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Assessment of progress towards the eradication of dracunculiasis in the Afram Plains, Ghana

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A Thesis Submitted to the Yale University School of Medicine
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Persian physicians extracting guinea worms (from Velschius, 1674).

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ABSTRACT

In 1986 the World Health Organization endorsed a goal to eradicate guinea worm disease worldwide. Ghana established its Guinea Worm Eradication Program (GWEP) in 1987, fixing 1993 as the national goal for breaking disease transmission. The present study assesses progress towards eradicating the disease in the Afram Plains, a rural district in Ghana's Eastern Region. The study sought to characterize disease epidemiology, evaluate the GWEP's surveillance of disease incidence, determine how much at-risk populations knew about the disease and describe the preventative measures they took.

Data on the district's guinea worm surveillance system were gathered by working closely with GWEP workers and reviewing their records. Questionnaires were administered to adult residents of study villages and to victims of the disease in order to ascertain their water usage patterns and their knowledge of disease transmission and prevention.

Village-based surveillance, as stipulated by Ghana's national GWEP, existed in one of twenty-five villages previously identified as endemic. No endemic villages provided monthly data for disease incidence.

Forty-three percent of the one hundred ninety-four subjects interviewed for the household survey knew how the disease is transmitted; thirty-five percent correctly named a method of preventing the disease. Twenty-eight percent reported having received information on guinea worm disease from health workers. Thirty-five percent of the one hundred

eighty-seven subjects living in villages with potentially contaminated ware sources took some precaution against the disease.

Sixty-eight percent of guinea worm disease victims were male and ninety-three percent were between the ages of ten and fifty. Twelve percent of victims most probably contracted the disease outside of their home village.

It is concluded that deficiencies of organization and motivation, combined with geographic, demographic and other factors, have hampered the implementation of an effective GWEP in the Afram Plains. Recommendations for improving surveillance and educational methods are provided.

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INTRODUCTION

Guinea worm disease (Dracunculiasis) afflicts hundreds of thousands of people each year in Asia and Africa (Figure 1) leaving a legacy of pain, mutilation and economic hardship. The disease is caused by a parasitic nematode transmitted through ingested water. Meter long worms emerge through their victims' skin, producing painful lesions that can lead to permanent disability and, rarely, death. The West African nation of Ghana, responding to the WHO's 1986 call for the global eradication of dracunculiasis, established a National Guinea Worm Eradication Program (GWEP) in 1987.

The present field study evaluated the local GWEP in the Afram Plains district of Ghana's Eastern Region, pursuing answers to the following questions:

* Does the program effectively monitor dracunculiasis incidence?
* How much do villagers know about dracunculiasis transmission and prevention?
* Do those at risk for the disease take measures to reduce their risk?
* Has the Guinea Worm Eradication Program educated at-risk populations about the disease and its prevention?
* What impact have the program's interventions made on villagers' water usage patterns?

The Afram Plains District was selected as a study area, not because of the disease burden there, which by Ghanaian

standards is relatively light, but rather because the GWEP itself was inadequate. The present study aimed to provide feedback on the Afram Plains' GWEP to national and regional GWEP coordinators and to make recommendations that would help district and regional health officials realize the program's goals in a manner consistent with the district's other health promoting activities. In addition to the research described herein, the author developed and tested a guinea worm education program designed to reach at-risk populations in remote areas. It is hoped that the author's recommendations can be applied to GWEP's in other areas facing similar challenges.

GUINEA WORM DISEASE - HISTORICAL PERSPECTIVE

Guinea Worm's notoriety dates to the Old Testament's description of a "fiery serpent" which harassed the Israelites during their peregrinations in the Sinai Desert.[28] Plutarch and Pliny describe the guinea worm, as did the famous Persian physician Avicenna, who believed the disease to be of nervous origin. In more modern times, the Russian naturalist Fedchenko's elucidation of D. medinensis' life cycle constituted the first description of an arthropod vector for human disease.[28] Today, even as nations mobilize to eradicate it as a scourge of humanity, the pesky worm has perhaps already insured its immortality in symbols of the medical

profession. *

PATHOPHYSIOLOGY

Guinea worm disease, caused by the nematode Dracunculus medinensis, manifests spectacularly as a painful skin ulcer from which a long white worm emerges. The emerging worm is a mature female which extrudes a milky fluid containing myriad, tiny (0.5mm) Dracunculus larvae.

Once the larvae are released into water, minute crustaceans of the genus Cyclops ingest them (Figure 3). Cyclops, D. medinensis' intermediate host, thrive in stagnant water such as that found in ponds or stream remnants. Once ingested, the larvae penetrate Cyclops' gut, develop, moult twice and, given favorable temperatures (T >19 C) reach the infective stage in twelve to fourteen days, at which point they are capable of causing infection in a definitive host. Larvae that have remained in water longer than four to five days lose the ability to infect Cyclops, perhaps because they lack sufficient motility to penetrate Cyclops' gut. If the temperature falls below 19 C, larval development ceases until the temperature again reaches 19 C. In nature, usually only a single larva infects each Cyclops, but experimentally as many as five larvae per Cyclops have been observed.[28]

* the Aesculpian Staff, which appears on the Yale School of Medicine's emblem, according to some, alludes to the time honored treatment of winding the emerging worm around a small stick [6].

D. medinensis' subsequent migration in its secondary host has been investigated experimentally in dogs (ref.). The secondary host contracts the disease by ingesting water containing infected Cyclops. The infective worms, activated by gastric HCL, leave Cyclops while still in the (definitive) host's stomach, and penetrate the duodenal wall about thirteen hours after ingestion. The migrating worms are found on the mesenteries up to twelve days after ingestion, and in approximately fifteen days reach the thoracic and abdominal muscles. They then cross subcutaneous connective tissue to axillary and inguinal regions. Their close association with lymph nodes has prompted speculation that they travel along the lymph system.[28]

D. medinensis reproduces sexually, and mating is usually accomplished by the fourth month. Afterwards, the male dies and becomes encysted. The female continues to migrate, and reaches its final position, usually in the extremities. Embryos are fully formed by ten months, and the female emerges at ten to fourteen months.[28]

The mature female, D. medinensis is one of the largest nematode species known, measuring between 0.5 and 1.0 meters long, and 1 to 2mm in diameter. The worm extrudes its burden of embryos in installments over two to six weeks, an average of three million embryos in total.[28] It is hypothesized that contact with cool water stimulates the worm to emerge more rapidly. The embryos, released into water, are ingested by

Cyclops to begin another cycle.

SYMPTOMS

Guinea worm disease victims typically remain unaware of infection during the ten to fourteen month migration of the female worm, though a few report generalized urticaria, fever, giddiness, dyspnea or gastrointestinal symptoms during the month preceding the worm's emergence. Most often, formation of a blister is the first symptom. The blister, thought to be caused by tissue reaction to subcutaneously released worms, grows to a few centimeters in diameter and is accompanied by intense burning pain and itching. The sterile fluid inside the blister contains monocytes, eosinophils, and embryos.[28]

The blister usually bursts one to three days after its appearance, and the worm issues from the resulting ulcer. Subsequently, the worm is extruded a few centimeters each day; the process may be accelerated by frequently immersing the lesion in cool water or, according to some sources, by taking anthelminthic medications. In the absence of secondary bacterial infection, epithelium closes around the worm and the worm is extruded, causing little pain and incapacity. Usually one to three worms emerge at the same time, but multiple infection with as many as forty worms (emerging in a single season, simultaneously, or one after another) has been documented[28]. Eighty percent of worms emerge from the lower extremity with most of the rest issuing from the upper extremity. Rarely, a worm emerges from the trunk, head, or

genitals.

COMPLICATIONS

The most common complication of guinea worm disease is secondary bacterial infection, most frequently with staphylococcus sp., streptococcus sp., or _E_. _coli_. Sequelae include cellulitis, acute abscess, arthritis, synovitis, fibrous ankylosis of joints, and tendon contracture. Such complications cause most of the extended morbidity and permanent disability seen with the disease; uncomplicated guinea worm disease lesions seldom cause disability. Bacteria may be introduced into the lesion if the worm breaks during extraction and retracts into the wound. Breakage of the worm may also result in the release of embryos within the host, producing an exuberant local tissue reaction and increased inflammation around the lesion.

Estimates of permanent disability stemming from secondary infection rage from 0.5[29] to 0.9 percent[23]. Mortality, usually from tetanus, is rare, occurring in fewer than one in one thousand cases. Non-emergent worms encyst and often calcify, but rarely cause symptoms, and are a frequent incidental finding on x-rays in endemic regions.

DIAGNOSIS AND TREATMENT

Diagnosis is usually made by history and physical findings and can be confirmed by microscopic identification of embryos obtained from open blisters or needle aspirates of deep seated abscesses. Recently, Garate et al[13] have devised an ELISA specific for dracunculiasis.

Practitioners of traditional medicine in many endemic areas have treated guinea worm disease the same way for centuries by gradually winding the emerging worm around a small stick until the worm is completely extracted. Combined with aseptic care of the lesion, this treatment usually results in complete extraction of the worm over a period of two to six weeks, with no sequelae. Although endemic areas abound with herbal remedies, investigations have failed to demonstrate their efficacy against guinea worm disease. On the contrary, studies suggest that at least some herbal treatments increase the likelihood of cellulitis.[28]

In some areas native practitioners have long treated guinea worm infection surgically, making an incision down to the worm and aspirating the worm through a tube. Worms can be removed this way with a single small incision when the entire worm is subcutaneous. However, worms located in deeper connective tissues, or wound around tendons, complicate the procedure and may require multiple incisions.

Trials of antihelminthics, such as niridazole,

thiabendazole, and metronidazole have produced conflicting reports of these drugs' efficacy in treating guinea worm disease. Kale[25] concludes that these drugs reduce patient discomfort, perhaps by reducing inflammation, but do not significantly increase the speed with which the worms can be extracted, though he reports that manual extraction is easier in patients treated with antihelminthics.

PREVENTION

Guinea worm disease can be prevented by ensuring the consumption of guinea worm-free water. Small diameter wells (boreholes) provide water devoid of guinea worm and afford the added benefit of eliminating other pathogens from the water supply. However, boreholes are expensive to drill and occasionally malfunction. In addition, some complain that borehole water is unpleasantly salty.

"Safe" water can also be ensured by eliminating the worm's intermediate host through monthly application of the insecticide Temephos (Abate) to water supplies. Abate is tasteless, colorless and has been shown to be safe for human consumption when applied correctly. Its main disadvantage, in addition to its expense, is that it must be applied monthly to all potentially contaminated water sources. Application to large bodies of water is impractical.

In the absence of safe water supplies, individuals can

ensure guinea worm-free water by boiling or filtering the water through material woven densely enough to strain out Cyclopoidae. In addition, communities can safeguard water supplies by preventing people with guinea worm lesions from contacting drinking water supplies. These measures require education of large numbers of people and, while potentially the least expensive in terms of capital outlay, education requires effective coordination and utilization of human of human resources.

ERADICATION

Since guinea worm is self-limited and produces no long term carrier state, breaking the cycle of transmission in a village for one year effectively eliminates the disease from that village, provided guinea worms are not reintroduced to the water supply. This fact makes the worldwide eradication of guinea worm contemplatable. Eradication, rather than mere control of guinea worm, is sensible considering the benefits are permanent and control is likely to cost almost as much as eradication. Moreover, an eradication crusade can attract support more easily than a mere control program.[17]

The International Drinking Water Supply and Sanitation Decade (IDWSSD: 1981-1990) provided the first great impetus towards global eradication of guinea worm disease. Since guinea worm is transmitted solely by ingesting contaminated

water, the IDWSSD selected guinea worm disease incidence as one measure of its impact on drinking water quality in endemic countries. As a result, guinea worm surveillance became an official sub-goal of IDWSSD.[18] Figure 4 indicates disease incidence for endemic African countries in 1989.

The movement to eradicate guinea worm disease gained momentum in 1986 when the World Health Organization (WHO) endorsed the goal of global eradication of the disease. Since then, national governments of endemic countries, with the help of organizations around the world, have been planning and implementing eradication programs. The African Regional Office of the WHO has officially targeted the end of 1995 for breaking transmission of the disease worldwide. Technical consultation is being provided by the WHO collaborating Center for Research, Training and Eradication of Dracunculiasis at the CDC in Atlanta, Georgia. Funding has been received from the United Nations Development Program (UNDP), the U.S. Agency for International Development (USAID), UNICEF, and the Global 2000 Project of the Carter Presidential Center. In addition, the Dupont Corporation has donated filters and the American Cyanamide Company has donated insecticide to the eradication effort.

GUINEA WORM ERADICATION STRATEGY

The Global 2000 Project of the Carter Presidential Center

has assisted in the establishment and administration of Guinea Worm Eradication Programs in Pakistan (1986), Ghana (1987) and Nigeria (1988). Global 2000's general eradication strategy comprises three phases. In the first phase a national coordinator for guinea worm eradication is appointed and a national village by village baseline survey is implemented to identify endemic villages and tally annual cases. This information provides the basis for preparing a national plan of action.

Active surveillance (where mobile agents seek out cases, as opposed to passive surveillance, where medical authorities count cases as they present to hospitals or clinics) is critical to the second, or intervention phase. Surveillance during this phase relies on village-based workers, at least one in each endemic village. Monthly incidence reports are sent to district, regional and national guinea worm project representatives. Village-based surveillance is useful as an indicator of program effectiveness and a tool for measuring staff performance, and can also provide a corps of trained workers capable of providing simple treatment, health education and assistance to other health projects.

Interventions emphasize health education and community mobilization. These are the least costly activities and act to facilitate other interventions. Three basic messages are conveyed to villagers:

* guinea worm disease is transmitted through drinking contaminated water

* guinea worm disease can be prevented by boiling or filtering all ingested water

* people with lesions should be prevented from contacting the community's water sources.

Provision of safe water supplies and vector (Cyclops) control are other, though more costly, interventions.

Phase three of Global 2000's strategy is implemented as countries near their goal of eradication, at approximately one thousand cases recorded annually. This phase calls for rapid response to each detected case to prevent further transmission. The WHO is expected to require that recently endemic countries maintain adequate surveillance networks at least three years after the last recorded case.

GHANA'S GUINEA WORM ERADICATION PROGRAM

Early studies on guinea worm disease incidence in Ghana [Waddy (1940), Lyons (1972), Scott (1960), Belcher et al (1975)] revealed widespread distribution of the disease. Monthly monitoring of incidence through passive surveillance began in 1960 and recorded approximately four thousand cases annually. Researchers had little idea of the total scope of guinea worm disease in the county.

In 1987 Ghana launched its national eradication program,

setting the end of 1993 as the target date for breaking transmission. In 1989 the program began training District and Zonal coordinators and these in turn identified volunteers in endemic villages who were charged with reporting monthly incidence. Figure 5 indicates guinea worm disease incidence in Ghana from 1982 through 1989. The dramatic increases in reported cases starting in 1987 coincide with the implementation of active surveillance and thus are likely due to improve disease reporting.

The national case search, a massive undertaking involving some twelve thousand workers, was carried out in two phases. In the first phase, ninety-two percent of all villages were visited and questionnaires were administered to "reliable" residents who were asked if there had been any cases of guinea worm disease in the previous year. If so, the village was identified as endemic and a volunteer was chosen to go house to house and report guinea worm disease incidence over the previous year. The case search reported nearly one hundred eighty thousand cases. The disease burden falls unevenly amount Ghana's fifteen regions. (Figure 6) Fully fifty-seven percent of Ghana's guinea worm disease cases in 1989 were reported in the Northern Region, twenty-three percent in the Volta Region, and another ten percent in the Brong Ahafo Region. The Eastern Region, which contains the Afram Plains, accounted for only two percent of the country's cases.

Phase two of the program has been in operation since

early 1990. As of the end of 1991, approximately eighty percent of endemic villages in Ghana were reporting incidence data.

AREA DETAIL: THE AFRAM PLAINS

The present study was undertaken in the Afram Plains District of Ghana's Eastern Region (Figures 7 and 8). The district is bounded by the Afram River on the South and Southwest, the Obosom River on the North and Northwest and by Lake Volta on the East, making it a peninsula with a total area of approximately four thousand kilometers squared. The terrain is generally flat wooded savannah, with baobab and acacia trees interspersed with tall grasses. Average elevation ranges from 50 to 100 meters above sea level, sloping gently from the shore to the Afram Ridge, running west-east. Mean annual temperature is 27C. Most of the precipitation falls during two rainy seasons, May to June and September to October.[1]

The most recent population statistics projected 100,405 inhabitants for mid-year 1991, living in four hundred thirty-four settlements. Forty-one percent of the population (Fig. 8) lives in villages with populations greater than five hundred, twenty percent in villages of three hundred to five hundred, twenty-seven percent in villages of one hundred to three hundred, and twelve percent in villages of fewer than

one hundred inhabitants. The population is growing at approximately three and one tenth percent per year.[1]

The Afram Plains is a land of immigrants. Many settled there after being displaced by the creation of Lake Volta in 1960. Others were drawn by the Afram Plains' fertile soils. Members of the Ewe tribe make up thirty-nine percent of the population, Akan speaking peoples make up thirty-four percent, and the remaining twenty-seven percent are divided among several other tribes (amount them Dagatai, Dagomba, Krachi, Konkonba) who have migrated from areas inside as well as outside Ghana. Many of these immigrants maintain family and social ties in areas highly endemic for guinea worm disease. As a result, in spite of daunting travel times, conditions and costs, the population is highly mobile.

Farming is by far the predominant occupation; yearly half of all men and women farm exclusively, with an additional thirty-five percent who farmed in addition to doing other kinds of work.[1] The main crops are yam, casaba, corn and plantain. Many farmers employ slash and burn techniques, moving on to a new plot of land every few years as the soil becomes depleted. This practice tends to promote diffuse villages with fluctuating populations.

EDUCATION

Average schooling differed by ethnic group, size of

settlement and sex. The average Akan received over seven years of schooling, while Ewes received approximately five, and other tribes averaged four or less. While ten percent of children from villages with populations over five hundred attended school, this number increased to forty percent in villages with a population of less than one hundred. Women averaged two and a half less years of schooling than their male counterparts and were twice as likely to have no schooling at all. No data on literacy were available, through it should be noted that illiteracy is the rule rather than the exception, especially in more remote villages.

INFRASTRUCTURE

The Afram Plains resemble an island rather than a peninsula in the sense that vehicles can reach it only by pontoon across the four kilometers wide Afram River from Adoso (Figure 8). When the pontoon is not operational, as occurred for four months in 1985, the Afram Plains are completely isolated from vehicular traffic. The main road in the Afram Plains, passable year round, runs from the pontoon port at Ekye Amanfrom to Amankyakrom, passing through the large villages of Tease and Donkorkrom (Donkorkrom is the district administrative center). Most routes leading off the main road can be travelled by four wheel vehicles, motorcycles and bicycles during the dry season, but only by farm tractors and

in some cases Jeeps during the biannual rains. The Afram Plains' undeveloped infrastructure poses a significant limitation for outreach efforts, especially guinea worm eradication; all but three villages identified as endemic during the 1989 case search are more than three kilometers off the main road, and most are far more isolated.

The Presbyterian Hospital in Donkorkrom uses its generator to provide electricity to the hospital compound for about four hours each evening and when the operating room is in use. Aside from a handful of small privately owned generators, this provides the only electricity available in the Afram Plains. Villagers use kerosene lamps to provide light, and use wood to cook. There is no telephone or postal service outside of Donkorkrom.

WATER SUPPLY

Adequate water supply is a difficult problem for inland villages. Larger villages along the main road often have boreholes or large cisterns for collecting rainwater. More remote villages use ponds and streams, many of which disappear during the dry season. In these villages it is common for villagers to walk up to five kilometers to reach the nearest water source during the dry season. Some must walk as far as ten kilometers. The present study further addresses issues of water use.

HEALTH CARE

Donkorkrom Presbyterian Hospital is the only hospital in the Afram Plains. Two full-time physicians staff the forty-five bed facility. A third physician also serves as district Medial Officer and is responsible for coordinating all health-promoting activities in the district. A mission clinic, staffed by six nurses, is located in Tease which is an hour's drive from Donkorkrom. Three private maternity homes are located in the Afram Plains as well. Hospital use, not surprisingly, varies depending on where people live. Residents of Donkorkrom averaged one and six tenths outpatient visits per year, while villagers in remote villages averaged less than half this figure. A survey asking villagers where they first sought treatment when they were ill revealed that thirty-seven percent went first to a druggist, twenty-eight percent used traditional remedies, twenty-eight percent went to the hospital or clinic, five percent self-medicated and two percent did nothing.[1]

GUINEA WORM ERADICATION IN THE AFRAM PLAINS

As in the rest of Ghana, the Afram Plains conducted a two phase case search at the end of 1989. This search covered two hundred thirteen villages and found two hundred forty-three cases in twenty-five villages. Village volunteers were

identified in these villages, zonal coordinators (designated to collect data from a group of village volunteers and relay it to the District Coordinator) were recruited and a district guinea worm coordinator was appointed. Subsequently it is unclear what became of the program. The district did not submit any monthly data during 1990 and 1991, and its tally of cases for 1990 straggled into the national office several months late (Table 1). These data listed nine new villages as endemic. The district's poor record of reporting surveillance data earned it not a little notoriety. However, a visit to the Afram Plains by a Global 2000 epidemiologist, in the summer of 1991, failed to elucidate the problem or stimulate any changes.

METHODS AND MATERIALS

STUDY PERIOD

Data were collected during a four month period from September 1991 through December 1991 (which included a month and a half hiatus during the October through November rains when villages were inaccessible due to poor road conditions). This interval was chosen for its convenience to the author and because it coincided with the period of peak disease incidence and transmission, which the author deemed an opportune time for educational intervention.

Village Selection

Of the twenty-five villages identified as endemic (Table 1) during the 1989 case search, researchers visited twenty-two and gathered questionnaire data in twenty villages. Researchers were unable to reach three villages due to time constraints and did not collect questionnaire data in the remaining two due to a procedural oversight. Data on the surveillance system in all twenty-five villages were available through the District Coordinator, although they were independently corroborated only in those villages which were visited.

Both surveillance and questionnaire data were collected from seventeen additional villages. [Twelve of these were villages from which unconfirmed case reports (from a variety of sources) had been received during the previous year. Nine

of these twelve villages were listed as endemic in the GWEP's 1990 report; anecdotal reports were received from three others]. The five remaining villages were found to be endemic by asking villagers about the disease as we were passing through to another destination.

The geographic scope of the study was constrained by researchers' lack of prior knowledge of the location, and in some instances, existence of endemic villages, especially in the most difficult to access regions around Nsugyaso and Bonkron (see Figure 7). Existing maps of the Afram Plains do not show most of the endemic villages. Indeed, the population's mobility often defies map making. Since fuel can be purchased at only a handful of locations along the main road, motorbikes could not reach the most distant villages, and we were determined to avoid running out of fuel in these areas. As a result, we did not reach several villages from which we heard anecdotal reports of cases.

DATA ON THE SURVEILLANCE SYSTEM

The District Coordinator, who spoke excellent English, worked closely with the author for over a month, allowing access to all relevant records and materials and providing an excellent opportunity to observe closely the program at the district level. Since records were scarce, observations and

conversations with him constituted the preponderance of data on the surveillance system's structure and function. Data on the zonal coordinators' and village volunteers' activities were based on their verbal accounts and written records (in two cases) presented during our visits to their villages.

DATA FROM THE HOUSEHOLD QUESTIONNAIRE

STUDY POPULATION

Researchers followed the same procedure in each village. Upon arriving in a village, we introduced ourselves and the project to the village chief(s), CDR's (government-appointed workers) and elders, and asked general questions about water supply, population and guinea worm disease incidence. Afterwards, we walked around the village, randomly selected compounds and interviewing adults for the household survey. Only one adult per compound was interviewed for the household survey and an effort was made to select compounds in different parts of the village. Early in the study it was decided to attempt to interview women when possible since women do most of the cooking and thus are more familiar with family water usage; we were interested in characterizing water use affecting the largest possible number of people. Of the subjects approached, none declined to be interviewed.

Interviews were conducted in the subjects' native language, usually Twi or Ewe, but on a few occasions in other

languages, such as Krobo and Dagati. A different translator was used for each language; all the translators also spoke English.

QUESTIONNAIRE DETAILS

Both questionnaires were based on a previous study of population awareness of guinea worm disease prevention. (ref.) The author added relevant items.

Among other basic information, the household questionnaire (see Appendix) elicited the number of people in the subject's household, which we defined as the number of people eating from the same pot. This definition was chosen for its inherent link to water consumption and because it was used in previous demographic studies of the Afram Plains.

Subjects were considered to know what guinea worm disease is if they described a painful or pruritic lesion from which a worm emerges.

Subjects were considered to understand how guinea worm disease is transmitted if they indicated that guinea worm disease is contracted by ingesting contaminated water, even if they also (erroneously) believed that the disease could be transmitted through skin contact with water.

Subjects were considered to know how to prevent guinea worm disease if they mentioned boiling and/or filtering drinking water.

Subjects were asked if any family members had suffered guinea worm disease. Only cases occurring within the past five years were counted.

In determining the subjects' drinking water sources, care was taken to elicit all sources for both the dry season and the wet season.

Subjects who indicated that they filtered their water were asked to show us the filter they used. Filters were judged grossly inadequate if they had no tears or pores greater than approximately half a millimeter, measured by sight.

Subjects were asked whether they remembered anyone coming to their village to talk about guinea worm disease. Several subjects recalled visits by medical outreach groups (Guinea Worm Disease Eradication team, Red Cross or the Donkorkrom Hospital's vaccination team) but could not specifically remember mention of guinea worm disease. These responses were considered positive since medical outreach efforts in the Afram Plains reach remote villages infrequently and thus use the opportunity to provide information on a spectrum of health problems, which would possible include guinea worm disease in a known endemic region.

THE GUINEA WORM CASE QUESTIONNAIRE

The guinea worm case questionnaire (Appendix) was

administered to all victims of the disease encountered, except in Dunkro, where, owing to time constraints, we interviewed only five of over thirty people suffering from the disease. There we chose subjects as we did for the household questionnaire, interviewing victims from compounds in different parts of the village. The same person was never interviewed for both questionnaires.

The guinea worm case questionnaire was administered to those who had experienced onset of guinea worm disease within the previous year. It covered many of the same issues as the household questionnaire, and in addition sought to determine, by travel history, whether each case was endemic or imported from an endemic region. Subjects were also asked if they had been prevented by the disease from working or going to school and, if so, to approximate the length of time so disabled.

STATISTICAL TESTS

Chi square was used to determine the statistical significance of the association between the subjects' information sources and their likelihood of taking precautions against guinea worm. Chi square also evaluated the statistical significance of the association between surveillance by village and zonal workers and the subjects' knowledge of guinea worm disease transmission and prevention, and thus their likelihood of taking precautions against the disease.

EDUCATIONAL PROGRAM

The research presented herein constituted one aspect of the author's guinea worm project activities in the Afram Plains. He also developed and tested an educational program designed to inform villagers about guinea worm disease and its prevention. This program was presented in each village after data had been collected. Early in the study only one village was contacted each day since the evening slide presentation could be shown in only one village each day. Equipment failures during the last week freed us to reach up to three villages per day. As a result, data during the last week was collected during the morning as well as the afternoon.

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The educational slide program which accompanied the research project was conceived by the author who bore all associated costs, including film, film developing, production materials, generator rental, fuel and motorcycle repairs. The Ghanaian National Ministry for Community Development kindly permitted the use of their portable generator and the Eastern

Region Office of Health Education lent the author a slide machine. Global 2000's Guinea Worm Eradication office in Accra granted the use of their computer and quasi-functional copier.

RESULTS

SURVEILLANCE

Only one of the twenty-five villages identified in the 1989 case search as endemic for guinea worm disease was found to be monitored by a village volunteer (Table 1). One village identified as endemic, subsequent to the 1989 search, also was monitored by a village volunteer, through the district coordinator's data did not correspond to his data. Zonal coordinators provided sporadic surveillance for six villages, two of which were identified as endemic during the 1989 case search. The district coordinator claimed to monitor incidence in the district administrative center, Donkorkrom. Neither the district coordinator, zonal coordinators, nor village volunteers kept monthly records of guinea worm disease incidence, though they did record annual data. No worker made an attempt to distinguish endemic from imported cases.

HOUSEHOLD QUESTIONNAIRE

The household questionnaire was administered to one hundred ninety-four adults, one hundred eighty (ninety-three percent) of them women. The total number of people living in households of those interviewed was one thousand four hundred thirty-five, comprising one and four tenths percent of the Afram Plains' population. The average household size was

seven and a half (S.D. = 4.8).

Nearly all subjects (ninety six percent) were familiar with guinea worm disease and knew the major disease symptoms, even though many had not actually seen a lesion themselves. Forty-three percent knew that guinea worm is transmitted by ingesting contaminated water (Figure 10). Thirty-five percent correctly named at least one method of preventing the disease (Figure 11).

Subjects reported using water from a variety of sources. Sixty-three percent used water from flowing streams, forty-two percent used stream remnants (during the dry season), thirty-two percent used pond water, twenty-two percent used unprotected wells, seventeen percent used borehole water, fifteen percent used river water, six percent used rain catchment (during the rainy season) and two percent used water from a protected well (Figure 12).

Fully ninety-six percent of subjects lived in villages with potentially contaminated drinking water. Sixty-five percent (Figure 13) of these villagers took no precautions against guinea worm disease. Seven percent drank water exclusively from guinea worm-free water sources (i.e. borehole water or water from a flowing stream). Five percent boiled water at least some of the time, twenty-two percent filtered boiled water at least some of the time, twenty-two percent filtered their water at least some of the time, and one percent both boiled and filtered. However, of the forty-one

subjects who reported filtering their water, only six (fifteen percent) used filters that on gross inspection sufficed to remove Cyclops from the water.

Almost two thirds (sixty-three percent) of subjects denied ever receiving information about guinea worm from any source (Figure 14). Eighteen percent recalled receiving information from medical outreach teams, nine percent received information from friends or family members, seven percent received information from either a village or zonal guinea worm project representative and three percent received information at a hospital or clinic. The village of Dunkro, with an annual high prevalence of disease, was visited by a private midwife who advised villagers to filter drinking water, but reportedly did not teach or advocate sterile dressing of lesions. One subject (in the village of Abotanso III) was approached by drug peddlers who offered him pills that they claimed cured guinea worm disease. Two subjects received information from health messages on the radio, and one reported that she had learned about the disease at school.

Of the twenty-nine percent of households reporting at least one case within the previous five years, ninety-two percent applied herbs to the lesions, four percent reported using a sterile dressing and four percent administered oral antibiotics (Figure 15).

Subjects who named at least one method of preventing guinea worm disease were statistically more likely ($p<0.001$)

to filter or boil water or to drink from guinea worm-free sources than those who failed to name a method of guinea worm disease prevention (Figure 16).

An association between subjects' information sources and their likelihood of taking precautions against guinea worm disease was observed (Figure 17), with people getting information from medical outreach and guinea worm project representatives significantly more likely to take precautions than others ($p<0.01$ for outreach and $p<0.05$ for guinea worm project representatives).

Subjects living in the villages monitored by a village representative or zonal coordinator were significantly more likely to know about transmission ($p<0.01$) and prevention ($p<0.02$) as well as more likely to take precautions against the disease ($p<0.01$) (Figure 18).

In villages with some form of surveillance, twenty-nine percent of the population knew of a village volunteer or zonal representative designated to monitor guinea worm incidence and provide education to villagers.

GUINEA WORM DISEASE CASE SURVEY

The case survey was administered to forty-one people who had suffered from guinea worm disease within the year prior to the study. Sixty eight percent of these victims were male (Figure 19), and the average age was twenty-seven years, with

the maximum age at sixty-seven and the minimum age at seven years. Figure 20 shows the age distribution of victims interviewed. Eighty percent of victims identified themselves as farmers by occupation, ten percent were students and another ten percent reported other occupations. Eighty-eight percent had been prevented from working by guinea worm lesions. Those whose symptoms had resolved by the time of the interview reported an average disability to work of five and eight tenths weeks. Those with ongoing disease at the time of the interview reported an average of four and nine tenths weeks' disability.

Figure 21 shows the annual distribution of disease incidence by month. Thirty-five of forty-one victims reported onset of symptoms in September, October and November.

Most guinea worm disease victims reported infection with a single worm. The maximum number of emerging worms was fifteen. Ninety-seven percent reported a lesion (or lesions) in the lower extremity, ten percent reported a lesion in the upper extremity, and eight percent reported a lesion on the trunk. Thirty-two percent reported at least one prior infection.

Twelve percent of guinea worm disease victims provided travel histories consistent with disease transmission in an area other than their home villages (Figure 22). Eighty-six percent of cases were locally acquired by the same criterion. In two percent of cases, it was not possible to determine

probable source of the disease.

Twenty-seven percent of victims (over the age of fifteen) knew how the disease is prevented and fifteen percent reported boiling or filtering drinking water. All subjects applied herbs to the lesions.

A TALE OF TWO VILLAGES

As we scanned the data for guinea worm disease incidence, the figures for the two villages of Asikam and Dikuo immediately impressed us. Asikam, listed as a small village with only eighty inhabitants, recorded eight cases in 1989 and eleven cases in 1990, making it one of the hardest hit villages in the Afram Plains. However, when we finally reached Asikam and met with the village chief, he informed us that Asikam had not experienced a single case during the previous five years. We encountered the same story at every house in the village. Finally, the village chief suggested we talk with the palm wine merchant, who lived a half hour's walk from Asikam. The palm wine merchant cordially offered us akptoteshi, the local gin, and freshly tapped palm wine while we sat and chatted. He sheepishly explained how he, being literate, had been appointed Asikam's guinea worm village volunteer, and how the zonal coordinator had suggested that he submit bogus data in the hope that regional officials, alarmed by a guinea worm disease outbreak, would decide to drill a borehole near Asikam to supply the villagers with clean water.

Neither the District Coordinator nor anyone else I had asked could enlighten me as to the location of the mysterious village of "Dikuo," which had chalked up impressive incidence figures, some of the highest in the Afram Plains. I was led to believe we would eventually stumble across "Dikuo" at the

end of a tortuous quagmire-filled path through the bush. The mystery unraveled as we passed through the village of Dunkro, a large village only three kilometers from the main road. There, dozens of people, young men, children and old women, lay on mats in the shade of their huts, their legs swollen, with telltale guinea worm disease ulcers encrusted with herbs. It was the worst year in memory, the village elders told us, and no one had come to help them fight the disease.

DISCUSSION

DISEASE ERADICATION: THE SMALLPOX EXPERIENCE

The international alliance against guinea worm disease has a precedent in the fight against smallpox, the first infectious disease to be eradicated through concerted global action. In 1966 the Nineteenth World Health Assembly proposed a ten year goal to eradicate smallpox. Ten years and ten months later the last case of smallpox was reported in Ethiopia. Henderson,[16] in reviewing the campaign against smallpox and its implications for future public health initiatives, dismisses the suggestion that other health campaigns should use it as a "template" to guide their approach, since each disease's combination of clinico-epidemiological properties necessitates a unique approach. Nevertheless, he adds that certain basic lessons can be learned from the smallpox program:

* agents at all levels should be committed to the program and its goals.
* campaigns should adapt to the respective national health care systems and contribute to developing services within existing frameworks when possible.
* emphasis should be directed towards outreach efforts as opposed to centralized provision of services.
* services should be provided at a time and place convenience to recipients of services.
* the experience, competence and motivation of professional staff are crucial to the program's success.

* Where village-based workers are employed, the quality and nature of their supervision is vitally important. WHO, national and provincial staff should make frequent excursions into the field to provide feedback to field staff and resolve problems that they encounter.

STUDIES ON GUINEA WORM EPIDEMIOLOGY

Prior studies on guinea worm disease have stressed the importance of defining the disease's local epidemiological parameters as a means to designing effective countermeasures within a target area. These studies[3,9,24,27,30,35,36] examine disease prevalence, and describe infected populations in terms of sex, age and occupation. Most of the areas chosen for study have been hyperendemic (>20% of population infected each year) or mesoendemic (5%> x >20%) for guinea worm disease. Watts[36] reviews several studies undertaken in India and West Africa and argues that guinea worm infection patterns in India differ from those seen in West Africa, and, furthermore, that these differences reflect cultural differences which have significance for planning interventions. Work has also been done to investigate the economic impact of guinea worm disease.[4,14,32]

IMPORTANCE OF SURVEILLANCE

The importance of surveillance in eradicating the disease is a recurrent theme in the guinea worm literature. Effective

surveillance is critical to successful control of guinea worm since one must know the true scope of the disease in order to intelligently plan and implement interventions. Surveillance also allows a program to monitor the effectiveness of intervention measures so that adjustments can be made when necessary.

Passive surveillance has consistently underreported guinea worm disease incidence because victims, who tend to live in more remote areas and are often incapacitated by the disease, seldom present to hospitals and clinics. Additionally, the disease has historically received little attention from health authorities because it causes little mortality and geographic spread changes from year to year, in contrast to a disease like smallpox, which can spread rapidly. Moreover, health officials have not felt compelled to act quickly to intervene against guinea worm disease since they have no treatment or vaccine to limit spread.

Active surveillance, where it has been instituted, has revealed the true extent of guinea worm disease. In Ghana, for example, implementation of active surveillance in 1988 increased reported incidence from less than twenty thousand cases (1987) to over seventy thousand cases in 1988, and nearly one hundred eighty thousand cases in 1989 (see Figure).

INTERVENTION STUDIES

A few studies have measured the impact of interventions designed to decrease incidence of guinea worm disease. Edungbola[10] examined the effect of a comprehensive UNICEP-sponsored water project on disease incidence in the Kwara State of Nigeria. A total of forty-four initially functioning boreholes were drilled around twenty study villages, which ranged in population from one hundred forty to two thousand. Results showed a significant reduction in guinea worm disease incidence in study villages compared to control villages. However, the results also showed that problems with the taste of borehole water, poor reliability of the boreholes, distance from villages to boreholes and situation of boreholes in more densely populated areas limited their effectiveness in decreasing guinea worm disease incidence. Nevertheless, boreholes lacking these deficiencies succeeded in reducing guinea worm disease incidence from an average of over fifty percent to less than five percent within three years of intervention.

Akpovi[2] analyzed the effects of an intensive educational program on disease incidence and villager awareness of transmission and prevention in ten villages with a total population just under one thousand in the Ibarapa District of western Nigeria. Significantly, the villages participating in the study were self-selected, the villagers themselves having

expressed a desire to improve water resources. Three public health students trained designated village volunteers for four months in 1978, then returned to the villages twice per month for several months to evaluate the volunteers' progress and provide feedback. In addition, for ten months during 1980 through 1981, staff from Ibadan University commuted to the study area to provide weekly training sessions to volunteers. This rigorous education program succeeded in raising the villagers' awareness of modes of prevention from four percent before the initial four month intervention to seventy-five percent afterwards. In addition, guinea worm disease incidence declined in three years from pre-study rates of over thirty percent to less than twenty percent in study villages, compared to thirty-five percent incidence in control villages.

PRESENT STUDY

Whereas the above cited papers examined interventions independent of a national eradication program (the studies were performed before national guinea worm eradication projects had been implemented) the present study sought to gauge how well an established program functioned, measure the population's awareness of guinea worm disease transmission and prevention, and evaluate the program's impact on this knowledge.

As the original rationale for selecting the Afram Plains

as the study area was its poor record of reporting data, compared to other districts in Ghana, the author does not wish to imply that the Afram Plains' program is representative of Guinea Worm Eradication Programs in Ghana. Rather, by elucidating some of the causes of this poor performance, it is hoped that lessons learned here will be applicable in other settings as well.

SURVEILLANCE IN THE AFRAM PLAINS

With the completion of the National Case Search in late 1989, the Afram Plains' Guinea Worm Eradication Program moved into its second phase. During this phase, district coordinators rely on village-based volunteers identified during the case search to monitor disease incidence. At the same time, district coordinators are responsible for ensuring that data are collected, organized and passed on to regional and national levels.

The present study revealed serious deficiencies in this surveillance network. Though the national guinea worm eradication strategy calls for monthly reporting of incidence from all endemic villages, only one of the twenty-five villages identified as endemic in 1989 (see Table) (Asakensu) was monitored by a village volunteer. This person provided annual, not monthly, reports of disease incidence. Another volunteer provided bogus reports for two consecutive years.

Since there was no list of volunteers appointed in 1989, it was not possible to discern who they were or what had become of all of them, though we did chance upon two former volunteers who had moved to other villages in the time between the case search and the present study.

Two additional villages listed as endemic in the 1989 search were monitored by zonal coordinators who did not live in the villages themselves, but made random visits and communicated annual incidence data to the district coordinator.

The district coordinator knew the zonal coordinators, but did not know any of the village volunteers in the district and was unaware of the location, or even correct name of Dunkro, a village reporting the fourth highest number of cases in the district, through it is located only three kilometers from a main road. Furthermore, for two years he passed on bogus data, reporting an epidemic in Asikam to the regional guinea worm coordinator without attempting to investigate the outbreak further.

Thus, at least one reason for the district's poor record of reporting disease incidence is clear; very little organized active surveillance has been carried out.

Though the study did not set out to evaluate the adequacy of the 1989 case search itself, we did travel through at least two villages, Nsugyaso and Nsrogya Ahafo (villagers in a third village, Dukoman, were unsure about previous years' cases) not

listed as endemic in the search, which had experienced cases during the two previous years. In addition, we heard anecdotal reports of several remote villages in the Nsugyaso and Bonkron areas which had been endemic. Though it was not possible to confirm these reports, they hint that the 1989 case search may have undercounted guinea worm disease cases in the most remote areas. Taken together, lack of surveillance and the likelihood of undercounting of endemic villages indicate that the full scope of guinea worm disease in the Afram Plains is still unknown.

VILLAGER'S AWARENESS OF GUINEA WORM CONTROL

The data measuring villagers' knowledge of prevention and transmission of guinea worm disease constitute a baseline for future studies. To date there have been no similar studies in the Afram Plains to provide a reference, so it is not possible to compare the level of villager awareness at the time of the 1989 case search to that observed during this study. However, it is clear that a substantial proportion of people living in study villages drank potentially contaminated water and are uninformed about guinea worm transmission and modes of prevention.

Results of the household questionnaire suggest that those able to name a method of preventing guinea worm disease were more likely than their uninformed neighbors to take

precautions against the disease. Still, forty-eight percent of those informed about guinea worm disease prevention failed to take precautions despite their knowledge. Several factors may account for this observation. First of all, guinea worm disease affects a small percentage of the population in the Afram Plains; the 1989 census shows only one village with over ten percent incidence, so concern about guinea worm disease may be low owing to perceived low risk. Secondly, villagers may be reluctant to spend money on filter material, and firewood required for boiling water is a scarce commodity. It is also possible that those who filter their water do so for reasons other than guinea worm prevention (i.e. the water is muddy) and that filtering is not a response to concern over guinea worm disease. Given the dearth of education provided to villagers, it is not surprising that of those filtering their water, few used adequate filters.

Sixty-three percent of those interviewed had not received any information about guinea worm disease. Of the thirty-seven percent who had received information, eighteen percent received it from outreach groups, few of which included workers from the Guinea Worm Eradication Program. Another seven percent received information from guinea worm representatives. Of interest was the relationship between subjects' information sources and their likelihood of taking precautions. These data suggest that information provided by guinea worm monitors and medical outreach workers (active

modes of eduction) may be more effective in changing villagers' behavior than information provided by friends and family. Data indicate that people, living in villages which received some kind surveillance, are more likely to know about transmission and prevention. This suggests that the surveillance system, where it exists at all, is making some impact.

GUINEA WORM DISEASE CASE SURVEY

Results showed twice as many male victims of the disease as female. Victims were hindered from working for over a month on the average, creating a substantial economic impact on their families, since the preponderance of the disability occurred during the harvest season. This disability most likely resulted from secondary infection of the lesions, since none of those interviewed dressed their lesions sterilely, and all applied herbs to the lesions. A possible explanation for the predominance of males among victims is that many of the cases may have been contracted by drinking water from sources near farmers' fields, and it is generally considered that men spend more time farming than women. All but three of the victims were older than ten years of age and younger than fifty, further suggesting work-related exposure.

Guinea worm disease sufferers knew less about transmission and prevention and were less likely to report

taking precautions against the disease than people from the same villages interviewed for the household survey, though this may be due to sampling bias; the populations interviewed by the two surveys differed as the household survey interviewed mostly women, while two thirds of the guinea worm sufferers were male.

The discovery of twelve percent imported cases among guinea worm disease victims is significant for eradication efforts in the Afram Plains. The population's mobility creates the constant danger that disease will be introduced from endemic areas into previously non-endemic villages. This is especially true for the many people who travel regularly to highly endemic areas in neighboring Volta Region. Thus, villages in the Afram Plains are vulnerable to continual infection and reinfection from endemic areas both within and without the district.

LIMITATIONS OF THE PRESENT STUDY

The undeveloped infrastructure of the Afram Plains posed formidable obstacles to data collection which, combined with time and resource constraints, prevented researchers from reaching three of the twenty-five villages mentioned in the 1989 case search (data on the presence or absence of village volunteers in these villages was available from other sources). These obstacles also prevented researchers from

investigating many anecdotal reports of cases in remote villages.

Several kinds of bias could have affected the data presented. Though efforts were made to sample compounds in different parts of each village, sampling error could have been introduced in this fashion. Sampling error also could have been introduced in the selection of the villages (other than those reporting cases during the 1989 case search) sampled.

Importantly, the household survey examined water consumption patterns predominantly in the home. The survey did not report on water usage outside of the home. As indicated above, a significant amount of disease transmission may take place at the workplace. This is an extremely important issue in analyzing the proposing solutions for guinea worm endemicity.

Reporting bias may have skewed data in several ways. Translating between English and local dialects could also have generated reporting error, as could the presence of people from outside the village (especially a caucasian). For example, subjects may have overreported their use of precautions taken against guinea worm disease.

Recall bias may have caused inaccurate reporting of data as well, such as recollection of educational interventions, guinea worm incidence in the household, or time spent disabled by the disease. Also, it might have led to underreporting of

imported cases if victims did not recall travel undertaken the year prior to developing the disease.

Arbitrary definitions may have produced methodological bias. For example, subjects who recalled any visit to their village by a health care team, within the previous three years, were considered to have received information on guinea worm disease. Outreach teams from the Red Cross and Donkorkrom Hospital have provided some services to villages in the past two years, and typically address a number of germane health issues in each village they visit. It is possible that some teams (few of which included GWEP workers) did not mention guinea worm disease during their visits. Thus, our data may overestimate the number of subjects who actually received information about the disease.

GENERAL CONCLUSIONS

The results of this study suggest that since the 1989 case search, little has been done to eradicate guinea worm disease in the Afram Plains. The present system for monitoring and reporting incidence is insufficient, poorly organized and ineffective. In the few villages where surveillance is being practiced at all, villagers are more knowledgeable about transmission and prevention, as well as more likely to take precautions. However, even in these villages, many remain unaware of this information. Villagers

at risk for the disease have received little information about its transmission and prevention. Prior to the present study, the Guinea Worm Eradication Program had made virtually no effort to provide education for people at risk for the disease. At the same time, other, more expensive interventions have not reached endemic villages; the same number of study villages have boreholes now as at the end of the case search in 1989. Insecticide for vector control has not been made available for use in the Afram Plains.

In certain respects the guinea worm program in the Afram Plains is now in the same position it was prior to the 1989 case search. The number of endemic villages is unknown. There is little active surveillance of endemic villages and little is being done to increase villager awareness and influence water usage patterns.

ANALYSIS

Compared with the rest of Ghana, where over eighty percent of endemic villages report their monthly incidence of disease, the Afram Plains clearly lags behind in surveillance. This poor performance is attributable to several interrelating and mutually reinforcing phenomena.

The success of a Guinea Worm Eradication Program depends, to a great extend, on the effectiveness of its outreach efforts. The Afram Plains' poor roads and scattered, remote

villages make transportation a constant challenge. Vehicles are scarce and expensive to maintain. Spare parts are difficult to secure. Fuel is often not available. Additionally, the transportation shortage is exacerbated by the failure of health workers to coordinate their activities in order to make the most of the available vehicles. The remoteness of the Afram Plains itself shields the project from scrutiny. Under the very best of conditions, the journey from the Eastern Region capital of Koforidua to the Afram Plains' administrative center in Donkorkrom takes at least six hours, and the ferry schedule makes it impossible to travel back and forth on the same day, even for the few with sufficient stamina to attempt it. This makes it difficult for regional and national workers to make regular trips and provide the continuous feedback needed for the program to run smoothly.

The afram Plains' isolation and lack of infrastructure also cause it to be an unappealing place for Ghanians to work. Health workers are often assigned there involuntarily, subsequent to unsatisfactory performance in previous posts. Thus, health workers in the Afram Plains may tend, on the average, to be less motivated in their work than workers elsewhere in Ghana. There are, of course, many exceptions to this generalization. The dearth of supervision and feedback further undermine the performance of health workers at all levels.

The lack of a general fund to pay for small, essential

day-to-day expenses further hampers the efficiency and effectiveness of the Guinea Worm Eradication Program. A request for money to repair a flat tire, for example, can take days to weeks to produce the necessary funds, while the request travels to the regional capital in Koforidua and back. Also, lack of compensation for health workers engaging in outreach activities poses a significant problem for accomplishing outreach work. Since workers often expect compensation above their normal salaries for work that requires them to spend nights away from home, they may decline to participate in outreach efforts if such compensation is not forthcoming. Compensation has become an issue at the village level as well. A rumor circulated, after the 1989 search, that village volunteers were to receive pushbikes to help them perform their surveillance activities. The volunteers' disappointment at not receiving the expected equipment and compensation may help to explain why so few were carrying out their responsibilities in 1991.

Ironically, the Afram Plains' hypoendemicity also hinders the establishment of an effective Guinea Worm Eradication Program. Even in endemic villages, for the most part few cases are seen each year and mortality is rare. As a result, most villagers do not perceive the disease as a major health problem. Such attitudes contrast with those of people living in hyperendemic areas. For example, the population studied by Akpovi eagerly sought outside help to alleviate their guinea

worm problem. Whereas a hyperendemic community suffers significantly from the economic effects of the disease, economic impact is generally felt only at the family level in the Afram Plains.

In addition, health workers at the district and regional levels rightly channel resources into combatting more widespread and mortal health problems. Guinea worm project workers at the national level are more concerned with hyperendemic and mesoendemic areas than areas like the Afram Plains. This attitude finds its way to the village level, where village volunteers perceive a half-baked national, regional and district commitment to guinea worm eradication.

Poor organization plagues the Afram Plains' Guinea Worm Eradication Program. Workers at all levels are unaware of their responsibilities. At the village level, volunteers do not know that they are expected to provide monthly incidence reports. The district coordinator is charged with organizing surveillance but has developed no plan for improving surveillance or providing education. Lack of supervision and feedback from the regional and district levels is at least partly responsible for poor organization.

Scarcity of educational resources also impedes the program's ability to provide effective education about guinea worm transmission and prevention to villagers in the Afram Plains. Though literature on disease prevention was available at the regional and national offices, it had not reached the

Afram Plains, and was, at any rate, ill-suited for the predominantly illiterate population. It was surprising to find that, though the national program had supposedly entered the intervention phase (which calls for dissemination of health education) one and a half years earlier, the national office in Accra did not have any posters appropriate to raising villagers' awareness of the disease.

Essentially, the present Guinea Worm Eradication Program in the Afram Plains violates most of Henderson's guidelines for a successful disease eradication initiative: workers are not committed to the program, the program is not well integrated with other health programs in the Afram Plains, little outreach is done, personnel are unmotivated, and village workers receive little supervision.

Currently the Afram Plains does not suffer from high rates of endemicity, yet guinea worm still can profoundly mark communities. Significant exceptions to the Afram Plains' hypoendemicity underscore the sporadic and unpredictable nature of the disease there. The village of Apapa, for instance, supposedly had a population of three hundred in 1989, when ninety-four cases were reported. When we passed through Apapa two years later and noted only a handful of families, a villager explained that his neighbors, suffering under the vicious epidemic, had chosen simply to move elsewhere. If the GWEP is allowed to continue along its present path, guinea worm disease is likely to simmer on at

low levels with sporadic outbreaks beyond the 1993 goal for eradicating the disease in Ghana. Action taken in the next few months will determine whether or not this goal is met in the Afram Plains.

RECOMMENDATIONS

The present study identifies several factors which affect the implementation of a successful Guinea Worm Eradication Program in the Afram Plains:

1) widespread use of water sources capable of harboring guinea worm disease
2) a highly mobile population which frequently travel to hyperendemic regions
3) a majority of the population which is unaware of modes of disease transmission and prevention
4) an inadequate surveillance system
5) a poorly motivated, disorganized corps of workers
6) funding constraints
7) hypoendemicity with sporadic outbreaks of disease
8) the likelihood that a substantial percentage of victims contracts the disease outside of the home (while farming)
9) scarcity of educational materials

Surveillance is a sine qua non for effective guinea worm control. Thus, establishing a functional surveillance network should be the Afram Plains' Guinea Worm Eradication Program's top priority. Ideally, since the current extent of disease is

not known, another case search should be performed. However, given personnel and resource constraints, this is unlikely, so health workers should first appoint village volunteers in villages previously (from 1989 on) identified as endemic, and follow up anecdotal reports of newly endemic villages. This follow up should emphasize the region around Bonkrom and Nsugyaso, in which there are likely to be several additional endemic villages.

The surveillance system must be organized in such a way that each worker's responsibilities are clearly defined. Workers at every level should know exactly what is expected of them and how to perform their functions.

VILLAGE VOLUNTEERS:

* go compound to compound once every month, recording name, age, sex, and water source of all new cases, indicating whether cases are likely endemic or imported (by ascertaining travel history)
* send monthly data to district coordinator
* distribute filters, teach and encourage their use
* provide education to individuals
* notify village of upcoming educational events

ZONAL COORDINATORS:

* coordinate initial response to non-reporting villages
* make three visits each dry season (late November, January and March) to endemic villages, verify cases, ensure that village representatives perform their jobs correctly

DISTRICT COORDINATOR:

* sends monthly incidence reports to the regional coordinator in Koforidua

* monitors reports as they come in from the field

* appoints new village representatives as needed

* visits villages with reported cases to verify endemicity

* does spot checks to ensure that village volunteers continue to keep monthly records

* provides education to villages with high endemicity and to market villages on the eve of market day

* provides T-shirts as well as filters and education materials to newly recruited village and zonal workers

* takes charge of enforcing surveillance

* reappoints village volunteers if they are not compliant

* keeps records of monthly incidence on charts in CDR offices in Donkorkrom, Tease and Ekye Amanfrom.

Timing is an important aspect of effective surveillance and educational intervention. Fortunately, guinea worm disease lends itself to convenient and strategic education and surveillance. Since most disease incidence (and, therefore, transmission) occurs from September through December, intense education efforts should directly precede this period. Education programs should be planned for August in order to increase villager awareness during the peak transmission interval. September and October rains make travel nearly impossible, but excursions into the bush ensure that cases are

being counted should be carried out in late November and again perhaps in January, with a final round in March.

The district coordinator must integrate his guinea worm eradication endeavors with his other responsibilities. He can facilitate this greatly by planning his guinea worm eradication activities ahead of time with the aid of a calendar. The disease's predictable annual pattern, and the Afram Plains' relatively stable annual weather patterns make this possible.

Adequate supervision of the District Coordinator is critical. This is normally the function of the Regional Coordinator, but, as has been demonstrated, he may be unable to fulfill this role since regular travel to the Afram Plains from Koforidua is burdensome. In the Afram Plains the District Medical Officer, who oversees some of the District Guinea Worm Coordinator's other work, can greatly encourage him to perform his duties. He can accomplish this by requesting copies of monthly incidence reports as well as by checking the charts in Tease and Ekye Amanfrom (while passing through) and in Donkorkrom (down the hall from his own office). A major benefit of this supervision is that the District Medical Officer directs the entire district's health outreach programs and thus is well placed to help the district Guinea Worm Coordinator place guinea worm activities in the context of his other work. Of course, all additional supervision provided by the Regional Coordinator would be

helpful. Optimally, the Regional Coordinator and the District Medical Officer should coordinate this work.

INTERVENTIONS

Since endemic villages are hypoendemic and the number of at-risk villages is large, solving the Afram Plains guinea worm problem by embarking on a large borehole drilling project, while in itself a worthwhile endeavor, is both unrealistic and impractical. Widespread application of insecticide to water sources would not solve the problem either, given the tendency for disease to be reintroduced from outside sources. These approaches, while potentially useful in limited contexts, are inappropriate bases for the Afram Plains Guinea Worm Eradication Program. Rather, an aggressive education program designed to reach the largest possible number of villagers is called for. Top priority should be given to providing effective educational programs and distributing free filters (made possible by a recent donation from Dupont) in endemic villages.

EDUCATION

Surveillance and education should reinforce each other. A functional surveillance network directs education to places where it is most needed. An educated population in turn

realizes the importance of reporting guinea worm incidence and thus facilitates the reporting of new cases.

Education materials and programs must be clear, concise, accessible and interesting. Accessibility refers to time and location as well as to content. Successful education also addresses villagers' practical concerns (i.e. how to filter water in the workplace). Important criteria in the Afram Plains include portability and parsimonious resource utilization.

The ideal purveyors of education are the village volunteers themselves. However, they are usually unequipped to provide effective education, since they lack the necessary time and resources and may not be able to answer challenging questions directed at them, thus undermining their message. Nevertheless, they can make a great impact by reminding their neighbors to take precautions against the disease.

The educational program which accompanied the present study centered on a slide presentation. This medium was chosen for several reasons. By evening, the villagers have finished their work and have nothing else to do, since villages lack electricity. In the village setting the slide show constitutes a form of entertainment, which increases interest. Large pictures projected onto a screen clearly illustrate relevant points and allow many to view the program at once. Slides provide convenient pauses to answer audience questions and test their understanding. The program was

structured around four main messages: 1) guinea worm is transmitted through drinking water, 2) symptoms appear one year after ingesting contaminated water, 3) the disease can be prevented by filtering or boiling all ingested water, and 4) people with guinea worm lesions should be prevented from contacting water supplies. The slide presentation included a demonstration of how to correctly filter water, and also provided an opportunity to "introduce" village volunteers to their villages. This attempted to link the educational program with ongoing surveillance efforts and promote volunteers' sense of responsibility to their neighbors. The educational program described here was shown on fifteen occasions to a total audience estimated conservatively at twenty-five hundred to three thousand people.

Slide programs are well-suited for villages with populations exceeding four hundred or so. In small villages, a scaled-down, daytime version of the presentation can be shown. The advantages of the smaller presentation are that several villages can be reached in a single day and the educator can make eye contact with individuals to ensure that everyone understands the major points. Disadvantages include smaller audiences (maximum of about forty to fifty was our experience) and failure to reach adult men, who are usually still working in the fields.

Since reaching all potentially endemic villages is not possible given the time constraints and limited resources of

health workers, educational programs should be presented in market centers on market days in order to reach as many people as possible. The crucial education message here is for villagers to understand disease transmission and remember to prevent people with guinea worm disease from contacting water supplies. People should also be encouraged to report cases, occurring in previously non-endemic villages, to the proper authorities.

The problem of difficult access turns out not to be as difficult as previously assumed. Guinea worm education does not require four wheel drive vehicles or even large, expensive motorbikes, as have been used to date. Outreach can be provided on relatively inexpensive mopeds. Though these are not favored by health workers because they are less glamorous than more powerful models, they are adequate for the task, and their light weight often gives them an advantage in traversing deep sand and mud. They are also more fuel efficient.

These activities, while designed to conserve resources by parsimonious spending of resources, still need small regular injections of cash to cover the day to day expenses incurred. In order to facilitate the smooth function of the project, a small fund should be made available and replenished upon handing in of receipts. This is necessary to avoid needless delays in acquiring items like fuel, minor repairs and the like.

Worker motivation may be a difficult problem, and much

needs to be done in this area. First of all, the workers must know exactly what is expected of them as well as detailed knowledge of procedures to be followed. Secondly, workers must not be wooed into working by false promises of future compensation. However, some experience shows that token gestures (giving new village volunteers T-shirts) can be very useful in recruiting workers. Recruitment is useless, of course, unless workers remain committed to their work. It is important to foster a sense of responsibility to the community and the aims of the project and the nation. In our education/recruitment work, we have accomplished this by "introducing" guinea worm village volunteers to their villages during educational programs and, at the same time, presenting them with T-shirts. We hope this encourages a feeling of responsibility to community well-being on the part of the volunteers, on one hand, and on the other hand fosters subtle pressure from their neighbors to carry our their responsibilities in good faith. In addition, we attempted to emphasize to volunteers their importance to a system which is tied to a national effort.

Another important approach which would improve health care in remote villages is providing village volunteers with training and materials to provide sterile dressings to guinea worm lesions. These volunteers would thus also be able to provide treatment for minor wounds which, as they are usually treated with herbs, often become infected.

Perhaps the most important measure to improve worker performance is follow up by zonal and district, and even regional officials, to check compliance and provide feedback. Workers at all levels need to have supervision and as steady a flow of feedback as possible. Such supervision has several positive effects. In addition to ensuring legitimate data is being collected, providing feedback on volunteer performance, and enabling first-hand observation of villager water usage patterns, it increases morale among village volunteers, who receive confirmation of their importance to the project.

APPENDIX

Table 1.

Village	Population[a]	Water Sources (wet season)	Water Sources (dry season)	Cases, 1989	Cases, 1990	Village Volunteer (as of Sep. 1991)	Zone Volunteer (as of Sep. 1991)
Abomasarefour	5000	1,5,6,7	5,6,7	0	3	-	-
Abotanso I	?	1,4,5	1,5	0	0	-	+
Abotanso II	?	1,3,5	1,3,5	0	0	-	+
Abotanso III	?	3,4,5,7	3.4.5.7	0	0	-	+
Adeimra	?	1,2,4,5	2,4,5,8	3	0	-	-
Adukrom I	75	1,3,5	3,5	0	1	-	+
Adukrom II	375	1,3,5	3,5	0	1	-	+
Alavanyo	100	1	2	0	0	-	-
Ameyawkrom	225	3,5	3,5	4	7	-	-
Anane Akura	75	1,3	3,8	5	5	-	-
Apapa[b]	30	1,3	3,8	94	12	-	-
Apapasu I	200	1	8	0	14	+	-
Asakensu	125	1	8	3	0	+	-
Asanyansu	500	1	8	?	5(U)	-	-
Asikam[c]	50	3	3	8	11	-	-
Asimpaning	450	1	8	1	0	-	-
Atonsu	500	1,3	3,8	?	4(U)	-	-
Bluben	6000	6	6,	1	0	-	-
Boakyekrom	1500	1,3	3,8	3	3	-	+
Bonkrom	1500	1	8	24	0	-	-
Donkorkrom	6000	1,2,4,5	2,4,5,8	1	0	-	-
Dukoman	1000	1,3	3,8	0	2(U)	-	-
Dunkro[d]	2000	1	8	22	10	-	-
Fodua II	500	1	8	1	1	-	-
Iddrisu Akura	150	1	8	1	0	-	-
Kayera	500	5,7	5,7	3	0	-	-
Kojo Gari[e]	200	1,2	2,8	3	0	-	-
Konkonba	200	?	?	1	0	-	-
Koranten Krankyi	1000	1,3	3,8	26	0	-	-
Kwabensa Kusie	150	1,3	8	3	0	-	-
Kwaekese (D'korm)	7000	3,5	3,5	4	15	-	+
Akwaekese (K'fante)	2000	3	3	?	3(U)	-	-
Kwasifante	1000	3	3	?	0	-	-
Lomnava	175	1,3	3,8	15	0	-	-
Memchemfre	1800	1	6,8	12	0	-	-
Nsrogya Ahafo	1900	1	8	?	3(U)	-	-
Nsugyaso	2500	1	8	?	4(U)	-	-
Odumasua	2000	?	?	2	0	-	-
Praprababida	400	2	2	0	5	-	-
Salekwanta	25	1	8	2	2	-	-
Seou Lomnava/Aliheli	?	6	6	1	2(U)	-	-
Wawase	150	2	6	0	17	-	-

a Approximate population- intended to provide a general idea of village size. Actual populations may differ substantially due t(population fluxes.
b Apapa - population in 1989 listed at approximately 300. Reportedly most of the villagers left after guinea worm epidemic of 1989
c Asikam - (see a "Tale of Two Villages"). These data were shown to be false. Asikam has not had a case of guinea worm for the las five years.
d Dunkro - incorrectly identified on previous GWEP data as "Dikuo".
e Kojo Gari - Unconfirmed reports elicited during the present study indicate at least three cases during 1990, contradicting GWE data.
U unconfirmed report elicited during the present study.
1 flowing stream
2 unprotected well
3 dam or pond
4 protected well
5 borehole
6 river
7 rain catchment
8 stream remnant

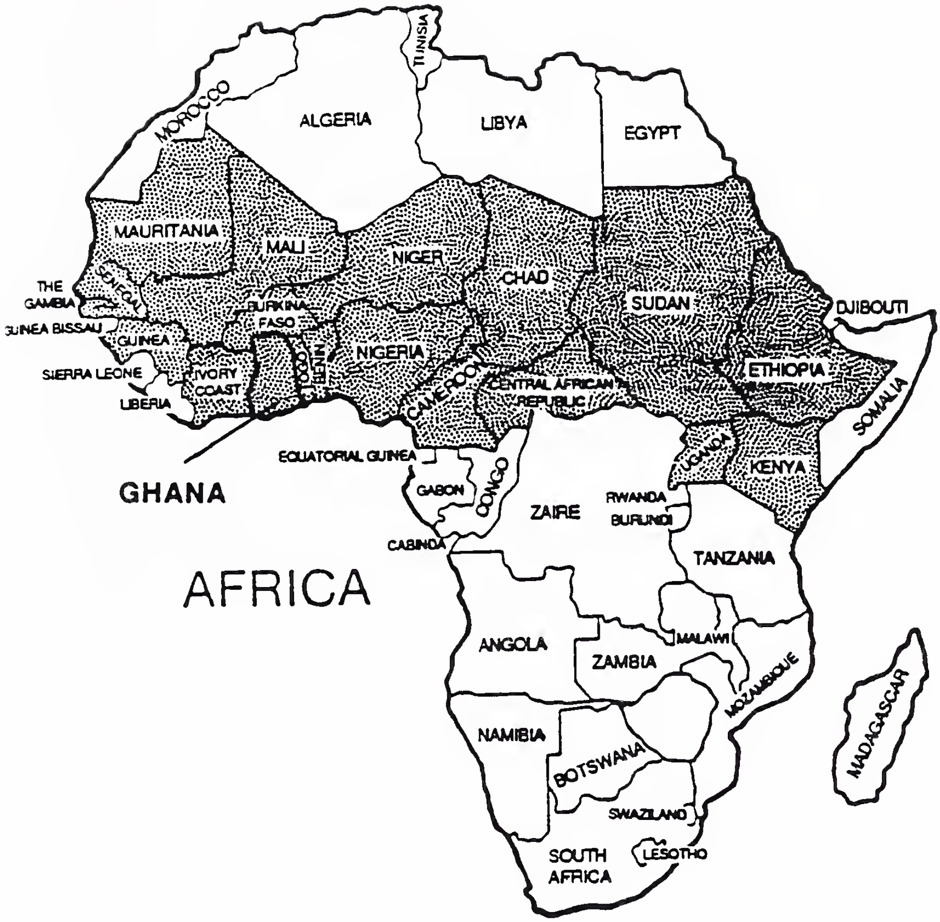


Figure 1. Guinea worm endemic countries in Africa.

Figure 2. Guinea worm disease. The mature female Dracunculus is seen emerging from the lesion.

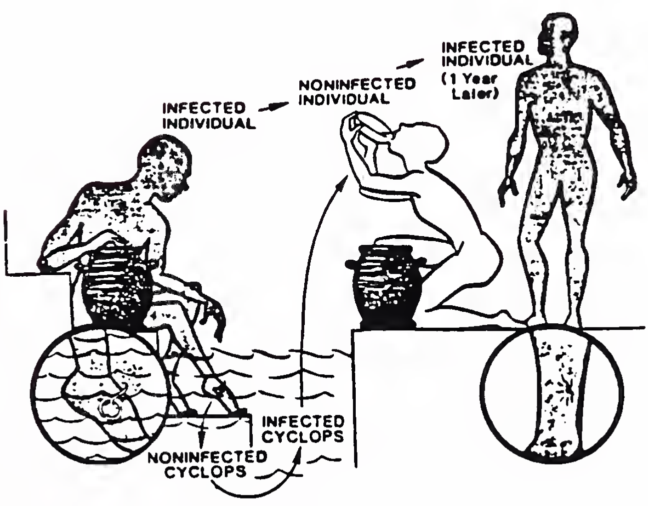


Figure 3. Life cycle of D. medinensis. (source: Centers for Disease Control)

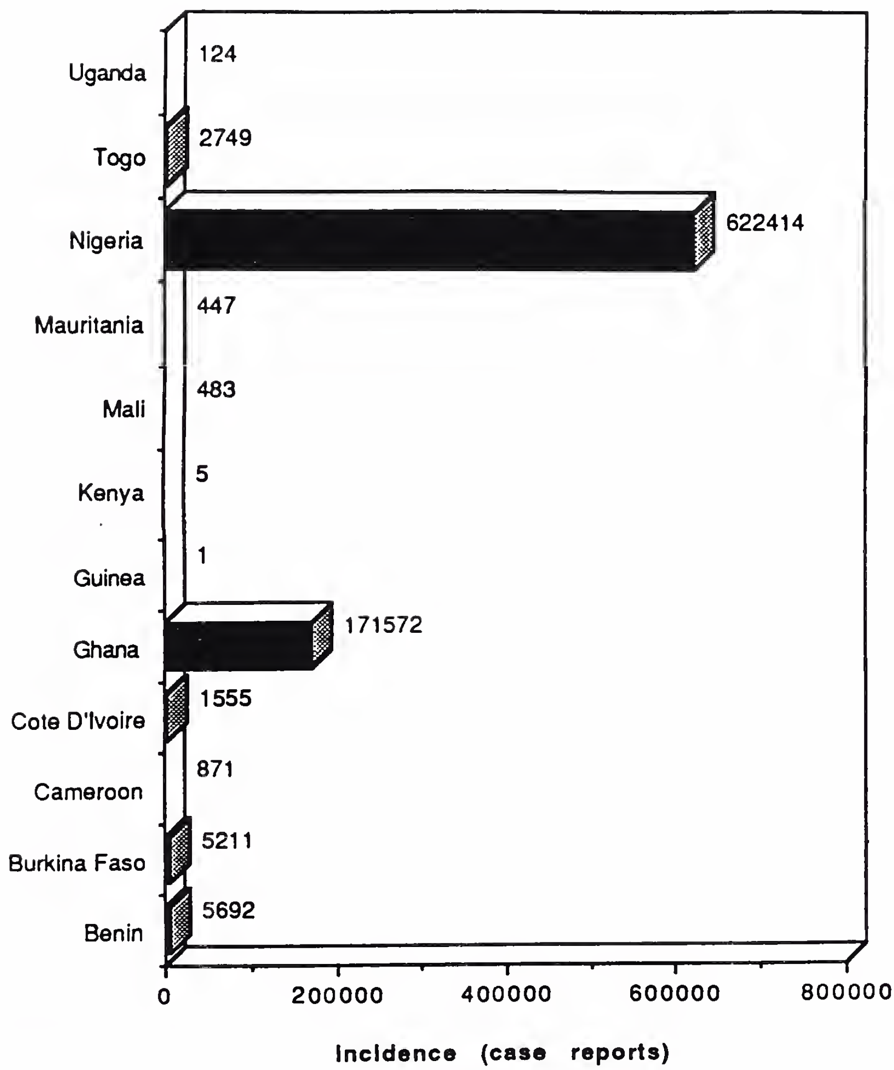


Figure 4. Guinea worm incidence in Africa, 1989. (from Hopkins and Ruiz-Tiben, 1990.)

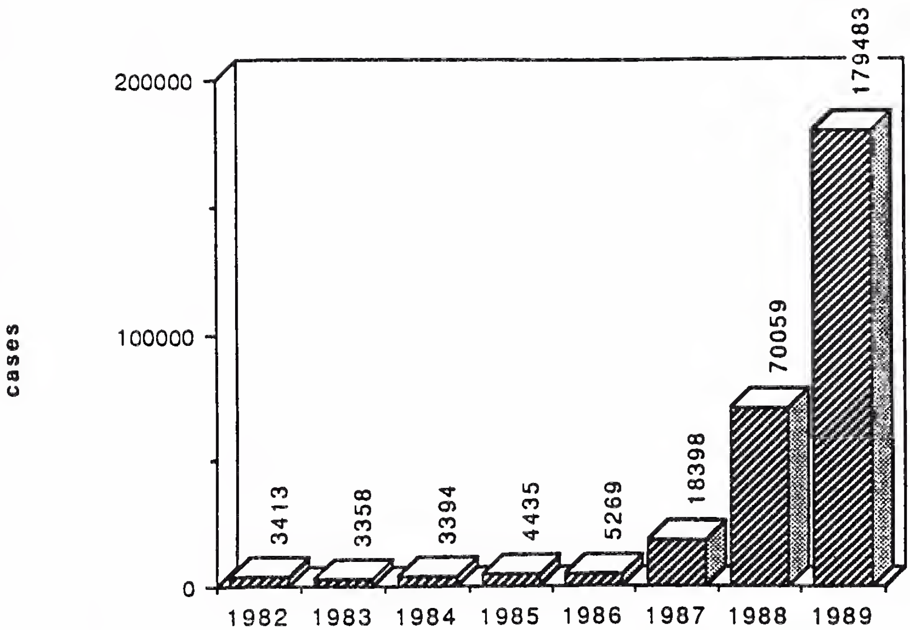


Figure 5. Guinea Worm incidence in Ghana, 1982-1989.

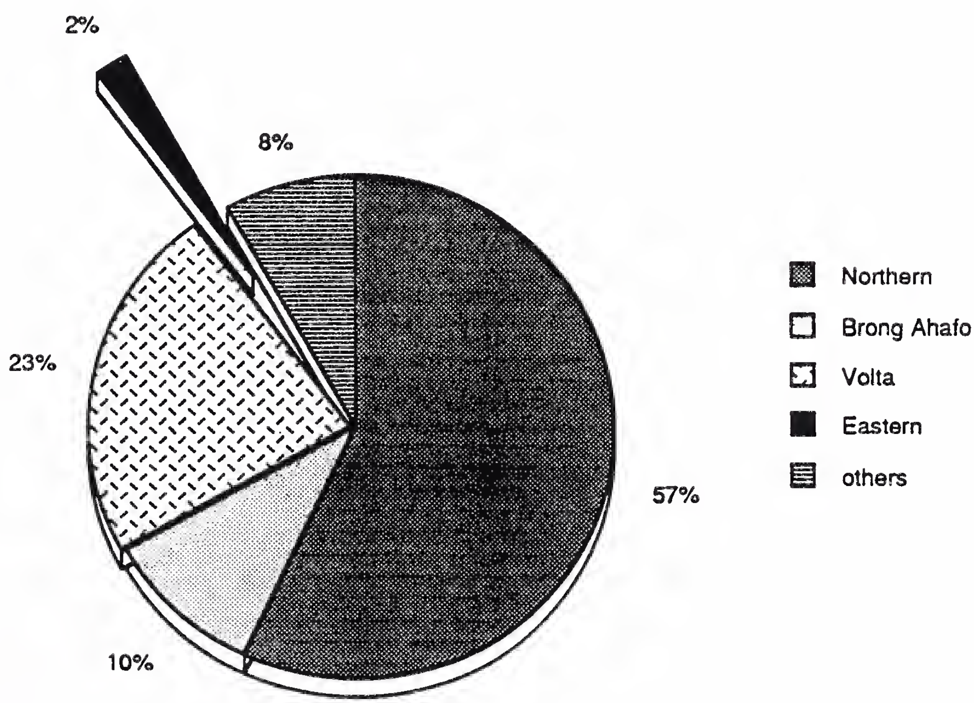


Figure 6. Guinea worm incidence in Ghana by region, 1989.

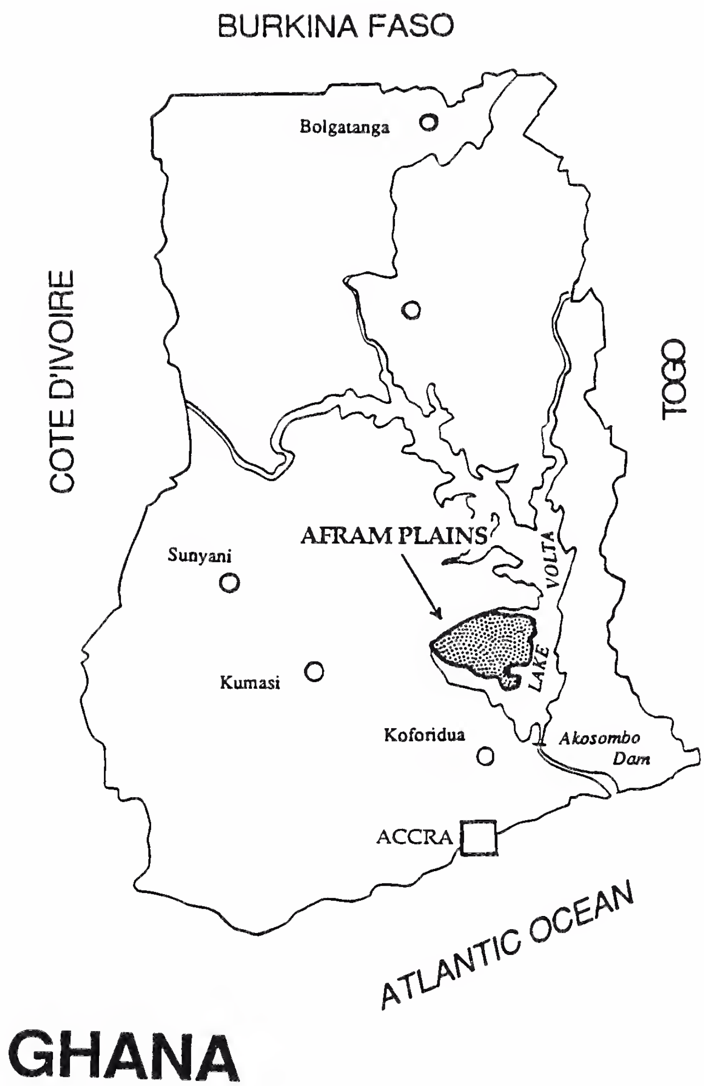
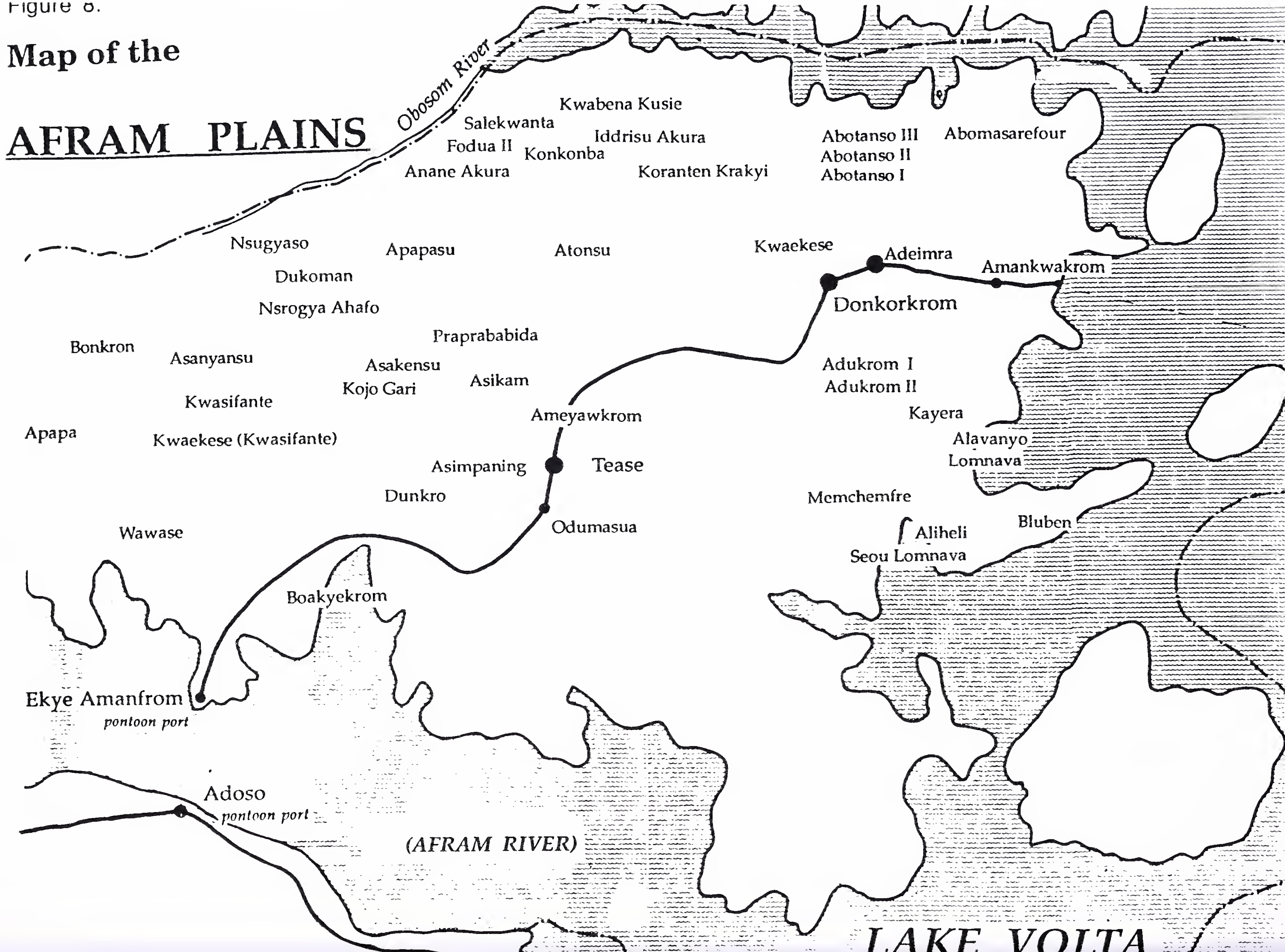

BURKINA FASO
Bolgatanga
COTE D'IVOIRE
TOGO
AFRAM PLAINS
Sunyani
VOLTA
LAKE
Kumasi
Koforidua
Akosombo
Dam
ACCRA
ATLANTIC OCEAN
GHANA

Figure 7.

Figure 8.

Map of the AFRAM PLAINS



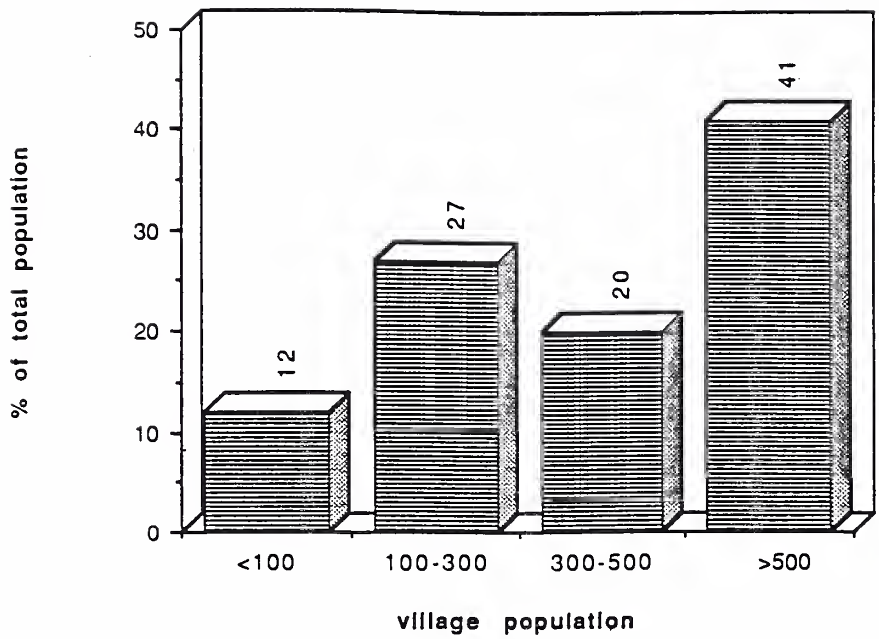


Figure 9. Distribution of the Afram Plains' population with respect to village population.

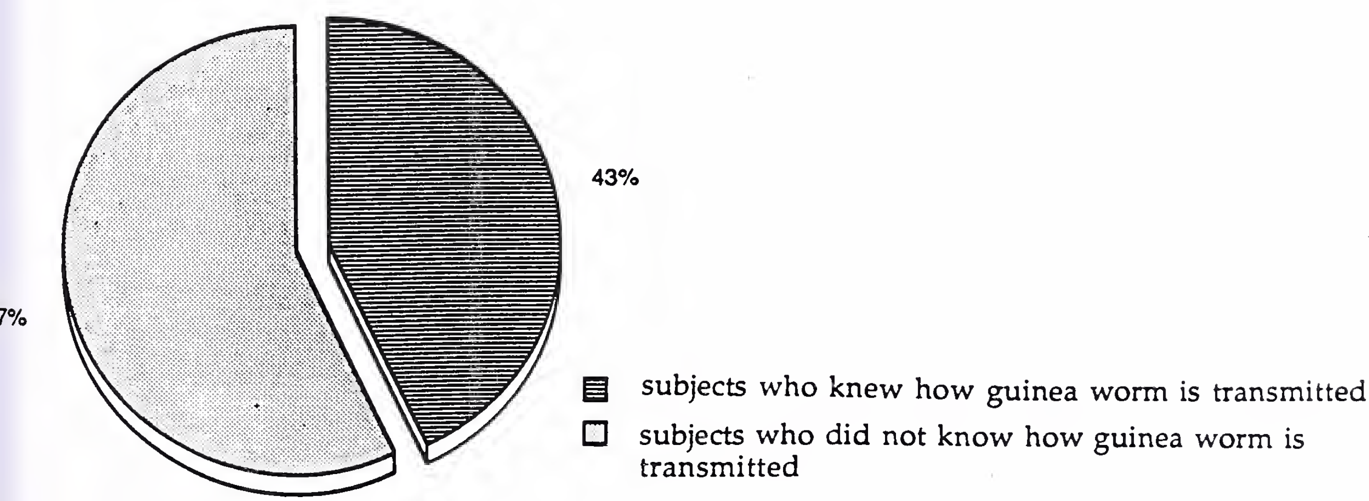


Figure 10. Percentage of subjects who knew how guinea worm disease is transmitted. (data from household survey)

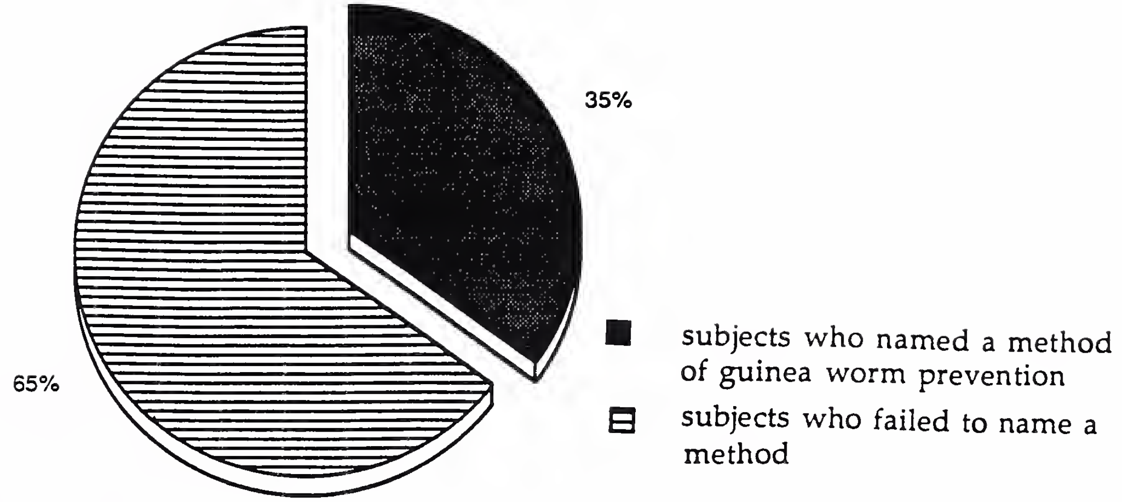


Figure 11. Percentage of subjects who knew how guinea worm disease can be prevented. (data from household survey)

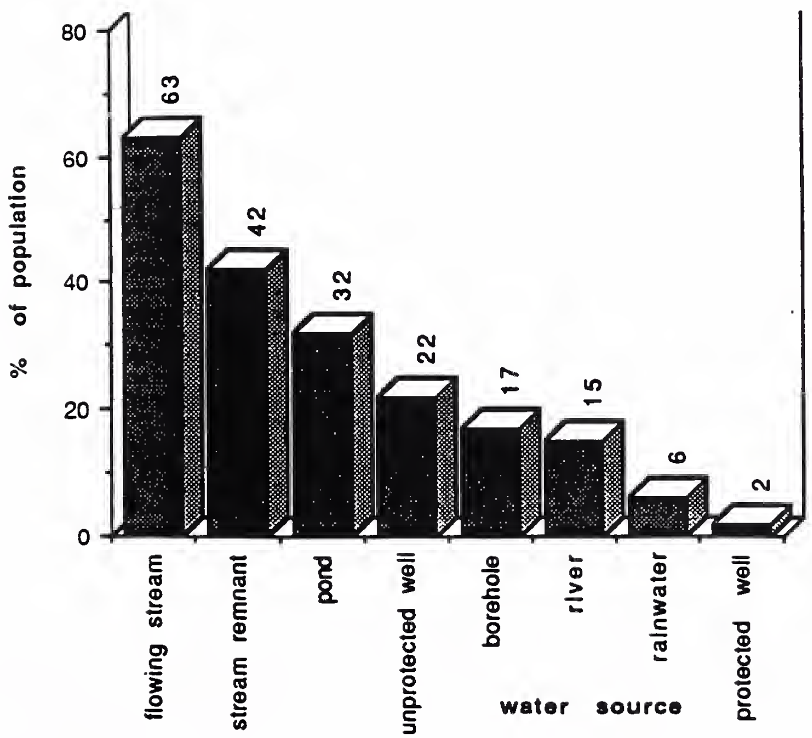


Figure 12. Subjects' drinking water sources. (household survey)

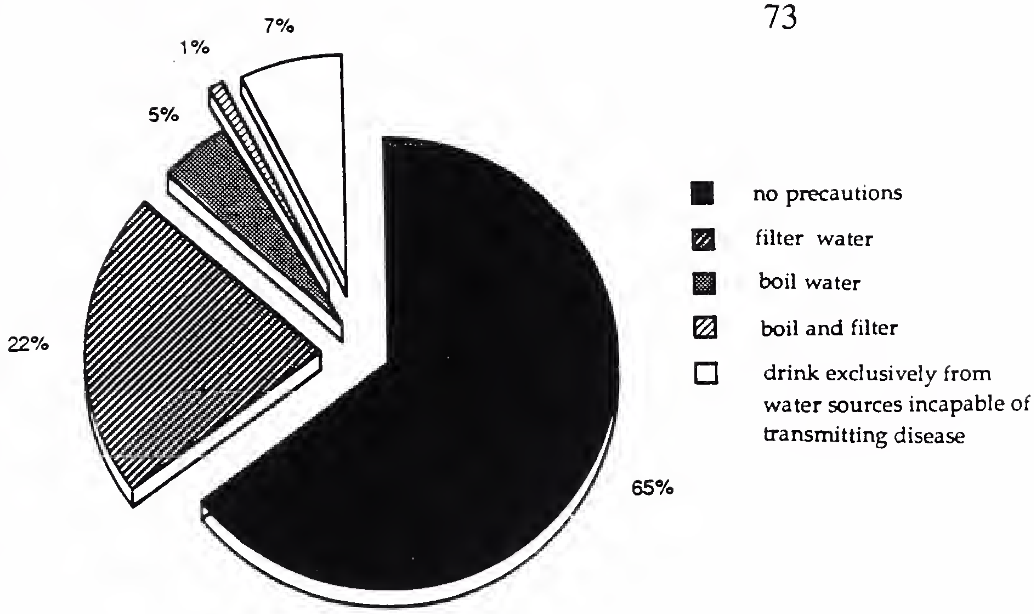


Figure 13. Precautions against guinea worm disease taken by residents of villages with potentially contaminated water supplies.

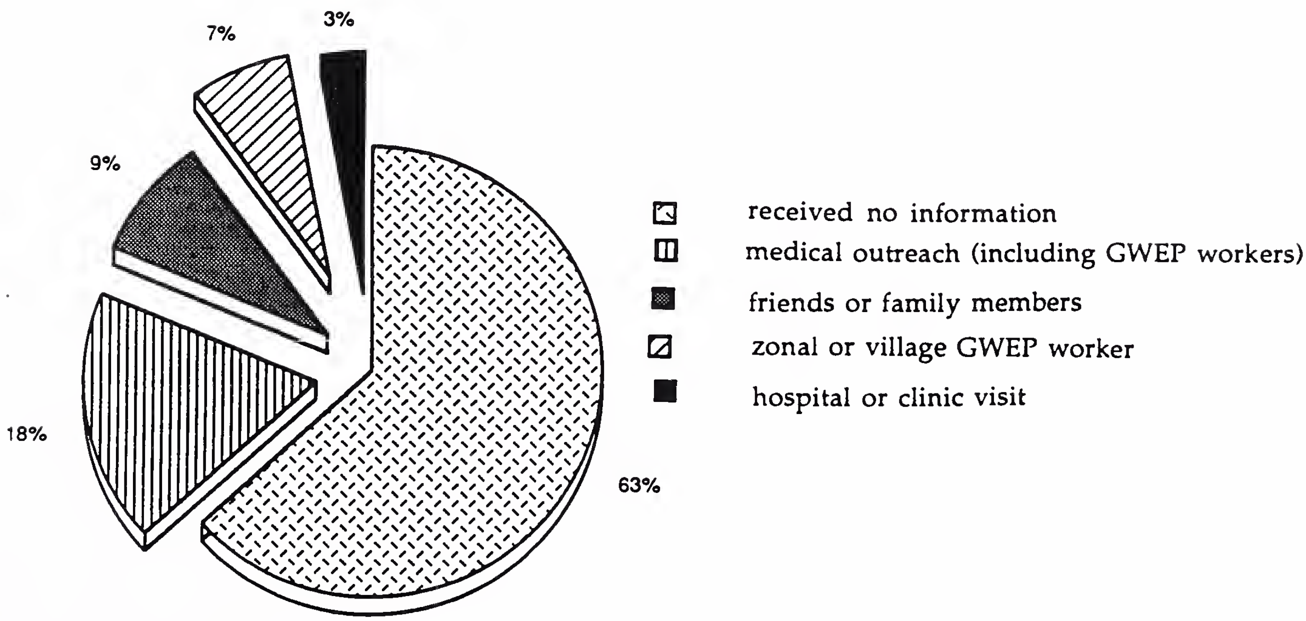


Figure 14. Subjects' sources of information on guinea worm disease. (data from household survey)

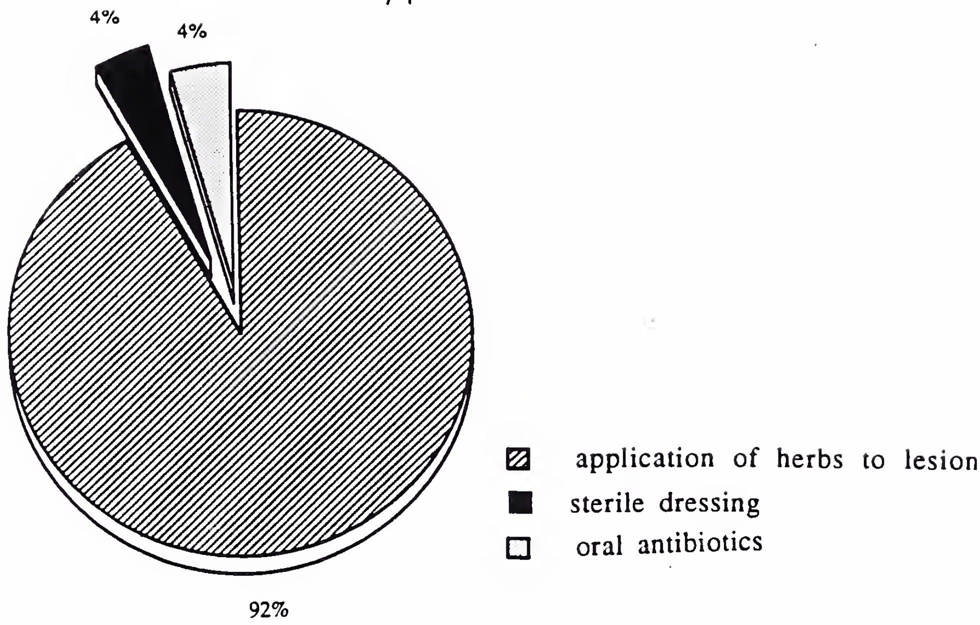


Figure 15. Therapy provided for guinea worm disease. (data from household survey)

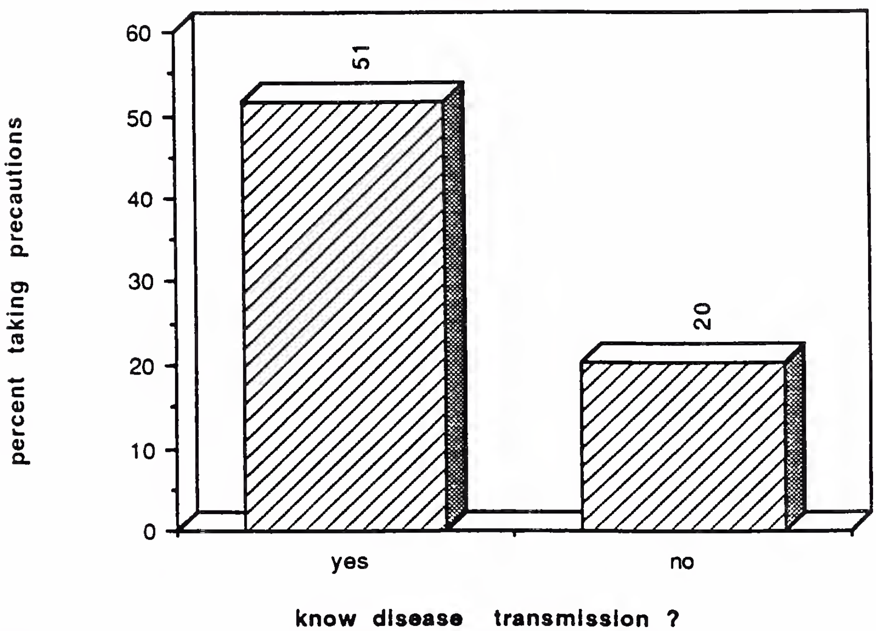


Figure 16. Influence of awareness of guinea worm prevention on likelihood of taking precautionary measures against the disease. (data from household survey)

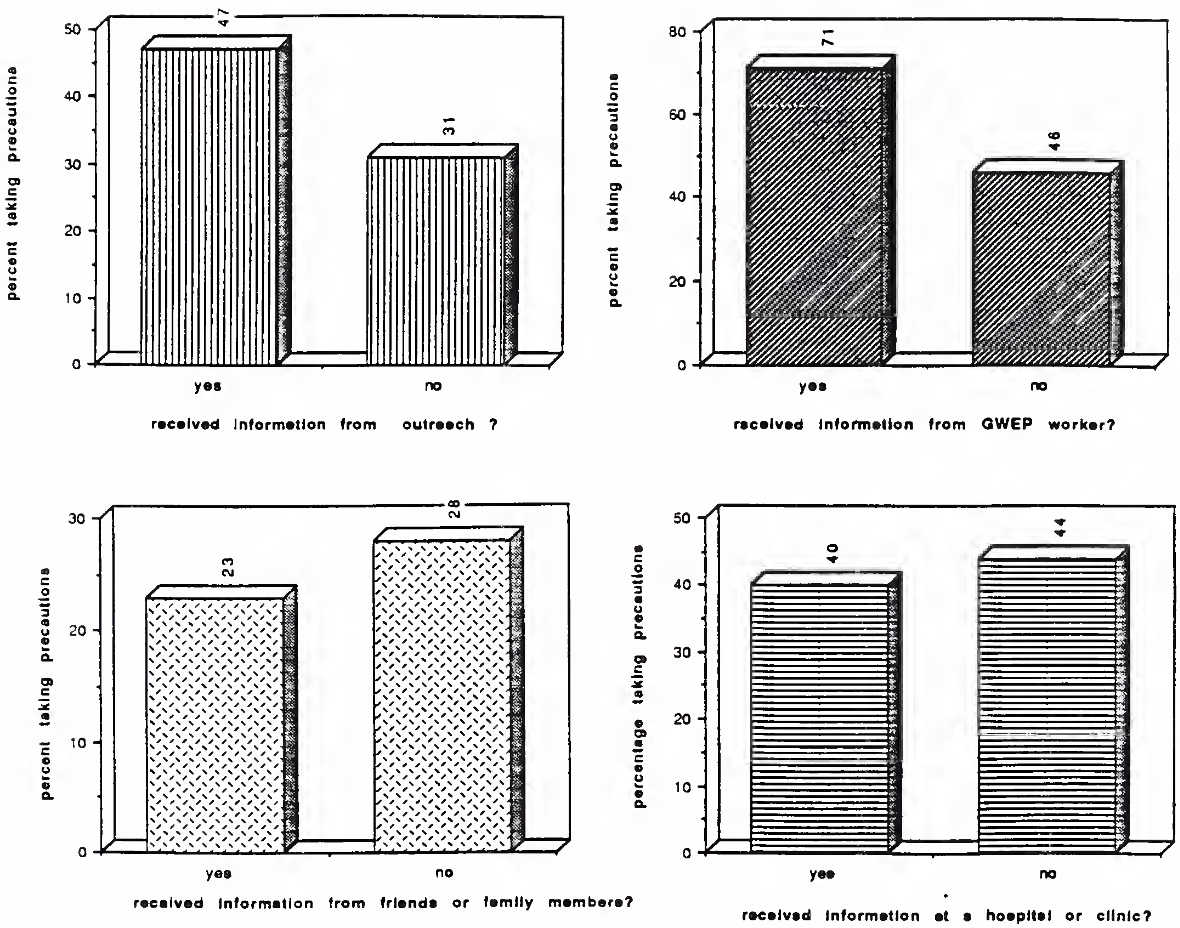


Figure 17. Association of subjects' information sources and their likelihood of taking precautionary measures. (data from household survey)

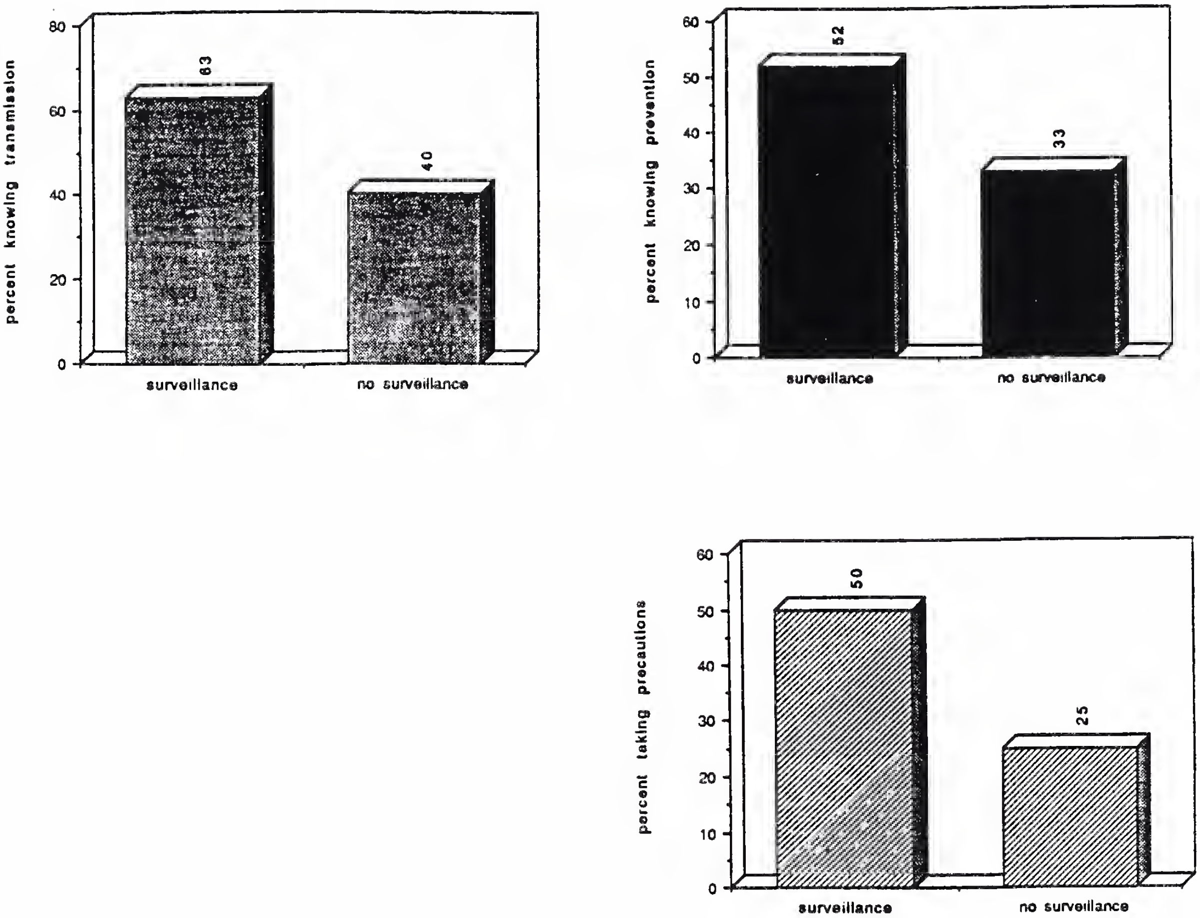


Figure 18. Comparison of subjects' knowledge of disease prevention and transmission and likelihood of taking precautionary measures between villages with and without surveillance. (data from household survey)

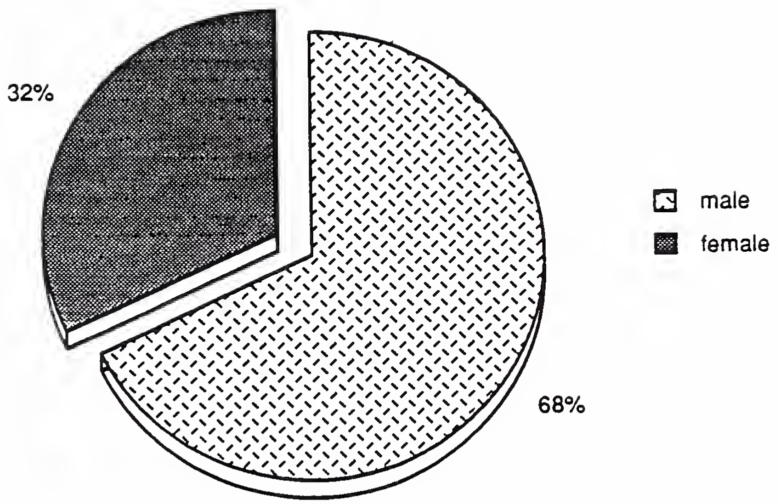


Figure 19. Guinea worm victims by sex. (data from guinea worm case survey)

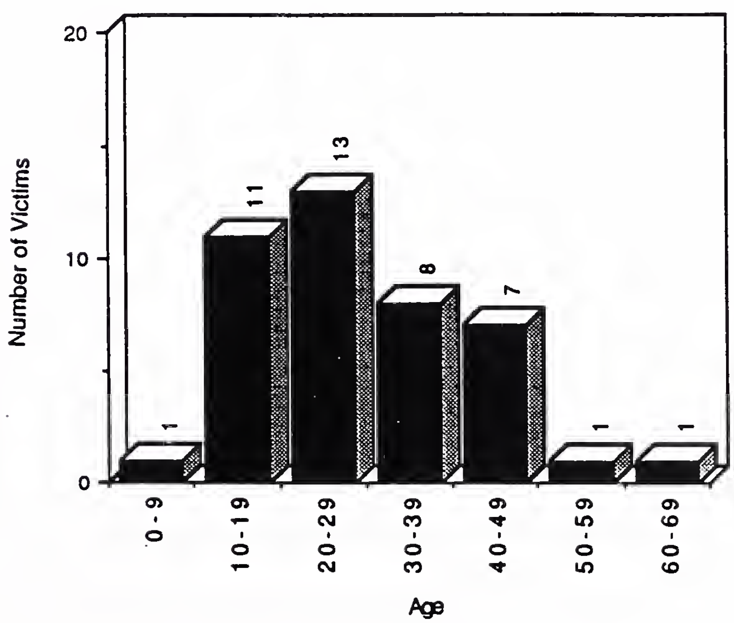


Figure 20. Age distribution of guinea worm victims. (data from guinea worm case survey)

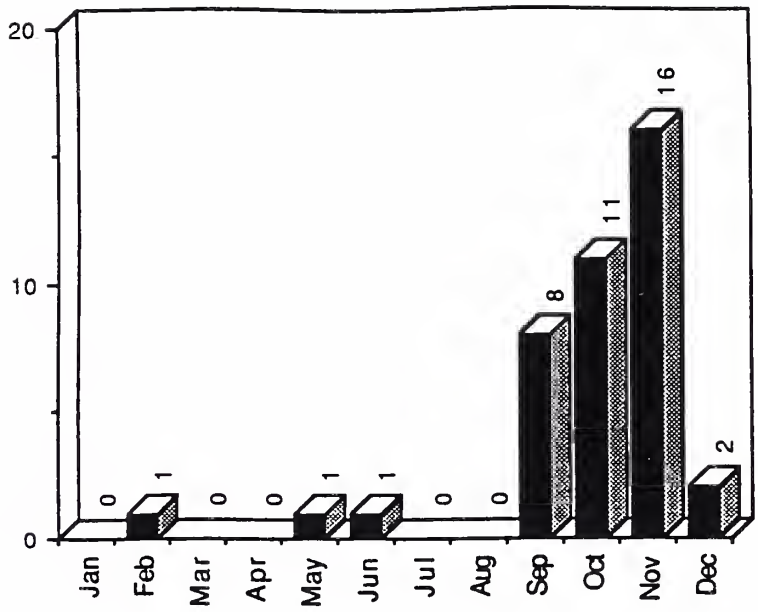


Figure 21. Annual distribution of guinea worm incidence. (data from guinea worm case survey)

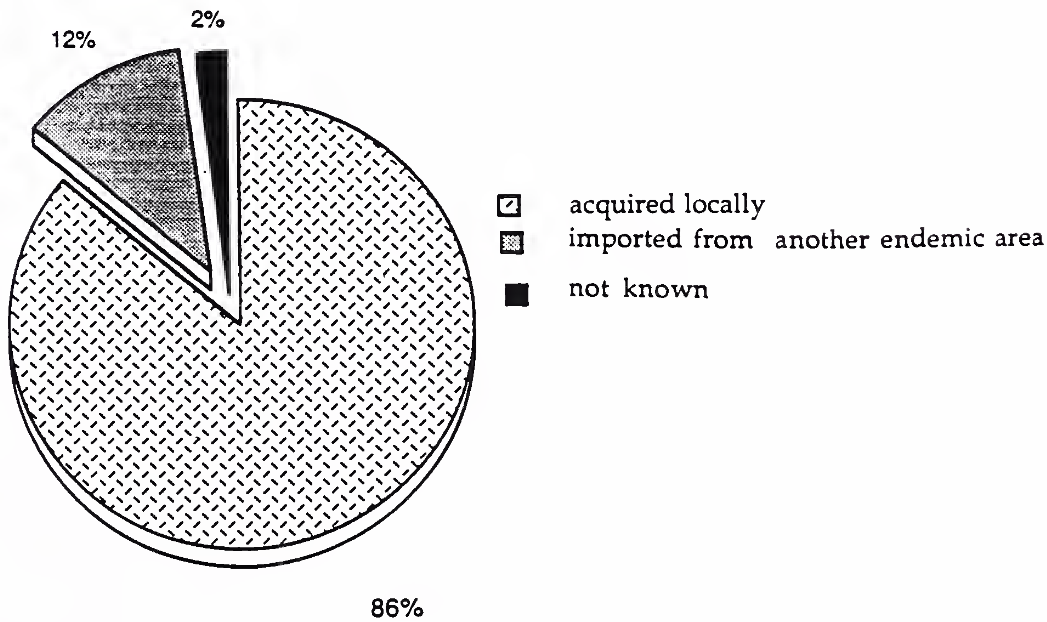


Figure 22. Victims' probable source of disease.

HOUSEHOLD QUESTIONNAIRE

Village ______________________________ Date __________________________
Age _________ Sex ________

Do you know what Guinea Worm Disease is? Y N

If yes, describe

How does a person get GWD?

How can one prevent him/herself from getting GWD?

In this household, how many people have had GWD?

a) this year sex ___ age ___

b) previous years sex ___ age ___

How did you treat the GWD?

From where do you get your drinking water?

Dry season:	_______________	Wet season:	_______________
	_______________		_______________
	_______________		_______________
	_______________		_______________
	_______________		_______________

Do you boil ___ or filter ___ water before drinking or cooking?

If filter is used, demonstrate use.

Who is your village GWD representative? Has he spoken to you about GWD prevention?

Has someone from outside the village informed you about GWD prevention?

QUESTIONNAIRE FOR GUINEA WORM DISEASE VICTIMS

Village ______________________ Date ___________________

Age ______________ Sex: __________

Has anyone ever explained to you how you get Guinea Worm Disease? (describe)

What can one do to prevent Guinea Worm Disease? (describe)

When did you first notice Guinea Worm Disease? (month/year)

Describe your symptoms:

number of lesions: __________

location of lesions: a) trunk or head ___

b) arms ___

c) legs ___

Occupation ____________________

How long, if at all, were you prevented from working? ______

Have you had Guinea Worm Disease before? ________

If so, how many times? _____

From where do you draw you drinking water?

Dry season: ___________ Wet season: __________
___________ __________
___________ __________
___________ __________
___________ __________

Do you boil ___ or filter ___ water before drinking?

Has someone from outside the village informed you about GWD prevention?

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