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# Seroprevalence of Hepatitis B virus surface antigen among African blood donors: a systematic review and meta-analysis

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**Background:** Transfusion Transmitted Infections (TTIs) are still a growing public health problem in Africa. Studies that synthesize the available evidence on the seroprevalence of Hepatitis B Surface Antigen (HBsAg) among African blood donors are scarce. Therefore, this study aimed to synthesize qualitatively and quantitatively the seroprevalence of Hepatitis B Virus Surface Antigen (HBsAg) among blood donors in Africa.

**Methods:** We conducted a systematic review and meta-analysis where we included all studies that reported the seroprevalence of HBsAg among blood donors in Africa. The references were searched from electronic databases: PubMed, Web of Science, Cochrane, Scopus, WHO research database-HINARI, Global Index Medicus and ClinicalTrials.gov. We further analyzed the full list of references of all included studies. The pooled seroprevalence was estimated through random effect model. The heterogeneity was assessed through Cochrane's *Q* test and *I*<sup>2</sup>, respectively. Meta-regression, subgroup and sensitivity analyses were conducted.

**Results:** We obtained 124 studies that met our inclusion criteria, comprising 3,573,211 blood donors tested for HBsAg. The pooled seroprevalence of HBsAg among blood donors in Africa was 6.93% (95% CI: 5.95-7.97%;  $l^2 = 100\%$ ; p < 0.001). We found that the heterogeneity was explained by the study performed country and, African region. The higher prevalence was observed in Western 10.09% (95% CI: 8.75-11.50%), Central 7.81% (95% CI: 5.34-10.71%), and Eastern African region 4.87% (95% CI: 3.77-6.11%) and lower prevalence were observed in Southern 2.47% (95% CI: 0.54-5.75%) followed by Northern Africa region with 1.73% (95% CI: 0.45-3.79%). Additionally, based on the date of publication, we found that the highest prevalence was observed in studies published between 2001 and 2010 (9.41, 95% CI: 7.19-11.90) and the lowest prevalence was observed in studies published between 2011 and 2024 (6.26%; 95% CI: 5.19-7.42).

**Conclusion:** The seroprevalence of HBsAg among blood donors in Africa is still very high and heterogeneous. Therefore, intensifying the screening and vaccination of the population for Hepatitis B is critical to ensure blood safety toward eliminating Hepatitis B in Africa.

**Systematic review registration:** https://www.crd.york.ac.uk/prospero/display\_record.php?RecordID=395616, PROSPERO CRD42023395616.

KEYWORDS

blood donors, seroprevalence, serologic tests, Hepatitis B virus, African countries

## Introduction

Hepatitis B Virus (HBV) remains one of the most serious public health concerns challenging the world, with an estimated 257–291 million individuals having chronic Hepatitis B (1). Africa is one of the highest-burden regions for Hepatitis B, where it is estimated that nearly 116 million people live with Hepatitis B and 81 million are chronically infected (2). An infected person can transmit HBV through direct contact with blood, unprotected sexual intercourse, use of contaminated needles and syringes, mother to child transmission during delivery, and transfusion of infected blood (3). Transfusion of infected blood is one of the main modes of HBV transmission, particularly in the sub-Saharan Africa region (4). Therefore, the World Health Organization (WHO) recommends that all countries provide access to screening and preventive measures such as vaccination and treatment for Hepatitis B (5).

Blood transfusion can be potentially lifesaving, but the risk of several Transfusions-Transmissible Infections (TTIs) such as Hepatitis B is high. For this reason, screening of blood donors for TTIs is essential for transfusion safety.

Although more sensitive tests are highly recommended for screening Hepatitis B among blood donors, most of lower- and middle-income countries still widely use rapid diagnostic tests. These methods are still indispensable to guarantee blood donation safety in many African countries (6). To maintain a safe supply of blood transfusion and products, the WHO recommends that all blood donations be screened for infections before use (7).

Several systematic reviews and meta-analyses have estimated the prevalence of hepatitis B among blood donors in some specific African countries (8–12). However, comprehensive studies on the prevalence of Hepatitis B among blood donors in Africa are scarce. Therefore, this study aimed to systematically synthesize the available evidence on the seroprevalence of Hepatitis B Virus Surface Antigen (HBsAg) among Blood Donors in Africa.

## **Methods**

## Study design

This study is a systematic review and meta-analysis based on The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA Statement Guideline updated in 2020) (13). The study protocol was registered in the PROSPERO with the number CRD42023395616.

#### Search strategy and study selection

We included primary studies published in any language from inception through March 1st 2024, and having extractable data on seroprevalence of HBsAg among blood donors in Africa aged 16–65. We excluded case series, reviews, comments, editorials, and studies with duplicate data.

All relevant articles were searched in electronic databases, namely: PubMed/Medline, SCOPUS, Web of Science, WHO research database-HINARI, Cochrane database library, Global Index Medicus and Clinicaltrials.gov. The research query is in the Supplementary Table S1. We further analyzed systematically the full list of references of all included studies.

Two reviewers (AEQ, NC) carried out the study selection process independently, and discrepancies were resolved by the third reviewer (LA). This study was part of a more extensive research project that assessed the seroprevalence of Serologic Markers of Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), Human Immunodeficiency Virus (HIV), and Syphilis in Blood Donors in Africa.

Due to the considerable volume of results, we decided to split such a study into four separate analyses based on the transmitted blood infection disease (Hepatitis B virus, Hepatitis C Virus, Syphilis, and HIV).

## Data extraction

Two reviewers, AEQ and NC independently extracted the data for each included study based on a predefined and agreed-upon data extraction form designed for this study. The differences in extracted data were discussed, and persistent discrepancies were resolved by a third reviewer (LA). For each included study, we extracted the following information: Author name, year of publication, date of participant enrolment, study design, name of the country and African region where the study was performed, the total number of participants for each study, the total number of blood donors who tested positive for HBsAg, age, sex, type of blood donors (VNRBD-Voluntary Non-Remunerated Donors, RD- Replacement or Paid Donors/FD and FD-Family Donors), and the method used for screening and Hepatitis B diagnosis. This data was stored in a

Abbreviations: AIDS, Acquired immunodeficiency syndrome; Anti-HBc, Hepatitis B virus core antibody; Anti-HCV, Hepatitis C virus antibody; Anti-HCV+, Hepatitis C virus antibody positive; Anti-HIV, Human Immunodeficiency Virus antibody; BD, Blood donors; ELISA, Enzyme-linked immunosorbent assay; FRBD, Family replacement blood donor; HBV, Hepatitis B virus; HBV-OBI, Occult Hepatitis B infection; HBsAg, Hepatitis B virus surface antigen; HBsAg-, Hepatitis B virus surface antigen negative; HBsAg+, Hepatitis B virus surface antigen positive; HCV, Hepatitis C virus; HIV, Human immunodeficiency virus; HIV-1, Human immunodeficiency virus type 1; HIV-2, Human immunodeficiency virus type 2; QGIS, Quatum geo graphic information system; STDs, Sexually transmitted diseases; TPHA, *Treponema pallidum* hemagglutination assay; *T pallidum, Treponema pallidum*; TTIs, Transfusion-transmitted infections; VDRL, Venereal Disease Research Laboratory; VNR, volunteer's non-remunerated; VNRBD, volunteer's non-remunerated blood donors; WHO, World Health Organization.

Microsoft Excel 2021 spreadsheet (Microsoft Corporation, Redmond, Washington, USA).

#### Study's quality assessment

Two reviewers, AEQ and NC, independently assessed the quality of each included study using the risk of bias tool SeroTracker-RoB: a decision rule-based algorithm for reproducible risk of bias assessment of seroprevalence studies (14). The differences in the quality assessment of the included studies were discussed, and persistent disagreements were resolved by the third reviewer (LA). This tool derives from the Joanna Briggs Institute Checklist for Prevalence Studies and asks nine questions to assess the risk of bias. The questions are (a) Was the sample frame appropriate to address the target population? (b) Were study participants recruited in an appropriate way? (c) Was the sample size adequate? (d) Was the data analysis conducted with sufficient coverage of the identified sample? (e) Were valid methods used for the identification of the condition? (f) Was the condition measured in a standard, reliable way for all participants? (g) Was there appropriate adjustment for test characteristics? (h) Was there appropriate adjustment for population characteristics? (i) Was the response rate adequate, and if not, was the low response rate unlikely to introduce bias? And the last was the assessment of the overall risk of bias (lower, moderate, high and unclear) according to the scores from the responses of the previous nine items.

#### Data analysis

All the data were analyzed through R software version 4.3.2 (2023-10-31) using meta package and the functions for meta-analysis of proportion (15). We used the proportion of blood donors who tested positive for HBsAg as the parameter of interest to be estimated as our effect measure and meta-analyzed. We used the DerSimonian-Laird random effects model to estimate the pooled seroprevalence of HBsAg among blood donors in Africa, and the proportions were estimated based on Freeman-Tukey double arcsine transformation (FTT) (16). The findings were presented with 95% confidence intervals.

We run a Cochrane Q test and I<sup>2</sup> statistic (percentage of total variability due to true heterogeneity, that is, to between-studies variability) to assess the presence of heterogeneity and its relative magnitude, respectively (17). We performed subgroup and sensitivity analysis to investigate the moderator variables of the observed heterogeneity. Because we are analyzing and synthesizing prevalence studies from all of Africa and several different countries, we inherently assumed the presence of heterogeneity, and we mainly focused our analysis and results on subgroups and the assessment of moderators of heterogeneity.

The subgroup analysis studies were stratified by the country, African region, and year of publication. The years of publication were categorized into three categories (before 2000, 2001–2010 and 2011–2024). This cut-off was chosen based on the behavior of the distribution of the number of studies by year. To determine the moderators of heterogeneity, temporal trends and regional differences in our study, we performed meta-regression analyses using the following variables: year of study publication and African region (Western, Northern, Eastern, Central, and Southern), risk of bias, study location (unicentric and multicentric), setting (Urban and Rural), proportion of men, age, type of blood donors and country where the study was performed. In our study, we defined study location as unicentric if the study was carried out in a single center or one hospital. In contrast, a multicentric study means the study was conducted in multiple centers or hospitals. The setting variable refers to whether the study was conducted in an urban or rural area.

The publication bias was assessed through a funnel plot and by Egger's statistics regression test. We mapped the spatial pattern of the pooled estimates of seroprevalence of HBsAg among blood donors in Africa by country. The map was created using Quantum Geographic Information System (QGIS) software (18).

## Results

A total of 4,408 were identified through database and manual searching, and 500 duplicate articles were removed. The title and abstract of the remaining 3,908 were screened, and 3,605 articles were removed as they were found to be irrelevant to our study. The remaining 303 references were assessed for eligibility through the complete text examination, and 179 were excluded because they did not meet our inclusion criteria. The remaining 124 studies were considered for qualitative and quantitative synthesis involving 3,573,211 participants.

Among 179 that did not meet our inclusion criteria, 77 did not study the prevalence of Hepatitis B among blood donors, 43 were systematic reviews, 16 studies did not have relevant data, five studies did not have their full text available, 12 studies included population already positive to Hepatitis B, 12 studies included children, 14 studies included pregnant women (See Figure 1; Supplementary Table S3).

## Study characteristics

Supplementary Table S2 shows the characteristics of the studies included in this work. Thirty (55.5%) of the 54 African countries are represented in the 124 studies included. Most of the studies were conducted in Western Africa 51 (41.13%), followed by Eastern Africa 32 (25.81%), then by Central 26 (20.97%), and lastly by the Northern 9 (7.26%) and Southern 6 (4.84%) African region.

The year of study publication ranged from 1990 to 2024. The majority, 89 (75%), were published after 2010. The median proportion of men in the included studies was 83.75%.

Regarding the risk of bias, most studies had a moderate risk of bias 70 (56.45%), followed by a low risk of bias 36 (29.03%), and lastly by a high risk of bias 18 (14.52%).

# Seroprevalence of hepatitis B surface antigen

We found that the pooled seroprevalence of HBsAg among blood donors in Africa was 6.93% (95% CI: 5.95–7.97%; see the forest plot in Figure 2).

In subgroup analysis, we found statistically significant differences in the seroprevalence of HBsAg among blood donors in Africa



according to the study country (p < 0.01), year of study publication (p < 0.03) and African region (p < 0.01), (Figures 2, 3; Table 1).

Regarding the seroprevalence of HBsAg by African regions, we found that the Western region had the highest prevalence of HBsAg at 10.09% (95% CI: 8.75–11.50%), followed by the Central region with 7.81% (95% CI: 5.34–10.71%), then by the Eastern Africa region with 4.87% (95% CI: 3.77–6.11%) the Southern with 2.47% (95% CI: 0.54–5.75%) and finally, by the Northern African region with 1.73% (95% CI: 0.45–3.79%).

Regarding to the year of study publication, highest prevalence was observed in studies published between 2001 and 2010 (9.41%; 95% CI: 7.19–11.90%) followed by studies published from 1990 to 2000

(8.07%; 95% CI: 3.80–13.73%) and the lowest prevalence was observed in the studies published between 2011 and 2024 (6.26%; 95% CI: 5.19–7.42%) (see Table 1).

We generally found high heterogeneity among pooled studies (Cochran *Q*-test p < 0.001 and  $I^2 = 100\%$ ). In the meta-regression analysis, we observed that the heterogeneity was moderated by the African region (p < 0.01) and the country where the study was performed (p < 0.01) (see Table 2).

Among the studied moderator variables, 44.69% of the heterogeneity was explained by the country where the study was performed (p < 0.01), and by the African region 28.60% (p < 0.01). We did not find a statistically significant variation in the seroprevalence

olddy (year)	04363			Trevalence(70)	5576 0.1.	Weight	
Algeria			_				
Djoudi.F, et al 2023	143	140168		0.10	[0.09; 0.12]	0.8%	
Angola							
L.Peliganga, et al 2021	4928	57979	*	8.50	[8.27; 8.73]	0.8%	
Quintas E.A, at al 2023	1373	2734		50.22	[48.33; 52.11]	0.8%	
Random effects model	-0.12 p -	60713		26.57	[ 0.35; 72.93]	1.7%	
Heterogeneity. $I = 100\%$ , $\Box =$	- 0.12, <i>μ</i> – 1	0					
Botswana W.Choga, et al 2019	128	12757	4	1.00	[ 0.84; 1.19]	0.8%	
Burkina Faso							
N Wongiarupong, et al 2021	1 22376	166681		13 42	[13 26: 13 59]	0.8%	
M Nagalo et al 2011	676	4520	+	14.96	[13 93: 16 04]	0.8%	
A Vooda, et al 2019	5854	84200		6.94	[677.711]	0.8%	
A Simpore et al 2014	24	242	1	0.04	[0.77, 7.11]	0.0%	
A. Simpole, et al 2014	24	242		9.92	[0.03, 14.34]	0.0%	
Namia D, et al 2009	90	000		19.20	[15.90, 22.90]	0.0%	
1000a A.P, et al 2018	12	909		1.20	[ 0.70; 9.12]	0.8%	
Noura. IVI, et al 2017	535	12969		4.13	[ 3.73; 4.42]	0.8%	
Random effects model	0.5.	270200	$\diamond$	10.28	[ 6.69; 14.52]	5.7%	
Heterogeneity: $I^{-} = 100\%$ , $\Box^{-} =$	= < 0.01, p =	= 0					
Burundi							
R.Kwizera, et al 2018	94	5569	•	1.69	[ 1.37; 2.07]	0.8%	
Cameroon							
F Ankouane et al 2016	1137	9024	+	12 60	[11 91 13 20]	0.8%	
M Samie et al 2021	16	250		6.40	[3.88.10.3/]	0.8%	
M Kengne et al 2021	21	200	1	11 70	[8 17 16 26]	0.8%	
M Mogtomo et al 2000	01	200		6.01	[ / /7. 10.20]	0.0%	
C T Tagny of al 2018	∠ I 100	1506		0.91	[4.47, 10.49]	0.0 %	
Meanya N.D. at al 2010	123	1090		1.11	[7.24, 45.00]	0.0%	
Allein Let al 2010	27	252		10.71	[7.24, 15.26]	0.0%	
Andin J, et al 2010	282	3325		8.48	[1.34; 9.28]	0.0%	
	393	2320		10.90	[15.27; 18.37]	0.8%	
Odom D, et al 2016	229	3364	*	0.81	[ 5.98; 7.72]	0.8%	
Ankouane F, et al 2015	1137	9024		12.60	[11.78; 13.17]	0.8%	
Random effects model		29730	$\diamond$	9.97	[7.96; 12.19]	8.0%	
Heterogeneity: $I^2 = 96\%$ , $\Box^2 =$	< 0.01, p <	0.01					
Côte d`Ivoire							
Bengue M.K A, et al 2008	1	43		2.33	[ 0.53; 12.92]	0.6%	
Seri B, et al 2018	46957	422319		11.12	[11.01; 11.20]	0.8%	
Random effects model		422362	$\diamond$	7.15	[ 1.18; 16.95]	1.4%	
Heterogeneity: $I^2 = 77\%$ , $\Box^2 =$	< 0.01, p =	0.04					
Democratic Republic of C	ongo						
J.Kabinda, et al 2014	27	568	-+-	4.75	[ 3.21; 6.89]	0.8%	
A.T.Kabamba, et al 2021	120	1512	+	7.94	[ 6.51; 9.31]	0.8%	
P.Kombi, et al 2018	186	5408	+	3.44	[ 2.97; 3.96]	0.8%	
M. Nzaji, et al 2013	17	1015	+	1.67	[ 1.02: 2.71]	0.8%	
Ndilu K.L. et al 2016	6	372	+	1 61	[0.70: 3.59]	0.8%	
Jager H. et al 1990	294	2237		13 14	[11.79: 14.63]	0.8%	
Namululi B.A. et al 2012	220	6048		3 64	[3.18: 4.14]	0.8%	
Mudii J. et al 2021	117	3493	+	3.35	[2.78: 4.01]	0.8%	
Random effects model		20653	$\diamond$	4.47	[ 2.44: 7.08]	6.5%	
Heterogeneity: $I^2 = 98\%$ , $\Box^2 =$	< 0.01, p <	0.01	Ť		,oo]	/ 0	
Eavpt							
E Hussein et al 2013	3756	308762		1	[1.18] 1.251	0.8%	
Ibrahim Y et al 2014	270	17118	•	1.22	[137:175]	0.8%	
FI-Zavadi R A et al 2009	210	760	+	1.00	[0.60. 2.30]	0.8%	
Random effects model	Э	326640	1	1.10	[107: 165]	2.5%	
Heterogeneity: $I^2 = 87\%$ , $\Box^2 =$	< 0.01, p <	0.01	a de la companya de la compa	1.34	[ 1.07, 1.00]	2.9/0	
Equatorial Guinea							
D.Xie, et al 2015	294	2937	+	10.01	[ 8.60; 10.83]	0.8%	
Eritreia							
N.Siraj, et al 2018	1203	60236	•	2.00	[1.89: 2.11]	0.8%	
N.Fessehave, et al 2011	761	29501	1	2.58	[2.38: 2.75]	0.8%	
		1939	+	5.00	[3.95: 5.95]	0.8%	
Y.Keleta, et al 2019	51/	1					
Y.Keleta, et al 2019 Random effects model	97	91676		3.03	[ 1.58: 4.94]	2.5%	

FIGURE 2 (Continued)

Existing a set of the					
SAdolell, et al 2020 13319 564854 24 94 (2.55, 2.43) 0.6 (3.7, 4.17, 5.57) 0.6 (3.7, 5.5, 7.5, 7.5, 7.5, 7.5, 7.5, 7.5, 7	Ethiopia				
$\begin{aligned} \text{Ababe, et al} 2016 & 647 & 6627 & 9.48 & [5.78, 10.19] & 65 & 658, 11.74 & 058 & 1.78 & 0.98 & [5.78, 10.19] & 65 & 658, 11.74 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 1.78 & 0.58 & 0.58 & 1.78 & 0.58 & $	S.Abdella, et al 2020	13319	554954	•	2.40 [2.35; 2.43] 0.8
Mohammed, et al 2016 460 4224 4 10.089 $[9.83, 11.37]$ 0.68 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.69 $[9.83, 11.37]$ 0.60 $[9.83, 11.$	M.Abate, et al 2016	647	6827	4 (A)	9.48 [8.78; 10.19] 0.8
B. Besema, et al 2010 298 6351 200 445 7745 384 05 4477 (537) 05 6063 420 57 (147) 42 47 05 65 (147) 42 47 15 65 (147)	Y.Mohammed, et al 2016	460	4224	+	10.89 [9.83; 11.74] 0.8
A Yam, ist all 2011 126 6003 14 2016 129 2806 445 1417; 557 10 50 451 13.62, 915 13.62, 915 13.6	B.Tessema, et al 2010	298	6361		4.68 [4.18; 5.24] 0.8
$\begin{aligned} J: Ramos, et al. 2016 & 129 & 2666 & 495 & [4.17; 5.67] & 6.57 & [3.62] & 1.75 & [5.7] & 6.57 & [3.62] & 1.75 & [3.62] & 1$	A.Yami, et al 2011	126	6063	•	2.08 [1.74; 2.47] 0.8
$\begin{aligned} M \operatorname{Alegash}_{23} \operatorname{eta} 2019 & 18 & 310 & 501 & 13.62 & 1510 & 0.5 \\ M \operatorname{Abebe}_{23} \operatorname{ata} 2020 & 546 & 17810 & 3.7 & 12.82 & 3.33 & 0.5 \\ E \operatorname{Derv}_{23} \operatorname{ata} 2018 & 407 & 10728 & 3.7 & 12.82 & 3.33 & 0.5 \\ E \operatorname{Derv}_{23} \operatorname{ata} 2018 & 407 & 10728 & 3.7 & 12.82 & 3.33 & 0.5 \\ E \operatorname{Derv}_{23} \operatorname{ata} 2018 & 407 & 10728 & 3.7 & 12.84 & 4.17 & 0.5 \\ E \operatorname{Derv}_{23} \operatorname{ata} 2018 & 407 & 10728 & 3.7 & 12.84 & 4.17 & 0.5 \\ E \operatorname{Derv}_{23} \operatorname{ata} 2016 & 37 & 300 & 4.6 & 12.1 & 10.99 & 14.7 & 12.5 & 17.7 & 10.5 \\ TDeressa_{23} \operatorname{ata} 2016 & 102 & 2460 & 1.2 & 10.98$	J:Ramos, et al 2016	129	2606	+	4.95 [4.17; 5.87] 0.8
$\begin{aligned} \text{Ababebe et al 2020} & 546 & 1780 & 307 & [2.82; 3.33] & 62 & 379 & [3.44; 4.17] & 63 & 379 & [3.44; 4.17] & 64 & 12018 & 407 & 10728 & 3.79 & [3.44; 4.17] & 64 & 12018 & 106 & 227 & 4.74 & [3.31; 5.72] & 64 & 379 & [3.44; 4.17] & 66 & 12018 & 12018 & 12018 & 12018 & 12018 & 326 & 4.74 & [3.31; 5.72] & 12018 & 541 & [1.635; 1.27] & 106 & 541 & [1.635; 1.27] & 106 & 541 & [1.635; 1.27] & 106 & 541 & [1.635; 1.27] & 106 & 541 & 12018 & 12018 & 12018 & 12018 & 12018 & 136 & 563 & 566 & 556 & [3.94; 7.43] & 11.65; 1.76 & [0.56 & [3.94] & 7.43] & 13.65 & [1.635; 1.27] & 106 & 568 & 568 & 568 & 568 & 728 & 728 & [1.77] & 684 & 568 & 568 & 568 & 568 & 728 & [1.77] & 1251; 6.78] & 006 & 568 & 5686 & 728 & 728 & [1.77] & 728 & 568 & [3.94; 7.43] & 13.65 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 3.30] & 10.00 & [1.298; 1.27] & 108 & 11000 & 12.28 & [1.598; 1.27] & 108 & [1.271; 1.282; 1.471] & 128 & [1.271; 1.282] & 128 & [$	M.Negash, et al 2019	18	310	-	5.81 [3.62; 9.15] 0.8
YBelyhun, et al 2021         145         1720         38.43         [7.18, 9.86]         6.53         [7.14]         8.71         0.55           EDore, et al 2016         407         10728         4.74         [1.391, 5.72]         0.6           EDore, et al 2016         37         330         -         4.74         [1.391, 5.72]         0.6           Raihenbeck 1.5, et al 2015         73         549         -         4.74         [1.391, 5.72]         0.6           Raihenbeck 1.5, et al 2015         73         549         -         4.74         [1.231, 17.61]         0.6           Raihenbeck 1.5, et al 2014         1.454         46018         -         -         5.56         [.394; 7.41]         1.55           Raihenbeck 1.5, et al 2014         1.454         46018         -         -         7.28         -         4.74         1.539, 5.81         1.50         3.80         6.66         [.599; 7.39]         0.6         F.749         -         4.74         [.501; 7.47]         0.6         1.74         7.4         7.4         1.74         1.74         7.4         7.4         1.74         7.3         -         4.77         1.517         0.8         1.007         7.75         5.44         1.001<	M.Abebe, et al 2020	546	17810		3.07 [2.82; 3.33] 0.8
B Degela, et al 2018 407 10728 379 [3.44, 4.17] 05 16 14 (10.69) 05 474 (3.91, 5.72] 05 44 Ambachew, et al 2018 106 227 4 (3.91, 5.72] 05 474 (3.91, 5.72] 05 474 (3.91, 5.72] 05 474 (3.91, 5.72] 05 474 (3.91, 5.72] 05 484 (5.91, 7.43] 12 (0.98, 1.47] 05 476 (5.98, 7.43] 12 (0.98, 1.47] 05 484 (5.98, 7.43] 12 (0.98, 1.47] 05 484 (5.98, 7.43] 12 (0.98, 1.47] 05 484 (5.98, 7.43] 12 (0.98, 1.47] 05 484 (5.98, 7.43] 12 (0.98, 1.47] 05 484 (5.98, 7.43] 13 (5.98, 1.47] 05 (5.98, 7.43] 12 (5.98, 4.47] (5.98, 1.42] 05 (5.98, 7.43] 05 (5.98, 7.44] 01 (5.98, 7.43] 05 (5.98, 7.44] 01 (5.98, 7.43] 05 (5.98, 7.44] 01 (5.98, 7.43] 05 (5.98, 7.44] 01 (5.98, 7.43] 05 (5.98, 7.44] 01 (5.98, 7.4	Y.Belyhun, et al 2022	145	1720	+	8.43 [7.18; 9.86] 0.8
E Dro, et al 2003 H Ambachev, et al 2016 102 Brandender, L3, et al 2017 103 Brandender, L3, et al 2017 104 Brandender, L3, et al 2017 105 Brandender, L3, et al 2014 105 Brandender, et al 2015 105 Brandender, et al 2015 105 Brandender, et al 2017 Brandender, et al 2017 Brand	B.Degefa, et al 2018	407	10728		3.79 [3.44; 4.17] 0.8
H Ambachew, et al 2016 106 227 1 4.4 (13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.1; 5.72) 0.6 (2.5; 13.2; 14.2) (2.5; 14.	E.Diro, et al 2008	49	600	-+	8.17 [6.14; 10.69] 0.8
EBiselegen, et al 2016 102 8460 Rahlenbeck IS, et al 2015 79 549 1 Rahlenbeck IS, et al 2015 79 549 1 Rahlenbeck IS, et al 2015 79 549 1 Rahlenbeck IS, et al 2016 79 549 1 Rahlenbeck IS, et al 2016 79 549 1 Rahlenbeck IS, et al 2016 79 549 1 Rahlenbeck IS, et al 2014 164 46018 2 Classey, et al 2014 164 46018 2 Classey, et al 2014 164 46018 3 Classey, et al 2014 164 46018 3 Classey, et al 2014 164 46018 3 Classey, et al 2014 164 46018 3 Rahlenbeck IS, et al 2014 164 46018 3 Rahlenbeck IS, et al 2014 164 46018 3 Rahlenbeck IS, et al 2014 164 46018 3 Classey, et al 2016 533 300 5 Classey, et al 2012 64 719 5 Classey, et al 2015 33 300 5 Allani, J, et al 2010 568 1000 1 Adalin J, et al 2010 568 1000 1 Adalin J, et al 2010 543 2264 5 Sarkode F, et al 2017 2 Classer 100 5 Rahdom effects model 51737 8 Allani, J, et al 2010 5 Sarkode F, et al 2017 2 Classer 2 Allani, J, et al 2010 5 Sarkode F, et al 2017 2 Classer 2 Allani, J, et al 2016 3 Sarkode F, et al 2017 3 Sarkode F, et al 2018 2 Sarkode F, et al 2018 2 Sarkode F, et al 2017 3 Sarkode F, et al 2018 3 Sarkode F, et al 2018 3 Sarkode F, et al 2018 3 Sarkode F, et al 2017 3 Sarkode F, et al 2018 3 Sarkode F, et al 2018 3 Sarkode F, et al 2017 3 Sarkode F, et al 2018 3 Sarkode F, et al 2019 3 Sarkode F, et al 2018 3 Sarkode F, et al 2019 3 Sarkode F, et al 2018 3 Sarkode F, et al 2017 3 Sarkode F, et al 2017 3 Sarkode F, et al 2018 3 Sarkode F, et al 2017 3 Sarkode F, et al 2017 3 Sarkode F, et al 2018 3 Sarkode F, et al 2018 3 Sarkode F, et al 2019 3 Sarkode F, et al 2014 100 758 3 Sarkode F	H.Ambachew, et al 2018	106	2237	+	4.74 [3.91; 5.72] 0.8
T.Deressa, et al 2018       102       8460       1.21       [0.99; 1.47]       6.8         Rahenbeck I.S. et al 2015       16       384       4.17       [2.51; 6.78]       6.6         Random effects model       6.2423       6.56       [3.94; 7.43]       13.5         Cabon       5.56       [3.94; 7.43]       13.6       [2.85; 3.17]       6.6         Labrance at al 2014       1454       46018       3.16       [2.85; 3.17]       6.6       6.69; 7.28       7.47       4.47       1.21       1.00       7.74       9.447       1.21       1.02       7.28       7.47       4.47       1.28       1.01       7.20       0.28       1.01 <t< td=""><td>F.Bisetegen,et al 2016</td><td>37</td><td>390</td><td></td><td>9.49 [6.85; 12.91] 0.8</td></t<>	F.Bisetegen,et al 2016	37	390		9.49 [6.85; 12.91] 0.8
Rahebook i S, et al 2015 79 549 14.39 [11.63, 17.66] 0.6 844 44.001, $p = 0$ Random effects model 624223 44.66 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.94; 7.43] 13.6 [2.86; 3.17] 0.6 (5.56 [3.96] 1.6 (3.16) [2.26; 0.	T.Deressa, et al 2018	102	8460	4	1.21 [0.99; 1.47] 0.8
Kebede E, et al 2020       16       384       4.17       [2.51; 6.78]       0.8         Random effects model       62423       5.56       [3.94; 7.43]       13.0         Lereambian, et al 2014       1.454       46018       5.56       [3.94; 7.43]       13.0         L. Breambian, et al 2014       1.454       46018       6.66       5.99; 7.38]       0.6         L. Reambian, et al 2014       1.454       46018       3.16       [2.28; 3.01]       0.8         Random effects model       1.67749       4.47       [2.22; 6.47]       4.17       [2.22; 6.47]       4.17         Chubo, et al 2012       64       719       8.90       [6.98; 11.27]       0.6       6.95       1.36       1.28       1.50       3.30       0.16       1.00       7.75       2.28       1.50       3.6       5.40       1.51       1.00       7.75       2.68       6.66       5.96       5.63       5.64       5.63       5.64       7.77       0.8       8.90       [6.98; 11.27]       0.8       1.00       7.35       0.6       0.75       1.41       1.00       7.75       1.51       0.5       6.35       5.40       7.77       0.8       1.54       1.29       7.77       0.8	Rahlenbeck I.S, et al 2015	79	549	+	14.39 [11.63; 17.66] 0.8
Random effects model $62223$ • $5.66$ $[3.94; 7.43]$ 13.0 Hererogeneity: $l^2 = 995$ , $l^2 = < 0.01$ , $p = 0$ Gabon L Rerambian, et al 2014 1454 46018 C. Gisseye, et al 2018 338 5076 G. Gisseye, et al 2018 5083 69862 L. Rerambian, et al 2014 1244 46018 Random effects model 16773 C. Malo, et al 2012 64 719 C. Malo, et al 2013 1568 1000 Halori, et al 2010 1569 1000 Halori, et al 2010 1401 10740 C. Oryango, et al 2017 64 2046 C. Oryango, et al 2017 64 2046 C. Oryango, et al 2017 64 2046 C. Oryango, et al 2018 142 1215 S. Malori, et al 2010 1401 10740 Malian J, et al 2010 1401 10740 Malian J, et al 2010 1401 10740 Malian J, et al 2010 1401 10740 Malori, et al 2010 1401 10740 Malian J, et al 2012 140 1401 10740 Malian J, et al 2010 1401 10740 Malian J, et al 2012 1700 11100 Malian J, et al 2018 42 524 43 1388 [13,47; 14,32] 0.8 Malong 6, A, et al 2022 22 22 229 Sandom effects model 227218 1 Malori, et al 2012 1700 11100 Marcaco Sandom effects model 227218 1 Malori, et al 2013 1083 16805 Soubber, et al 2013 1083 16805 Soubber, et al 2013 109 750 Soubber, et al 2011 140 24761 Swa	Kebede E, et al 2020	16	384	+	4.17 [2.51; 6.78] 0.8
Heterogeneity: $r^2 = 90\%$ , $t^2 = < 0.01$ , $\rho = 0$ Gabon L. Ferambiah, et al 2014 1454 46018 C. Bisseye, et al 2018 508 69862 7.28 L. Ferambiah, et al 2014 1454 46018 Random effects model 167749 Heterogeneity: $r^2 = 100\%$ , $t^2 = < 0.01$ , $\rho < 0.01$ Ghana C. Kubio, et al 2012 64 719 E. Cogle, et al 2013 508 100 Alian J, et al 2001 548 2264 Alian J, et al 2010 1568 11000 142 [13,67] 1482 [0,67] 1487 [14,01] 156 2455 [14,07] 140 [14,07] 140 [13,04] [12,39] 13,68] [0,67] [14,67] 148 [14,07] 1482 [0,67] 1487 [14,01] 156 [14,07] 1482 [0,67] 1487 [14,01] 156 [14,07] 1482 [13,67] 1480 [14,17] 1482 [13,67] 1480 [14,17] 1482 [13,67] 1480 [14,17] 1482 [13,67] 1480 [14,17] 1482 [13,67] 1480 [14,17] 1482 [13,67] 1480 [14,17] 1480 [14,	Random effects model		624223	Ø	5.56 [3.94; 7.43] 13.0
Gabon       316       [2.85, 3.17]       0.4         L. Reramblah, et al 2014       1454       46016       3.16       [2.85, 3.17]       0.4         L. Reramblah, et al 2014       503       6962       7.28       [7.01, 7.40]       0.4         Reramblah, et al 2014       21       776       4.4       [1.50, 3.96]       0.4         Reramblah, et al 2014       22       776       4.47       [2.25, 6.47]       4.1         Reramblah, et al 2012       64       719       2.44       [1.50, 3.96]       0.6         C Kubio, et al 2013       233       300       1.00       [1.76, 151]       0.6         Allain J, et al 2001       548       2845       9.5       9.56       [1.56, 11.07]       0.6         Sarkodie F, et al 2016       156       2455       1.6       6.35       [5.40, 7.38]       0.6         Galma       41010       1401       10740       13.04       [1.29, 13.68]       0.6         Sarkodie F, et al 2010       1401       10740       13.04       [1.29, 13.68]       0.6         Allain J, et al 2010       1401       10740       13.04       [1.23, 13.68]       0.6         Compage, et al 2013       1001       1401 <t< td=""><td>Heterogeneity: <math>I^2 = 99\%</math>, <math>\Box^2 = &lt;</math></td><td>0.01, p =</td><td>0</td><td></td><td></td></t<>	Heterogeneity: $I^2 = 99\%$ , $\Box^2 = <$	0.01, p =	0		
Learnable, et al 2014 1454 46018 C Bisseye, et al 2016 339 6076 Learnable, et al 2018 5038 60862 Learnable, et al 2014 22 Learnable, et al 2014 22 Learnable, et al 2014 22 Learnable, et al 2014 22 Learnable, et al 2015 33 S000 Heterogeneity: $l^2 = 0.01, p < 0.01$ C Kubio, et al 2012 64 A 179 E Dogbe, et al 2015 33 S000 Heterogeneity: $l^2 = 100\%, l^2 = < 0.01, p < 0.01$ C Kubio, et al 2012 82 Secold E 4 2014 140 A Nankop, et al 2015 15 Sancdie F, et al 2016 156 A Nankop, et al 2010 1568 11000 A Alar, tet al 2010 1568 11000 A Cadal-Meash 0, et al 2015 27 Adola-Meash 0, et al 2015 27 Adola-Meash 0, et al 2015 159 2455 C Convang, et al 2010 1568 11000 Addal-Meash 0, et al 2015 27 Adola-Meash 0, et al 2015 27 Adola-Meash 0, et al 2015 27 Adola-Meash 0, et al 2015 27 Heterogeneity: $l^2 = 100\%, l^2 = 0.01, p = 0$ C Convang, et al 2010 1401 10740 Kenya Allain J, et al 2010 1401 10740 Kandom effects model 57737 Kandom effects model 51737 Kandom effects model 525 Adola, Meash 0, et al 2015 2465 Allain J, et al 2010 1401 10740 Malawi ADiarra, et al 2009 3648 25543 Allain J, et al 2017 64 2046 C.Owyang, et al 2018 369 204920 Malia A Diarra, et al 2009 3648 25543 Allain J, et al 2010 1401 10740 Malawi Malonga G. A, et al 2012 156 2946 Solo (4, et al 2013 1668 1699 41, et al 2016 162 22 229 Sandom effects model 73912 Heterogeneity: $l^2 = 99\%, l^2 = 0.01, p = 0.01$ Malawi Malonga G. A, et al 2021 156 2946 Solo (4, et al 2019 1177 31952 1486 14, ft 515, 616 0.6 Allain J, et al 2010 3564 25543 Allain J, et al 2013 1603 169605 C Solo (4, et al 2014 140 24761 C Sof (3, 3, 1, 1, 0, 58) 0.6 C Solo (4, 4, 90, 7, 1, 1) 0.6 C Solo (4, 4, 90, 7, 1, 1) 0.7 C Solo (5, 61, 41, 2013, 1, p < 0.01 Macambinger, et al 2019 112 1665 C Andom effects model 222218 C Maeveneyneyne, et al 2014 140 24761 C Sof (3, 4, 1, 3, 7, 1, 5, 6) 0.6 C Solo	Gabon				
C. Bisseys, et al 2018 338 5076 778 778 788 7898 7978 778 728 77.0 77.740 0.6 788 7898 778 778 778 7728 77.0 77.740 0.6 788 7898 778 778 7728 77.0 77.740 0.6 788 7878 778 778 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.740 0.6 728 77.0 77.1515 0.6 75 74.0 0.6 728 77.0 77.1515 0.6 75 74.0 0.6 748 77.0 75.1515 0.6 75 14.0 77.1515 0.6 75 14.0 77.1515 0.6 75 14.0 77.1515 0.6 75 14.0 10.0 14.25 1737 11.0 0.6 745 14.25 173.7 14.25 1868 11000 1.425 173.7 14.25 1868 11000 1.425 173.7 14.25 1868 11000 1.425 173.7 14.25 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.425 173.7 18.0 1.504 12.0 1.528 1.200 1.425 173.7 18.0 1.504 12.0 1.528 1.200 1.425 173.7 18.0 1.504 12.0 1.528 1.200 1.425 173.7 18.0 1.504 12.0 1.528 1.200 1.425 13.3 1.508 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.25 13.3 1.588 0.6 14.201 1.598 1.599 1.478 14.015 15.8 1.599 1.478 14.015 15.8 1.599 1.478 14.015 15.8 1.599 1.478 14.015 15.8 1.599 1.478 14.015 15.8 1.599 1.478 14.016 1.558 1.599 1.478 14.016 1.558 1.599 1.479 1.558 1.599 1.479 1.558 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.015 15.58 1.599 1.478 14.599 1.575 1.576 1.478 1.588 1.595 1.597 1.5	L.Rerambiah, et al 2014	1454	46018	4	3.16 [2.85: 3.17] 0.8
JAtta, stel 2016       5083       69862       7.28       7.701; $r.401$ 0.6         Rerambiah L, K, et al 2014       22       775       2.44       [1.50; 3.96]       0.6         Random affocts model       167749       4.47       [2.82; 6.47]       4.1         Atlan, J, et al 2012       64       719       8.90       [6.98; 11.27]       0.6         CMain, J, et al 2012       64       719       8.90       [6.98; 11.27]       0.6         Allan, J, et al 2012       53       300       11.00       [7.75; 15.16]       0.6         Allan, J, et al 2010       1568       11000       14.25       [1.679]       [1.504; 7.38]       0.6         Allan, J, et al 2010       1568       11000       14.25       [1.504; 7.38]       0.6       6.35       [5.46; 9.77]       0.6         Allan, J, et al 2010       1401       10740       13.04       [12.39; 13.68]       0.6         Allan, J, et al 2010       1401       10740       13.04       [12.39; 13.68]       0.6         Conyago, et al 2018       42       1215       3.46       [2.49; 4.64]       0.6         SingogoE, et al 2013       109       3548       25543       3.46       [2.49; 4.64]       0.6	C Bisseve et al 2018	338	5076		6.66 [5.99 7.38] 0.8
The armbian bit of a 2014 1454 440018 3 16 12.08 13.00 05 Rarambian L, K, et al 2014 22 775 24 001, $p = 0.01$ Hearogeneity: $f^2 = 0.08$ , $f^2 = < 0.01$ , $p = 0.01$ Ghana C.Kubia, et al 2012 64 719 4.0 1100 1757 1515 0 Allain, J, et al 2015 33 300 1100 1757 1515 0 Sarxolo F, et al 2021 858 3984 1100 1401 1071 168 1400 1425 1127 85 Sarxolo F, et al 2010 1568 1100 146 1100 1425 1135 1142 0 Sarxolo F, et al 2010 1568 1100 146 1100 1425 1135 1142 0 Sarxolo F, et al 2010 1568 1100 146 1100 1425 1135 1142 0 Sarxolo F, et al 2010 1568 1100 146 1100 1425 1135 1142 0 Sarxolo F, et al 2010 1568 1100 146 1100 1425 1135 1142 0 Sarxolo F, et al 2010 1568 1100 146 1100 1425 1135 1142 0 Sarxolo F, et al 2010 1568 1100 140 100 140 13.04 [12.38; 13.68] 0.6 Sarxolo F, et al 2010 1401 10740 13.04 [12.38; 13.68] 0.6 Kenya D.Vamamba, et al 2017 64 2046 3.13 [2.38; 3.94] 0.6 C.Onyang, et al 2017 64 2046 3.13 [2.38; 3.94] 0.6 S.Onyang, et al 2017 64 2046 3.13 [2.38; 3.94] 0.6 S.Onyang, et al 2018 1401 10740 13.04 [12.39; 13.68] 0.6 Malawi Singogo E, et al 2023 809 204920 0.39 [0.36; 0.42] 0.5 Malawi Malawi Malawi Maiong G, A, et al 2023 809 204920 0.39 [0.36; 0.42] 0.5 S.On [4.51; 6.16] 0.6 S.So [4.51; 6.14] 0.5 S.So [4.51; 6.14] 0.5 S.S	I Mba et al 2018	5083	69862		7.28 [7.01: 7.40] 0.8
$\begin{array}{c} \text{Localitation of all 2011} \ for all 2012 \$	Rerambiab et al 2014	1454	46018		3 16 [2 98: 3 30] 0.0
$\begin{aligned} & \text{Advalument} P, P \in \text{Advalument} P, P \in \text{Advalument} P, P \in \text{Advalument} P, P = 0.004, D = 4.011, P < 0.011 \\ & \text{Heterogeneity}, P = 1004, D = 4.011, P < 0.011 \\ & \text{Heterogeneity}, P = 1004, D = 4.011, P < 0.011 \\ & \text{Allami, J, et al 2012} & \text{C4} & \text{T19} \\ & \text{Elogpe, et al 2013} & \text{S2} & \text{S3994} & \text{S3904} & $	Recombiably K et al 2014	22	775		2.84 [1.50; 3.98] 0.9
$ \begin{array}{c} And constrained and the calculation of the constraints of th$	Pandom offects model	22	167740		2.04 [1.30, 3.90] 0.0
Chana C	Heterogeneity: $J^2 = 100\%$ $r^2 = -$	< 0.01 p	< 0.01	V	⇒.41 [∠.02; 0.41] 4.1
Ghama       64       719       8.90       [6.98; 11.27]       0.6         Chubio, et al 2012       64       719       100       [7.75; 1516]       0.6         Allain, J. et al 2003       25       13994       11.00       [7.75; 1516]       0.6         Allain, J. et al 2010       1568       1100       14.25       [1.51; 161]       0.6         Allain, J. et al 2010       1568       1100       14.25       [1.52; 1.43]       0.6         Aldain J. et al 2010       1568       11000       14.25       [1.53; 1.43]       0.6         Allain J. et al 2010       1668       11000       14.25       [1.54; 1.43]       0.6         Acida-Mensah O, et al 2010       1401       10740       6.75       [4.61; 9.77]       0.6         Random effects model       3.13       [2.38; 3.99]       0.6       6.6       6.6         Random effects model       3.25       [2.66; 3.89]       1.6       6.6         Random effects model       3.25       [2.66; 3.89]       0.6       6.6         Random effects model       3.25       [2.66; 3.89]       0.6       6.6       6.6       6.6       6.6       6.6       6.6       6.6       6.6       6.6       6.6	. iotorogenoity: / = 10076, □ = 1	. o.o i, p	0.01		
C.Kubo, et al 2012 64 719 8.90 [6.98; 11.2] 0.6 C.Dogbe, et al 2015 33 300 1.00 [7.75; 15.15] 0.6 Allain J, et al 2021 825 8605 9.59 [6.81; 10.07] 0.6 Sarkodie F, et al 2010 1568 11000 1425 [6.35 [5.40; 7.38] 0.6 Sarkodie F, et al 2010 1568 11000 14.25 [13.61; 14.92] 0.6 Sarkodie F, et al 2010 1568 11000 14.25 [13.61; 14.92] 0.6 Sarkodie J, et al 2010 1568 11000 14.25 [13.61; 14.92] 0.6 C.Audai-Mensah, ot et al 2015 27 400 6.75 [5.40; 7.38] 0.6 Random effects model 51737 8.81 [5.04; 13.49] 7.3 Heterogeneity, $l^{2} = 0.05_{c}$ , $l^{2} = 0.01, p = 0$ Guines Allain J, et al 2010 1401 10740 13.04 [12.39; 13.68] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Ovyango, et al 2019 1191 8059 14.78 [14.0; 15.68] 0.6 Koné M.C, et al 2012 156 2946 5.30 [1.45; 14.61] 0.6 Malian J, et al 2010 3548 25543 13.89 [13.47; 14.32] 0.6 Malian J, et al 2010 3548 25543 13.89 [13.47; 14.32] 0.6 Malian J, et al 2019 1722 11592 14.86 [14.15; 15.46] 0.6 Malian J, et al 2019 1722 11592 14.86 [14.16; 15.68] 0.6 Malong aG, A, et al 2029 1722 22 29 Random effects model 22 729 Random effects model 22 729 Random effects model 22 7218 10.00 [15.32 [14.53; 15.88] 0.6 Random effects model 22 7218 10.00 [1.40; 0.71] 0.55 [0.41; 0.56] 0.6 Random effects model 22 7218 10.00 [1.40; 0.71] 0.55 [0.41; 0.56] 0.6 Random effects model 25 906 [0.57 [0.39; 0.59] 0.6 Random effects model 25 906 [0.57 [	Ghana				
Lubge, et al 2015 33 300 Lubge, et al 2003 25 13994 ANlank, pet al 2003 25 13994 ANlank, pet al 2001 825 8605 Sarkodie, F, et al 2010 1568 3264 Allain J, et al 2010 1568 11000 Allain J, et al 2010 1568 11000 Cuinea Allain J, et al 2010 1401 10740 Cuinea Allain J, et al 2017 64 2046 Conyang. et al 2017 64 2046 Conyang. et al 2017 64 2046 Singogo E, et al 2023 809 204920 Malawi Singogo E, et al 2023 809 204920 Malawi Singogo E, et al 2020 3548 25543 A.Diarra, et al 2010 1568 11592 Allain J, et al 2010 3548 25543 A.Diarra, et al 2010 201, $p < 0.01$ Maurdania Maveriania W.Manbuda, et al 2012 170 011100 A.Bat (a.diara, et al 2014 1	C.Kubio, et al 2012	64	719		8.90 [6.98; 11.27] 0.8
Alain J, et al 2003       25       13994       0.18       [0.12]       0.26       0.65         Sarkode F, et al 2021       548       3264       16.79       [15.51]       11.11       0.6         Alain J, et al 2010       1568       11000       14.25       [15.51]       11.11       0.6         Alain J, et al 2010       1568       11000       14.25       [15.51]       14.92       0.6         Aldain J, et al 2010       1568       11000       14.25       [15.52]       14.81       0.6         Random effects model       51737       51737       5.81       [5.04]       13.49       7.3         Random effects model       51737       51737       5.81       [5.04]       13.49       7.3         Bardom effects model       3261       3.13       [2.38]       3.94       0.6         C.Oryango, et al 2018       42       12.51       3.46       [2.49]       4.64       0.6         Sindgoge E, et al 2023       809       204920       0.39       [0.36]       0.42       0.6         Malia       A.1ary, et al 2019       1191       8059       1.389       [13.47]       14.32]       0.6         Tounkara A, et al 2009       12.24	E.Dogbe, et al 2015	33	300	_ +	11.00 [7.75; 15.15] 0.8
A.Niankpe, et al 2021 225 6605 9.59 (5.81, 10.07) 0.52 Sarkodie F, et al 2001 548 3264 16.77 [15.51; 16.11] 0.6 Alian J, et al 2010 1568 11000 14.25 [13.62; 14.82] 0.6 G, 35 [5.40; 7.38] 0.6 Alian J, et al 2010 1568 11000 14.25 [13.52; 14.84] 0.6 G, 35 [5.40; 7.38] 0.6 Alian J, et al 2010 1568 11000 14.25 [13.52; 14.84] 0.6 G, 35 [5.40; 7.38] 0.6 Alian J, et al 2010 1568 11000 14.25 [13.52; 14.84] 0.6 G, 35 [5.40; 7.38] 0.6 Alian J, et al 2010 1401 10740 13.04 [12.39; 13.68] 0.6 C. Onyango, et al 2017 64 2046 3.13 [2.38; 3.94] 0.6 C. Onyango, et al 2017 64 2046 3.261 3.25 [2.66; 3.89] 1.6 Haterogeneity: $P^2 = 0.96$ , $P^2 = 0.00$ Malawi Singogo E, et al 2023 809 204920 0.39 [0.36; 0.42] 0.58 [13.47; 14.32] 0.6 Malawi Singogo E, et al 2023 809 204920 0.39 [13.47; 14.32] 0.6 Malawi Singogo E, et al 2020 1722 11592 14.86 [14.15; 15.46] 0.6 F. Standom effects model 3.261 4.201 1191 8059 14.78 [14.01; 15.58] 0.6 Koné M.C, et al 2012 156 2946 5.30 [4.51; 6.16] 0.6 F. Standom effects model 7.3912 4.46 [14.15; 15.46] 0.4 Standom effects model 7.3912 4.46 [14.15; 15.46] 0.4 Standom effects model 7.3912 4.46 [14.15; 15.46] 0.4 Standom effects model 7.3912 4.46 [14.15; 14.21] 0.6 Standom effects model 7.3912 4.46 [3.46; 5.05] 0.5 Baha W, et al 2019 177 31952 0.55 [0.41; 0.58] 0.55 [0.41; 0.58] 0.5 Baha W, et al 2019 177 31952 0.55 [0.41; 0.58] 0.5 Baha W, et al 2019 177 31952 0.55 [0.41; 0.58] 0.5 Baha W, et al 2019 177 31952 0.55 [0.41; 0.58] 0.5 Baha W, et al 2019 177 31952 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 1503 (19605 1.46) 0.40 [0.21; 0.36] 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 1503 (19605 1.40) 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 1603 (19605 1.40) 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 1603 (16965 1.40) 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 1603 (16965 1.40) 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 1603 (16965 1.40) 0.55 [0.41; 0.58] 0.5 Baha W, et al 2013 1003 169055 1.400 0.55 [0.41; 0.58] 0.5 Baha W, et al 2014 100 750 0.55 [0.41; 0.58] 0.5 Baha W, et al 2014 100	Allain.J, et al 2003	25	13994		0.18 [0.12; 0.26] 0.8
Sarkodie F, et al 2010 548 3264 16.79 [15.17, 18.11] 0.65 Sarkodie F, et al 2010 1568 11000 14.25 [13.61; 14.32] 0.6 Sarkodie F, et al 2016 156 2455 6.6.5 [14.61; 9.77] 0.6 Random effects model 51737 400 6.75 [14.61; 9.77] 0.6 Salkodie F, et al 2015 27 400 6.75 [14.61; 9.77] 0.6 Sarkodie F, et al 2015 27 400 6.75 [14.61; 9.77] 0.6 Sarkodie F, et al 2010 1401 10740 13.04 [12.39; 13.68] 0.6 Sarkodie F, et al 2010 1401 10740 13.04 [12.39; 13.68] 0.6 Sarkodie Smodel 2.0.01, $p = 0$ Sumano, et al 2017 64 2046 3.13 [2.38; 3.94] 0.6 C.Oryango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 C.Oryango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6 Sarkodie Smodel 3.25 [2.66; 3.89] 1.6 Malawi Singogo E, et al 2023 809 204920 0.39 [0.36; 0.42] 0.6 Malia A.Jary, et al 2019 1191 8059 14.77 [14.55] 0.6 Malia J, et al 2019 1722 11592 14.86 [14.15, 15.6] 0.6 Tounkara A, et al 2009 1722 11592 14.86 [14.15, 15.6] 0.6 Sandom effects model 73912 11.87 [3.68; 15.46] 0.6 Sandom effects model 73912 11.87 [3.68; 15.46] 0.6 Sandom effects model 73912 11.87 [3.68; 15.46] 0.6 Sandom effects model 73912 11.86 [3.45; 15.46] 0.6 Sandom effects model 73912 1.10 Morocco Sandom effects model 227218 1 Mazambigue N.Mabunda, et al 2022 124 2783 4.46 [3.48; 5.05] 0.6 Sandom effects model 227218 1 Mazambigue N.Mabunda, et al 2021 140 750 [0.67 [6.44; 13.00] 0.6 Sandom effects model 25398 4.657 [0.37; 10.53] 2.4 Heterogeneity: $P^2 = 99\%$ , $P^2 = < 0.01$ , $p < 0.01$ Mazambigue N.Mabunda, et al 2021 12 [156] [124 2761 [126] [1	A.Nlankpe, et al 2021	825	8605	-	9.59 [8.81; 10.07] 0.8
Alian J, et al 2010       1568       11000       14.25       [13,61,14.22]       0.26         Alian J, et al 2010       1568       11000       14.25       [13,61,14.22]       0.26         Addai-Mensah O, et al 2015       27       400       6.75       [4,61; 9,77]       0.6         Random effects model       51737       8.81       [5.04; 7.38]       0.6         Guinea       Alian J, et al 2010       1401       10740       13.04       [12.38; 3.94]       0.6         Conyang, et al 2017       64       2046       3.13       [2.38; 3.94]       0.6         Conyang, et al 2017       64       2046       3.25       [2.66; 3.89]       1.6         Random effects model       3261       3.46       [2.49; 4.64]       0.6         Random effects model       3261       3.45       [3.89]       [13,47; 14.32]       0.6         Malawi       Singego.E, et al 2023       809       204920       0.39       [0.36; 0.42]       0.6         Singego.E, et al 2019       1722       156       3.46       [2.43; 14.64]       0.6         Alama et al 2010       3548       25543       13.89       [13,47; 14.32]       0.6         Nalian , et al 2010       3548 <t< td=""><td>Sarkodie F, et al 2001</td><td>548</td><td>3264</td><td>+</td><td>16.79 [15.51; 18.11] 0.8</td></t<>	Sarkodie F, et al 2001	548	3264	+	16.79 [15.51; 18.11] 0.8
Sarkodie F, et al 2016 166 2455 6.35 [5.07, 7.38] 0.6. Malain J, et al 2016 1568 11000 4.25 [13.52; 14.84] 0.6. Addai-Mensah Q, et al 2015 27 400 6.75 [4.61; 9.77] 0.6. Random effects model 51737 6.8. Guinea Allain J, et al 2010 1401 10740 1.3.04 [12.39; 13.68] 0.6. Kenya D.Wamamba, et al 2017 6.4 2046 3.13 [2.38; 3.94] 0.6. C.Onyango, et al 2018 42 1215 3.46 [2.49; 4.64] 0.6. Random effects model 3.261 1.2. Malawi Singogo, E, et al 2023 809 204920 0.39 [0.36; 0.42] 0.6. Malawi Singogo, E, et al 2023 809 204920 0.39 [0.36; 0.42] 0.6. Malawi Singogo, E, et al 2012 156 2946 1.3.261 1.4. Albarra, et al 2019 1191 8059 1.4.78 [14.01; 15.56] 0.6. Koné M.C, et al 2012 156 2946 1.3.28 [14.15; 15.46] 0.6. Malain effects model 73912 1.1592 1.4.88 [14.15; 15.46] 0.6. Malain al 2010 3548 25543 1.3.89 [13.47; 14.32] 0.6. Maling G, G, A, et al 2022 22 22 9 9.61 [6.15; 14.21] 0.6. Malong G, G, A, et al 2022 1.2. Random effects model 73912 1.1.87 [8.68; 15.49] 4.9. Heterogeneity: $l^2 = 93\%$ , $l^2 = < 0.01$ , $p < 0.01$ Mauritania Widemouge, et al 2019 1.77 31952 0.55 [0.41; 0.58] 0.6. Random effects model 273912 1.8.79 [0.55] [0.44; (3.06] 0.55 Shoukker, et al 2019 1.77 31952 0.55 [0.44; 0.56] 0.6. Shoukker, et al 2019 1.77 31952 0.55 [0.44; 0.56] 0.6. Baha W, et al 2019 1.77 31952 0.55 [0.44; 0.56] 0.6. Shoukker, et al 2019 1.77 31952 0.55 [0.44; 0.56] 0.6. Baha W, et al 2021 1.4 0.750 0.001 Mauritania Morocco Shoukker, et al 2019 1.77 31952 0.55 [0.44; 0.56] 0.6. Baha W, et al 2021 1.4 0.27218 1 Mozambigue N.Mabunda, et al 2022 1.24 2.783 0.6. Random effects model 5.398 6.6. 11.3.70; 10.63] 2.4. Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01$ , $p < 0.01$ Mauritania Maritania 0.57 [0.39; 0.58] 0.6. Random effects model 5.398 6.6. 11.3.70; 10.63] 2.4. Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01$ , $p < 0.01$ Namibia R.Mavenyengwa, et al 2014 1.40 2.4761 Random effects model 5.398 6.6. 11.3.10 6.8. Random effects model 5.398 6.6. 11.3.10 6.8. Random effects model 5.399 6.6.0; 11.310 6.8.	Allain J, et al 2010	1568	11000		14.25 [13.61; 14.92] 0.8
Allain J, et al 2010       1568       11000       14.25       [13.27, 14.84]       0.8         Random effects model       51737       6.75       [4.61; 9.77]       0.6         Guinea       Allain J, et al 2010       1401       10740       13.04       [12.39; 13.68]       0.8         Guinea       Allain J, et al 2017       64       2046       3.13       [2.38; 3.94]       0.8         Random effects model       3.251       3.46       [2.49; 4.64]       0.8         Random effects model       3.251       3.25       [2.66; 3.39]       1.6         Heterogeneity: $P^2 = 0.9_{e}$ , $l_{e}^2 = 0.0$ 0.39       [0.36; 0.42]       0.8         Malin       A.Diarra, et al 2023       809       204920       0.39       [13.47; 14.32]       0.6         Malin       A.Diarra, et al 2019       1191       8059       5.30       [4.57; 6.16]       0.8         Malin J, et al 2010       3548       25543       13.89       [13.47; 14.32]       0.6         Malina J, et al 2010       3548       25543       13.89       [13.47; 14.32]       0.6         Malina J, et al 2012       1700       11100       11.37       [8.68; 15.49]       4.5         Malina Let al 2012       1	Sarkodie F, et al 2016	156	2455	+	6.35 [5.40; 7.38] 0.8
Adda-Mensah O, et al 2015       27       400       6.75       [4.61; 9.77]       0.8         Random effects model       51737       51737       8.81       [5.04; 13.49]       7.3         Heterogeneity: $l^2$ = 100%, $l^2$ = 0.01, $p$ = 0       13.04       [12.39; 13.68]       0.8         Summaba, et al 2017       64       2046       3.13       [2.38; 3.94]       0.8         C.Onyango, et al 2018       42       1215       3.46       [2.49; 4.64]       0.8         Random effects model       3261       3.25       [2.66; 3.89]       1.6         Malaini       A.Diarra, et al 2009       3548       25543       13.89       [13.47; 14.32]       0.8         A.Diarra, et al 2009       3548       25543       13.89       [13.47; 14.32]       0.8         Malini A., et al 2019       1722       11592       14.86       [14.15; 15.46]       0.8         Alara, et al 2009       3548       25543       13.89       [13.47; 14.32]       0.8         Random effects model       73912       14.86       [14.15; 15.46]       0.4       0.18       0.43       0.45       0.45       0.42       0.55       0.41       0.22       22       22       9.61       0.61       0.42	Allain J, et al 2010	1568	11000	<u>_</u>	14.25 [13.52; 14.84] 0.8
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Malawi       Singogo.E, et al 2023       809       204920       0.39 $[0.36; 0.42]$ 0.89         Mali       A.Diarra, et al 2009       3548       25543       13.89 $[13.47; 14.32]$ 0.8         A.Jary, et al 2019       1191       8059       14.78 $[14.15; 15.6]$ 0.8         Koné M.C, et al 2012       156       2946       5.30 $[4.15; 15.6]$ 0.8         Allain J, et al 2010       3548       25543       13.89 $[13.47; 14.32]$ 0.8         Mallonga G. A, et al 2020       2       229       9.61 $[6.15; 14.21]$ 0.8         Malom effects model       73912       11100       15.32 $[14.53; 15.88]$ 0.8         Morocco       S.Boubker, et al 2011       102       25661       0.40 $[0.21; 0.36]$ 0.8         J.Uwingabiye, et al 2013       1603       169605       0.95 $[0.41; 0.58]$ 0.8         Baha W, et al 2013       1603       169605       0.95 $[0.43; 0.96]$ 2.5         Random effects model       227218       0.61 $[0.34; 0.96]$ 2.5         Meterogeneity: $l^2 = 99\%, l^2 = <0.01, p < 0.01$ 0.61 $[0.34; 0.96]$ 2.4 <t< td=""><td>Heterogeneity: <math>I^2 = 0\%</math>, <math>\Gamma^2 = 0</math>,</td><td>p = 0.60</td><td>5201</td><td>v</td><td>5.25 [2.00, 5.05]</td></t<>	Heterogeneity: $I^2 = 0\%$ , $\Gamma^2 = 0$ ,	p = 0.60	5201	v	5.25 [2.00, 5.05]
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A.Jary, et al 2019       1191       8059       14.78 $[14.01; 15.58]$ 0.6         Koné M.C, et al 2012       156       2946       5.30 $[4.45; 16.6]$ 0.6         Allain J, et al 2010       3548       25543       13.89 $[13.47; 14.32]$ 0.6         Allain J, et al 2010       3548       25543       13.89 $[13.47; 14.32]$ 0.6         Malonga G. A, et al 2022       22       229       9.61 $[6.15; 14.21]$ 0.6         Malonga G. A, et al 2012       1700       11100       15.32 $[14.53; 15.88]$ 0.6         Mauritania       W.Mansour, et al 2012       1700       11100       15.32 $[14.53; 15.88]$ 0.6         Morocco       S.Boubker, et al 2019       177       31952       0.55 $[0.41; 0.58]$ 0.6         Baha W, et al 2013       1603       169605       0.95 $[0.80; 0.90]$ 0.6         Random effects model       227218       0.61 $[0.34; 0.96]$ 2.5         Mozambique       N.Mabunda, et al 2022       124       2783       0.61 $[0.34; 0.96]$ 2.4         Heterogeneity: $I^2 = 99\%, I^2 = <0.01, p < 0.01$ 6.01 $[4.46; 13.80; 5.05]$ $0.67$ <	A.Diarra, et al 2009	3548	25543	•	13.89 [13.47; 14.32] 0.8
Koné M.C, et al 2012       156       2946       5.30       [4.57]; 6.16]       0.5         Tounkara A, et al 2009       1722       11592       14.86       [4.57]; 6.16]       0.6         Allain J, et al 2010       3548       25543       13.89       [13.47]; 14.32]       0.6         Random effects model       73912       9.61       [6.15]; 14.21]       0.6       0.65       [16.15]; 14.21]       0.6         Mauritania       W.Mansour, et al 2012       1700       11100       15.32       [14.53]; 15.88]       0.6         Morocco       S.Boubker, et al 2019       177       31952       0.55       [0.41]; 0.58]       0.6         J.Dwingabiye, et al 2016       102       25661       0.40       [0.21]; 0.36]       0.6         Baha W, et al 2013       1603       16605       0.40       [0.21]; 0.36]       0.6         Random effects model       227218       0.61       [0.34]; 0.96]       2.5         Jocelijn Stokx, et al 2011       80       750       10.67       [8.44]; 13.00]       0.6         Gudo S.E, et al 2009       112       1865       6.75       [3.70]; 10.63]       2.4         Heterogeneity: $l^2 = 94\%, l_2^2 = <0.01, p < 0.01$	A.Jary, et al 2019	1191	8059	+	14.78 [14.01: 15.58] 0.8
Tounkara A, et al 2009       1722       11592       14.86       [14.15; 15.46]       0.68         Allain J, et al 2010       3548       25543       13.89       [13.47; 14.32]       0.68         Malonga G, A, et al 2022       22       229       96.1       [6.15; 14.21]       0.68         Random effects model       73912       11.87       [8.68; 15.49]       4.58         Heterogeneity: $l^2 = 98\%$ , $l^2 = < 0.01, p < 0.01       15.32       [14.53; 15.88]       0.88         Morocco       S.Boubker, et al 2019       177       31952       0.55       [0.41; 0.58]       0.88         JUwingabiye, et al 2016       102       25661       0.40       [0.21; 0.36]       0.88         Baha W, et al 2013       1603       169605       0.95       [0.30; 0.90]       0.61         Random effects model       227218       1       0.61       [0.34; 0.96]       2.5         Heterogeneity: l^2 = 99\%, l^2 = < 0.01, p < 0.01       12       1865       6.01       [4.490; 7.11]       0.62         Mozambique       N       112       1865       6.01       [4.90; 7.11]       0.62         Random effects model       2598       6.75       [3.70; 10.63]       2.4         Heterogeneity: l^2 = 94$	Koné M.C. et al 2012	156	2946		5.30 [4.51: 6.16] 0.8
Allain J, et al 2010 $3548$ $25543$ $13.89$ $[13.47; 14.32]$ $0.65$ Malonga G. A, et al 2022 $22$ $229$ $9.61$ $[6.15; 14.21]$ $0.68$ Random effects model $73912$ $11.87$ $[8.68; 15.49]$ $4.5$ Heterogeneity: $l^2 = 98\%$ , $l^2 = < 0.01$ , $p < 0.01$ $11.87$ $[8.68; 15.49]$ $4.5$ Mauritania       W.Mansour, et al 2012 $1700$ $11100$ $15.32$ $[14.53; 15.88]$ $0.68$ Morocco       S.Bouker, et al 2016 $102$ $25661$ $0.40$ $[0.21; 0.36]$ $0.68$ S.Bouker, et al 2013 $1603$ $169605$ $0.95$ $[0.80; 0.90]$ $0.61$ $[0.34; 0.96]$ $2.5$ Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01$ , $p < 0.01$ $0.61$ $[0.34; 0.96]$ $2.5$ Mozambique       N.Mabunda, et al 2002 $124$ $2783$ $4.46$ $[3.48; 5.05]$ $0.61$ $[4.90; 7.11]$ $0.67$ Macomeffects model $5398$ $6.75$ $[3.70; 10.63]$ $2.4$ Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01$ , $p < 0.01$ $9.89$ $[8.60; 11.31]$ $0.57$ $[0.39; 0.58$	Tounkara A. et al 2009	1722	11592		14.86 [14.15: 15.46] 0.8
Malonga G. A, et al 2022       22       229       9.61       [6.15; 14.25]       0.62         Random effects model       73912       11.87       [8.68; 15.49]       4.5         Heterogeneity: $l^2 = 98\%$ , $l^2 = < 0.01$ , $p < 0.01$ 15.32       [14.53; 15.88]       0.6         Mauritania       W.Mansour, et al 2012       1700       11100       15.32       [14.53; 15.88]       0.6         Morocco       S.Boubker, et al 2019       177       31952       0.55       [0.41; 0.58]       0.6         JUwingabiye, et al 2016       102       25661       0.40       [0.21; 0.36]       0.6         Baha W, et al 2013       1603       169605       0.95       [0.80; 0.90]       0.8         Random effects model       227218       0.61       [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01$ , $p < 0.01$ 0.61       [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01$ , $p < 0.01$ 6.75       [3.70; 10.63]       2.4         Mozambique       N.Mabunda, et al 2014       140       24761       0.57       [0.39; 0.58]       0.6         Random effects model       5398       6.75       [3.70; 10.63]       2.4       4.46       [0.00; 17.95]       1.6	Allain J, et al 2010	3548	25543	•	13.89 [13.47: 14.32] 0.8
Random effects model       73912       11.87       [8.68; 15.49]       4.5         Heterogeneity: $l^2 = 98\%$ , $l^2 = < 0.01, p < 0.01$ 15.32       [14.53; 15.88]       0.6         Mauritania       W.Mansour, et al 2012       1700       11100       15.32       [14.53; 15.88]       0.6         Morocco       S.Boubker, et al 2019       177       31952       0.55       [0.41; 0.58]       0.6         JUwingabiye, et al 2016       102       25661       0.40       [0.21; 0.36]       0.6         Baha W, et al 2013       1603       169605       0.95       [0.80; 0.90]       0.6         Random effects model       227218       0.61       [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01, p < 0.01$ 10.67       [8.44; 13.00]       0.6         Mozambique       Nadounda, et al 2022       124       2783       0.61       [0.47; 0.63]       2.4         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01, p < 0.01$ 80       50       0.67       [3.48; 5.05]       0.6         Mauritania       0.57       [0.39; 0.58]       0.57       [0.39; 0.58]       0.57         Random effects model       2598       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 90\%$	Malonga G. A, et al 2022	22	229	-	9.61 [6.15: 14.21] 0.8
Heterogeneity: $l^2 = 98\%$ , $l^2 = < 0.01$ , $p < 0.01$ Initial (0.00), (0.00)         Mauritania       W.Mansour, et al 2012       1700       11100       Initial (0.00), (0.00)         Morrocco       S.Boubker, et al 2016       102       25661       0.40       0.21; 0.36]       0.80         J.Uwingabiye, et al 2016       102       25661       0.40       0.21; 0.36]       0.80         Baha W, et al 2013       1603       1603       166055       0.40       0.21; 0.36]       0.80         Baha W, et al 2013       1603       1603       166055       0.40       0.21; 0.36]       0.80         Baha W, et al 2013       1603       166055       0.61       0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = <0.01$ , $p < 0.01$ 0.61       0.34; 0.96]       2.5         Mozambique       N.Mabunda, et al 2002       124       2783       4.46       [3.48; 5.05]       0.6         Rudow effects model       5398       6.01       [4.90; 7.11]       0.8       6.01       [4.90; 7.11]       0.8         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Namibia       0.57       [0.39; 0.58]       0.8       8.60; 11.31]       0.8 <td< td=""><td>Random effects model</td><td></td><td>73912</td><td><math>\diamond</math></td><td>11.87 [ 8.68: 15.49] 4.9</td></td<>	Random effects model		73912	$\diamond$	11.87 [ 8.68: 15.49] 4.9
Mauritania         W.Mansour, et al 2012       1700       11100       15.32 [14.53; 15.88]       0.8         Morocco       S.Bouker, et al 2019       177       31952       0.55 [0.41; 0.58]       0.8         J.Uwingabiye, et al 2016       102       25661       0.40 [0.21; 0.36]       0.8         Baha W, et al 2013       1603       160605       0.40 [0.21; 0.36]       0.8         Random effects model       227218       0.61 [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = <0.01, p < 0.01$ 0.61 [0.34; 0.96]       2.5         Mozambique       N.Mabunda, et al 2012       124       2783       4.46 [3.48; 5.05]       0.6         N.Mabunda, et al 2002       124       2783       4.46 [3.48; 5.05]       0.6       0.61 [4.90; 7.11]       0.5         Gudo S.E, et al 2009       112       1865       6.01 [4.90; 7.11]       0.5         Random effects model       5398       6.75 [3.70; 10.63]       2.4         Namibia       Random effects model       26702       3.84 [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84 [0.00; 17.95]       1.6         Niger       Mayaki Z, et al 2012       495       3213       15.41 [13.37; 15.95]       0.5	Heterogeneity: $I^2 = 98\%$ , $\Box^2 = <$	0.01, p <	0.01	-	The Freed Initial and
Matriania         W.Mansour, et al 2012       1700       11100       15.32       [14.53; 15.88]       0.6         Morocco       0.55       [0.41; 0.58]       0.6       0.65       0.40       [0.21; 0.36]       0.6         J.Uwingabiye, et al 2013       1603       166805       0.40       [0.21; 0.36]       0.6         Baha W, et al 2013       1603       166805       0.95       [0.80; 0.90]       0.6         Random effects model       227218       0.61       [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01$ , $p < 0.01$ 0.61       [0.34; 0.96]       2.5         Mozambique       12       1865       6.01       [4.46; 7.11]       0.6         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01, p < 0.01$	Mi				
Morocco       0.52 [14.33, 15.86]       0.6         S.Boubker, et al 2019       177       31952       0.55 [0.41; 0.58]       0.6         Baha W, et al 2013       1603       169605       0.40 [0.21; 0.36]       0.6         Baha W, et al 2013       1603       169605       0.40 [0.21; 0.36]       0.6         Random effects model       227218       0.61 [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01$ , $p < 0.01$ 0.61 [0.34; 0.96]       2.5         Mozambique       N.Mabunda, et al 2022       124       2783       4.46 [3.48; 5.05]       0.6         Mozambique       N.Mabunda, et al 2011       80       750       10.67 [8.44; 13.00]       0.5         Gudo S.E, et al 2009       112       1865       6.01 [4.90; 7.11]       0.6         Random effects model       5398       6.75 [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = <0.01$ , $p < 0.01$ 9.89 [8.60; 11.31]       0.5         Namibia       8.41 [999       192       1941       9.89 [8.60; 11.31]       0.5         Feterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84 [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84 [0.00; 17.95]       1.6	Mauritania W Mansour et al 2012	1700	11100		15 32 [1/ 53: 15 88] 0.0
Morocco         S.Boubker, et al 2019       177       31952       0.55       [0.41; 0.58]       0.65         Baha W, et al 2013       1603       169605       0.40       0.21; 0.36]       0.65         Random effects model       227218       1       0.61       [0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01, p < 0.01$ 0.01       0.61       [0.34; 0.96]       2.5         Mozambique       N       0.61       [0.34; 0.96]       2.5         Jocelijn Stokx, et al 2011       80       750       10.67       [8.44; 13.00]       0.5         Gudo S.E, et al 2009       112       1865       6.01       [4.90; 7.11]       0.6         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01, p < 0.01$	www.ividiiouui, et di 2012	1700	11100		10.02 [14.00, 10.00] 0.0
S.Boubker, et al 2019 177 31952 0.55 $[0.41; 0.58]$ 0.65 $[0.41; 0.58]$ 0.65 $[0.41; 0.58]$ 0.62 $[0.21; 0.36]$ 0.28 $[0.21; 0.36]$ 0.28 $[0.21; 0.36]$ 0.29 $[0.21; 0.36]$ 0.21 $[0.21; $	Morocco			_	
J.Uwingabiye, et al 2016       102       25661       0.40 $[0.21; 0.36]$ 0.8         Baha W, et al 2013       1603       169605       0.95 $[0.80; 0.90]$ 0.6         Baha W, et al 2013       1603       169605       0.95 $[0.80; 0.90]$ 0.6         Random effects model       227218       0.61 $[0.34; 0.96]$ 2.5         Mozambique       N.Mabunda, et al 2022       124       2783       4.46 $[3.48; 5.05]$ 0.6         Mozambique       N.Mabunda, et al 2011       80       750       10.67 $[8.44; 13.00]$ 0.5         Gudo S.E, et al 2009       112       1865       6.01 $[4.90; 7.11]$ 0.8         Random effects model       5398       6.75 $[3.70; 10.63]$ 2.4         Namibia       R.Mavenyengwa, et al 2014       140       24761       9.89 $[8.60; 11.31]$ 0.6         E.Vardas, et al 1999       192       1941       9.89 $[8.60; 11.31]$ 0.6         Heterogeneity: $l^2 = 100\%, lt^2 = 0.03, p < 0.01$ 3.84 $[0.00; 17.95]$ 1.6         Niger       Mayaki Z, et al 2012       495       3213       15.41 $[13.37; 15.95]$ 0.5 </td <td>S.Boubker, et al 2019</td> <td>177</td> <td>31952</td> <td></td> <td>0.55 [0.41; 0.58] 0.8</td>	S.Boubker, et al 2019	177	31952		0.55 [0.41; 0.58] 0.8
Baha W, et al 2013       1603       169805       0.95       0.80; 0.90]       0.8         Random effects model       227218       0.61       0.34; 0.96]       2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01, p < 0.01$ 0.61       0.34; 0.96]       2.5         Mozambique       N.Mabunda, et al 2022       124       2783       4.46       [3.48; 5.05]       0.6         Mozambique       N.Mabunda, et al 2011       80       750       10.67       [8.44; 13.00]       0.8         Gudo S.E, et al 2009       112       1865       6.01       [4.90; 7.11]       0.8         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = <0.01, p < 0.01$ 9.89       [8.60; 11.31]       0.8         Random effects model       26702       3.84       [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03, p < 0.01$ 3.84       [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03, p < 0.01$ 3.84       [0.00; 17.95]       1.6	J.Uwingabiye, et al 2016	102	25661		0.40 [0.21; 0.36] 0.8
Random effects model       227218       0.61 $[0.34; 0.96]$ 2.5         Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01, p < 0.01$ 0.61 $[0.34; 0.96]$ 2.5         Mozambique       N.Mabunda, et al 2022       124       2783       4.46 $[3.48; 5.05]$ 0.6         N.Mabunda, et al 2022       124       2783       10.67 $[8.44; 13.00]$ 0.6         Jocelijn Stokx, et al 2011       80       750       10.67 $[8.44; 13.00]$ 0.6         Random effects model       5398       6.01 $[4.90; 7.11]$ 0.6       6.75 $[3.70; 10.63]$ 2.4         Namibia       R.Mavenyengwa, et al 2014       140       24761       0.57 $[0.39; 0.58]$ 0.6         E.Vardas, et al 1999       192       1941       9.89 $[8.60; 11.31]$ 0.6         Heterogeneity: $l^2 = 100\%$ , $l_1^2 = 0.03$ , $p < 0.01$ 3.84 $[0.00; 17.95]$ 1.6         Niger       15.41 $[13.37; 15.95]$ 0.8	Baha W, et al 2013	1603	169605	1	0.95 [0.80; 0.90] 0.8
Heterogeneity: $l^2 = 99\%$ , $l^2 = < 0.01$ , $p < 0.01$ Mozambique         N.Mabunda, et al 2012       124       2783         Joceling Stokx, et al 2011       80       750         Gudo S.E, et al 2009       112       1865         Random effects model       5398       6.01         Namibia       6.75       [ 3.70; 10.63]       2.4         Revenyengwa, et al 2014       140       24761       0.57       [ 0.39; 0.58]       0.8         Random effects model       26702       3.84       [ 0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84       [ 0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84       [ 0.00; 17.95]       1.6         Niger       Mayaki Z, et al 2012       495       3213       15.41       [ 13.37; 15.95]       0.8	Random effects model		227218	1	0.61 [0.34; 0.96] 2.5
Mozambique       4.46       [3.48; 5.05]       0.8         Joceling Stokx, et al 2011       80       750       10.67       [8.44; 13.00]       0.8         Gudo S.E, et al 2009       112       1865       6.01       [4.90; 7.11]       0.8         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = <0.01$ , $p < 0.01$ 0.57       [0.39; 0.58]       0.8         Namibia       8.Advenyengwa, et al 2014       140       24761       0.57       [0.39; 0.58]       0.8         E.Vardas, et al 1999       192       1941       9.89       [8.60; 11.31]       0.8         Random effects model       26702       3.84       [0.00; 17.95]       1.6         Yeterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 15.41       [13.37; 15.95]       0.8	Heterogeneity: $I^2 = 99\%$ , $\Box^2 = <$	0.01, <i>p</i> <	0.01		
N.Mabunda, et al 2022       124       2783       4.46       [3.48; 5.05]       0.8         Jocelin Stokx, et al 2011       80       750       10.67       [8.44; 13.00]       0.8         Gudo S.E, et al 2009       112       1865       6.01       [4.90; 7.11]       0.8         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = <0.01$ , $p < 0.01$ 0.57       [0.39; 0.58]       0.8         R.Mavenyengwa, et al 2014       140       24761       0.57       [0.39; 0.58]       0.8         E.Vardas, et al 1999       192       1941       9.89       [8.60; 11.31]       0.8         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84       [0.00; 17.95]       1.6         Niger       Mayaki Z, et al 2012       495       3213       15.41       [13.37; 15.95]       0.8	Mozambique				
Jocelijn Stokx, et al 2011       80       750       10.67 $[8.44; 13.00]$ 0.8         Gudo S.E, et al 2009       112       1865       6.01 $[4.90; 7.11]$ 0.8         Random effects model       5398       6.75 $[3.70; 10.63]$ 2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = <0.01, p < 0.01$ 0.57 $[0.39; 0.58]$ 0.8         Namibia       0.57 $[0.39; 0.58]$ 0.8         E.Vardas, et al 1999       192       1941       9.89 $[8.60; 11.31]$ 0.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 3.84 $[0.00; 17.95]$ 1.6         Niger       Mayaki Z, et al 2012       495       3213       15.41 $[13.37; 15.95]$ 0.8	N.Mabunda, et al 2022	124	2783	+	4.46 [3.48; 5.05] 0.8
Gudo S.E, et al 2009       112       1865       6.01       [4.90; 7.11]       0.8         Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $t^2 = < 0.01$ , $p < 0.01$ 0.57       [0.39; 0.58]       0.57         Namibia       0.57       [0.39; 0.58]       0.57       [0.39; 0.58]       0.57         R.Mavenyengwa, et al 2014       140       24761       0.57       [0.39; 0.58]       0.57         Random effects model       26702       3.84       [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $t^2 = 0.03$ , $p < 0.01$ 3.84       [0.00; 17.95]       1.6         Niger       Mayaki Z, et al 2012       495       3213       15.41       [13.37; 15.95]       0.6	Jocelijn Stokx, et al 2011	80	750		10.67 [8.44: 13.00] 0.8
Random effects model       5398       6.75       [3.70; 10.63]       2.4         Heterogeneity: $l^2 = 94\%$ , $l^2 = < 0.01$ , $p < 0.01$ 6.75       [3.70; 10.63]       2.4         Namibia       R.Mavenyengwa, et al 2014       140       24761       0.57       [0.39; 0.58]       0.8         E.Vardas, et al 1999       192       1941       9.89       [8.60; 11.31]       0.8         Random effects model       26702       3.84       [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 15.41       [13.37; 15.95]       0.8	Gudo S.E. et al 2009	112	1865	+	6.01 [4.90: 7.11] 0.8
Heterogeneity: $l^2 = 94\%$ , $t^2 = < 0.01$ , $p < 0.01$ 0.57 [0.39; 0.58]       0.8         Namibia       0.57 [0.39; 0.58]       0.8         E.Vardas, et al 1999       192 1941       9.89 [8.60; 11.31]       0.8         Random effects model       26702       3.84 [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 15.41 [13.37; 15.95]       0.8	Random effects model		5398	$\overline{\diamond}$	6.75 [ 3.70: 10.631 2.4
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National       0.57       [0.39; 0.58]       0.6         R.Mavenyengwa, et al 2014       140       24761       0.57       [0.39; 0.58]       0.6         E.Vardas, et al 1999       192       1941       9.89       [8.60; 11.31]       0.6         Random effects model       26702       3.84       [0.00; 17.95]       1.6         Heterogeneity: $I^2 = 100\%$ , $I^2 = 0.03$ , $p < 0.01$ 15.41       [13.37; 15.95]       0.6	Newshie				
Kind and State 214       143       21401 $9.89$ $[0.35, 0.50]$ $0.57$ $[0.35, 0.50]$ $0.57$ Random effects model       26702 $3.84$ $[0.00; 17.95]$ $1.6$ Heterogeneity: $l^2$ = 100%, $l^2$ = 0.03, $p < 0.01$ $3.84$ $[0.00; 17.95]$ $1.6$ Niger       Mayaki Z, et al 2012       495 $3213$ $15.41$ $[13.37; 15.95]$ $0.8$	Namibia R Mavenvengwa et al 2014	140	24761		0.57 [0.39-0.58] 0.5
Liver (use, 6t al 1399)       192       1941       9.09       [8.00; 11.31]       0.0         Random effects model       26702       3.84       [0.00; 17.95]       1.6         Heterogeneity: $l^2 = 100\%$ , $l^2 = 0.03$ , $p < 0.01$ 15.41       [13.37; 15.95]       0.8         Niger       15.41       [13.37; 15.95]       0.8	E Vardas, et al 1000	140	24/01		
Random energy model         20702         3.84 [0.00; 17.95]         Heterogeneity: $l^2 = 100\%$ , $L^2 = 0.03$ , $p < 0.01$ Niger         Vayaki Z, et al 2012       495       3213         15.41 [13.37; 15.95]       0.8	E.varuas, et al 1999	192	1941		9.09 [8.00; 11.31] 0.8
Niger Mayaki Z, et al 2012 495 3213 🔤 15.41 [13.37; 15.95] 0.8	UANAAN ATTAATA MAAAA		20/02		3.64 [0.00; 17.95] 1.0
Niger Mayaki Z, et al 2012 495 3213 🔤 15.41 [13.37; 15.95] 0.8	Heterogeneity: $I^2 = 100\%$ $r^2 - I$	0.03 n <	0.01		
Mayakı ∠, et al 2012 495 3213 <b>=</b> 15.41 [13.37; 15.95] 0.8	Heterogeneity: $I^2 = 100\%$ , $\Box^2 = 0$	0.03, p <	0.01		
	Heterogeneity: $I^2 = 100\%$ , $\Box^2 = 0$	0.03, p <	0.01	_	
	Handom effects model Heterogeneity: $I^2 = 100\%$ , $\Box^2 = 0$ Niger Mayaki Z, et al 2012	0.03, <i>p</i> < 1 <b>495</b>	0.01 3213	-	15.41 [13.37; 15.95] 0.8

FIGURE 2 (Continued)

Nigeria						
F.Buseri, et al 2009	262	1410		18.58	[16.60; 20.72]	0.8%
H.Okoroiwu, et al 2018	1013	24979		4.06	[3.81; 4.31]	0.8%
D.Ogbolu, et al 2016	27	186		14.52	[ 9.99; 20.56]	0.7%
C.Uneke, et al 2005	25	175	_ <b>.</b> _	14.29	[ 9.69; 20.53]	0.7%
E.Nna, et al 2014	13	113	· · · · ·	11.50	[ 6.64; 19.14]	0.7%
F.Fasola, et al 2022	15	274	-	5.47	[ 3.25; 9.00]	0.8%
B.Motavo, et al 2015	13	130		10.00	[5.76: 16.74]	0.7%
Mabavoie O.V. et al 2018	380	2496		15.22	[13.84: 16.69]	0.8%
Nnodu O. et al 2003	1005	20574	4	4.88	[4.40: 5.00]	0.8%
Jeremiah A.Z. et al 2011	23	266		8.65	[5.71: 12.81]	0.8%
Nwankwo E. et al 2012	31	280	· · ·	11.07	[7 78 15 46]	0.8%
Salawu L. et al 2011	38	457		8.32	[6.05: 11.32]	0.8%
Ogbenna A. A. et al 2022	2791	45002	1	6.20	[5.93: 6.37]	0.8%
Adekanle O, et al 2010	40	234	· · · ·	17.09	[12,50:22,54]	0.8%
Mutimer D.I. et al 1994	9	104		8 65	[4 32: 16 01]	0.7%
Shittu A O et al 2014	38	350	÷	10.86	[7.52, 14.36]	0.8%
Janhe M O et al 2011	18	92		19.50	[12 43 29 37]	0.7%
Mahavoje O V et al 2010	28	207		9.43	[6 50: 13 46]	0.7%
Garba B et al 2023	46	400	-	11 50	[854:15.40]	0.0%
Pandom effects model	40	97819	<b>A</b>	10.41	[8 35: 12 65]	14.6%
Heterogeneity: $I^2 = 98\%$ , $\Box^2 = < 0$	0.01, p <	0.01	Ť	10.41	[ 0.00, 12.00]	14.070
Rwanda						
TwagirumugabeT, et al 2017	591	45061	1	1.31	[ 1.21; 1.42]	0.8%
Senegal						
M.Seck, et al 2016	592	8048		7.36	[ 6.69; 7.85]	0.8%
Vray M, et al 2006	10	175		5.71	[ 3.02; 10.47]	0.7%
Gadji.M, et al 2024	218	5002		4.36	[ 3.81; 4.96]	0.8%
Random effects model		13225	♦	5.73	[3.81; 8.01]	2.4%
Heterogeneity: $I^2 = 96\%$ , $\Box^2 = < 0$	0.01, p <	0.01				
Sierra Leone	0000	00740		40.77	140.04 44.001	0.00/
F. lognon, et al 2020	3200	29/13		10.77	[10.31; 11.02]	0.8%
E. rambasu, et al 2018	1633	10807		9.72	[9.26; 10.16]	0.8%
Heterogeneity: $I^2 = 92\%$ , $\Box^2 = < 0$	0.01, p <	<b>40520</b> 0.01	v	10.25	[9.24, 11.30]	1.770
South Africa						
M.Vermeule, et al 2017	2638	39764	i i	6.63	[5.93: 6.43]	0.8%
Casteling A, et al 1998	6	510	+	1.18	[0.48: 2.59]	0.8%
Jacobs G. et al 2023	3433	515397		0.67	[0.49: 0.53]	0.8%
Random effects model	5.00	555671	$\diamond$	2.27	[ 0.15: 6.67]	2.5%
Heterogeneity: $I^2 = 100\%$ , $\Box^2 = <$	0.01, p	= 0	-		L 3, 0.01]	=10 /0
Sudan						
S.Mahgoub, et al 2010	48	404		11.88	[ 8.98; 15.52]	0.8%
E.Ahmed, et al 2020	607	10897	+	5.57	[5.15; 6.02]	0.8%
Random effects model		11301	$\diamond$	8.30	[ 3.17; 15.54]	1.6%
Heterogeneity: $I^2 = 95\%$ , $\Box^2 = < 0$	0.01, p <	0.01				
Tanzania						
B.Jacobs, et al 1997	132	1205		10.95	[ 9.28; 12.89]	0.8%
Z.Mohamed, et al 2019	262	6402	*	4.09	[3.62; 4.60]	0.8%
S.Lidenge, et al 2020	37	504	÷	7.34	[ 5.31; 10.06]	0.8%
M.Matee, et al 2006	140	1599	+	8.76	[ 7.44; 10.27]	0.8%
	17	326	-	5.21	[ 3.09; 8.24]	0.8%
Croce F, et al 2007		10036	$\diamond$	7.10	[4.80; 9.81]	4.0%
Croce F, et al 2007 Random effects model			1			
Croce F, et al 2007 Random effects model Heterogeneity: $l^2 = 96\%$ , $c^2 = < 0$	0.01, p <	0.01				
Croce F, et al 2007 Random effects model Heterogeneity: $l^2 = 96\%$ , $l^2 = < 0$ Random effects model	0.01, p <	0.01 3573211	<b></b>	6.93	[ 5.95; 7.97]	100.0%
Croce F, et al 2007 Random effects model Heterogeneity: $l^2 = 96\%$ , $\mathbb{C}^2 = < 0$ Random effects model Heterogeneity: $l^2 = 100\%$ , $\mathbb{C}^2 = 0$ .	0.01, p <	0.01 3573211 0		6.93	[ 5.95; 7.97]	100.0%
Croce F, et al 2007 Random effects model Heterogeneity: $l^2 = 96\%$ , $\Box^2 = < 0$ Random effects model Heterogeneity: $l^2 = 100\%$ , $\Box^2 = 0$ . Subgroup test $\Box^2_{29} = 13857.63$ , df	0.01, p < 01, p = = 29 (p	0.01 <b>3573211</b> 0 = 0)	0 10 20 30 40 50 6	<b>6.93</b>	[ 5.95; 7.97]	100.0%

FIGURE 2

Forest plot of the pooled seroprevalence of Hepatitis B Surface Antigen among Blood donors in Africa by country, Random-effect model: subgroup analysis by region. ES estimated prevalence of HBV.

of HBsAg by the risk of bias (p=0.92), study location (p=0.05), setting (p<0.69), year of study publication (p=0.07) type of blood donor (p=0.64), age (p=0.89) and proportion of males (p=0.31) (see Table 2).

Although the year of study publication was not statistically significant in the meta-regression analysis, we did find a decreased trend in the seroprevalence of hepatitis B among African blood donors over the years (see Figure 4).

The funnel plot showed asymmetry, and the regression Egger's test was statistically significant (p < 0.01). Meaning that the evidence of the presence of risk of publication bias was identified (see Figure 5).



TABLE 1 Sub-group analysis of the pooled prevalence of HBsAg estimation in African bloo	d donors by regions (1990–2024).
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Moderator variables	Category	Number of studies	Aggregate sample size	Prevalence % (95% CI)	l² (%)	<i>p</i> -value
Africa region	Western	51	1,000,828	10.09 (8.75; 11.50)	99.7	0.01
	Eastern	32	990,144	4.87 (3.77; 6.11)	99.7	
	Central	26	281,782	7.81 (5.34; 10.71)	99.7	
	Northern	9	705,327	1.73 (0.45; 3.79)	99.8	
	Southern	6	595,130	2.47 (0.54; 5.75)	99.9	
Year of publication	1990-2000	5	5,997	8.07 (3.80; 13.73)	96.4	0.03
	2001-2010	26	151,880	9.41 (7.19; 11.90)	99.7	
	2011-2024	93	3,415,334	6.26 (5.19; 7.42)	99.9	

 $I^2$  = Heterogeneity; *p*-value: significance test of subgroup differences.

TABLE 2 Moderators of heterogeneity on the seroprevalence of HBsAg in blood donors in Africa.

Variables	Moderators test p-value	R² (%)
African region	< 0.01	28.60
Country	< 0.01	44.69
Risk of bias	0.92	0.0
Location	0.05	2.05
Setting	0.69	0.00
Type of Blood donors	0.64	0.00
Age	0.89	0.00
Proportion of male	0.31	0.07
Year of study publication	0.07	2.02

 $R^2$ : The amount of heterogeneity accounted for.

## Discussion

Our study shows that the seroprevalence of HBsAg among blood donors in African countries was 6.93% (95% CI: 5.95–7.97%). This finding is consistent with a report on the prevalence of HBsAg in the general population in Africa, which is considered to be higher (19). This means the Hepatitis B virus remains an enormous public health problem in Africa (5). These findings are worrisome as there are reports of transmission of the Hepatitis B virus infection by blood transfusion (20, 21). The risk of becoming infected with HBV in sub-Saharan Africa from a blood transfusion is high and around 4.3 per 1,000 units (4).

In our study, the seroprevalence of HBsAg among blood donors was higher compared to data reported from the European Union, which is 1.1% among first-time blood donors (22), China 1.32% (23), Laos (Southeast Asian country) which was around 2.6% (24)





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and in the Eastern Mediterranean and Middle Eastern countries which were 2.03% (25).

We found statistically significant differences in the prevalence of HBsAg based on the African region where the study was performed.

The Western Africa region had the highest prevalence of 10.09%, followed by the Central region (7.81%) and Eastern (4.87%), while the Southern (2.47%) and Northern African regions (1.73%) exhibited lower prevalence.

These findings are consistent with the systematic reviews and metaanalyses conducted in countries of the Western region, such as Burkina Faso (26), Kenya (27) in Eastern Africa, and Cameron (28) in the Central region of Africa, which show a higher prevalence of Hepatitis B ranging from 8 to 12%. In contrast, the low prevalence observed in the countries of Northern and Southern Africa is consistent with the epidemiological study on the prevalence of the Hepatitis B virus in Africa, which shows a low endemicity level (<2%) in the Northern region (19, 29).

We found an inverse relationship between the prevalence of Hepatitis B among blood donors in Africa and the year of the study publication, although it was not statistically significant in the meta regression analysis, we did find statistically differences in subgroup analysis splitting the year into three categories. We found that, published studies (after 2010) tended to present lower seroprevalence of Hepatitis B than studies published before 2010. This finding can be explained by the introduction of universal infant and childhood hepatitis B vaccination programs in 1997 (30) and improved screening and treatment of Hepatitis B.

Additionally, we found that the country where the study was carried out was a statistically significant moderator of the heterogeneity of the seroprevalence of HBsAg. These findings can be explained by the existing differences in the access and quality of screening procedures, the social and demographic profile of each country, lifestyle, prevalence of hepatitis B in the general population, and much more importantly, availability of vaccination and treatment services in these countries (19, 31).

Our systematic review has some limitations: The pooled seroprevalence of HBsAg among blood donors that we found cannot be generalized to the whole of Africa as 24 (44%) of African countries did not have any study on the topic. The studies overrepresented countries located in the Western, Central and Eastern regions of Africa and underrepresented those countries in the Northern and Southern regions of the continent. Therefore, further studies are needed concerning underrepresented African areas to complement our findings and to have a good overview of the seroprevalence of HBsAg in Africa. Additionally, we found higher heterogeneity among the included studies ( $I^2 = 100\%$ ). Moreover, we found greater variation in the precision of our estimates due to differences in the total sample sizes of studies across different periods and African regions. Specifically, fewer populations were included in studies conducted in the 1990s compared to the larger number included in studies after 2001. Similarly, smaller sample sizes were observed in the Southern and Northern regions compared to the Western, Eastern, and Central African regions.

Notwithstanding the above limitations, this study has some strengths worth mentioning: to the best of our knowledge, this is the first systematic review and meta-analysis study that analyzed and synthesized the seroprevalence of HBsAg among blood donors in Africa and investigated the reasons for the variability of the prevalence of HBsAg across Africa.

Conclusion: The prevalence of HBsAg among blood donors in Africa is still very high, and it widely varies according to the country, African regions, and year of study publication. Therefore, there is a need for scale-up strategies to intensify the screening of blood donors and extend access to the Hepatitis B vaccine and improve public policy for blood transfusion safety toward Hepatitis B virus elimination.

## Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Author contributions

AQ: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. NC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. LC: Conceptualization, Supervision, Validation, Writing – review & editing, Investigation. AS: Conceptualization, Investigation, Supervision, Validation, Writing – review & editing. LA: Conceptualization, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing, Formal analysis, Writing – original draft.

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# **Conflict of interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1434816/ full#supplementary-material

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