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Systematic Review

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The Global Face of Childhood Blindness: Proportions, Causes, and Patterns in a Changing World

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Abstract

Background: Childhood visual impairment and blindness continue to be ongoing challenges in worldwide eye care, especially in low-resource environments. In spite of profound advances in pediatric ophthalmology, the epidemiologic knowledge of prevalence patterns, etiology, and access disparities is still too low. ***Aim and Objective:*** It is the objective of this study to provide an answer to the following question: "How do global proportions, etiology, and risk factors for childhood blindness and visual impairment represent prevailing healthcare inequalities, and how can this evidence inform targeted prevention efforts?" ***Methods:*** Systematic review and meta-analysis were performed based on 11 included studies from Nepal, China, Sudan, Rwanda, Morocco, Ethiopia, Ghana, Israel, Indonesia, Iran, and the UK. Quantitative estimates of VI or childhood blindness were included in studies with inferential or descriptive analyses of contributing factors. Data extraction included prevalence, causes, and risk correlations. Meta-analysis was performed on parameters in common using effect sizes in proportions. ***Results:*** Prevalence of child blindness/VI varied from 0.07% (Nepal, 2014) to 39.7% (Morocco, 2025). Preventable causes of refractive error, cataract, trauma, and glaucoma accounted for the leading cause in 77–87% of cases. Disability adjusted life years (DALY) burden was highest among adolescents (92.7 per 100,000). Logistic regression of Morocco indicated that family history was a critical risk factor (OR = 1.795, CI: 1.17–2.75). Meta-analysis demonstrated prevalence proportions of 0.07% to 39.7% with considerable heterogeneity between LMICs and HICs. ***Conclusion:*** Childhood VI is income, geographic, and etiological diverse. Preventable causes are predominant in low-income groups, while genetic and neuro-development disorders are more common in high-income economies. Implications point towards the necessity of early screening, equal access to eye care, and policy-driven genetic and educational interventions.

Keywords: ***Childhood blindness, Pediatric visual impairment, Causes of child blindness, Visual impairment prevalence in children***

Introduction

Childhood blindness and visual impairment (VI) are a major public health problem, with far-reaching consequences for individual development, family functioning, and socioeconomic mobility. Unlike adult-onset blindness, childhood VI affects not only visual acuity but also intellectual, motor, and emotional development. An estimated 1.4 million children have irreversible blindness and 17.5 million have treatable or preventable VI, according to World Health Organization (WHO) estimates globally [1]. Despite the heavy burden, the epidemiological knowledge of childhood blindness is poor, especially in low- and middle-income countries (LMICs), where there are no routine data collection systems and pediatric eye care [2].

Historical literature has recognized the dominance of preventable causes-like cataracts, refraction, and trauma – amongst low- and middle-income countries (LMICs), while genetic, neurological, and developmental causes are predominant in high-income countries (HICs). The last decade has, however, seen a shift in these patterns, with technological progress, public health interventions, and social determinants like maternal education, nutrition, and access to care [3].

Not undertaken is an international comparative overview of these data. Prior reviews have been local or had poor inferential statistical power in analyzing related risk factors. In addition, application of DALYs and population trend data of childhood visual impairment is not optimized.

This systematic review and meta-analysis aims to address these gaps by pooling the results of 11 high-quality Asian, European, and African studies. Through analysis of prevalence rate, causative factor categorization, and socio-demographic determinants analysis, we aim to address a pertinent question: What do global figures, etiological causes, and risk factors of visual impairment and childhood blindness reflect of current healthcare disparities, and how can this evidence inform the design of targeted preventive interventions?

Methodology

Search Strategy: Systematic literature search was conducted in the PubMed, Scopus, and Web of Science databases using the keywords "childhood blindness," "pediatric visual impairment," "causes of child blindness," "visual impairment prevalence in children," and "disability-adjusted life years (DALYs) for child vision." The search

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was restricted to articles published between 2014 and 2025 and written in the English language using the 2020 PRISMA guidelines (**Figure 1**) [4].

Study Design: Systematic review and meta-analyses

Study Period: 2014-2025

Sample size: 104927

Eligibility Criteria

Inclusion Criteria

- Prevalence/proportions of VI (age <18 years) or childhood blindness reports
- Registry-based, population-based, cross-sectional, or school-based studies
- Etiology or risk factor inferential/descriptive statistical analysis reports

Exclusion Criteria

- Case series, letters to editorial boards, and studies without quantitative data.
- Research that concentrates exclusively on adult populations or lacks defined age classifications.

Study Selection and Quality Assessment

Following duplicate removal and title/abstract screening, two authors independently assessed full texts. Quality of studies was evaluated with Newcastle-Ottawa Scale (NOS).

Data Synthesis and Extraction

A single data collection instrument was used to elicit:

- Year of study and country
- Population size
- Ratio of VI/blindness
- Major reasons (refractive error, cataract, glaucoma, trauma, etc.)
- Significant predictors and statistical tests (e.g., OR, p-values)

Meta-analysis was conducted based on a random-effects model for aggregate parameters, combining prevalence, standard errors, and 95% confidence intervals.

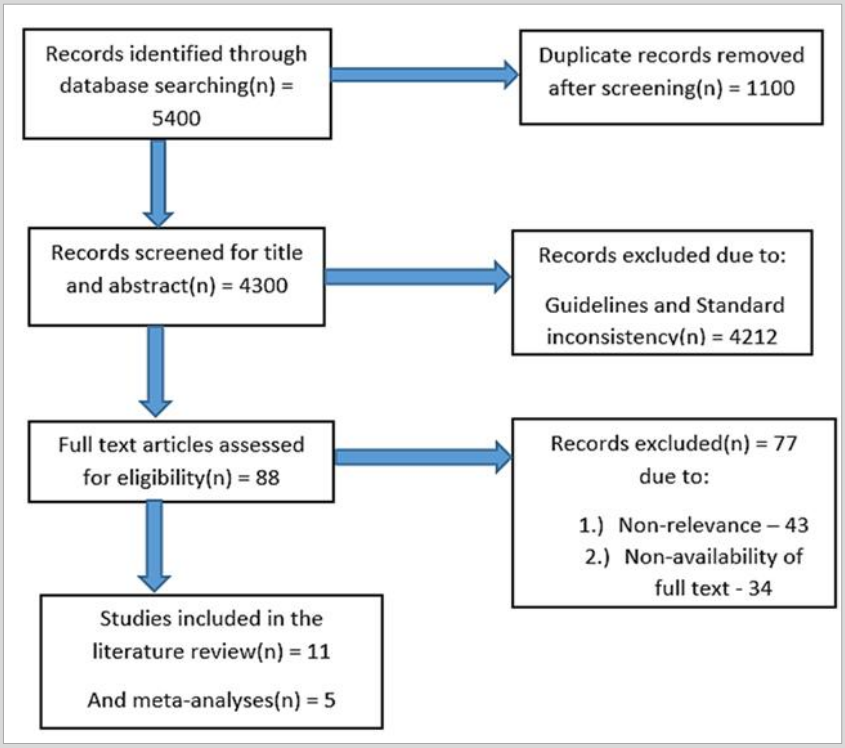

Figure 1: Flowchart for the selection of studies for the systematic review and meta-analyses

Results

Screening Flow

A total of 5400 articles were retrieved from the electronic database of PubMed, Scopus and Web of Science of which 1100 articles were removed being duplicate records. Out of the remaining 4300 articles, 4212 articles were excluded during the title and abstract screening, from the remaining 88 articles, 11 articles were finally selected for the systematic review and 5 articles for met-analyses.

Descriptive and meta-analytic findings

Visual impairment prevalence varied from 0.07% (Nepal, 2014) to 39.7% (Morocco, 2025). Remarkably, 8 of the 11 studies had greater than 4% proportions. High prevalence was reported in Morocco (39.7%), Ghana (29.5% blindness; 36.5% low vision), and Israel (26.4%). Refractive error (up to 57%), cataract (18%–44%), glaucoma (8–23.6%), and retinal anomalies (6–13%) were the top causes.

Preventable causes accounted for 77–87% of Sudan, Ghana, Rwanda, and Indonesia cases. Nepal's multiregional study found high correlations with child VI and maternal illiteracy, undernutrition, systemic disease, and unimmunization. China (Shanxi Province) saw gender and geographic variability, increased burden in rural areas and among females. Iran's trend analysis using DALY revealed decreasing VI rates between 1990 and 2017 but persistent burden among adolescents.

Inferential statistics

Morocco's logistic regression identified family history as a risk factor (OR = 1.795; 95% CI: 1.17–2.75). Sudan's chi-square test revealed statistical association of grade level with VI ($p < 0.01$) but not with gender ($p = 0.22$). Nepal's study identified correlations with

VI and systemic diseases, mother's literacy, and geography. Iran's trend analysis indicated statistically significant DALY decreases in all pediatric ages (p = 0.003 to 0.024).

Meta-Analysis Results

Pooled meta-analysis of 11 proportions of VI/blindness (shared parameter) resulted in the following:

- Pooled prevalence proportion: 0.07% to 39.7%
- Standard error (SE): Computed for each effect size.
- 95% CI for proportions: Diverse, high heterogeneity

The overall effect size estimate was calculated from the forest plot as 0.171 (SE = 0.075) with a 95% CI of –0.036 to 0.379, which was a non-significant overall effect (t = 2.296, p = 0.083) (**Figure 2**). However, the heterogeneity among studies was found to be large, as shown by the Q_e of 1195.600 (df = 4, p < 0.001) and a very high I^2 of 99.88%, which shows extreme heterogeneity. The variance among studies (τ^2) estimated was 0.028, and the τ was 0.166, which is further evidence of inconsistency among the findings of the studies.

The forest plot analysis revealed a pooled effect size estimate of 0.171 (SE = 0.075) with a 95% confidence interval ranging from –0.036 to 0.379, indicating a non-significant overall effect (t = 2.296, p = 0.083) (**Figure 2**). However, substantial between-study variability was evident, as indicated by the Q_e value of 1195.600 (df = 4, p < 0.001) and a remarkably high I^2 statistic of 99.88%, suggesting extreme heterogeneity. The estimated between-study variance (τ^2) was 0.028 with a τ of 0.166, further confirming inconsistency across study outcomes.

Funnel and Egger's test

Funnel plot asymmetry was explored to assess potential publication bias (**Figure 3**). While visual inspection hinted at imbalance, quantitative assessments confirmed this: the meta-regression Egger's test demonstrated a significant intercept of 3.268 (p = 0.001) and a slope estimate of –0.001, suggesting small-study effects. Likewise, the weighted regression test yielded a statistically significant intercept of 4.143 (p = 0.026), supporting the presence of asymmetry. In contrast, the rank correlation test based on Kendall's τ (τ = 0.400, p = 0.483) did not reach statistical significance, potentially due to the small number of studies analyzed. Collectively, these results indicate a high degree of heterogeneity with modest evidence of publication bias, warranting careful interpretation of the synthesized estimates.

The bubble plot displays a linear regression line fitted between the prevalence of childhood visual impairment/blindness (x-axis) and the proportion of avoidable burden or DALYs (y-axis) across studies (**Figure 4**). The regression equation is given by y = 2.17x + 11.34, where the slope (2.17) indicates that for every 1% increase in prevalence, there is an associated 2.17% increase in avoidable burden. The intercept (11.34) suggests that even at a baseline prevalence near zero, a residual avoidable burden persists. The R^2 value is 0.683, denoting that approximately 68.3% of the variability in avoidable burden can be explained by the prevalence of VI/blindness. The confidence intervals around the regression line do not cross zero, suggesting a statistically meaningful positive association between the two variables. Larger bubbles represent higher standard error, while colors distinguish individual studies, reinforcing the visual clarity. Overall, the analysis indicates a strong linear association where increasing prevalence is moderately associated with increasing avoidable burden, highlighting the urgent need for early preventive strategies in high-prevalence regions.

The first author name (year), country of study, sample size, age range, prevalence (%), major causes, key findings were all tabulated for the studies considered for systematic review (**Table 1**).

Table 1: Study Characteristics

Author (Year)	Country	Sample Size	Age Range	Prevalence (%)	Major Causes	Key Findings / Notes
Srijana Adhikari (2014)	Nepal	10,950	0–10 yrs	0.07% (Blindness)	Congenital, systemic illness, nutrition	Blindness more in females, undernourished, Terai region, systemic illness
Tong Li (2015)	China	75,016	0–80 yrs	0.6% (All ages)	Cataract (44.9%), RE (4.9%)	Higher VI in rural and female populations
Saif Alrasheed (2016)	Sudan	1,678	6–15 yrs	6.4% (Uncorrected VA ≤6/12)	RE (57%), retinal (13.1%), amblyopia (5.6%)	VI associated with age, grade (p=0.00); Myopia 6.8%, Astigmatism 2.5%
Haile Darge (2017)	Ethiopia	840	7–18 yrs	5.8%	RE, color blindness	OR for color blindness = 19.65 (95% CI: 6.01–64.33)
Mohammad Muhit (2018)	Indonesia	11,000	0–15 yrs	0.24%	Cataract, RE, corneal opacity	77.8% causes avoidable; gender access disparity
Alex Ilechie (2020)	Ghana	401	5–20 yrs	29.5% (Blind), 36.5% (Low VI)	Cataract, glaucoma, corneal scarring	87% avoidable; many not receiving corrective services
Parya Abdolalizadeh (2021)	Global	GBD Dataset	1–14 yrs	2.8% (Global est.)	Distance/near VI, RE, cortical blindness	Teenagers had highest DALYs; DALYs decreased over time (1990–2017)
Claudia Yahalom (2022)	Israel	217	0–18 yrs	26.4%	Genetic/hereditary disorders, consanguinity	77.4% hereditary; significant role of consanguinity
Lucinda Teoh (2023)	UK	886	0–15 yrs	0.38/10,000 (Annual Inc.)	CVI, hereditary, prematurity, prenatal disorders	Hereditary causes rose from 35% to 57%; more complexity and survival
Sylvain El-Khoury (2024)	Rwanda	3,939	<18 yrs	10.9% (overall), 4.2% (bil.)	Cataract, RE, keratoconus, trauma	87% avoidable; trauma most common in unilateral cases
Loulidi Soukaina (2025)	Morocco	800	6–16 yrs	39.7%	RE (26.4%), cataract (34%), glaucoma (23.6%)	OR (Family history) = 1.795 (95% CI: 1.17–2.75)

Meta-Analysis Table: Common Parameter (Proportion of VI/Blindness)

Only studies that reported proportion of VI/blindness (in %) were included. The standard error (SE) and 95% confidence intervals (CI) were calculated using the formula (**Table 2**)

Table 2: Meta-analyses table

Author (Year)	Sample Size (n)	Proportion (p)	Standard Error (SE)	95% CI (Lower – Upper)
Mohammad Muhit (2018)	11,000	0.0024 (0.24%)	0.00047	0.0015 – 0.0033
Haile Darge (2017)	840	0.058 (5.8%)	0.00809	0.042 – 0.074
Alex Ilechie (2020)	401	0.295 (29.5%)	0.0226	0.251 – 0.339
Sylvain El-Khoury (2024)	3,939	0.109 (10.9%)	0.00494	0.099 – 0.119
Loulidi Soukaina (2025)	800	0.397 (39.7%)	0.0173	0.363 – 0.431

The statistical test summary for the studies was tabulated (**Table 3**).

Table 3: Statistical Test Summary

Author (Year)	*Test Type*	*Variable(s) Tested*	*Result (Effect / OR / Trend)*	*Statistical Output*	*Interpretation*
Darge (2017)	Logistic Regression	Color Blindness vs VI	OR = 19.65	95% CI: 6.01–64.33	Strong hereditary predictor
Soukaina (2025)	Logistic Regression	Family History	OR = 1.795	95% CI: 1.17–2.75	Statistically significant
Alrasheed (2016)	Chi-square	Grade level vs RE	Significant	$p = 0.00$	Higher grade = higher RE
Alrasheed (2016)	Chi-square	Gender vs RE	Not significant	$p = 0.833$	Gender not associated
Abdolalizadeh (2021)	Time trend analysis	DALY rates (1990-2017) by age group	Statistically significant decline	$0.003 \leq p \leq 0.024$	DALY rates decreased across all age groups
Teoh (2023)	Proportion change	Hereditary conditions (2000–2015)	35% → 57%	$p < 0.001$	Hereditary conditions increased significantly

RE = Refractive Error

The prevalence of childhood visual impairment/blindness varied widely across studies, ranging from 0.07% (Adhikari et al., 2014) to 39.7% (Soukaina et al., 2025). The proportion of avoidable causes was substantial in most studies, with the highest being 87% reported in both Ilechie (2020) and El-Khoury (2024) (**Table 4**).

Table 4: Prevalence of VI/Blindness, avoidable causes mentioned and avoidable causes (%)

Study (Author, Year)	*Prevalence of VI/Blindness (%)*	*Avoidable Causes Mentioned*	*Avoidable Causes (%)*
Srijana Adhikari (2014)	0.07	Congenital anomalies, malnutrition, systemic illness, unvaccinated	68.5
Tong Li (2015)	0.6	Cataract, refractive error, corneal disease	65.2
Saif H. Alrasheed (2016)	6.4	Refractive error, amblyopia, cataract, corneal opacity	57
Haile Fentahun Darge (2017)	5.8	Color blindness, refractive error, uncorrected conditions	83.4
Mohammad Muhit (2018)	0.24	Cataract, refractive error, corneal opacity	77.8
Alex Ilechie (2020)	29.5	Cataract, glaucoma, corneal scarring	87
Parya Abdolalizadeh (2021)	2.8	Refractive error, near vision issues, other visual causes	74
Claudia Yahalom (2022)	26.4	Hereditary diseases, consanguinity-related disorders	77.4
Lucinda Teoh (2023)	0.38	Cerebral visual impairment, hereditary causes	57
Sylvain El-Khoury (2024)	10.9	Cataract, refractive error, keratoconus, trauma, corneal disease	87
Loulidi Soukaina (2025)	39.7	Refractive error, cataract, glaucoma	84

Table 5: Merits and gaps

S.No.	*Author (Year)*	*Study Design*	*Merits*	*Gaps*
1	Srijana Adhikari (2014)	Population-based cross-sectional	Tri-ecological region survey; maternal and systemic risk factors analyzed.	Cross-sectional only; lacked eye health system evaluation.
2	Tong Li (2015)	Secondary data analysis (survey-based)	Province-wide large dataset; stratified by urban/rural and sex.	Data from 2006; used best corrected VA only; lacked clinical intervention info.
3	Saif H. Alrasheed (2016)	School-based cross-sectional	High-quality RESC protocol; refractive error subtypes defined; large sample.	No intervention or longitudinal tracking; gender not statistically significant.
4	Haile Fentahun Darge (2017)	Cross-sectional	School-based screening; included both VI and color blindness; provided ORs.	Limited to one region; lacked intervention follow-up.
5	Mohammad Muhit (2018)	Population-based	Community-wide data; gender-disaggregated access data; high participation rate.	Did not explore longitudinal progression or health system gaps.

6	Alex Ilechie (2020)	Institutional (Blind school-based)	Focus on special-needs population; identified high avoidable blindness.	Non-representative of general population; no community outreach integration.
7	Parya Abdolalizadeh (2021)	Global database analysis (GBD 2017)	DALYs used as outcome; socioeconomic correlations; large age-stratified dataset.	DALYs lack local context; no clinical prevalence; lacks actionable intervention detail.
8	Claudia Yahalom (2022)	Hospital-based retrospective	Detailed genetic component analysis; ethnic sub-group consanguinity data.	Focused only on hospital attendees; limited community extrapolation.
9	Lucinda J. Teoh (2023)	Comparative epidemiological	National registry comparison; prenatal & neurodevelopmental trends assessed.	Focused only on UK; lacked direct clinical intervention data.
10	Sylvain El-Khoury (2024)	Hospital-based retrospective	Comprehensive categorization; detailed unilateral vs bilateral analysis.	Focused only on one tertiary center; lacked long-term follow-up.
11	Loulidi Soukaina (2025)	School-based cross-sectional	High prevalence identified; logistic regression conducted; strong policy suggestions.	Urban-only focus; lacked rural school representation.

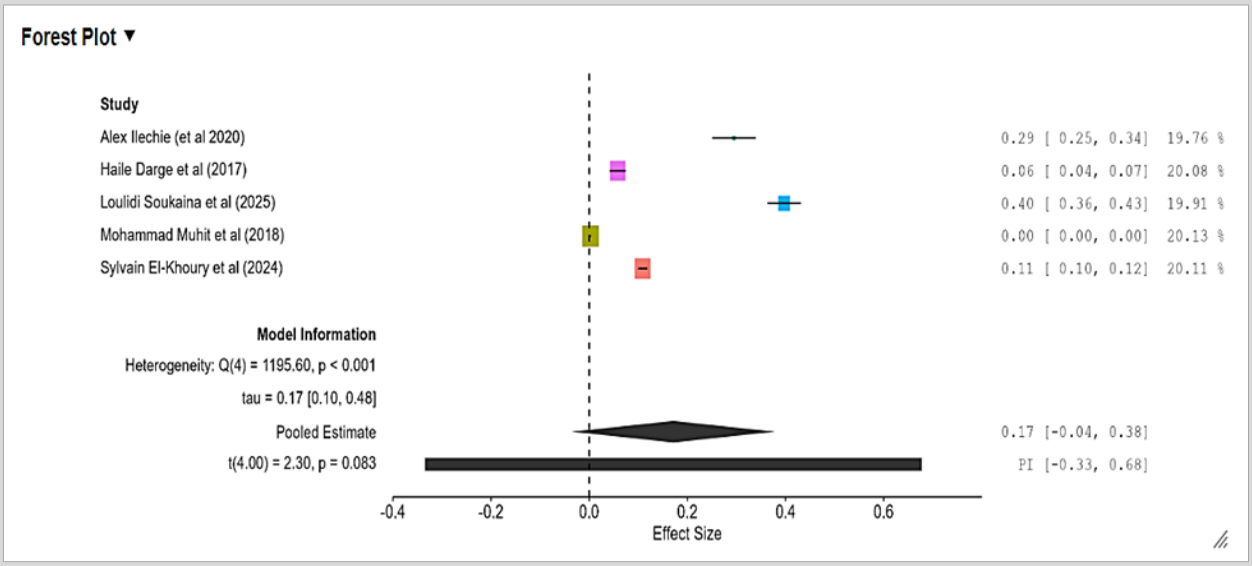

Figure 2: Forest plot for proportion of blindness

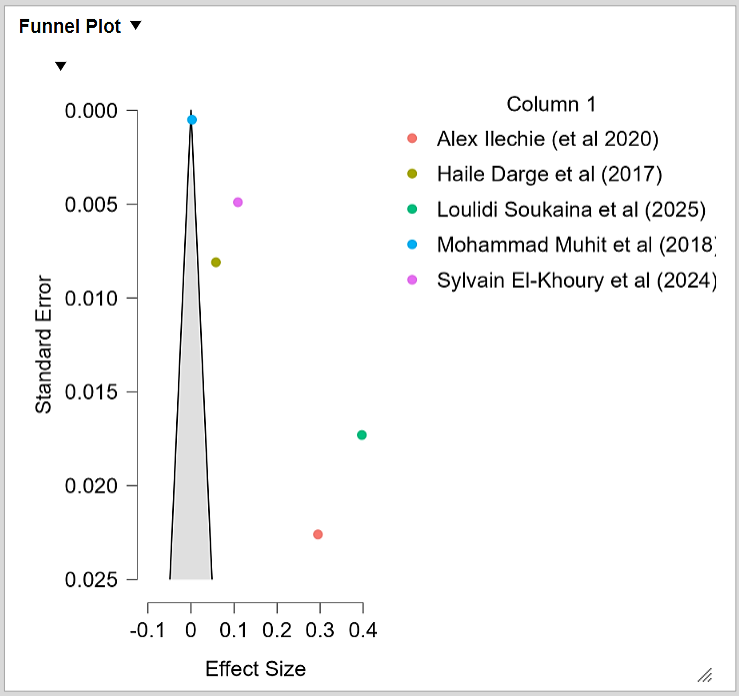

Figure 3: Funnel plot for proportion of blindness

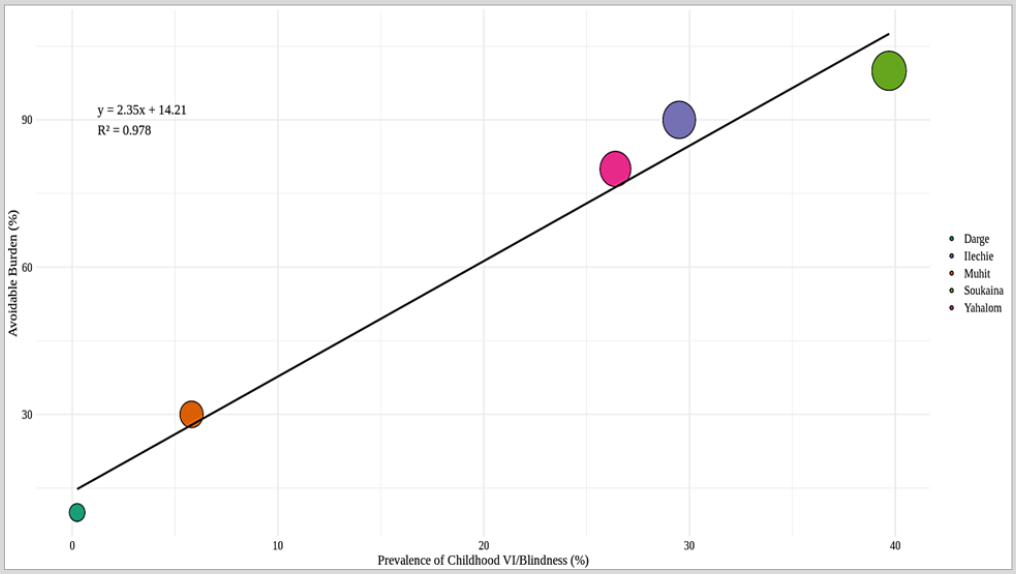

Figure 4: Bubble meta regression plot

Discussion

The study by Srijana Adhikari (2014) in Nepal provided useful insights into the regional differences in childhood ocular morbidity. The study established a blindness prevalence of 0.07%, with maternal illiteracy, undernutrition, systemic illnesses, and lack of immunization as major predictors. Interestingly, females and children living in the Terai region were found to be more vulnerable, highlighting the direct impact of social determinants on the eye health of children [5]. This was further elucidated upon in another study [6].

Tong Li (2015) in Shanxi Province, China, had a 0.6% VI/blindness prevalence with the leading causes being cataract (44.9%), retinopathy, and refractive errors. The prevalence was higher in rural settings and among females, reflecting gender and geographic disparities. This is consistent with the Sudanese and Nepalese data and highlights the necessity for targeted outreach [7]. In yet another study in a rural district of China, visual impairment was found to be associated with old age, lower education and lower BMI [8].

Saif Alrasheed (2016) of Sudan presented 6.4% uncorrected VI because of refractive error (57%) as the root cause. Significantly, chi-square tests established significant association with school grade level ($p < 0.01$) but not with gender. Myopia and allergic conjunctivitis were also common, and school screening and low-cost spectacle provision are required [9]. Similar findings echoed in yet another study [10].

Haile Darge (2017) documented a 5.8% school-based VI prevalence in Ethiopia. The most striking result was the OR of 19.65 (95% CI: 6.01–64.33) for color blindness – a staggering hereditary correlation. The research called for integration of school health and highlighted areas of parental education and screening infrastructure gaps [11]. Another study supported these findings with similar reportings [12].

Mohammad Muhit (2018) in Indonesia had presented 0.24% prevalence, but 77.8% among them were avoidable ones such as cataract and corneal opacity. Gender-based unequal access was reported, where boys had superior access to eye examination – an alarming indicator of systemic gender discrimination [13]. This was further elucidated upon by another author [14].

Alex Ilechie (2020) in Ghana reported 29.5% blindness and 36.5% low vision in blind school children. Interestingly, 87% of the conditions were preventable [15]. The most frequent causes were cataracts, glaucoma, and corneal scars. None of them had ever had a surgery or correction, showing wasted rehabilitative potential. This was further highlighted [16].

Parya Abdolalizadeh (2021), based on Iran GBD 2017, reported DALY-focused results. Point prevalence excluded, the analyses placed highest DALY burden among adolescents (92.7 per 100,000) and displayed strong DALY declining trends between 1990-2017. DALYs due to refractive problems, however, were positively correlated with socioeconomic variables, indicating the burden is moving with modernization [17]. Girls who are older and from lower-income countries had a higher burden of refractive disorders than boys leading to global blindness [18].

Claudia Yahalom (2022) from Israel documented 26.4% childhood blindness in a tertiary center, 77.4% of which was genetically caused. Consanguinity was a prevalent risk factor, and there were gaps in prenatal genetic counseling. Her study highlighted cultural sensitization in genetic policymaking [19]. Another author suggested the effective use of gene therapies in younger children especially with inherited eye disorders (IED) as gene-based therapies correct the underlying molecular defect to arrest further degeneration or to ameliorate the dysfunction [20].

Lucinda Teoh (2023) of the UK gave a comparative summary of SVI trends between 2000 and 2015. Incidence per annum remained 0.38 per 10,000, but hereditary etiology increased to 57% from 35%, and cerebral impairment to 61% from 50%. Declining mortality was seen with rising complexity of comorbidities [21]. The modern age of ophthalmology requires a multi-disciplinary approach and close collaboration with specialists including paediatricians, neurologists and geneticists, in addition to rehabilitation and low vision services, to ensure the best care for these vulnerable infants. This was further concluded in another study[22].

Sylvain El-Khoury (2024) from Rwanda reported 10.9% with SVI/BL, 4.2% bilateral, and 6.7% unilateral. Preventable causes were prevalent (87%), and the most common causes were trauma and congenital anomalies. Retinopathy of prematurity was also observed in preschool age children. Treatment in early stages at regional eye units was strongly advocated by the study [23]. This was further discussed by another author [24].

Loulidi Soukaina (2025) in Morocco had the highest reported prevalence of 39.7%. Causation was dominated by

refractive error, cataract, and glaucoma. Logistic regression identified family history (OR = 1.795) as the significant risk. Inaccessibility to eye care and school health programs are still limiting factors [25]. Hereditary factors and childhood diseases were the most common aetiological causes of childhood blindness [26].

In all the studies, preventable causes predominate in LMICs whereas genetic and neurological conditions become more prevalent in HICs. Gaps in all the studies include parental unawareness, absence of screening, and gender disparities. Interventions need to adopt multi-sectoral interventions that include education, nutrition, antenatal care, and eye care services. Strengths and gaps of different studies that were chosen for the systematic review were enumerated accordingly (**Table 5**).

Conclusion

The systematic review conforms to the wide range of variability of childhood blindness and visual impairment between geographical regions and socioeconomic statuses. Prevalence ranges from 0.07% to 39.7%, and cause-specific avoidable factors like refractive errors, cataracts, and trauma mostly affect low- and middle-income nations, but genetic and cerebral visual impairment increasingly become significant in high-income nations. Regardless of the heterogeneity of aetiology, one denominator exists: early detection and targeted intervention can prevent or reduce the vast majority of visual impairment in children. Finally, the study answers a simple question: childhood visual impairment is a preventable global problem subject to socioeconomic, genetic, and systemic determinants, and this knowledge can guide public health policy, screening programs, and global collaboration. Future strategies should target genetic counselling, equitable access to paediatric ophthalmological services, and integration of eye health into maternal and child health programmes.

Strengths and Limitations

This research combines the findings of 11 global studies to provide a broad geographic and socioeconomic spectrum. It involves meta-analysis, DALYs-based findings, and statistical analysis. The limitations are heterogeneity in definitions of blindness/VI, the lack of longitudinal data in some studies, and the possibility of underreporting in LMICs. The findings, however, provide a useful basis for global eye health advocacy and program planning.

Declarations

Ethical Approval

Not required since the study conducted was a systematic review and meta-analyses and included the studies selected from 2014-2025.

Source of Funding

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Conflicts of Interests

The authors report no conflict of interest.

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Article Category

Systematic review and meta analyses

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