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Epidemiology and Geographical Distribution of Human Schistosomiasis in Kenya: A Systematic Review

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ABSTRACT

Schistosomiasis is a neglected tropical disease of significant public health importance in sub-Saharan Africa, ranking second in terms of years lived with disability. Despite numerous epidemiological studies conducted in Kenya, a comprehensive overview of the disease status nationally is lacking. This systematic review aimed to synthesize existing knowledge on the epidemiology and geographical distribution of human schistosomiasis in Kenya. Following PRISMA guidelines, we systematically searched PubMed, Web of Science, CAB Direct, and grey literature sources for records published between January 2000 and December 2020. Studies reporting prevalence data on human schistosomiasis conducted in Kenya were included. Study quality was assessed using Joanna Briggs Institute appraisal tools. Prevalence data were extracted and mapped using QGIS version 3.16.8. Of 1,343 initially retrieved records, 99 met inclusion criteria. Schistosoma mansoni and S. haematobium were the only species reported, with infections occurring across all age groups including preschool children, schoolaged children, and adults. S. mansoni was predominantly distributed in Western Kenya around Lake Victoria, while S. haematobium was concentrated along the Kenyan Coast. Spatiotemporal analysis revealed emergence of new transmission foci, with prevalence declining in some counties, increasing in others, and remaining stable in several areas. Hotspot counties included Homabay, Kirinyaga, Busia, Tana River, and Siaya. Key drivers of infection included geographical location, environmental factors, intermediate snail host distribution, human water contact patterns, and untreated atrisk populations. Schistosomiasis remains a public health challenge in Kenya. These findings highlight the need for expanded preventive chemotherapy to all atrisk populations, integrated with complementary interventions including health education, focal mollusciciding, and improved water, sanitation, and hygiene services.

1. Introduction

Schistosomiasis (bilharzia) is caused by trematode parasites of the genus Schistosoma, transmitted when humans come into contact with freshwater contaminated with cercariae released by infected intermediate snail hosts [1]. In Africa, Schistosoma mansoni and Schistosoma haematobium are the predominant species, causing intestinal and urogenital schistosomiasis respectively [2,3]. The disease is closely associated with poverty, poor sanitation, lack of clean water access, and limited health education [4,5].

Globally, schistosomiasis affects over 249 million people, with 97% of cases occurring in Africa [6]. The disease accounts for an estimated 2456 million disabilityadjusted lifeyears (DALYs) lost globally [7], with approximately 3.3 million DALYs in subSaharan Africa [8]. In Kenya, approximately 6 million people are infected, with an estimated 17.4 million at risk of infection [9,10]. The Kenyan government, through the Ministries of Health and Education, launched a national schoolbased deworming program in 2009, incorporating praziquantel (PZQ) in 2012 for schistosomiasis control [11,12]. Mass drug administration (MDA) targeting schoolaged children (SAC) remains the primary control strategy, aligned with WHO's global schistosomiasis control roadmap [13,14].

Despite numerous epidemiological studies investigating schistosomiasis prevalence, distribution, and risk factors across Kenya [1518], no comprehensive synthesis of this evidence exists. Following the adoption of WHO's Neglected Tropical Diseases roadmap 20212030 [19], which emphasizes disease elimination and expanded treatment coverage, understanding the current epidemiological landscape is crucial for guiding evidencebased control strategies. This systematic review aims to synthesize existing knowledge on the epidemiology and geographical distribution of human schistosomiasis in Kenya to inform effective, sustainable control strategies.

2. Methodology

2.1 Search Strategy

This systematic review followed the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) guidelines [20]. Two independent reviewers systematically searched PubMed, Web of Science, CAB Direct, and grey literature sources (OpenGrey, OAIster) using the search phrase: (schistosomiasis OR Schistosom OR Bilharzia OR "S. mansoni" OR "S. haematobium" OR "trematode infection") AND Kenya. Additionally, MSc/PhD theses from Kenyan university archives were searched using "schistosomiasis AND Kenya" in Google. A date restriction of January 2000 to December 2020 was applied.

2.2 Eligibility Criteria

Records were included if they: (i) investigated human schistosomiasis; (ii) were conducted in Kenya; (iii) were published between 20002020; (iv) were in English; (v) reported prevalence data with clearly stated geographical location. Exclusion criteria included duplicate records, studies with different scope (experimental studies, reviews, model predictions), studies on special populations (travelers, immigrants, refugees), and articles whose full text was unavailable even after author contact. Reference lists of included articles were manually searched for additional relevant records. Disagreements between reviewers were resolved through discussion and consensus with a third party.

2.3 Quality Assessment

Study quality was assessed using Joanna Briggs Institute (JBI) critical appraisal tools for prevalence studies [21] and cohort studies [22]. Each checklist item was scored 0 (not reported/unclear) or 1 (yes), with total scores ranging from 09 (prevalence studies) and 012 (cohort studies). Studies meeting ≥50% of quality assessment criteria were included in the final analysis.

2.4 Data Extraction

From each included study, we extracted: author information, publication year, study period, study design, study setting, county/province, study population, age range, diagnostic method, Schistosoma species, number tested and positive, prevalence with 95% confidence intervals (CI), and morbidity markers where reported.

2.5 Data Analysis and Mapping

Data were categorized into two periods: preMDA (20002011) and postMDA (20122020). Prevalence and species distribution maps were generated using QGIS version 3.16.8. Prevalence was categorized according to WHO thresholds [13]: low (<10%), moderate (1050%), and high (>50%). "No information" was added for counties with no retrievable data. "Hotspots" were defined as areas with persistent high prevalence despite MDA. Confidence intervals were calculated in R version 3.4.2 using binconf() function from the Hmisc package. Graphical representations were created using Microsoft Excel.

3. Findings

3.1 Study Selection and Characteristics

The search yielded 1,343 records. After removing 262 duplicates, 880 records were excluded based on title and abstract screening. Fulltext assessment of 201 records led to exclusion of 102, resulting in 99 studies included in the final analysis (Figure 1). No additional records were identified through manual reference searching.

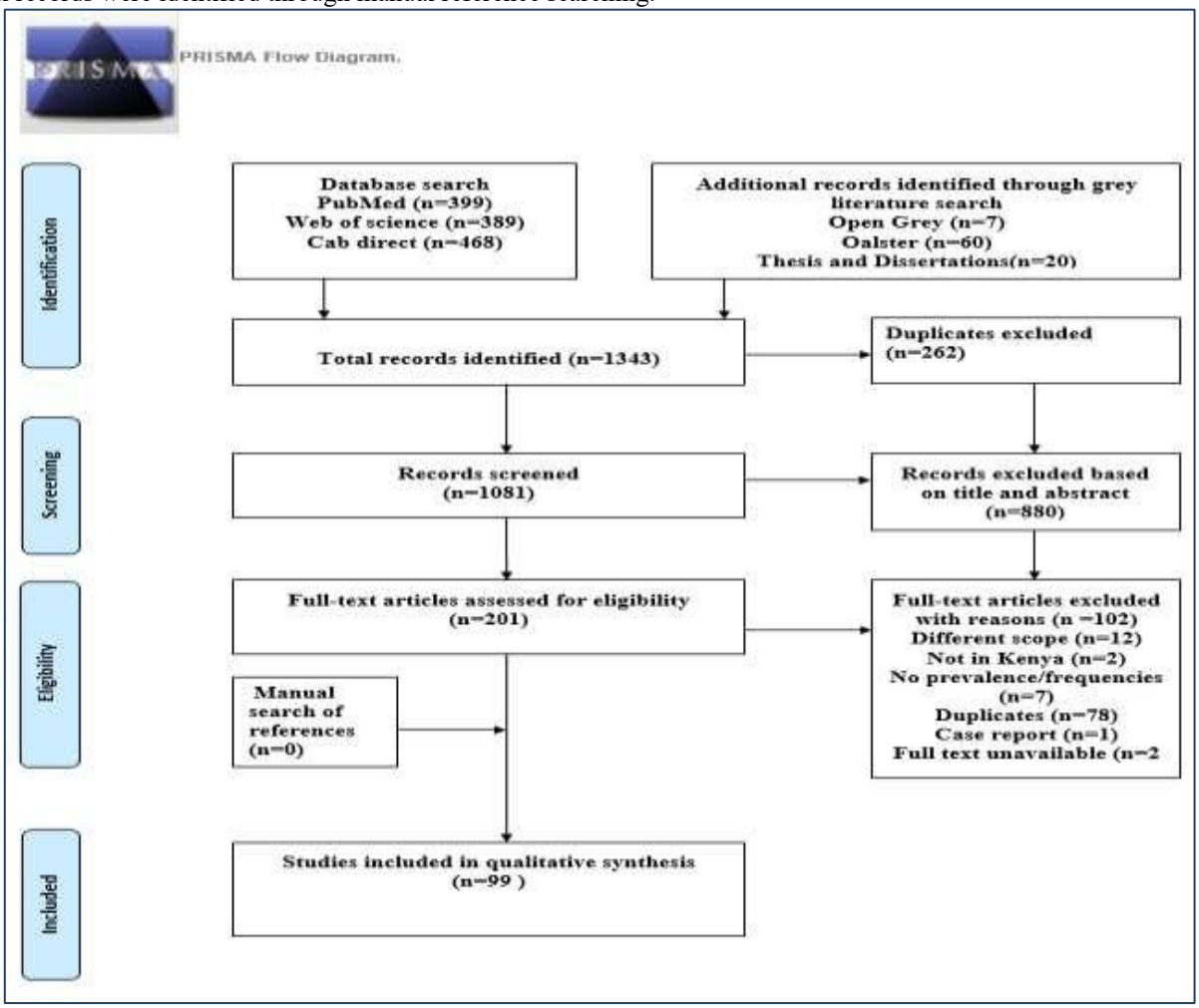

Figure 1. PRISMA flow diagram showing study selection process

Among included studies, 36 were published between 20002011 and 63 from 2012 onward. Study designs included crosssectional (85.9%, n=85), longitudinal cohort (13.1%, n=13), and clusterrandomized trials (0.1%, n=1). Study settings comprised schoolbased (52, 55.5%), communitybased (41, 44.4%), and hospitalbased (3, 0.03%) studies. Records were distributed across all eight Kenyan provinces, with most from Nyanza (39.4%) and Coast (38.3%) provinces, while North Eastern (0.01%) and Rift Valley (0.01%) had the fewest reports. Participant age ranged from 197 years, with most studies (58.6%) conducted in SAC (518 years). S. mansoni was reported in 58 studies (58.6%), S. haematobium in 32 (32.3%), and mixed infections in 9 (9.1%). Sample sizes ranged from 36 to 29,619 participants. Microscopy (KatoKatz, 67.1%; urine filtration, 41.8%) were the most common diagnostic methods (Figure 2).

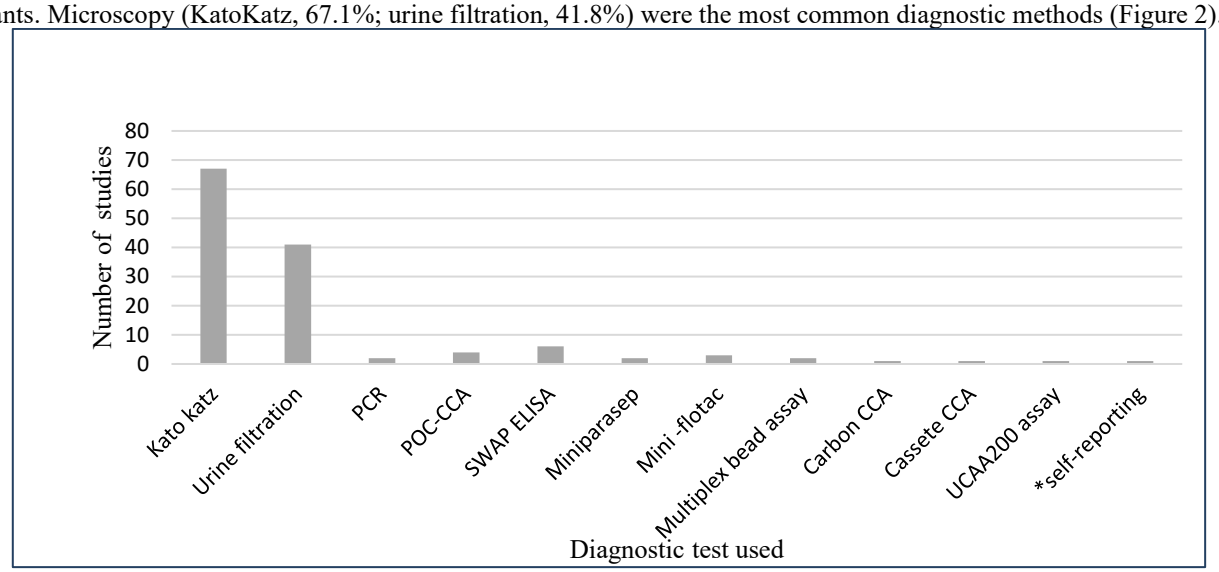

Figure 2. Diagnostic tests used in the studies included in this systematic review.

Figure 2. Diagnostic tests used in included studies. PCR: Polymerase Chain Reaction; POC-CCA: Point of Care Circulating Cathodic Antigen; ELISA: Enzyme Linked Immunosorbent Assay; CCA: Circulating Cathodic Antigen; *blood in urine

All age groups tested positive for Schistosoma infection, including preschool aged children (PSAC) [2326], SAC [10,2730], adults [3135], and pregnant women [36,37]. SAC showed the highest prevalence, reaching 94.3% for S. haematobium in Coast Province and 88.5% for S. mansoni in Nyanza Province [38,39]. Among PSAC, S. mansoni prevalence ranged from 2580.3% [23,24], while only one study reported S. haematobium prevalence of 2.9% in this age group [40]. In adults, S. mansoni prevalence ranged from 0.973.2% [41], with no S. haematobium infection reported.

Mixed S. mansoniS. haematobium infections were documented exclusively in SAC [15,17,42,43]. Table 1 summarizes the characteristics of included studies.

Table 1. Summary of key characteristics of included schistosomiasis studies by province, Kenya (2000–2020)

Province	Studies (n, %)	Dominant Schistosoma Species	Main Study Populations	Common Diagnostic Methods	Key Epidemiological Findings
Nyanza	39 (39.4%)	S. mansoni (highly endemic)	School-aged children (SAC), Pre-SAC, Adults	Kato-Katz, Urine filtration	Highest S. mansoni prevalence (up to 88.5%); intense transmission around Lake Victoria shores and islands; multiple hotspots (e.g., Homabay, Siaya).
Coast	38 (38.3%)	S. haematobium (highly endemic)	SAC, Adults, Pregnant women	Urine filtration, Kato-Katz	Highest S. haematobium prevalence (up to 94.3%); transmission linked to inland ponds, streams, and dams; persistent hotspots in Tana River and Kwale.
Western	5 (5.1%)	S. mansoni	SAC, Pre-SAC	Kato-Katz, POC-CCA	Endemic foci; notable transmission in Busia and Kakamega; moderate prevalence (e.g., 28.7% in Busia).
Eastern	5 (5.1%)	S. mansoni	SAC, Adults	Kato-Katz	Foci associated with irrigation schemes; historically high prevalence (e.g., Makueni ~88%) but significant declines noted in recent periods.
Central	5 (5.1%)	S. mansoni	SAC, Adults, Pre-SAC	Kato-Katz	Persistent hotspot in Kirinyaga (Mwea Irrigation Scheme); prevalence rebounded despite MDA (increased from <10% to >50% over time).
Rift Valley	2 (2.0%)	S. mansoni	SAC	Kato-Katz, POC-CCA	Low overall prevalence; scattered transmission foci (e.g., Bomet, Narok) with prevalence generally <5%.
Nairobi	2 (2.0%)	S. mansoni	SAC, Adults	Kato-Katz	Very low prevalence (<1%); minimal local transmission reported.

North Eastern	1 (1.0%)	S. haematobium	SAC	Urine filtration	Extremely low prevalence (0.5%); thermal exclusion likely limits snail hosts, though data are sparse.

3.3 Geographical Distribution

Schistosomiasis was distributed across all eight provinces and 24 of 47 counties (Figure 3). In Nyanza Province, infection was concentrated along Lake Victoria shores, with higher prevalence on islands compared to mainland [44,45]. In Coast and Eastern provinces, transmission occurred around inland water bodies including ponds, streams, dams, and rivers. Scattered S. mansoni foci were identified in Central, Eastern, and Rift Valley provinces associated with irrigation schemes [10,46,47].

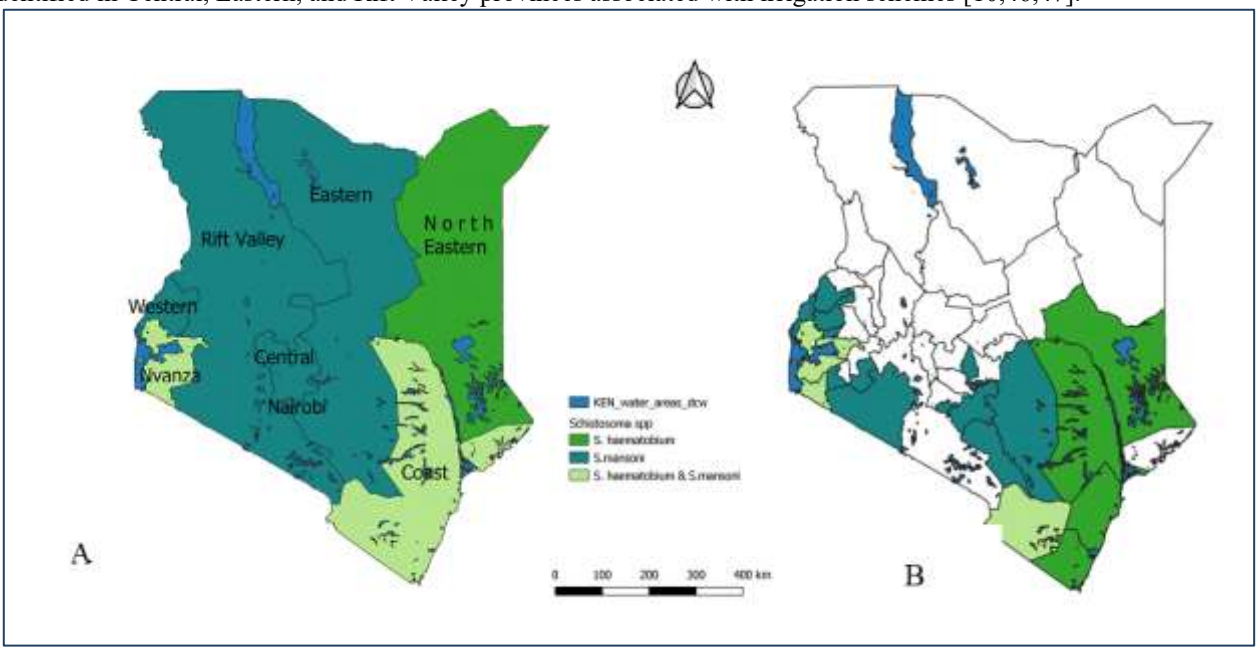

Figure 3. Geographical distribution of Schistosoma spp. infection in Kenya (A) by province and (B) by county

[Insert two maps: provincial distribution showing species patterns and countylevel prevalence map]

S. haematobium predominated in North Eastern Province, while S. mansoni was reported in Western, Nairobi, Central, and Eastern provinces. Both species were documented in Nyanza and Coast provinces. A positive correlation between infection prevalence and proximity to water sources was noted across multiple studies [18,42,48,49].

3.4 SpatioTemporal Patterns

Prevalence among SAC showed significant changes between 20002011 and 20122020 (Figure 4). In Machakos and Makueni counties (Eastern Province) and Kilifi County (Coast Province), prevalence declined from >50% to <10%. Conversely, Kirinyaga County (Central Province) transitioned from lowrisk (<10%) to highrisk (>50%) in the second period [50]. Homabay County (Nyanza Province) emerged as a new highrisk area with prevalence >50% [51,52], despite being nonendemic in the earlier period.

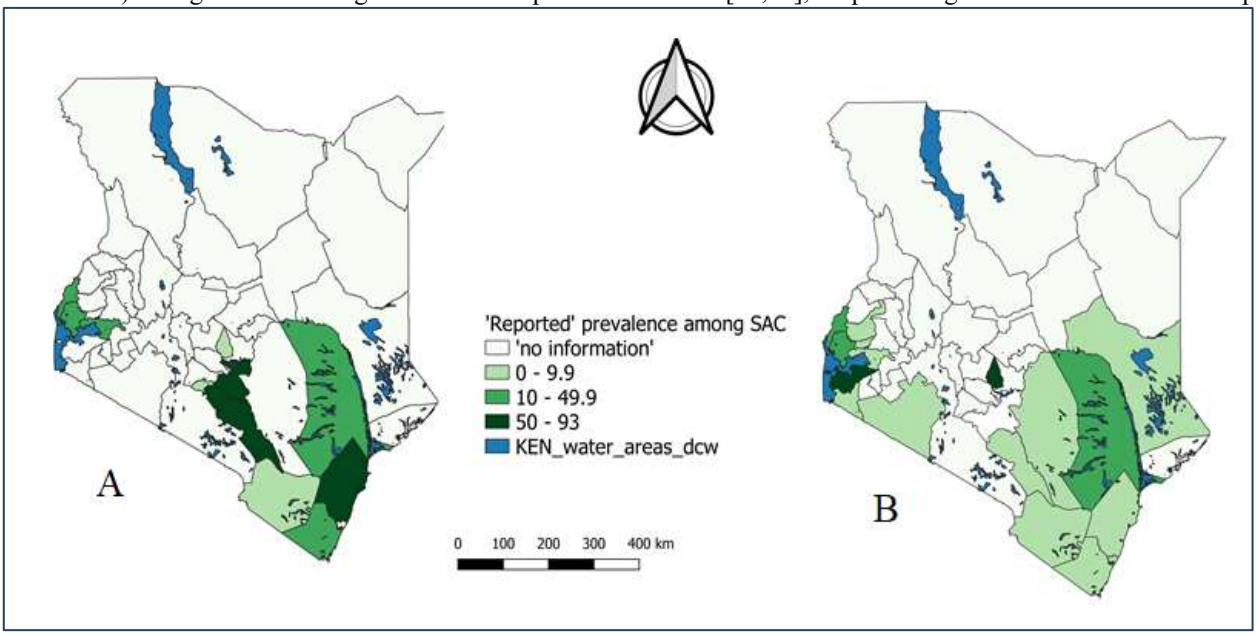

Figure 4. Spatiotemporal changes in Schistosoma spp. prevalence among SAC (A) 20002011 and (B) 20122020

Persistent hotspots included Tana River, Siaya, and Busia counties, with stable high prevalence across both periods. Specific transmission hotspots identified included Budalangi School (Busia County) [53], Mianya School (Kirinyaga County) [10,54,55], Dunga and Kaenyika Schools (Homabay County) [56], and Luanda K'Otieno beach (Siaya County) [57].

3.5 SchistosomiasisAssociated Morbidity

Only 18.2% (18/99) of studies reported schistosomiasisassociated morbidity, primarily conducted in SAC [36,58,59]. Reported morbidities included hepatomegaly (666.9%), splenomegaly (29.256.3%), hepatosplenomegaly (951.1%), anemia (19.354.7%), macrohematuria (9.568.1%), urinary tract abnormalities (1784%), wasting (710%), and stunting (20.532.5%) (Table 2). Assessment methods included ultrasonography for organopathology, hemoglobin measurement for anemia, urine dipstick for hematuria, and anthropometric measurements for nutritional status.

Table 2. Schistosomiasis's associated morbidity markers retrieved from included studies.

Study Period	Study design	Study group	Hepatomegaly (%)	Splenomegaly P (%)	HS (%)	Anemia P (%)	UT abnormalities (%)	Macro-hematuria (%)	Wasting and, stunting (%)	Ref
2000-2011	CS	SAC	_	_	51.1	_	17	_	_	[130]
2000-2011	CS	All-age	_	_	_	_	54	_	_	[68]
2000-2011	CS	All-age	_	_	_	_	14	51	_	[100]
2000-2011	CS	All-age	_	_	_	_	4	_	_	[90]
200-2011	Cohort	adults	_	_	_	_	5	39	_	[67]
2000-2011	Cohort	SAC	6	50.7	_	_	_	_	_	[71]
2000-2011	Cohort	SAC	6	36	9	_	_	_	_	[78]
2012-2020	Cohort	SAC	66.9	56.3	_	19.3-20.5	47.1	_	7-10.8 &20.5-32.5	[43]
2012-2020	CS	SAC	_	_	_	_	84	_	-	[40]
2012-2020	CS	SAC	_	_	_	_	41	_	_	[60]
2012-2020	CS	SAC	_	_	_	54.7	_	_	_	[47]
2012-2020	CS	PSAC	50	29.2	_	_	_	_	_	[64]
2012-2020	Cohort	Adults	_	_	_	71	_	_	_	[85]
2012-2020	CS	Adults	_	_	_	_	17	_	_	[54]
2012-2020	CS	SAC	_	_	_	33.9	_	33.8	_	[94]
2012-2020	CS	All-age	_	_	_	_	_	13.5	_	[105]
2012-2020	CS	SAC	_	_	_	25.7	_	_	_	[35]
2012-2020	CS	All age	_	_	_	_	_	68.1	_	[82]

P: prevalence, UT: Urinary tract, CS: Cross-sectional studies, HS; Hepatosplenomegaly; Ref: Reference.

4. Discussion

This is the first systematic review synthesizing the epidemiology and distribution of human schistosomiasis in Kenya over a 20year period (20002020). Our findings demonstrate that both S. mansoni and S. haematobium remain prevalent across Kenya, with transmission occurring in all age groups, reflecting ongoing exposure and active transmission cycles.

4.1 AgeSpecific Infection Patterns

The high prevalence observed in SAC aligns with findings from other African countries [60,61] and reflects the increased water contact patterns and behavioral factors in this age group. The documented infection in PSAC [23,25,26,40] underscores the need for expanding treatment coverage to younger children, as recommended in a recent subSaharan Africa systematic review [62]. Adults, including pregnant women, also maintain significant infection prevalence [34,36,63], acting as reservoirs sustaining community transmission. These findings challenge the current schoolfocused MDA approach and support calls for communitywide treatment strategies [64].

4.2 Diagnostic Method Trends

While KatoKatz and urine filtration remained the predominant diagnostic methods throughout the study period, there was increased utilization of more sensitive tests including PointofCare Circulating Cathodic Antigen (POCCCA) and PCR in the second decade (20122020). This shift likely reflects WHO's recommendation for improved diagnostics as prevalence declines with intensified interventions [13]. The use of more sensitive methods may partly explain the emergence of new foci and detection of lowintensity infections previously missed by microscopy [65,66].

4.3 Morbidity Assessment

The increased reporting of morbidity markers in the second study period corresponds with WHO recommendations to assess chemotherapy impact using morbidity indicators [67,68]. SAC bear the highest morbidity burden, correlating with their higher infection prevalence and intensity. The lower morbidity observed in adults likely reflects acquired immunity and benefits of early antischistosomal treatment [69]. These findings emphasize the need for continued morbidity monitoring to evaluate control program effectiveness.

4.4 Geographical Distribution Drivers

The heterogeneous distribution of schistosomiasis in Kenya reflects the ecology of intermediate snail hosts and human water contact patterns. The Lake Victoria basin's high S. mansoni prevalence is associated with abundant Biomphalaria snails, favorable climatic conditions, and communities' reliance on lake water [18,44,45,70]. Similarly, S. haematobium predominance along the Coast

correlates with Bulinus snail distribution in inland water bodies with suitable temperatures and currents [71,72]. The overlap of both species in Coast and Lake Victoria regions indicates risk of coinfections in predisposed populations [15,17,42,43].
The limited data from North Eastern Province may reflect either minimal transmission due to thermal exclusion of snail hosts [71,73,74] or underinvestigation of these areas. This pattern mirrors observations from northern Uganda [75].

4.5 SpatioTemporal Dynamics and Hotspots
The changing prevalence patterns over 20 years reveal important epidemiological transitions. Declining prevalence in some counties likely reflects positive impacts of MDA combined with other control measures. However, the emergence of new foci (Homabay) and increasing prevalence in previously lowrisk areas (Kirinyaga) suggest ongoing transmission dynamics. Several factors may explain these changes: population migration from endemic areas, use of more sensitive diagnostics, lack of improved water sources [46], poor hygiene practices [43,48,49], high population density [43], waterway obstruction increasing snail habitats [76], and untreated populations perpetuating transmission [46,50,63].
Persistent hotspots demonstrate ongoing high transmission despite interventions. In Mwea County, where MDA was first piloted but implemented without complementary health education and WASH interventions, prevalence rebounded over time [54]. This underscores the limitation of chemotherapy alone and the critical need for integrated approaches [10,55,77].

4.6 Implications for Control
WHO recommends preventive chemotherapy for all atrisk populations in hotspot areas, combined with complementary interventions [13]. Our findings support this recommendation, particularly regarding expansion beyond SAC. Evidence from Kenya demonstrates that communitybased approaches can be effective for mass treatment [78], while combining chemotherapy with intermittent molluscicide provides longerterm benefits than chemotherapy alone [79].

4.7 Study Limitations
Several limitations should be considered. First, variation in diagnostic methods may have led to under or overestimation of prevalence. Second, despite studies from all provinces, data were not available for all counties, with some provinces underrepresented. Third, data heterogeneity in terms of province, study groups, design, and setting precluded metaanalysis for pooled prevalence estimates. Nonetheless, this review's strengths include the comprehensive search across three major databases and grey literature, inclusion of 99 goodquality studies, and adherence to PRISMA guidelines, ensuring robust synthesis.

5. Conclusion and Recommendations
Schistosomiasis remains a significant public health problem in Kenya, with both S. mansoni and S. haematobium infections occurring across all age groups. The disease is geographically heterogeneous, with S. mansoni predominating in the Lake Victoria region and S. haematobium along the Coast. Over the past 20 years, spatiotemporal patterns have shown emerging foci, persistent hotspots, and variable trends in prevalence. Key transmission drivers include geographical location, environmental factors, intermediate snail distribution, human water contact patterns, and untreated atrisk populations. These findings provide critical evidence for policy discussions and the design of effective, sustainable control strategies aligned with the 20212030 NTD roadmap. The authors recommend: (1) expanding preventive chemotherapy to all age groups in highrisk areas; (2) integrating schoolbased programs with communitydirected interventions; (3) implementing focal molluscicide in hotspot areas; (4) promoting health education to reduce water contact behaviors; and (5) improving water, sanitation, and hygiene (WASH) infrastructure.

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