MONITORING USE OF MONOFILAMENT NYLON WATER FILTERS FOR GUINEAWORM CONTROL IN A RURAL NIGERIAN COMMUNITY*

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ABSTRACT

Guineaworm, a disabling waterborne helminthic disease, has been targeted for eradication from endemic areas of Africa and South Asia. One short-term intervention consists of filtering pond water through a clean cloth. Monofilament nylon cloth has been found to be more effective in straining out the vector–various species of the small crustacean, cyclops–than local cotton cloth, though the former is more expensive. A concern with any new technique is whether the community will accept the idea and subsequently use it properly. Previous reports in this series have documented the process by which the rural community of Idere, Nigeria, through its volunteer primary health workers, was involved in production, distribution, and education concerning filters. One-third of households in monitored sections of the community bought filters, while others thought that filters could not prevent the disease, cost too much, or were inferior to other solutions (e.g., wells). This report looks at filter use and factors associated with use and durability. Monthly monitoring visits by a field assistant served to identify problems and reinforce correct and continued filtration. Mobility of the population between farm and town hampered regular use. Difficulty in understanding the nature of

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the nearly invisible vectors meant that users did not perceive tiny holes in their filters as dangerous. While filters were ultimately seen as useful in guineaworm eradication efforts, they should not take the place of more long-term community water supply interventions which will have a greater impact on community and women's development.

Guineaworm is a disabling waterborne helminthic disease that is transmitted with the assistance of a small crustacean vector known as cyclops. Various species of cyclops are found in the ponds, water holes, and step wells of rural Africa and south Asia where the disease is endemic. They swallow guineaworm larvae that are released when a person with an open guineaworm ulcer wades into a pond. After growing for two weeks inside the cyclops, the guineaworm larvae have reached an infective stage, allowing the disease to spread when people drink water containing these cyclops.

Though guineaworm does not kill, it is responsible for much disability, suffering, and loss of productivity caused by the painful ulcers, usually in the lower limbs, where the worm emerges [1]. Children miss weeks of school [2]. Mothers are rendered incapable of performing domestic and economic duties [3]. Farmers must leave crops unharvested or new fields unplanted [4].

The existence of guineaworm is symbolic of the neglect that characterizes rural areas in developing countries [5]. A nation's ability to eliminate guineaworm therefore is a sign of its political will to improve the lot of rural people. Several approaches to the problem are available [6, 7].

Long-term measures to eliminate guineaworm focus on provision of safe and reliable water supplies such as pipe systems, bore hole wells, and even simple hand dug wells. Using these interventions in all endemic villages is often more expensive than communities and governments can immediately afford. In Nigerian alone, it is estimated that over 6,000 villages currently harbor the disease, while two or three times that number are still at risk because of their poor water quality [8].

Short-term control measures include boiling water, which is not acceptable in most communities. Ponds can be protected or guarded to prohibit infected persons with open guineaworm ulcers from wading. An easier measure would be simply to filter pond water through a piece of clean cloth as this could catch cyclops large enough to contain guineaworm larvae [9].

THE FILTER OPTION

Though easier, filtering is not without its problems, both technical and behavioral. Cotton cloth becomes clogged with pond mud and debris after several uses [10]. This makes filtering slower and frequent cleaning necessary. Irregularities in weave mesh size and small tears in the cloth will allow cyclops to pass, and one infected vector is enough to spread the disease. Nylon cloth has been found more durable [10], and can, in a monofilament form, be made to exact mesh size standards which will not allow infected cyclops through [11]. Unfortunately, this monofilament is more expensive than the locally available cotton cloths.

Behavioral concerns are several and begin with the fact that the act of filtering must be done every time family drinking water is collected from the pond to guarantee that the disease cycle is broken in that one home. Then, family members must be sure that they do not drink unfiltered water when they visit friends and neighbors. If the whole village wishes to rid itself of guineaworm using the filter strategy, everyone must practice this behavior for upwards of two years. This long duration of preventive action is necessary because the life cycle, from drinking water containing infected cyclops until the mature guineaworm breaks through with an ulcer on one's leg, takes approximately twelve months.

The act of filtering can be made easier by the design of the filter. The simplest form, a plain piece of cloth held over the pot, is also the most awkward since one family member must hold the cloth while a second person pours the water. Equipping filters with rubber bands, draw strings, or small weights at the edges are alternatives that allow one person to filter effectively.

The issue of encouraging regular use of filtering is the subject of this article, which follows previous reports on the process of involving the community in production and distribution of monofilament nylon filters [12, 13]. In the small community of Idere in southwestern Nigeria, a primary health care approach was used wherein volunteer primary health workers (PHWs) took major responsibility for organizing local tailors to produce the filters, for educating the community on filter use, and for selling the filters at cost to local residents. About one-third of Idere households purchased a filter. This article explores whether purchasers actually used the filter and did so properly.

METHODS

The filter project spanned a fifteen-month period (1985-86) during which baseline survey, technical development, filter production and distribution, purchase and use monitoring, and a follow-up survey were conducted. The goal of the project was to test the social acceptability of monofilament nylon water filters in the broader context of primary health care and guineaworm control in the Idere community.

The Study Community

Idere, like many towns in southwestern Nigeria, consists of a main settlement (8,000 people) surrounded by many small farm hamlets averaging about fifty residents each. The dispersion of the population made it difficult to serve the whole community when pipeborne water was installed in 1968. Consequently, when the pipes failed in the mid 1970s, hamlet residents who still suffered from guineaworm, reintroduced the disease into the main settlement during their weekend and holiday visits. A major lesson for guineaworm control learned from this settlement pattern was the need for a multi-strategy approach [7].

Prior to 1985, the main focus of control had been the promotion of improved water sources (hand dug wells) through community effort. The poor quality of local well technology, the increasing costs of materials for improved wells, and the very rocky soil in many corners of the community meant that dug wells could not be the total solution. Borehole wells were not even considered due to their high cost and the low ground water yield in the area.

Filters therefore offered an opportunity to protect the smaller hamlets and those sections of the community with poor soil conditions. The UNDP/World Bank/WHO Special Programme of Research and Training in Tropical Diseases (TDR) agreed to provide monofilament nylon cloth for the project and fund monitoring of use.

Setting Up the Project

The first preparatory step was to identify the technical and social aspects of filter design which in turn would determine correct use procedures and form the foundation for monitoring. The baseline survey documented common pot mouth widths and residents' familiarity with the filtering concept [13]. The nylon cloth was also tested by a research assistant to determine the conditions under which cyclops might survive in the monofilament cloth and inadvertently wind up in drinking water. Discussions with local tailors and inspection of materials available in the market rounded out the preparatory phase.

The volunteer PHWs, a few local traders, and one research assistant began the distribution and sale of the filters on October 1, 1985, just before the beginning of the guineaworm transmission season. (It is worth noting that the proceeds from sales were contributed to a community well fund.) The research assistant was not originally slated to distribute filters but, during his visits to the more distant hamlets that did not have resident PHWs, requests from these villagers for filters made it necessary for him to carry a supply at all times.

Steps in Monitoring

The monitoring process also began in October and continued through March 1986. The research assistant, a local resident, and recent secondary school graduate, visited every household in each Idere hamlet plus a sample of extended family compounds in the main town. The selected town compounds consisted of all where a PHW was resident and an equal number where one was not, making a total of thirty compounds out of the seventy-five in town.

The monthly monitoring form consisted of two parts: one to note the current filter ownership status of the home and basic demographic information about the household, and the second to record on every visit after filter acquisition the condition of the filter, reported use and opinions and problems arising from its use. Filters were purchased throughout the dry season. Consequently, use was monitored from between one and five months, depending on when the family bought their filter.

At the first visit after purchase, filter users were questioned on correct filtering procedures. On this and subsequent visits the research assistant not only inspected the filter for dirt and tears, but also noted where and how it was stored after use and requested owners to demonstrate use.

Monthly monitoring was discontinued in April after the rainy season began and guineaworm transmission ceased. A follow-up survey was conducted with the assistance of medical students in October 1986 in one cluster of sixteen hamlets to determine current use, retained knowledge of correct use, and filter condition.

Limitations of the project include quality of monitoring and measures of outcome. A choice was made between gathering indepth data on a small group of filter buyers and looking at the broad scope of filter adoption in the community at large. The result was monthly visits to 779 households using indirect methods (filter condition, ability to demonstrate, and verbal reports) as proxies for actual use.

The second limitation was inability to monitor subsequent guineaworm incidence as funding covered only a one-year period. Since filters were sold throughout one transmission season, the effect, if any, could not be observed fully until at least two more transmission seasons had passed. For example, persons who bought their filter in December 1985 may have already become infected before purchase and use. They would still come down with guineaworm in the 1986-87 season, necessitating nearly two years of continual filter use before efficacy could be judged.

RESULTS

Presentation of results parallels the stages of program development and study, beginning with baseline work that helped establish correct use procedures that formed the basis for monitoring.

Filter Use Procedures

Experiment with the cloth itself showed that cyclops could survive in a damp cloth overnight. The chance for survival was increased if the filter was not shaken out after use, if it was left folded, and if it was kept like this inside the house. This implied that if a person used the filter again the next morning and placed it on the pot reverse side up, cyclops could be washed into the pot.

Background discussions with local tailors found that they felt capable of sewing the monofilament nylon, and suggested sewing rubber strips (cut from old inner tubes and commonly sold in the market for sling shots) in a band to help hold filters on the pots. When told of the problem of using the filter upside down, the tailors suggested sewing the band with two colors of thread such that black would show on top and white underneath.

The baseline survey revealed that 56 percent of 371 persons interviewed were aware of filtering as a water treatment procedure, and 10 percent reported actual practice. Both awareness and reported practice were significantly higher in hamlets and compounds where a PHW was resident [13]. This meant that filtering was not a totally alien idea, and that education on correct use of the monofilament filter would build on an existing foundation.

From the above, ten steps for correct filter use were developed as follows:

1. Place filter on pot with black thread facing upwards.
2. Allow filter to sag slightly so water will not splash.
3. Pour water slowly.
4. Let all the water drain out.
5. Remove filter carefully to prevent cyclops falling in.
6. Shake out filter after each use.
7. Wash the filter after use.
8. Hang the filter outside to dry.
9. Store in safe place to avoid sharp objects.
10. Inspect filter before use for holes and tears.

Findings from Monthly Monitoring

A total of 254 households obtained filters among the 779 monitored. Most purchasers (94%) said that the PHW or other salesperson had both explained and demonstrated filter use. One person said she received neither explanation nor demonstration, while the remainder had been given explanation only.

The initial knowledge test on first visit after purchase showed that users generally remembered what they should have been told by the salesperson: 99 percent knew why they should place the black thread upwards; 96 percent said that the water should be poured slowly; 94 percent noted that all water should be allowed to drain out before the filter is removed from the pot; 94 percent remembered that the filter should be shaken out after use; 98 percent mentioned washing the filter; and 93 percent said it should be hung outside to dry.

A moderate number (74%) cited the need to remove the filter carefully from the pot, and about half (53%) remembered to allow the filter to sag in the middle before pouring. Few (34%) mentioned the need to protect the filter from sharp objects and less (28%) noted the requirement to inspect the filter for holes before use.

A first month filter inspection was possible with 150 owners. Four had purchased theirs on the very last visit of the research assistant. Of the remaining 250, 37.2 percent were not at home at the time of the village visit and 4.4 percent had

Table 1. Problems Observed during Monthly Filter Inspection

Observations	Month of Ownership (Percent)				
	One	*Two*	*Three*	*Four*	*Five*
Stored in open	33.3	36.4	49.0	33.3	28.6
Stained	20.7	24.5	33.7	21.0	28.6
Used upside down	14.7	14.5	16.3	11.4	16.7
Rubber band broken	1.3	0.9	2.0	1.7	0
Difficult fit pot	1.3	0.9	0	0.9	0
Dry inside house	0.7	0	1.0	0	2.4
Number Observed	150	110	98	114	42
Total filters purchased	250	181	154	133	48
% Left filter elsewhere	4.4	6.0	5.8	1.7	4.5

left their filters at another residence, demonstrating the mobility between town and hamlet.

The most common problems observed after one month of use included filters stored in the open where they could be damaged by sharp objects (33%). On demonstration, 15 percent of users placed the filter upside down on their pots. The rubber band had broken on two filters (and these were replaced for free by the research assistant). One person was found to be drying her filter inside the house.

Two complained of trouble fitting the filters on their pots. This problem arose because of a technical difficulty. The baseline survey of drinking water pot sizes found them ranging from six to twenty-five inches in diameter. Thus, filters were made in small, medium, and large sizes. It became uneconomical to make filters larger than twenty-three inches across. Persons who had difficulty fitting their filters either had a pot larger than twenty-three inches or had tried to economize by buying a medium sized filter (twelve to sixteen inch diameter pot) for a larger pot.

These problems persisted at about the same frequencies during subsequent months of monitoring (see Table 1). Of the forty-eight persons who bought their filters in October, it was possible to monitor forty-two in March (the fifth month of use). Four were not at home, and two had left their filters elsewhere. Here too, 29 percent stored in the open and 17 percent demonstrated putting the filter on upside down.

During the whole monitoring period only seven filters had broken rubber bands. The rubber bands were generally 3/16-inch wide, but were irregular as they had been hand cut. Breaks occurred where the bands were too thin. No holes and tears were observed during this initial monitoring period. About one-third of filters

Table 2. Comments about Filters Made during Monthly Monitoring

Comments	Month of Ownership (Percent)				
	One	*Two*	*Three*	*Four*	*Five*
Removes impurities	42.0	59.1	69.4	50.0	57.1
Removes leaves and insects	13.3	22.7	36.7	45.6	50.0
Fast	20.0	24.5	6.1	0.9	0
Easy to use	11.3	12.7	7.1	1.8	0
Good/healthy	19.3	7.3	4.1	1.8	0
Prevents drinking dirty water	2.7	1.8	6.1	6.1	4.8
Better than boiling	2.7	0	5.1	2.6	0
Useful	2.0	0.9	0	0	0
No comment	21.3	10.9	9.2	2.6	0
Number	150	110	98	114	42

were found to be stained gray or brownish at any one visit, possibly a result of storing in the open near the cooking fire, but stains did not seem to impair functioning.

As would be expected, almost all owners reported during the monthly visit that they used the filtered water primarily for drinking. The second most common use–cooking–was mentioned by an average of 40 percent each month. A few (7% average) reported washing dishes with filtered water. One or two each month said they bathed with the water.

Water collection patterns showed an equal division between those who reported collecting daily and those who collected their drinking water every other day. Both morning and evening were popular water fetching times.

Table 2 shows the comments made about the filters by users at each monthly monitoring visit. Three comments persisted throughout the period:

1. The filter removes impurities;
2. The filter removes leaves and insects; and
3. The filter prevents one from drinking dirty water.

Other initial comments showed that people found the filter easy to use, fast, and better than boiling water. Such observations trailed off with continued use.

Follow-Up Survey

Records showed that eighty-eight households had acquired filters in the sixteen farm hamlets clustered to the northeast of Idere. Follow-up survey found

Table 3. Knowledge of Filter Use Procedures after Purchase and at Follow-Up

Procedure	*After Purchase (Percent)*	*At Follow-Up (Percent)*
Black thread up	99.2	83.3
Sag in middle	53.0	79.6
Pour water slowly	96.0	98.1
Let all water go out	93.6	100.0
Remove carefully	74.3	70.4
Wash	98.4	100.0
Shake out	94.4	96.2
Dry outside	92.8	[a]
Store safely	33.7	42.6
Inspect before use	28.5	35.9
Number	249	54

[a] Shake and dry recorded together as a response on follow-up.

sixty-five of these at home, of whom fifty-four were still using their filters. Reasons for not using included lax or broken rubber bands (four people), torn filter (three people), filter left in town (two people), and current use of rain water for drinking (one person, although the rainy season had just ended). In one home the parents were not there and the children could not say why the family was no longer using the filter.

Table 3 indicates that users had retained very much the same level of knowledge about correct filter use as was evident in the first round of interviews during the preceding year. As before, those points having the lowest recall were the need to keep the filter in a safe place (43%) and inspecting for holes before use (36%). The seriousness of this latter point became evident on inspection of the filters.

Most of the filters still in use (59%) had holes and tears. Holes ranged in size from a pin prick to two inches long, and averaged six per damaged filter. Interestingly, 86 percent of these were found in the peripheral area of the filter, while only 14 percent were located in the middle.

In addition to holes, several other problems were seen. While most were stained or discolored (85%), some even had accumulated dust or soot (46%), raising doubt about their recent and current use. The rubber band had gone lax on twelve; five had frayed edges; and the stitching had come out of the band on two. Six reported that the rubber band on their filter had gone lax, but that they had retightened it themselves.

Table 4. Frequency of Weekly Filter Use Compared to Damage

Condition of Filter	Percent Frequency of Weekly Use[a] 1 to 3 Times	4 or more	Total
Holes and tears	41.4	80.0	59.2
Intact	58.6	20.0	40.8
Number of filters	29	25	54

Note: $x^2 = 8.295$, $d.f. = 1$, $p < 0.005$.
[a] Average frequency = 4.2 times per week.

When asked if anyone wanted to purchase a new filter, only five of these "current" users responded affirmatively. Four of these had filters with visible holes. The remainder whose filters were damaged may not have perceived the holes as problems.

Filter damage was compared with three different factors–number of users, storage methods, and frequency of use–to determine possible reasons for the holes and tears. While 66 percent of filters were damaged in families with two or more users and 44 percent in the sixteen households with one user, the difference was not significant ($x^2 = 2.265$, $d.f. = 1$, $p = 0.01$). Clearly, there was no difference in damage between storage methods with holes found in 61 percent of twenty-three filters kept "safely" in a plastic bag and in 58 percent of those kept in the open or thrown together in a basket with dishes and pots.

Frequency of use did make a difference (see Table 4). Average reported use was 4.2 times per week. The filters of twenty-nine people who reported using their filter one to three times per week were less likely to have holes (41.4%) than those of the twenty-five owners who reported filtering four or more times a week (80%).

DISCUSSION

Earlier conclusions from this study found that filters could not provide the total solution to the guineaworm problem in Idere. Two-thirds of households in the monitored area did not purchase filters for economic, cultural, and other reasons [13]. This article has shown that even among those who bought filters, problems still arose that might make them less than effective. Thus, the strategy in a national control program of providing everyone a free filter may not hold water.

As noted, if filters are to succeed as a control measure, they must be used religiously by the population through one if not two complete transmission seasons. The monofilament filter appears to last through one transmission season, but most would have to be replaced the second year, an expense for which control programs must plan.

Problems of Perception

The question arises, who will initiate replacement? Idere filter owners did not recall the need to inspect their filters, and most whose filters were damaged did not perceive the need to replace them. Furthermore, they seemed satisfied that the visible collection of leaves, insects, and dirt after filtration was enough evidence that the filter was working, even though the tiny cyclops may be passing through small holes in their filters. It is therefore incumbent on the health staff to stress filter inspection more during initial demonstration and education on filter use and to carry out the replacement process annually well before the beginning of another transmission season. But replacement alone may not be enough as witness the role of the research assistant.

The results of the follow-up survey imply that the research assistant had more than an investigative function. By observing demonstrations of use, correcting mistakes, tightening lax rubber bands, and replacing damaged filters, the assistant inadvertently reinforced regular filter use. During the post-monitoring period, filters gathered dust or became damaged and went unreplaced. The implications for programming is that this habitual behavior of filtering may not be maintained without regular reinforcement from a health worker.

The monitoring process also highlighted how the mobility of the population in this relatively small community could have potentially disruptive effects on guineaworm control. Table 1 showed that many people were not at home during the monthly visit, and a portion of those found had left their filters at another residence (town or farm). It was not possible to determine whether those absent at the time of visit had carried their filters with them.

This frequent movement helped reintroduce guineaworm into Idere town ponds in the 1970s when the pipe water system broke down, and will continue to hamper other control strategies. Solving this problem in Idere and similar communities may require distributing more than one filter per family. It certainly requires that program planners study carefully the patterns of movement in an area before embarking on wide-scale control.

Technical Improvements

Lessons on the technical side of filter design can also be drawn from the Idere experience. Looking together at the issues of frequent use and location of most holes and tears leads to the conclusion that it may be rough pot edges that ultimately contribute to the demise of the filter. The fact that few people remembered the need to allow a sag in the middle of the filter before pouring means that cyclops-laden water would likely splash into these peripheral holes.

The traditional earthen pots used to hold water in Idere are not smooth and glazed. An option suggested by staff of the Nigerian Guineaworm Eradication Programme is making pots with small spouts inserted near the bottom so that filters may remain permanently affixed at the top. Since it would be another major and expensive intervention to improve and distribute new pots, this lesson may simply lead to the need to monitor and replace filters more often, especially in families that use them frequently.

Although few rubber bands broke, this problem shows the need to monitor more closely the production process. Rubber bands with thin sections should be discarded. Generally, the local tailors displayed good workmanship.

Monitoring identified two of the original ten "correct use" steps that may not be an important as initially thought, showing the difference between laboratory testing of a product and field testing under normal use conditions. The time gap between filter uses appeared to range upward from twenty-four hours, adequate for the filter to dry and the cyclops to die. Also, filter damage did not appear contingent on place of storage, but instead on frequency of use. This means that in the Idere context one might reduce emphasis on the steps of concerning placing one side upwards and the need to store safely. From the communication point of view, a simpler set of instructions would certainly be better.

Conclusions

Filters are certainly a useful short-term component in the war against guineaworm, but their successful implementation may require a higher investment of time and energy than anticipated. The research assistant in this project performed much the same role of reinforcing use that a health worker should employ. Unfortunately, the local government health inspectors and other staff, like their counterparts throughout much of the country, do not have official vehicles nor a research grant to provide them with transport funds to reach all the outlying hamlets. And it is these very staff who are expected to carry out the bulk of national guineaworm eradication activities. Hopefully, funds raised during recent donors meetings on guineaworm will find their way to the local level where action is needed.

It is also hoped that the social and behavioral lessons learned during the Idere project will inform national planning and intervention. In particular, the behavior of human beings is more varied and difficult to influence than that of disease vectors. People do not stay fixed in one place, while the cyclops are stuck in their ponds (unless people remove them and drink them). People find it difficult to adopt new habitual behaviors like filtering, especially when they cannot perceive the dangerous little creatures with which health workers try to frighten them. People need continual encouragement and reinforcement to try and continue new practices. Providing information alone is not enough to overcome these problems.

Although the long-term solutions, like wells, are not without their own problems, they do not require the adoption of such a new and different behavior as does the filter strategy. Wells necessitate mainly a change in where one draws water and a modification in water drawing procedures. In terms of communication, promoting the use of wells for guineaworm control may be easier since one can fall back on emphasizing the convenience of well water over ponds, whereas acceptance of filters requires in large part a new belief that some barely visible creature, which causes disease, is in the water.

Finally, freeing a remote rural village from guineaworm by using filters will certainly also free them from much suffering and disability, and hopefully local agriculture production and school attendance will increase accordingly. Filters do not free village women from trekking miles to scrape dirty water out of nearly desiccated ponds in the height of the African dry season.

The filter option, aimed at water quality, does not have the full developmental effect on a community as does improved water quantity and accessibility. A convenient village well that yields water year round will free village women from drudgery and provide them time to earn supplementary income. It will mean that young girls can stay in school rather than follow their mothers to the distant water holes each day. Thus, through the elimination of guineaworm, governments can truly demonstrate the validity of their paper policies about improving the life of rural people.

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