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RESEACH ARTICLE
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Prevalence of Refractive Errors Among Saudi Population: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Refractive errors are common globally with an estimated number of 2.3 billion people suffering from impaired vision secondary to uncorrected refractive errors. This study aimed to estimate a piece of proper evidence about the overall prevalenceof refractory errors within the kingdom.

Methods: A process of collection of relevant key words was conducted followed by database search. All data were analyzed with R software version 4.0.2. Using a "meta" package. The event rate and the corresponding 95% confidence interval (CI) was used to assess the prevalence of refractive errors in the study.

Results: The sample size was 16850 individual with the highest sample size was 5176 and the lowest one was 162. The male prevalence in our sample was 55%. All the included papers were published after 2010 and were of fair quality. Eleven studies of 12,121 individuals reported the overall prevalence of different refrative erros. The pooled overall prevalnce rate was 27.28% (95% CI= 18.29-40.69) (Figure 2A); ranging from 4.55% to 72.20% among individual studies. This wide range of the reported prevalence rates was evident with a significant heterogenity among the included studies (I2= 99%; P-value< 0.001).

Conclusion: A huge part of the high rates might be attributable to medical students. Moreover, myopia was the most common refractive error followed by astigmatism and hyperopia.

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INTRODUCTION

It has been estimated that vision disorders are the first leading causes of handicap disorders among children and the fourth commonest disorders causing disabilities.[1] Refractive errors are common globally with an estimated number of 2.3 billion people suffering from impaired vision secondary to uncorrected refractive errors.[2] In 2010, estimates show that it is the second commonest cause of blindness globally.[3] Previous studies also showed that the global number of patients with refractive errors causing visual impairment in 2010 is 101.2 million. The rate was even higher by 15% from the rate that was reported in 1990.[4] In addition to the social and personal impact of refractive errors, a total cost of $121.4 million is being spent on these disorders globally which explains the huge economic burden [5]. A single refractory error as myopia, hyperopia, or astigmatism can be present alone or combined, occurring as hyperopic or myopic astigmatism.[6]

The distribution of refractory errors is hugely variable per country and some countries within East Asia have recorded the highest prevalence rates.[7-9] Many associated factors have been identified in populations with high prevalence rates of refractory errors.[10-12] These include being young and with higher educational levels.[13] Moreover, genetics and environmental factors are also important in the development of refractory errors. Previous studies showed that increased outdoor activities were significantly associated with an increased risk of myopia.[14-16] On the other hand, He *et al*. [17] reported that increased outdoor activities were associated with a reduced risk of developing myopia. This was associated with a previous meta-analysis which estimated that near-work is significantly associated with developing myopia.[18] The effect of gender, socio-economic status, race, and aging is also significant on refractory errors development and management.[19]

The distribution of refractory errors within the Kingdom of Saudi Arabia has also been found hugely variable among the different areas within the kingdom. In Aljouf province, a study showed that refractory errors were the only cause of visual impairment in their population.[20] In Qassim province,[21] the prevalence rate of refractory errors was 9.8% while in Alhassa region,[22] the prevalence was 47.5% among participants

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Prevalence, refractive errors, KSA, Systematic review, meta-analysis.

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within the approximate age ranges. Besides, Algorinees *et al*. [23] reported that the prevalence of myopia was 53.5% in their study that was conducted on medical students from Riyadh and Hail provinces.

OBJECTIVE

In this study, we aimed to conduct a meta-analysis of the previously mentioned studies within Saudi Arabia to estimate a piece of proper evidence about the overall prevalence of refractory errors within the kingdom.

METHODS

Search strategy and study selection

A process of collection of relevant key words was conducted followed by database search (seven databases) according to the well-known PRISMA guideline for performing systematic reviews.[24] The EQUATOR site was used as a reference in selecting the appropriate checklist for the study.[25] We searched in Web of Science (ISI), Virtual Health Library (VHL) Google Scholar, Scopus, System for Information on Grey Literature in Europe (SIGLE), New York Academy of Medicine (NYAM) and PubMed databases. The search term used was (myopia OR hyperopia OR hypermetropia OR astigmatism OR presbyopia OR refractive error OR refractive errors) and (saudi arabia) and conducted in 8th Febrauary 2021. To avoid missing papers according to the inclusion criteria we did a manual search in PubMed and Google Scholar.

Any paper –with cross-sectional study design only- reported relevant information about the prevalence of refractive errors in Saudi Arabia was included, without restriction to publication year, age, sex and recruited population (preschool children, school children, medical students or elderly). We excluded papers that reported unreliable extracted data, reported the prevalence of uncorrected errors of refraction only (to avoid hyperinflation of our results), reviews and commentaries.

Two authors did the systematic search after approval of the search term from the senior author. A process of title and abstract screening was done by all the study members and followed by full text screening process for checking the relevance of the previously included papers. At each stage of screening the senior author did an extensive revision for avoiding missing relevant paper.

Data extraction

One author made a sheet for extraction with the help of senior author. All authors did the extraction process with the revision of senior author to ensure cleaned data. Certain items were reported in the extraction sheet: study ID, title of the study, sample size, demographic of the included population (age, prevalence of male and recruited participants), outcomes which included prevalence of total refractive error among all the study participants and prevalence of each specific refractive error.

Quality assessment

According to the inclusion criteria of including cross-sectional study design only, we intended to use The National Institutes of Health (NIH) quality assessment tool for rating the quality of the included papers [26]. The quality rating was previously done by members and reviewed by the senior author. The quality was ranked according to the NIH guideline into good, fair and poor quality.

Statistical analysis

ll data were analyzed with R software version 4.0.2. Using a "meta" package. The event rate and the corresponding 95% confidence interval (CI) was used to assess the prevalence of refractive errors in our study. For the overall prevalence, we did a sensitivity analysis with removing the studies including only medical/phramacy students since those groups have higher prevakences than the general population [27]. We further tested for the gender (male and female) and place of residence (urban and rural) disparities. This was done through calculating the odd ratio (OR) and corresponding CI for each comparison. Heterogeneity will be assessed by Q statistics and I^2 test, where $I^2 > 50\%$ and P-value <0.05 considered significant [28]. Whenever the heterogeneity exists in our analysis, random effect model was used and the Baujat plot was conducted to detect studies overly contributing to the heterogeneity of the meta-analysis [29, 30]. Publication bias was assessed using Egger's regression test and Begg's funnel plot whenever ten or more studies were pooled [31]. If a publication bias existed, we adjuted the effect size using trim and fill method to enhance funnel plot symetry [32].

RESULTS

Search results

The systematic search resulted in 1107 records including 256 duplicates. 851 records were screened by title and abstract then the resulted 78 records were full text screened for assessing eligibility. We included 11 papers and additional 5 papers by manual search making a total of 16 included papers.[33-48] (Fiugre 1).

Characteristics and quality of the included studies

The sample size was 16850 individual with the highest sample size was 5176 and the lowest one was 162. The male prevalence in our sample was 55%. All the included papers were published after 2010 and were of fair quality (Table 1).

Overall prevalence of refractive errors

Eleven studies of 12,121 individuals reported the overall prevalence of different refrative erros. The pooled overall prevalnce rate was 27.28% (95% CI= 18.29-40.69) **(Figure 2)**; ranging from 4.55% to 72.20% among individual studies. This wide range of the reported prevalence rates was evident with a significant heterogenity among the included studies (I^2= 99%; P-value< 0.001) **(Supplementray Figure 1)**. Nevertheless, there was no significant risk of bias as showed by Egger's regression test (P-value= 0.381). Upon the removal of medical/pharmacy students-only studies, as expected, the overall prevalence rate droped into 17.54% (95% CI= 9.93-30.96); however, the heterogenity persisted (I^2= 100%; P-value< 0.001) and the ranges were still wide (4.55%-55.61%) among the individual studies **(Supplementray Figure 2)**.

Table 1: Characteristics of the included studies

Reference ID	*Sample size*	*Participants*	*Age in years (Mean (SD))*	*Male prevalence*	*Quality rating*
Al-Rowaily/2010	1319	Pre-school children	4-6 *	557	Fair
Almudhaiyan/2020	660	Healthy Saudi adults (20-40 years old)	20-40 *	385	Fair
Mohanna/2019	1798	Male primary school children	9.74 (1.8)	1798	Fair
Alghamdi/2020	417	Students aged 6-13 years old	9.2 (1.9)	417	Fair
Al-Shaaln/2020	617	18 years and older	38.6 (16.2)	348	Fair
Al-Batanony/2016	223	Medical and pharmacy female students	20.2 (1.3)	0	Fair
Alemam/2018	1215	Patients attending a pediatric outpatient clinic between 3-14 years	9.7 (3.6)	525	Fair
Aldebasi/2014	5176	Primary school children	9.5 (1.8)	2573	Fair
Al Wadaani/2013	2246	Primary school children	9.48 (2.3)	966	Fair
Abuallut/2021	447	Medical students	21.7	222	Fair
Al-Rashidi/2018	162	Medical Students	22.44 (1.7)	111	Fair
Darraj/2016	385	Children	0-18 *	180	Fair
Alsaqr/2018	998	Adolescents	12-20 *	337	Fair
Alsaif/2018	338	College students	21	162	Fair
Algoriness/2017	454	Medical Students	NR	307	Fair
Al Bahhawi/2018	395	Primary School Students	6-14 *	395	Fair

NR = not reported, * = range

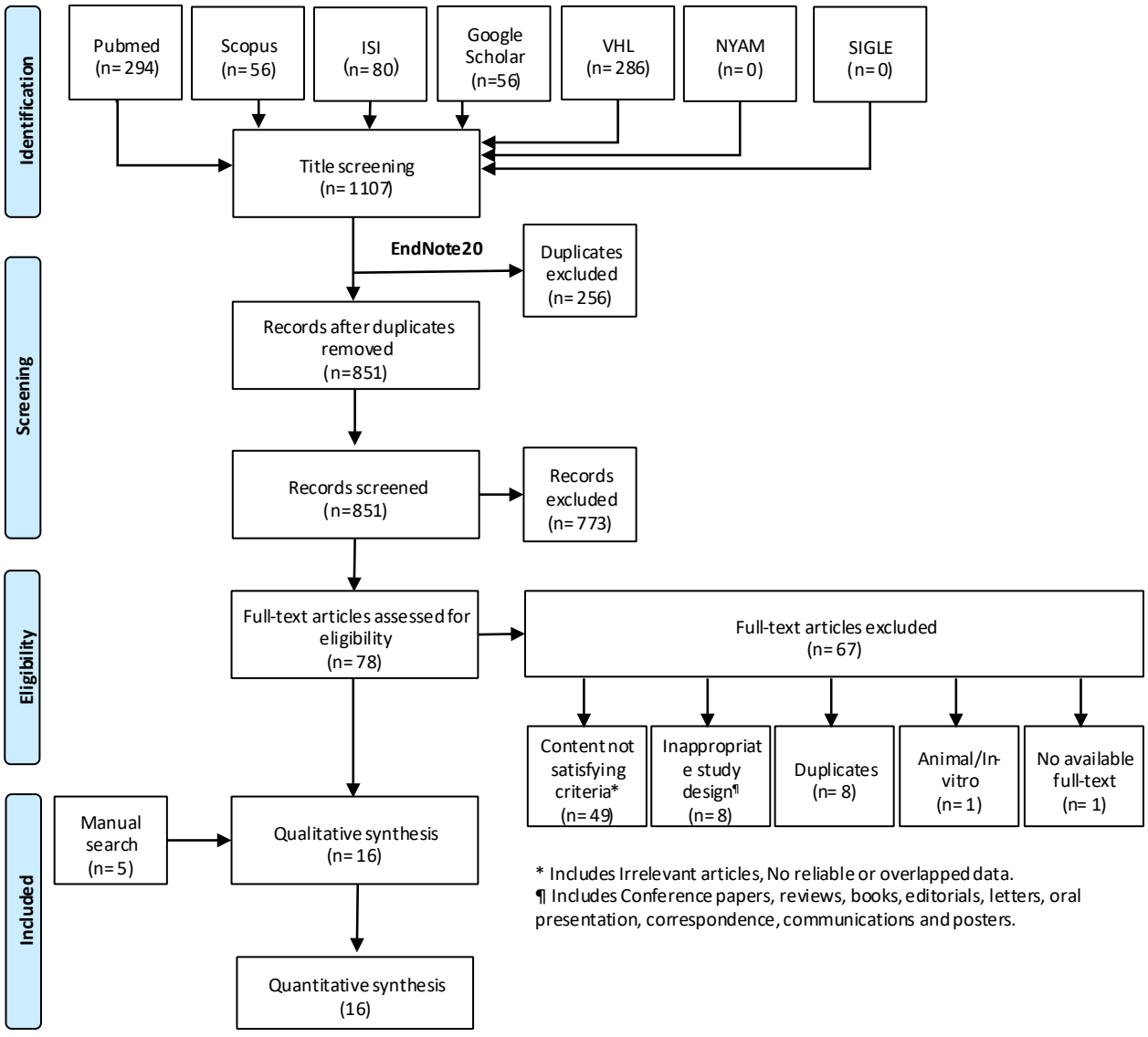
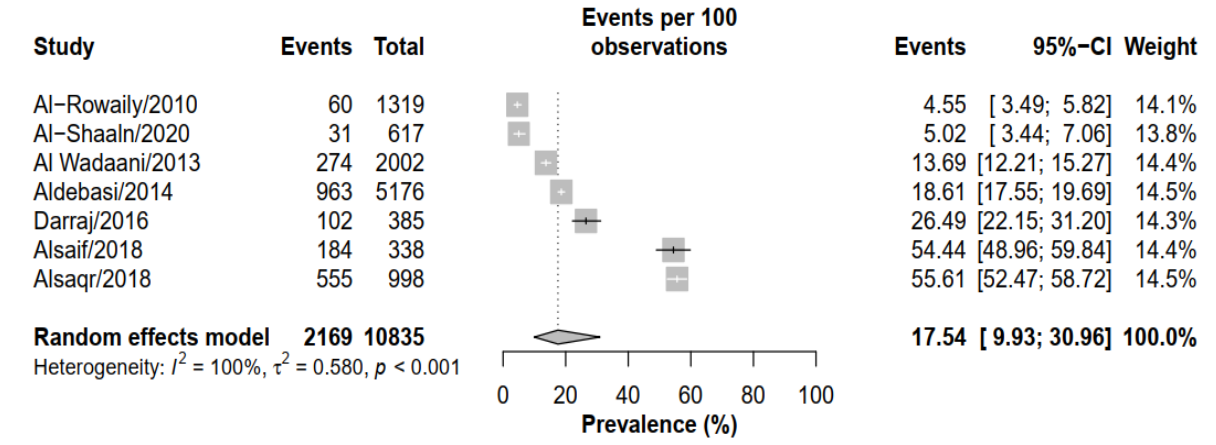


Figure 1: PRISMA flow diagram



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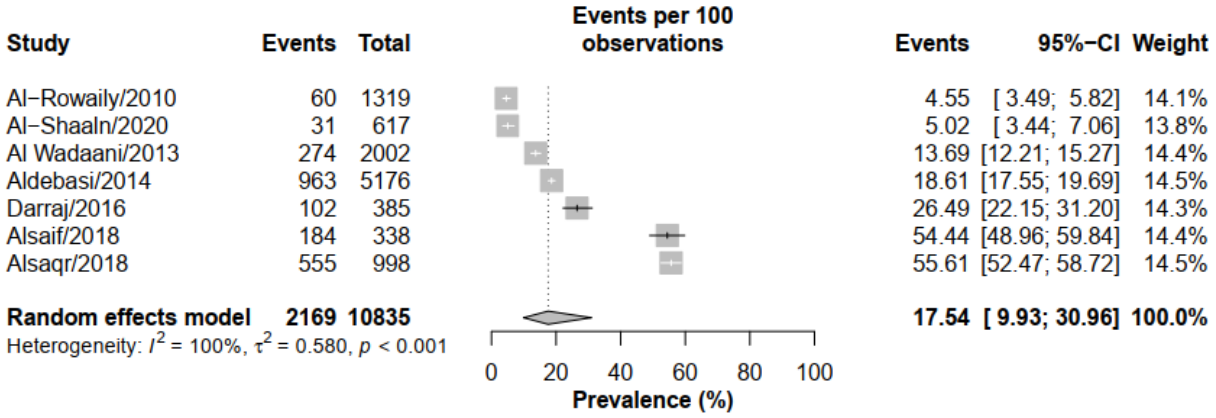


(B)

Figure 2: A_Overall Prevalence. 2B_Overall Prevalence_Medical students removed.

Prevalence of individual refractive errors

For myopia, 15 studies of 16,221 individuals assessed its prevalence among Saudi population.The pooled prevalence was 16.89% (95% CI= 11.09-25.74) with a wide range of 1.62% to 61.43% among the individual studies, which was evident as a significant heterogenity (I^2= 99%; P-value< 0.001) **(Figure 3)**. Moreover, there was a signifiant risk of bias (P-value= 0.021) and on adjusting for bias (using trim and fill method), the prevalnce rate brought to be as high as 37.80% (95% CI= 23.86-95.89) **(Supplementary Figure 3)**. The cotribution of different studies in the overall heterogenity is summarized in **Supplementary Figure 4**.

In the same context, hyperopia prevalence rates among Saudi population were reported in 13 studies of 14,783 individuals. The pooled prevalence was 5.23% (95% CI= 2.80-9.76) with a wide range of 0.91% to 32.15% among the individual studies, which was evident as a significant heterogenity (I^2= 99%; P-value< 0.001) **(Figure 4)**. Moreover, there was a signifiant risk of bias (P-value= 0.001) and on adjusting for bias (using trim and fill method), the prevalnce rate brought to be as high as 19.59% (95% CI= 9.97-38.48) **(Supplementary Figure 5)**. The cotribution of different studies in the overall heterogenity is summarized in **Supplementary Figure 6**.

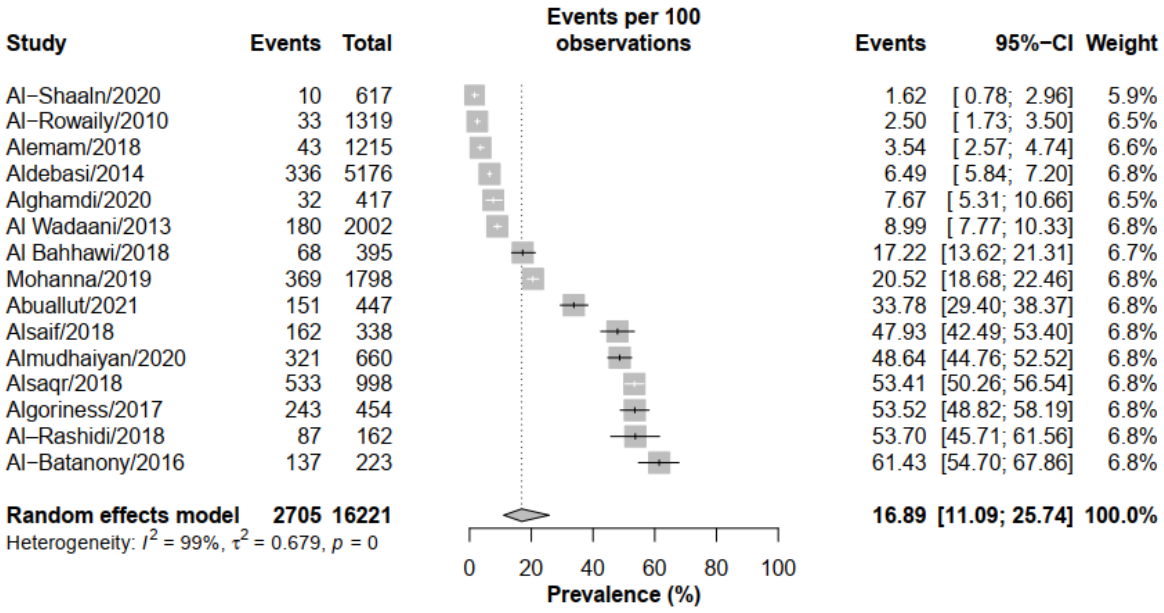
Additionally, astigmatism prevalence rates among Saudi population were reported in 11 studies of 14,783 individuals. The pooled prevalence was 8.73% (95% CI= 5.02-15.17) with a wide range of 0.49% to 66.36% among the individual studies, which was evident as a significant heterogenity (I^2= 100%; P-value< 0.001) **(Figure 5)**. Moreover, there was a signifiant risk of bias (P-value= 0.041) and on adjusting for bias (using trim and fill method), the prevalnce rate brought to be as high as 32.14% (95% CI= 19.09-54.11) **(Supplementary Figure 7)**. The cotribution of different studies in the overall heterogenity is summarized in **Supplementary Figure 8**.

Disparities in prevalence rate

As compared to females, males had lower overall refractive errors (OR= 0.70; 95% CI= 0.58-0.84; P-value< 0.001) and myopia (OR= 0.70 (95% CI= 0.59-0.84; P-value< 0.001) prevalence rates. In contrast, there was no gender differences in terms of hyperopia (OR= 1.35 (95% CI= 0.85-2.15; P-value= 0.208) and astigmatism (OR= 1.16 (95% CI= 0.78-1.72; P-value= 0.476) prevalnce rates **(Supplementary Figure 9)**. Furthermore, the comparsion of refractive errors among urban and rural residence, there prevalnce rates were comparable in all tested variables **(Supplementary Figure 10)**.

DISCUSSION

The impact of refractive errors on the affected patients is unignorable as they can impact many aspects of their lives including the ability to pursue their education and career which imply many social and economic consequences that will impact the affected patients' quality of life [49]. Moreover, ignoring the



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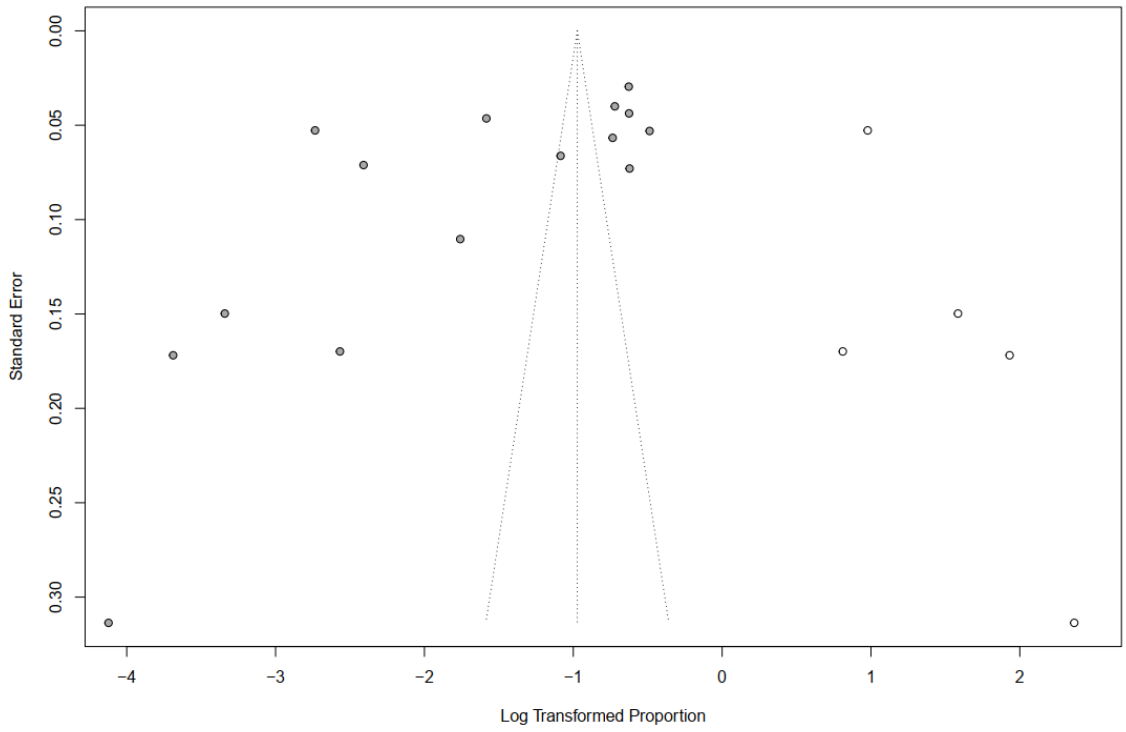

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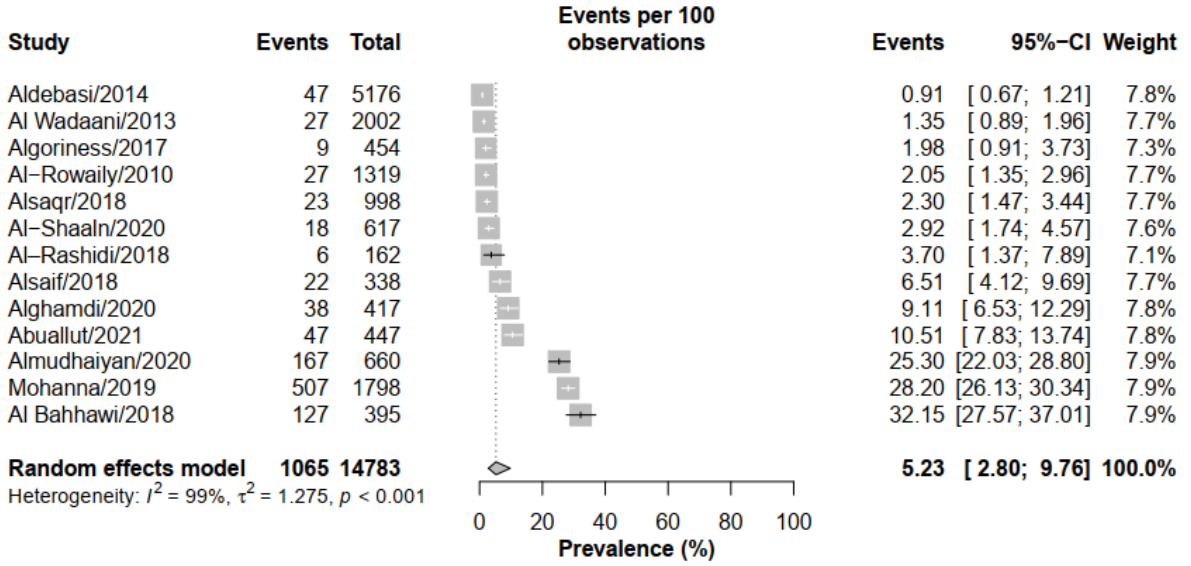
Fig. 3: A_Myopia Prevalence; B_Myopia Funnel Plot_Trim n Fill.

presence of refractive errors without seeking medical attention has a bigger impact on the affected patients' quality of life. Such practices can be attributable to many reasons as inadequate personal and family awareness about the disorder, the unavailability of adequate medical attention due to low socioeconomic status, and the potential poor compliance to the treatment [6]. Therefore, early identification and proper management of these problems can reduce the potential burdens and enhance the quality of life in the affected individuals. In the present study, we aimed to estimate the overall prevalence of refractive errors within Saudi Arabia based on the data from previously published studies within the kingdom. Our results showed that the overall prevalence rate is 27.3% in our study.

The prevalence rates of refractive errors are hugely variable among countries as obtained from published studies in the relevant literature. In Iran, Fotouhi *et al*. [50] reported that 2.1% of their population had refractive errors. This rate was similar to other rates that were reported from other countries. In South Africa [51], the rate was 1.8%, in Singapore, the rate was 4.3%, in India [52], the rate was 8%, in Australia [53], the rate was 5%, in Egypt [54], the rate was 24%. On the other hand, other studies from other countries have reported higher results than ours and the aforementioned countries. For instance, the prevalence rate in China was 95.6% [55], in Malaysia was 90.7% [56], while in Thailand [57], around 74% suffered from moderate visual impairment and 52% suffered from moderate blindness.



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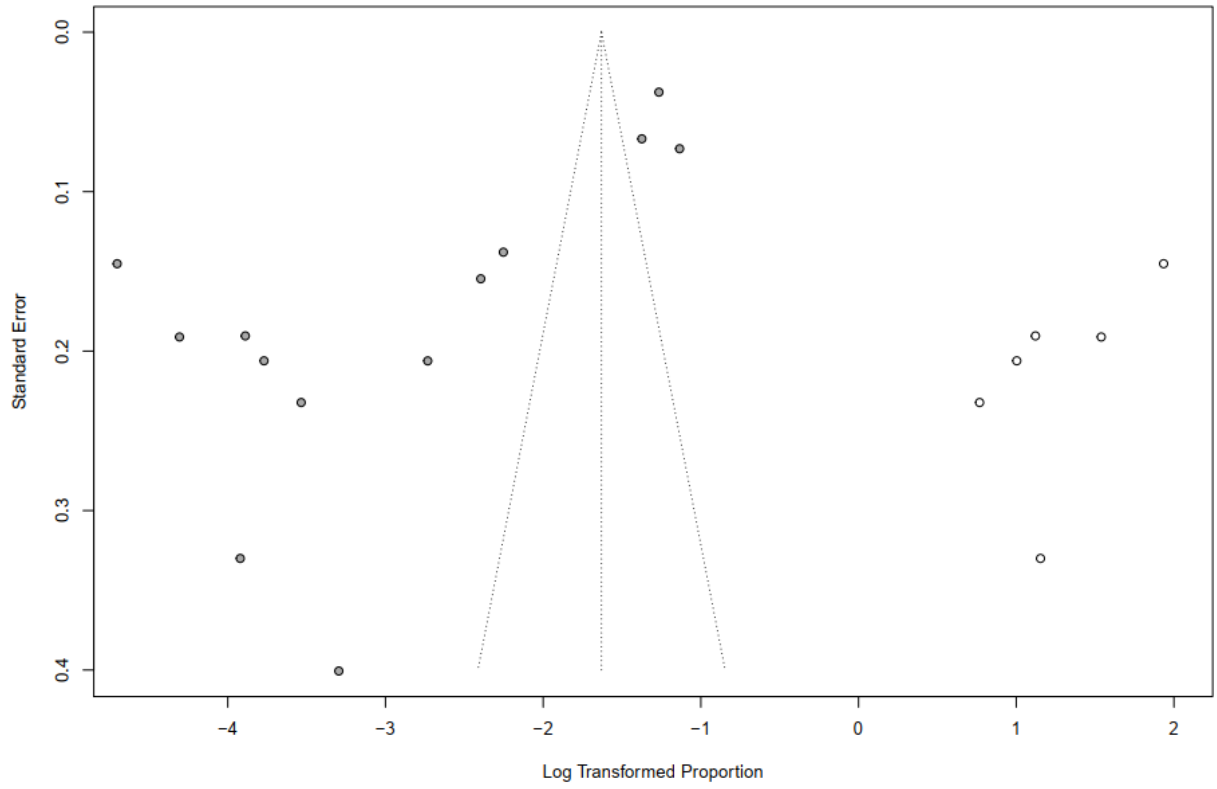

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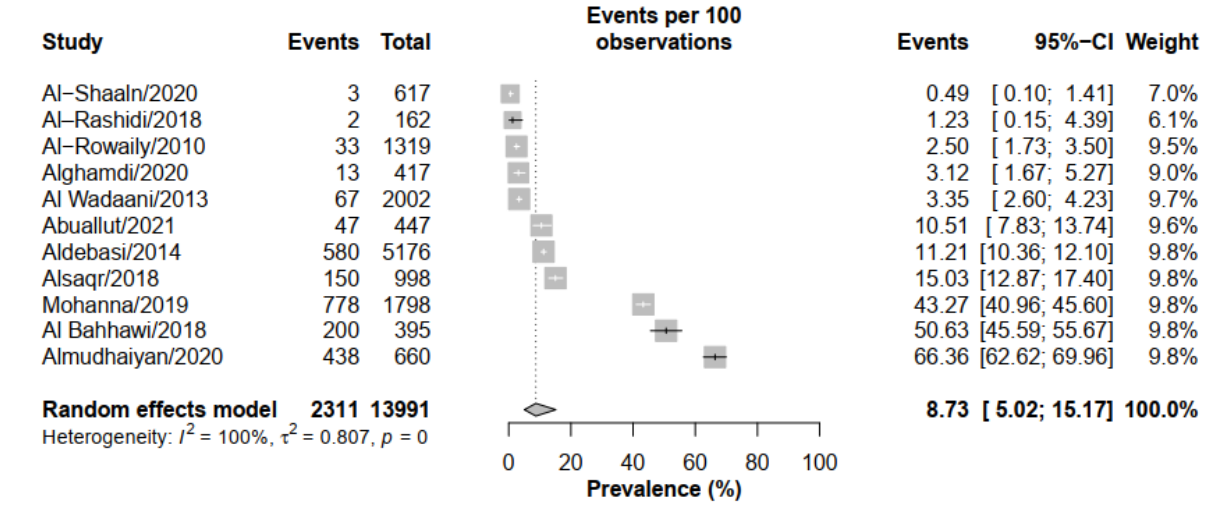
Figure 4: A_Hyperopia Prevalence; B_Hyperopia Funnel Plot_Trim n Fill.

Concerning the prevalence rates per each error, myopia was the commonest error (16.9%), followed by Astigmatism (8.7%), and hyperopia (5.2%). This is consistent with the results of previous studies from Singapore [58]. On the other hand, a large study from the U.S. reported that myopia was the least common refractive error in their population while astigmatism was the most common [19]. This was consistent with the large meta-analysis by Hashemi *et al*. [59] that reported that the global prevalence of astigmatism was higher than hyperopia and myopia, respectively. Another study from South Africa reported that hyperopia was the commonest error followed by astigmatism and myopia [60]. Moreover, Hashemi *et al*. [59] also reported that the prevalence rate of myopia increased from 10.4% in 1993 to 34.2% in 2016. In general, patients in East Asia, Southeast Asia, and Asia-pacific regions have the highest prevalence rates of myopia [61].

Our results also showed that the prevalence of refractive efforts and myopia was significantly higher in female than male participants while no significant differences were noticed regarding the other hyperopia or astigmatism. Huge variabilities were also noticed between the results of previous studies from different countries. Vitale *et al*. [62] reported that among their 20-39-year-old multinational participants, the prevalence of myopia was significantly higher in women than men while the significance was lost in other age groups.

Moreover, hyperopia was more common in females while astigmatism was more common in 60-year-old or older males. Mashige *et al*. [60] reported that women had significantly higher rates of hyperopia while men had significantly higher rates of myopia and astigmatism. We did not find significant differences regarding the prevalence of refractive errors between patients residing in rural and urban regions. On the other hand, Uzma *et al*. [63] reported that the overall prevalence of refractive errors and myopia was significantly higher in urban more than rural children while hyperopia was similar in both groups. This was also supported by previous studies [64-67]. The differences between races have also been previously reported. Pan *et al*. [19] reported that Chinese patients had significantly higher rates of myopia and astigmatism while Hispanic patients had significantly higher rates of hyperopia.

It is hard to accurately compare the results between the different countries due to the huge variability between countries and the different trends of the reported prevalence rates within each country per time. A previous study by Bar Dayan *et al*. [68] investigated the prevalence of myopia in their population over 13 years to understand the trends of the disorder in their country. A significant increase in the rates of myopia was annually noticed among males and females. In our study, the overall prevalence rate of refractive errors decreased from 27.3% to 17.5% when medical students were removed from the analysis. Moreover, the prevalence per each region was different and Aldebasi *et al*. [21] accounted for most of the heterogeneity and had a considerable influence on the overall results, although no limitations were stated by the study authors



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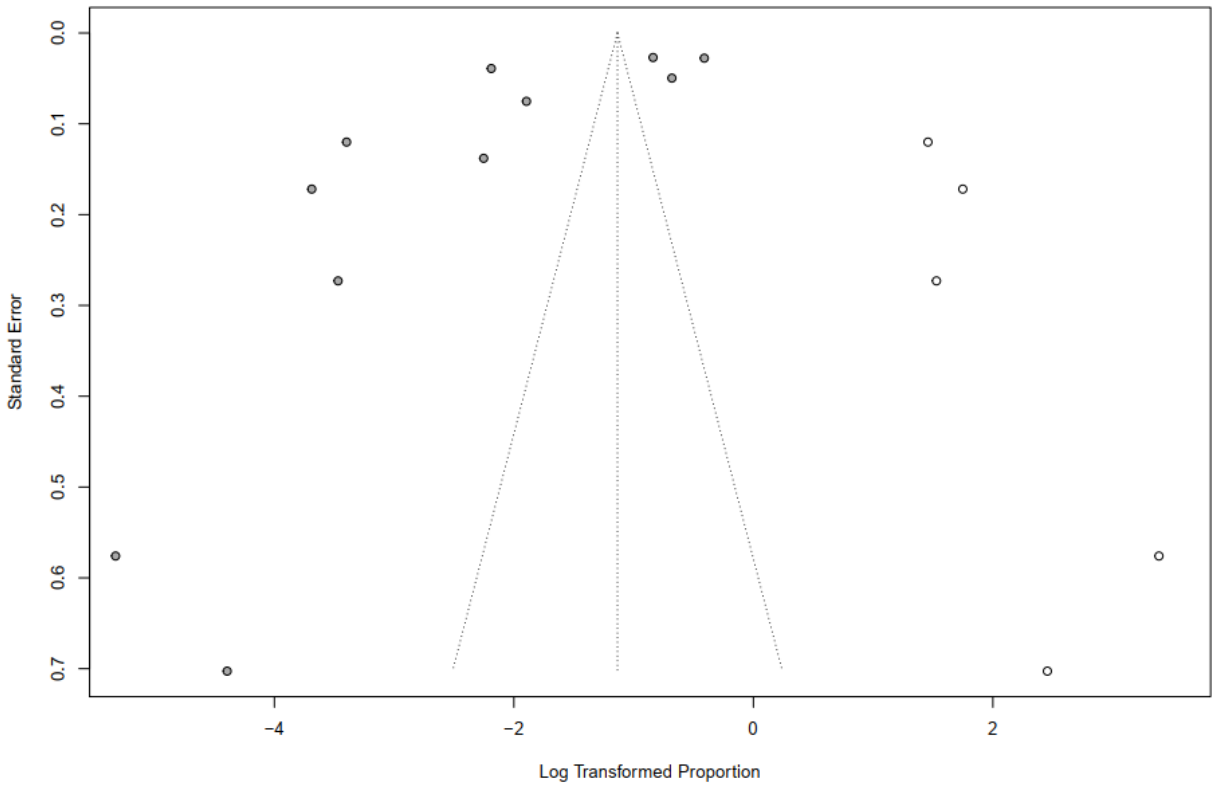

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Figure 5. A_ Astigmatism; B_Astigmatism_Funnel Plot_Trim n Fill.

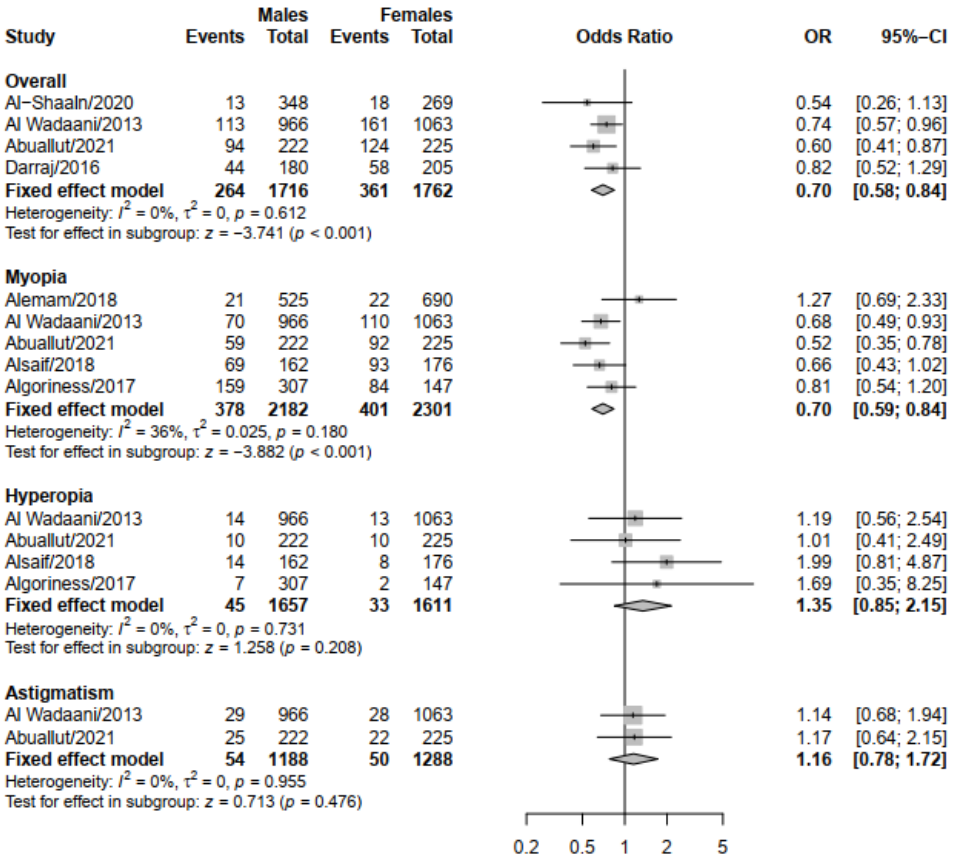

Fig. 6: Males Vs Females.

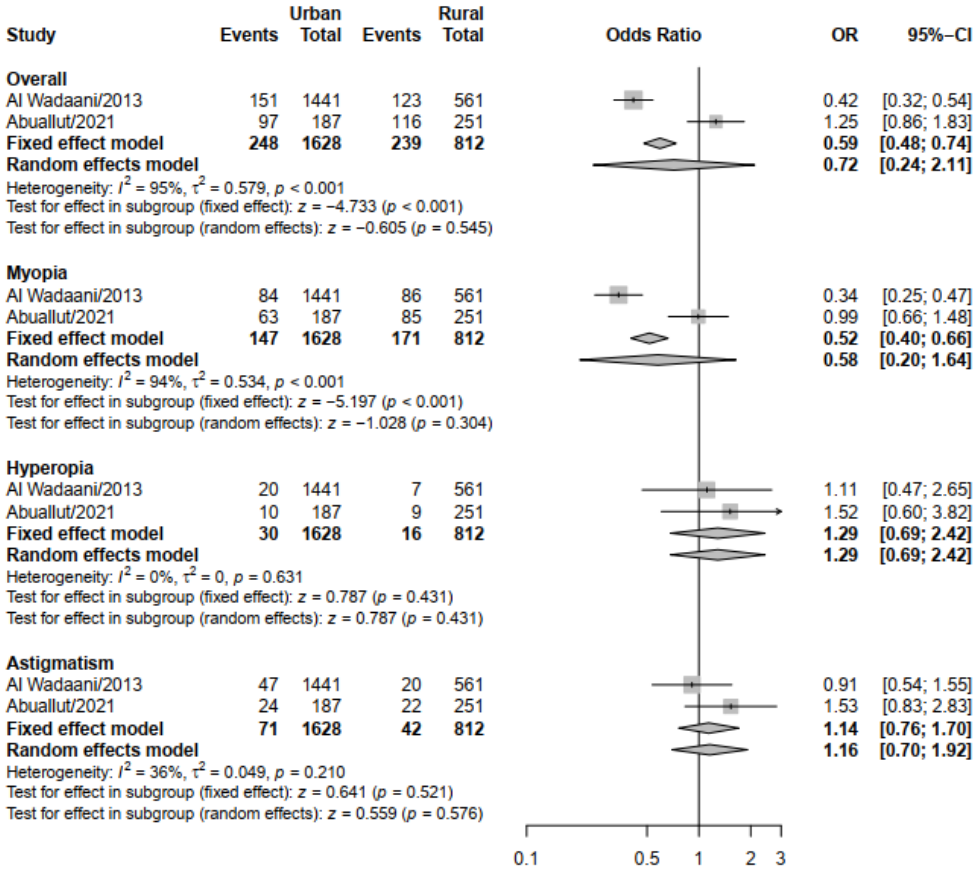

Fig. 7: Urban_rural.

Expert opinion and limitations

The prevalence rate of refractive errors is expected to increase in the coming years as previous projections showed that the prevalence of myopia would increase from 28.6% in 2020 to 53% in 2050 in South Asia [61]. Therefore, it is important to draw more attention to refractory errors in Saudi Arabia, especially for medical students. This can be done by the early screening of refractive errors for school children and providing adequate resources for better management of the pre-existing errors. Screening is marked as a cost-effective approach in the identification of refractive errors when performed in 5-15 years old school children [56]. Moreover, educational campaigns should be conducted for both students and their families to increase awareness about the early presentation of patients with refractive errors and the importance of compliance to the determined management plan, in addition to increasing awareness about the possible interventions. We also encourage that each country should conduct a similar meta-analysis for better estimation of the overall prevalence rates per each country due to the huge variability between studies in the literature.

CONCLUSION

In the present study, we showed that the prevalence of refractive errors is high across Saudi Arabia. A huge part of the high rates might be attributable to medical students. Moreover, myopia was the most common refractive error followed by astigmatism and hyperopia. The overall and myopia rates were significantly higher in women than men. No significant differences were found between rural and urban populations.

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