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Prevalence and associated factors of malaria among the displaced population in refugee camps in Africa: a systematic review and meta-analysis

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Abstract

Background The increased occurrence of malaria among Africa's displaced communities poses a new humanitarian problem. Understanding malaria epidemiology among the displaced population in African refugee camps is a vital step for implementing effective malaria control and elimination measures. As a result, this study aimed to generate comprehensive and conclusive data from diverse investigations undertaken in Africa.

Methods This review adhered to PRISMA standards, involving searches across electronic data bases such as Google Scholar, PubMed, Web of Science, Scopus, and Science Direct. In addition, grey literature was retrieved from several professional associations. The quality of selected studies was evaluated using the Newcastle–Ottawa Quality Assessment Scale. Data extraction was executed using Microsoft Excel, and the meta-analysis was performed with STATA 14 software. A random-effects model was used to estimate the pooled prevalence and associated factors of malaria. Meta-regression and subgroup analysis were used to identify heterogeneity, while funnel plots and Egger's statistical tests assessed the publication bias. Furthermore, a sensitivity analysis was performed.

Results The overall random-effects pooled prevalence of malaria infection (comprising symptomatic and asymptomatic cases) across all included studies was 35.93% (95% CI 24.71–47.15). This study showed a high level of heterogeneity between studies ($I2 = 97.1$; $P < 0.001$). Of the identified *Plasmodium* species, *Plasmodium falciparum* constituted 99.3%. The frost plot indicated that the overall prevalence of *P. falciparum* was 34.94% (95% CI 24.34–45.53). Subgroup analysis revealed significant variation ($P < 0.001$) in malaria prevalence between asymptomatic and symptomatic cases, with a prevalence of 4.39% (95% CI 2.57–6.21) and 45.10% (95% CI 27.28–62.92), respectively. Lack of insecticide-treated mosquito net utilization (AOR 2.43; 95% CI 1.01–5.88) and living near mosquito breeding sites (AOR 2.76, 95% CI 1.56–4.87) were risk factors of malaria.

Conclusion This study determined that the pooled prevalence of malaria among displaced individuals in refugee camps was high and exhibited variations across different population groups. This signifying there is still a need to improve and recheck existing malaria prevention and control strategies to establish an effective malaria control and elimination programme in Africa.

Keywords Malaria, *Plasmodium* species, Displaced population, Refugee camps, Africa

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Background

Malaria is a deadly vector-borne tropical disease that persists as a leading cause of fatality in many developing countries [1]. Despite substantial control efforts over the recent years, malaria continues to pose a significant threat to the health of refugee populations, especially in sub-Saharan Africa [2]. It is responsible for up to 50% of all deaths and 16% of child fatalities, and is prevalent in more than 80% of existing refugee camps [3, 4]. As of late 2021, the United Nations Refugee Agency estimated that 89.3 million individuals were forcefully displaced globally, with nearly two-thirds of them residing in areas with elevated malaria rates [5, 6].

Among all refugees, the average annual malaria incidence rate is 95 cases per 1,000 people, with Tanzanian refugee camps having the highest rates. The annual malaria fatality rate is 3.6 per 1,000 refugees, with the highest rates observed in Sudan and Thailand, and the lowest in Ethiopian camps [7]. Factors such as malnutrition, unclean water, poor sanitation, overcrowding and limited healthcare access render refugees more susceptible to diseases [8]. Refugee camps, due to insufficient surveillance, monitoring, and response, may facilitate the resurgence of previously controlled diseases, underlining the necessity of effectively managing infectious diseases in these settings [7]. As the world aims to eliminate malaria, the plight of refugees, displaced individuals, and asylum seekers must not be disregarded [9].

The increasing prevalence of malaria among Africa's displaced inhabitants represents a new humanitarian challenge [10]. The risk of malaria infection among refugees can increase, particularly when individuals with limited prior exposure to malaria move to areas with higher transmission rates [6, 10]. Additionally, the epidemiological nature of imported malaria has been substantially altered by long-distance travel and migratory movements shaping the spread of imported malaria from endemic countries. This leads to heightening the risk of secondary transmission and treatment resistance, thus impeding long-term elimination goals [11, 12].

With an increasing influx of immigrants from malaria-endemic regions, non-endemic nations must develop approaches for identifying, diagnosing, and treating imported malaria, not only for their own benefit but also to avert the reintroduction of malaria and subsequent indigenous malaria transmission [7]. The risk of malaria infections tends to increase among refugees, especially when individuals with limited or no prior exposure to malaria move to regions with higher transmission rates [10]. Refugees are prone to malaria infections due to a lack of protective immunity, concentrated living in exposed settings, limited access to insecticide-treated nets (ITNs), inadequate indoor residual spraying (IRS), and delayed clinical diagnosis and treatment responses [13]. Other contributing risk factors include outdoor activities at night, wearing shorts, living in unfinished buildings, poor drainage, and acute malnutrition in children [14]. Extending malaria control measures to refugees is crucial to attaining malaria control and elimination in countries with substantial refugee populations.

Although numerous studies have been conducted throughout various African regions, there remains inconsistency in the extent and overall prevalence of malaria among refugees. Until now, no study has comprehensively established the total prevalence and associated factors of malaria in refugee camp populations. Consequently, this systematic review and meta-analysis represents the first of its kind, aiming to furnish comprehensive data on malaria prevalence. A comprehensive understanding of the aggregate prevalence of malaria infections in refugee settlements is crucial for formulating humanitarian responses. It is also used for implementing effective intervention strategies for malaria prevention, control, and potential eradication, underlining the importance of ample research and evidence to aid in the development of effective long-term management approaches.

Methods

Protocol registration

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were followed for this systematic review and meta-analysis [15]. The process of the selecting the articles was based on the checklist in additional file 1. The study protocol was recorded as CRD42023426433 in the International Prospective Register of Systematic Reviews (PROSPERO).

Search strategy and study selection

The current systematic review and meta-analysis aimed to determine the prevalence and its associated factors of malaria among the displaced population in African refugee camps. To avoid duplications, the existence of similar systematic reviews and meta-analyses published on this issue was examined. Exhaustive searches for studies on the prevalence and associated risk factors of malaria among displaced populations in refugee camps were carried out across various electronic databases, namely Google Scholar, PubMed, Web of Science, Scopus, and Science Direct. Relevant search terms, aligned with the Medical Subject Heading (MeSH), were meticulously chosen, and these search phrases were employed individually as well as in combination using Boolean operators such as "OR" and "AND".

The keywords used in this study encompassed terms such as "prevalence, magnitude, proportion, malaria, *Plasmodium falciparum*, *Plasmodium vivax*, risk factors,

determinants, associated factors, displaced population, refugee camps, Africa." Duplicate studies were eliminated, and three independent reviewers (HD, AG, and EA) meticulously screened the title and abstract of all potentially suitable studies. The full texts of potentially relevant research articles documenting the prevalence of malaria infection in refugee camps were then obtained. Discrepancies among authors during data extraction were resolved through discussion. This comprehensive search was conducted from March to April of 2023.

Inclusion and exclusion criteria

In this systematic review and meta-analysis, all studies focusing on the prevalence and influencing factors of malaria among displaced populations residing in African refugee camps were included. The selected papers consisted of original research works published in English language, offering basic information regarding sample size, diagnostic methods, malaria prevalence, *Plasmodium* species and associated factors among refugees in diverse African regions. These studies encompassed both symptomatic and asymptomatic participants in health institutions or in the community setting. However, papers that are duplicated within the search documents, not accessible and published before 2011 were excluded. Moreover, brief communication reports, reviews, posters, non-human studies and studies that exclusively reliant on clinical signs and symptoms for reporting malaria prevalence were also excluded.

Outcome measurement

The key focus of this systematic review and meta-analysis is the pooled prevalence of malaria among displaced population residing in African refugee camps. It was calculated using the metan prevalence standard error command after generating prevalence and standard error of prevalence. In the primary studies, malaria diagnosis was confirmed through microscopy, a rapid diagnostic test, and/or a polymerase chain reaction. The pooled prevalence of malaria was estimated by multiplying the number of individuals infected with malaria by 100, and then dividing it by the total number of participants engaged in the study.

Data extraction and quality assessment

Three reviewers (HD, AG, and EA) independently selected the papers based on the title, abstract, and full text using the specified eligibility criteria. Subsequently, these reviewers employed Microsoft Excel Sheets to extract data from the whole text of potentially suitable papers. Information such as the primary author's name, year of publication, country, study subjects, research design, refugee category, sample size, diagnostic methods, prevalence of malaria, and *Plasmodium* species among refugees were collected from each study. To evaluate the overall quality of the included studies, the Newcastle–Ottawa Scale was adopted, which is specifically designed to assess the quality of cross-sectional studies [16, 17].

Additionally, for data extraction and quality assessment in this systematic review and meta-analysis, the methods outlined in the article "Method for Conducting Systematic Literature Review and Meta-Analysis for Environmental Science Research" were employed [18]. Reviewers compared their findings and resolving any discrepancies in the inclusion and quality assessment of specific papers through mutual consensus.

Statistical analysis

The essential information was retrieved from each qualifying original study utilizing a Microsoft Excel spread sheet format. The data was subsequently transferred to STATA version 14 for analysis employing metan commands. Forest plots, ascertained through I2 and Cochrane's Q tests [19, 20], were utilized to exhibit the heterogeneity among these studies or the variation in their outcomes. The I^2 test statistics categorized as 25, 50, and 75% were denoted as indicating low, moderate, and high heterogeneity [21]. Given the noticeable heterogeneity, a random-effects model was performed to calculate the pooled prevalence of malaria. The results were presented using a forest plot.

The potential presence of publication bias was explored through visual examination with a funnel plot and statistically through Egger's regression test [20, 22]. An asymmetrical funnel plot and a p-value of < 0.05 in Egger's test indicated the presence of significant publication bias. Additionally, trim-and-fill method was used to "estimate the number of missing studies that might exist in a meta-analysis and the impact of these studies might have had on its outcome" [22]. Furthermore, subgroup analysis was carried out based on the year, nation, sample type, symptoms, and diagnostic methods. Moreover, sensitivity analysis was carried out to investigate the influence of a single study on the total pooled estimate.

Description of included studies

A total of 1128 studies were obtained from database searches and other sources, 486 duplicates were removed. Following this, the remaining 534 articles underwent screening based on title and abstract. Subsequently, 44 full-text articles were thoroughly evaluated against the eligibility criteria. From these, 31 full-text articles were excluded. Finally, only 13 articles were identified as potentially eligible for inclusion in the systematic review and meta-analysis (Fig. 1).

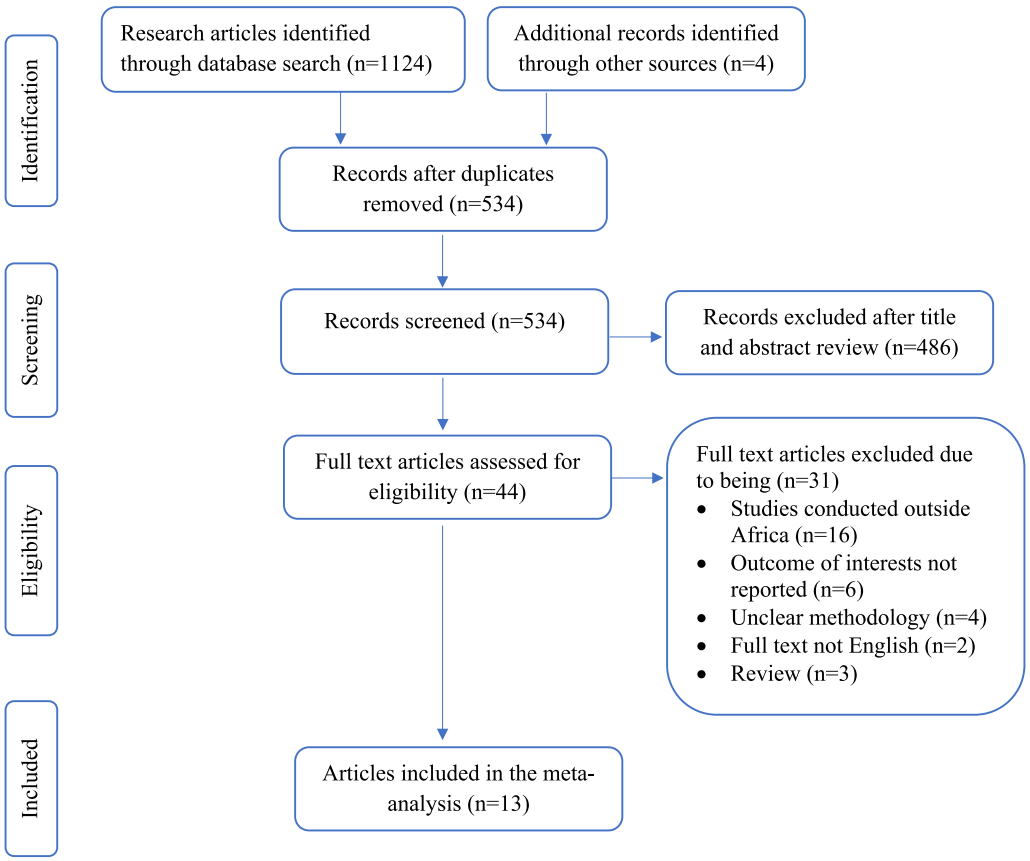

Fig. 1 PRISMA flow diagram illustrating the process of selecting eligible studies for the systematic review and meta-analysis, 2023

Results

Characteristics of the included studies

In this study, 13 original articles involving a total of 4460 study participants were included [2, 11, 23–33]. Among the 13 studies, three were conducted in Sudan, two in Uganda, two in the DRC, two in South Africa, two in Nigeria, one in Kenya, and one in Ethiopia. Concerning patient types, eight focused on symptomatic individuals, three included both symptomatic and asymptomatic cases, and the remaining two studies specifically targeted asymptomatic malaria. The age groups considered for analysis varied across the studies. Regarding refugee types, 8 studies included on IDPs, 2 focused on both IDPs and across, and three solely on across (Table 1).

The sample sizes across the eligible studies ranged from 76 [23] to 751 [2] participants. The majority studies employed rapid diagnostic tests for detecting *Plasmodium* species. Out of the 4460 individuals tested for malaria infection in the eligible articles for this review, 1708 participants tested positive. Regarding species distribution, 1696 (99.3%), 2 (0.1%), and 10 (0.6%) were accounted by *P. falciparum*, *P. vivax*, and mixed infections, respectively (Table 2).

Prevalence of malaria among displaced population in refugee camps

The prevalence of malaria in each study as well as the pooled estimate was indicated by a forest plot. A greater disparity in the prevalence of malaria was revealed in the studies. The prevalence ranges from 3.93% (95% CI 1.85–6.01) reported in Ethiopia to 67.93% (95% CI 44.73–91.14) reported in Nigeria. The overall pooled prevalence of malaria among displaced populations in refugee camps in Africa from the random effects model was 35.93% (95% CI 24.71–47.15). There was a high level of heterogeneity between studies ($I^2 = 97.1$, $P < 0.001$) (Fig. 2).

Prevalence of *Plasmodium falciparum*

The prevalence of *Plasmodium* parasite species was compared between studies among participants in refugee camps in Africa. All of the studies (13) included in this review reported the prevalence of *P. falciparum* infection, and only one study reported *P. vivax*, while the prevalence of mixed infection was reported in four studies. The overall pooled prevalence of *P. falciparum* was 34.94% (95% CI 24.34–45.53) (Fig. 3).

Table 1 Distribution and characteristics of studies on malaria in refugee camps in Africa, 2023

Author/year/reference	Country		Study design	Type of cases	Study population	Refugee type	Origin of refuges came from
Abdulmuneim et al. (2021) [23]	Ethiopia		Cross-sectional	Asymptomatic	Children	Across	South Sudanese, Sudanese, Congolese, and Burundi
M Nabie et al. (2011) [24]	Kenya		Cross-sectional	Symptomatic	All age	IDP and across	Sudan, Somali, Ethiopian, Other, and Kenyan
Miskelyemen et al. (2012) [25]	Sudan		Cross-sectional	Symptomatic	All age	IDP	
Hamza et al. (2020) [11]	Sudan	Cross-sectional		Symptomatic	All age	IDP	
Ayman et al. (2021) [26]	Sudan		Cross-sectional	Symptomatic	All age	IDP	
Paul et al. (2019) [27]	Uganda		Cross-sectional	Symptomatic & asymptomatic	Children	IDP and across	Uganda, SSD, Rwanda, Congo and Burundi
Henry et al. (2023) [28]	Uganda		Cross-sectional	Symptomatic & asymptomatic	Children	Across	South Sudanese, DRC, Burundi, Ethiopia, Eritrea, Rwanda, Somalia and Sudan
Rhianna et al. (2016) [29]	DRC		Cross-sectional	Symptomatic	Children	IDP	
Hannah et al. (2017) [2]	DRC		Cross-sectional	Symptomatic	All age	IDP	
Joyce et al. (2014) [30]	South Africa		Cross-sectional	Asymptomatic	Adults	Across	Sub-Saharan African countries
U E Okafor et al. (2016) [31]	South Africa		Cross-sectional	Symptomatic & asymptomatic	All age	IDP	
Evelyn et al. (2020) [32]	Nigeria		Cross-sectional	Symptomatic	Children	IDP	
Oluwaremilekun et al. (2020) [33]	Nigeria		Cross-sectional	Symptomatic	Children	IDP	

Subgroup analysis

Subgroup analysis of malaria prevalence by country

All studies included in this review were carried out in seven countries. However, the subgroup analysis done by five different countries in Africa indicated that the highest pooled prevalence of 60.44% (95% CI 45.56–75.31) was observed in Nigeria, followed by 45.41% (95% CI 27.34, 63.47) in Uganda. On the other hand, the lowest prevalence of 6.34% (95% CI 2.40–10.29) was reported in South Africa (Fig. 4).

Subgroup analysis by study year of publication

Subgroup analysis based on the publication year of studies showed that the highest pooled prevalence of malaria, 43.62 (95% CI 19.51–67.73), was reported in 2020–2023, followed by 39.0% (95% CI 25.59–52.42) in 2016–2019. On the other hand, the lowest prevalence of 18.59% (95% CI 4.70–32.4) was reported in 2011–2015. According to the results of this meta-analysis, the pooled prevalence of malaria among the displaced population in refugee camps in Africa highly increased from 2011–2015 to

Table 2 Clinical characteristics of included articles describing malaria in refugee camps in Africa, 2023

Author/year/reference	Sample size	Diagnostic method			Total cases	Prevalence of malaria (%)	Identified *Plasmodium* species					Prevalence of Pf
		RDT	Microscopy	PCR			Pf	Pv	Pf + Pv	Pf + Po	Pf + Pm	
Abdulmuneim et al. (2021) [23]	356	14			14	3.93	12	2				3.37
M Nabie et al. (2011) [24]	320	163	143		165	51.56	163		1		1	50.94
Miskelyemen et al. (2012) [25]	300		24		24	8.00	24					8.00
Hamza et al. (2020) [11]	380			232	232	61.05	232					61.05
Ayman et al. (2021) [26]	76		32		32	42.11	32					42.105
Paul et al. (2019) [27]	476		262		262	55.04	262					55.04
Henry et al. (2023) [28]	675	247			247	36.59	247					36.59
Rhianna et al. (2016) [29]	300	113			113	37.67	113					37.67
Hannah et al. (2017) [2]	751	323			323	43.01	323					43.01
Joyce et al. (2014) [30]	290	11	17		17	5.86	15		1	1		5.17
U E Okafor et al. (2016) [31]	102	11	16		16	15.69	10			6		9.80
Evelyn et al. (2020) [32]	184		125		125	67.93	125					67.93
Oluwaremilekun et al. (2020) [33]	250	138			138	55.20	138					55.20

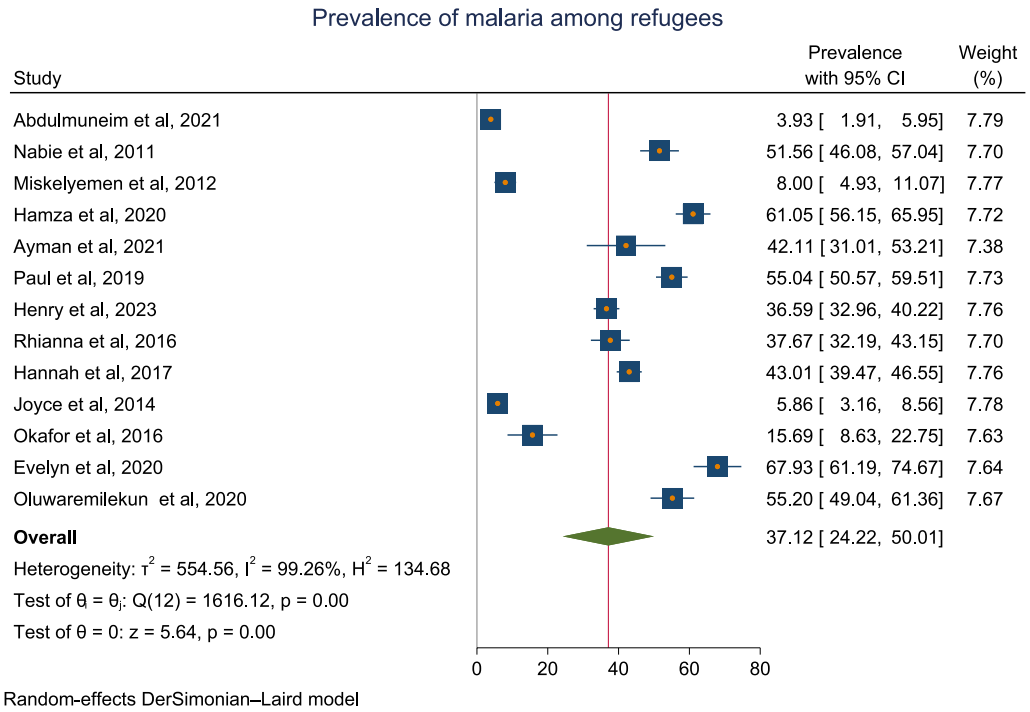

Fig. 2 Forest plot showing the pooled prevalence of malaria in refugee camps in Africa, 2023

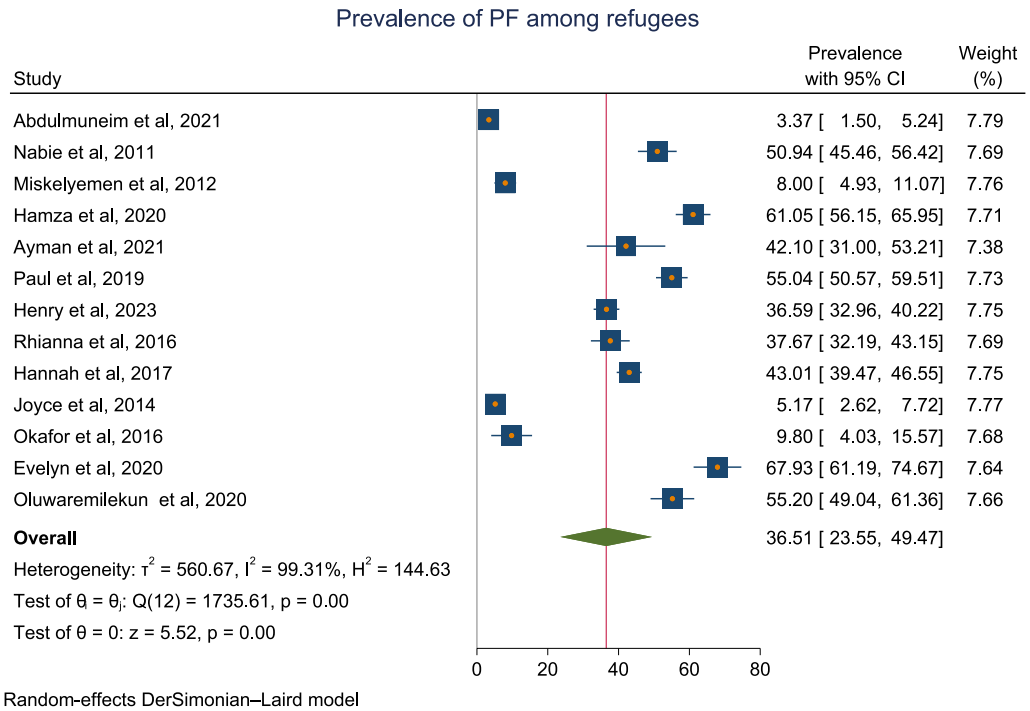

Fig. 3 Forest plot showing the pooled prevalence of *Plasmodium falciparum* in refugee camps in Africa, 2023

2020–2023. There was significant variation within and

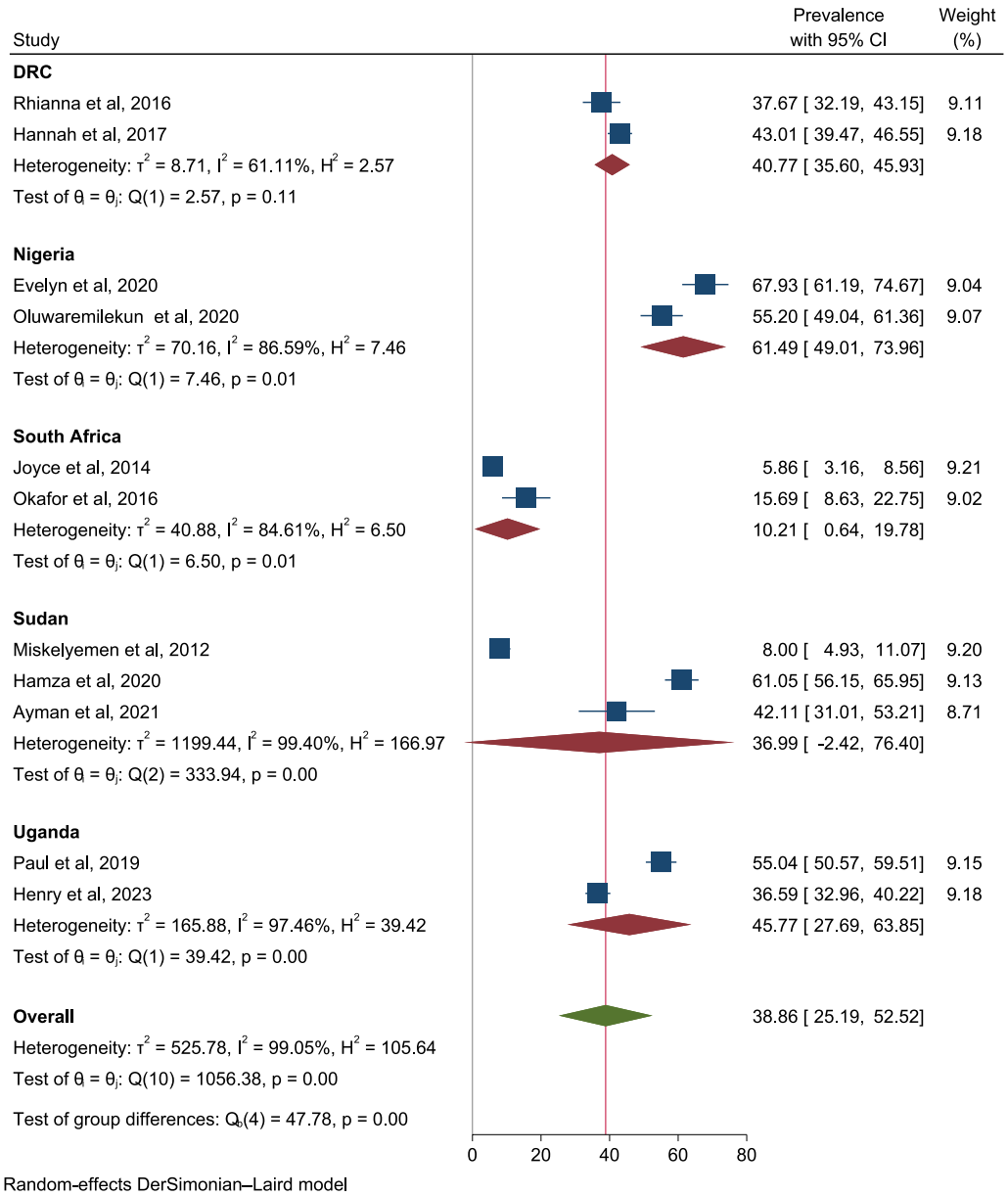

Fig. 4 Subgroup analysis based on country where the studies are conducted in refugee camps in Africa, 2023

across groups (Fig. 5).

Subgroup analysis by type of cases

According to the subgroup analysis, based on the existence of malaria symptoms, the prevalence of malaria among asymptomatic and symptomatic participants was 4.39% (95% CI 2.57–6.21) and 45.10% (95% CI 27.28–62.92), respectively. Moreover, the prevalence of malaria among both asymptomatic and symptomatic participants was 36.65 (95% CI 18.48–54.83) (Fig. 6).

Subgroup analysis by diagnostic methods

In this comprehensive systematic review and meta-analysis, variations in malaria prevalence were observed across studies employing different diagnostic methods. Among participants in refugee settlements, the pool prevalence of malaria identified through microscopy was 42.48% (95% CI 10.17–74.78). Likewise, the prevalence of malaria detected via RDT was 40.82% (95% CI 35.14–46.51), while using both microscopy and RDT was 7.73 (95% CI 0.17–15.28) (Fig. 7).

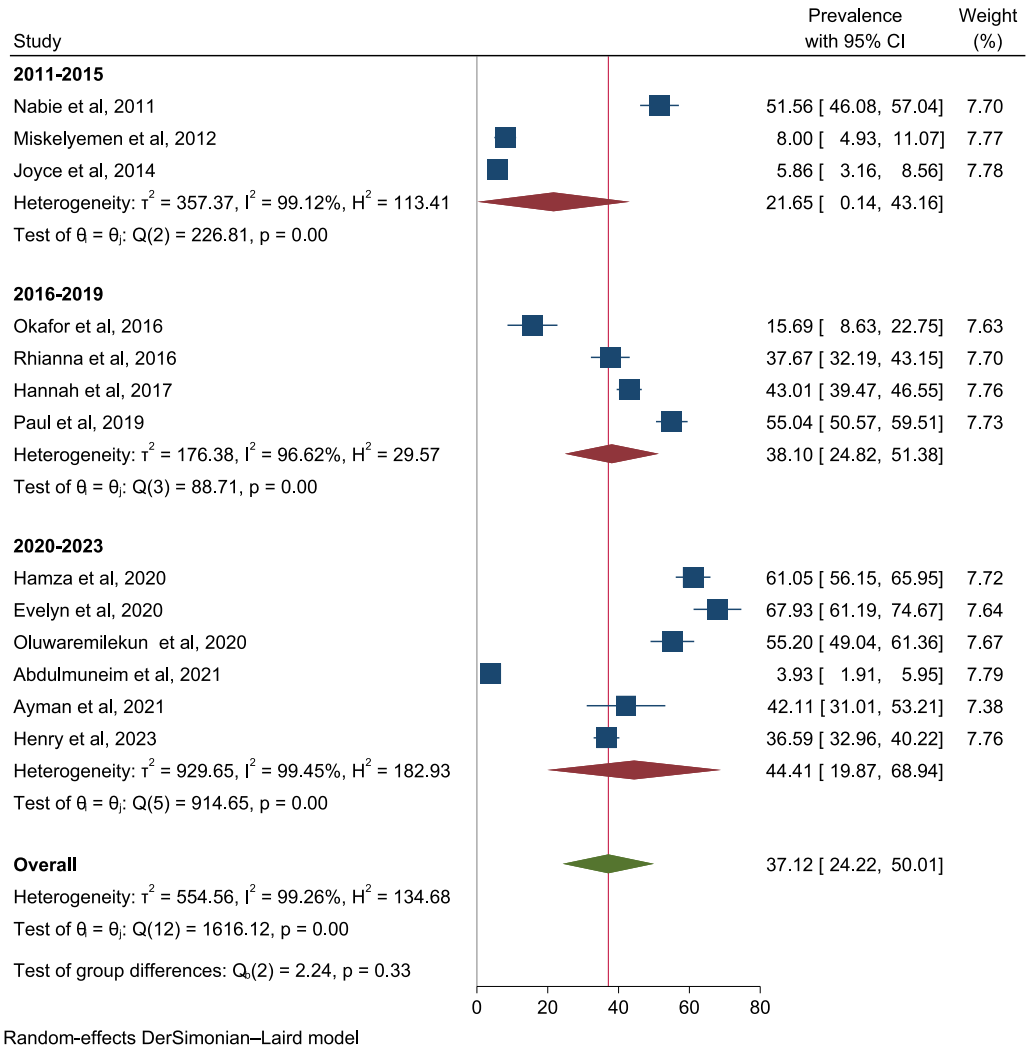

Fig. 5 Subgroup analysis based on year of studies publication, in refugee camps in Africa 2023

Subgroup analysis by study population

The results of the original study, involving various population segments, suggest an irregular and indecisive occurrence of malaria within displaced communities in Africa. Upon reviewing the forest plot, it was evident that the most significant prevalence was observed in a study conducted on children and all age groups in African refugee camps, with a prevalence of 41.82% (95% CI 18.60–65.04) and 36.62% (95% CI 16.58–56.67), respectively (Fig. 8).

Subgroup analysis by refugee type

Another subgroup analysis was done for the types of refugees. The pooled prevalence of malaria infection in both IDP and across, IDP and across refugee types was 53.97% (95% CI 45.49–62.45), 40.57% (95% CI 23.14–58.0), and 15.03% (95% CI 1.09–28.97), respectively, as indicated in Fig. 9.

Meta-regression analysis

Meta-regression was computed to see the underlying sources of heterogeneity using the year of publication, sample size, and number of cases. Both years of publication and sample size did not show a statistically significant presence of heterogeneity. However, the number of malaria cases indicated there was statistically significant heterogeneity (Table 3).

Publication bias

The funnel plot was used to assess the impact of the small-studies effect or publication bias on the estimated pooled prevalence. The graph of the funnel plot becomes asymmetrical, indicating the presence of publication bias

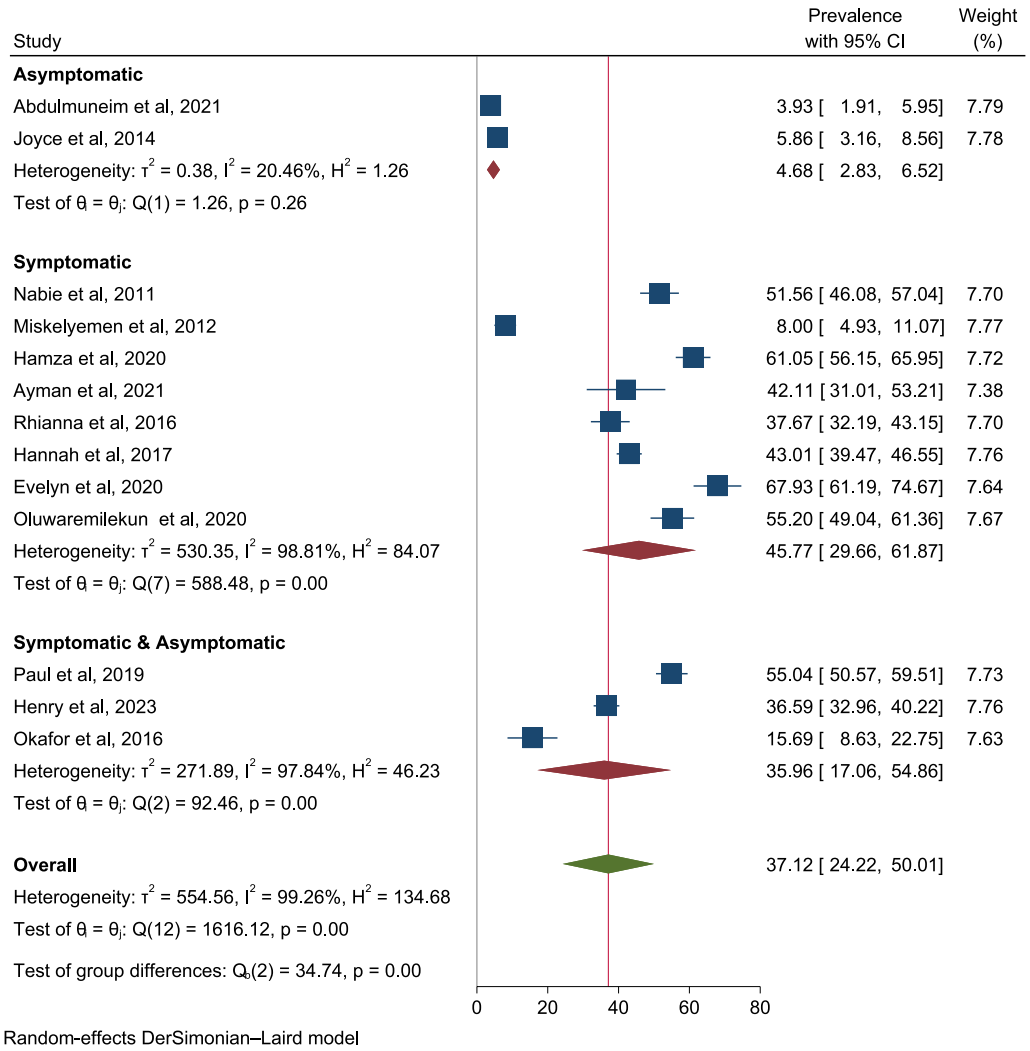

Fig. 6 Subgroup analysis based on type of cases in refugee camps in Africa, 2023

(Fig. 10). Furthermore, Eggers test statistics confirmed the presence of marginally significant publication bias at a P-value of 0.001 (Table 4).

Trim and fill analysis

A trim and fill analysis was performed due to the presence of publication bias. After adding six studies, the total number of studies remained at 19. Then, the pooled prevalence of malaria in refugee camps in Africa was 12.414% (95% CI 0.888–23.940) at a p-value of 0.035 (Table 5).

Sensitivity analysis

The random effect model was used to conduct a sensitivity analysis aiming to assess how a single study might impact the overall estimation. Yet, the findings indicated that there was no observable influence of any individual study on the overall estimation. Upon exclusion of individual studies, the combined effect size consistently fell within the 95% confidence interval of the overall pooled effect size, affirming that no single study significantly impacted the overall prevalence of malaria infection (Table 6).

Risk factors of malaria among the displaced population in refugee camps in Africa

Several primary studies were included to determine the pooled factors associated with malaria among the displaced population in refugee camps in Africa. In this study not using ITNs and the presence of stagnant water near to the resident sites were associated with malaria. All selected studies revealed the presence of a statistically significant association between ITN utilization and malaria infection. The pooled finding also indicated that

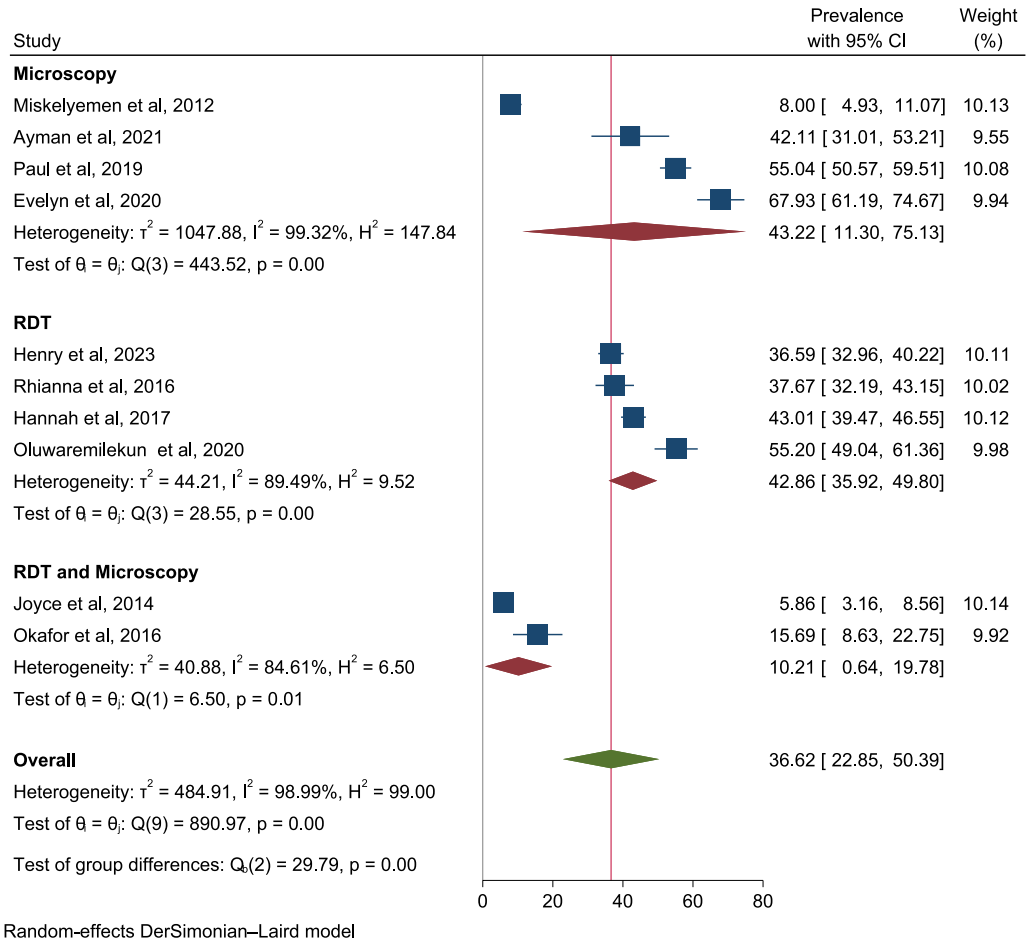

Fig. 7 Subgroup analysis based on diagnostic methods in refugee camps in Africa, 2023

there is a statistically significant association between ITN utilization and malaria infection. The odds of infecting with malaria were 2.43 times higher among the population who had not used ITN as compared to those who had used ITN (OR = 2.43; 95% CI 1.01–5.88). For this finding, random-effect model was used as heterogeneity was observed (I2 = 79.63%, p-value = 0.01) (Fig. 11).

Furthermore, in this meta-analysis, two main studies were incorporated to examine the correlation between residing in close proximity to mosquito breeding grounds and the prevalence of malaria. The findings revealed that individuals living near such breeding sites were almost three times more likely to contract malaria parasites (AOR = 2.76; 95% CI 1.56–4.87) compared to those residing near non-breeding areas (Fig. 12). Moreover, the two primary studies were included to investigate the link between lack of access to health information and malaria infection. However, the combined analysis indicated that there is no statistically significant association between not receiving health information and malaria infection (Fig. 13).

Discussion

Despite the decreasing trend of malaria prevalence in Africa, the disease remains a significant public health problem [34]. In this systematic review and meta-analysis, the overall pooled prevalence of malaria among displaced populations in refugee camps in Africa calculated from the random effects model, was 35.93% (95% CI 24.71–47.15). The results emphasize the need for the African continent's 2030 national malaria elimination programme [35] to prioritize malaria control strategies. The displaced population plays a crucial role in malaria transmission, and interventions to target this reservoir of parasites may be required to achieve malaria elimination in both low and high-transmission areas [6, 11].

The prevalence observed in this study was comparable with a systematic review and meta-analysis of asymptomatic malaria infection in pregnant women in sub-Saharan Africa (26.1%) [36] and Nigeria (34.3%) [37]. However, the pooled prevalence in the present study was higher than that reported in meta-analysis and systematic review conducted in Ethiopia among asymptomatic

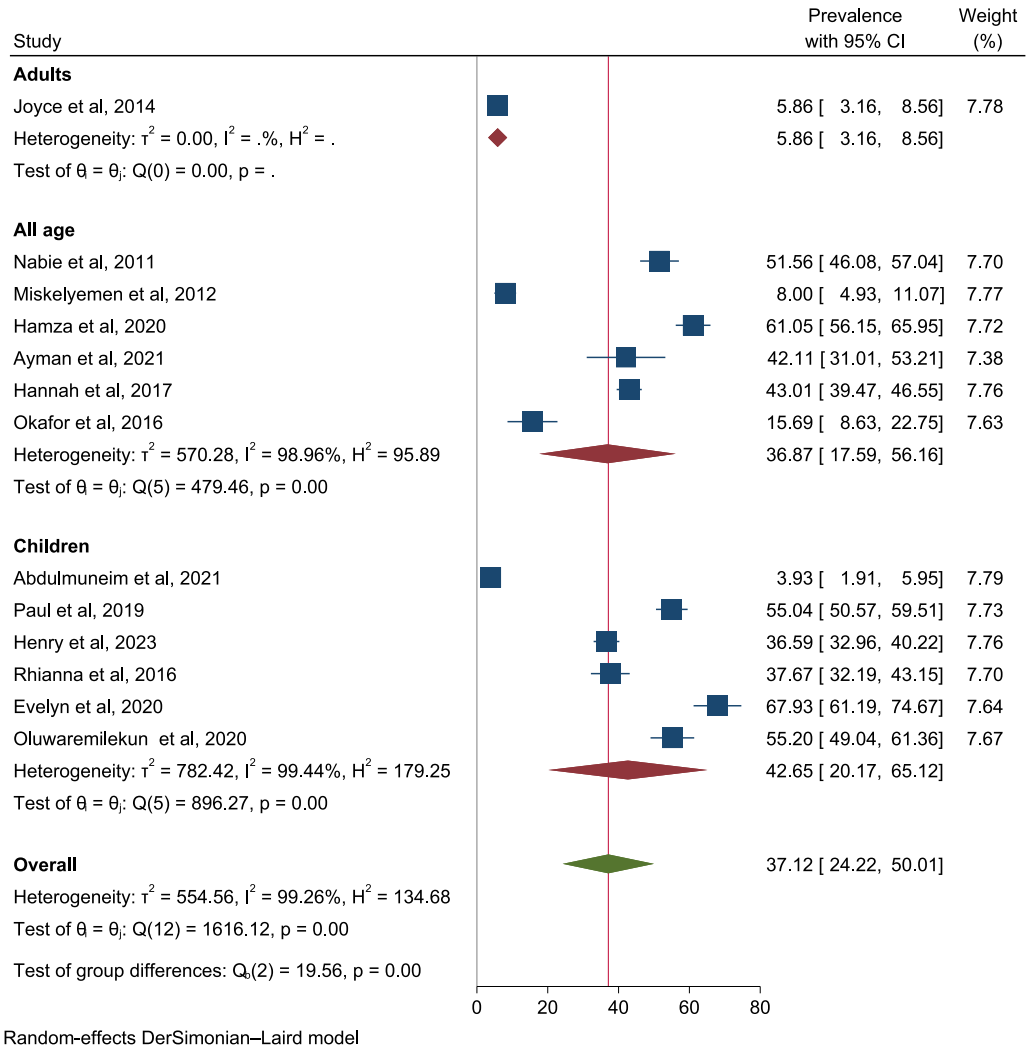

Fig. 8 Subgroup analysis based on study population in refugee camps in Africa, 2023

individuals (6.7%) [38], children (9.07%) [39], adults (13.61%) [40], under five children (22.03%) [41], in Mauritania (14.9%) [42] and Pakistan (23.3%) [43]. This disparity may be attributed to the study setting, as the current study focused on a refugee population. Vector-borne and other infectious diseases pose numerous challenges in refugee settlements due to disparities, limited access to healthcare services, and crowded environments that facilitate rapid disease transmission [11].

The overall pooled prevalence of *P. falciparum* in this study was 34.94% (95% CI 24.34–45.53) with, *P. falciparum* accounting 99.3% of all confirmed cases. The high proportion of *P. falciparum* observed among displaced populations in refugee camps is unique in Africa, where *P. vivax* is also prevalent and represents a significant number of cases. In the Horn of Africa, particularly in Ethiopia [44] and Madagascar [45], the ratio of *P. falciparum* to *P. vivax* is approximately 3:2. This variation could be due to the fact that this study covered a large malaria-endemic area in Africa, potentially causing species prevalence to differ. Additionally, the parasite density of falciparum is higher than that of any other species, and *P. falciparum* has developed resistance to many anti-malarial drugs through various mechanisms [46]. This presents a significant challenge for achieving malaria elimination goals. The findings from this study call for further a re-evalution of the global distribution map of *P. falciparum* malaria, particularly in Africa.

The high degree of heterogeneity with an I^2 of 97.2% in the overall prevalence found in our analysis could be attributed to several factors. The authors attempted to assess potential sources of heterogeneity through subgroup analysis. Additionally, meta-regression was conducted to see underlying sources of heterogeneity using

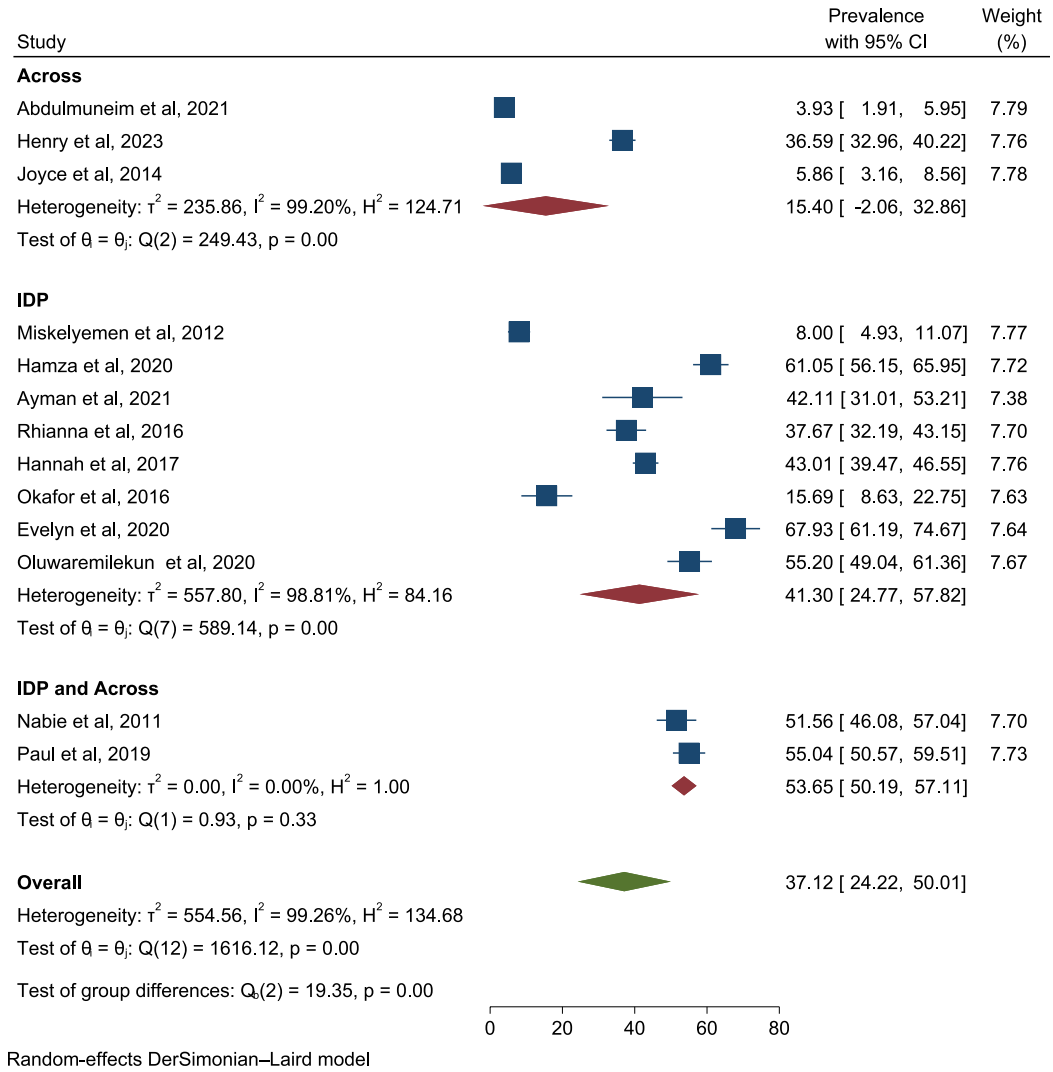

Fig. 9 Subgroup analysis based on refugee type in refugee camps in Africa, 2023

Table 3 Meta-regression using year of publication, sample size and number of cases to observe related heterogeneity on the prevalence of malaria in refugee camps in Africa, 2023

	Coef	Std. Err	T	P>|t|	[95% conf. interval]
Year of publication	1.85	1.72	1.07	0.31	− 1.94–5.63
Sample size	0.01	0.03	0.40	0.70	− 0.06–0.09
Number of cases	0.14	0.04	3.22	0.01	0.04–0.23

year of publication, sample size, and type of cases and number of cases. Factors such as variation in diagnostic procedures, demographic diversity, patient type (symptomatic and asymptomatic), seasonal differences, and levels of malaria endemicity could all contribute to this variance.

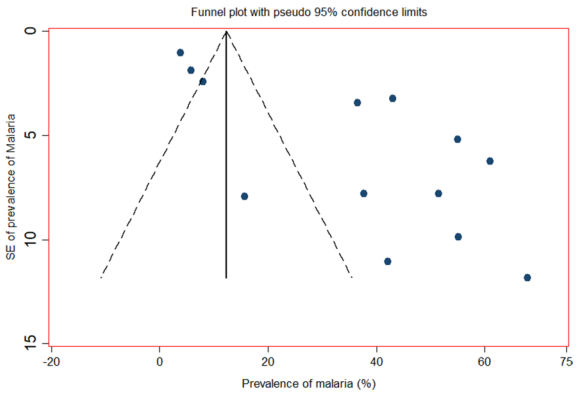

Fig. 10 Funnel plot on the prevalence of malaria in refugee camps in Africa, 2023

Table 4 Egger's test statistics of the prevalence of malaria in Africa

Std_Eff	Coef	Std. Err	T	P>|t|	95% CI
Slope	− 2.65	4.31	− 0.61	0.552	− 12.15–6.85
Bias	7.07	1.54	4.61	0.001	3.69–10.45

The pooled prevalence of malaria was significantly lower (4.4%) among individuals who showed no symptoms compared to those who did (45.1%) in the subgroup analysis. The difference in malaria prevalence between the two groups is likely due to the fact that asymptomatic individuals often have a low level of parasites in their blood smears and RDT for malaria [47]. Therefore, they play a crucial role as reservoir of parasites, contributing to its ongoing transmission [48]. Asymptomatic carriers have been identified as the primary source of gametocytes, which perpetuates the spread of malaria [49]. Moreover, in areas with low malaria prevalence, such as certain regions in India, it has been reported that even a small percentage of asymptomatic carriers is enough to trigger a resurgence of malaria [50].The study also revealed that the pooled prevalence of malaria in Nigeria (60.44%) and Uganda (45.41%) was significantly higher than that documented in South Africa (6.34%). This difference is likely due to the inclusion of a large number of asymptomatic individuals in South Africa. Since the overall prevalence of malaria in asymptomatic individuals across studies is very low (4.4%), the high proportion of asymptomatic cases could account for the low malaria prevalence in these studies. Moreover, this variation could be attributed to differences in the prevalence and impact of malaria across countries. Compared to other malaria-endemic countries in sub-Saharan Africa such as Nigeria, Mozambique, Tanzania and Uganda, South Africa has lower malaria prevalence [35].

Subgroup analysis based on the publication year of studies showed that the highest pooled prevalence of malaria reported was 43.62% during the period of 2020–2023. Furthermore, there was an observed upward trend

Table 6 Sensitivity analysis of the prevalence of malaria in refugee camps in Africa, 2023

S. No	Authors' name	Publication year	Estimate	95% confidence interval
1	Abdulmuneim et al	2021	39.11	26.18–52.04
2	Nabie et al	2011	34.63	23.18–6.08
3	Miskelyemen et al	2012	38.70	25.82–51.58
4	Hamza et al	2020	33.64	22.60–44.69
5	Ayman et al	2021	35.49	23.92–47.07
6	Paul et al	2019	34.08	23.06–45.11
7	Henry et al	2023	35.84	24.25–47.42
8	Rhianna et al	2016	35.79	24.14–47.43
9	Hannah et al	2017	35.10	24.06–46.14
10	Joyce et al	2014	39.01	25.37–52.64
11	Okafor et al	2016	37.56	25.80–49.34
12	Evelyn et al	2020	33.75	22.38–45.11
13	Oluwaremilekun et al	2020	34.48	23.02–45.94
	Combined*		35.93	24.71–47.15

Table 5 Trim and fill analysis of the prevalence of malaria in refugee camps in Africa

Meta-analysis[a]					
Method	**Pooled est**	**95% CI**	**Z-value**	**P-value**	**No. of studies**
Fixed	12.320	10.792–13.848	15.803	< 0.001	13
Random	35.929	24.709–47,149	6.276	< 0.001	
Iteration	Estimate	Tn	# to trim	Diff	
1	12.320	82	6	91	
2	7.382	86	6	8	
3	7.382	86	6	0	
Filled meta-analysis[b]					
Method	**Pooled est**	**95% CI**	**Z-value**	**P-value**	**No. of studies**
Fixed	7.382	5.94–8.83	10.002	0.000	19
Random	12.414	0.89–23.94	2.111	0.035	

[a] Test for heterogeneity: Q = 427.586 on 12 degrees of freedom (p < 0.000). Moment-based estimate of between studies variance = 380.775

Trimming estimator: Linear; Meta-analysis type: Fixed-effects mode

[b] Test for heterogeneity: Q = 826.038 on 18 degrees of freedom (p < 0.001). Moment-based estimate of between studies variance = 606.242

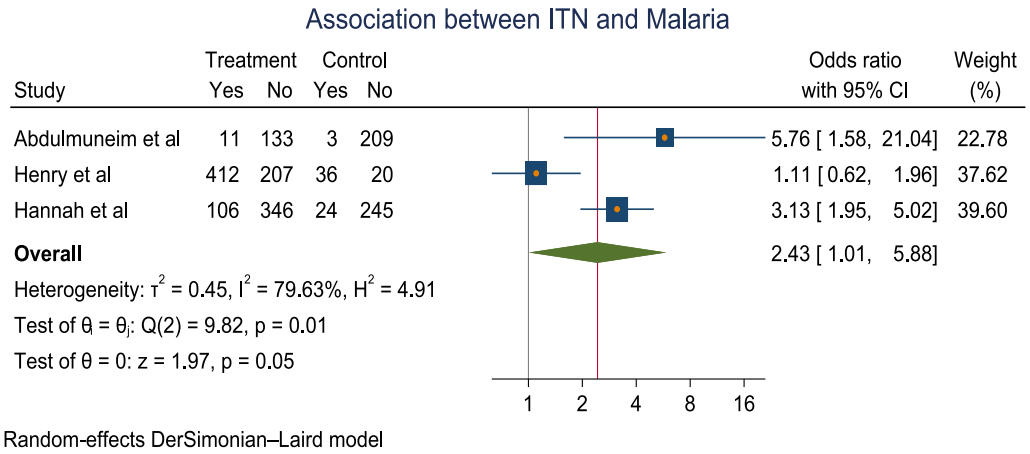

Fig. 11 Association between insecticide-treated net utilization and malaria in refugee camps in Africa, 2023

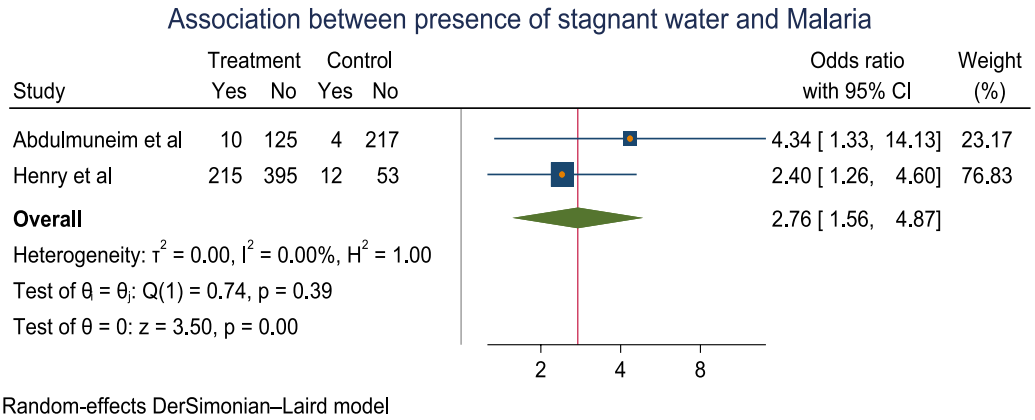

Fig. 12 Association between presence of stagnant water and malaria in refugee camps in Africa, 2023

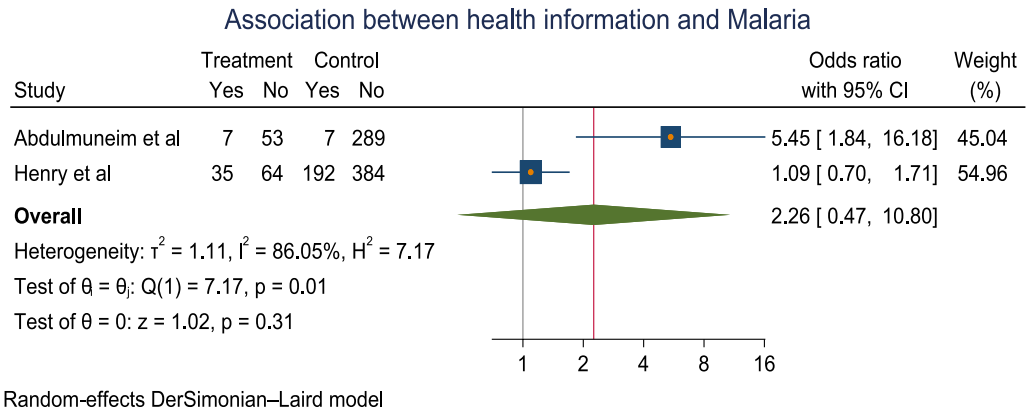

Fig. 13 Association between health information and malaria in refugee camps in Africa, 2023

in malaria prevalence from 2011–2015 to 2020–2023. This increase could be attributed to the fact that the studies conducted during the 2020–2023 period were in areas with high malaria endemicity, such as Nigeria. Additionally, the impact of disruptions caused by coronavirus disease 2019 (COVID-19) on malaria control measures,

including constraints on malaria chemoprevention, distribution of insecticide-treated bed nets (ITNs), indoor residual spraying (IRS), malaria testing and treatment, further exacerbated the burden of malaria [51]. The rising trends in the nature of malaria in refugee camps present challenges to the planned elimination of malaria globally and particularly in Africa [11].

In the current meta-analysis and systematic review, the pooled prevalence of malaria found to be highest (54.0%) among both internally displaced persons (IDP) and across type refugees. The risk of malaria infections tends to increase among refugees, especially when individuals with limited or no prior exposure to malaria move to regions with higher transmission rates [10]. Furthermore, the migration of refugees from malaria-endemic countries has been linked to imported malaria [6], which could contribute to secondary transmission and the development of drug resistance, posing a threat to long-term malaria elimination goals [13]. As a result, extending malaria control measures to refugees is crucial to attaining malaria control and elimination in countries with substantial refugee populations.

In this study, 41.82% (95% CI 18.60–65.04) of children were found to be infected with malaria. The finding is comparable to the pooled estimate in sub-Saharan countries (18.8%) [52] and in Ethiopia, where the prevalence among children and those under five years old was found to be 9.07% [39], and 22.03% [41], respectively. These results highlight that malaria remains a a significant concern for children under 5 years old. This susceptibility may be attributed to their limited natural immunity, making them highly vulnerable to malaria infection. This vulnerability could be linked to inadequate malaria control measures or insufficient monitoring and assessment of malaria control programmes. The development of immunity is slow and requires repeated exposure to the *Plasmodium* parasite by the Anopheles mosquito vector. Additionally, protection from the disease seems to decline without continuous exposure. The rate at which natural immunity is acquired is largely influenced by the intensity of transmission and the age of the individual [53].

The meta-analysis indicated the presence of publication bias, as evidenced by the asymmetry of the funnel plot and a significant P-value of 0.001 in Egger's test statistics. Additionally, the sensitivity analysis showed that no individual study significantly influenced the overall effect size. Despite the fact that research selection criteria and independent study selection by three reviewers, it was unable to completely eliminate publication bias, which may have impacted the results. Even after conducting subgroup analysis for various variables, substantial heterogeneity remained. In light of these findings, there is a clear need for further large-scale studies and targeted interventions for high-risk groups to mitigate the risk of disease transmission.

In this research, the association between not using insecticide-treated nets (ITNs) and the presence of stagnant water near residential areas was found to be linked to malaria. The lack of access to or failure to use ITNs is a risk factor for a higher prevalence of malaria among participants, as seen in studies conducted in Ethiopia [38, 41], sub-Saharan countries [53, 54], and Uganda [28]. This is because refugee populations who use ITNs are less exposed to *Plasmodium* species and are therefore less likely to become infected with the parasite. It is recommended that the Government distribute ITNs and promote their use to prevent high malaria transmission among refugee populations.

Living in close proximity to mosquito breeding sites, such as stagnant water, increases the transmission of malaria. This discovery aligns with findings from studies in Ethiopia [38, 41], sub-Saharan countries [54] and Nigeria [55]. Mosquitoes can breed and thrive in stagnant and unprotected water sources, putting refugee populations living near these areas at a heightened risk of malaria infection. To reduce malaria among refugee populations in Africa, it is advisable to clean and eliminate mosquito breeding sites.

A comprehensive search was carried out to gather published and unpublished studies, and the quality of each study was assessed using the Newcastle–Ottawa Scale for cross-sectional studies quality assessment tool. This approach will enhance the overall quality of the review and produce conclusive findings. The findings of this study are important for the countries striving for continent-wide malaria elimination by 2030. Nevertheless, it is advisable to interpret the results with caution due to some limitations of this review. Firstly, the majority of the studies utilized microscopy and RDT diagnostic tests which have limited capability to detect all asymptomatic malaria infections. This could potentially lead to erroneous conclusions when attempting to generalize the reduced pooled prevalence reported in this study. Additionally, there was considerable heterogeneity among the studies, which may impact the interpretation of the results.

Conclusion

The current systematic review and meta-analysis revealed a high pooled prevalence of malaria among the displaced individuals with *P. falciparum* being the predominant species in African refugee camps. The prevalence was particularly elevated among those with symptomatic malaria and children under five years old. Furthermore, the pooled prevalence of malaria varied based on factors

such as sample size, type of refuge, host country, study year, and diagnostic methods. The risk factors that have been identified are preventable, with factors such as not using ITNs and residing close to areas where mosquitoes breed being linked to malaria. It is recommended that the governments enhance malaria control measures by eliminating mosquito breeding sites, providing access to ITNs for the population, and implementing effective environmental control methods, with a focus on this specific population in Africa. The study's findings are valuable for policymakers and stakeholders, serving as a basis for future research and evidence-based decision-making.

Supplementary Information

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Supplementary Material 1

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Author contributions
Habtu Debash was involved in developing the proposal. Habtu Debash, Alemu Gedefie and Ermiyas Alemayehu were involved in the design, selection of articles, and data extraction and statistical analysis. Habtu Debash, Melaku Ashagrie Belete, Hussen Ebrhahem, Mihret Tilahun, Daniel Gebretsadik, Ousman Mohammed were involved in developing the initial drafts of the manuscript. Habtu Debash, Alemu Gedefie and Ermiyas Alemayehu participated in the final preparation of the manuscript and they approved the final draft of the manuscript for submission.

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Data availability
All data analysed during this study are included in the manuscript.

Declarations

Ethics approval and consent to participate
Not applicable.

Competing interests
The authors declare no competing interests.

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