A COMMUNITY-BASED TRIAL FOR THE CONTROL OF LYMPHATIC FILARIASIS AND IODINE DEFICIENCY USING SALT FORTIFIED WITH DIETHYLCARBAMAZINE AND IODINE

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Abstract. To evaluate the effectiveness of salt fortified with diethylcarbamazine (DEC) and iodine for elimination of Bancroftian filariasis and iodine deficiency, all consenting residents of Miton, Haiti (n = 1,932) were given salt fortified with 0.25% diethylcarbamazine and 25 ppm of iodine for one year. Wuchereria bancrofti microfilaria prevalence and intensity, antigenemia, and urinary iodine were measured before and one year after salt distribution began. To measure the effect of DEC-fortified salt on adult worm motility, 15 microfilaria-positive men were examined by ultrasound of the scrotal area. Entomologic surveys were conducted to determine the proportion of W. bancrofti-infected Culex quinquefasciatus. After one year of treatment, the prevalence and intensity of microfilaremia were both reduced by more than 95%, while antigenemia levels were reduced by 60%. The motility of adult worms, as detected by ultrasound, was decreased, but not significantly, by DEC-fortified salt. The proportion of vector mosquitoes carrying infective stage larvae decreased significantly from 2.3% in the nine months before the intervention to 0.2% in the last three-month follow-up period. Iodine deficiency, which had been moderate to severe, was eliminated after one year of iodized salt consumption. The DEC-fortified salt was well accepted by the community and reduced microfilaremia and transmission to low levels in the absence of reported side effects. Based on these results, salt fortified with DEC and iodine should be considered as a concurrent intervention for lymphatic filariasis and iodine deficiency elimination programs.

INTRODUCTION

With an estimated 120 million persons infected and 44 million with elephantiasis or hydrocele, lymphatic filariasis is a leading cause of disability worldwide. In addition to obvious physical manifestations of the infection, sub-clinical lymphatic and kidney damage occur among persons harboring adult worms and microfilaria, respectively. The physical impairments faced by victims are compounded by the social and psychological implications of overt disease. The cost of acute filariasis is estimated at more than four million Disability-adjusted life years (DALYs) worldwide, in addition to the economic burden of lost productivity and medical costs. With the advent of simple and sensitive diagnostic techniques (ICT card tests) and new therapeutic strategies (drug combinations) as well as strategies to control morbidity, widespread interest has developed for the elimination of this disease.

For years, the recommended treatment for lymphatic filariasis has been 12 days of diethylcarbamazine (DEC), a course of therapy that is not amenable to mass treatment campaigns. This drug is an effective microfilaricide and partially effective macrofilaricide, although treatment is often accompanied by adverse side effects including fever, malaise, and headache, related to the death of the microfilaria or painful scrotal nodules associated with the killing of the adult worms. Demonstration of the effectiveness of single dose treatment opened the door to new programmatic options, including mass administration of single dose DEC, ivermectin, albendazole, or combinations thereof, for a period of 5–8 years. Barriers to the successful implementation and completion of filariasis elimination programs based on annual treatment can include 1) the difficulty of developing an infrastructure capable of distributing the drug, 2) the need to achieve high coverage levels, and 3) diminished compliance because of adverse reactions.

Salt fortified with DEC may offer an alternative that avoids many of the difficulties associated with tablet-based elimination programs. In pilot studies under controlled conditions in Brazil, Tanzania, and India and region-wide programs in China and India, DEC-salt (0.1–0.6% [w/w]) was shown to be a very effective microfilaricide. The low dose of DEC in these studies was well tolerated and rarely associated with adverse reactions. Fortified salt (e.g., iodized salt) can also be provided to a population without developing a dedicated distribution system. These potential advantages led us to ask about the feasibility of using dual fortified salt for elimination of filariasis and iodine deficiency in Haiti, in a village setting where both filariasis and iodine deficiency are present.

MATERIALS AND METHODS

Study population. The community of Miton, with a population of approximately 2,000, is located 30 km west of Port-au-Prince, Haiti, and 2.5 km east of the larger township of Leogane. This community was selected as the study site because of the existence of an established community health care infrastructure centering on the Saint Croix Hospital in Leogane. Miton also has well-defined borders and is surrounded by sugar cane fields, creating an isolated and compact study area. Preliminary entomologic studies demonstrated the presence of Wuchereria bancrofti infective-stage larvae (L3) in trapped mosquitoes. In addition, previous examination of urinary iodine in Leogane school children showed moderate to severe iodine deficiency in this cohort.

Community mobilization and informed consent. The protocol for this study was reviewed and approved by the...
Sodium iodide status was determined before salt distribution comenzamento. The population's median iodine values were assessed using the ICCIDD/UNICEF guidelines to assess the level of iodine deficiency. Women of childbearing age were asked to indicate if they became pregnant. Microfilaremia was determined by direct microscopic examination of a capillary filled with blood. The number of microfilariae per milliliter of blood was counted. Salt preparation and analysis. The salt premix of 0.25% DEC and 25 ppm of iodine (recommended by WHO/UNICEF/ICCIDD) was prepared by the University of Iowa School of Pharmacy. The resulting fortified salt was analyzed by the University of Iowa to verify even distribution of DEC and iodine throughout the fortified product. The salt was packaged in 1-kg labeled polyethylene bags and then shipped to Haiti. Distribution of salt and monitoring of salt consumption. Each household was visited monthly and at that time census information was collected and an amount of salt anticipated to be required for the next month was distributed (15 grams per person per household x the number of days). Extra salt was also available for families who requested it. Overall, salt consumption was estimated by determining the salt consumed per household per month and dividing by the number of persons residing in the household for each month.

Iodine deficiency. Urinary iodine was measured before and 12 months after salt distribution began. Matched urine specimens were collected from a convenience sample of persons in the community (n = 260, median age = 13 years, range = 0–90) to determine the effect of the iodized salt on community iodine deficiency. Urinary iodine concentrations were analyzed by means of manual acid digestion and spectrophotometric detection of iodine by ceric ammonium reduction in the Sandell-Kolthoff reaction. Current WHO/ICCIDD/UNICEF guidelines were used to assess the level of iodine deficiency (median iodine values [grams/liter]: <20 = severe iodine deficiency, 20–49 = moderate, 50–99 = mild, and >99 = no iodine deficiency.).

Parasitologic examinations. Baseline W. bancrofti infection status was determined before salt distribution commenced. Stool samples were collected and processed by a modified concentration technique to assess parasite infection and burden. Stool specimens were collected and processed by a modification of the Asah and Orihel formalin-ethyl acetate concentration technique to assess parasite infection and burden as previously described. Briefly, 1 ml of feces was measured by displacement into 9 ml of 10% formalin, strained through gauze to remove debris, and concentrated by centrifugation (10 min at 500 x g). The sediment was resuspended in 10% formalin, mixed with ethyl acetate, and the centrifugation was repeated. The final volume of sediment was resuspended in 10% formalin (total volume = 2 ml) and 0.05 ml was examined microscopically for intestinal parasites. Infection intensity (eggs per gram of feces [epg]) was estimated by multiplying the ova or parasites counted x 2 ml/0.05 ml. Worm burden was defined by epg: A. lúcias: light <7,000 epg; medium 7,000 to ≤35,000 epg; heavy >35,000 epg; Trichuris: light <1,000 epg; medium 1,000 to ≤10,000 epg; heavy >10,000 epg; hookworm: light <2,000 epg; medium 2,000 to ≤7,000 epg; heavy >7,000 epg. Specimens were collected before salt distribution and 3 months after. Salt was distributed, and monitoring adult worm motility before and 12 months after salt distribution began. Fifteen microfilaremic adult men were examined by ultrasound, using a 5.0-MHz transducer (Acuson, Mountain View, CA). The scrotal areas were examined microscopically for intestinal parasites. Infection intensity (eggs per gram of feces [epg]) was estimated by multiplying the ova or parasites counted x 2 ml/0.05 ml. Worm burden was defined by epg: A. lúcias: light <7,000 epg; medium 7,000 to ≤35,000 epg; heavy >35,000 epg; Trichuris: light <1,000 epg; medium 1,000 to ≤10,000 epg; heavy >10,000 epg; hookworm: light <2,000 epg; medium 2,000 to ≤7,000 epg; heavy >7,000 epg. Specimens were collected before salt distribution and 3 months after it began. All Miton residents (excluding pregnant women and children less than two years old) were offered treatment with mebendazole (oral, 200 mg per day for 3 days) after the three-month follow-up.

Assessment of adult worm motility. The adulticidal efficacy of sustained low-dose DEC was investigated by monitoring adult worm motility before and 12 months after salt distribution began. Fifteen microfilaremic adult men were examined by ultrasound, using a 5.0-MHz transducer (Acuson, Mountain View, CA). The scrotal areas were examined microscopically for intestinal parasites. Infection intensity (eggs per gram of feces [epg]) was estimated by multiplying the ova or parasites counted x 2 ml/0.05 ml. Worm burden was defined by epg: A. lúcias: light <7,000 epg; medium 7,000 to ≤35,000 epg; heavy >35,000 epg; Trichuris: light <1,000 epg; medium 1,000 to ≤10,000 epg; heavy >10,000 epg; hookworm: light <2,000 epg; medium 2,000 to ≤7,000 epg; heavy >7,000 epg. Specimens were collected before salt distribution and 3 months after. Salt was distributed, and monitoring adult worm motility before and 12 months after salt distribution began. Fifteen microfilaremic adult men were examined by ultrasound, using a 5.0-MHz transducer (Acuson, Mountain View, CA). The scrotal areas were examined microscopically for intestinal parasites. Infection intensity (eggs per gram of feces [epg]) was estimated by multiplying the ova or parasites counted x 2 ml/0.05 ml. Worm burden was defined by epg: A. lúcias: light <7,000 epg; medium 7,000 to ≤35,000 epg; heavy >35,000 epg; Trichuris: light <1,000 epg; medium 1,000 to ≤10,000 epg; heavy >10,000 epg; hookworm: light <2,000 epg; medium 2,000 to ≤7,000 epg; heavy >7,000 epg. Specimens were collected before salt distribution and 3 months after it began. All Miton residents (excluding pregnant women and children less than two years old) were offered treatment with mebendazole (oral, 200 mg per day for 3 days) after the three-month follow-up.

Entomologic assessment. To assess the impact of fortified salt on filarial transmission, the proportion of W. bancrofti-infected vector mosquitoes was estimated. Five gravid mosquito traps (Bioquip, Gardena, CA) were distributed evenly on a 1.3-km tangent along the main road through the center of Miton (Figure 1). Traps were operated every 2–3 weeks, for four consecutive nights, beginning nine months before and continuing throughout the period of salt distribution. Trapped female Culex quinquefasciatus were dissected individually and examined microscopically for the presence of W. bancrofti first-, second-, and third-stage larvae.

Statistical analysis. Prevalence data for W. bancrofti microfilariarla and antigenemia and intestinal parasites were analyzed using the MacNamara chi-squared test for matched individuals. Differences in pretreatment and post-treatment geometric mean intensity of these infections were analyzed by Student’s t-test using the log-transformed data (logarithm of the actual count (n) + 1). Percent reduction in microfilaremia (log transformed data) and antigenemia was determined by dividing the difference between pretreatment and post-treatment concentrations by the pretreatment value. Differences in reduction of antigenemia with respect to age group were analyzed by the Kruskal-Wallis test. Poisson regression was used to investigate the effect of treatment on...
number of infected mosquitoes, while controlling for month to month changes.

RESULTS

Initial community support for the program was high; only four of the 355 families in Miton were not interested in participating. All of the 355 households eventually agreed to take part in the study except one (4 members who were unwilling to accept the proffered explanations of the causes of elephantiasis and were also concerned about the safety of the fortified salt). Of the 1,932 people participating in the study, 947 (49.3%) were less than 18 years old and 1,020 (52.9%) were female.

The population of Miton was 1,932 when the study began and 239 new people moved in to the area in the 12 months of fortified salt distribution. More than half of the new enrollees (140) joined in the first three months of the program and may represent individuals who were reluctant to give their names until the program was well accepted by the community. Seventy-eight persons moved out of Miton during the study period and were offered DEC tablets (6 mg/kg) and their supply of fortified salt was discontinued.

In our study community, daily consumption rates for the fortified salt ranged from 11 to 39 grams, with an average of 19 grams per person per day. For a 50-kg adult, this amount of salt correlated to a yearly intake of 347 mg of DEC per kilogram of body weight, or 4.8 times that supplied by a 12-day course of DEC. There was no evidence of leakage of the fortified product to the local market or of hoarding, but the fortified salt may have been given to family members or friends who were living outside of the project area or used for purposes other than for food.

Urinary iodine levels were measured to assess the level of iodine deficiency in the community. The median urinary iodine level was 43.4 μg/L before the intervention, a level correlating with a designation of moderate iodine deficiency for the community.29 One year after introduction of the iodized salt, the distribution of urinary iodine concentrations shifted substantially towards higher values, and the median urinary iodine levels increased to 316.0 μg/L, indicating that iodine deficiency had been eliminated (Figure 2).

For persons who provided samples before and 12 months after the intervention started, the microfilarial prevalence before salt distribution was 20.1% (82 of 409), and 1.0% (4 of 409) after one year ($P < 0.0001$) (Figure 3). The geometric mean intensity of infection decreased by 98.8% after 12 months of DEC-salt. Similar reductions in microfilaria prevalence and intensity were observed when all specimens collected were included in the analysis ($n = 719$ at time zero and $n = 441$ at 12 months, respectively). Of the population tested before treatment, 40.2% (140 of 348) were antigen positive. The prevalence of antigenemia increased with age, and ranged from 23.2% (13 of 56) for children ≤ 5 years
old to 64.7% (11 of 17) for persons greater than 60 years old. Antigen levels decreased in intensity for 95% (133 of 140) of the infected population with a median reduction in antigen levels of 59.8% from pretreatment values. The degree of reduction in antigen levels was not correlated with pretreatment microfilarial status but was significantly greater in children ≤ 10 years than in older persons (Table 1).

After collection of baseline microfilaria data, all of the microfilaria-positive men (greater than 17 years old) were invited to the hospital for an ultrasound examination. Of the 19 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination. Of the 15 men who received two ultrasound exams, 14 men, four were eventually excluded from analysis, with one refusal, two persons moving out of the study area, and one with a large hydrocele that hindered accurate examination.

Our results show that salt co-fortified with diethylcarbamazine and ibonazole produces a dramatic reduction in microfilaria prevalence and intensity, reduces the prevalence of W. bancrofti infection in mosquitoes, and eliminates iodine deficiency. The reduction in microfilaria prevalence that we observed at 12 months was as great as that obtained in our previous clinic-based studies using a combination of DEC with ivermectin or ivermectin and albendazole.31,32 However, our current results are significantly better than we obtained in community-based programs using ivermectin or combinations of DEC and ivermectin (Streit TG, unpublished data). Similarly, in previous community-based studies using ivermectin, we did not see a sustained reduction in the prevalence of infective-stage larvae (L3) in vector mosquitoes. (Streit TG, unpublished data). The dramatic reduction in parasite prevalence that we observed is consistent with results reported from other studies and highlights one of the potential challenges:

**Table 1**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>Pretreatment</th>
<th>Post-treatment</th>
<th>% Reduction</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>45</td>
<td>740.9</td>
<td>279.6</td>
<td>68.5%</td>
<td>0.001</td>
</tr>
<tr>
<td>&gt;10</td>
<td>95</td>
<td>647.2</td>
<td>300.2</td>
<td>57.0%</td>
<td></td>
</tr>
</tbody>
</table>

Pretreatment microfilaria status
- Positive: 67 (1,056.0 to 420.0) with 59.0% (0.23)
- Negative: 73 (404.0 to 177.1) with 60.3%

*P values refer to the difference in % reduction in antigen level for different groups, as defined by age or microfilarial status. Analysis is restricted to antigen-positive persons. P values were determined by the Kruskal-Wallis test.

**Table 2**

<table>
<thead>
<tr>
<th>No. (%) of men with adult worm nests</th>
<th>Pretreatment</th>
<th>One year post-treatment</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence</td>
<td>12 (80%)</td>
<td>8 (53.33%)</td>
<td>0.10 (NS)</td>
</tr>
<tr>
<td>Geometric mean no. of nests per person</td>
<td>0.94</td>
<td>0.53</td>
<td>0.11 (NS)</td>
</tr>
</tbody>
</table>

*By MacNemar’s chi-square test. NS = not significant. Duration of each scrotal examination was 30 min. Seven of 15 men had a decrease in the number of adult worm nests (7 remained the same and 1 increased in number).

**DISCUSSION**

Our results show that salt co-fortified with diethylcarbamazine and ibonazole produces a dramatic reduction in microfilaria prevalence and intensity, reduces the prevalence of W. bancrofti infection in mosquitoes, and eliminates iodine deficiency. The reduction in microfilaria prevalence that we observed at 12 months was as great as that obtained in our previous clinic-based studies using a combination of DEC and ivermectin (Streit TG, unpublished data). Similarly, in previous community-based studies using ivermectin, we did not see a sustained reduction in the prevalence of infective-stage larvae (L3) in vector mosquitoes. (Streit TG, unpublished data). The dramatic reduction in parasite prevalence that we observed is consistent with results reported from other studies and highlights one of the potential challenges:

**Figure 4**

Infection of the vector Culex quinquefasciatus with Wuchereria bancrofti. There were 4,006 female Culex quinquefasciatus mosquitoes examined during the nine months preceding treatment and 5,226 were examined throughout the following 12 months. Mosquitoes collected in the treated group were significantly less likely to carry W. bancrofti (P = 0.0001) than were those collected before treatment.
tial advantages of DEC-salt for filariasis elimination programs, specifically its effectiveness.\textsuperscript{17,20,21,23,33}

Adverse reactions associated with the death of the adult worm or microfilaria, which are often observed with more concentrated doses of DEC, were not reported by the community. It is important to note that surveillance for adverse reactions was passive rather than active, and this passive surveillance relied on health workers to report any side effects that they may have observed or were reported to them by members of the community. This approach does not exclude the possibility that undetected side effects occurred; nonetheless, they were not severe enough to come to the attention of the health workers nor did they discourage the continued use of the salt; a frequent problem with conventional DEC treatment. Furthermore, in other fortified-salt programs, where millions of people were treated with DEC-fortified salt (China and India), adverse reactions were rarely reported.

The absence of reported side effects was undoubtedly one of the reasons that the community support for the project remained strong throughout the entire one-year study period. Participants in this study were encouraged, though not required to use the fortified salt, and compliance exceeded 99%. Admittedly, this salt was delivered to each community member’s home, once a month, free of charge and it is difficult to extrapolate from this situation to one where DEC-fortified salt might be offered on the open market at market price. Experience in China with a government controlled salt industry also achieved very high coverage (\textgreater{} 97%) with similar reductions in microfilaria.\textsuperscript{22} In Karaikal in southern India where 120,000 persons were treated with DEC-salt, investigators worked hand in hand with salt producers to ensure that all salt that reached consumers was fortified. Programs based on pill distribution will find it difficult to achieve this level of coverage for several reasons: 1) locating each and every resident in a particular area is inherently a difficult, time-consuming, and laborious process; 2) current recommendations for programs using tablets of DEC or ivermectin are to exclude pregnant women and children less than two years of age; and 3) when individuals experience side effects caused by the death of microfilariae or adult worms, it is likely more difficult to convince them to take the pills again the following year. Without an intensive educational effort, persons experiencing adverse reactions might be less likely to accept medication in a second or third round of treatment and may negatively influence the compliance of relatives or friends. In addition, the need for multiple years of treatment will further decrease participation, a phenomenon noted in other public health programs. For example, experience with DPT vaccination efforts in Senegal and elsewhere has shown a decrease in compliance of repeated treatments even in the absence of adverse reactions. Even when first-round coverage exceeded 80\%, subsequent years of treatment often decreased by 10–15\%.\textsuperscript{24}

Perhaps the most attractive reason for using DEC-salt for elimination of lymphatic filariasis is the hypothetical ease with which it could be incorporated into existing salt iodization programs, thereby making the program more likely to be self-sustaining. Iodized salt has been proven in this study and countless others to be a very effective means of delivering adequate levels of iodine to deficient populations at a reasonable cost. Cost comparisons of several drug treatment regimens including mass distribution of single-dose DEC and DEC-salt in Tanzania predicted similar costs for both strategies.\textsuperscript{35} Interest in expanding the use of DEC-salt in other endemic areas has been limited because of a number of concerns related to the difficulty of controlling salt distribution. Distribution of salt, unlike pills, necessitates collaboration among salt producers, healthcare providers, and government officials. This collaboration is necessary to ensure quality control of the fortification process and high fortification rates. Fortified salt, as a passive approach, would make high coverage rates more feasible, especially if fortification was mandated at the national level. Efforts to iodize salt by international organizations such as UNICEF have paved the way for national dual fortification programs in regions where filariasis and iodine deficiency co-exist. Fortification of salt with DEC and iodination are technically similar processes. Even using manual mixers, it is possible to accomplish adequate mixing using either a powder-based or liquid formulation of the premix. However, in areas where salt is not already iodized, it may require more investment in infrastructure to begin a fortified salt program.

In this study, we chose to fortify salt with 25 ppm of iodine, based on World Health Organization recommendations, and the population responded rapidly. Based on our median urinary iodine values after one year of iodized salt consumption and a relatively high salt consumption rate in this population (19 grams/person day versus a predicted intake of 15 grams/person day based on worldwide averages), we probably could have used 20 ppm and still achieved elimination of iodine deficiency.

Ultrasound examination of adult worm motility did not provide conclusive evidence that the salt was affecting adult worms, although nearly half of the men followed experienced a decrease in the number of adult worm nests. Because of the absence of a control group, it is impossible to tell if this decrease was due to an adulticidal action of DEC, nat-
ural attrition of the adult worms, or was merely a chance event in a small sample size. If DEC in the salt were killing the adult worms by the same action as is observed with higher single doses of DEC, we would have expected to observe painful scrotal nodules in the community. In any case, the absence of adverse reactions is a meaningful finding, since this may make higher levels of coverage achievable with DEC-salt.

Antigen assays did not provide unambiguous evidence of the macrofilaricidal effects of DEC-salt. There was an almost universal reduction in antigen levels, and the level of reduction was not associated with pretreatment microfilaria status. Therefore, decreased antigenemia could not be attributed only to clearance of microfilaria from the blood. Reductions in antigen levels may be related in part either to the adulticidal action of the DEC-salt or to normal attrition of the adult worms in the absence of re-infection. The percent reduction in antigen levels was greater in children less than 10 years old than in the general population. It is not clear why this might be the case, although preliminary evidence suggests that adult worms may reside in different anatomic locations in children and adults.36 If true, it is possible that in children, W. bancrofti are more accessible to the adulticidal mechanisms triggered by DEC. Alternatively, children and adults may have different proportions of susceptible and non-susceptible adult worm populations.37,38

DEC-fortified salt appeared to affect intestinal parasite infection prevalence and intensity. It should be noted that in this setting, we have observed that helminth infection prevalence and intensity may vary seasonally. Since our study did not include an untreated group monitored in parallel, the observed decreases in prevalence and intensity may not be related to the consumption of fortified salt. The decreases observed also were not comparable with those achieved by commonly used anthelminthic drugs such as mebendazole or albendazole. This fact must be considered when designing community-wide treatment programs for lymphatic filariasis. Albendazole, in particular, is effective against Ascaris, Trichuris, and hookworm. Equivalent reductions in the prevalence and intensity of these infections cannot be realized with DEC salt alone. At this time, there are no data on the effectiveness of combined treatment with DEC-salt and albendazole, or whether a synergistic effect will be observed for filarial and intestinal parasite clearance as has been reported for the ivermectin/albendazole combination.31,39 Further exploration into the combined usage of DEC-salt with an anthelminthic drug is warranted for combined antifilarial and antihelminth control programs.

In summary, a successful lymphatic filariasis elimination program must interrupt transmission of the infection and maintain a high coverage rate to reduce the opportunity for resurgence of transmission. We have shown that salt fortified with DEC and iodine can effectively interrupt transmission of lymphatic filariasis without eliciting severe side effects and provide an added benefit by eliminating iodine deficiency. High levels of coverage, low cost, and feasibility argue that salt fortified with DEC should be seriously considered for lymphatic filariasis elimination programs. Further research at the operational level is now required to determine how long programs based either on DEC-salt or pill distribution will have to last to completely eliminate transmission of filariasis. Ideally, such efforts will also permit a more detailed comparison of the relative merits of these two strategies.

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References


