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Prevalence and associated risk factors of malaria in Ethiopia: An umbrella review

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Abstract

Background: Malaria is a major public health problem globally, particularly in Africa. Ethiopia is among the sub-Saharan African countries where malaria is a major cause of morbidity and mortality. Therefore, comprehensive evidence on the pooled prevalence of malaria had a valuable role in minimizing its burden.

Objective: This review aimed to assess the nationwide prevalence and associated risk factors of malaria.

Methods: Potential papers were searched systematically in Web of Science, PubMed, Science Direct databases, and Google Scholar search engine. A total of eleven relevant articles on prevalence and associated factors of malaria were identified for final umbrella review. Microsoft Excel with separate sheets for prevalence and associated factors of malaria were used to extract data. Extracted data was analyzed using STATA software version 17.0. A sensitivity analysis was performed to determine the role of each study in the final findings. The presence of publication bias was assessed by using Egger's test and funnel plot. Trim and fill analysis was implemented to obtain a bias-adjusted effect estimate. Heterogeneity across studies was checked by Inverse of variance statistics; if I^2 value ≥50%, significant heterogeneity was considered and subgroup analysis was implemented.

Results: A total of 45,597 studies were identified by the systematic search. Among these articles 11 studies were included for this umbrella review. The pooled prevalence of malaria in this review was 14.93 % (95% CI: 9.88-19.99). In addition, the pooled prevalence of *P. falciparum* and *P. vivax* were 17.79 % (95% CI: 0.93-34.95) and 9.68 % (95% CI: 1.44-17.91), respectively. The subgroup analysis based on number of studies (P=0.00) and number of sample size (P=0.01) showed significant differences in the pooled prevalence of malaria. On the other hand, the subgroup analysis based on number of sample size showed significant differences in the pooled prevalence of P. vivax (P=0.04). Among the associated risk factors, the use of insecticide-treated bed nets, indoor residual spraying, stagnant water, health education, staying outside at night, and mosquito breeding places were all statistically significant risk variables for the incidence of malaria.

Conclusions: This umbrella review showed that malaria is prevalent in Ethiopia. The observed rise in malaria prevalence highlights the need for improved infection control techniques and surveillance systems for reducing malaria burden and transmission in Ethiopia. Furthermore,

joint efforts at the local and national levels are needed to address the factors that contribute to malaria and reduce its impact on public health.

Key words: Prevalence; Malaria; associated risk factors; Ethiopia

Introduction

Malaria is a major public health problem globally, particularly in Africa and other endemic countries [1]. It is caused by protozoan parasites of the genus *Plasmodium* and transmitted by female *Anopheles* mosquitos [2]. *Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae, Plasmodium ovale,* and *Plasmodium knowlesi* are the species that infect humans among the *plasmodium* species [3]. *Plasmodium falciparum* and *P. vivax* are responsible for most of malaria infections worldwide [4]. It is highly endemic throughout sub-Saharan Africa in which 85% of global malaria cases and 90% of malaria deaths occur [5]. Approximately 12% of *P. vivax* cases and fatalities worldwide occur in Ethiopia, which also accounts for 6% of all malaria cases worldwide [6]. According to the World Health Organization's most recent World Malaria Report, there were an anticipated 263 million malaria cases and 597,000 deaths worldwide in 2023. This represents about 11 million more cases in 2023 than in 2022, with almost the same number of fatalities. Approximately 95% of fatalities occurred in the World Health Organization African Region, where many at-risk people continue to lack access to the resources they require to prevent, diagnose, and treat disease [7].

Ethiopia is among the sub-Saharan African nations where malaria is a major cause of morbidity and mortality. Because malaria occurs during harvest seasons, which lowers agricultural productivity and hence causes food insecurity and poverty. It is a major problem in the nation and has the potential to seriously harm the nation's health and socioeconomic growth [8]. Malaria also has extremely detrimental economic effects. Malaria's economic burden includes expenditures for prevention and treatment, absence from work, decreased productivity, and financial losses from neonatal mortality and morbidity [9]. Approximately 68% of Ethiopia's population lives in malaria-risk regions, which make up roughly 75% of the country's surface [10, 11]. The most common and well-known malaria-causing parasites in Ethiopia are *P. falciparum* and *P. vivax*, which cause 60% and 40% of cases, respectively [12].

Malaria is most prevalent in the western lowlands of Oromia, Amhara, Tigray, nearly the whole Gambella Regional State, and Benishangul Gumuz Regional State. In Ethiopia, the major

epidemics happen cyclically every 5–8 years, whereas focused epidemics happen annually [13]. Many factors, including the environment, human host, parasite, and vector, determine malaria transmission and rate of incidence [14]. Furthermore, the targeted malaria intervention involves the appropriate identification of factors impacting malaria risk in the population [15]. The Ethiopian federal ministry of health has been attempting to reduce the morbidity and death rate from malaria by utilizing insecticide-treated nets, regulating the environment, delivering chemoprophylaxis, and swiftly diagnosing and managing patients[16]. In Ethiopia, a number of risk factors for malaria infection have been detected, including sociodemographics, study location, living circumstances, mosquito breeding grounds, malaria prevention and control methods, sleeping habits, and knowledge and practice of malaria [17, 18].

Despite the huge distribution of malaria prevention treatments, a recent study demonstrated that there are still inadequacies and disparities in the burden, coverage, and utilization of interventions [19]. In the past several years, the incidence of parasites has increased in a few specific locations. Thus, monitoring the incidence of malaria in endemic regions on a regular basis aids in assessing the effectiveness of current therapies [20, 21].

A comprehensive study of malaria prevalence and related causes in Ethiopia is important for a variety of reasons. As a result of combining data from many systematic reviews and meta-analyses, an umbrella review gives a comprehensive picture of Ethiopia's malaria status, influencing public health policy, identifying risk factors, improving monitoring systems, and directing research objectives. Accurate epidemiological data on malaria burden are critical for all areas of malaria management, including resource allocation, targeted interventions, progress monitoring, advocacy, and funding [22]. This study supports and provides data for World Health Organization, which has goals to reduce malaria incidence by 90% by 2030, and reduce malaria mortality by 90% by 2030 [23].There is no available comprehensive nationwide evidence on the pooled prevalence of malaria in Ethiopia. So, the purpose of this umbrella review is to summarize the evidence from multiple research syntheses of prevalence of malaria in Ethiopia [24]. In this study we aimed to conduct an umbrella review to determine the pooled prevalence of malaria in Ethiopia and its associated risk factors.

Methods

Protocol, registration, and study design

The protocol for this umbrella review had already been developed and registered (PROSPERO: CRD42024598344). We used umbrella reviews to thoroughly examine studies describing malaria prevalence.

Database and Search Strategy

This umbrella review initial searches were started on 01/9/2024 and the protocol was registered on 17/10/2024. Studies published in English and conducted in Ethiopia until 4/10/2024 were included in this umbrella review. An inclusive literature search was conducted to identify studies about the prevalence and associated factors of malaria reported among the Ethiopian population of various study subjects. Systematic searches were conducted for both electronic and grey literature. PubMed, Science Direct, Web of science, and Google Scholar were used to retrieve data. Boolean operators like "OR" and "AND" have been used in addition to search terms used alone. An example of keywords used in Google Scholar to select relevant studies was as follows: [Prevalence AND malaria OR *P. falciparum* OR *P. vivax* OR *P. ovale* OR *P. malariae* OR *P. knowlesi* AND associated factors OR risk Factors," "Ethiopia" 2014-2024]. Furthermore, a snowball search was performed on the citation lists of the included studies. The researcher incorporated studies recorded from 2014 until October 4, 2024.

Eligibility criteria

Articles obtained from the abovementioned databases were imported to EndNote version 20 reference managing software (Tomson Reuters, New York, NY. For this umbrella review, the included studies were: 1) systematic reviews and meta-analyses of cross sectional and observational studies that gave a prevalence of malaria 2) Articles published in peer-reviewed journals; and 3) articles published in English from 2014 to October 04, 2024. We rejected studies if: 1) they had a low quality score according to the mentioned criteria. 2) Case series, letters, comments, and editorials: and/or failed to measure the desired outcome (i.e. prevalence and/or associated risk factors of malaria); 3) Study designs beyond systematic reviews and meta-analyses were excluded; 4) If they were not provided sufficient data for pooling of prevalence were excluded.

Outcome of Interest

The main outcome of interest was the prevalence and associated risk factors of malaria in Ethiopia reported in the systematic reviews and Meta analyses both as a percentage and as the number of cases (n)/total number of participants (N).

Study Selection and Quality Assessment

Each included systematic review and meta-analysis using the assessing the methodological quality of systematic reviews (AMSTAR) tool [25]. Two independent reviewers (W.A and A.M) screened the titles identified in the abovementioned databases. Following this, three reviewers (W.A, A.BZ, and H.SN) independently screened eligible studies for abstract. Finally, full-text screening was conducted by four reviewers (W.A, A.M, A.BZ, and H.SN). The nine critical appraisal checklists were assessed for evaluation of quality of systematic review papers. This review includes studies having a final quality score of at least 50%.

Data Extraction

A standardized data extraction form on Microsoft Excel 2010 was utilized to systematically gather or record relevant information from each included potential study. The extraction process covered various domains, including study characteristics, such as first author, year of publication, the study design, number of participants, study area, the prevalence and associated factors of *plasmodium* species and malaria in each study were collected. The extracted data were checked by two reviewers (W.A and A.M) for accuracy and consistency. The third reviewers (H.SN) were also engaged where necessary.

Statistical Analysis

The extracted data were entered into Microsoft Excel and analyzed using STATA version 17 (Stata Corp. Stata Statistical Software. College Station, TX: Stata Corp LP). A random-effects model was used to get an overall summary estimate of the prevalence across studies. Point estimation with a confidence interval of 95% was used. Sensitivity analysis was conducted to assess the role of each study in the final result by excluding each study one by one and presence of publication bias was assessed by using visually inspecting funnel plots and Egger's test. Trim and fill technique studies were performed to generate a bias-adjusted effect estimate. Heterogeneity across studies was checked by Inverse of variance (I^2) statistics; if the I^2 value

was≥50%, significant heterogeneity was considered. When studies were significantly different (I^2 ≥50%), we explored sources of heterogeneity through subgroup analysis.

Results

Overall, 2,688 relevant articles were found during the initial search. These articles were arranged using citation management software (EndNote X 20) after obtaining them from various databases and search engines. The 1204 articles were excluded due to redundancy. Of the 1484 items examined for title, 1271 were excluded. Furthermore, 68 papers were removed based on their abstracts since they were unrelated to the current review. After a full-text screening, 134 publications from the remaining 145 researches were disqualified since they had no bearing on the current review. After a comprehensive examination utilizing predetermined standards and a quality evaluation, 11 studies were included in the final meta-analysis [26-36] . The included studies were all released between January 01, 2014 and October 30, 2024. A flow diagram elucidating the literature screening process is presented in (**Figure 1)**.

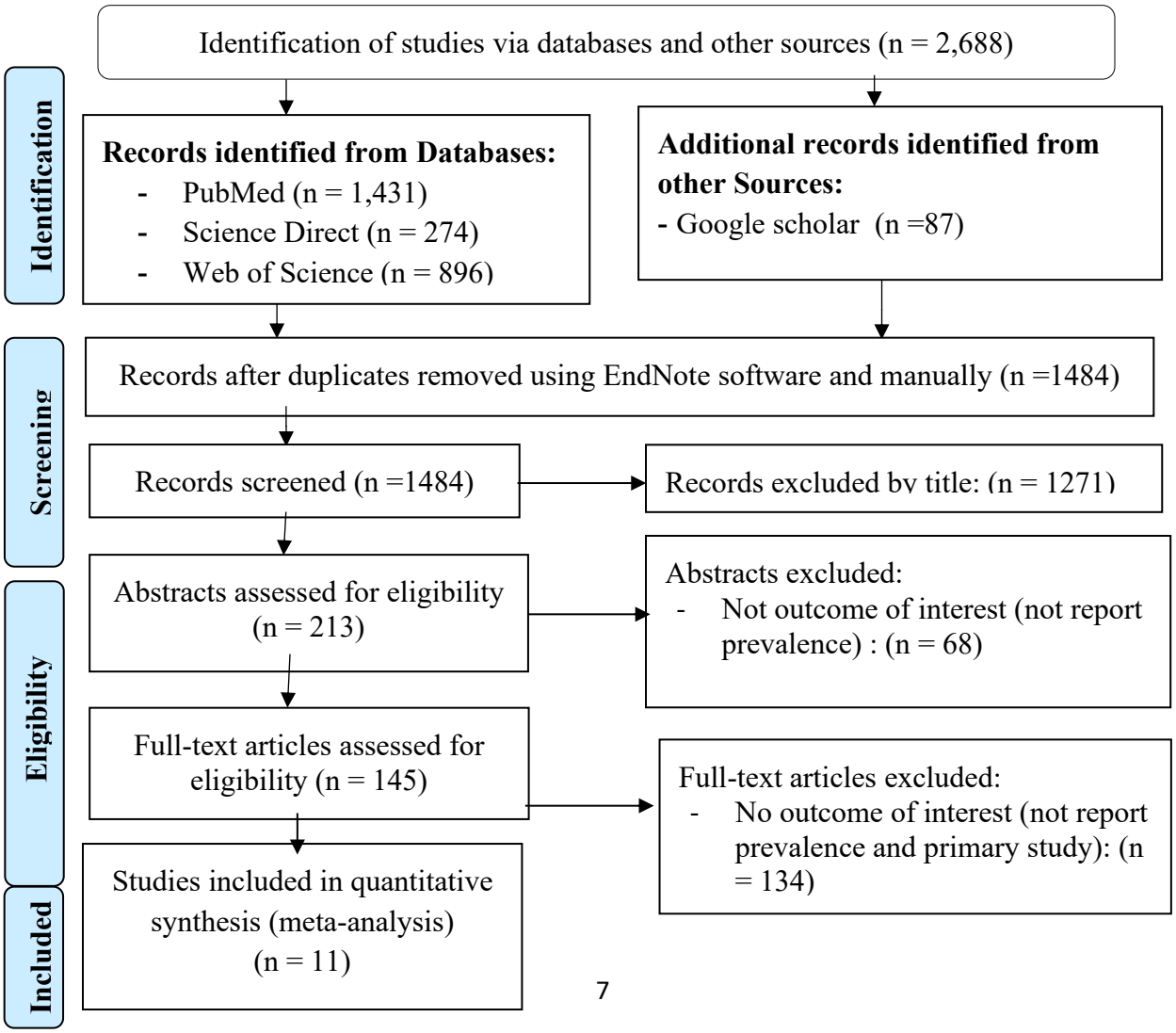


Figure 1: PRISMA flow diagram indicated the results of the search and reasons for exclusion [37]

Characteristics of the included studies

All systematic review and meta-analysis studies included in this review were cross sectional and observational in design. Also, they included a total of 208 studies, providing a total sample of 8,706,234 study participants. The number of studies per systematic review and meta-analysis ranged from 6 (lowest) [28] to 79 (highest) [34]. The sample size per meta-analysis ranged 1857 (lowest) [28] to 5,930,976 (highest) [34]. The overall characteristics of the included studies, including the topic they addressed, are shown in (**Table1)**.

Table.1 Characteristics of the included studies in an umbrella review.

Author	Year of Publication	Country	Study participants	Sample Size	Number of article	Study design	Malaria prevalence (%)	Quality
Gizachew A. et al [26]	2024	Ethiopia	Pregnant women	3277	10	Bayesian study design (Cross-sectional study design)	7.03	9
Addisalem W. et al [27]	2024	Ethiopia	vulnerable population	7597	12	Bayesian study design (Cross-sectional study design)	11.10	9
Tadesse D. et al [28]	2023	Ethiopia	pregnant women	1857	6	Bayesian study design (Cross-sectional study design)	7.2	9
Afework T. et al [29]	2022	Ethiopia	General population	5924	14	Bayesian study design (Cross-sectional study design)	6.7	9
Anmut A. et al [30]	2022	Ethiopia	General population	1,622,356	18	Bayesian study design (Cross-sectional, retrospectives, and longitudinal research design)	16.24	9

Gebeyaw B. et al [31]	2022	Ethiopia	Children	34,842	12	Bayesian study design (Cross-sectional, retrospective and Bayesian study design)	22.03	9
Yalewayker T. et al [32]	2021	Ethiopia	Children	26,148	7	Bayesian study design (Cross-sectional study design)	9.07	9
Fasil A. et al [33]	2021	Ethiopia	Adult population	7895	8	Bayesian study design (Cross-sectional and longitudinal research design)	13.61	9
Tsige K. et al [34]	2021	Ethiopia	General population	5,930,976	79	Bayesian study design (Cross-sectional and retrospective study design)	28.3	9
Yalewayker T. et al [35]	2019	Ethiopia	Pregnant Women	10207	7	Bayesian study design (Cross-sectional study design)	12.72	9
Teshiwal D. et al [36]	2019	Ethiopia	General population	1,055,155	35	Bayesian study design	25.8	9

Heterogeneity of included studies

The heterogeneity was assessed for prevalence of malaria. There was significant heterogeneity on prevalence of malaria, with I^2 statistics showing higher than or equal to 99.99% at P value = 0.00 [26-36].

Publication bias of included studies

A funnel plot was used for assessing potential publication bias in the included studies. As a result, the visually inspected funnel plot showed asymmetry, indicating that publication bias existed among studies. An Egger's test was used to evaluate the potential publication bias in the included studies. The Egger's test of malaria prevalence indicated that there was publication bias with a p-value= 0.0006 [26-36]. Also, the visually inspected funnel plot of malaria, *P. falciparum,* and *P. vivax* prevalence indicated that there was publication bias (Figure 2, 3, and 4), respectively. To reduce and correct for the observed publication bias in the studies, a trim and fill analysis was done to estimate the number of potentially missing studies. After adjusting for publication bias, the estimated pooled prevalence of malaria, *P. falciparum*, and *P. vivax* was 15.758 (95% CI = 10.868 - 20.648), 23.085 (95% CI = 8.489-37.681), and 12.763 (95% CI = 5.309-20.217), based on trim and fill analysis **(Table 2, 3, and 4),** respectively.

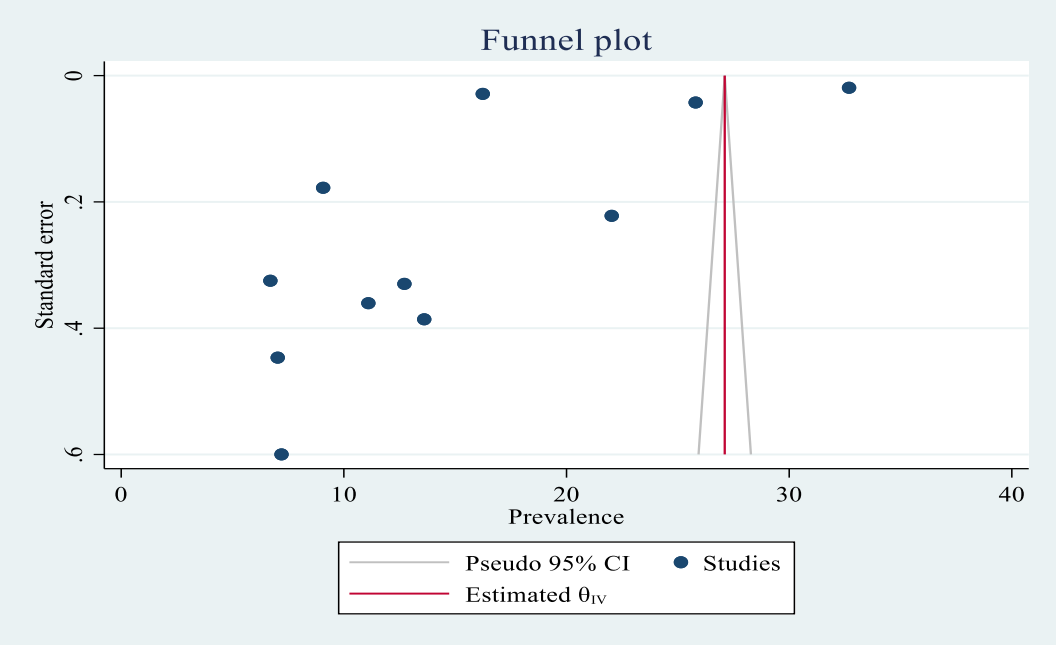


Figure 2: Funnel plot for Publication bias of studies for prevalence of malaria.

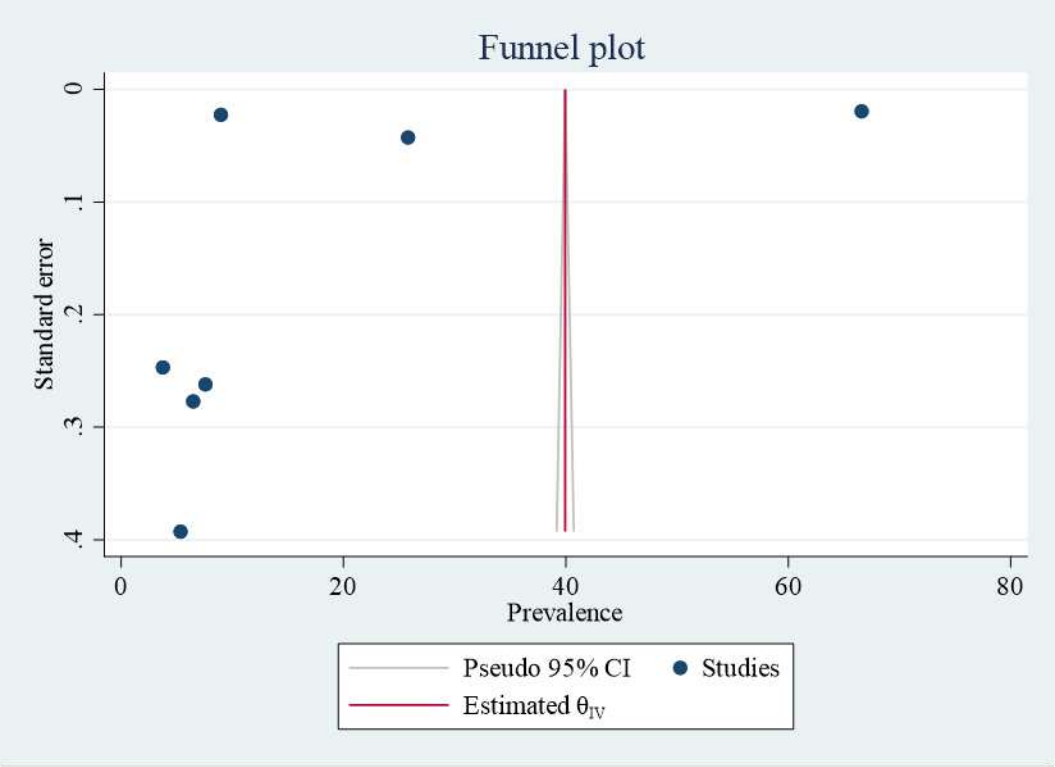


Figure 3: Funnel plot for Publication bias of studies for prevalence of *P. falciparum*.

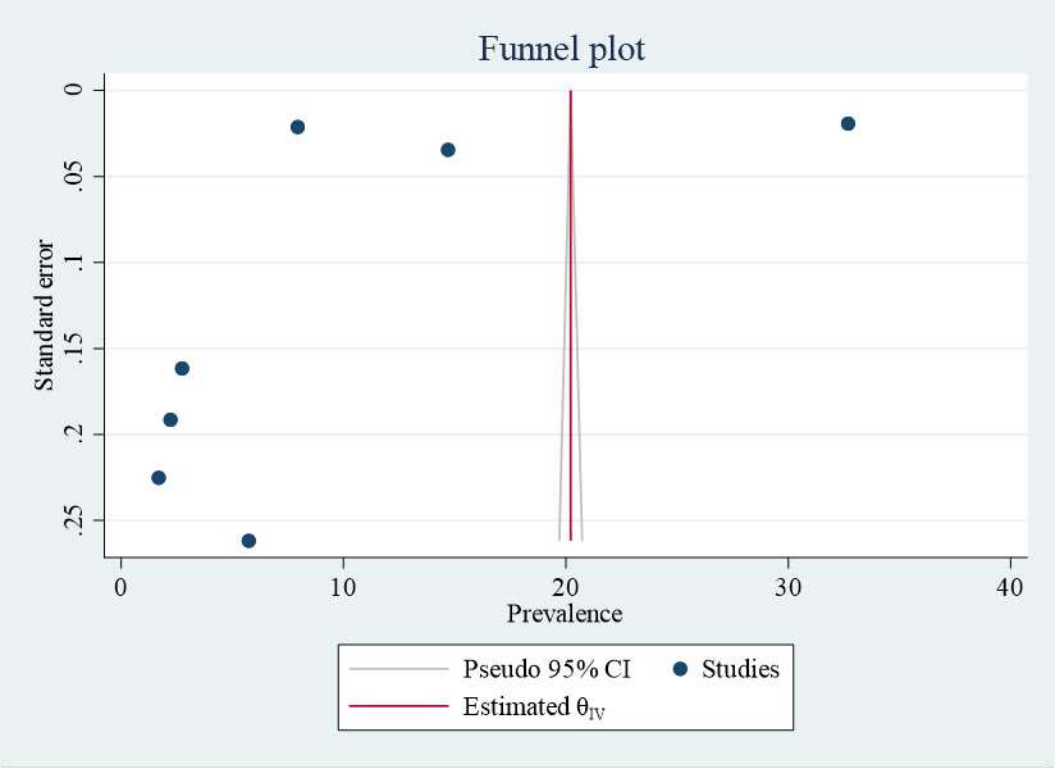


Figure 4: Funnel plot for Publication bias of studies for prevalence of *P. vivax*.

Table 2: Trim-and-fill analysis for the prevalence of malaria.

Studies	Effect size	[95% CI]
Observed [11]	14.934	9.878-19.990
Observed + Imputed [11+1]	15.757	10.868-20.646

Table 3: Trim-and-fill analysis for the prevalence of *P. falciparum*.

Studies	Effect size	[95% CI]
Observed [7]	17.788	0.928-34.649
Observed + Imputed [7+2]	23.085	8.489-37.681

Table 4: Trim-and-fill analysis for the prevalence of *P. vivax*.

Studies	Effect size	[95% CI]
Observed [7]	9.676	1.443-17.908
Observed + Imputed [7+2]	12.763	5.309-20.217

Sensitivity: In sensitivity analyses utilizing the leave-one-out strategy, eliminating none of the studies had a significant influence on pooled burden estimates and heterogeneity measures within review studies. Therefore, sensitivity analysis employing the random-effects model indicated that no one research altered the overall prevalence of malaria, *P.falciparum*, and *P.vivax* **(Figure 5, 6, and 7), respectively, [26-36]**.

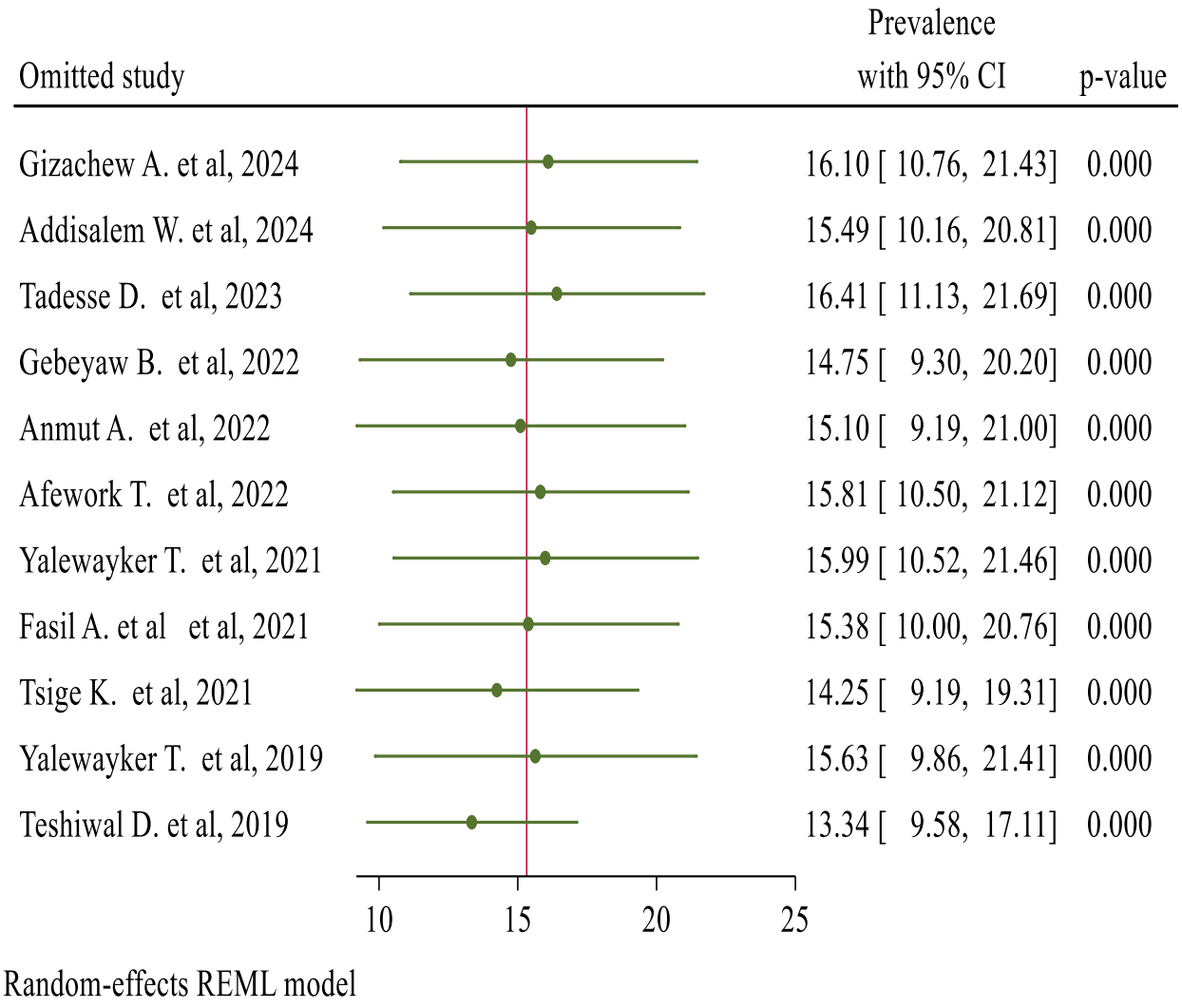


Figure 5: Sensitivity analysis result of included studies on prevalence of malaria.

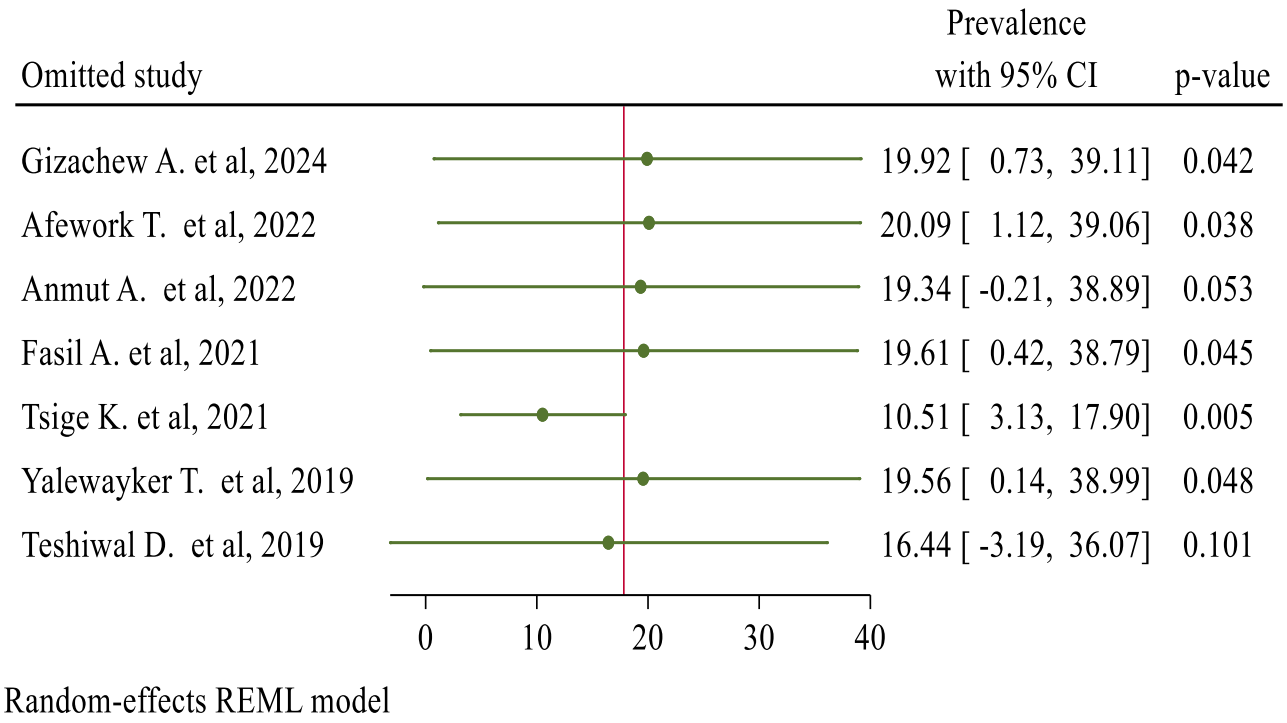


Figure 6: Sensitivity analysis results of included studies on prevalence of *P. falciparum*.

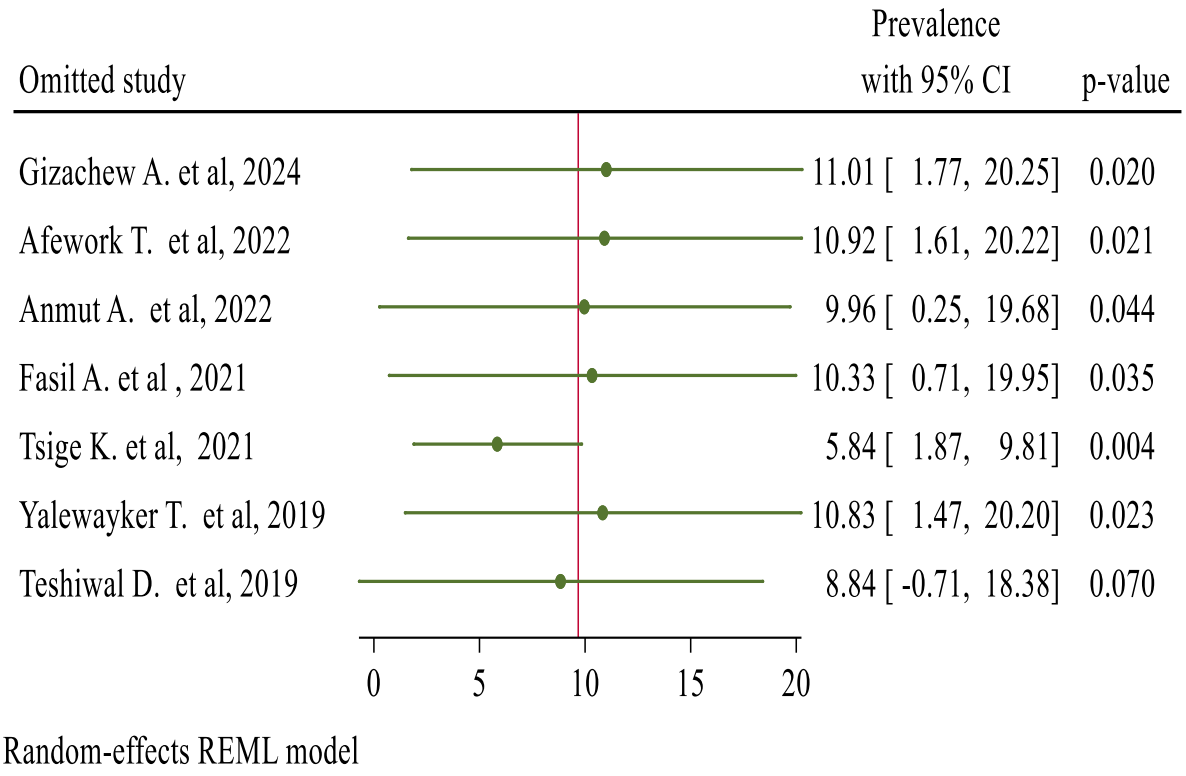


Figure 7: Sensitivity analysis result of included studies on prevalence of *P. vivax*.

Pooled prevalence of malaria, *P. falciparum*, and *P. vivax* in Ethiopia

The pooled prevalence of malaria was 14.93 % (95% CI: 9.88-19.99) [26-36]. Similarly, the pooled prevalence of *P. Falciparum* and *P. vivax* was 17.79 % (95% CI: 0.93-34.95) and 9.68 % (95% CI: 1.44-17.91), respectively. A random-effects model shows the presence of heterogeneity among the included studies which deals about prevalence malaria, *P. falciparum*, and *P. vivax* with 95% CI (I^2 = 99.99 %, 100%, and 100% and P-value = 0.00,0.00, and 0.00 , respectively).

Due to the presence of significant heterogeneity between the included studies, subgroup analysis was carried out to know the prevalence of malaria, *P. falciparum*, and *P. vivax* among review articles **(Figure 8, 9, and 10),** respectively.

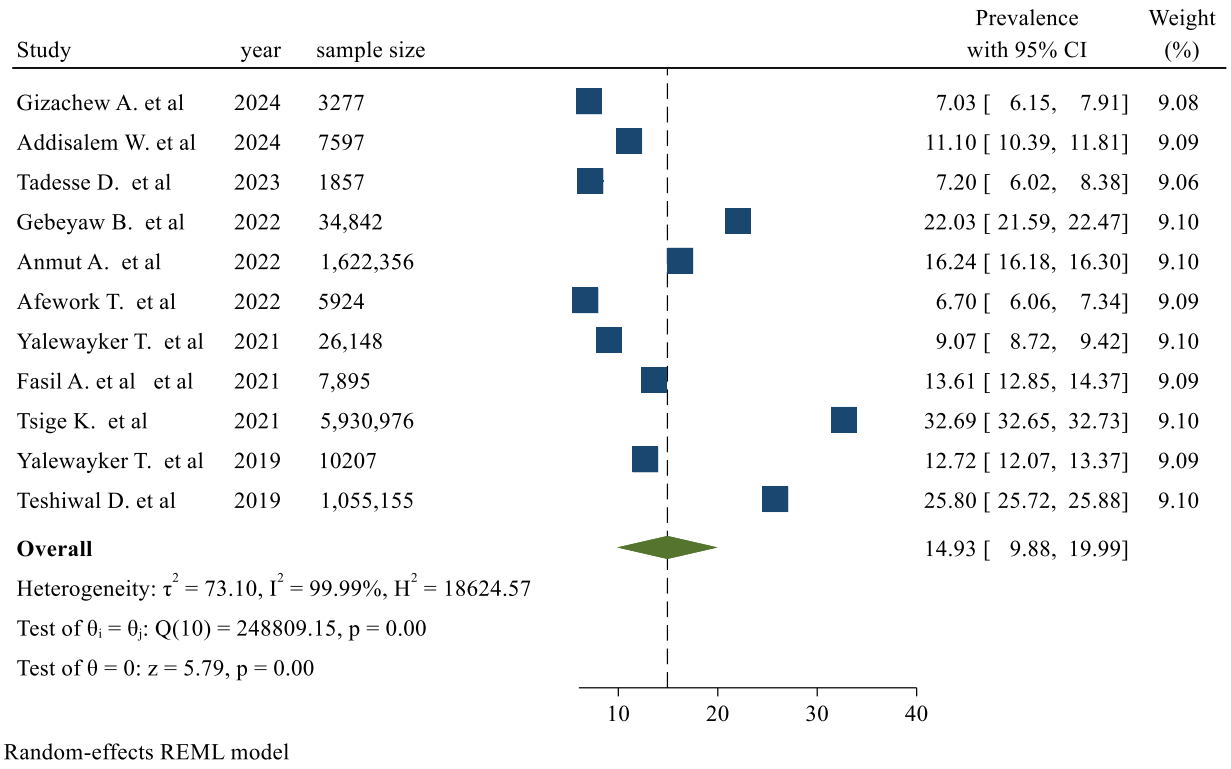


Figure.8 Forest plot for the pooled prevalence of malaria

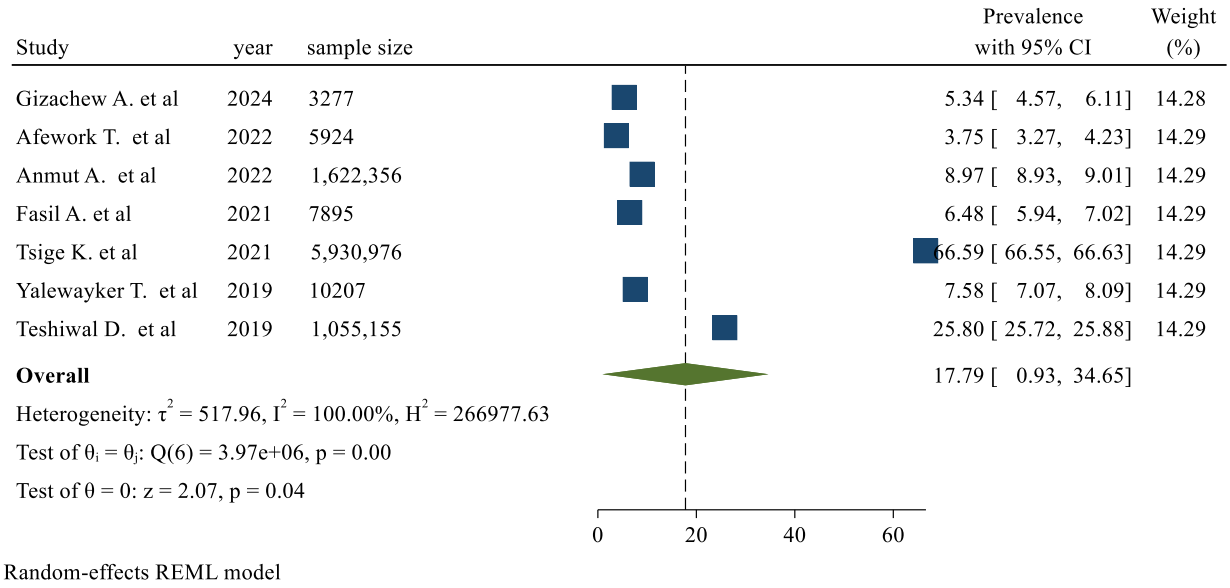


Figure.9 Forest plot for the pooled prevalence of *P. falciparum.*

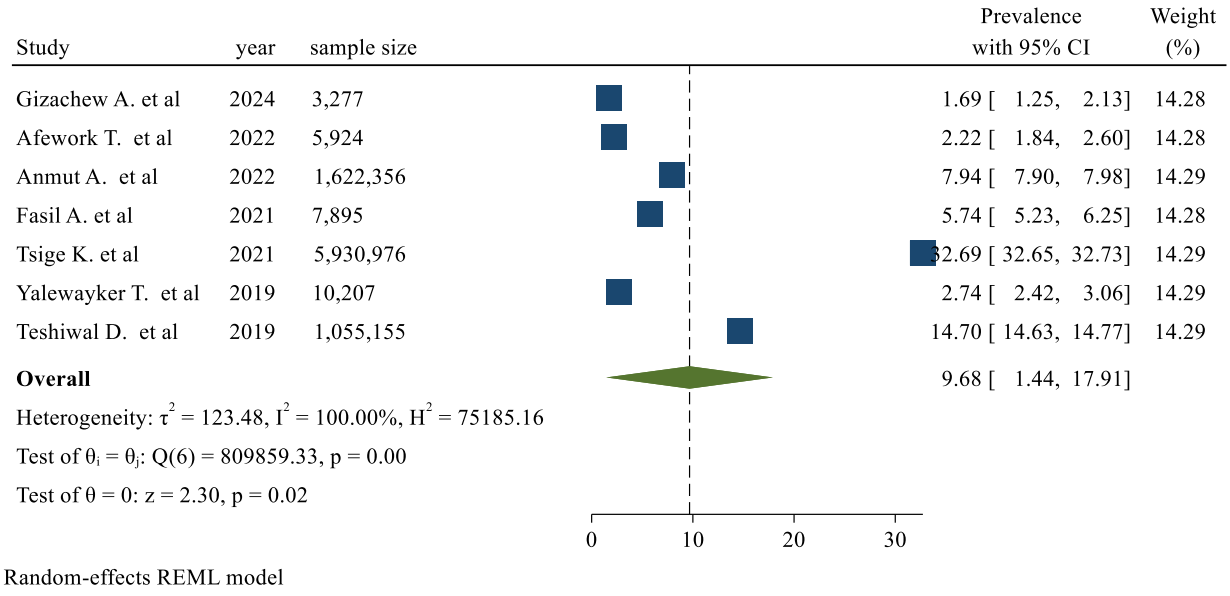


Figure.10 Forest plot for the pooled prevalence of *P. vivax.*

Subgroup analyses of malaria prevalence, *P. falciparum*, and *P. vivax* in Ethiopia by number of studies and sample size.

There was high significant heterogeneity among included studies about prevalence of malaria, *P. falciparum,* and *P. vivax*. Inverse of variance (I^2) statistics showed greater than or equal to 99.99 % heterogeneity among studies for prevalence of malaria. To identify the possible source of heterogeneity, subgroup analysis was performed for prevalence of malaria on number of studies and number of sample size. Consequently, the analysis showed significant difference in frequency of malaria among studies on number of studies and number of sample size **(Figure 11 and 12)**. Also, Inverse of variance (I^2) statistics showed greater than or equal to 100% heterogeneity among studies for prevalence of *P. falciparum*. Similarly, to identify the possible source of heterogeneity, subgroup analysis was performed for prevalence of *P. falciparum* on number of sample size. The analysis showed no significant difference in frequency of *P. falciparum* among studies on number of sample size **(Figure 13)**. Inverse of variance (I^2) statistics showed greater than or equal to 100 % heterogeneity among studies for prevalence of *P. vivax*. Likewise, to identify the possible source of heterogeneity, subgroup analysis was performed for prevalence of *P. vivax* on number of sample size. Therefore, the analysis showed significant difference in frequency of *P. vivax* among studies on number of sample size **(Figure 14)**.

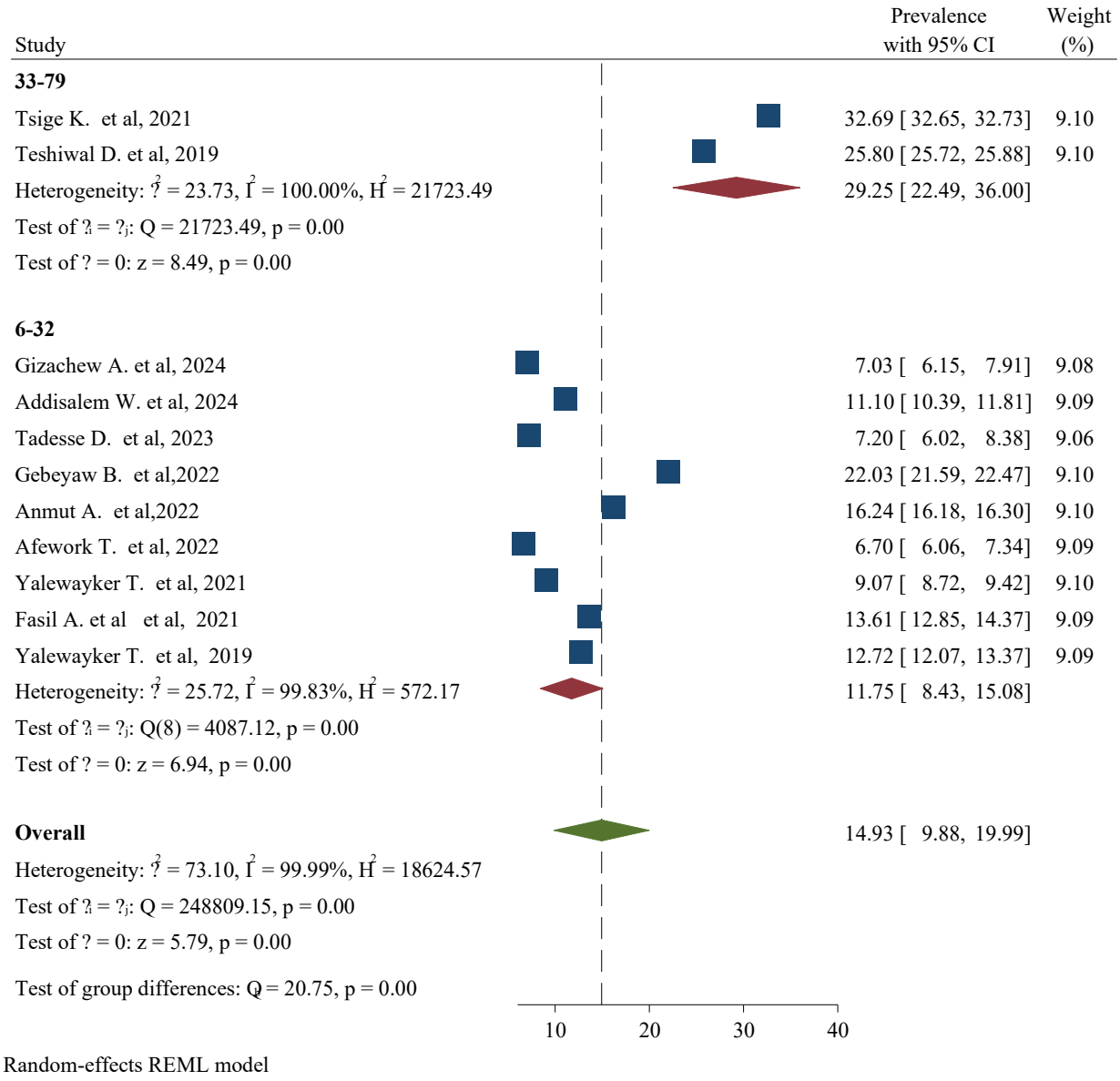


Figure.11 Subgroup analysis for pooled prevalence of malaria based on number of studies.

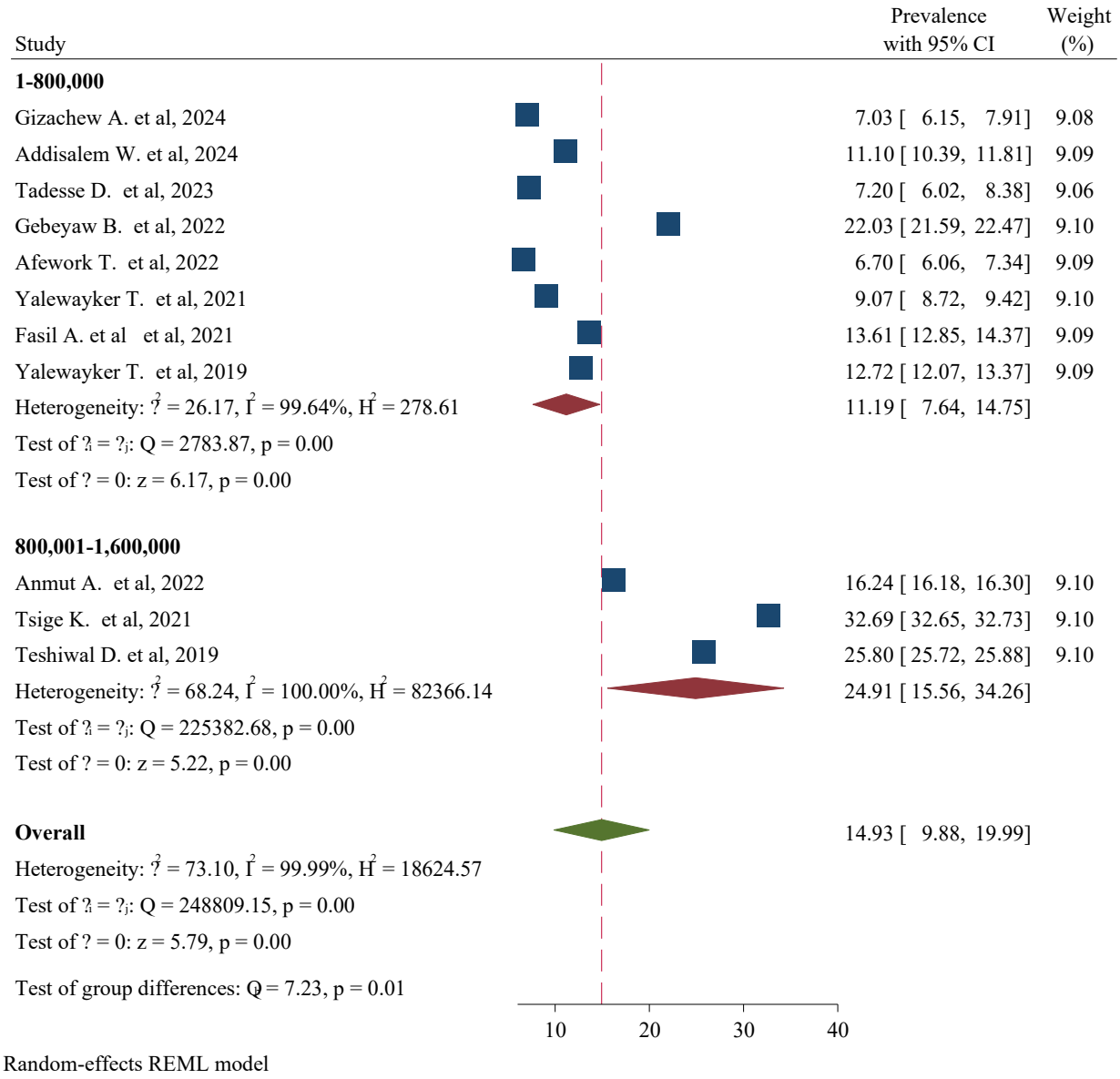


Figure. 12 Subgroup analysis for pooled prevalence of malaria based on number of sample size.

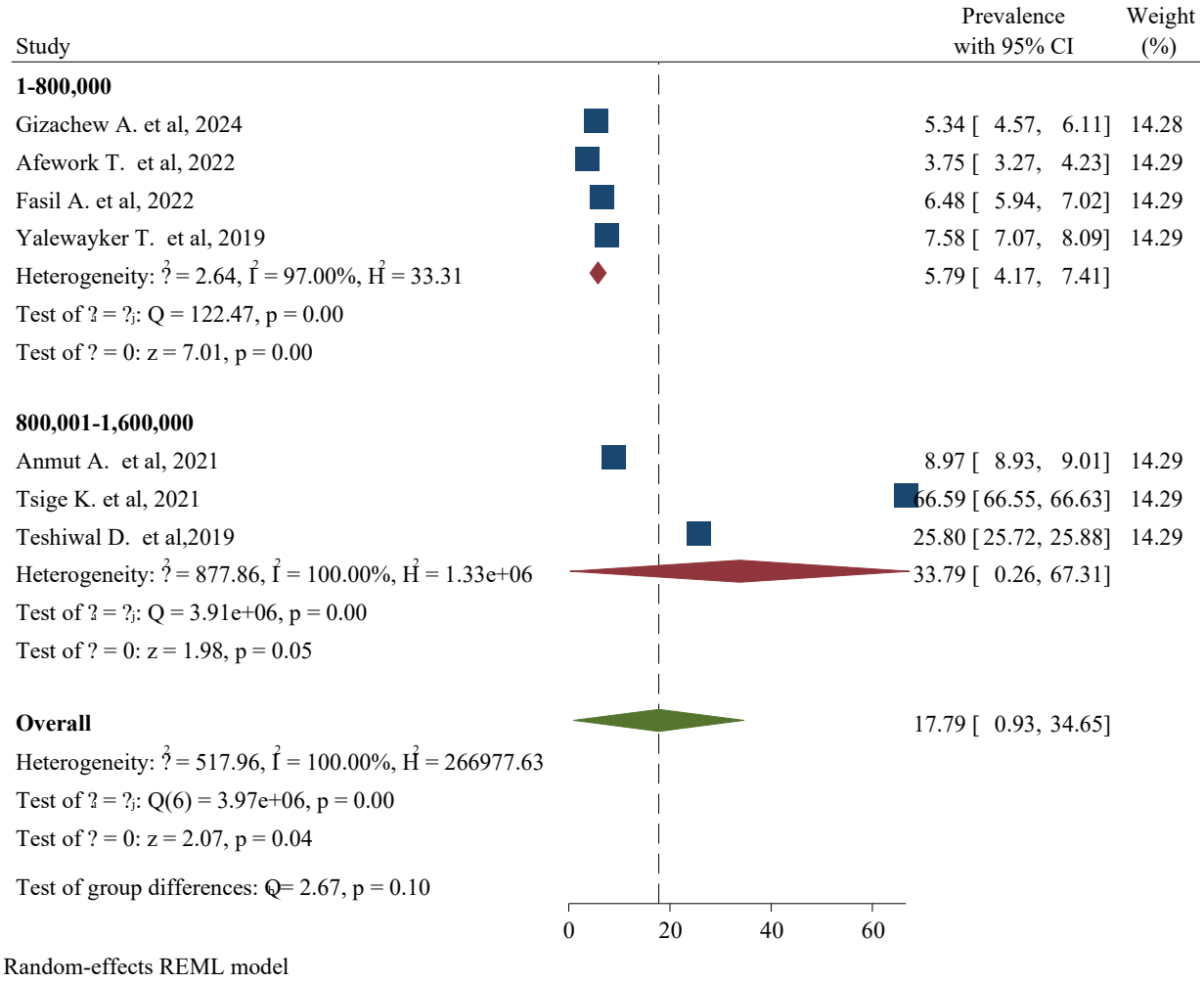


Figure.13 Subgroup analysis for pooled prevalence of *P. falciparum* based on number of sample size.

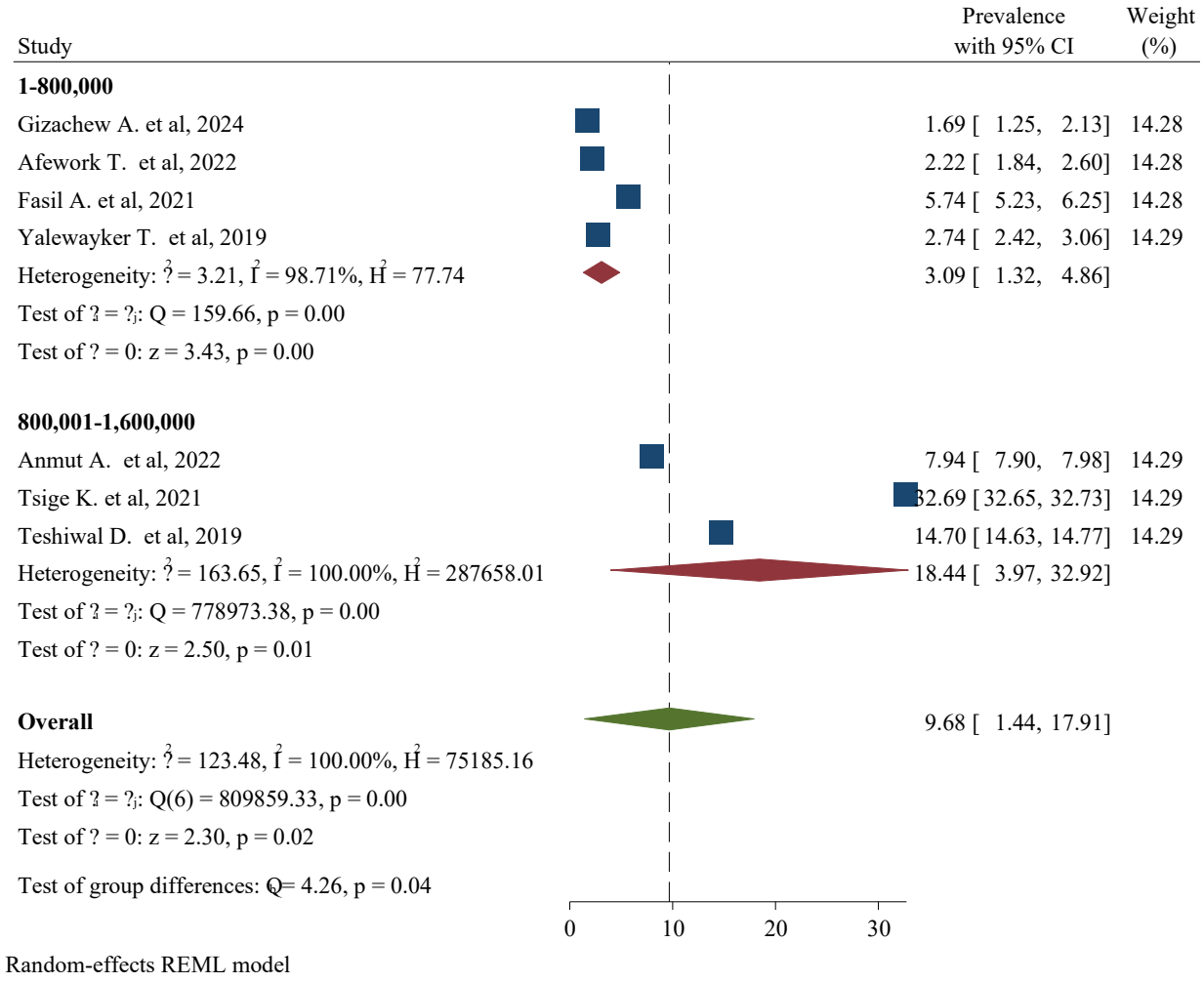


Figure.14 Subgroup analysis for pooled prevalence of *P. vivax* based on number of sample size.

Systematic review on associated factors of malaria

According to this review, almost all of malaria studies reported data from Amhara, Oromia, and the Southern Nations, Nationalities, and Peoples' Region [34]. In addition, this study found that the Southern Nations, Nationalities, and Peoples' Region had the highest pooled prevalence of asymptomatic malaria infection during pregnancy, whereas Amhara had the lowest. In terms of study setting, the pooled prevalence of asymptomatic malaria infection during pregnancy in facility-based studies was lower than in community-based studies [26]. Similarly, regional subgroup analysis revealed that the highest malaria prevalence was found in the Southern Nations, Nationalities, and Peoples' Region, followed by Oromia Regional State, and the lowest in Amhara Regional State [33]. In the regional subgroup analysis of the overall malaria prevalence, the greatest pooled estimate was reported from the Oromia region, followed by Southern Nations, Nationalities, and Peoples' region, while the lowest frequency was seen in the Amhara region [36]. Based on this review, the associated risk factors for malaria were identified as independent predictors among pregnant women gravidity, insecticide-treated bed net utilization, indoor residual spray service, the presence of stagnant water, staying outside at night, and health education [26-29]. Furthermore, it was found that the prevalence of malaria varied significantly depending on the following factors: decreasing age, not using an insecticide-treated bed net, not receiving health consultations or education about malaria prevention, being pregnant in the second trimester, having gravidae II, living close to mosquito breeding sites, inadequate knowledge of child caregivers, and not using an insecticide-treated mosquito net [31, 38] [Table.5].

Table.5 Associated risk factors of malaria in the included studies in an umbrella review.

Author	Year of Publication	County	Study participants	Sample Size	Number of article	Study design	Risk factors
Gizachew A. et al [26]	2024	Ethiopia	Pregnant women	3277	10	Cross-sectional study design	-Not using insecticide-treated bed nets -Being primi-gravida - Lack of health education about malaria prevention
Addisalem W. et al [27]	2024	Ethiopia	vulnerable population	7597	12	Cross-sectional study design	- Stagnant water - No insecticide-treated net utilization - Staying outdoors at night
Tadesse D. et al [28]	2023	Ethiopia	pregnant women	1857	6	Cross-sectional study design	NA
Afework T. et al [29]	2022	Ethiopia	General population	5924	14	Cross-sectional study design	- Indoor residual spray service - Never used insecticide-treated nets - Presence of stagnant water in

							the vicinity
Anmut A. et al [30]	2022	Ethiopia	General population	1,622,356	18	Cross-sectional, retrospectives, and longitudinal research design	NA
Gebeyaw B. et al [31]	2022	Ethiopia	children	34,842	12	Cross-sectional, retrospective and Bayesian study design	-Lack of insecticide-treated mosquito net utilization -Poor knowledge of child caretakers towards malaria transmission -Living near mosquito breeding sites
Yalewayker T. et al [32]	2021	Ethiopia	Children	26,148	7	Cross-sectional study design	NA
Fasil A. et al [33]	2021	Ethiopia	Adult population	7895	8	Cross-sectional and longitudinal research design	NA
Tsige K. et al [34]	2021	Ethiopia	General population	5,930,976	79	Cross-sectional and retrospective study design	NA

Yalewayker T. et al [35]	2019	Ethiopia	Pregnant Women	10207	7	Cross-sectional study design	NA
Teshiwal D. et al [36]	2019	Ethiopia	General population	1,055,155	35	Cross-sectional	NA

Abbreviation: NA=Non-applicable

Discussion

This umbrella review showed the prevalence and associated factor of malaria on a period of eleven years in Ethiopia. In this review, the pooled prevalence of malaria was 14.93 % (95% CI: 9.88-19.99). This finding was inline with that reported in the review study (11%) [39] and endemic settings of sub-Saharan Africa (12%) [40]. There might be a number of reasons for the data of malaria prevalence that are comparable in these studies.This might be the result of using similar data collection methods, diagnostic approaches, public health measures being implemented similarly, and comparable sociodemographic characteristics. Correspondingly, data revealed similar improved malaria control measures such as insecticide-treated bed nets, indoor residual spraying, and a rise in household wealth index in the studies [41].

Conversely, this finding was lower than that reported in African And America (41%) [42], Pakistan (23.3%) [43], Mauritania (25.6%) [44], and endemic settings of Sub-SaharanAfrica (26.1%, 30%, 33%) [40, 45, 46]. This might be due to the existence of insecticide-resistant mosquitoes and good climatic and environmental circumstances conductive to vector survival, which makes malaria transmission high in these studies areas [47, 48].

However, this finding was higher than that reported in the review [9%] [49] and from migrants screened in non-endemic areas like European country, USA, Canada, Australia, and New Zealand [8%] [50]. This might be due to variation extent from different factors such as target populations and groups, intervention types, study designs, and measurement outcomes [51]. Correspondingly, this might be due to financial constraints, which may limit individuals' capacity to use available goods and services to cure malaria. For example, the poorest individuals may not have adequate money to cover transportation, consultation with healthcare providers, and payment for medications when they are unwell, resulting in people not seeking care [52].

Moreover, in this review, the pooled prevalence of *P. falciparum* was 17.79 % (95% CI: 0.93-34.95). This finding was consistent with that reported in Sub-Saharan Africa (22.1%) [45], Pakistan (16.29%) [43], and Africa (17.76%) [53]. Conversely, this finding was lower than that reported in the world (36.4%) [42], Ethiopia (45%) [17], and Mauritania (51.14%) [44]. This might be due to climates with adequate temperature, humidity, and rainfall circumstances foster disease endemicity because they are conducive to parasite replication inside the *Anopheles*

mosquito, which is native to these regions. Likewise, this could be due to lower income and living in wooden house [54].

Furthermore, in this review, the pooled prevalence of *P. vivax* was 9.68 % (95% CI: 1.44-17.91). This finding was comparable with that reported in the world (11.6%) [42]. Conversely, this finding was lower than that reported in Mauritania (37.55%) [44], Ethiopia (54%) [17], and Pakistan (79.13%) [43]. This might be due to different factors such as socio-demographic, place of study, house conditions, breeding site of mosquitoes, human host, and vector, which affect the prevalence of malaria [17, 18, 55]. This revealed that improved insights into the reasons of fine-scale variation in malaria spread may enhance the implementation of treatments to target hotspots [56].

Moreover, this review showed that signifcant difference in the prevalence of malaria among studies on number of studies and number of sample size. This could be due to variations in methodologies, sample size, climate, topography,vector control measures, and demographics of study populations, all of which could alter the reported frequency of infection throughout time. This study also found a substantial variation in malaria prevalence, indicating that seasonal malaria transmission is varied and unstable [57, 58].

Furthermore, this review indicated that signifcant difference in the prevalence of *P. vivax* among studies on number of sample size. The significant difference in *P. vivax* prevalence identified in the review based on sample size can be attributed to a variety of reasons. These include diversity in environmental conditions, vector control measures, local malaria transmission dynamics, diagnostic sensitivity, methodological quality, and statistical techniques.

In this review the pooled malaria prevalence was high in Oromia and Southern Nations, Nationalities, and Peoples' Region. This could be due to favorable climates for mosquito breeding, limited access to healthcare, lack of resources for prevention, ineffective implementation of vector control measures, population movement between areas, and certain local practices, such as staying outdoors at night in these areas.

According to this review, the associated risk factors like insecticide-treated bed net utilization, indoor residual spray service, presence of stagnant water health education, staying outdoors at night, and mosquito breeding sites were statistically significant risk factors for malaria prevalence. This finding was similar with studies that reported associated risk factors of malaria

prevalence [15, 55, 59]. This indicated that using a multifaceted approach that includes education, community involvement, promoting safe practices, strategic resources allocation, evidence-based policies, environmental management, and targeted interventions can lead to sustainable reductions in malaria burden, transmission, and ultimately save lives.

Strength of this study

To the best of our knowledge, this is the first comprehensive umbrella review of malaria prevalence in Ethiopia. We adhered to a predefined search strategy and data abstraction approach. We employed widely acknowledged methodologies for critical appraisal and evaluating the quality of individual studies. The data may facilitate the development of efficient malaria management and, eventually, elimination programs by primary care providers and policymakers.

Limitations of this study

The very limited number of reviewed articles in this umbrella review may have an impact on the overall proportion estimate. Furthermore, the data from this study did not contain the pooled value of the associated malaria risk factors. Since there were no indicated associated risk factors for malaria in the included studies. In addition, the uneven distribution of publications around the country may have an influence on the results of the study.

Conclusion and recommendation

This review's findings on malaria prevalence in Ethiopia revealed a high pooled prevalence of malaria and its parasites, such as *P. falciparum* and *P. vivax*, indicating a significant difficulty in treating malaria parasite infections. Based on this review, the associated risk factors like insecticide-treated bed net utilization, indoor residual spray service, presence of stagnant water, and mosquito breeding sites were statistically significant risk factors for malaria frequency. The observed rise in malaria incidence highlights the requirement for improved infection control strategies and surveillance systems for limiting malaria transmission in Ethiopia. Moreover, collaboration at the local, national, and international levels is required to address the factors that trigger malaria and mitigate its impact on public health.

Abbreviation

Not applicable

Declarations

We declare that this manuscript is review and has not been submitted or published in other journal.

Ethics approval and consent to participate

Not applicable to this umbrella review

Clinical Trial

In this manuscript ‘Clinical trial number: not applicable’.

Consent for publication

Not applicable

Availability of data and material

Data supporting the study's findings are available in the manuscript and upon request from the corresponding author.

Conflict of interest

The authors of this umbrella review declared that they have no conflict of interest.

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Author's contribution

WA led the umbrella review, article selection, data mining, data screening, data extraction, statistical analysis, manuscript preparation, and overseeing the study's conceptualization.

WA, AS, and **AM** performed a critical role in finding relevant papers, extracting data, full-text screening, and doing statistical analysis. **WA, HSN,** and **ABZ** were involved in statistical analysis consultation of the overall process of this umbrella review. **WA, AM, ABZ,** and **HSN** involved in data mining, data extraction, manuscript writing, editing, and ensuring accuracy and completeness. Moreover, all authors actively engaged in critically reviewing the study's progress, data analysis, and manuscript preparation, involved in the approval of the final manuscript for submission, thereby affirming their endorsement of its content and findings.

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