following closely behind. The important findings include the following:
Gender and Age Factors - As people age, the prevalence of myopia tends to rise while that of hyperopia generally decreases. There is contradictory data about the prevalence of myopia in relation to gender, with some research reporting a higher frequency in females and others finding no discernible differences.

Environmental and Ethnic Disparities- The incidence of refractive error varied significantly throughout the cultural groupings, with varying rates observed in each group. The increased rates of myopia are linked to various factors, especially in academically challenging contexts, including environmental impacts, near-work activities, and educational pressure.

Life quality: Visual wellness and daily quality are negatively impacted by untreated refractive defects, as the analysis makes clear. The quality of life is significantly reduced for very low myopes in particular, highlighting the necessity of appropriate treatment.

In conclusion, the findings show an alarming pattern of rising childhood and teenage refractive errors, particularly myopia, requiring significant attention to visual health programs. In terms of lessen the detrimental impact of refractive errors on children's visual health and general quality of life, the findings support routine vision examinations, awareness campaigns, and focused interventions. Improving accessibility to eye care services is essential to ensuring that individuals with refractive problems receive optimal diagnosis and care.

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