MAKING NUTRITION IMPROVEMENTS AT LOW COST THROUGH PARASITE CONTROL

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Making Nutrition Improvements at Low Cost through Parasite Control

Guidelines for Designing and Implementing Mass Treatment Interventions

by

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ABSTRACT

The 1993 World Development Report includes mass delivery of anthelminthic (or deparasitization or deworming) treatment in its "essential package of health interventions" that will address at lowest cost the diseases that cause the greatest burden. School-based mass delivery is singled out as one of the most cost-effective measures. Until now this intervention has received little attention in Bank operations; more emphasis is deserved.

Worm or parasite (technically known as intestinal helminth) infections are among the most prevalent of human infections. Most common in the least-developed countries, and among children in those countries, such infections hinder children's physical and intellectual development and reduce the productivity of adults. Reversing the nutrient leakage, anorexia, and malabsorption of food caused by such infections can improve the growth and learning capacity of children and the productive output of adults. Attractive new approaches and tools for controlling parasite infections in endemic communities are low-cost and have high return.

The following guidelines were prepared to assist World Bank task managers responsible for nutrition, health, education and other related projects in the preparation of parasite control interventions. Written in question-answer format, they are intended to provide easily accessible answers to the major questions that arise when considering the incorporation of parasite control interventions into such projects. A list of references and agencies to contact for additional information is included.
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NEED: WHY BE CONCERNED?

What are the nutritional consequences of intestinal parasite infection?

Parasite (or helminth) infection influences nutrition in three ways. First, infection reduces food intake. Heavily infected children tend to eat less, even when food is available. Second, infection reduces intestinal absorption of certain nutrients, increasing the likelihood of deficiencies. This effect is particularly marked in roundworm infection associated with the poor absorption of vitamin A, protein, lipid and carbohydrate. Third, infection results in nutrient losses. Iron losses due to hookworm infection, for instance, increase as the worm burden increases; even relatively light infections require an infected person to more than double the daily intake of iron. In moderate whipworm infection, protein losses can be significant. The effects of nutrient losses are particularly severe for individuals consuming marginal diets and maintaining low body stores of nutrients, the typical situation in areas where helminth infection is endemic.

What are the consequences for growth and development? Are these reversible?

The most intense roundworm and whipworm infections occur in school-aged children, and are associated with low weight-for-age, height-for-age and weight-for-height. Removing worms by drug treatment can accelerate growth and weight gain. Twice the normal growth rate has been observed in stunted children following drug treatment, even without improving their diet. Both nutritional and physiological benefits from deworming explain this remarkable improvement. Nutritional benefits: the child is likely to eat more, absorb more and lose less from the existing diet. Physiological benefits: parasite-induced changes in blood chemistry that, for example, negatively affect growth mechanisms among children with intense whipworm infection, can be reversed by helminth treatment.

What are the consequences for school achievement?

Studies in Jamaica show that treating helminth infection in school children improves their performance on cognitive tests. A longitudinal study of whipworm infection in the West Indies showed not only a significant improvement in learning capacity in the treated group compared to the placebo group, but also that cognitive scores of treated children were comparable to those of uninfected children. These improvements were achieved by a single treatment, and without nutrition supplements or improvements in education.

In endemic areas, children judged to be least able academically are more likely to be infected with helminths and to harbor large worm burdens. Stunting and anemia, two common consequences of worm infection, are well known to be associated with impaired learning capacity.

What are the consequences for adult morbidity and productivity?

Hookworm anemia -- chronic iron loss due to infection -- has been shown to reduce productivity. For example, the amount of latex collected daily by anemic rubber plantation
workers in Indonesia was nearly 20 percent lower than that collected by non-anemic workers. Studies of male roadworkers in Kenya and female tea-pickers in Sri Lanka show that people with anemia have decreased work capacity and productivity. Although hookworm anemia may be rectified temporarily by iron supplementation alone, sustained improvement requires anthelminthic therapy.

Hookworm anemia in adult women can have additional consequences. Anemia in pregnancy is associated with higher risk of childbirth-related maternal mortality, as well as low birthweight, subsequent failure of the child to grow and infant mortality.

Why are the consequences of helminth infection not more widely recognized?

Although helminth infection is common, affecting more than a third of the world's population, its consequences -- stunting, anemia, diarrhea, impaired learning capacity and reduced productivity -- have multiple causes. Thus, it is impossible to attribute any one of these conditions directly to worm infection by observation; carefully constructed intervention studies are necessary. Also, the ill-effects of helminth infection develop slowly. The anemia associated with blood loss from hookworm infection, for example, is the sequel of several months of chronic blood loss.

The role of helminth infection in stunting growth tends to pass unrecognized. In a study of a West Indies community, for example, among school children with chronic mucoid diarrhea and stunted growth associated with whipworm infection, only 2 percent of the cases had been recognized by health personnel.

What is the prevalence of helminth infection worldwide?

Roundworms and whipworms occur in almost any community without adequate sanitation, safe drinking water, or hygienic health practices. Hookworms are more typically tropical. These infections are most prevalent in poor and overcrowded communities, both rural and urban. The world-wide prevalence of the major helminths is shown in Box 1.

What causes intestinal helminth infections?

The feces of infected individuals contain the eggs of helminths and cause other infections either by being ingested in contaminated food, water or hands, or,

<table>
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<td>Number of Infections (estimated) (in billions):</td>
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<tr>
<td>Intestinal Helminths</td>
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<tr>
<td>Roundworm (Ascaris)</td>
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<td>Hookworm (Necator, Ancylostoma)</td>
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<tr>
<td>Whipworm (Trichuris)</td>
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<tr>
<td>Other Helminths</td>
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<td>Schistosomes</td>
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in the case of hookworms, by larvae penetrating the skin. None of the common helminths multiply in humans; each worm is the result of a separate infection.

Intestinal worm infection commonly involves four of the more than 30 different helminth species that occur in humans. The roundworm, \textit{(Ascaris)} and two species of hookworm (\textit{Necator} and \textit{Ancylostoma}) live in the small intestine, while the whipworm (\textit{Trichuris}) inhabits the colon. The large (20cm) roundworm feeds on the contents of the gut, and the small (2cm) whipworm and hookworm feed on the gut wall to which they attach. These helminths have complex life cycles, but the need to understand these, or even to define precisely the target organism, has been eliminated with the advent of broad-spectrum anthelmintics (deworming drugs) that are effective against all the common species.

What are the clinical symptoms and consequences of parasite infections?

Initially, roundworm infection may cause cough, shortness of breath and fever lasting about 12 days. Subsequently, the infections may cause digestive disorders -- nausea, vomiting and abdominal pain. Intestinal obstruction is an additional complication occurring in about 0.2 percent of infections. The symptoms of whipworm infection may include diarrhea, protein loss in urine and, in rare cases, complications of rectal prolapse and cardiac failure. Common symptoms of hookworm infection are lassitude, shortness of breath, pallor, anorexia and swelling of the legs. A frequent complication is iron deficiency anemia.

Do all individuals infected with helminths suffer from these symptoms?

No, parasite infections can be asymptomatic. The most heavily infected individuals, those harboring the greatest number of worms, suffer the greatest risk of disease. The distribution of worm burdens in a population is highly skewed (Box 4, Figure 1); a few individuals have many worms, most have a few. Typically some 70 percent of worms in a population are found in less than 15 percent of those infected. This pattern is consistent for all major helminth species.

Which age groups are most seriously affected by which intestinal helminth infection?

Roundworm and whipworm infections usually occur during the early preschool years, peak in prevalence among 4-5 year olds, then remain at high prevalence in all subsequent age groups. Although adults are almost as likely to be infected with these helminths, children have much larger worm burdens. The intensity of infection (the number of worms harbored by an individual) peaks in children 5-10 years old but declines rapidly in adults. Heavy worm burdens and disease are less common in younger children, however death due to intestinal obstruction appears to be more common in children under five.

Hookworm infection, on the other hand, peaks in adulthood. It is both more common and intense in adults than in children.
RESPONSE: MASS TREATMENT INTERVENTIONS

What is mass treatment? How does it compare to selective treatment?

Mass treatment of worms means that all persons are offered treatment, regardless of individual infection status. Mass delivery is common, for example, in school helminth control programs in developing countries. Communities that receive mass treatment are carefully targeted on the basis of risk of disease while selective treatment means that only infected individuals identified through screening and diagnosis are treated. The latter requires examining individual fecal specimens prior to each round of treatment. This involves: a minimum of two patient visits, one each for diagnosis and treatment; enough microscopists to handle the target population; and an infrastructure for patient follow-up. Large-scale screening is usually beyond the technical resources of endemic areas. Where feasible it is roughly estimated to be three to six times as costly as mass treatment. Screening may also reduce effectiveness because individuals who fail to provide a fecal specimen, a significant proportion in some communities, remain untreated, whether or not infected.

What is the effect of mass treatment against helminths?

Box 2 shows the results of a school-based program managed by the Ministries of Health and Education in the Caribbean island of Montserrat. Single-dose albendazole, a broad-spectrum anthelminthic, was offered to all schoolchildren (4-12 years of age) at four-month intervals for two and one-half years. More than 90 percent of children were treated at each cycle. Few adults, less than 4 percent, received treatment during the same period.

There was a highly significant decline in roundworm (Ascaris) and whipworm (Trichuris) infection among schoolchildren, as expected with frequent administration of a broad-spectrum anthelminthic to this more heavily infected target group. A significant decline in both infections also occurred among the untreated adult population, due to reduced transmission from the school-aged
population. Thus, this treatment provided both an immediate benefit to infected school children and a long-term preventive benefit to the broader community.

**How does the cost-effectiveness of mass treatment compare to selective treatment?**

Under typical conditions, mass (community) treatment is both less costly and more effective than individual screening and selective treatment. The effectiveness of selective (screening) treatment is improved by enhanced compliance -- becoming about equal to the effectiveness of mass treatment -- but at higher cost. The mass option becomes more expensive than the selective option only if drug costs are excessively high.

**What frequency and coverage of treatment is required for mass delivery of anthelmintics?**

The rate of reinfection following treatment depends on the species of helminth and the local intensity of transmission. High initial levels of infection require more frequent cycles of treatment. Current estimates indicate that treatment for whipworm and roundworm is required every 6-12 months, and for hookworm every two years, to achieve appropriately low rates of reinfection -- not eradication.

These rates of treatment assume high levels of coverage, 80-90 percent of the target population, since if a substantial proportion of individuals remain untreated the rate of reinfection will be greater. Coverage and frequency of treatment are inversely related, higher frequency being required in areas where coverage is low.

**How does the cost-benefit ratio of anthelminthic intervention compare with other health interventions?**

Comparing the discounted healthy life years gained from anthelminthic treatment to other health interventions, school-based worm control programs are at least as cost-beneficial as other child health interventions commonly implemented at the community level (Box 3). Anthelminthic treatment through schools is estimated to cost about US$19 per healthy year of life gained. This is about the same as DPT plus polio immunization, and less than oral rehydration therapy. This captures only part of the benefit of helminth control; other benefits are improved learning capacity, and reversal of anorexia, malabsorption and nutrient leakage. Thus, mass delivery of anthelminthics may serve as a low-cost approach to enhancing the benefits of a school feeding program.

If helminth infection is not eradicated by mass treatment, aren’t people likely to become reinfected?

Yes, reinfection may be inevitable. However, eradication of helminth infection is not necessary for reducing the disease and consequences associated with heavy infections. The individual benefits immediately from the removal of worm burdens. Moreover, reducing the
number of individuals infected in the community slows the rate of reinfection, the build-up of heavy worm burdens, and thus prevents the disease associated with intense infections.

**ASSESSMENT: DETERMINE THE NEED FOR HELMINTH CONTROL**

How is the level of morbidity from intestinal helminth infection assessed?

Illness from helminth infection is generally assessed on a regional or provincial level since it is unlikely to be a homogeneous national problem. Hospital records may be helpful in highlighting areas of high occurrence of disease, yet they generally tend to be uninformative because most cases are not reported to health authorities. Data on the intensity of worm infection in communities are obtained by examining the feces of individuals for helminth eggs. The density of eggs in feces — usually expressed as eggs per gram or EPG — gives a crude estimate of worm number, and hence the risk of morbidity. Counting eggs is labor-intensive, slow and expensive, however, and such data are rarely available. Rapid assessment procedures for intestinal helminth morbidity currently do not exist.
What is an alternative to assessing the level of morbidity from helminth infection?

Data showing the presence or absence of infection -- not involving counting egg density in individual stool samples -- are easier to collect, more commonly available, and can provide a useful estimate of potential morbidity. Such prevalence data, if unavailable, can be collected through regional school surveys of 5-12 year-old children or similar surveys of adults via primary health care (PHC) clinics. More than 50 stools can be examined daily for the presence or absence of infection by a trained technician using the Kato procedure, the cheapest and most efficient available. The major inputs required for such a survey include: a person to collect stools from each school, usually a local PHC worker or teacher; a technician for stool examination, usually recruited temporarily within a central hospital laboratory; and a stool collection pot and microscope slide per examination.

How can prevalence data be used to determine the need for helminth control?

As noted, a few individuals in a population have intense infections (heavy worm burdens) while most have few worms (see Box 4, Figure 1). Paired data giving both the prevalence of roundworm infection (percent of population infected) and intensity (average worm burden) for different communities are presented in Box 4, Figure 2. Each data point represents the average intensity and prevalence for a separate community. As observed, mean intensity of infection increases as prevalence rises, but in a strikingly non-linear fashion. Up to 60 percent prevalence, the worm burden changes relatively little; thereafter, small changes in prevalence result in disproportionately large changes in intensity. For example, as prevalence increases from 80 percent to 90 percent, average roundworm burden increases from 10 to 34 worms.

Since worm burden determines morbidity, this relationship has important consequences for the risk of disease as shown in Box 4, Figure 3. This figure shows the proportion of the population likely to have a worm burden large enough to cause disease compared to the prevalence of infection. Each curve represents a different estimate of the risk of disease, moving from the risk associated with five or more worms to a threshold of 30 worms. All the curves show the same pattern: the risk of disease increases disproportionately with increasing prevalence of infection in the community. In the case of roundworm, for example, where the threshold for the worm burden that causes disease is conservatively assumed to be about 25 worms, a prevalence of infection of 60 percent is associated with little or no morbidity, while a prevalence of 90 percent results in almost half of the population exceeding the threshold for morbidity. Thus, if prevalence surveys show that more than 60 percent of the population is infected, the communities are at significant risk of helminth disease and treatment should be high priority.
Box 4. Relationship between Prevalence of Helminth Infection and Level of Helminth-Induced Morbidity

Figure 1

Figure 2

Figure 3
IMPLEMENTATION: INVESTING IN WORM CONTROL

Anthelmintics

Which anthelmintics (drugs, usually in tablet form, that destroy parasites) are useful in which situations?

Some anthelmintics (albendazole and mebendazole) are effective across a broad spectrum while others (piperazine) are effective for one species in single dose (Box 5). A narrow-spectrum drug may offer some cost advantage in certain areas where a single helminth species is prevalent; however additional costs are incurred in confirming the uniqueness of infection. For the majority of endemic areas a broad-spectrum drug is preferable, since whipworm infection is ubiquitous and only effectively treated by broad-spectrum anthelmintics.

Is the use of anthelmintics contraindicated for certain groups?

Albendazole and mebendazole are currently contraindicated in pregnancy. Indeed, no anthelmintic is recommended for use in pregnancy. This presents few problems when treating children of school age, but has the unsatisfactory consequence that women of child-bearing age must be excluded from treatment.

Can more than one anthelmintic be administered at the same time?

In some areas, programs of treatment for helminth infections other than those above (e.g. praziquantel for schistosomiasis and ivermectin for onchocerciasis) may be in place or are planned. Since infection with multiple species is common, there are obvious cost advantages in using the same delivery system for all anthelmintics required locally. There may be similar advantage in companion delivery of micronutrient supplements (vitamin A and iodine). The World Health Organization is currently investigating the safety of administering albendazole and praziquantel concurrently. Until these studies are completed, WHO guidelines recommend that
these drugs should be taken at least a week apart to avoid potential interaction. The interactions of other drug combinations have not yet been assessed.

Are logistics an obstacle to anthelmintic delivery?

Generally, no. Anthelmintic tablets are taken orally, have a storage life of several years, and require protection only from moisture and extremes of temperature. Their transport and storage are straightforward.

Among the commonly used anthelmintics listed (Box 5), albendazole and mebendazole are prescribed as a fixed dose, regardless of a person's weight. For the other anthelmintics, the dose is dependent upon body weight, introducing a complication in delivery since the appropriate individual dosage must be calculated.

Target Groups

Why are school-aged children high priority for treatment?

School-aged children have the heaviest burdens of roundworms and whipworms, therefore are more at risk of disease and, at the same time, are a major source of infection. Fortunately, children in school are a highly accessible group, and schools offer opportunities for surveillance, health education and community mobilization.

Targeting anthelmintic treatment at school children is the lowest cost option, in some cases perhaps the only affordable option, for reducing community transmission of helminth infection. Where resources are limited, targeting school-aged children is likely to achieve the most general benefit — including benefits for pre-school children and women of child-bearing age. Seasonal school absenteeism, although a common problem, need not be a major obstacle provided the intervention is appropriately timed. Low enrollment may, however, vitiate the effectiveness of this approach.

Which other age groups should be considered targets for treatment?

Where possible and affordable, it is desirable to also directly provide deworming treatment to preschool children. Young children, heavily infected with helminths, are at higher risk for malnutrition and its long-term consequences. The available epidemiological evidence, however, indicates that intense infection with worms is much less common in this age group than in children 4 years of age and older. Schools can serve as the focal point for the delivery of treatment to younger children and those not attending school for other reasons.

Adults may also be a target for treatment, particularly where hookworm anemia presents a problem for a workforce. Delivery could then be organized via plantation or workplace clinics, with hookworm treatment required only at two-year intervals.
Delivery Mechanisms

What are the mechanisms for implementing a school-based delivery system?

A common approach involves the distribution of anthelminthics in schools by the school administrators and teachers while drug purchase and monitoring is undertaken by the health authorities. This division preserves sectoral responsibility for health while taking maximum advantage of the scale of the education infrastructure, usually far larger than health.

An alternative structure involves the use of mobile health teams, which visit schools, but remain under direct supervision of the health sector. This approach has proved successful in some settings, but obviously requires specific equipment that incurs costs, raising questions as to its affordability and sustainability. Another approach that may be particularly useful in highly populated urban areas involves non-govermental organizations in program implementation.

What are the other routes for mass treatment delivery?

Anthelminthics may, of course, be delivered through any existing health system. The primary health care infrastructure is an obvious route and one that is already likely to be playing some role in anthelminthic treatment. Maternal and child health programs, in particular, should focus on parasitic infection in vulnerable young children. Treatment of adult hookworm infections, via PHC or workplace clinics, may be effective.

To reduce transmission among all age groups, however, school-aged children -- the major source of community infection -- must receive treatment. Infant-based treatment may help to prevent disease in this age group, but will not control related morbidity for the community as a whole. Broadening the scope of PHC programs to regularly include all school-aged children is unlikely to be affordable, unless undertaken as part of a school-based program.

Complementary Activities

What activities need to accompany delivery of anthelminthics to school children?

Education. Educational programs to change practices related to the transmission of parasite infections are necessary to support mass anthelminthic delivery. Improving hygiene will extend the benefits of drug therapy, reducing the frequency and coverage of treatment required. Educational efforts also can encourage compliance with anthelminthic treatment. Approaches involving children, schoolteachers and parents have been shown to be most effective. At the same time delivery of anthelminthics can serve as a focal point for participatory health education in the curriculum, and encouraging community support for improving sanitation in the community.

Educational packages can be developed by government health education agencies, situated administratively in either the health or education sectors, and be supplemented by materials from
the commercial health sector and international agencies. School-based educational programs can also be linked to those under MCH programs and to mass media campaigns to increase outreach and impact.

Training. All teachers involved in school-based programs and other workers involved in the delivery of anthelminthics should receive training. Ideally, training is offered as part of continuing education or other worker training programs, rather than being established as a specific program that would require additional resources to implement.

Costs

What are the costs of anthelminthics?

Drug costs depend on the drugs used. Current (1991) quotes from the UNICEF Essential Drug Price List indicate that mebendazole costs US$ 0.07 per dose, while piperazine costs US$ 0.05 per 500mg dose. Acquiring the drugs through local sources is likely to be more expensive but with bulk purchase a single dose of an anthelminth typically costs less than US$ 0.25.

What are the delivery costs associated with mass treatment helminth control?

Management of mass drug delivery by a mobile health team (supervising 200 schools per year) might add US$ 0.20-0.40 cents per child per year, while using a school health worker for a broad range of health-related activities (25 percent of time of one teacher per 500 students) would add 1-2 percent to annual education costs per child.

Few mass programs for intestinal helminths have been costed in detail, but one school-based program in the Caribbean was estimated to have an all-inclusive cost of US$ 1.50 per capita of the total population for 8 cycles over 2.5 years. A single treatment would be considerably less than US$ 1.00, and might be further reduced if existing transport facilities (e.g. school deliveries) or health systems were used. Adding additional therapies, such as micronutrients, to the same delivery system could be achieved for little more than the cost of the additional therapy itself.
INFORMATION AND ASSISTANCE

Key References


Organizations Dealing with Parasite Control

Centre for International Child Health
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30, Guilford Street
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IRC International Water and Sanitation Centre
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Partnership for Child Development
Scientific Coordinating Centre
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Program Against Micronutrient Malnutrition
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WHO
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Switzerland
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