Prevalence of refractive errors among school students in Ethiopia: A systematic review and meta-analysis

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Abstract
Objective: Refractive errors are most common ocular disorders among children and adolescents. They remain as secondary causes of avoidable blindness in impoverished areas in Africa, most notably in Ethiopia. The problem worsens if it is not managed and addressed early. The aim of this systematic review and meta-analysis was to determine the prevalence of refractive errors among school students in Ethiopia.

Methods: We searched international databases such as PubMed/Medline, Web of Science, CINAHL, Embase, Scopus, Cochrane Library, Google Scholar, and Science Direct for relevant articles. Data were extracted using Microsoft Excel and exported to Stata version 14.0 software for analysis. The Cochrane Q and I² tests were used to assess heterogeneity. Funnel plot, Egger’s, and Begg’s tests were used to assess reporting bias. Random effect meta-analysis model was employed to estimate pooled prevalence of refractive errors. A regional subgroup analysis was carried out.

Results: We reviewed 22 qualified studies with 23,355 study participants. The overall prevalence of refractive errors among school students was 7.36% (95% confidence interval = 6.05, 8.67). The prevalence of myopia, hyperopia, and astigmatism was 5.10% (95% confidence interval = 3.79, 6.40), 0.95% (95% confidence interval = 0.59, 1.31), and 0.01% (95% confidence interval = 0.01, 0.04), respectively. From subgroup analysis, the highest prevalence of refractive errors was reported in Amhara Region (9.18%, 95% confidence interval = 6.63, 11.74), followed by Southern Nations, Nationalities, and Peoples’ region (6.78%, 95% confidence interval = 4.65, 8.92) while the lowest prevalence of refractive errors was reported in Addis Ababa (3.93%, 95% confidence interval = 3.30, 4.56).

Conclusion: In Ethiopia, the prevalence of refractive errors among school students is higher (7.36%) compared to what it was 5 years (7.05%) ago. Amhara Region has the highest prevalence of refractive errors among school students in Ethiopia with myopia being the most common type of refractive error.

Keywords
Prevalence, refractive errors, school students, Ethiopia

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Introduction
Refractive errors (REs) are conditions in which the optical system of the eye fails to focus parallel beams of light on the retina. As a result, the perceived picture is blurred, and refractive correction is necessary to see the image clearly.1 Myopia, hyperopia, and astigmatism are the three types of REs.2 Myopia was described as a spherical power of ≤−0.50 diopter sphere in one eye or both eyes.3,4 Hyperopia was described as a spherical power of ≥+1.50 diopter sphere in one or both eyes.5 Astigmatism was defined as a cylindrical power of ≥0.50 diopters in one or both eyes.4,6 In myopia, light is focused to a position anterior to the retina due to excessive refraction either at the cornea, lens, or more typically an increased length of the eye.7 In hyperopia, the image is formed posterior to the retinal plane as a result of either insufficient refraction or a short axial length.8 In astigmatism, the refractive power of the eye is unequal across

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distinct meridians, resulting in blurred vision because the ocular system is unable to form a sharply focused image on the retina.

REs are primary causes of visual impairment and secondary causes of blindness around the world. For instance, myopia is a risk factor for ocular diseases such as glaucoma. The global report on vision 2019 revealed that about 123.7 million people had visual impairment due to uncorrected REs, of which 12 million were children in the age group 5–15 years. REs, especially myopia, are most common visual problems among children and adolescents. It has a significant impact on children’s social and emotional well-being, which can limit their academic performance as well as access to education. The consequences of undetected and untreated REs are severe particularly in school children, and affect their ability to read words and contents on the blackboard. They are also barred from productive working lives with serious economic and social implications in late adulthood life.

Vision 2020 global initiative for elimination of avoidable blindness suggests visual acuity test in school health programs and provision of spectacles to all children with significant REs as a priority for national eye programs. A person who becomes blind as a result of REs at a young age and does not fix it would endure many more years of blindness than a person who becomes blind as a result of cataract in the old age. These impose huge socioeconomic burden on the individual and the society. Hence, the World Health Organization recommends frequent visual screening programs in school children.

Ethiopia is one of the Africa’s least developed countries with relatively inadequate healthcare coverage, particularly in the area of eye health services, and is believed to have the highest rates of blindness. Many individuals continue to lose their sight because of lack of accessible and affordable primary eye care services. In Ethiopia, more than 85% of causes of low vision and blindness are either preventable or curable. According to the 2006 National Survey Report in Ethiopia, uncorrected REs caused 7.8% of blindness and 33.4% of low vision.

Many individual studies were conducted to assess the prevalence of REs among school students in different areas of Ethiopia: Gondar, 9.4%, Gurage Zone, 3.5%, Central Ethiopia, 6.3%, Debark and Kola Diba towns, 7.6%, and Addis Ababa, 4.0%. However, the magnitude of REs in those studies greatly varied. To the best of our knowledge, the pooled estimate of REs among school students in Ethiopia is not reported so far. Therefore, this systematic review and meta-analysis was conducted to estimate the pooled prevalence of REs among school students in Ethiopia. The findings of this review would help governmental and non-governmental organizations for evidence-based interventions like school-based visual screening and dissemination of free spectacles. It would also help policymakers and other concerned bodies to plan and campaign aimed at REs for elimination of avoidable and curable blindness.

Methods

Study design and setting

In September 2002, Ethiopia adopted vision 2020 global initiative to develop comprehensive and sustainable healthcare system. This initiative aimed to ensure best possible vision for all people with disease prevention, human power, and infrastructure development. Thus, this systematic review and meta-analysis was conducted to estimate the pooled prevalence of REs among school students in Ethiopia. Ethiopia is one of the East African countries and is neighbored by Eritrea to the North, Djibouti and Somalia to the East, Sudan and South Sudan to the West, and Kenya to the South. It has ten regional states (Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations, Nationalities, and Peoples (SNNP), Sidama, Gambella, and Harari) and two city administrations (Addis Ababa and Dire Dawa).

Literature searching strategies

Searching strategies and protocols have been registered in PROSPERO for systematic review and meta-analysis with registration no. CRD42022296352. We have used the guidelines for Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) to report searched articles. International electronic databases (PubMed/Medline, Web of Science, Embase, Scopus, CINAHL, Google Scholar, Science Direct, and Cochrane Library) were searched to retrieve pertinent peer-reviewed articles. Reference lists of eligible studies were also intensively searched. In addition, we have searched official websites of local and international organizations (Addis Ababa University institutional repository and African journals online). The two authors (B.W.S. and G.S.) have searched and reviewed all retrieved articles independently using the PRISMA protocol. “Prevalence,” “refractive error,” “school students,” and “Ethiopia” were the key words for searching published articles in electronic databases (Supplemental additional file 1). “Medical subject heading (MeSH) terms,” “keywords,” and “Boolean operators” were used in separation and combination for searching the articles (Supplemental additional file 2).

Eligibility criteria

Inclusion criteria. The contents of each retrieved articles were thoroughly scrutinized by the two investigators (B.W.S. and G.S.) independently. Finally, only those literatures that met the following criteria were included in the study:

Population: studies done among school students.

Study design: all original articles reporting prevalence of REs and/or myopia, hyperopia, and astigmatism.

Study setting: only studies conducted in Ethiopia.
Language: only articles published and written in English language.

Publication status: all published articles and gray literatures that met the inclusion criteria.

**Exclusion criteria.** Articles reporting prevalence of REs and conducted at health facilities (clinics, health center, and hospitals) were excluded. Articles did not also report outcome of interest were also excluded.

**Outcome of the study.** The outcome of this study was to estimate the prevalence of REs including myopia, hyperopia, and astigmatism among school students in Ethiopia.

**Data extraction and quality assessment.** Microsoft Excel spreadsheet format was used to extract data. The extraction format consists of author/s name, year of publication, study region, study design, sample size, response rate, and prevalence of REs including myopia, hyperopia, and astigmatism. The two authors (B.W.S. and G.S.) independently extracted the data from 10 October 2021 to 1 January 2022. Quality of recruited articles was assessed using the Joanna Briggs Institute’s (JBI) critical appraisal checklist. Methodological quality of the articles was also evaluated using modified version of Newcastle–Ottawa Scale (NOS) for cross-sectional studies.

**Risk assessment of bias for the included studies.** The 10 items rating scale was employed to assess risk of bias for the included studies. The studies were graded as having low risk of bias or “Yes” or high risk of bias or “No” answers to the domain questions. Items answered “Yes” had score “1” and “No” had score “0.” Thus, total item scores “8–10,” “6–7,” and “0–5” declared as having low risk of bias, moderate risk of bias, and high risk of bias, respectively. Items 1–4 examine the study’s external validity (domains include selection and non-response bias), while items 5–10 assess the study’s internal validity (items 5–9 assess the domain of measurement bias, and item 10 assesses bias related to the analysis) (Supplemental additional file 3).

**Statistical analysis.** Microsoft Excel extracted data were exported to Stata version 14 statistical software for analysis. Cochrane’s Q statistics and inverse variance ($I^2$) were employed to assess heterogeneity of the selected studies. Low, moderate, and high heterogeneity was quantified with $I^2$ test statistics for 25%, 50% and 75%, respectively. As a result of significant heterogeneity, random effect meta-analysis model was used to estimate the DerSimonian and Laird’s pooled effect. Egger’s and Begg’s tests were also used to assess publication bias. The pooled estimate with 95% confidence interval (CI) was presented using the Forest plot. The size of each box in the plot indicates the weight of the study while each crossed line indicates the CI. Regions and publication years were used for subgroup analysis. Meta-regression model was conducted to assess random variations among the selected studies. Sensitivity analysis was also performed to assess effect of a single study on the pooled estimate.

**Results**

**Search results and study selection**

A total of 10,577 articles were identified from electronic databases using MeSH terms, keywords, and Boolean operators in separation and combination. These articles were assessed, managed, and screened using their titles and abstracts through EndNote software. Due to duplications in the retrievals, 2222 of them were removed from inclusion. After reviewing the titles and abstracts, 8327 retrievals were excluded because they were unrelated to the outcome of interest in this meta-analysis. Then, 28 full-text articles were evaluated for eligibility using the eligibility criteria. Finally, 22 peer-reviewed articles were identified to be eligible for this systematic review and meta-analysis. However, six articles were not met the inclusion criteria and excluded with clear reasons (Figure 1).

**Characteristics of included articles**

Twenty-two articles were recruited for this systematic review and meta-analysis. About 23,355 Ethiopian school students aged 5–24 years were involved in these studies. They were cross-sectional in design and published from 2002 to 2021. The largest (n = 4238) and smallest (n = 313) sample sizes were reported from studies done in Gurahe Zone (SNNP region) and Gonder (Amhara Region), respectively. Nine studies with 7438 participants were conducted in Amhara Region, 8 studies with 11,122 participants were done in SNNP, 1 study with 1137 participants was conducted in Tigray, and 4 studies with 3658 participants were done in Addis Ababa. The included studies had the lowest response rate of 77% and the lowest quality score of 8 (Table 1).

The highest prevalence of RE (16.70, 95% CI = 13.74, 19.66) was reported in Bahir Dar, Amhara Region, and the lowest prevalence of RE (2.50, 95% CI = 1.56, 3.44) was found in Gurahe Zone, SNNP region. The highest prevalence of myopia (11.90, 95% CI = 9.05, 14.75) and hyperopia (7.20, 95% CI = 5.15, 9.25) among school students was also revealed in Gonder and Bahir Dar, Amhara Region, respectively (Table 2).

**Pooled prevalence of REs among school students in Ethiopia**

The overall pooled prevalence of REs was 7.36% (95% CI = 6.05, 8.67). Due to high heterogeneity ($I^2$ = 94.4%; $p = 0.000$), random model effect analysis was conducted.
Figure 1. PRISMA flowchart for refractive errors among school students in Ethiopia, 2021 (N = 22).

Table 1. Characteristics of included articles in this systematic review and meta-analysis of refractive errors among school students in Ethiopia, 2021 (N = 22).

| Author name          | Publication year | Region       | Study site       | Study design          | Age group (years) | Sample size | Response rate (%) | Quality score (10 points) |
|----------------------|------------------|--------------|------------------|------------------------|-------------------|-------------|-------------------|--------------------------|
| Yared et al.         | 2015             | Amhara       | Gondar           | Cross-sectional        | 5–24              | 1722        | 93                | 9                        |
| Mehari and Yimer     | 2012             | SNNP         | Gura Zone        | Cross-sectional        | 7–18              | 4238        | 77                | 8                        |
| Sewunet et al.       | 2014             | Amhara       | Debre Markos     | Cross-sectional        | 7–15              | 420         | 97                | 9                        |
| Kassa and Alene      | 2014             | Amhara       | Gondar           | Cross-sectional        | 5–15              | 1112        | 98                | 9                        |
| Kedir and Girma      | 2014             | SNNP         | Gura Zone        | Cross-sectional        | 7–15              | 570         | 96                | 9                        |
| Dhaneshu et al.      | 2018             | Tigray       | Mekelle          | Cross-sectional        | 11–15             | 1137        | 95                | 8                        |
| Hailu et al.         | 2019             | Addis Ababa  | Addis Ababa      | Cross-sectional        | 7–17              | 773         | 95                | 8                        |
| Zelalem et al.       | 2019             | Amhara       | Sekela Woreda    | Cross-sectional        | 8–18              | 875         | 100               | 9                        |
| Woldeamanuel et al.  | 2020             | SNNP         | Gura Zone        | Cross-sectional        | 7–18              | 1064        | 100               | 9                        |
| Tegegne et al.       | 2021             | Amhara       | Bahir Dar        | Cross-sectional        | 6–18              | 611         | 97                | 8                        |
| Alem and Gebru       | 2021             | SNNP         | Hawassa          | Cross-sectional        | 5–20              | 529         | 95                | 8                        |
| Ferede et al.        | 2020             | Amhara       | Gondar           | Cross-sectional        | 5–15              | 1289        | 100               | 9                        |
| Gessesse and Teshome | 2020             | SNNP         | Welkite          | Cross-sectional        | 13–26             | 1271        | 89                | 8                        |
| Misganaw and Woldeyes| 2014             | Addis Ababa  | Addis Ababa      | Cross-sectional        | 5–18              | 1789        | 99                | 9                        |

(Continued)
considering this fact (Figure 2). The highest proportion of RE was found in Amhara Region (9.18%, 95% CI = 6.63, 11.74), followed by SNNP (6.78%, 95% CI = 4.65, 8.92) and Addis Ababa (3.93%, 95% CI = 3.30, 4.56). From a single multicenter study, 11% (95% CI = 9.18, 12.82) proportion of RE was reported in Tigray region (Figures 3 and 4). The prevalences of myopia and hyperopia were 5.10% (95% CI = 3.79, 6.40) and 0.95% (95% CI = 0.59, 1.31), respectively (Figures 5 and 6). The prevalence of astigmatism was 0.01% (95% CI = −0.01, 0.04).

**Publication bias and meta-regression**

Funnel plot, Egger’s, and Begg’s tests were used to assess publication biases. The funnel plot showed asymmetrical distribution as subjectively shown (Figure 7). But, the Begg’s (p = 0.640) and Egger’s (p = 0.756) tests revealed no significant publication biases. Meta-regression analysis also revealed heterogeneity was not explained by sample sizes (p = 0.207), publication years (p = 0.374), and study regions (p = 0.238).

**Table 1.** Prevalence of refractive error, myopia, hyperopia, and astigmatism of included articles for this systematic review and meta-analysis among school students in Ethiopia, 2021 (N = 22).

| Author name          | Refractive error (95% CI) | Myopia (95% CI) | Hyperopia (95% CI) | Astigmatism (95% CI) |
|----------------------|--------------------------|----------------|------------------|----------------------|
| Yared et al.        | 10.10 (8.68, 11.52)      | 3.20 (2.37, 4.03) | 2.70 (1.93, 3.47) | NR                   |
| Mehari and Yimer     | 6.30 (5.57, 7.03)        | 6.00 (5.28, 6.72) | 0.30 (0.14, 0.46) | NR                   |
| Sewunet et al.       | 10.20 (7.31, 13.09)      | 5.50 (3.32, 7.68) | 1.40 (0.28, 2.52) | 0.02 (−0.11, 0.15)   |
| Kassa and Alene      | 7.70 (6.13, 9.27)        | 7.60 (6.04, 9.16) | 0.2 (−0.06, 0.46) | NR                   |
| Kedir and Girma      | 3.50 (1.99, 5.01)        | 2.60 (1.29, 3.91) | 0.90 (0.12, 1.68) | NR                   |
| Dhanesha et al.      | 11.00 (9.18, 12.82)      | 3.90 (2.77, 5.03) | 0.40 (0.03, 0.77) | 0.01 (−0.06, 0.09)   |
| Hallu et al.         | 4.10 (2.70, 5.50)        | 1.90 (0.94, 2.86) | 0.90 (0.23, 1.57) | 0.01 (−0.07, 0.09)   |
| Zelalem et al.       | 3.80 (2.53, 5.07)        | NR              | NR               | NR                   |
| Woldeamanuel et al.  | 2.50 (1.56, 3.44)        | 1.50 (0.77, 2.23) | 0.50 (0.08, 0.92) | 0.01 (−0.04, 0.05)   |
| Tegenge et al.       | 16.70 (13.74, 19.66)     | 7.70 (5.59, 9.81) | 7.20 (5.15, 9.25) | 0.02 (−0.09, 0.12)   |
| Alem and Gebru       | 12.90 (10.04, 15.76)     | 9.80 (7.27, 12.33) | 1.10 (0.21, 1.99) | 0.02 (−0.10, 0.14)   |
| Ferede et al.        | 3.90 (2.84, 4.96)        | NR              | NR               | NR                   |
| Gessesse and Teshome | 7.20 (5.78, 8.62)        | 6.50 (5.14, 7.86) | NR               | NR                   |
| Misganaw and Woldeyes | 3.90 (3.00, 4.80)     | 1.10 (0.62, 1.58) | 0.30 (0.05, 0.55) | 0.01 (−0.04, 0.07)   |
| Assem et al.        | 8.50 (6.27, 10.73)       | 8.50 (6.27, 10.73) | NR               | NR                   |
| Belete et al.       | 11.9 (9.05, 14.75)       | 11.90 (9.05, 14.75) | NR               | NR                   |
| Bezabih et al.      | 3.6 (2.24, 4.96)         | 1.40 (0.54, 2.26) | 0.4 (−0.06, 0.86) | 0.02 (−0.08, 0.12)   |
| Darge et al.        | 4.5 (2.41, 6.59)         | NR              | NR               | NR                   |
| Ezinne              | 11.5 (7.97, 15.03)       | 6.10 (3.45, 8.75) | 2.90 (1.04, 4.76) | 0.03 (−0.15, 0.20)   |
| Abayo et al.        | 4.8 (3.30, 6.30)         | NR              | NR               | NR                   |
| Worku and Bayu       | 11.8 (10.33, 13.27)      | NR              | NR               | NR                   |
| Shaffi and Bejiga    | 6.3 (4.64, 7.96)         | NR              | NR               | NR                   |

NR: not reported; CI: confidence interval.
### Table 1

| Study ID | ES (95% CI) |
|----------|-------------|
| Worku et al (51) (2002) | 11.80 (10.33, 13.27) |
| Kassa T et al (42) (2004) | 7.70 (6.13, 9.27) |
| Shaffi M et al (52) (2005) | 6.30 (4.64, 7.96) |
| Mehari ZA et al (35) (2012) | 6.30 (5.57, 7.03) |
| Ezinne NE (36) (2013) | 11.50 (7.97, 15.03) |
| Sewunet SA et al (39) (2014) | 10.20 (7.31, 13.09) |
| Kedir J et al (46) (2014) | 3.50 (1.99, 5.01) |
| Misganaw C et al (55) (2014) | 3.90 (3.00, 4.80) |
| Yared AW et al (45) (2015) | 10.10 (8.68, 11.52) |
| Belete GT et al (43) (2016) | 11.90 (9.05, 14.75) |
| Bezabih L et al (56) (2016) | 3.60 (2.24, 4.96) |
| Darge HF et al (57) (2017) | 4.50 (2.41, 6.59) |
| Dhaneshia U et al (53) (2018) | 11.00 (9.18, 12.82) |
| Haile Y et al (54) (2019) | 4.10 (2.70, 5.50) |
| Zelealem M et al (30) (2019) | 3.80 (2.53, 5.07) |
| Woldeamanuel GG et al (47) (2020) | 2.50 (1.58, 3.44) |
| Ferede AT et al (37) (2020) | 3.90 (2.84, 4.96) |
| Gessesse SA et al (49) (2020) | 7.20 (5.78, 8.62) |
| Tegenge MM et al (44) (2021) | 16.70 (13.74, 19.66) |
| Alem KD et al (48) (2021) | 12.90 (10.04, 15.76) |
| Assem AS et al (41) (2021) | 8.50 (6.27, 10.73) |
| Abayo G et al (50) (2021) | 4.00 (3.30, 4.60) |
| Overall (I-squared = 94.4%, p = 0.000) | 7.36 (6.05, 8.67) |

**NOTE:** Weights are from random effects analysis.

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**Figure 2.** Pooled prevalence of refractive errors among school students in Ethiopia, 2021 (n = 22).

ES: effect size; CI: confidence interval.

The dotted vertical line indicates the pooled effect size.

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**Figure 3.** The map illustrates the distribution of refractive error prevalences among school students in Ethiopian regions.57

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**Legend:**

- Amhara = 9.18% (95% CI: 6.63, 11.74%)
- SNNPR = 6.78% (95% CI: 4.65, 8.92%)
- Tigray = 11% (95% CI: 9.18, 12.82%)
- Addis Ababa = 3.93% (95% CI: 3.30, 4.56%)
Discussion

REs are the most common ocular disorders among children and adolescents. They continue to be a secondary cause of avoidable blindness in impoverished areas throughout Africa, most notably in Ethiopia. The problem worsens if it is not discovered and addressed early in the young age population, particularly among children. In this study, the pooled prevalence of REs among school students in Ethiopia was 7.36%, of which myopia, hyperopia, and astigmatism accounted 5.1%, 0.95%, and 0.01%, respectively. The prevalence of REs in this study was in line with studies conducted in India, 8%,58 Baltimore, 8.2%,59 and Nepal, 8.6%.60 However, our finding was lower than reported studies from Saudi Arabia, 16.8%,61 Japan, 10.4%,62 the United States, 18.2%,63 and Uganda, 12%.64 The possible plausible explanation for the highest prevalence in the reported studies might be owing to increased educational demand which lead to greater near vision activities.65 Nevertheless, the finding of the current review was higher than studies from Riyadh, 4.5%,66 Iran, 3.8%,67 and Brazil, 4.82%.67 The higher prevalence in this study might be due to lack of accessible and affordable primary eye care services in Ethiopia, or it might be due to REs that could be rectified with spectacles but have not been.

The prevalence of myopia in this study was comparable with previous studies in Africa, 4.7%,68 the Middle East, 4%,69 and India, 5.3%–7.5%.58,70 But, our finding was lower than other studies in Norway, 35%,71 Colombia, 14.7%,72 China, 38.0%,73 and Asia, 14.1%.74 The higher prevalence in these studies could be due to myopia was more common in developed countries than developing countries. Myopia has historically been seen as an Asian health issue, with the prevalence being substantially greater in Asian societies than in Western communities.75–77 This was supported by a reported study from India revealed myopia was more common in urban children than rural children.78 This might be due to relatively increased literacy rate and duration of study hours of urban child than rural child. Myopia had also a direct relation with community development.79 As a result, we believed that the correlation between myopia and close work remains obscure.80

| Author and Year | Publication Year | ES (95% CI) | % Weight |
|-----------------|-----------------|-------------|---------|
| Anhara et al.   | 2004            | 7.70 (6.13, 9.27) | 4.68    |
| Emmez NE et al. | 2013            | 11.50 (7.97, 15.03) | 3.67    |
| Steunut S A et al. | 2014          | 10.20 (7.31, 13.09) | 4.03    |
| Yared AW et al. | 2015            | 10.10 (8.68, 11.52) | 4.74    |
| Biele A et al.  | 2016            | 11.90 (9.05, 14.75) | 4.05    |
| Zelaem M et al. | 2019            | 3.80 (2.53, 5.07) | 4.79    |
| Ferdeke AT et al. | 2020        | 3.90 (2.84, 4.96) | 4.86    |
| Tegenge MM et al. | 2021       | 16.70 (13.74, 19.66) | 3.99    |
| Subtotal (I-squared = 94.4%, p = 0.000) | | | |
| SNNP            | 2021            | 8.50 (6.27, 10.73) | 4.38    |
| Subtotal (I-squared = 95.4%, p = 0.000) | | | |
| Tipay           | 2018            | 11.00 (9.18, 12.82) | 4.57    |
| Subtotal (I-squared = , p = ) | | | |
| Addis Ababa     | 2014            | 3.90 (3.00, 4.80) | 4.69    |
| Misgraw C et al. | 2014         | 3.60 (2.24, 4.96) | 4.76    |
| Bezabhi L et al. | 2016         | 4.50 (2.21, 6.99) | 4.45    |
| Haile Y et al.  | 2019            | 4.10 (2.70, 5.50) | 4.75    |
| Subtotal (I-squared = 0.0%, p = 0.900) | | | |
| Overall (I-squared = 94.4%, p = 0.000) | | | 100.00 |

Figure 4. Subgroup analysis of refractive errors by regions among school students in Ethiopia, 2021 (n = 22). ES: effect size; CI: confidence interval.

The dotted vertical line indicates the pooled effect size.
Figure 5. Pooled prevalence of myopia among school students in Ethiopia, 2021 (n = 16).
ES: effect size; CI: confidence interval.
The dotted vertical line indicates the pooled effect size.

Figure 6. Pooled prevalence of hyperopia among school students in Ethiopia, 2021 (n = 13).
ES: effect size; CI: confidence interval.
The dotted vertical line indicates the pooled effect size.
In this study, the prevalences of hyperopia and astigmatism were similar and comparable to studies conducted in India among rural school children (hyperopia = 0.39%, astigmatism = 0.21%), Vietnam (hyperopia = 0.4%, astigmatism = 0.7%), Thailand (astigmatism = 0.3%), Malaysia (hyperopia = 1%, astigmatism = 0.6%), and Pakistan (astigmatism = 0.7%). However, our findings were lower than other study findings from Iran (hyperopia = 16.6%, astigmatism = 18.7%), Pakistan (myopia = 52.6%, astigmatism = 28.4%), Jordan (hyperopia = 5.67%, astigmatism = 36.8%), Turkey (astigmatism = 11%), China (astigmatism = 40.8%), and the Netherlands (hyperopia = 8%, myopia = 28%). This discrepancy might be because of variations in geography, socioeconomic condition, race, and ethnicity. This was supported by a study which showed the Whites had the highest prevalence of hyperopia than the Hispanics, and African Americans had the lowest prevalence of astigmatism than Asian followed by Whites. This discrepancy could be also due to differences in study design (cycloplegia vs non-cycloplegia) or different definition of myopia, hyperopia, and astigmatism.

The subgroup analysis of this study also revealed that the prevalence of REs among school students significantly varies across different regions of Ethiopia. The highest prevalence was reported in Amhara Region followed by SNNP region. However, the lowest prevalence was reported in Addis Ababa. This regional discrepancy might be due to differences in the students’ physical activity, time spent outdoors, and near-work activity across those regions of Ethiopia. The other inherent regional variation could be attributed to access to government and private-owned primary eye care services including eye glasses and prescribed spectacles. This supports the lower prevalence reported in Addis Ababa, the capital city of Ethiopia, where primary eye care services and eye clinics are relatively available. This regional discrepancy suggests special campaign aimed REs among school students in Amhara and SNNP regions.

**Limitations of the study**

This systematic review and meta-analysis did not include all regional states of Ethiopia due to lack of published articles in those excluded regional states. In addition, this study did not assess predisposing factors of REs among school students in Ethiopia.

**Conclusion**

The pooled prevalence of REs among school students in Ethiopian was 7.36%. The prevalence of REs among Ethiopian school students is higher compared to what it was 5 years (7.05%) ago. The Amhara Region had the highest prevalence of REs among school students, followed by the SNNP region. Myopia was the most common RE among school students in Ethiopia.

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**Author contributions**

The two authors (B.W.S. and G.S.) participated equally in designing the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) protocol, literature review, data extraction, and developing the manuscript. Both authors approved the final manuscript.

**Availability of data and material**

The data sets used for this systematic review and met-analysis are available from the corresponding author upon reasonable request.

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**Supplemental material**

Supplemental material for this article is available online.

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