Prevalence and trend of Urinary Schistosomiasis in West Africa: A systematic Review and Meta-analysis

ABSTRACT

Background: Urinary schistosomiasis remains a major cause of public health concern with the global burden predominant in Sub-Sahara Africa. Over 78 countries are affected and approximately 800 million people are exposed to the disease in Sub-Saharan Africa (SSA) accounting for 90% of cases and an estimated 280,000 deaths each year. The disease poses a substantial public health challenge causing an estimated 70 million Disability-Adjusted Life Years. There is however no consolidated data on the prevalence of urinary schistosomiasis in West Africa.

Aim: This study assessed the prevalence of urinary schistosomiasis in West Africa.

Methods: This research employed a systematic literature review to meticulously gather and analyze existing data, with the primary aim of establishing the weighted prevalence of *S. haematobium* infection in West Africa rigorously adhering to the PRISMA guidelines between March 1 and March 12, 2023, spanning key databases including MEDLINE via PubMed, Scopus, and Google Scholar. Prevalence metrics were presented using proportion. Random effects model was used as significantly large heterogeneity was observed among the studies. The DerSimonian-Laird random effects method was used as the between study variance estimator in estimating the pooled proportion estimate and its confidence interval. Publication bias was assessed using the Egger's test and the Beggs test as well as funnel plots. The MedCalc statistical software version 14 and OpenMeta [Analyst] meta-analysis tools were used for the meta-analysis. A p-value of <0.05 was considered statistically significant.

Results: This review included 133 articles out of which 91 (68.40%) representing the majority were contributed by Nigeria. Overall, this review comprised 126508 participants out of which 40019 were identified to be infected with *S. haematobium*. The pooled prevalence based on the random effect model was 37.6% (95%CI: 33.9% - 41.3%). Pooled prevalence rates of 41.4% (95% CI: 36.1% - 46.7%), 40.2% (95% CI: 24.7% – 55.6%) and 23.9% (95% CI: 16.8% - 30.9%) were recorded among rural, suburban and urban dwellers respectively. A meta regression analysis revealed a significantly decreasing trend in the prevalence of schistosomiasis with advancement in year of publication (Coeff. -0.007, p=0.004).

Conclusion: The results from this study hightlights the positive impact of control measures instituted in fighting urinary schistosomiais in West Africa. Targeted interventions, especially in rural areas may further aid in the elimination of the schistosomiasis menace in the subregion. Age-specific disparities underscore the need for tailored approaches. This review emphasize the importance of sustained control measures and continued research to achieve long-term disease reduction and, ultimately, elimination.

Keywords: West Africa, Schistosomiasis, Prevalence, Urinary, Systematic Review

1. INTRODUCTION

Schistosomiasis is a parasitic disease of significant global concern caused by the trematode Schistosoma [1, 2]. The disease is ranked as the second most economically devastating parasitic infection, surpassed only by malaria, and represents the most prevalent waterborne disease affecting rural populations [3]. Five distinct Schistosoma species are known to infect humans including *S. haematobium*, *S. japonicum*, *S. mansoni*, *S. intercalatum*, and *S. mekongi* [2]. Of these, *S. haematobium* is responsible for urogenital/urinary schistosomiasis, characterized by recurring haematuria and lower urinary tract symptoms [4, 5].

Infection with urinary schistosomiasis is closely associated with poverty and inadequate sanitation, particularly in regions where individuals have direct exposure to water contaminated with urine and feces [6, 7, 8]. Those residing near rivers and other bodies of water are at a higher risk of contracting the disease [7, 9]. Consequently, children and adults engaged in water-related activities are disproportionately affected by the disease [1, 7, 10, 11]. Urogenital schistosomiasis primarily manifests as haematuria and dysuria, resulting from chronic inflammation of the bladder and urethra induced by schistosome eggs deposited into the vesical venous plexus where adult schistosomes reside, subsequently traversing through the tissue into the bladder and triggering an immune response [8].
Both males and females, encompassing adults and children, are susceptible to schistosomiasis and its associated complications, including bladder cancer and renal failure in cases of chronic urinary tract infections, as well as infertility, ectopic pregnancies, miscarriages, fatigue, stunted growth, potential cognitive impairment, and an elevated risk of HIV infections, particularly among females, associated with chronic genital tract infections [12, 13].

Schistosomiasis is highly prevalent in Africa, the Middle East, South America, and Asia. However, more than 95% of global schistosomiasis burden is in sub-Sahara Africa [2, 4]. In 2007, the World Health Organization reported roughly 250 million cases of schistosomiasis worldwide, with approximately 732 million individuals at risk of infection [6]. By 2011, it was estimated that 243 million people across 78 countries faced a high risk of contracting the disease [2]. Recent data indicates that in 2019, 236.6 million people globally required preventive treatment for schistosomiasis, with over 105 million successfully treated [14]. So far, over 78 countries are affected and approximately 800 million people are exposed to the disease in Sub-Saharan Africa (SSA) accounting for 90% of cases and an estimated 280,000 deaths each year [3, 15, 16]. The disease poses a substantial public health challenge causing an estimated 70 million Disability-Adjusted Life Years (DALYs) [16, 17]. Varying prevalence rates of schistosomiasis have been reported in different countries within the African Continent including 65.7% [18], 45.9% [19], 44.4% [20], 44.3% [21], and 7.1% [3] all in Nigeria as well as 26.2% in Gabon [22], 46.8% in Cameroon [23], 14.0 in Côte D'Ivoire [24], 76% in Zambia [25] and 10.4% [11], 49% [26], 54.8% to 60% [27] and 95% [9] all within varying settings in Ghana.

Controlling schistosomiasis, like many other tropical diseases, requires a multidisciplinary approach that encompasses environmental understanding, mode of transmission, immunology, enhanced access to diagnosis, treatment, and vaccine development. Current strategies focus on mass drug administration (MDA) as recommended by the WHO, primarily targeting the reduction of schistosomiasis morbidity among school-age children (SAC), preschool-age children (PSAC), and women of reproductive age [28]. Additionally, improving access to water, sanitation, and hygiene (WASH) interventions has been a significant focus [13]. While these approaches have reduced the intensity of infection, reinfection remains a public health concern. This suggests the need for further investigations, as individuals may persist in risky behaviours due to a lack of access to adequate water infrastructure, limited knowledge of schistosomiasis transmission mechanisms, or attitudes that disregard existing water infrastructure [13]. Currently, there is lack of harmonized data on the prevalence of urinary schistosomiasis in West Africa, hence this study.

2. METHODOLOGY

2. 1 Study area

The research focuses exclusively on the West African region.

2.2 Study Design/Protocol

This research employs a systematic literature review to meticulously gather and analyze existing data, with the primary aim of establishing the weighted prevalence of *S. haematobium* infection in West Africa. To ensure methodological transparency and adherence to best practices, the study adheres rigorously to the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, as delineated by Page, McKenzie [29]**.**

2.3 Criteria for considering studies for this review

2.3.1 Types of studies

This systematic review incorporates cross-sectional studies, as well as prospective or retrospective cohort studies, exclusively cantered on reporting the prevalence of *S. haematobium* infection. The selection encompassed scholarly journal articles published as primary research studies. The timeframe for inclusion ranges from January 1, 1980, to December 31, 2021, exclusively within the West African geographical context. Studies deficient in comprehensive data for thorough evaluation or those solely presented in non-English languages were excluded.

2.3.2 Participant Profile

The review enrolled individuals of all ages and gender identities, afflicted with urinary schistosomiasis. Diagnosis is predicated on the identification of schistosome eggs via urine microscopy or the detection of parasite antigens in blood or urine or Polymerase chain reaction (PCR).

2.4 Search methods for identification of studies

2.4.1 Information sources

Data Sources: The literature search is conducted meticulously between March 1 and March 12, 2023, spanning key databases including MEDLINE via PubMed, Scopus, and Google Scholar (accessible through https://scholar.google.com).

2.4.2 Search strategies

The various databases were searched using 'free terms' and 'indexed terms' funnelled using the Boolean operators (OR, AND), into a search string. These search terms were derived from a well-developed protocol that addressed the review question related to the outcome's occurrence, incidence or prevalence of *S. haematobium* infection among humans. The search terms ("*S. haematobium*" OR "Schistosomiasis haematobia" *"S. haematobium"*) AND ("prevalence" OR "incidence" OR "occurrence") were used. The search strategy used in each database and the outcome has been described in table 1.

Table 1: Search method and hits from the various databases used

Database	Search	Date searched	Filters or Limits	Hits
Google Scholar	**("*S. haematobium*" OR "S. haematobium" OR "Schistosomiasis haematobia") AND (prevalence OR incidence OR occurrence)**	March 2023	1980 – 2022 Excluding the term "patents"	900
MEDLINE via PubMed	("*S. haematobium*" OR "S. haematobium" OR "Schistosomiasis haematobia") AND (prevalence OR incidence OR occurrence)	March 2023	-	1111
Scopus	("*S. haematobium*" OR "S. haematobium" OR "Schistosomiasis haematobia") AND (prevalence OR incidence OR occurrence)	March 2023	-	2909

2.5 Data collection and analysis

2.5.1 Selection of studies

Search results from the various databases were subjected to automated screening for eligibility using electronic filters available in the electronic databases based on pre-determined eligibility criteria as described in **table 2**. Citations with abstract of resultant studies were exported to Endnote [30]. Microsoft Excel 2016 and Endnote [30] were used to manage citations and the screening process including duplicate identification. Studies were prescreened using "title" and "abstract" to determine study relevance and subsequent selection. The eligibility of potentially relevant articles was assessed based on full text publications for inclusion. Search of bibliography of included studies was not sourced and no hand search was done due to the volume of articles retrieved via electronic search of databases and resultant studies included in the review. The outcome of the selection process is described in **figure 1**.

2.6 Data extraction and management

The data collection process was independently performed by two main reviewers and a third reviewer to address discrepancies. Data relating to the characteristics of each study such as the author and year of publication, study design, sample size, Country of study, method for detecting *S. haematobium* infection, study period, community type, age range of participants, study population segment and specimen used were abstracted from each study. All data retrieved from the studies were entered into Microsoft Excel 2016. First author's surname, and year of publication of the study were used as identities for each study. The sample size (total participants) and no of *S. haematobium* infected cases in each was used for the meta-analysis. For longitudinal and prospective studies with interventions, only baseline characteristics were extracted for the purpose of the review. In prospective studies where no intervention was involved, averaged summary estimates of prevalence and sample size were extracted for the purpose of this review.

2.7 Investigations of heterogeneity

We inspected forest plots to visually assess heterogeneity between study-specific difference in means for cases and controls. Heterogeneity test (I^2 heterogeneity test) was also performed to ascertain the variations in the prevalence among the various studies. A significantly high heterogeneity (I^2 >50%) was determined. A subgroup analysis was also performed to investigate the sources of heterogeneity. The factors, community type, year of publication, population segment, diagnostic method etc were assessed in the subgroup analysis. None of the factors used explained the source of heterogeneity as high heterogeneity (I^2 >90%) was observed with each subgroup.

2.8 Statistical analysis and data synthesis

Data on study frequency based on descriptive factors such as country of study and year of study were reported as count and percentages and presented using charts and tables. Prevalence metrics were presented using proportion. The untransformed proportion estimates (prevalence) of each study with the pooled estimate were plotted using forest plots. The random effects model was used as significantly large heterogeneity was observed among the studies. The DerSimonian-Laird random effects method was used between study variance estimator in estimating the pooled proportion estimate and its confidence interval. A p-value of <0.05 was considered statistically significant. A subgroup analysis was also performed to investigate the sources of heterogeneity. The factors, community type, population segment, diagnostic method and age group were assessed in the subgroup analysis. None of the factors used explained the source of heterogeneity as high heterogeneity (I^2 >90%) was observed within each subgroup. Publication bias was assessed using the Egger's test and the Beggs test as well as funnel plots. The MedCalc statistical software version 14 and OpenMeta [Analyst] meta-analysis tools were used for the meta-analysis.

3. RESULT

3.1 Outcome of search

A total of 4920 articles were retrieved from initial search in bibliographic databases. Out of this 1619 were removed as duplicates using Endnote and Systematic review accelerator. The remaining 3301 articles were subjected to Title and abstract screening of which 2995 studies that did not meet the inclusion criteria for this review were excluded. Full text of 87 studies could not be retrieved. Two hundred and nineteen (219) studies were assessed in full text of which only 133 articles met the inclusion criteria and thus included in this review for quantitative assessment (figure 1).

As shown in table 2, this systematic review encompasses an analysis of 133 individual studies conducted in West Africa over a range of years 40 years comprising a total participant of 126508 out of which 40019 were identified to be infected with *S. haematobium*. Most of the studies were based in rural areas (74.40%) whereas 1.50% and 10.50% were based in suburban and urban areas respectively. The results show that a substantial proportion of the research were among children (69.90%) while 5.30% and 24.10% were among adults, and both adults and children respectively. Of the 7 studies that focused exclusively on adults, 2 studies were conducted among pregnant women, 1 in adults diagnosed with obesity and the remaining from the general adult population. This review revealed that four of the studies were among preschool children. The preponderance, 100 (75.17%) of the studies included in this review employed a cross-sectional study design. Finally, microscopy was the predominant diagnostic method used, 123 (92.48%) while only 5 (3.8%) utilized PCR. Out of the 123 studies that employed microscopy, filtration was the most employed method in 83 studies, while Sedimentation/centrifugation technique was used in 36 studies.

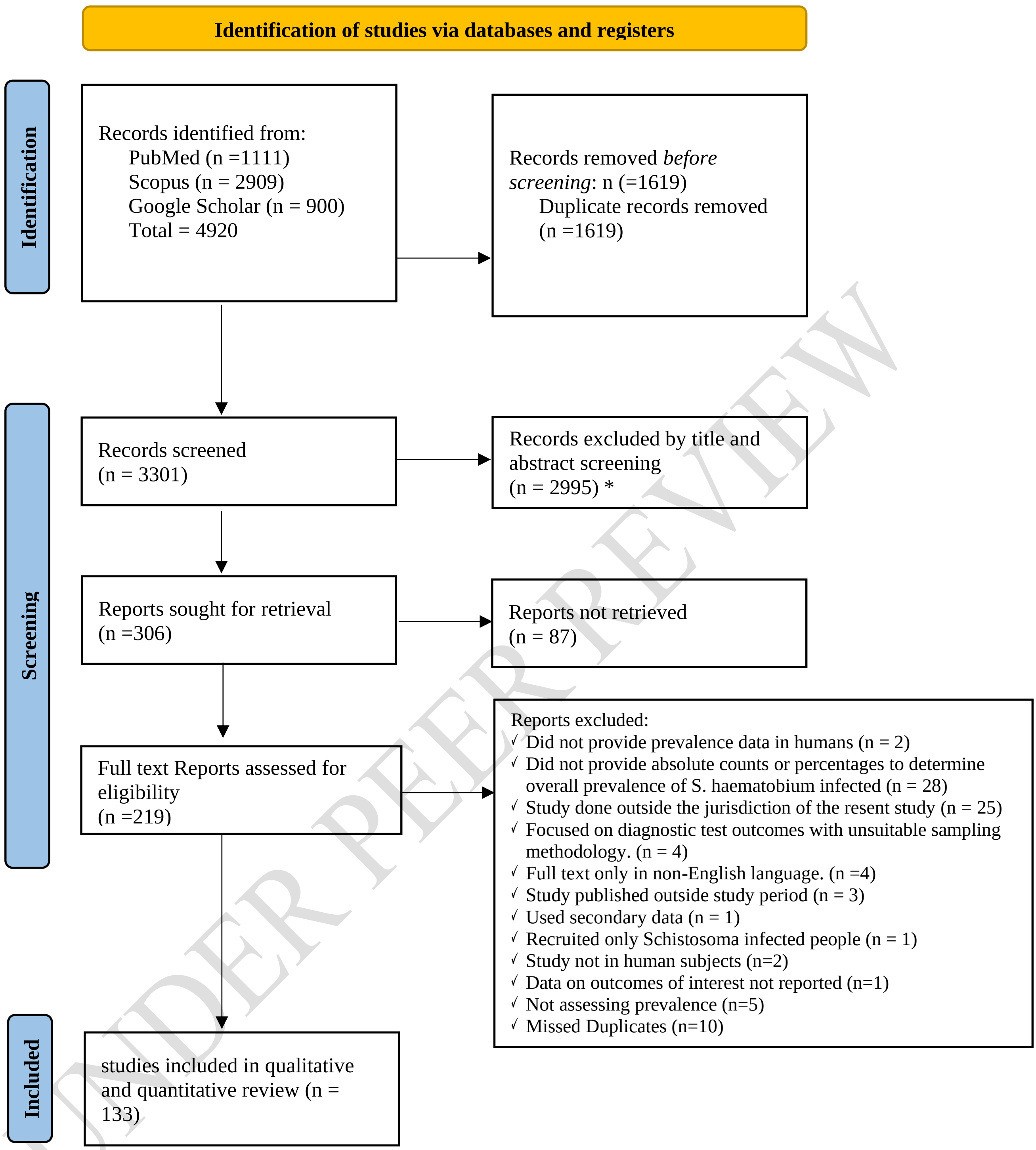

Figure 1: PRISMA flowchart of the outcome of search
* Screening was performed by humans with no automation used.
Adapted from [29]

Table 2: Characteristics of included studies

Study	Year of publication	No. S. haematobium positive	Total Participant	Study design	Community type	Type of sample	Diagnosis method	Country	Study population	Age group	Study period
[19]	2018	332	724	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	4–18 years	March 2015 and July 2016
[18]	2017	46	70	Cross-sectional study	Rural	Urine	PCR	Nigeria	Adults	15 and 65	NS
[20]	2015	452	1017	Cross-sectional study	Rural	Urine	Kato-Katz, microscopically	Nigeria	School children	4–15 years	October 2012 to May 2013
[31]	*2012*	250	456	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	3-20 years	November 2010 and June 2011
[21]	2018	108	244	Survey	Rural	Urine	Microscopy, filtration	Nigeria	School children	5-18 years	12 months
[32]	2017	220	300	Cross-sectional study	NS	Urine	Microscopy	Nigeria	School children	13-21 years	Oct-16
[33]	2018	57	413	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	10-18 years	NS
[34]	2013	33	63	Cross-sectional study	Rural	Urine and blood	PCR	Nigeria	General population	7-63 years	NS
[35]	2011	98	200	NS	Urban	Urine	PCR	Nigeria	School children	6 to 13 years	NS
[36]	1996	1381	2888	NS	Rural	Urine	Sedimentation and microscopy	Nigeria	Children and adults	5-9 years and 20-24 years	May 1992 and June 1993
[37]	2004	496	1173	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	General population	General population	May and September 1998.
[38]	1989	15	100	Cross-sectional study	NS	Urine	Simple sedimentation procedure	Nigeria	School children	NS	NS
[39]	1997	85	333	NS	Rural	Urine	Microscopic, filtration using malachite green	Nigeria	School children	5-18 years	NS
[40]	2014	165	300	Cross-sectional study	NS	Urine	Filtration	Nigeria	School children	1-15 years	NS
[24]	2020	166	1187	Cross-sectional study	NS	Urine	Filtration and molecular analysis	Côte d'Ivoire	School children	5–14 years	January to April 2018
[41]	2013	347	920	NS	Rural	Urine	Centrifugation	Ghana	School children	6-15 years	NS
[42]	2000	2562	4636	Cross-sectional study	Rural	Urine	Filtration	Ghana	School children	10-19 years	August 1992 and June 1993

[43]	2016	163	718	Cross-sectional study		Urine	Microscopy	Nigeria	School children	10–23 year	May and August,2015
[44]	2018	42	491	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	6–15 year	March and July, 2016
[45]	2021	47	1000	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	Hospital patients	General population	NS
[46]	2020	346	620	Cross-sectional study	Rural	Urine	Filtration	Nigeria	General population	3-22 years	NS
[47]	2002	55	160	Cross-sectional study	Urban	Urine	Microscopy	Ghana	School children	6 - 17 years	NS
[48]	2013	95	141	Cross-sectional study	NS	Urine	Filtration	Ghana	School children	4–17 years	June and December 2009
[49]	2013	15	60	Cross-sectional study	Urban	Urine	Centrifugation	Nigeria	Adults	11 - 30 years	NS
[50]	2009	14	218	Cross-sectional study	Urban	Urine	Sedimentation and microscopy	Nigeria	School children	5-19 years	1 May and 28 June 2009
[51]	2016	5	120	Cross-sectional study	Urban	Urine	Microscopic analysis	Nigeria	Hospital patients	1-25 years	NS
[52]	2014	113	300	Cross-sectional study	Rural	Urine	Sedimentation method	Nigeria	General population	General population	NS
[53]	1992	193	425	Prospective and cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	5-18 years	NS
[54]	2015	88	150	Cross-sectional study	Rural	Urine	Microscopy examination	Nigeria	School children	9-16 years	NS
[55]	2016	18	90	Pilot study	NS	Urine	Microfiltration using nucleopore filters	Guinea-Bissau	School children	6-15 years	NS
[56]	2016	52	250	Cross-sectional study	Rural	Urine	Sedimentation and microscopy	Ghana	School children	5-20 years	NS
[57]	1998	104	580	Cross-sectional study	Rural	Urine and stool	Filtration	Mali	School children	6-11 years	NS
[58]	1994	401	2597	Cross-sectional study	Rural	Urine	Microscopy examination	Mali	General population	General population	NS
[59]	2011	173	338	NS	Rural	Urine	Filtration	Mali	Pre-school children	Infants and preschool-aged	NS
[60]	2014	110	200	Cross-sectional study	Rural	Urine	Sedimentation techniques	Nigeria	General population	8-19 years	July to August 2013.
[61]	2016	46	551	NS	Rural	Urine and stool	Filtration	Nigeria	General population	1-90 years	NS

[62]	2021	1982	12237	Cross-sectional study	NS	-	Ns	Côte d’Ivoire	School children	9-12 years	May to September 2015
[63]	2017	46	910	Cross-sectional study	NS	Urine	Filtration	Côte d’Ivoire	School children	6–15 years	between 2007 and 2012.
[64]	2009	218	493	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	5-16 years	NS
[65]	2010	97	167	NS	Rural	Urine	Filtration	Nigeria	Pre-school children	1-6 years	NS
[66]	2011	17	100	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	0-6 years	NS
[67]	1994	104	200	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	General population	NS	1990 and 1992
[68]	1999	6	786	Cross-sectional study	Rural	Urine	Microscopy	Ghana	School children	6-16 years	NS
[69]	2011	466	1124	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	3-27 years	November 2008 to September 2009
[70]	2012	466	1124	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	NS	NS
[71]	2011	112	255	Cross-sectional study	Rural	Urine	Filtration	Ghana	School children	8-18 years	2008
[72]	2012	143	708	Cross-sectional study	Rural	Urine	Filtration	Ghana	School children	8-22 years	2008-2010
[73]	2011	364	3324	Cohort	Urban	Urine	Ns	Burkina Faso	School children	7-11 years	2007-2008
[74]	2012	395	640	Cross-sectional study	Rural	Urine	Filtration	Mali	School children	7–14 years	2004-2010
[75]	2020	36	150	NS	Rural	Urine	Filtration	Nigeria	School children	8-14 years	2017
[76]	2020	792	1585	Systematic survey	Rural	Urine and stool	Filtration	Senegal	Children and adults	5-78 year	2016-2018
[77]	2018	3	728	Cross-sectional study	Urban	Urine	Filtration	Côte d’Ivoire	School children	Children aged between 5 and 15 years	March 2015-
[78]	2009	300	657	Cross-sectional study	Rural	Urine	Filtration	Nigeria	Children and adults	0-40 years	2004-2006
[79]	2012	431	857	Cross-sectional study	Rural	Urine and stool	Filtration	Senegal	Children and adults	0-85 years	2009
[80]	2018	128	200	NS	Rural	Urine	Filtration	Nigeria	School children	5-14 years	2016

[81]	2014	278	487	Cross-sectional study	Rural	Urine	Sedimentation technique	Nigeria	School children	3-19 years and above	March - April 2010.
[82]	2015	130	173	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	6-18 years	NS
[83]	2011	89	276	Prospective	Sub-urban	Urine	Sedimentation technique	Nigeria	School children	8-13 years	NS
[84]	2019	192	400	Cross-sectional study	Sub-urban	Urine	Standard filtration technique	Nigeria	School children	4-13 years and above	NS
[85]	2006	1005	2071	NS	Rural	Urine	Filtration	Nigeria	School children	5-20 years	NS
[86]	2001	371	1139	NS	Rural	Urine	Filtration	Nigeria	Children and adults	NS	1999-2000
[87]	2005	195	300	NS	Rural	Urine	Filtration	Nigeria	Adults	5-60 years	NS
[88]	2007	43	138	NS	Rural	Urine	Filtration	Nigeria	Children and adults	NS	NS
[89]	2017	164	251	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	5-16 years	NS
[90]	2007	1069	1612	Longitudinal study	Rural	Urine	Filtration	Nigeria	School children	5-12 years	2003-2005
[91]	2018	20	504	Cross-sectional study	Rural	Urine	Sedimentation and microscopy	Nigeria	School children	5-16 years	2016-2017
[92]	2012	49	500	NS	Rural	Urine	Sedimentation and microscopy	Nigeria	School children	5-15 years	NS
[93]	2015	57	325	NS	Rural	Urine	Sedimentation and microscopy	Nigeria	School children	<10-16 years	NS
[94]	2018	1144	1479	NS	Rural	Urine	Filtration	Nigeria	School children	4-20 years	NS
[95]	2018	19	404	Cross-sectional study	Urban	Urine	Filtration	Ghana	School children	9-14 years	April and June 2016
[96]	1997	560	1241	NS	Rural	Urine	Centrifugation	Nigeria	NS	All ages	April/May 1991 and April/May 1992
[97]	2000	150	220	NS	Rural	Urine	Ns	Nigeria	NS	NS	April/May 1991
[98]	2012	234	1337	Cross-sectional study	Rural	Urine	Sedimentation and microscopy	Nigeria	Children and adults	0->46 years	2006-2007
[99]	2021	89	466	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	NS	NS
[100]	2014	245	350	NS	Rural	Urine	Filtration	Nigeria	School children	9-15 years	July 2011 and March 2012
[101]	2003	88	160	NS	Urban	Urine	Sedimentation and microscopy	Ghana	School children	6-17 years	NS
[102]	2014	50	184	Cross-sectional study	Rural	Urine	Microscopy examination	Nigeria	School children	5–13 years	NS

[103]	2013	15	323	Cross-sectional study	Urban	Urine	Centrifugation	Nigeria	School children	4-15 years	2012
[104]	2006	55	487	NS	Rural	Urine	Filtration	Nigeria	General population	1-60+ years	NS
[105]	2004	880	3504	Cross-sectional study	Rural	Urine	Centrifugation	Nigeria	General population	1-60+ years	1998-2000
[106]	2014	66	192	Cross-sectional study	Rural	Urine	Centrifugation	Nigeria	School children	5-13 years	October-December, 2012
[107]	2013	80	102	NS	Urban	Urine	Centrifugation	Nigeria	School children	5-15 years	NS
[108]	2020	79	447	Cross-sectional study	Rural	Urine	Centrifugation	Nigeria	Adults	20 years and above	December 2015 and March 2017.
[109]	2015	128	507	Cross-sectional study	Rural	Urine	Filtration	Nigeria	Females	5-78 years	NS
[110]	2016	15	200	NS	NS	Urine	Centrifugation	Nigeria	School children	5-20 years	NS
[111]	2018	105	528	NS	Rural	Urine	Centrifugation	Nigeria	School children	4-15 years	NS
[112]	2011	105	173	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	NS	NS
[113]	2011	100	200	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	7-13 years	NS
[114]	2019	3380	19250	Parasitological survey	NA	Urine	Filtration	Benin	School children	8–14 years	2013 to 2015
[115]	2007	25	126	NS	Rural	Urine	NS	Nigeria	Pre-school children	0–5 years	March and July 2005
[116]	2021	38	630	Cross-sectional study	NS	Urine	Urine sedimentation and Kato-Katz techniques	Nigeria	School children	5-16 years	October 2017 to January 2018.
[117]	2021	153	1113	Cross-sectional study	Rural	Urine	Sedimentation quantitative technique	Nigeria	School children	4-14 years	June to December 2016
[118]	2021	57	550	Cross-sectional study	NS	Urine	Centrifugation	Ghana	School children	NS	NS
[119]	2017	57	500	Cross-sectional study	Rural	Urine	Centrifugation	Ghana	School children	NS	NS
[120]	2019	57	550	Cross-sectional study	Rural	Urine	Filtration	Ghana	School children	6–14 years	NS
[121]	2012	287	900	Cross-sectional study	Rural	Urine	Centrifugation	Nigeria	School children	5-15 years	NS
[122]	2014	49	94	Cross-sectional study	Rural	Urine	Sedimentation/centrifugation	Nigeria	General population	All ages	NS
[123]	2019	64	145	Cross-sectional study	NS	Urine	Sedimentation and microscopy	Nigeria	General population	5-59 years	May and July 2017

[124]	2016	287	3514	Cross-sectional surveys	NS	Urine	Filtration	Burkina Faso	School children	7–11 years	2008 and 2013
[125]	2018	2	56	Cross-sectional study	Rural	Urine	Centrifugation	Nigeria	General population	NS	NS
[126]	2011	429	667	Cross-sectional study	Rural	Urine	Filtration	Mali	School children	7-14 years	NS
[127]	2013	65	313	Cross-sectional study	Rural	Urine	Filtration	Nigeria	Pregnant women	15-42 year	February 1, 2010, and February 15, 2011
[128]	2013	60	419	Cross-sectional study	Rural	Urine	Centrifugation	Nigeria	Pre-school children	NS	NS
[129]	2009	370	890	Cross-sectional study	Rural	Urine	Sedimentation	Nigeria	Children and adults	NS	July and September, 2001
[130]	1982	3881	5332	Parasitological survey	Rural	Urine	Centrifugation	Ghana	NS	All ages	NS
[131]	2015	240	329	Longitudinal cohort survey		Urine	Filtration	Senegal	School children	5-15 years	June 2011 and March 2012.
[132]	2014	121	210	Cross-sectional study	Rural	Urine	Filtration	Senegal	School children	7-15 years	February to June 2009,
[133]	1992	8	112	Cross-sectional study	Rural	Urine	Filtration	Ghana	Pregnant women	17-25 years	January 1987 and July 1989
[134]	2016	228	375	Cross-sectional study	Rural	Urine and stool	Filtration	Nigeria	School children	5–15 years	May 2012 and March 2015
[135]	2011	324	1569	Cross-sectional study	Rural	Urine	Filtration	Ghana	Hospital patients	NS	January 2000 to December 2009
[136]	2013	18	200	Cross-sectional study	Urban	Urine	Filtration	Ghana	School children	NS	NS
[137]	2017	13	66	Cross-sectional study	Urban	Urine	Microscopy	Nigeria	Vulnerable children	NS	NS
[138]	2009	63	108	Cross-sectional study	Rural	Urine	PCR	Nigeria	School children	NS	NS
[139]	2009	228	447	NS	Rural	Urine	Microscopy	Nigeria	School children	1-17 years	NS
[140]	2012	328	419	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	3-17 years	NS
[141]	2010	634	1023	Cross-sectional study	Rural	Urine	Filtration	Nigeria	General population	≤9-≥21 years	November 2006 - June 2007
[142]	2017	107	325	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	7-14 years	July 2013 to July 2014
[143]	2016	80	120	Cross-sectional study	Rural	Urine	Filtration	Nigeria	General population	6-≥56 years	October 2014 to February 2015

[144]	2005	163	718	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	9-16 years	May - August, 2015
[145]	2020	24	300	Cross-sectional study	Rural	Urine	Microscopy	Nigeria	School children	≤5->15 years	July and December 2016.
[146]	1999	497	560	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	6-14 years	February, 1998
[147]	2016	423	600	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	7-14 years	NS
[148]	1994	307	353	Cross-sectional study	Rural	Urine and stool	Filtration	Senegal	General population	0->59 years	September 1991 and July 1992
[149]	1997	532	824	Cross-sectional study	Rural	Urine	Filtration	Mali	General population	0->40 years	NS
[150]	2003	297	354	Cross-sectional study	Rural	Urine	Filtration	Ghana	School children	NS	NS
[151]	1984	263	389	Cross-sectional study	Rural	Urine and stool	Filtration	Ghana	School children	5-18 years	NS
[152]	2017	570	1398	Cross-sectional study	Urban	Urine	Centrifugation	Nigeria	School children	NS	February and July, 2009
[153]	2014	286	5104	Cross-sectional study	NS	Urine	Reagents strips as a proxy for S. haematobium infection	Côte d’Ivoire	School children	5-16 years	November 2011 to February 2012
[154]	2017	220	353	Cross-sectional study	Rural	Urine and stool	Filtration	Côte d’Ivoire	School children	4-15 years	April to September, 2001
[155]	2018	238	385	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	1-18 years	NS
[156]	2011	1534	3301	Cross-sectional study	Rural	Urine	Filtration	Ghana	Adults	15-89 years	NS
[157]	2016	70	272	Cross-sectional study	Rural	Urine	Filtration	Nigeria	School children	5-20 years	December 2013 to January 2014
[158]	2016	74	287	Cross-sectional study	NS	Urine	Filtration	Burkina Faso	Females	5-50 years	November–December 2012 -Kombissiri and January–February 2013 in Dori

NS-Not specified

As depicted in figure 2 below, the temporal dimension of the dataset revealed varying numbers of studies conducted in each year. The early 1980s had limited number of studies with only three of the studies included was reported in the 1980s with one study per year. An average of two studies per year were seen for the 1990s and early 2000s. Notable increases in research occurred in 2009, 2011 through to 2021 where 6 to 12 studies were observed per year. The highest number of studies, 12, were recorded in 2011, 2016 and 2018.

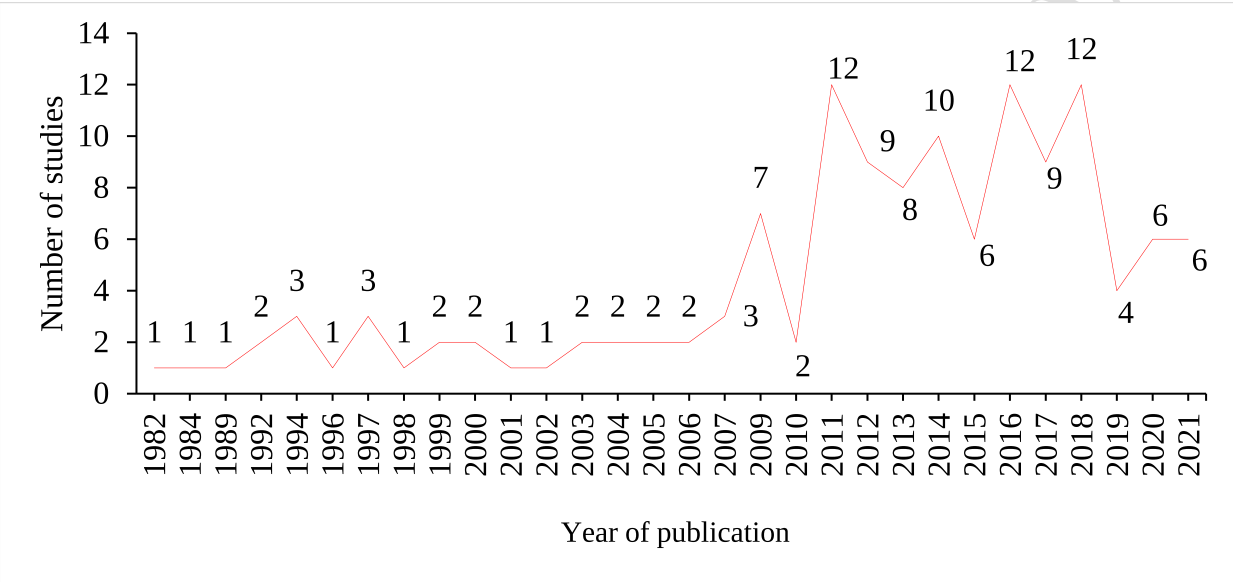

Figure 2: Number of studies by year of publication

Nigeria emerged as the most prominent contributor, with a total of 91 studies conducted during this period. This accounts for the majority (68.40%) of the included studies, indicating a substantial commitment to understanding and addressing the impact of schistosomiasis within the country. Studies in Ghana also made substantial representation with 20 studies, which represent 15.00% of the total studies included in this review. Côte d'Ivoire and Mali conducted six studies each, contributing 4.50% each to the overall research pool. Five studies were conducted in Senegal, accounting for 3.80% of the included studies. Other West African nations, including Benin, Burkina Faso, Guinea-Bissau, made smaller contributions to the research efforts, each having between one and three studies (figure 3).

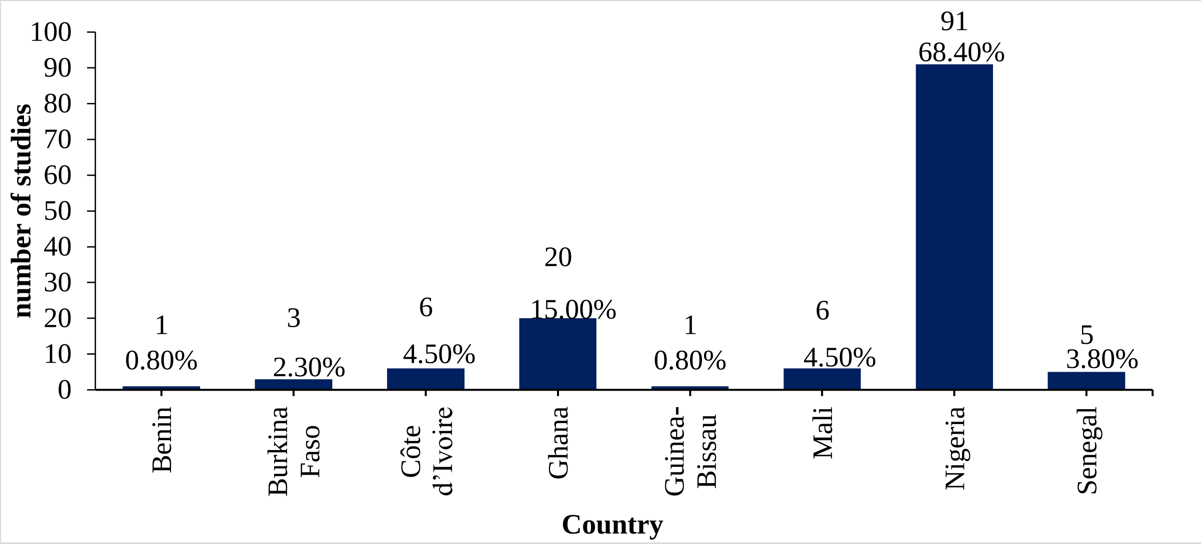

Figure 3: **Distribution of number of included studies by country**

3.2 Publication bias assessment

The results from table 3 and figure 4 shows the results from the funnels plots as well as the Egger's test were used to assess publication bias. There was however a likely publication bias from the funnel plots which was supported by the Egger's test. See Figure 4 and Table 3.

Table 3: Egger's test analysis in determining publication bias

Egger's test	
Intercept	6.25
95% CI	1.82 to 10.68
Significance level	P = 0.0060
Begg's test	
Kendall's Tau	0.008
Significance level	P = 0.8929

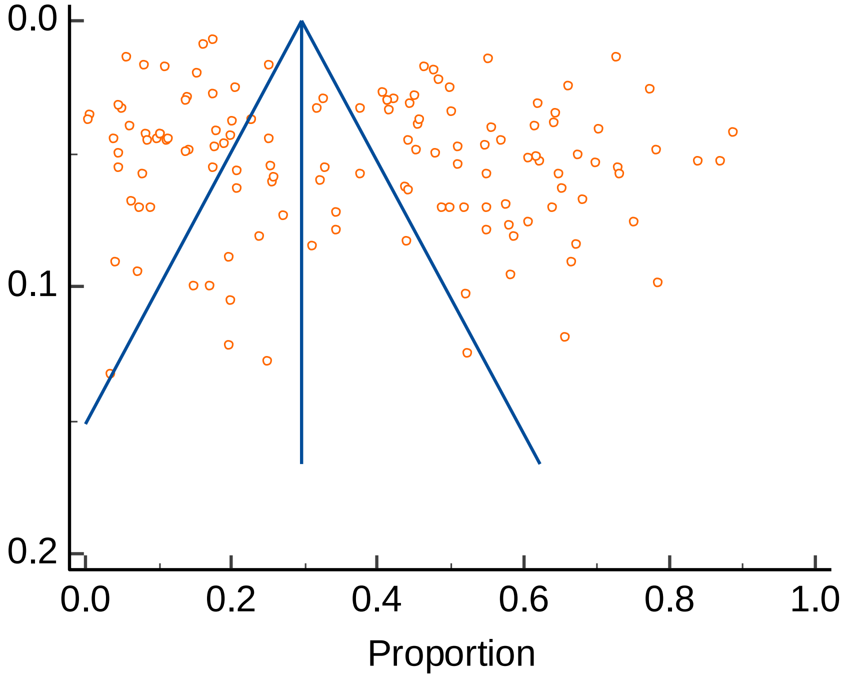

Figure 4: Funnel plot of included studies on the prevalence of *S. haematobium* in West Africa.

The prevalence of *S. haematobium* varied from 0.4% to 88.7% among the studies analysed (Fiqure 6). This study encompassed a total participant of 126508 out of which 40019 were identified to be infected with *S. haematobium.* The pooled prevalence based on the random effect model was 37.6% (95%CI: 33.9% - 41.3%). A cumulative meta-analysis was performed to identify or track the trends in the prevalence of *S. haematobium* with time. It was however observed that there is a decline in the prevalence of *S. haematobium* especially from studies published in the last five years (2016-2021) of the review.

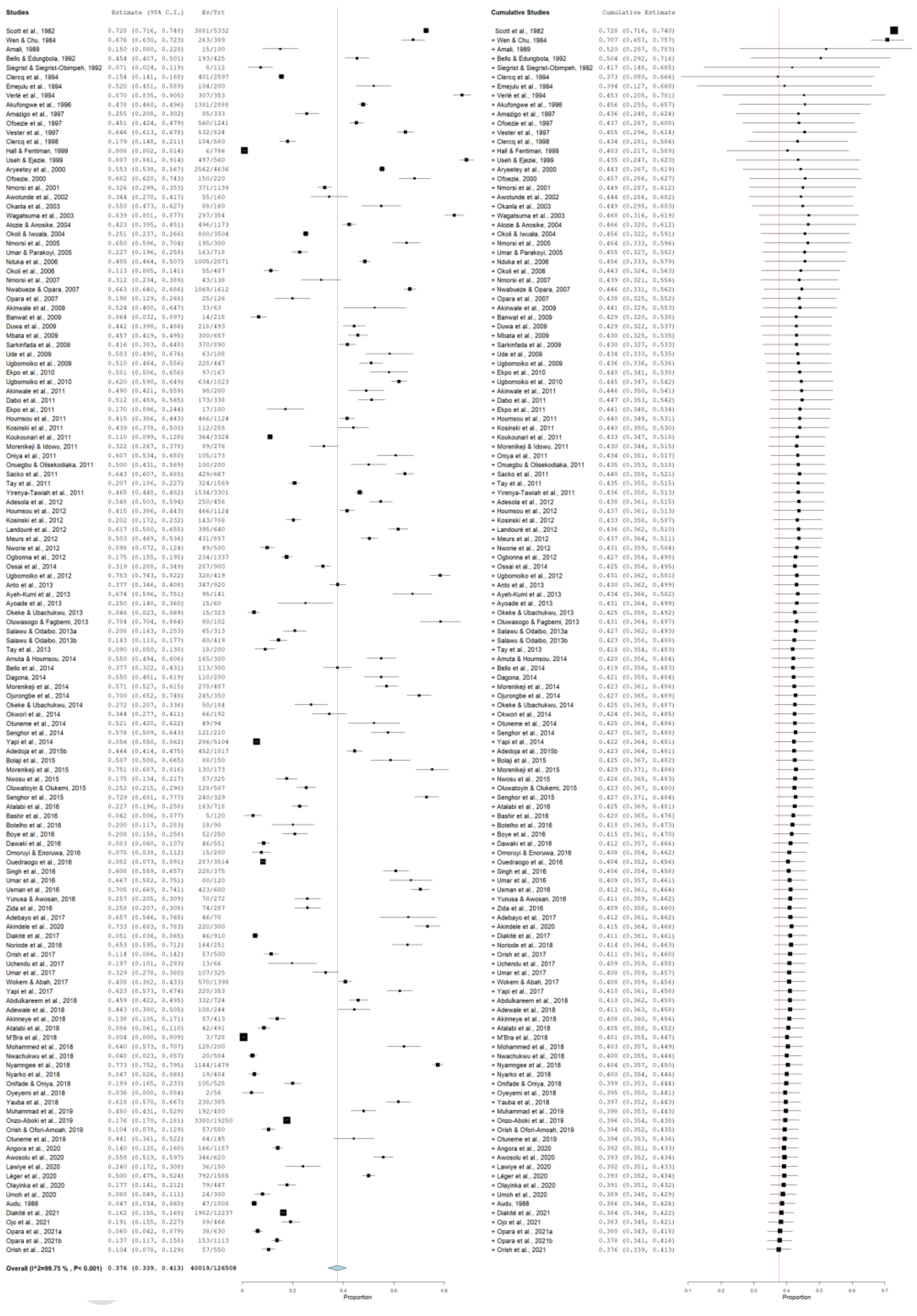

Figure 5: Overall pooled prevalence of *S. haematobium* in West Africa

A subgroup analysis was performed and encompassed age groups, study population types, diagnostic method used, community type, and year of publication. As depicted in table 4 below, a higher prevalence of 41.4% (95% CI: 36.1% - 46.7%) was seen for studies from rural areas which contrasts with the lower prevalence 23.9% (95% CI: 16.8% - 30.9%) in studies undertaken in urban centers.

Pooled prevalence of studies in Suburban areas fell in between, with a prevalence of 40.2% (95% CI: 24.7% – 55.6%). Prevalence of *S. haematobium* varied by diagnostic method and was highest in studies using PCR [47.6% (22.7% - 72.6%)] which is higher than the prevalence in studies that employed microscopy with the least prevalence seen in studies employing urine centrifugation with microscopy [28.9% (20.8% - 36.9%)].

Table 4: Sub-group analysis of *S. haematobium* prevalence by Population segment/type, Method of diagnosis, community type and age group.

Category	Subgroup	Studies reviewed	Prevalence % (95% CI)	I^2 (%)	P-value
Population segment	School children	89	37.0 (33.0 – 41.1)	99.74	<0.0001
	Pregnant women	2	14.0 (0.6 – 27.3)	93.98	<0.0001
	General population	32	39.0 (30.4 – 47.6)	99.71	<0.0001
	Pre-school children	4	35.8 (13.4 - 58.2)	98.53	<0.0001
	Adults	5	43.9 (26.6 – 61.1)	98.68	<0.0001
Method	Urine filtration with microscopy	67	44.8 (38.6 – 50.9)	99.79	<0.0001
	Microscopy (unspecified technique)	21	30.4 (22.4 – 38.3)	99.55	<0.0001
	Urine centrifugation with Microscopy	35	28.9 (20.8 - 36.9)	99.65	<0.0001
	PCR	5	47.6 (22.7 - 72.6)	98.46	<0.0001
Community type	Rural	99	41.4 (36.1 - 46.7)	99.72	<0.0001
	Urban	14	23.9 (16.8 - 30.9)	99.33	<0.0001
	Suburban	2	40.2 (24.7 – 55.6)	94.30	<0.0001
Age group	Children	93	37.0 (33.0 – 41.0)	99.73	<0.0001
	Adults	7	35.2 (19.7 – 50.8)	98.94	<0.0001
	Both	32	39.0 (30.4 – 47.6)	99.71	<0.0001

A meta regression analysis was performed to explore the trends of *S. haematobium* infection over the past four decades in West Africa and it showed that the prevalence estimates significantly decline with advancing year of study publication (Coeff. = -0.007, p=0.004). See figure 6

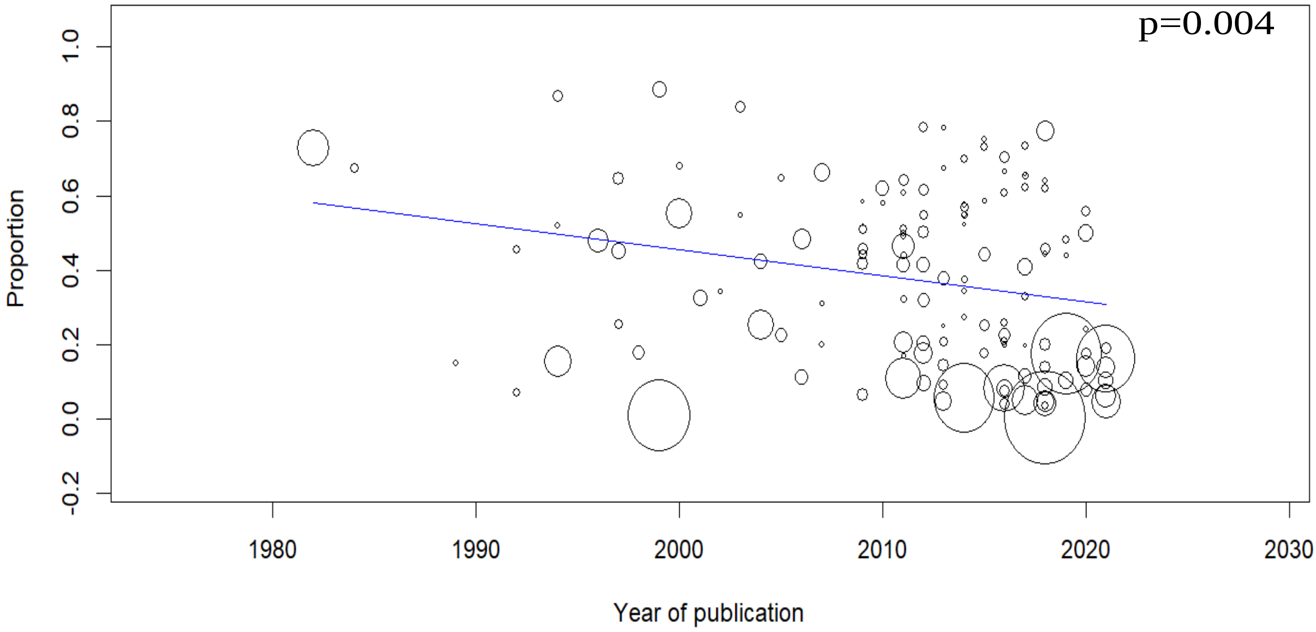

Figure 6: A meta-regression plot of *S. haematobium* prevalence trend with year of publication

4. DISCUSSION

This systematic review and meta-analysis provide valuable insights into the prevalence of *S. haematobium* infection in West Africa over a 40-year period, shedding light on various factors influencing its distribution and trends. The findings are instrumental in understanding the epidemiology of this parasitic disease in the region and can inform public health interventions.

This study observed an increasing trend in research activity on prevalence of *S. haematobium* infection in West Africa. A review by Ayabina, Clark [159], also described a similar increasing trend in research activity in Africa underlining the enduring commitment to comprehending and addressing schistosomiasis in West Africa and the continent at large. This sustained interest signifies the disease's enduring public health importance and its intricate and dynamic nature.

Prevalence of *S. haematobium* infection is a critical indicator of the disease's impact on public health in West Africa. Our analysis encompassed a wide range of prevalence rates, with studies reporting rates as low as 0.4% to as high as 88.7%. This substantial variation underscores the heterogeneous nature of schistosomiasis in the region, reflecting differences in geographic location, population demographics, and local control efforts [160, 161]. Our meta-analysis, pooling data from these diverse studies, estimated a weighted average prevalence of 37.6% (95%CI: 33.9% - 41.3%) using a random-effects model. This prevalence rate serves as a crucial reference point for understanding the overall burden of *S. haematobium* in West Africa. It signifies that more than one-third of the individuals studied were infected with the parasite, reaffirming the disease's significance in the region. Earlier

review studies of the disease in sub-populations on the continent have revealed *S. haematobium prevalence of* 15% (95% CI: 6–25) among pre-school children [162] and 13.44% (CI: 8.90–19.80) among pregnant women [163]. These reviews involved studies published only in the 21st century.

A noteworthy finding of our study is the observed decline in schistosomiasis prevalence, especially in studies published during the last five years (2016-2021). This trend suggests that efforts aimed at disease control and prevention may be yielding positive results. These efforts may include varrying treatment regimes such as mass drug administration (MDA) campaigns and distribution of albendazole or mebendazole for the control of STH. [164, 165], health education, improved sanitation, and increased access to clean water sources, all of which are essential components of schistosomiasis control programs [166, 167, 168]. The declining prevalence trend is an encouraging indicator that these interventions are making a difference in reducing the disease's burden. However, continued surveillance and monitoring of prevalence trends are essential to ensure that progress is sustained and that the ultimate goal of disease elimination is achieved in the region.

The subgroup analysis provided additional insights into prevalence variations based on various factors. Notably, rural areas exhibited the highest prevalence at 41.4% (95% CI: 36.1% - 46.7%). This finding underscores the need for targeted interventions in remote and underserved communities where schistosomiasis prevalence remains high. In contrast, urban centers showed a lower prevalence of 23.9% (95% CI: 16.8% - 30.9%) likely due to better access to healthcare and improved sanitation infrastructure.

Prevalence also varied by diagnostic method, with PCR-based studies reporting the highest prevalence at 47.6% (95% CI: 22.7% - 72.6%). This variation may be due to the high sensitivity of PCR to detect *S. haematobium* than Microscopy [169, 170]. While PCR offers enhanced sensitivity, it may not always be readily available in resource-constrained settings, which explains its limited use in our dataset.

Conversely, microscopy, the most widely employed diagnostic method, reported lower prevalence rates especially when centrifugation was used as the concentration technique, emphasizing the need for enhancing diagnostic techniques while considering the practicability and accessibility of this technique for assessing *S. haematobium* infection.

This study has several significant limitations that should be considered when interpreting the findings. Firstly, the inclusion of diverse study designs, diagnostic methods, and the detection of publication bias introduce variability and potential bias in prevalence estimates. Temporal bias is evident due to an uneven distribution of studies over time. Insufficient socioeconomic data and limited subgroup analyses hinder a comprehensive understanding of prevalence variations. Data accessibility issues may have led to the omission of relevant research. Moreover, the dynamic nature of schistosomiasis and the lack of a dynamic analysis may not fully capture evolving trends. These limitations underscore the need for further research and data refinement to enhance our understanding of *S. haematobium* prevalence in West Africa.

5. CONCLUSION

In conclusion, this comprehensive analysis of *S. haematobium* prevalence in West Africa reveals a heterogeneous disease landscape. While the average prevalence stands at 37.0% 37.6% (95%CI: 33.9% - 41.3%), a declining trend in recent years suggests the potential impact of control measures. Targeted interventions, especially in rural areas, and the practicality of microscopy and its concentration techniques are some key highlights to be considered. Age-specific disparities underscore the need for tailored approaches. This review contributes valuable insights for ongoing efforts to combat schistosomiasis in the region, highlighting the importance of sustained control measures and continued research to achieve long-term disease reduction and, ultimately, elimination.

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