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Linking Undernutrition and Selected Neglected Tropical Diseases

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I. Rationale for Integration

Both undernutrition and specific neglected tropical diseases (NTDs) are major global public health problems. Because they share risk factors and geographic locations, there may be value to linking the delivery of interventions for nutrition and NTDs to achieve program synergies.

The NTDs with greatest relevance for undernutrition include soil-transmitted helminths (STHs) or intestinal worms and blood flukes. Among the worms, the most relevant are *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and *Necator americanus* and *Ancylostoma duodenale* (hookworms). Among the flukes, the most relevant is *Schistosoma haematobium* and *S. mansoni* in Africa and *S. japonicum* in Asia. Collectively, STH infections are the most common form of NTDs affecting more than a billion people, most of whom reside in rural communities in low-income countries (1, 2), with over 600 million school age children and 266 million pre-school age children requiring preventive chemotherapy (3). STHs are the most infectious agents in humans among people residing in developing countries and produce a global burden that exceeds malaria and tuberculosis (2). In addition, schistosomiasis is also a global public health problem for which ~261 million people require preventive treatment (4).

Undernutrition, including micronutrient deficiencies (MNDs), affects over two billion people (5). Many individuals deficient in micronutrients also harbor worms and/or share risk factors for STH infections and schistosomiasis. A growing body of evidence, mostly from observational studies, shows plausible biological linkages between STH, schistosomiasis and undernutrition (6). With worm infestation, nutrient needs are greater due to the need to mount an immune response. Nutrient intake and absorption is often affected because the organisms disrupt absorption or digestion of nutrients, cause anorexia, and diminished appetite (6).


Undernourished child

Hookworm and schistosomiasis share a clear biological link with anemia. Hookworm infection, which can lead to blood loss, is a risk factor for anemia in both pregnant (7) and non-pregnant women as well as school age children (8, 9). Even light intensity hookworm infection (1-1,999 eggs per gram) is associated with a significant decrease in hemoglobin concentration (Hb), and the magnitude of the Hb decrement increases with infection intensity (8)

For many STHs and schistosomes, there is a difference between being infected and being diseased. The number of worms a person is infected with, for example, greatly affects the severity of the disease and any nutritional effects. Heavy infections with *S. mansoni* or hookworm significantly contribute to anemia in school age children and adults (8). For this reason, the aim of programs to control intestinal helminths and schistosomiasis is usually to reduce worm loads to minimize disease and undernutrition risk (6, 10). But more research is needed to understand and quantify the relationship between nutritional status and STH and schistosomiasis.

Diseases such as schistosomiasis and STH are underlying causes of stunting, wasting and micronutrient deficiencies. Evidence to date suggests that treating children known to be infected with intestinal worms with a single dose of deworming drugs may increase weight gain by 0.2 to 1.3 kg over the short-term (i.e. 1 to 6 months) (11). Investigations on large-scale deworming interventions showed not only that children exposed to more years of deworming had higher test scores in literacy and numeracy 7 to 8 years later (12), but also that there was a long-term positive cognitive effect on young children who did not receive treatment directly at the time, equivalent to between 0.5 to 0.8 years of schooling (13).

With respect to community deworming programs, treating all children living in endemic areas with a dose of deworming drugs probably shows little or no community-wide effect on average weight (even in settings with high prevalence of infection), average hemoglobin, or average cognition (11). This is because even in communities that are highly endemic for STH, only a small proportion of individuals have heavy worm burdens that result in most morbidity and disease, therefore, when evaluating the impact of deworming in endemic communities within a treatment framework any beneficial effects of deworming will inevitably be diluted (14). While more evidence has been summarized (15), more well designed research is indeed needed to assess treatment effects on hemoglobin, school attendance, cognitive functioning or physical well-being.


Child in Sierra Leone

II. Ways that STHs, Schistosomiasis and Undernutrition Can Overlap

Tropical Geographic: Both undernutrition and infection with STH overlap geographically (**Figures 1 and 2**). The majority of individuals affected of either condition live in tropical and subtropical regions. For STH, warm climates and adequate moisture are needed for eggs to survive in the soil and hatch hookworm larvae. Undernutrition is not exclusive to tropical or subtropical geographies, but most of the world's undernourished children reside in these regions. Sub-Saharan Africa and South and South-east Asia harbor >80% of stunted children under the age of 5 years (see Figure 1).

Figure 1. Global distribution of childhood stunting prevalence (16)

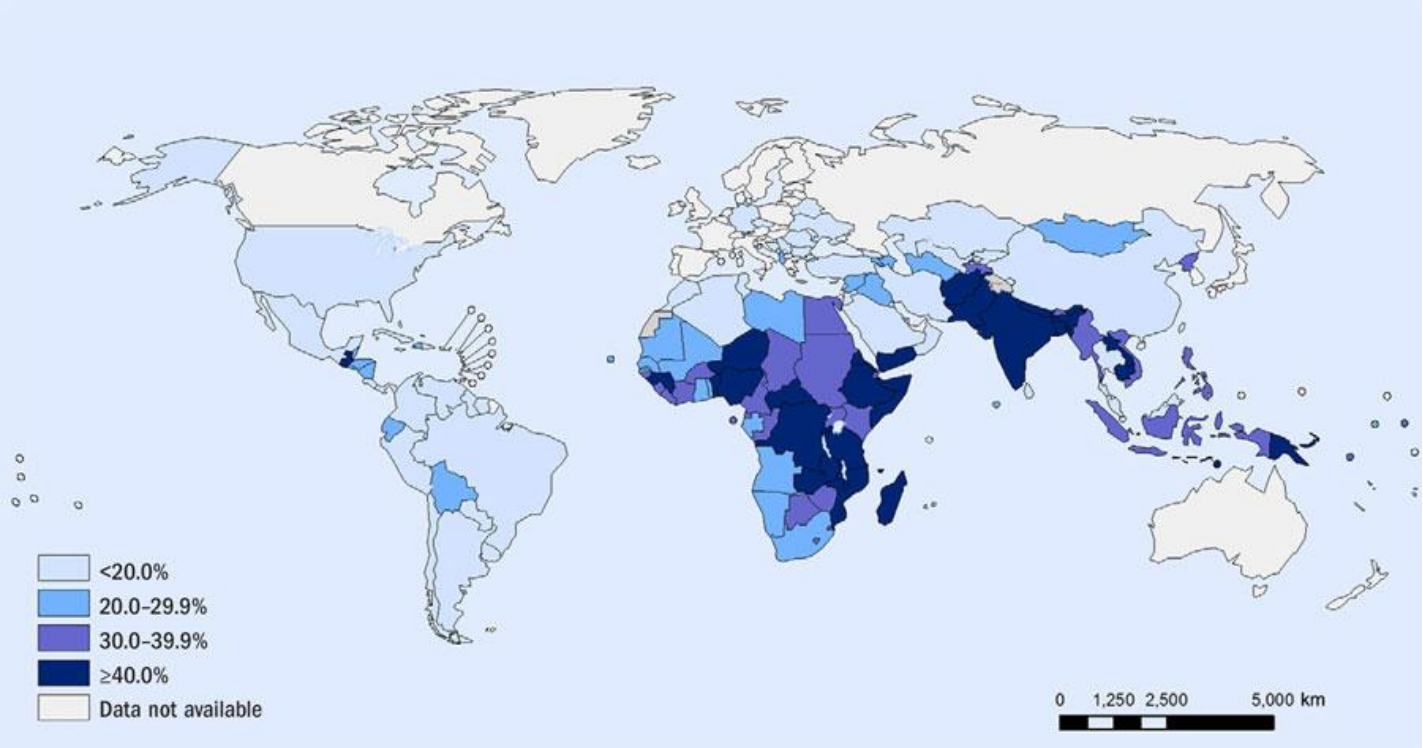
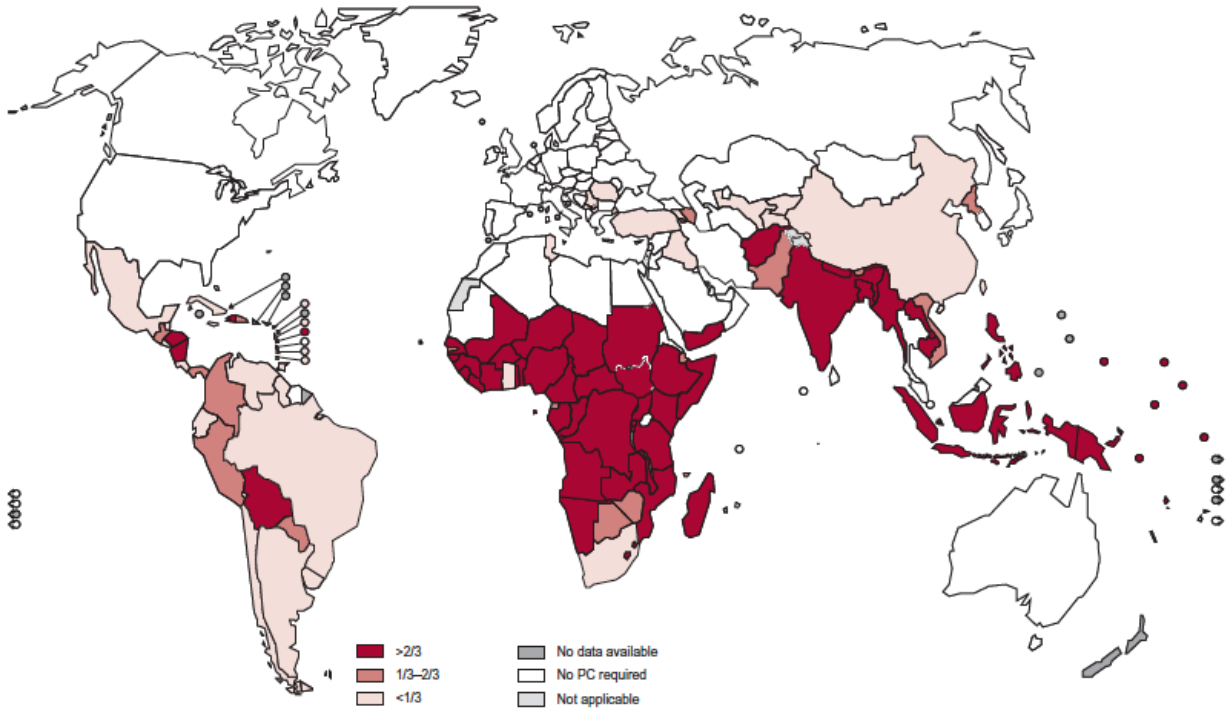


Figure 2. Distribution of soil-transmitted helminthiases and the proportion of children (1-14 years) in each endemic country requiring preventive chemotherapy for diseases, 2011 (17)

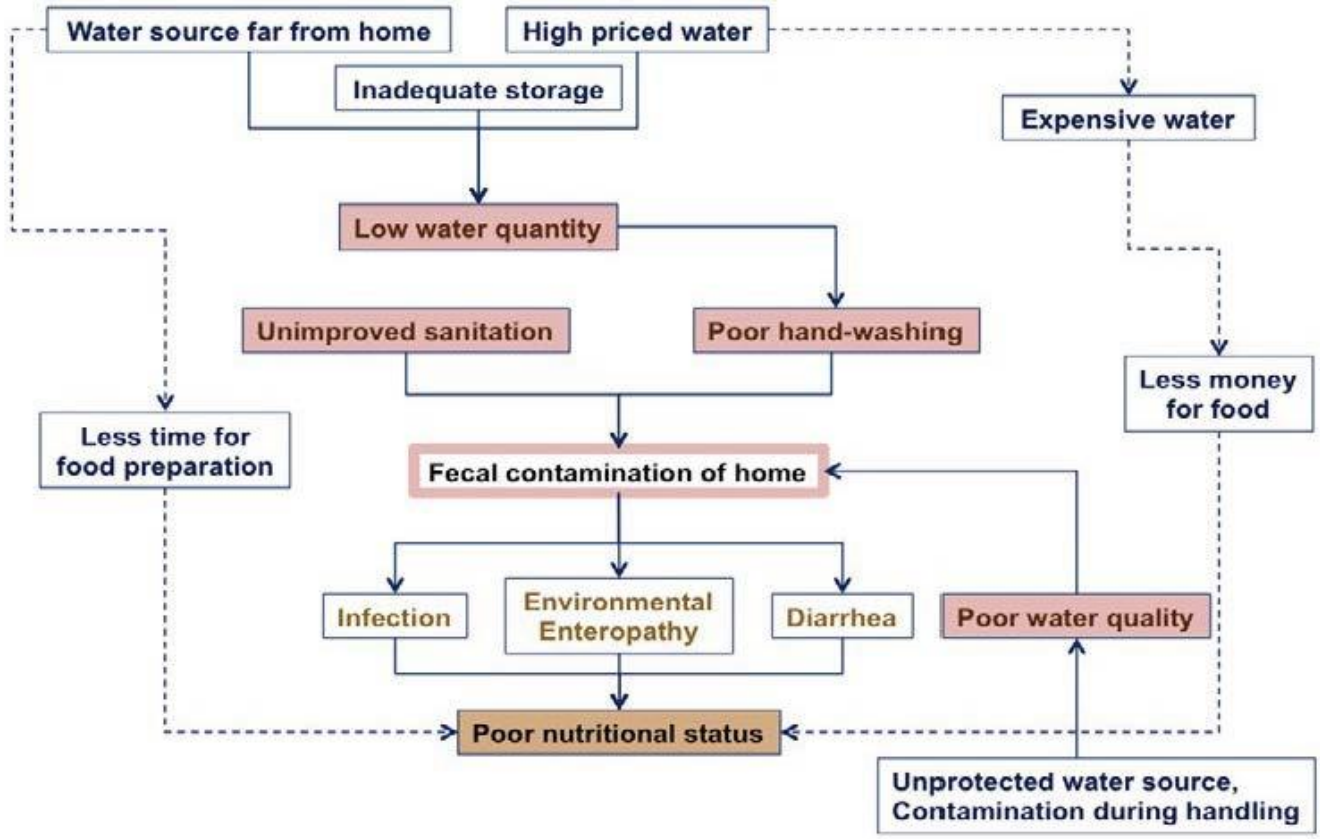


Risk Factors:

1. **Inadequate Water, Sanitation and Hygiene (WASH):** Both undernutrition and worm infections are common in contexts of poor personal hygiene, insufficient access to clean water, and inadequate disposal of human feces and urine. STHs colonize the human intestine and their eggs are shed in feces and enter the soil. Where hygiene behaviors are inadequate, humans ingest the eggs, either by eating with unwashed hands that touched contaminated ground or eating unwashed fruit and vegetables grown in soil contaminated with human feces. Where sanitation is poor, humans get infected by hookworms through penetration of the skin of bare feet by hookworm larvae in the soil. Where water is unsafe and sanitation and hygiene are inadequate, greater frequency and/or severity of diarrhea can increase the risk of undernutrition. Not only do NTD and WASH programs share common goals (**Figure 3**), but the WASH can also influence nutrition through different pathways (**Figure 4**).

Figure 3. WASH and NTDs—Common Goals (18)

Figure 4. WASH and Nutrition Pathways (19)



2. **Weak health care systems and facilities.** Both undernutrition and STH infections are exacerbated by poor health care systems and facilities. STH control, for example, is often neglected, even in endemic countries. Although World Health Assembly resolution 54.19 urged member states to treat at least 75% of all school-age children at risk of morbidity by 2010, this target was missed (20), in part because of weak health systems. These same system weaknesses hamper the reach and delivery of many nutrition interventions.

3. **Poverty:** Both STH and undernutrition are more common and more severe in poor communities. This is because factors such as inadequate water supply and sanitation, crowded living conditions, lack of access to health care and low levels of education combine to increase the risk of both conditions.

See **Table 1** below for a side-by-side comparison of STH/schistosomiasis and undernutrition. One important factor to note is that the delivery platforms for both NTDs and undernutrition have a great deal of overlap thus do offer potential for program integration and synergy.

Table 1.
Side-by-Side Comparison of Characteristics of NTDs (STH and Schistosomiasis) and Child Undernutrition

Characteristics	Neglected tropical diseases focusing on STHs & schistosomiasis	Undernutrition
Magnitude	Over 1 billion people including 600 million school-age children and 266 million pre-school age children are infected with STH worldwide. 261 million people of whom 120 million are school age children require preventive chemotherapy for schistosomiasis.	Micronutrient deficiencies affect ~2 billion people globally; Stunting affects 165 million children <5; Wasting affects 52 million children; Vitamin A deficiency affects ~90 million preschoolers
Major Forms	STH: *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Necator americanus* and *Ancylostoma duodenale* (hookworms) *Schistosoma haematobium*, *S. mansoni* and *S. japonicum* (fluke)	Stunting (abnormally short for one's age), Wasting (abnormally thin for one's age); vitamin A, zine, iodine, iron, folate, calcium and vitamin D deficiencies
Routes of Transmission	*A. lumbricoides* and *T. trichiura* are primarily spread through fecal transmission (usually ingestion of parasite eggs in feces), whereas hookworm species and *Strongyloides stercoralis* (threadworm) are through skin penetration of infective larva; and schistosome infections are through skin penetration when swimming or bathing in water containing infectious cercariae (larva stage).	
Consequences	STH and schistosome infections in children result in malnutrition, anemia, and they have a negative impact on development and educational performance. As high as 200 000 deaths per year may be due to schistosomiasis in sub-Saharan Africa.	Undernutrition, including fetal growth restriction, suboptimal breastfeeding, stunting, wasting and deficiencies of vitamin A and zinc cause 45% of child deaths resulting in 3.1 million deaths annually
Risk Factors	Inadequate sanitation, lack of clean drinking water and health care assistance, poverty and malnutrition	Inadequate diet, morbidity, food insecurity, inadequate sanitation, inadequate care, poverty

Delivery Platforms	• Child Health Days • Antenatal Clinic Visits during Pregnancy • Home visits • Schools • Health Centers • Sick and well child contact points within the health system	• Child Health Days • Antenatal Clinic Visits during Pregnancy • Home visits • Schools • Sick and well child contact points within the health system
Direct Interventions	**For STH:** Preventive chemotherapy (PC) is recommended. PC is a periodic administration of anthelminthic medicines (albendazole or mebendazole) to reduce morbidity and transmission of the following 4 species: *A. lumbricoides*, *T. trichiura*, *N. americanus* and *A. duodenale* in areas where the prevalence of STH is estimated to be over 20%. **For schistosomiasis**: As for STH, preventive chemotherapy is the mainstay of the recommended strategy. A single dose of praziquantel, a prescription medication, is taken to treat infections caused by all *Schistosoma* species. It is highly recommended to take praziquantel with food. The treatment frequency follows the WHO guidelines.	**Adolescents:** Family planning, delayed onset of first pregnancy, prolonged inter-pregnancy interval **Women of Reproductive Age and Pregnancy:** Iron and folic acid supplementation; Multiple micronutrient supplementation; Balanced energy and protein supplementation; Iodine supplementation; Disease prevention and treatment (Malaria prevention and Deworming) **Neonates:** Early initiation of breastfeeding; Delayed cord clamping **Infants and children**: Exclusive breast feeding; Complementary feeding; vitamin A supplementation (6-59 m); Preventive zinc supplementation; Multiple micronutrient supplementation; Disease prevention and treatment (Management of MAM and SAM; malaria prevention, deworming, feeding in diarrhea, WASH, therapeutic zinc for diarrhea)
Indirect Interventions	• Water, Hygiene and Sanitation (WASH)	• Water, Hygiene and Sanitation (WASH) • Agriculture • Social Safety Nets • Gender Equity • Education

III. Control Strategies and Program Linkages

Deworming of School Children: Among control strategies that are likely to impact on both STH and underweight in the short-run, the most feasible and direct intervention is treating children in the endemic communities as the deworming drugs are safe, effective and available free of charge. Strengthening STH deworming among school-age children through School Health Programs is also recommended. Frequency of regular treatment should vary according to the prevalence thresholds recommended by WHO (21). These factors must be considered in relation to the resources available and the cost involved in drug purchase and distribution.

Deworming and Prophylactic Treatment of Schistosomiasis of young children and women of child bearing age: The World Health Assembly in 2001 endorsed a strategy for the prevention and control of schistosomiasis and STHs in high-transmission areas. In the short term, morbidity will be reduced by access to drugs (praziquantel and broad-spectrum anthelminthics) and good case management in all health services; regular treatment of at least 75% of school-age children and targeting other high-risk groups (young children, women of child bearing age and occupational groups) through existing public health programs and channels. Integrating deworming into Child Health Days where vitamin A supplements and other services are provided is an excellent way to link STH and nutrition program interventions. Deworming is a component of the Essential Nutrition Action (ENA) framework[1]. HKI country offices should advocate for and monitor the coverage of both VAS and deworming for pre-school age children during Child Health Days/Weeks and other community-based platforms that reach other high-risk groups for STHs and undernutrition, such as maternal health services. At present, however, drugs for deworming women, preschool-age children and occupational groups need to be sourced because these groups fall outside the targets of the large global donations of deworming drugs.

Deworming with Albendazole

Shifting from morbidity control to transmission control: Deworming, while essential in STH-endemic areas, may not be sufficient, alone, to achieve sustained elimination of STHs and, consequently, of related STH-attributable anemia and undernutrition. A recent systematic review found that adequate waste management and sanitation is associated with reduced transmission of *A. lumbricoides*, *T. trichiura*, and hookworms (22). A study in Zanzibar, Tanzania found that, despite sustained large-scale deworming efforts, high prevalence levels of parasitic worm infections persisted, and concluded that deworming needs to be complemented with health education and improvements in water supply and adequate sanitation for sustained control of parasitic worm infections and STH-related undernutrition and anemia (23).

Improved Water, Sanitation and Hygiene (WASH): For long-term sustainability, environmental health will be required, improving access to safe water and sanitation and improving hygienic behavior through health education. Since human STHs are fecal-borne infections, and transmission occurs either directly (hand-to-mouth) or indirectly (through food and water), reducing fecal contamination of soil can be achieved by promoting the use of latrines, developing self-protection from re-infection, and promoting personal/family hygiene measures such as washing hands and proper food preparation.

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