• Meta-Analysis •

Retinopathy of prematurity among infants in East Africa: a systematic review and Meta-analysis

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Abstract

● **AIM:** To evaluate the pooled magnitude of retinopathy of prematurity (ROP) among infants' populations in East Africa.

● **METHODS:** A literature search was conducted using PubMed/MEDLINE, Google Scholar, Scopus, and African Journals Online to identify studies from East African published up to August 2025 that reported the magnitude of ROP and its associated factors. The quality of the included cohort and cross-sectional studies was assessed using a modified Newcastle-Ottawa Scale. A random-effects Meta-analysis was used to estimate the pooled magnitude of ROP and adjusted odds ratios (aORs) for associated factors, with results presented using 95% confidence intervals (CI). Heterogeneity among studies was assessed using the I^2 statistic, and subgroup analysis and meta-regression were performed to explore its sources. Publication bias was

assessed using funnel plots and Egger's regression test.

● **RESULTS:** A total of 11 studies were included. The pooled magnitude of ROP in East Africa was 18% (95%CI: 13%–24%, I^2=95.77%). The Meta-analysis result showed that infants who received oxygen therapy (pooled OR=4.61, 95%CI: 1.88–7.33), neonates with birth weight less than 1500 g (pooled OR=5.82, 95%CI: 2.89–8.75), and respiratory distress syndrome (pooled OR=3.92, 95%CI: 2.54–5.29) were factors associated with ROP.

● **CONCLUSION:** ROP is a significant public health concern in East Africa, affecting nearly one in five preterm infants. Policymakers and healthcare providers should prioritize evidence-based interventions targeting the prevention and early detection of ROP to mitigate its long-term impact on childhood blindness.

● **KEYWORDS:** retinopathy of prematurity; preterm infants; childhood blindness; risk factors; East Africa

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INTRODUCTION

Retinopathy of prematurity (ROP) is defined as a vasoproliferative retinal disorder that leads to childhood blindness and persists as the main cause of preventable childhood blindness[1]. ROP occurs due to abnormal development of retinal blood vessels and is a major worldwide cause of childhood blindness[2]. ROP is a potentially blinding retinal disease with poorly defined epidemiology[3]. Understanding of which infants are most at risk for developing ROP may foster targeted detection and prevention efforts[2].

Improved survival of very and extremely preterm infants in sub-Saharan Africa has been linked to an increase in reports of ROP and vision-threatening diseases, although this has historically been an issue in high-income settings[4]. Regional systematic reviews suggest a rising ROP magnitude across Africa (pooled nearly 30% in one review), and country-level studies from Ethiopia report variable magnitude depending on Neonatal Intensive Care Unit (NICU) level and screening criteria[5].

Despite these reports, the true national magnitude of ROP and the factors contributing to variation across studies such as region, screening criteria, birth weight and gestational age thresholds, and oxygen management remain unclear. A pooled estimate would provide essential guidance for screening policies, resource allocation, and advocacy toward establishing national ROP screening and treatment services[1,6]. The risk of ROP is further increased by prolonged oxygen therapy, concomitant neonatal sepsis, bronchopulmonary dysplasia (BPD), intraventricular hemorrhage (IVH), patent ductus arteriosus (PDA), and necrotizing enterocolitis (NEC)[7].

In East Africa, neonatal survival is improving, whereas NICU resources, oxygen monitoring, and standardized ROP screening programs are limited or inconsistently applied[8]. Although the main risk factors for ROP low gestational age, very low birth weight, unregulated oxygen therapy, respiratory distress, and sepsis are well recognized globally, evidence from East Africa remains fragmented and inconsistent[9-10]. Ethiopia has expanding neonatal care capacity and increasing preterm survival; single- and multi-center screening reports indicate ROP is now being diagnosed in Ethiopian NICUs and tertiary centers[11]. There are still significant uncertainties about the true pooled magnitude, the extent of region-specific risk factors, appropriate screening thresholds, and programmatic outcomes like screening coverage and treatment uptake, despite the fact that numerous studies have been carried out countries like Ethiopia[11-12], Tanzania[13], and Kenya[9,14].

This systematic review and Meta-analysis aim to generate strong pooled estimates, clarify region specific risk patterns, and provide evidence to guide context-appropriate screening policies, preventive interventions, and resource allocation. The findings will also support baseline metrics for quality improvement, directing future research priorities, and strengthening advocacy to incorporate ROP into national newborn and eye health strategies in East Africa. As a result, there is a lack of solid, combined evidence that clinicians and policymakers need to guide region-specific screening recommendations, resource distribution, training priorities, and preventative measures meant to lower preventable childhood blindness.

MATERIALS AND METHODS

Registration and Reporting The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria were followed. The protocol for this systematic review and Meta-analysis was registered with the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD420251133716.

Data Sources and Search Strategies A systematic review and Meta-analysis of both published and unpublished studies were carried out to assess the magnitude and risk factors for ROP among infants in East African countries (Kenya, Tanzania, Uganda, Somalia, Ethiopia, Rwanda, Burundi, Djibouti, South Sudan, Eritrea, Comoros, Mauritius, Madagascar, Seychelles, Malawi, Mozambique, Zambia, Zimbabwe). The search strategy utilized key terms such as "assessment",

"prevalence", "magnitude", OR "incidence", AND "retinopathy of prematurity", OR "ROP", AND "newborn", OR "neonates", "infants", AND "predictors", OR "determinants", OR "associated factors", OR "risk factors", in combination with "east African countries", applying Boolean operators ("AND" and "OR") where necessary. The search was independently conducted by three reviewers (Lakew G, Gemmechu MM, and Getahun OK). Additionally, a manual review of the reference lists from all included studies was performed to identify other relevant articles.

Generally, PubMed, Research4life, Cochran Library, Google Scholar, Scopus and Google were the databases used to search the citations. Searching attempt were tried to include grey literatures in Grey Net International.

Eligibility Criteria

Inclusion criteria This systematic and Meta-analysis review includes all relevant studies conducted in East Africa between 2015 and 2025, including both published and unpublished studies in the English language. The review covers investigations into the incidence, assessment, magnitude, predictors, determinants, risk factor, and associated factors of ROP among infants in East Africa. Included studies were conducted across both urban and rural settings. A wide range of factors sociodemographic, maternal and obstetric, neonatal, and treatment-related were examined in relation to their association with the occurrence of ROP for infants. Different study designs were included, such as cross-sectional, cohort (both prospective and retrospective), and surveillance or screening report as long as they provided the numbers needed to calculate the magnitude of ROP.

Exclusion criteria Editorials, conference abstracts, review articles, and qualitative studies were excluded, as they did not provide quantifiable data on ROP. Studies conducted outside East Africa, lack of standardized diagnostic criteria for ROP, insufficient data to estimate the magnitude or associated factors, and inappropriate study design were also excluded.

Outcome Variables and Operational Definitions In this systematic review and Meta-analysis, two research questions were assessed. The first was the percentage of people who had ROP. To account for possible heterogeneity, the pooled magnitude across the included studies was estimated using a random effects model. The second result concentrated on risk factors or predictors linked to ROP in infants in East African. Log odds ratios were used to evaluate associations based on binary data from the original studies.

Data Extraction and Management A preliminary search in Google Scholar and PubMed was done by seven authors (Ashebir YG, Getahun OK, Rundasa DT, Gemmechu MM, Zeleke ME, Atalay YA, Yirsaw AN). After this, the main searching had been done, and first, all citations from each database were exported to EndNote version 21.5, and duplications were tested to remove the duplicates. Then, five reviewers (Ashebir YG, Getahun GK, Rundasa DT, Tikuneh AH, Desalegn M) screened titles and abstracts against the inclusion criteria. Then, the full text of the articles was accessed, and an independent assessment was carried out by five reviewers (Jaleta CG, Seid K, Lorato SS, Jaleta FY, Bibi B) based on the predetermined inclusion and exclusion criteria. Discrepancies between the reviewers were resolved through discussion and common consensus of all investigators. Six authors (Belete AG, Lakew G, Bogale EK, Nigussie T, Lake EA, Hassen AA) independently extracted data from a random sample of 25% of the included papers in order to verify consistency. Prior to data analysis, the extracted data was then forwarded to each author for final approval. Name of the first author, year of publication, region, study setting, study design, sample size, response rate, number of participants with the outcome, and related factors were among the variables included in the extracted data. All information was systematically organized into individual columns for ease of analysis.

Data Quality Assessment The Newcastle-Ottawa Scale, a well-known instrument for evaluating the quality of non-randomized research, particularly cross sectional, cohort and case-control studies frequently found in systematic reviews and Meta-analyses, is reviewed in this study[15]. With a maximum score of nine, the Newcastle-Ottawa Scale evaluates research in three primary areas: comparability (up to two points), outcome or exposure (up to three points), and selection (up to four points). Studies with a score of seven or higher are regarded as high quality, while those with a score of less than seven are thought to be of lower quality. The included studies were generally of high methodological quality, as indicated by the review's average quality score of 7.45 out of 9 (Table 1[1,9,11-14,16-20]).

Data Synthesis and Analysis A standardized Microsoft Excel spreadsheet was used to extract relevant data from each study, including author names, region, study design, setting, sample size, and the reported magnitude of ROP. The extracted data were analyzed using STATA version 17. The results of this systematic review and Meta-analysis are presented as the pooled magnitude of ROP, along with 95% confidence intervals (CIs). Statistical significance was defined as a *P*-value less than 0.05. The primary outcomes were the pooled magnitude and associated factors of ROP among infants in East Africa. A random-effects model was employed to estimate the pooled effect size, accounting for variability across studies. Heterogeneity was assessed both quantitatively and qualitatively. The I^2 statistic was used to measure the degree of heterogeneity, with values <25% indicating low, 25%–50% moderate, and >75% high heterogeneity.

Table 1 The Newcastle-Ottawa Scale to assess the quality of the included 11 studies

Studies (first author, year)	Selection (4 points)	Comparability (2 points)	Outcome (3 points)	Total (9 points)
Sherief ST, 2023[11]	4	2	2	8
Woldemariam EB, 2020[1]	2	1	3	6
Asferaw M, 2020[12]	3	2	3	8
Sisay Z, 2021[16]	3	2	3	8
Ndyabawe I, 2023[17]	4	1	3	8
Onyango O, 2018[9]	3	2	2	7
Sitati S, 2019[14]	4	2	2	8
Uwizihiwe F, 2016[20]	3	2	3	8
Mutangana F, 2020[19]	3	2	3	8
Mhina C, 2025[13]	3	1	3	7
Muriithi M, 2023[18]	2	2	2	6

RESULTS

Identification of Studies This systematic review and Meta-analysis, conducted in accordance with PRISMA guidelines, aimed to evaluate the magnitude and risk factors for ROP among infants in East African. A comprehensive literature search was performed across PubMed, Google Scholar, Cochrane Library, Web of Science, and Science Direct, yielding 2123 articles. After removing 674 duplicate records, 587 articles deemed ineligible by automation tools, and 28 articles excluded for other reasons, 834 articles remained for screening. Of these, 25 full-text articles were assessed for eligibility, and 11 studies met the inclusion criteria for the final analysis. The rest 14 articles were excluded because of different criteria that include the study context, study area and study subject involvement for the study. The study selection process is illustrated in the PRISMA flow diagram below (Figure 1).

Characteristics of Included Studies From the total reviewed articles, the magnitude of ROP in East African shows wide variation across studies and settings. In Ethiopia, reported rates range from as low as 2.8% in a prospective study by Sisay[16] to as high as 35.5% in a retrospective review by Asferaw *et al*[12], with other studies reporting 13%[1] and 32.2%[11]. In Uganda, Ndyabawe *et al*[17] found a magnitude of 5.7%. Kenyan studies revealed the highest variability, with Onyango *et al*[9] reporting 41.7%, while Sitati *et al*[14] documented only 3.1%, and Muriithi *et al*[18] found 28.9%. In Rwanda, magnitude ranged between 7.3%[19] and 14.9%[20] across different study designs. A recent Tanzanian prospective study by Mhina *et al*[13] reported 29% (Table 2[1,9,11-14,16-20]).

Pooled Magnitude of ROP in East Africa The pooled magnitude of ROP among infants in East Africa, was 18% (95%CI: 13%–24%). The reported magnitudes ranged from as low as 3% (95%CI: 0–6%) to as high as 42% (95%CI: 32%–51%), with significant variation across individual studies. The heterogeneity statistics revealed significant inconsistency between studies (I^2=95.77%, Q test P<0.001). The need for uniform screening and reporting procedures across the region is highlighted by this variability, which is most likely the result of variations in study settings, populations, inclusion criteria, and methodological approaches (Figure 2).

Subgroup Analysis of ROP in East Africa The forest plot presents the pooled magnitude of ROP among infants from studies conducted in East African countries such as Ethiopia, Kenya, Rwanda, Tanzania and Uganda. In Ethiopia, four studies[1,11-12,16] reported magnitude estimates ranging between 0.03 and 0.35, with a pooled effect of 0.20 (95%CI: 0.07 to 0.34) and high heterogeneity (I^2=97.20%). In Kenya, three studies[9,14,18] showed magnitude estimates between 0.03 and 0.42, with a pooled effect of 0.24 (95%CI: -0.01 to 0.50) and significant heterogeneity (I^2=97.46%). In Rwanda, two studies[19-20] reported magnitude between 0.07 and 0.15, with a pooled effect of 0.11 (95%CI: 0.03 to 0.18) and lower heterogeneity (I^2=82.40%). In Tanzania[13] and Uganda[17], two studies reported magnitude between 0.06 and 0.29, with a pooled estimate of 0.17 (95%CI: -0.06 to 0.40). Overall, the pooled magnitude across all included East African studies was 0.18 (95%CI: 0.13 to 0.24), with substantial heterogeneity (I^2=95.77%; Figure 3).

Publication Bias The funnel plot demonstrated asymmetry, suggesting the presence of potential publication bias among the included studies on the magnitude of ROP in East Africa. Ideally, studies should be symmetrically distributed around the pooled effect estimate; however, in this analysis, studies were unevenly scattered, with several clustering on one side of the mean effect size. This visual impression of asymmetry was statistically supported by Egger's regression test, which yielded a significant result (P=0.000), confirming the likelihood of publication bias. This indicates that smaller studies with lower magnitude rates may be underrepresented in

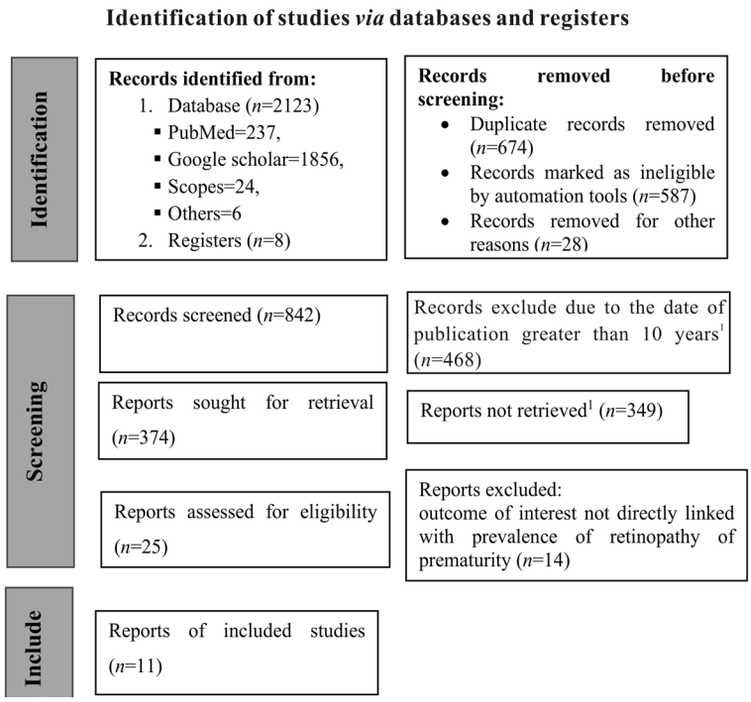


Figure 1 Preferred reporting items for systematic reviews and Meta-analyses [1]Flow chart for the review process (inclusion and exclusion of studies).

Table 2 Characteristics of 11 studies on pooled prevalence of ROP among infant in East Africa

Studies (first author, year)	Study area	Study design	Sample size	ROP (%)
Sherief ST, 2023[11]	Ethiopia	Prospective	202	32.2
Woldemariam EB, 2020[1]	Ethiopia	Retrospective	301	13
Asferaw M, 2020[12]	Ethiopia	Retrospective	93	35.5
Sisay Z, 2021[16]	Ethiopia	Prospective	174	2.8
Ndyabawe I, 2023[17]	Uganda	Cross-sectional	331	5.7
Onyango O, 2018[9]	Kenya	Retrospective	103	41.7
Sitati S, 2019[14]	Kenya	Prospective	131	3.1
Uwizihiwe F, 2016[20]	Rwanda	Cross-sectional	148	14.9
Mutangana F, 2020[19]	Rwanda	Prospective	424	7.3
Mhina C, 2025[13]	Tanzania	Prospective	193	29
Muriithi M, 2023[18]	Kenya	Retrospective	96	28.9

ROP: Retinopathy of prematurity.

the available literature, which could have influenced the pooled estimate. Consequently, nonparametric trim-and-fill analysis of publication bias was conducted and studies were imputed. The effect estimates obtained after multiple imputation were identical to those from the complete-case analysis, with similar CIs, indicating that the results were robust to missing data (Figure 4).

Sensitivity Analysis The Galbraith plot further illustrated the substantial heterogeneity found in the inclusion of studies on the magnitude of ROP in East Africa. Although most studies were plotted within the 95%CI zone, a few outliers appeared outside of it, indicating that they may have contributed disproportionately to the observed variability. Significant inconsistency across studies is indicated by the wide scattering of points around the regression line, which is consistent with the high heterogeneity statistics (I^2=95.77%, Q test P<0.001; Figure 5).

Factors Associated with ROP in East Africa According to the Meta-analysis, administering oxygen was significantly linked to a higher risk of ROP. The risk of developing ROP was approximately 4.6 times higher for infants who received oxygen therapy than for those who did not [pooled odds ratio (OR)=4.61, 95%CI: 1.88–7.33, P<0.0009]. Similarly, neonates with low birth weight (<1500 g) had a nearly six-fold increased risk of ROP (pooled OR=5.82, 95%CI: 2.89–8.75, P<0.0001), making it a significant predictor. Furthermore, neonates with respiratory distress syndrome (RDS) had nearly four times the risk of developing ROP in comparison to those without RDS

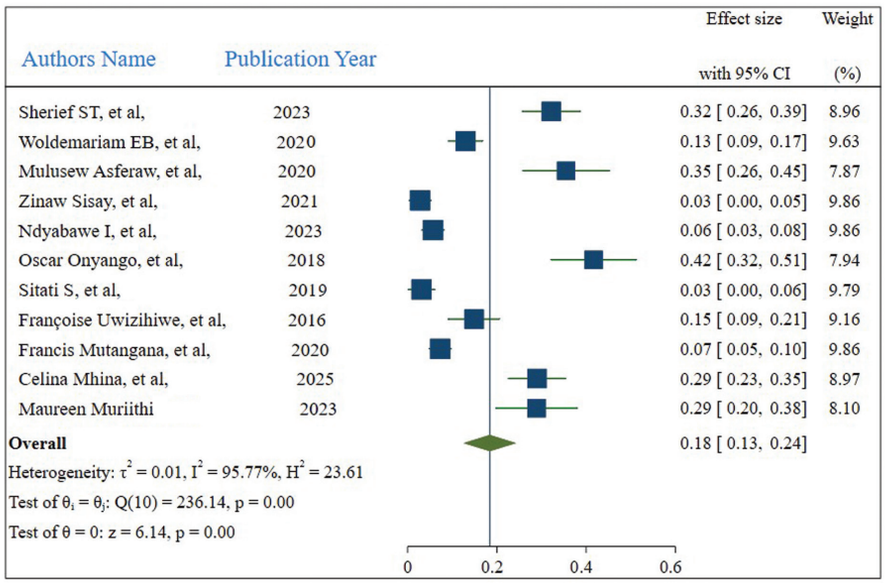


Figure 2 A forest plot for the pooled prevalence retinopathy of prematurity among infants in East Africa CI: Confidence interval.

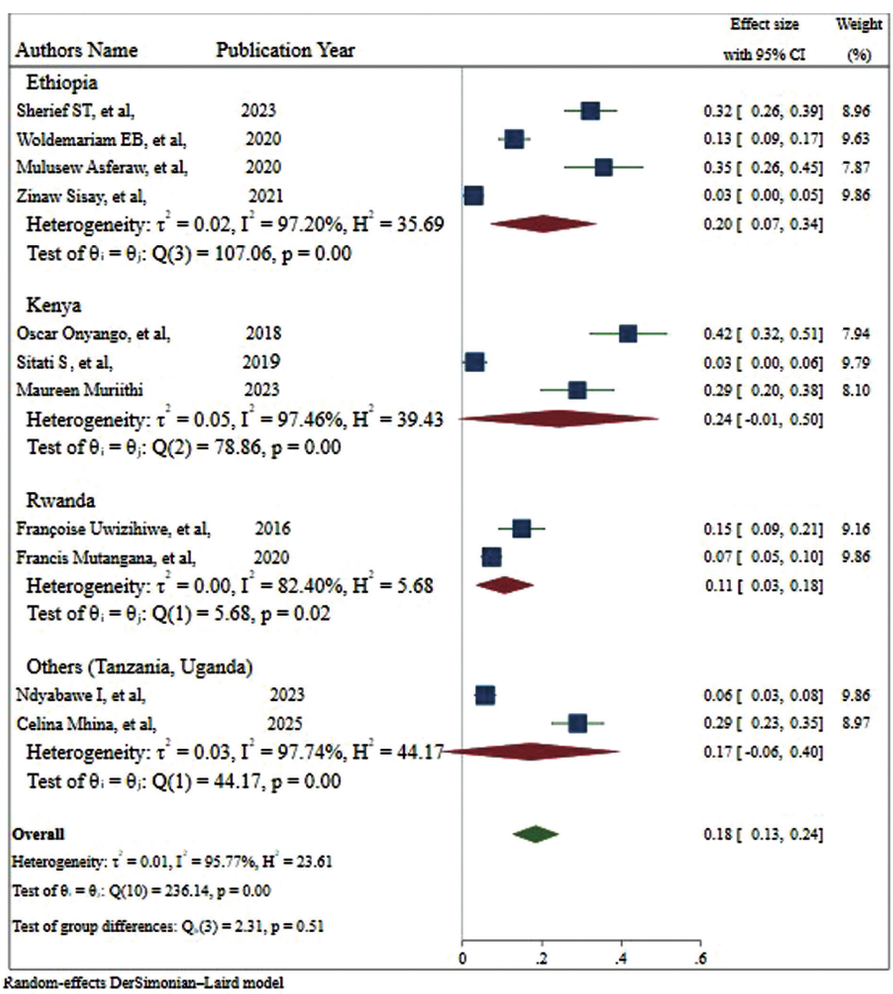


Figure 3 Subgroup analysis by region on pooled prevalence retinopathy of prematurity among infants in East Africa CI: Confidence interval.

(pooled OR=3.92, 95%CI: 2.54–5.29, *P*<0.0001; Figures 6–8).

DISCUSSION

The pooled magnitude of ROP among infants in East Africa studies was 18% with a 95%CI: 13%–24%. This study is in line with a previous study conducted in Nigeria, which reported a magnitude of 17.6%[21]. This might be due to similar neonatal care service levels, screening procedures, and preterm infant survival rates in the two areas. Both regions also face

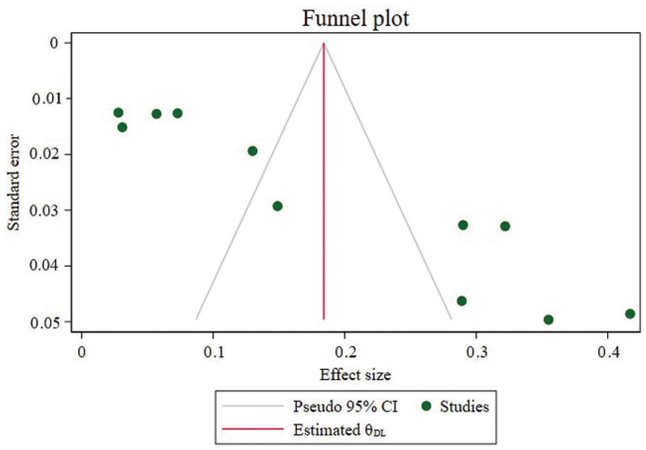


Figure 4 Funnel plot for the prevalence of retinopathy of prematurity in East Africa CI: Confidence interval.

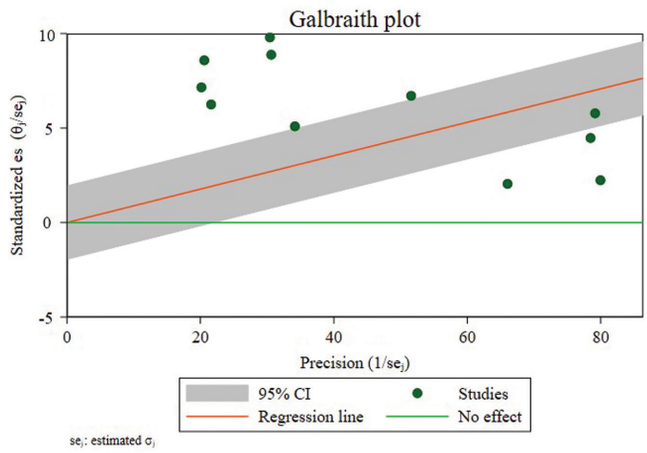


Figure 5 Galbraith plot for Meta-analysis of for the pooled prevalence of retinopathy of prematurity among infants in East Africa CI: Confidence interval.

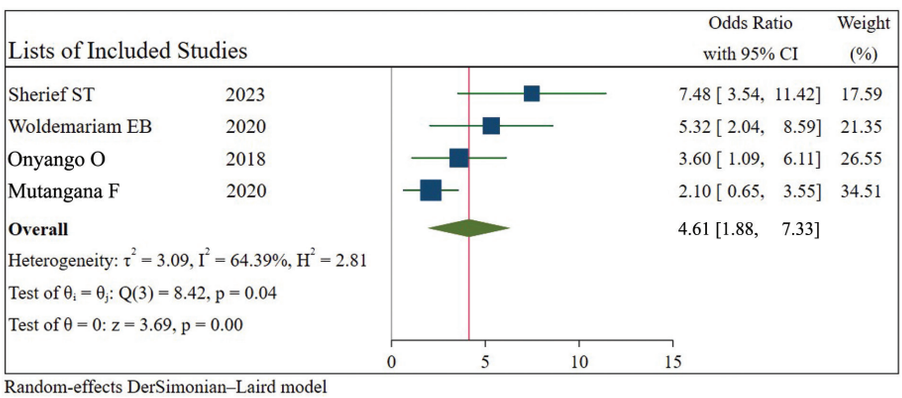


Figure 6 Pooled odds ratio of oxygen administration as a factor of retinopathy of prematurity in East Africa CI: Confidence interval.

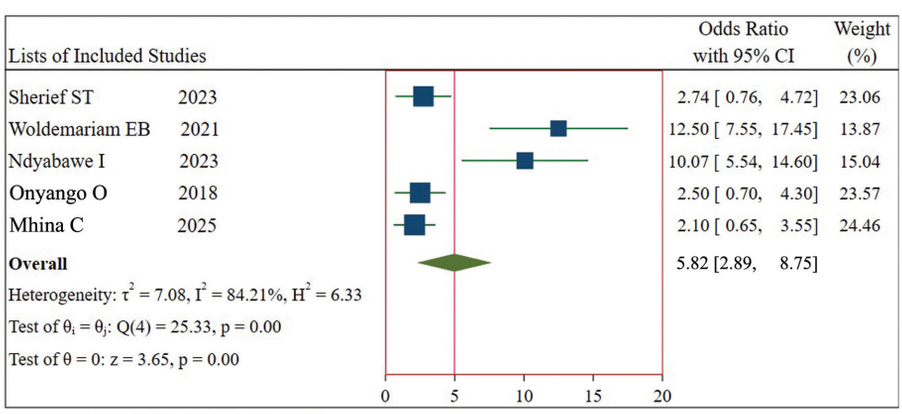


Figure 7 Pooled odds ratio of very low birth weight neonate as a factor of retinopathy of prematurity in East Africa CI: Confidence interval.

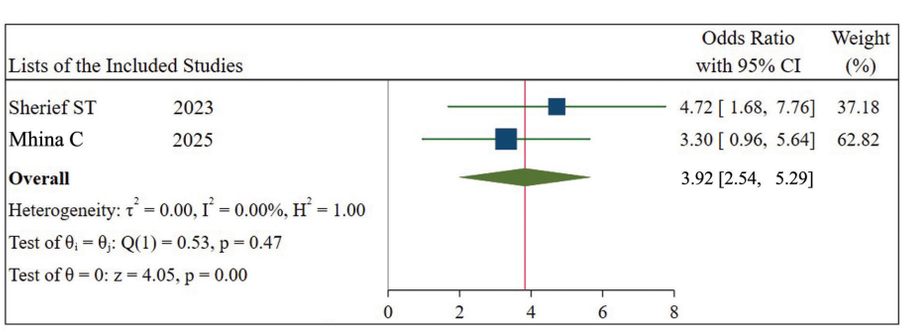


Figure 8 Pooled odds ratio for respiratory distress syndrome as a risk factor for retinopathy of prematurity in East Africa CI: Confidence interval.

similar challenges such as limited resources, inconsistent oxygen monitoring, and gaps in routine screening, which may contribute to the similarities seen in magnitude.

However, the pooled magnitude of ROP of our finding is higher than previous studies reported in Africa 30%[5], globally 31.9%[22]. This discrepancy may be attributed to differences in neonatal care practices, screening protocols, survival rates of preterm infants, study methodology, sample sizes, and clinical settings. In countries with advanced NICU, more extremely premature infants survive long enough to develop ROP, leading to higher reported magnitude. Conversely, in settings with limited resources, higher neonatal mortality before the onset of ROP may result in lower observed magnitude.

On the other hand, the pooled magnitude of ROP in the present study was lower than the studies in USA (8.1%)[2]. This variation could be explained by differences in the standards of neonatal care, the accessibility of cutting-edge screening tools, early detection and prompt intervention techniques, and study population characteristics like the distribution of gestational age and birth weight. Furthermore, the observed discrepancy may also be explained by differences in the survival of extremely preterm infants, variations in oxygen administration practices, and methodological variations in study design and diagnostic criteria.

Infants who received oxygen therapy had an approximately 4.6-fold higher risk of developing ROP compared to those who did not. This association can be explained by the effects of retinal hyperoxia caused by excessive or prolonged oxygen exposure, which leads to vasoconstriction and halts normal retinal vessel growth. Subsequent reduction in oxygen creates a relative hypoxic state, stimulating the release of vascular endothelial growth factor (VEGF) and promoting abnormal neovascularization, a key feature in the pathophysiology of ROP[23-24].

Low birth weight (less than 1500 g) was found to be a significant predictor, as the risk of ROP was almost six times higher for these neonates. This could be explained by the fact that prolonged or excessive oxygen supplementation can result in hyperoxia, which damages immature retinal vessels and causes vasoconstriction. One of the main pathological mechanisms in the development of ROP is abnormal neovascularization, which is triggered when oxygen levels are subsequently decreased[25-26]. Furthermore, preterm and critically ill neonates who already have a higher risk of developing ROP because of their low birth weight, immature organ systems, and comorbidities are frequently given oxygen therapy[27].

Additionally, neonates with RDS were nearly four times more likely to develop ROP than those without RDS. This may be explained by the fact that RDS often requires supplemental oxygen and respiratory support, both of which are major risk factors for ROP. Furthermore, pulmonary immaturity, which is characteristic of RDS, is closely associated with prematurity and low birth weight factors that substantially increase the risk of ROP[28].

This systematic review and Meta-analysis had several notable strengths. We conducted a thorough literature search across multiple databases following PRISMA guidelines, helping ensure that we captured as many relevant studies as possible. Using Meta-analysis allowed us to pool data, which increased the statistical power and provided more precise estimates of the magnitude of ROP. Importantly, these findings are particularly relevant for East African countries, where ROP is emerging as a preventable cause of childhood blindness and neonatal care services are rapidly improving.

At the same time, there are some limitations to acknowledge. We observed a high level of heterogeneity in the pooled magnitude estimates, which means that caution is needed when generalizing the findings across different settings. Publication bias is another concern, as studies with significant results are more likely to be published, potentially skewing the overall estimates. Finally, we only included English-language articles, which may have led us to miss relevant studies in other languages and slightly reduced the comprehensiveness of our review.

In conclusion, according to this systematic review and Meta-analysis, ROP represents a significant and developing public health concern in the countries. Additionally, the study identified important predictors like low birth weight, oxygen therapy, and RDS that significantly increase the risk of ROP. These findings demonstrate how urgently routine ROP screening programs, close observation of oxygen administration, and improved neonatal care procedures are needed in NICU across East Africa. Policy makers and region-based organizations, including the East African country, shall prioritize and strengthen the fight against the identified determinant factors.

The conclusions have a number of significant implications. Healthcare professionals who work in NICU should make sure that oxygen therapy is carefully administered and monitored, and that infants who are at high risk for ROP especially those with low birth weight and RDS are identified and managed as soon as possible. Reducing the risk of avoidable blindness requires incorporating regular retinal exams into neonatal care procedures and enhancing healthcare professionals' ability to screen for and treat ROP. The findings highlight the pressing need for East Africa to develop and execute standardized national and regional ROP screening and treatment guidelines. Additional risk factors that were not consistently reported in previous studies, such as sepsis, blood transfusions, maternal conditions, and genetic predisposition, should also be

investigated in future research. Furthermore, implementation research is essential to inform context-specific policies and practices by assessing the efficacy of preventive interventions and ROP screening programs in low-resource settings.

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