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Precision Public Health Approaches to Intestinal Parasitic Infections in Children under Five: A Policy Brief

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ABSTRACT

The majority of the burden of childhood disease and delayed development worldwide is attributed to one of the most neglected diseases, intestinal parasitic infections (IPIs). Helminth and protozoan infections continue to disproportionately affect under 5-year-old children, especially in low and low-middle income countries. These infections contribute to childhood diarrhea, malnutrition, growth failure, anemia, poor cognitive development, and preventable death. Nearly a third of all under 5 children globally have IPIs; however, this estimate could actually be significantly underestimated given low diagnostic sensitivity. This policy brief provides a comprehensive review of existing evidence on the global burden and causes of IPIs among under-fives, and identifies a range of evidence-based policy actions for governments, international organizations and development partners. Three proposed interconnected policy priorities are targeted geographically specific mass drug administration (MDA) and surveillance in high burden hotspots; climate-smart and context specific Water and sanitation and hygiene (WASH) interventions; and enhanced diagnostic and surveillance capacity for improved burden estimation and targeting resources. Despite the need for it, implementation is severely hampered by insufficient funding, under-developed health systems, inadequate inter-sectoral coordination, continuing environmental transmission environments, and under-diagnosis arising from use of low-sensitivity diagnostics. The challenge posed by IPIs in children under five will necessitate a shift from broad-based control plans to more precision public health approaches. These will include the implementation of hotspot targeting, environmentally tailored WASH interventions and enhanced diagnostic surveillance.

Keywords: Intestinal parasitic infections, Children under five years, Policy brief, Neglected tropical diseases, Mass drug administration

Introduction

Background and problem statement

Intestinal parasitic infections (IPIs) are the third most significant and neglected global public health issues (1). IPIs are caused by soil-transmitted helminths (e.g., *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm) and enteric protozoa (e.g., *Giardia lamblia*, *Entamoeba histolytica*, and *Cryptosporidium* species) (2,3). The greatest disease burden and susceptibility to IPIs is concentrated among children less than 5 years, due to immature immunity, poor nutritional status, constant exposure, poor quality Water and sanitation and hygiene (WASH) (4,5). A recent systematic review and meta-analysis of 41 studies (15,109 patients) suggested that the global pooled prevalence of IPIs among children aged under five is 31.6% (95% CI: 26.0-37.4%) (6), meaning that 1 out of every 3 children aged under five is infected. There is a high burden in resource-poor contexts and vulnerable social groups.

The long-term consequences of IPIs go well beyond the acute symptoms of gastroenteritis. Persistent and recurrent infections contribute to a range of chronic health issues, including nutritional deficits, anemia, impaired micronutrient absorption, stunted physical growth and cognitive development, diminished academic performance, and heightened vulnerability to other infectious illnesses. Furthermore, a self-perpetuating cycle exists between malnutrition and IPIs: the infections compromise intestinal integrity and nutrient uptake, while concurrent undernutrition weakens immune function, thereby increasing host susceptibility to further parasitic invasion (2,7,8).

The epidemiology of IPI is largely shaped by environmental conditions and social inequality. This is evidenced by the elevated infection rates seen in lower-income countries and regions with low HDI, specifically South Asia and East Africa (6). Environmental factors like moderate yearly rainfall, high humidity, savanna ecosystems, moist soils, and poor drainage promote IPI transmission. This risk is greatly increased by a lack of basic facilities and hygiene open defecation, no piped water, crowded homes, dirt floors, and inadequate sanitation all raise the chances of exposure (9–11).

Current prevalence estimates are likely underestimates of true infection levels; since many endemic countries solely use single method microscopy, which lacks the necessary sensitivity for protozoa and low intensity helminth infections. Using combined diagnostics, such as direct smear in combination with ELISA, significantly increases the estimated prevalence of infections.

Unless policy actions are increased and more targeted, the persistence of IPIs will hinder improvements in child survival, nutrition, Universal Health Coverage and targets regarding poverty, health, water, sanitation and inequality.

Policy options and implementation strategies

Policy option 1: Geographically targeted mass drug administration and surveillance

This approach will focus on routine deworming and enhanced surveillance in areas of high intensity of transmission in districts and communities (12–14). Core activities include execute sub-national mapping to determine high burden areas for transmission; introduce systematic surveillance to detect prevalence patterns, treatment coverage, reinfection levels and potential drug resistance; combine deworming with the child health service delivery platform (vaccination days, vitamin A supplementation, nutritional assessments, and community outreach); and conduct biannual MDAs with albendazole or mebendazole to endemic areas (13,14).

This policy has clear upsides. Combining geographically focused MDA with better surveillance quickly reduces parasitic worm levels and disease in high-transmission areas, and it is fairly in expensive to implement where prevalence is already elevated. This option can also be delivered using existing Maternal and Child Health (MCH) infrastructure and therefore is relatively low-cost for additional operational inputs and interruption of community transmission is possible with sustained high treatment coverage (12,15,16).

However, this approach has notable limitations: it does not avert reinfection in high-transmission settings and is ineffective against protozoan pathogens such as those causing giardiasis and cryptosporidiosis. Furthermore, it is unlikely to serve as a definitive solution, as it may necessitate repeated treatment cycles, consistent long-term financing, and could heighten the risk of antimicrobial resistance due to chronic drug exposure. Nevertheless, the strategy remains both feasible and broadly endorsed by governments and international bodies, given its alignment with WHO protocols and existing neglected tropical disease (NTD) programs (17–19).

Policy option 2: Climate-informed and locally adapted WASH interventions

These actions address the environment and structure of transmission by developing better water, sanitation, and hygiene infrastructure and practices. Core activities include focus WASH investments in the moist, low-lying, poorly drained and inadequately serviced zones, where transmission is high, so as to increase reach and sustainability; increase the availability of safe drinking water and sanitation services to the population; promote household-level environmental improvements-like replacement of earthen floor, proper waste disposal, reduction of stagnant water etc.; scale up behavioral change and hygiene promotion program, tailored for the target population, mainly caregivers and young children; and mainstream the climate change adaptation components into the planning and implementation of sanitation and drainage projects (9,20–22).

One key advantage of WASH interventions is that they tackle the ultimate environmental determinants of transmission, decreasing both helminthic and protozoan infections while achieving a wide range of public health co-benefits such as reducing diarrheal diseases and environmental pollution, ultimately yielding long-term social and economic returns; however, these interventions often have high capital costs and lengthy time frames for implementation, necessitating continuing inter-sectoral co-ordination between the health sector, water and sanitation, infrastructure, and education sectors, and benefits may not be immediate, although WASH interventions are well backed by development partners and public health communities, their feasibility and acceptability are critically influenced by political will, the capacity of local governance, and the ability to finance sustainable schemes (9,23,24).

Policy option 3: Strengthening diagnostic and surveillance capacity

This approach aims to enhance burden estimation accuracy and evidence-based targeting of interventions. Core activities include upgrade to sensitive diagnosis tools, e.g., combining microscopy and molecular methods in national and regional laboratories; extend the sentinel system in endemic area; train lab technicians on new parasitology diagnosis techniques; include detection of protozoa in the routine surveillance; and perform periodically prevalence surveys using standard and high sensitivity diagnosis tool (25,26).

A major advantage of strengthened diagnostic capacity includes detecting low intensity and poly-parasitic infections, gaining realistic estimates of prevalence, rational use of resources and interventions, being able to monitor intervention effect and drug resistance acquisition, but the limitations are significant in that labs would require vast investment for infrastructure, reagents, logistics and personnel; therefore, difficult to implement in remote/resource-poor settings. Furthermore, strengthened diagnostic capacity does not control transmission. Regarding feasibility and acceptability, there is a widely accepted technical rationale for strengthening diagnostics among technical experts and international bodies, although financial competition from actual treatment programs may prove to be a significant constraint (25).

Table 1 provides a comparative summary of the three policy options across key implementation and impact criteria.

Table 1: Comparison of policy options for IPI control in children under five

Criteria	*Policy option 1 (Geographically targeted MDA and surveillance)*	*Policy option 2 (Climate-informed and locally adapted WASH)*	*Policy option 3 (Strengthened diagnostic and surveillance capacity)*
Primary mechanism	Pharmacological reduction of parasite burden	Environmental disruption of transmission pathways	Accurate burden estimation and resource targeting
Effect on helminths	High (directly treats infections)	Moderate to high (prevents reinfection)	Indirect (enables targeting)
Effect on protozoa	None (not covered by MDA drugs)	High (interrupts fecal-oral transmission)	Indirect (enables detection and targeting)
Time to measurable impact	Immediate to short-term (weeks to months)	Long-term (years)	Medium-term (months to years)
Capital cost	Low to moderate	High	Moderate to high
Recurring cost	Moderate (drug procurement, distribution)	Low to moderate (maintenance)	Moderate (reagents, training, QA)
Inter-sectoral coordination needed	Low (primarily health sector)	High (health, WASH, infrastructure, education, finance)	Moderate (health, education, laboratory services)
Sustainability	Moderate (requires continued MDA rounds)	High (infrastructure provides lasting benefit)	Moderate (requires ongoing investment)
Addresses reinfection	No	Yes	No
Climate relevance	Low	High (explicitly climate-informed)	Low
Alignment with WHO NTD guidelines	Yes (current standard)	Yes (complementary)	Yes (emerging priority)

Major barriers and recommended implementation strategies

Financial limitations and integration strategies

Financial restrictions are one of the major challenges to effective IPI control. The upscaling of MDA, improvement of WASH infrastructure, and upgrade of diagnostic capacity, all require significant and sustained financial commitment which in many endemic countries, are beyond the available budget (19,27). Implementation strategies must therefore seek the involvement of both domestic funds and external grants, as well as the integration of IPI interventions into existing child health platforms and NTD programs, reducing redundancy (19,23). Phasing of activities, with initial focus on high-burden districts, will allow better allocation of limited resources and help build momentum towards wider scale-up (28).

Weak health systems and decentralization

Poor health systems also pose one of the major barriers to IPI control as most endemic regions suffer from severe lack of both primary health coverage and laboratory services, thus hindering adequate interventions, even well-designed ones (29,30). Expansion of community health worker programs can allow for access even into far to reach regions (31). Decentralization of surveillance system is also of utmost importance as it provides access to a rapid response to any emerging disease (32). Incorporating IPI activities into MCH care delivery can also assist in sustainability and at least at no additional cost on already over stretched health system (33).

Environmental transmission and climate-informed interventions

The persistence of ongoing environmental transmission, with varying factors dictated by climate and environment, is the principal challenge to IPI elimination (34,35). Even when treated, re-infection may happen quickly if the environmental conditions permit the parasites' survival and transmission (17). This challenge can be mitigated by having a climate-based approach where interventions are identified and focused in those areas which have been deemed to be most at risk through the risk mapping (36). Environmental contamination can be reduced through increased drainage and refuse collection (37). Household-based interventions are aimed at a readily accessible situation at home, that leverages pre-existing circumstances at community level (e.g., appropriate water storage, sanitation, access to water safety options etc.) and are an important first step prior to a large-scale infrastructure development (9).

Diagnostic limitations and laboratory strengthening

Under-estimation by diagnostics is a critical issue, as overreliance on low-sensitivity microscopy may fail to detect light infections, allowing continued transmission (38). Integrated diagnostic methods which use a combination of tests could help improve diagnosis (39). Standardized diagnostic methods for different IPIs should be established. Regional reference laboratories will be important in offering specialized tests, technical assistance and control services (40). The establishment and strengthening of quality assurance for diagnostic services will improve reporting and enable proper targeting of interventions.

Inter-sectoral coordination and governance

Inter-sectoral coordination deficiency is an important governance barrier because prevention of IPIs requires collaboration across health, water and sanitation, education, agriculture, and finance sectors (19,41). Lack of coordination has resulted in fragmented interventions and inefficient resource utilization (42). National multi-sectoral IPI task forces with clear accountability and budget coordination mechanisms are therefore essential for harmonizing priorities and maximizing impact (43).

Community awareness and health education

Lack of community awareness on transmission and prevention routes, is also a major challenge. Where there is little knowledge of how IPIs are contracted or why basic practices such as hand washing, sanitation and deworming are crucial for control, interventions have been found to be unsustainable (44,45). Culturally appropriate health education materials distributed by reliable community health workers and volunteers promote adherence because they take into account the beliefs and practices of the community (46,47).

Table 2 presented the major barriers hindering effective control of intestinal parasitic infections in endemic settings, with corresponding description of each barrier and evidence-based strategies recommended for implementation.

Table 2: Major barriers to intestinal parasitic infection (IPI) control and recommended implementation strategies

Barrier	***Description***	***Recommended strategies***
Financial constraints	Scaling MDA, WASH infrastructure, and diagnostic upgrades requires substantial and sustained investment (19,23,27).	Call on domestic funds, and global grants; link IPI activities with current children health platform and NTD platforms (19,23); roll out phased activities to high burden districts (28).
Weak health systems	Most endemic locations are under-resourced in terms of primary health care coverage and laboratory support (29,30).	Improve community health worker programs (31); decentralize surveillance systems (32); incorporate IPI services into routine maternal and child healthcare (33).
Persistent environmental transmission	The climatic and ecological factors encourage sustained transmission in most endemic areas (34,35).	Apply climate-targeted approaches to focus attention on highly vulnerable areas; improve drainage and waste management infrastructure (37); introduce interventions at household level in the environmental context (9).
Diagnostic underestimation	Reliance on low-sensitivity microscopy leads to under-detection of infections (38).	Standardize integrated diagnostic methods (39); set up regional reference labs (40); enhance the quality assurance systems (25, 26).
Limited inter-sectoral coordination	Effective prevention requires collaboration across multiple sectors (19,41).	Establish national, multi-sectoral, IPI task forces with common accountability and coordinated budgeting arrangements (42,43).
Low community awareness	Limited knowledge of transmission pathways reduces uptake of prevention measures (44,45).	Design culturally relevant health education campaigns(46); employ community-based service delivery(47).

Policy recommendations

Actions recommended for national governments in endemic countries: First, map hyper-endemic transmission foci at both district and community levels for prioritized targeting (48); second, implement combined, target-specific MDA targeting under-five population in highly endemic foci (48); third, improve surveillance with sensitive diagnosis tests for accurate national prevalence assessment (49); fourth, expand climate-resilient WASH facilities in climate-vulnerable foci (50); fifth, integrate protozoa-specific IPI prevention measures including safe water and hygiene practices into national IPI prevention programs (51,52); sixth, integrate IPI prevention and control into routine MCH service delivery. Actions recommended for international organization and development partners: revise the technical guidance on prevalence surveys, promote standard and highly sensitive tests (49); facilitate development of climate-informed transmission risk maps; develop dedicated funding streams for high-burden foci districts (48); facilitate trans-border cooperation and address vulnerable populations such as migrants, displace persons and refugees in endemic regions; encourage operational research for integrated MDA and WASH delivery systems. Actions recommended for donors and funding agencies: favor package intervention instead of single component vertical deworming; strengthen laboratory capacity, workforces training and investments in diagnostic innovation for low resource setting; demand good surveillance and sensitive tests at any surveys and program evaluation supported; fund operational research evaluating climate adaptations, environmental intervention and delivery models (53, 54).

Table 3 represents the priority actions recommended for each stakeholder group.

Table 3: Summary of policy recommendations by stakeholder group

Stakeholder group	*Priority action 1*	*Priority action 2*	*Priority action 3*	*Priority action 4*
National governments in endemic countries	Map high-transmission areas at district and community levels (48).	Implement targeted MDA for children under five in high-burden regions (13,48)	Expand climate-resilient WASH infrastructure in environmentally susceptible regions (20,50)	Integrate IPI prevention into routine maternal and child health (MCH) service delivery (30,33)
International organizations and development partners	Revise technical guidance to mandate uniform, highly sensitive diagnostic methods (25,49)	Facilitate development of climate-informed transmission risk maps (36,48)	Create specific funding windows for high-burden hotspot districts	Foster operational research into integrated MDA-WASH delivery models
Donors and funding agencies	Support integrated, multi-sectoral intervention packages over vertical deworming programs (19,53)	Strengthen laboratories, train workforce, and invest in diagnostic innovation for low-resource settings (25,26,54)	Insist upon strong surveillance and sensitive diagnostic methods in all funded program evaluations (38,49)	Fund implementation research assessing climate adaptation, environmental interventions, and sustained delivery (15,53,54)

Conclusion

Global IPI in children aged under five continues to afflict millions of children worldwide, and represents a significant source of preventable childhood illness, malnutrition and childhood deficit. Most IPI burden falls in low-income environments with limited resources, and in places where poverty and environmental conditions favor transmission, lack of safe water and poor sanitation are prevalent.

General interventions that lack sufficient and sensitive diagnostics to capture infection estimates that are most likely an underestimate, coupled with the relatively ineffective surveillance systems, are proving to be insufficient. Precision public health intervention approaches (combining geographically based interventions, climate smart WASH programs and increased diagnostics capacity) will be necessary to both control IPI and reduce its burden in the long run. Targeted MDA, and environmentally adapted preventative interventions coupled with stronger surveillance systems are not a trade-off between mutually exclusive actions, but can be seen as equally important complementary components of a robust and sustained action toward control.

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Ethics

No individual or identifiable human or animal data were used; therefore, ethical approval and informed consent were not required.

Conflicts of interest

The authors declare no competing interests.

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