Integrated programme for control of geohelminths: A perspective

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ABSTRACT
Infestation by geohelminths is an important public health problem in developing countries like India. It is a major cause of morbidity in school-age children who have the highest burden of worm infestation. Some of the morbid conditions attributed to intestinal helminthiasis are malnutrition, growth retardation, anaemia, vitamin A deficiency and impaired intellectual performance. Chemotherapy targeted at school-age children has been recommended as a cost-effective and feasible control programme for the control of geohelminths. To optimize resources a geohelminth control programme can be integrated with other existing national health programmes. The availability of drugs such as diethyl carbamazine (DEC) and albendazole, which have anthelminthic and antifilarial properties, opens the possibility of integrating a geohelminth control programme with a filaria control programme. However, co-administration of DEC and albendazole raises several issues of frequency of administration, efficacy, compliance and cost-effectiveness. Thus, integrating a geohelminth control programme with the existing mid-day meal or anaemia prophylaxis programme would be a more appropriate and cost-effective strategy to control geohelminths, alleviate the morbidity caused by them and improve the overall health of the community.


INTRODUCTION
The geohelminths—roundworm, hookworm and whipworm—are among the 10 most common infections in the world and are endemic in many developing countries. The highest intensity of worm infestation occurs in school-age children and is one of the leading causes of morbidity, accounting for 12.3% and 11.4% of disability adjusted life-years (DALYs) lost due to all causes in girls and boys, respectively. The disease conditions generally attributed to geohelminths are malnutrition, anaemia, vitamin A deficiency and impaired cognition. The high prevalence of malnutrition among children in India, despite the existence of national nutritional programmes such as the mid-day meal and anaemia prophylaxis programmes is, perhaps, to some extent due to the heavy infestation of geohelminths in them. A geohelminth control programme could help in improving their nutritional status.

However, constraints of available resources and the increasing number of public health problems in developing countries create the need for integrating several control programmes. India accounts for almost 40% of the total global burden of people with lymphatic filariasis and geohelminths are an important public health problem. The availability of broad spectrum and highly efficacious anthelminthics such as albendazole, which also have some antifilarial action, has opened up the possibility of integrating anthelmintic and antifilarial control measures in areas endemic for filariasis. Helminth control measures might also be integrated with existing nutritional programmes since malnutrition, anaemia and helminthiasis are observed to be important health problems in school-age children in India. The implications of having such integrated control programmes for geohelminths at a national level are discussed in this article.

PROBLEM AND CONTROL OF GEOHELMINTHS
The morbidity caused by geohelminths include malnutrition, growth retardation, vitamin A deficiency, anaemia, etc. and can be alleviated through effective control measures. These measures are particularly recommended in communities with a high prevalence of protein-energy malnutrition. Of the three measures needed for effective control of geohelminthic infections—good environmental sanitation, health education and chemotherapy—improving environmental sanitation and health education are preventive and have a long term impact. Good environmental sanitation and a high standard of living have resulted in a reduction in the prevalence of intestinal parasites in developed countries. However, the community does not perceive the benefits immediately. On the other hand, chemotherapy reduces the intensity of infection and quickly alleviates morbidity. The beneficial effects, though short-lived, are well perceived by the community in the form of expulsion of worms and/or improved appetite, growth, etc. These perceived benefits make chemotherapy the first choice in controlling geohelminths at the community level. However, the best results are obtained when chemotherapy is accompanied by improved environmental sanitation and health education.

ANTHELMINTHIC DRUGS
Levamisole, pyrantel pamoate, albendazole and mebendazole are some of the widely used anthelmintics. The benzimidazole derivatives, albendazole and mebendazole, are more effective than either levamisole or pyrantel pamoate against hookworm and whipworm. While albendazole is highly effective against roundworm
and hookworm, it is not very effective against whipworm.18-23 Mebendazole, on the other hand, is more effective than albendazole against whipworm but has only limited efficacy against hookworm.21,24 Therefore, the choice of drug for control of helminths in an area depends on the prevalent species.

MODALITIES OF TREATMENT
Chemotherapy could be selective, mass or targeted. Selective chemotherapy is time-consuming, expensive and may not be feasible at the community level. Mass chemotherapy of the entire community may not be cost-effective. Since a higher prevalence and burden of worm infestation is seen among the school-age group, treatment of this age group alone is expected to reduce transmission and thereby prevalence in the entire community.25 Therefore, targeted chemotherapy of school-age children is recommended as the most appropriate cost-effective strategy in reducing worm infestation in the community.17 Repeated treatment may ensure that despite re-infection, the infestation is kept below the level at which it causes morbidity.26

RE-INFECTION FOLLOWING CHEMOTHERAPY
Following a single dose of chemotherapy, re-infection occurs within 6-12 months, with the re-infection prevalence and/or intensity reaching almost pretreatment levels.21,23-27 While some investigators have observed a significant reduction in the prevalence and/or intensity of worm infestation when deworming was repeated once in 6 months over a 1-2-year period,18,26-30 others have found it to be effective only when repeated once in 3-4 months.31,32 A study from China reported that after giving albendazole twice a year for 2 years (between 1986 and 1988; 4 cycles), the prevalence of roundworm, hookworm and whipworm infestation was significantly lower than the pretreatment levels and persisted for over 8 years after completing chemotherapy.30 In order to be effective, deworming may have to be repeated at least once in 6 months for 1-2 years. Some studies have shown that in areas where the initial prevalence is very high, the worm infestation might be reduced though there may not be any significant fall in the prevalence.18,23,28,32,33 In a control programme it is more important to monitor the burden of worm infestation than the prevalence.74

IMPACT OF CHEMOTHERAPY ON NUTRITIONAL STATUS, HAEMOGLOBIN LEVELS AND COGNITION
Apart from a reduction in the worm burden and prevalence, several investigators observed an improvement in the nutritional status, haemoglobin levels and cognition of children after single or multiple doses of chemotherapy. Based on the frequency of intervention, these children were evaluated 6 months or 1-2 years after intervention. The reported nutritional benefits were an increase in weight (0.1-1.3 kg), height (0.1-0.6 cm) and mid-arm circumference (0.2-3 cm).18,24,35-48 In a study on preschool children in Lucknow, treatment with albendazole was found to reduce the risk of stunted growth although there was no difference in the overall morbidity or cognition between the treated and untreated groups.49 Following repeated deworming once in 3-6 months, a rise in haemoglobin levels (0.1-2 g/dl) has been observed after 1 year by some investigators.50,51 While Curtale et al.52 observed an increase in serum vitamin A levels following deworming, a slight improvement in cognition has also been observed by some.53,54,55 Objective testing for cognition in these studies involved performing a battery of tests for measuring the attention span, short- and long-term memory and the learning process. The improvement was observed only in a few of the parameters tested. Objective testing for cognition in children is not a simple task and the performance may be influenced by a number of factors. A single performance may not accurately evaluate the cognitive powers and one has to be guarded in interpreting the results of such tests. The prevalence of worm infestation ranged from 29% to more than 95% in these studies and the beneficial effects were seen mainly in malnourished children.

On the other hand, some investigators have not found any significant improvement in the nutritional status or cognition following chemotherapy, despite a reduction in the intensity of worm infestation and prevalence.22,45-47 Some of these studies22,55,56 were carried out in Guatemala, Malaysia and Bangladesh where the prevalence of worm infestation is high (26%-91%). Hadidjaja et al.57 observed that despite a high prevalence of worm infestation (44.5%), more than 80% of the children in the study were well nourished. They also observed an improvement in concentration and eye-hand coordination in the group of children who were given only mebendazole but not in those who had received mebendazole as well as health education. Other investigators also have not noticed any significant improvement in cognition after deworming in well-nourished children.45,57 Beach et al.58 studied the effect of combined ivermectin and albendazole on intestinal helminths and filariasis. They found that while the prevalence and intensity of worm infestation was reduced there was significant nutritional benefit only on stratification. Children who had only roundworms showed a height gain of 0.6 cm, while those who had only whipworms had a weight gain of 0.5 kg after treatment.

While there is unanimity on the efficacy of targeted chemotherapy of schoolchildren in reducing the worm burden and/or prevalence, there is no agreement regarding its impact on the nutritional and haemoglobin status or intellectual function of treated children. Therefore, the benefits and cost-effectiveness of deworming school-age children, particularly in areas of low prevalence, is doubtful.

COST-EFFECTIVENESS AND LIMITATIONS OF SCHOOL-BASED CHEMOTHERAPY
The World Health Organization recommends that mass treatment is warranted where the prevalence of worm infection is more than 50%. At this level of prevalence, the estimated cost per infected child treated with school-based delivery of albendazole is US$ 0.46. If the prevalence is about 25%, the cost per infected child treated would still be less than US$ 1.59 In India, the prevalence of intestinal parasites varies from 12.5% in some parts of Uttar Pradesh to 89.6% in some areas of Chandigarh.60,61 In a cross-sectional survey across the country the prevalence of roundworms was observed to be 16.35%, hookworms 7% and whipworms 3.7%.62 The variation in the prevalence of different species of geo helminths in India is shown in Tables I and II.14,30,41,63-68 Thus, it may not be cost-effective to have a school-based chemotherapeutic control measure all over the country. The other disadvantage of a school-based delivery system would be that it would miss children who are not enrolled or who are absent. Although Raj et al.61 did not find significant school absenteeism in children with intestinal helminthiasis, a study from Egypt found that more than 80% of girls infected with Schistosoma mansoni were not treated because they did not attend school. Olsen63 observed that, of the total population, a school-based programme would treat only between 31% and 50% of infected persons leaving out adults, and preschool and school-age children who were not enrolled. It might
TABLE I. Prevalence of geohelminths in different parts of India

<table>
<thead>
<tr>
<th>Place</th>
<th>Number surveyed</th>
<th>Overall prevalence (%)</th>
<th>Roundworm</th>
<th>Hookworm</th>
<th>Whipworm</th>
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<tr>
<td>Ambala†</td>
<td>586</td>
<td>32.7</td>
<td>12.7</td>
<td>8.4</td>
<td>na</td>
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<tr>
<td>Andaman and Nicobar†</td>
<td>204</td>
<td>79.2</td>
<td>46.2</td>
<td>21.0</td>
<td>21.0</td>
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<tr>
<td>Andaman and Nicobar†</td>
<td>29</td>
<td>82.7</td>
<td>34.5</td>
<td>20.6</td>
<td>48.2</td>
</tr>
<tr>
<td>Andhra Pradesh†</td>
<td>711</td>
<td>77.4</td>
<td>3.0</td>
<td>27.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Arunachal Pradesh*††</td>
<td>893</td>
<td>75.0</td>
<td>45.0</td>
<td>40.9</td>
<td>45.0</td>
</tr>
</tbody>
</table>

- **C 57.1: C 31.9**
- **A 34.8: A 48.4**

<table>
<thead>
<tr>
<th>Place</th>
<th>Number surveyed</th>
<th>Overall prevalence (%)</th>
<th>Roundworm</th>
<th>Hookworm</th>
<th>Whipworm</th>
</tr>
</thead>
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<tr>
<td>Chandigarh††</td>
<td>276</td>
<td>34.5†</td>
<td>7.2</td>
<td>0.7</td>
<td>5.1</td>
</tr>
<tr>
<td>Orissa*</td>
<td>276</td>
<td>19.9††</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pondicherry††</td>
<td>na</td>
<td>na</td>
<td>1.8</td>
<td>0.2</td>
<td>2.8</td>
</tr>
<tr>
<td>Rajastan††</td>
<td>305</td>
<td>32.5††</td>
<td>1.0</td>
<td>11.1</td>
<td>na</td>
</tr>
<tr>
<td>Tamil Nadu††</td>
<td>224</td>
<td>na</td>
<td>85.0</td>
<td>32.0</td>
<td>95.0</td>
</tr>
<tr>
<td>Varanasi†</td>
<td>249</td>
<td>89.6</td>
<td>34.1</td>
<td>24.9</td>
<td>na</td>
</tr>
</tbody>
</table>

- **C 87.6: C 42.4**

* includes prevalence of all intestinal parasites such as *Entamoeba histolytica*, *Giardia*, etc. † urban ‡ rural C children A adults na not available

TABLE II. Prevalence of geohelminths in preschool children in different parts of India

<table>
<thead>
<tr>
<th>Place</th>
<th>Number surveyed</th>
<th>Overall prevalence (%)</th>
<th>Roundworm</th>
<th>Hookworm</th>
<th>Whipworm</th>
</tr>
</thead>
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<tr>
<td>Delhi††</td>
<td>2493</td>
<td>50.6</td>
<td>9.6</td>
<td>2.7</td>
<td>1.4</td>
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<tr>
<td>West Bengal††</td>
<td>211</td>
<td>44.3</td>
<td>8.1</td>
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<td>0.9</td>
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<td>25</td>
<td>44</td>
<td>22.7</td>
<td>31.8</td>
<td>50</td>
</tr>
<tr>
<td>Udaipur††</td>
<td>1022</td>
<td>45.5</td>
<td>10.8</td>
<td>0.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* includes prevalence of all intestinal parasites such as *Entamoeba histolytica*, *Giardia*, etc. † urban ‡ rural

also leave out older adolescents in whom hookworm is more prevalent.

INTEGRATION OF A GEOHELMINTH CONTROL PROGRAMME WITH OTHER NATIONAL PROGRAMMES

Integration with filariasis control programme

In India, filariasis is another nematode infection recognized as an important cause of morbidity in adults as well as children. It is important to treat people during the initial stages of infection to prevent permanent damage to the lymphatic and renal system. India is a signatory to a resolution passed by the World Health Assembly for eliminating filariasis. Success has been achieved in controlling this helminth by repeated community-based chemotherapy. Consequently, as one of the elimination strategies, intense efforts are on to reduce the transmission of filariasis by mass treatment with diethyl carbamazine (DEC), a known effective antifilarial drug given alone or in combination with albendazole or ivermectin, which have also been shown to have antifilarial action. Administering a combination of albendazole with either DEC or ivermectin has been found to produce a rapid and sustained decrease in the prevalence of microfilaraemia. Hence, it has been suggested as an important chemotherapeutic option for reducing the transmission of filariasis. This combination is also presumed to have the added potential of controlling and alleviating the morbidity caused by intestinal helminthiasis. It is expected that these added benefits, perceived in the form of worm expulsion, improved growth and health in children might enhance the compliance rate within the community, and hence is advocated as an important control strategy in some endemic areas. However, the administration of both the drugs together raises several issues.

Efficacy. With respect to filariasis, the efficacy of DEC alone is comparable to that of a combination of albendazole and DEC (personal communication, VCRC). Studies have shown the superior efficacy of albendazole and DEC or albendazole and ivermectin as compared to albendazole alone in treating filariasis. However, the added efficacy of the combined regimen compared with the conventional single dose of albendazole in treating roundworm and hookworm infections has not been studied. Some studies have shown that albendazole in combination with ivermectin was more effective against whipworm than when given alone. In areas where the prevalence of filariasis and whipworm are high, this combination might be considered. The nutritional benefits of anthelminthic treatment were also found to be more significant with the combination therapy than with a single drug. The individual efficacy of albendazole, ivermectin and DEC against helminths is given in Table III.

Frequency. The treatment frequency of the drug combination has to be optimized. While an annual single dose of albendazole and DEC or ivermectin for 4–6 years is recommended for the control of filariasis, studies have shown that the optimum frequency of single-dose chemotherapy for the control of geohelminths may be 6-monthly for 2 years. Therefore, if combination therapy has to have an impact in controlling geohelminths, an annual single dose may not be ideal and it may have to be given at least once in 6 months. In a study from Bangladesh, Taylor et al. comparing 4 different regimens (mass chemotherapy, mass chemotherapy with health education, mass chemotherapy followed by targeted chemotherapy of children every 6 months, and mass chemotherapy with targeted chemotherapy of children along with health education) for control of geohelminths observed mass chemotherapy with albendazole given at an interval of 18 months to be the most cost-effective regimen. Further studies are required to evaluate the efficacy and cost-effectiveness of the annual single-dose combination drug regimen in controlling geohelminths.

Cost-effectiveness. For control of geohelminths the most cost-

TABLE III. Comparison of the efficacy of albendazole, diethylcarbamazine and ivermectin against geohelminths and *Wuchereria bancrofti*

<table>
<thead>
<tr>
<th>Helminth</th>
<th>Albendazole</th>
<th>Diethylcarbamazine</th>
<th>Ivermectin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundworm</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Hookworm</td>
<td>++</td>
<td>–</td>
<td>++</td>
</tr>
<tr>
<td>Whipworm</td>
<td>++</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td><em>Wuchereria bancrofti</em></td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

- not effective or not given + weakly effective ++ moderately effective +++ highly effective
effective strategy is targeted chemotherapy of school-age children since they harbour the highest worm burden.\textsuperscript{17} This needs an assessment of the feasibility and cost-effectiveness of school-based delivery of drugs. On the other hand, the prevalence of filarial infection increases with age and higher prevalence rates are found beyond the school-age group.\textsuperscript{89,90} Therefore, targeted chemotherapy of school-age children alone may not be effective for filariasis and treatment may have to be targeted at the community. Thus, from a school-based targeted chemotherapy of children, the control option will become community-based mass chemotherapy for filariasis and geohelminths. While school-based targeted chemotherapy is cost-effective if the prevalence of geohelminths is >25\%, for community-based mass chemotherapy to be cost-effective the prevalence has to be >50\%.\textsuperscript{99} Although there are a number of studies on the prevalence rates of filariasis and geohelminths in different parts of India,\textsuperscript{63-80, 93} there are little data on the co-existence of these two infections in endemic areas. This information is essential for stratifying geographic areas and age groups according to different levels of prevalence and co-existence of these two infections. Mass chemotherapy with DEC and albendazole may be implemented in those areas and/or age groups with a high prevalence of filariasis and geohelminths. Even then, the added nutritional impact and the cost-effectiveness will have to be resolved before integrating the anthelminthic programme with the filariasis control programme.

INTEGRATION WITH EXISTING NUTRITIONAL PROGRAMMES

Despite a mid-day meal and anaemia prophylaxis programme to provide supplementary calories, protein and iron, respectively, anaemia and malnutrition continue to be important health problems in schoolchildren.\textsuperscript{11-14} Some investigators have observed a nutritional benefit only when deworming of schoolchildren was combined with nutritional supplementation.\textsuperscript{35,50} The overall nutritional, health and intellectual status of schoolchildren may be improved by a combination of deworming, and macro- and micro-nutrient supplementation. This might also prove to be cost-effective. It has been reported that even after consuming mid-day meals, schoolchildren had a 45\% energy deficit.\textsuperscript{22} Despite this deficit, it is possible that growth might improve if anthelminthic measures are combined with the mid-day meal and/or anaemia prophylaxis programmes.

CONCLUSION

Infestation by geohelminths is an important health problem in many parts of India. However, it may not be appropriate to have a uniform school-based geohelminth control programme. The wide variation in the prevalence of different species of geohelminths in India makes it imperative to obtain further epidemiological details at the national level. The anthelminthic drugs used in the control programme have to be effective against the prevalent local species of geohelminths. The positive impact of deworming \textit{per se} on the physical and intellectual development of school-age children is doubtful and needs to be evaluated further, taking into consider-

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