Schistosoma haematobium and its impact on school children

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ABSTRAK

Skistosomiasis urogenital merupakan penyakit tropis terabaikan (*neglected tropical disease*) yang disebabkan oleh trematoda darah *Schistosoma haematobium*, dengan anak usia sekolah sebagai kelompok paling rentan akibat tingginya paparan terhadap sumber air tawar yang terinfestasi serta rendahnya kesadaran higiene. Kajian ini bertujuan menelaah secara komprehensif aspek epidemiologi, transmisi, patogenesis klinis, serta dampak sosio-edukasional infeksi *S. haematobium* pada anak-anak di wilayah endemis. Infeksi kronis menimbulkan morbiditas fisik sistemik seperti hematuria terminal, disuria, anemia defisiensi besi, gangguan pertumbuhan (*stunting*), hingga kerusakan struktural kandung kemih dan ginjal. Selain dampak fisik, infeksi berkepanjangan menurunkan kapasitas kognitif, daya ingat, kehadiran, dan capaian belajar siswa. Kendati pemberian obat massal (*mass drug administration*/MDA) dengan prazikuantel efektif menurunkan intensitas infeksi, tingginya laju reinfeksi menunjukkan keterbatasan pengobatan tunggal. Oleh sebab itu, diperlukan pendekatan multisektoral terpadu yang memadukan pengobatan rutin di sekolah, pengendalian vektor keong air tawar, penyediaan infrastruktur air bersih dan sanitasi, serta edukasi kesehatan guna memutus transmisi dan mewujudkan eliminasi penyakit secara berkelanjutan.

Kata Kunci: anak usia sekolah; fungsi kognitif; pemberian obat massal; *Schistosoma haematobium*; skistosomiasis urogenital

ABSTRACT

Urogenital schistosomiasis is a neglected tropical disease caused by the blood fluke parasite Schistosoma haematobium, disproportionately affecting school-aged children due to frequent exposure to infested freshwater bodies and low hygiene awareness. This review synthesizes current evidence on the epidemiology, transmission dynamics, clinical pathogenesis, and broader socio-educational impacts of S. haematobium infection among children in endemic regions. Chronic infection induces severe systemic morbidity, including terminal hematuria, dysuria, iron-deficiency anemia, growth stunting, and progressive structural lesions of the bladder and kidneys. Beyond physical health burdens, prolonged parasite exposure compromises cognitive function, memory, school attendance, and academic performance. Although preventive chemotherapy via mass drug administration (MDA) with praziquantel has substantially reduced infection intensity, high reinfection rates highlight the insufficiency of monotherapy. Consequently, sustainable disease control and eventual elimination necessitate an integrated, multi-sectoral framework combining school-based treatment with freshwater snail vector control, improved water and sanitation infrastructure, and targeted community health education.

Keywords: cognitive impairment; mass drug administration; praziquantel; Schistosoma haematobium; urogenital schistosomiasis

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1. INTRODUCTION

Urogenital schistosomiasis, caused by the blood fluke Schistosoma haematobium, remains a profound public health challenge across sub-Saharan Africa and other tropical regions. The transmission dynamics of

this parasite are governed by complex interactions among freshwater snail intermediate hosts, local environmental conditions, and human water contact behaviors. Fine-scale spatial epidemiology indicates that transmission hotspots are heavily concentrated around shared community water bodies, underscoring the necessity of targeted spatial interventions (Trippler et al., 2022). Moreover, molecular and genotypic investigations reveal that S. haematobium circulates within complex gene pools, including zoonotic hybrid variants such as Schistosoma haematobium × Schistosoma bovis in West Africa, which may influence parasite virulence, transmission intensity, and therapeutic response (Angora et al., 2022).

School-aged and preschool children constitute the most vulnerable demographic due to habitual domestic and recreational water exposure, underdeveloped acquired immunity, and limited personal hygiene awareness (Sánchez-Marqués et al., 2023). Epidemiological surveys across sub-Saharan Africa continue to report high infection burdens; in Nigeria, cross-sectional studies highlight sustained helminthic transmission among primary school pupils (Alade et al., 2023). In Ghana and Ethiopia, S. haematobium frequently occurs alongside co-morbidities such as malaria and polyparasitic infections, compounding the severity of iron-deficiency anemia, acute malnutrition, and physical debility (Dassah et al., 2022; Feleke et al., 2022). Beyond acute physical morbidity, persistent chronic infection causes growth stunting, chronic pelvic pain, and irreversible structural lesions of the urinary tract (Dassah et al., 2022; Kasambala et al., 2022).

Crucially, the developmental and socio-educational fallout of urogenital schistosomiasis among young learners is substantial. Chronic worm burden impairs cognitive performance, executive function, working memory, and classroom concentration, precipitating chronic absenteeism, poor academic attainment, and diminished long-term human capital (Kasambala et al., 2022). Although preventive chemotherapy through mass drug administration (MDA) with praziquantel has lowered infection intensity and morbidity, it fails to prevent rapid cercarial reinfection or eliminate local transmission reservoirs (Malibiche et al., 2023; Mushi et al., 2022). Longitudinal assessments in East Africa demonstrate that monotherapy alone cannot break transmission without concurrent freshwater snail vector control, improved water, sanitation, and hygiene (WASH) infrastructure, and community-wide behavioral change (Mazigo et al., 2022a). Consequently, this review synthesizes the biological mechanisms, clinical pathogenesis, and multi-sectoral public health strategies required to mitigate the systemic burden of S. haematobium on school-aged populations.

2. RESEARCH METHOD

This study was conducted as a comprehensive narrative literature review to synthesize current epidemiological, clinical, and socio-educational evidence regarding Schistosoma haematobium infections among school-aged and preschool children. The review methodology adheres to established reporting guidelines for narrative reviews to ensure transparency, rigor, and reproducibility.

A. Search Strategy and Data Sources

A comprehensive literature search was conducted across international multidisciplinary databases, including PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar, complemented by official policy documents and technical reports from the World Health Organization (WHO). The search employed a combination of Medical Subject Headings (MeSH) and Boolean operators (AND, OR) using the following keywords: ("Schistosoma haematobium" OR "urogenital schistosomiasis" OR "urinary schistosomiasis") AND ("school children" OR "school-aged children" OR "preschool children") AND ("cognition" OR "cognitive impairment" OR "anemia" OR "growth stunting" OR "academic performance") AND ("mass drug administration" OR "praziquantel" OR "vector control" OR "water, sanitation, and hygiene")..

B. Eligibility and Selection Criteria

tudies were screened based on predefined inclusion and exclusion criteria:

a) Inclusion Criteria: (a) Primary peer-reviewed research articles, epidemiological cross-sectional surveys, cohort studies, and meta-analyses published up to recent years; (b) studies evaluating *S. haematobium* biology, pathology, and diagnostic profiles; (c) research explicitly reporting physical, cognitive, nutritional, or educational impacts on children; and (d) studies assessing school-based deworming, mass drug administration (MDA), and integrated WASH interventions in endemic regions (particularly sub-Saharan Africa).

b) Exclusion Criteria: (a) Studies focusing exclusively on other schistosome species (e.g., *S. mansoni* or *S. japonicum*) without comparative relevance to *S. haematobium*; (b) studies lacking clear diagnostic validation for urinary schistosomiasis; and (c) duplicate publications or non-peer-reviewed commentaries without empirical data.

C. Data Extraction and Synthesis

To minimize disturbance while maintaining a broad field of view, observations were conducted from a tower Retrieved literature was evaluated and organized thematically using narrative synthesis. Extracted data were systematically categorized into four analytical domains:

1) Biological and Epidemiological Profiles: Parasite morphology, lifecycle dynamics involving intermediate snail hosts (*Bulinus* spp.), and transmission geography.
2) Clinical Pathogenesis: Systemic pathology across migratory, acute (Katayama fever), and chronic phases, with particular focus on urogenital lesions, anemia, and physical growth stunting.
3) Cognitive and Educational Ramifications: Neuro-cognitive deficits, memory retention impairments, school absenteeism, and long-term socio-economic productivity loss.
4) Therapeutic and Preventative Interventions: Efficacy and limitations of praziquantel monotherapy, vector eradication, sanitation infrastructure, and school-based health literacy programs

3. RESULTS AND DISCUSSION

A. Results

1) Epidemiological Distribution and Transmission Patterns in Pediatric Populations

Urogenital schistosomiasis caused by Schistosoma haematobium continues to impose a severe epidemiological burden across 74 endemic countries in Africa, the Middle East, and parts of the tropics, with over 110 million individuals affected in rural and peri-urban zones (Mushi et al., 2022). Sub-Saharan Africa accounts for approximately 93% of global infections, with Nigeria harboring the highest national burden—exceeding 25 million active infections and over 101 million individuals at risk (Alade et al., 2023; Mazigo et al., 2022b). Fine-scale geospatial mapping indicates marked focal heterogeneity, where transmission hotspots cluster tightly around shared freshwater bodies such as ponds, canals, and streams harboring Bulinus intermediate snail vectors (Ayele et al., 2024; Trippler et al., 2022).

School-aged children (5–14 years) and preschool-aged children represent the primary epidemiological reservoirs and the most heavily infected demographic (Kasambala et al., 2022; Wang et al., 2024). This disproportionate burden is driven by high-frequency water contact during domestic chores (washing, fetching water), subsistence agriculture, and recreational swimming, compounded by immature acquired immunity and insufficient hygiene literacy (Dassah et al., 2022; Sánchez-Marqués et al., 2023). Furthermore, molecular surveillance confirms the emergence of zoonotic hybridization, notably Schistosoma haematobium × Schistosoma bovis, circulating among schoolchildren in West Africa, with implications for transmission virulence and parasite resilience (Angora et al., 2022).

2) Parasite Morphology, Lifecycle, and Vector Interaction

Schistosoma haematobium exhibits distinct morphologic features: adult males possess a ventral gynaecophoral canal in which the longer, slender female resides, tegumental papillae tubercles, and 4–5 testes, while females produce terminal-spined, elliptical ova measuring approximately 110–170 μm (Angora et al., 2022; Feleke et al., 2022). The lifecycle requires an obligate alternation of generations between human definitive hosts and aquatic snails of the genus Bulinus (particularly Bulinus truncatus) (Alehegne & Mitiku, 2022; Liu et al., 2022). Free-swimming furcocercous cercariae penetrate unbroken human skin, shed their bifurcated tails, and transform into schistosomulae (Mazigo et al., 2022a; Wang et al., 2024). After transiting through the pulmonary vascular bed, they mature within intrahepatic portal venules, pair sexually, and migrate against venous flow to the perivesical venous plexus of the urinary bladder and pelvic organs (Kasambala et al., 2022; Zerdo et al., 2022). Oviposition averages 3,000 eggs daily per mating pair; retained ova evoke chronic immune-mediated tissue pathologies, while excreted eggs continue the freshwater lifecycle upon release via urination (Alehegne & Mitiku, 2022).

3) Pathogenesis and Phase-Specific Clinical Manifestations

The pathology of S. haematobium is predominantly driven by delayed-type hypersensitivity (DTH) granulomatous responses mounted against miracidial antigens released from trapped eggs, rather than adult worms directly (Kasambala et al., 2022). Progression occurs across three distinct clinical phases:

a) Migratory Phase: Cercarial cutaneous penetration elicits transient papular dermatitis and pruritus ("swimmer's itch"), occurring within hours to days post-exposure (Mushi et al., 2022; Sánchez-Marqués et al., 2023).
b) Acute Phase (Katayama Fever): Coinciding with initial oviposition (4–10 weeks post-infection), immune complex formation induces systemic hypersensitivity characterized by fever, headache, myalgia, hepatosplenomegaly, and abdominal pain (Mazigo et al., 2022b; Trippler et al., 2022).
c) Chronic Phase: Persistent egg trapping leads to pseudo-tubercle formation, extensive fibrosis, and mucosal granulomata along the bladder wall and ureters (Liu et al., 2022; Malibiche et al., 2023). Hallmark symptoms include terminal hematuria and dysuria (Alehegne & Mitiku, 2022; Wang et al., 2024). Long-standing untreated infection causes obstructive uropathy, hydroureter, hydronephrosis, secondary bacterial pyelonephritis, renal failure, and a documented predisposition to squamous cell bladder carcinoma (Alehegne & Mitiku, 2022; Wang et al., 2024). Rare ectopic egg deposition within

the spinal cord causes neuroschistosomiasis manifesting as acute transverse myelitis (Dassah et al., 2022; Feleke et al., 2022).

4) Physical, Nutritional, and Neuro-Cognitive Morbidities in Schoolchildren

Pediatric urogenital schistosomiasis inflicts substantial systemic debility beyond localized urinary lesions. Persistent microhematuria and chronic inflammation trigger severe iron-deficiency anemia, profound physical lethargy, and somatic growth stunting (Alehegne & Mitiku, 2022; Dassah et al., 2022; Zerdo et al., 2022). In sub-Saharan school settings, these conditions are frequently compounded by concurrent malaria parasitemia and soil-transmitted helminthiases (STHs), generating polyparasitic syndemics that suppress childhood nutritional status and physical vitality (Dassah et al., 2022; Feleke et al., 2022). Crucially, chronic worm burden exerts severe deleterious impacts on neuro-development and academic performance (Kasambala et al., 2022; Zerdo et al., 2022). Affected children exhibit measurable deficits in executive cognitive function, short-term and working memory, and sustained attention spans (Kasambala et al., 2022). Coupled with chronic lethargy, pain, and absenteeism, infected pupils demonstrate lower school attendance rates and compromised academic achievement, directly eroding baseline human capital formation in rural endemic communities (Ayele et al., 2024; Kasambala et al., 2022).

5) Diagnostic, Therapeutic, and Control Outcomes

Definitive parasitological diagnosis relies on detecting characteristic terminal-spined ova via microscopic examination of centrifuged or polycarbonate-filtered terminal urine specimens collected during peak diurnal egg-excretion hours (10:00–14:00) (Kasambala et al., 2022; Mushi et al., 2022). Microhematuria chemical reagent strips provide useful proxy screening tools in field settings (Mazigo et al., 2022a). Preventive chemotherapy with single-dose oral praziquantel (40 mg/kg) remains the cornerstone of disease control, demonstrating short-term egg reduction rates exceeding 90% and halting early bladder fibrosis (Alade et al., 2023; Dassah et al., 2022; Trippler et al., 2022). However, praziquantel exhibits limited efficacy against migrating immature schistosomulae and confers no prophylactic immunity against cercarial re-infection (Dassah et al., 2022; Trippler et al., 2022). Longitudinal follow-up assessments indicate that rapid re-infection occurs within months post-treatment in areas with sustained water contact and uncontrolled intermediate snail populations (Malibiche et al., 2023; Mushi et al., 2022).

B. Results

The findings demonstrate that Schistosoma haematobium is not merely an isolated clinical infection of the urogenital tract, but a multi-dimensional public health crisis deeply intertwined with pediatric development, educational equity, and rural socio-environmental conditions (Dassah et al., 2022; Kasambala et al., 2022). The concentration of peak worm burdens and structural bladder pathologies among 10–14 year-old pupils underscores their profound vulnerability during a pivotal phase of physical and intellectual maturation (Malibiche et al., 2023).

A central insight emerging from the synthesized evidence is the bidirectional relationship between chronic parasitic morbidity and educational underperformance. The physiological pathway from urinary blood loss to iron-deficiency anemia and systemic inflammation induces chronic neuro-fatigue and cognitive impairment, directly impairing cognitive processing and memory retention in young learners (Kasambala et al., 2022; Zerdo et al., 2022). This explains why mass deworming campaigns in school settings often yield immediate improvements not only in somatic growth markers, but also in classroom alertness and cognitive responsiveness, as demonstrated in recent pediatric cohort evaluations (Kasambala et al., 2022).

Nonetheless, the persistence of localized transmission foci despite extensive rounds of preventive chemotherapy highlights the clear limitations of drug monotherapy (Malibiche et al., 2023; Mazigo et al., 2022a; Mushi et al., 2022). Longitudinal data from East Africa confirm that mass drug administration (MDA) alone cannot achieve permanent transmission interruption because children inevitably return to infested freshwater habitats in the absence of clean municipal water and adequate sanitation infrastructure (Malibiche et al., 2023; Mazigo et al., 2022a). Treating pupils without modifying the environmental reservoirs creates a futile cycle of clearance and rapid re-infection (Mushi et al., 2022).

Consequently, progressing toward the World Health Organization's 2030 roadmap targets for schistosomiasis elimination demands a transition from chemotherapy-dominated programs toward an integrated, multi-sectoral strategy (Mazigo et al., 2022a; Wang et al., 2024). This framework requires four synergistic pillars:

1) Sustained Preventive Chemotherapy: Regular school-based and community-wide MDA with praziquantel to suppress egg excretion and severe clinical morbidity (Alade et al., 2023; Trippler et al., 2022).
2) Snail Intermediate Host Control: Targeted chemical molluscicide (e.g., using niclosamide) and ecological water-flow management to reduce cercarial densities at high-contact recreational sites (Alehegne & Mitiku, 2022; Mazigo et al., 2022b).

3) Water, Sanitation, and Hygiene (WASH) Infrastructure: Constructing piped safe water outlets, functional latrines, and community recreation facilities that eliminate human-water contact and prevent open urination into aquatic ecosystems (Mazigo et al., 2022a).
4) School-Based Health Literacy: Embedding contextualized parasitic disease education into primary school curricula to empower children with personal hygiene skills and protective behavioral practices (Liu et al., 2022; Sánchez-Marqués et al., 2023).

Ultimately, eliminating S. haematobium requires addressing the underlying biological, structural, and socio-environmental determinants of health (Mazigo et al., 2022a; Wang et al., 2024). Strengthening local institutional capacity, equitable public health resource allocation, and collaborative school health platforms are imperative to break transmission cycles permanently, protect children's learning potential, and safeguard long-term socio-economic productivity in endemic regions (Kasambala et al., 2022; Mushi et al., 2022).

4. CONCLUSION

Schistosoma haematobium continues to be a serious public health problem, undeniably impacting the physical growth, cognitive development, as well as health and well-being of school going children in endemic areas. Children are most likely to be involved in urogenital schistosomiasis transmission where they come into frequent contact with contaminated fresh water sources while engaging in recreational, domestic, and agricultural activities. This chronic pathology, which includes anemia, growth stunting, bladder wall lesions, renal impairment, and reduced learning ability, not only affects the ability of children to learn in the present but can also impair their future human capital development and community productivity.

Mass drug administration, with praziquantel, has shown a reduction in the amount of parasites and short-term morbidity, but it is not enough to interrupt the transmission cycle. The high reinfection rates and the persistence of the disease in endemic foci demonstrates the need for a multi-sectoral integrated approach. It is necessary to implement regular treatment in schools coupled with snail vector control (environmental management) to eliminate Schistosoma haematobium and provision of safe water and sanitation infrastructure that is inaccessible to humans to reduce the risk of human-water contact, while the introduction of effective health education into school curricula is essential to promote long-term behavioral change and achieve sustainable control and eventual elimination of Schistosoma haematobium.

Finally, to maintain the health and educational potential of school children in the future a shift from occasional interventions to chronic, community-wide disease management is needed. A coordinated socio-environmental approach to urogenital schistosomiasis can be achieved by tackling the biological transmission factors, alongside the social-economic-ecological determinants, through clear governance and equitable public health service provision, delivering a healthier and more productive future for future generations.

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