AN EVALUATION OF DRACUNCULIASIS AND THE INTERVENTION STRATEGIES ADOPTED FOR ITS ERADICATION IN BORNO STATE, NIGERIA

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DECLARATION

I hereby declare that this work is the product of my own research efforts; undertaken under the supervision of Professor C.O.E. Onwuliri and has not been presented elsewhere for the award of a degree or certificate. All sources have been duly distinguished and appropriately acknowledged.

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CERTIFICATION

This is to certify that the research work for this thesis and the subsequent preparation of this thesis by Celine Movihinze Adeiyongo (PGNS/UJ/13737/02) were carried out under my supervision.

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Supervisor
Professor C. O.E. Onwuliri

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Celine Movihinze
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DEDICATION

To

JESUS CHRIST

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ABSTRACT

Interventions adopted for the eradication of dracunculiasis in Borno State were evaluated between July 2003 and June 2004 to assess the feasibility of the 2009 target date set for the eradication of guinea worm. Data on cases in Nigeria; North east zone, and Borno State from 1995 - 2007 were obtained from Nigeria Guinea Worm Eradication Programme. Primary data on the cases occurring during the 2003/2004 were obtained through active surveillance. The various intervention strategies were ascertained through direct inspection of the facilities. Knowledge, Attitudes, Practices and Beliefs, (KAP), of members of the affected communities were carried out through administration of questionnaire. Studies on vector density, infectivity and impact of Abate on cyclops were also carried out. Results showed that in Nigeria, during the period under review, cases reduced from 16,374 in 1995 to 12,282 in 1996; rose to 13,417 in 1998 and then declined to 73 in 2007. In the North east zone, cases dropped from 2,794 in 1995 to 2,134 in 1996, rose to 4,077 in1998 and dropped to 0 in 2007. In Borno State, cases rose from 587 in 1995 to 2,053 in 1998 before declining to 0 in 2007. During the 2003/2004 survey, 5(55.55%) Local Government Areas out of the 9 and 12(8.1%) villages out of the 148 studied were still endemic. Thirty-four (0.01%) out of 310,092 persons examined were infected. All age groups in the male category were infected while only age groups 0-40 in the female category were infected. More males (25; 0.02%) than females (9; 0.01%) were infected although there was no significant difference (P>0.05) in infection rate between the sexes. Twenty-six (76.5%) out of the 34 cases were people who still depended on pond water. Farmers, (17; 0.02%)) and nomads (2; 0.04%) had higher infection rates than other occupational groups but showed no significant difference (P>0.05). Twenty-six (76.5%) cases were contained while 8(23.5%) were not. One (2.94%) imported case was encountered. The 34 cases were observed between July and November with September recording 12(35.29%) while November recorded the least (2; 5.88%). The status of intervention strategies showed that Health Education, filter usage, Abate application, Case Containment Strategy and Village-Based-Health-Workers were operational in all the study villages. There were 55 functional hand-dug-wells, 3 boreholes and 5 Case Containment Centres. KAP studies revealed that persons in affected communities became aware of the disease's transmission, treatment, prevention, and control. Vector studies showed that 25(0.35%) out of the 7,052 cyclops examined were infected with *Dracunculus medinensis* larvae. Infection rates were observed between July and November 2003 with the highest in September (11).The impact of Temephos on cyclops density showed that the cyclops densities before application of Abate were twice higher than the figures two weeks after application and just slightly higher than or equal to the figures obtained 4 weeks after. The outcomes of the study showed that increased health education, funding, partnership between local, state, federal governments and endemic communities can enhance eradication globally.

CHAPTER ONE

INTRODUCTION

1.1 DEFINITION AND BACKGROUND

Guinea worm disease or dracunculiasis is a debilitating tropical disease caused by the largest filarid nematode known as *Dracunculus medinensis* (WHO, 1989a, Hopkins 1982). The disease is caused primarily by emergent gravid female worms in a bid to release their larvae from their uterus. These female worms sometimes burst in the host tissue leading to a very large pus-filled abscess. Also, when there is involvement of the joints of the legs, they produce fibrous ankylosis, contracture of the tendons, septic and aseptic arthritis. There could be secondary infection of worm tracts by bacteria. These conditions give rise to serious disabilities leading to absence from farm work and school and other activities for weeks or even months.

Stoll (1947) estimated that there were 48.3 million cases of guinea worm infections annually throughout the world; about 30 million in Asia, 15 million in Africa and 3.3 million in other parts of the world. Hunter (1997) also reported that in 1986, there were an estimated 3.5 million cases of dracunculiasis worldwide and that by 1990 there were 623,000 cases. This fell to 165,000 by 1994 in 18 countries. Pilotto and Gorski (1992 cited by Hunter 1997) suggested gross under-reporting of the cases.

The disease is of public health importance in the interior savannah of West Africa where the population, which is entirely rural, often depends on ponds, streams and rivers that are shared by a large number of people for their water use. The disease is commonly associated with dry climates because of the concentration of water supplies in artificial ponds, step wells and a greater opportunity for the people to become more and more infected. It imposes a period of misery, poverty and disablement annually, of villagers who have no safe drinking water sources, who are ignorant of the mode of transmission and prevention of the disease and who lack the necessary resources to tackle the problem on their own.

Augustus Aikhomu (1989) on the occasion of the second national conference of guinea worm disease in Nigeria described the disease as that of "deprived rural communities", while Jerry Rawlings, the former Ghanaian president, characterized the disease as "a disease of under-development", during a weeklong tour of 21 affected villages in Ghana's highly endemic Northern region (Hopkins, 1989). Hopkins (1989) preferred to call the disease as that of ignorance, of suffering villagers who do not have this disease because they want to, but because they do not understand how they get it and how they can protect themselves from becoming infected. Ignorance of national officials in endemic countries who have not been aware of the enormous hidden economic, social and scholastic costs of the disease, and ignorance of international officials, all of whom themselves have unlimited supplies of safe drinking water, who appear not to recognize the opportunity to contribute to real developments by eliminating dracunculiasis, however obvious that opportunity may seem to any rational person.

Dracunculiasis affects both the physical and mental development of children and greatly diminishes productivity and strength of the adults. Thus, it has been associated with low academic performance among school children

(Onabamiro, 1952; Belcher et al. 1975; Adekolu-John, 1983; Edungbola, 1983; watts, 1984; Nwosu, et al. 1982).

The disease also predisposes patients to other secondary infections like tetanus (Lauckner et al. 1961; Primae and Becquet, 1963), through ulcers caused by worm emergence and disease progression (Kale, 1977; Nwosu et al. 1982); consequently, dracunculiasis is of great medical and socio-economic importance. Education, food and health have been described as the building blocks of societies, guinea worm disease attacks all these three (Hopkins, 1989)

1.2. LIFE CYCLE OF DRACUNCULUS MEDINENSIS

Infection of man by guinea worm is by drinking contaminated water containing cyclops that have ingested guinea worm larvae. Cyclops are small, freshwater crustaceans and are infected by larvae discharged by infected individuals into water bodies during feeding. When an infected person with an emergent worm from the leg or any part of the body, deliberately or ignorantly wades into the water body during process of water collection, bathing, swimming or to cool the burning sensation of the blisters, the gravid female guinea worm releases first stage larva (L1) into the water (Figure 1). The larvae, on average measure 643μ x 23μ, having fully formed guts (although they do not feed). The tail is long and pointed and the cuticle is striated. They are extremely active in water; their thrashing movements resemble those of free-living nematodes. They live for 4-7 days in pond water and for further development have to be ingested by various predatory species of cyclops, which are small (1-2mm). The larvae penetrate the gut of the

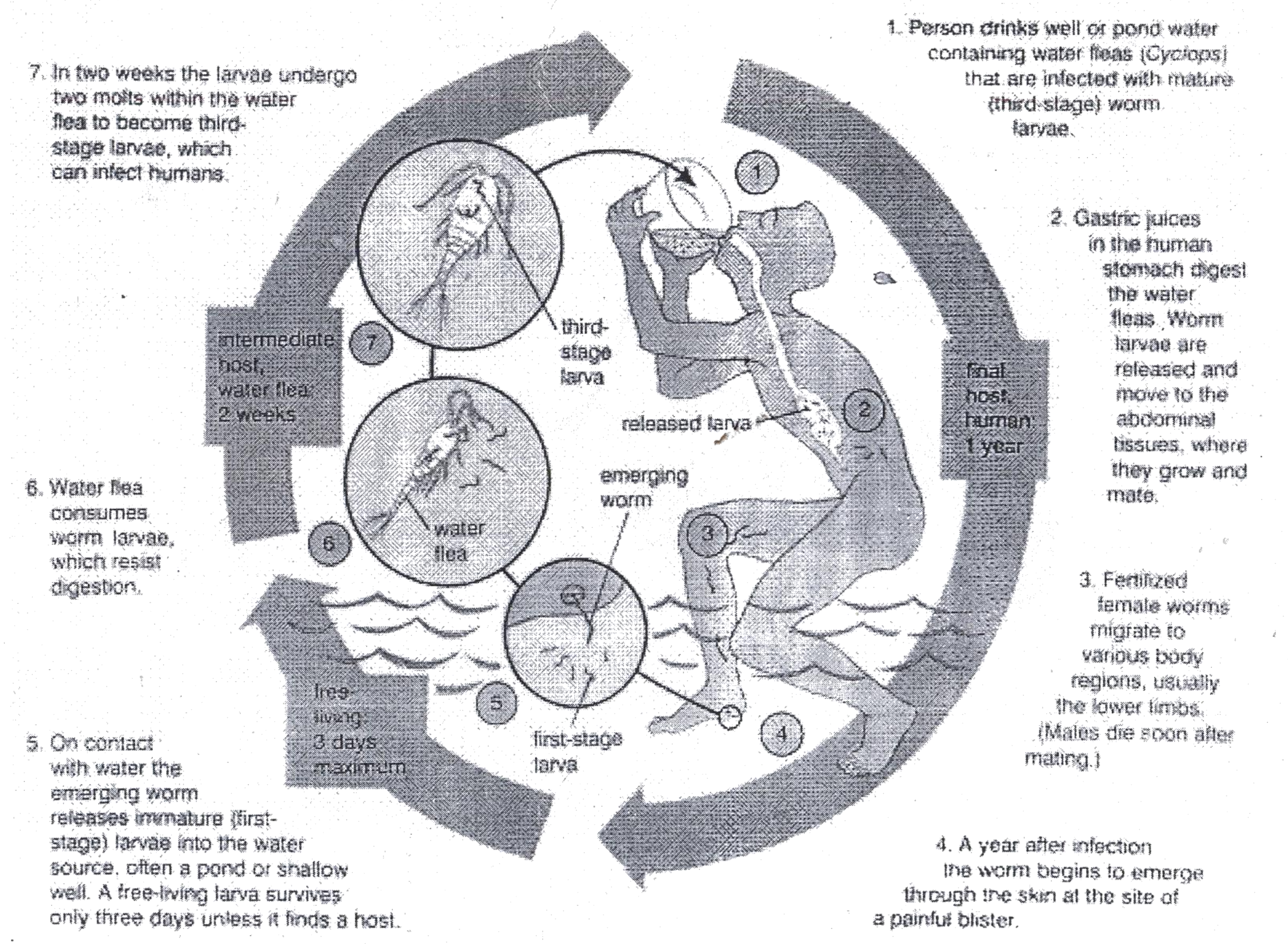

Figure 1: Life Cycle of *Dracunculus medinensis*

cyclops and after two weeks in the haemocoel reach the infective third stage larvae at appropriate temperature (24^0C). The infective larva measures on average 450μ x14μm and has a short bi-lobed tail.

When infected cyclops are ingested by human hosts in drinking water or other liquids, the gastric juice (dilute hydrochloric acid, HCL) in the stomach activates the release by the larvae. These burrow through the wall of the duodenum and migrate across the abdominal mesenteries and penetrate the abdomen and thorax in about 15 days. The presence of adult worms in the retro-placental region of a pregnant woman led George (1975) to propose that larvae may gain entry into the body through the vagina as well. The acidic vaginal exudates destroy the cyclops releasing the larvae, which then migrate to the retro-placental region in a similar manner as the migration from the stomach. However, this still needs actual confirmation. There is no increase in size during this early migration but after about two months, they become sexually mature. They then meet and mate in the subcutaneous tissue approximately 100 days after infection. After fertilization, the male becomes encapsulated and dies. Any female that does not mate dies also, and is reabsorbed by the body system. Occasionally, calcified specimens have been seen on x-ray (Muller, 1971). The fertilized females then continue to enlarge, reaching at times up to one meter in length as she becomes fully gravid. After a period of 9-12 months, the female desires to continue the life cycle and therefore seeks for ways of reaching the external environment to discharge the larvae (Hopkins, 1989). The female then first forms a blister on any part of the body, which turns into an ulcer, from where it emerges to discharge its larvae into water bodies, and thus continue the life cycle. More than one gravid female can emerge from a single individual at the same period, mostly from the lower abdominal region (Udonsi, 1987b). Sometimes mature females fail to emerge and become calcified.

1.3 SIGNIFICANCE OF THE STUDY IN RELATION TO INTERVENTION STRATEGIES SO FAR

This evaluation study has measured the successes of each ongoing intervention, identified and determined the causes of problems in implementing interventions; subsequently, these evaluation findings will be used to improve on planning and implementation of future community programmes relating to other diseases. It has also assessed the feasibility of the new target date/deadline, 2009, after the last three deadlines (1995, 2000, and 2005) have been missed for the complete eradication of dracunculiasis from the face of the globe.

Dracunculiasis is one of the most easily preventable diseases and much has been achieved to eradicate the disease with more than 95% reduction in cases reported worldwide as at December 1997 (News and Info 1998). Many believe that because of the rural nature of the disease, it is very difficult to be eradicated. In the rural communities affected, illiteracy has continued to remain above 60% and as a result, ignorance, culture and lack of modern amenities aid its persistence (Ward et al. 1979). What is worse is that so far, no curative drug has been found effective against the disease (Muller, 1979). However the disease can easily be controlled or actually eradicated using cultural methods including health education and provision of good water, all of which would lead to a reduction of contact between natural vector and humans. Thus, for about a decade now, efforts have been geared towards cultural control strategies usually supplemented with the provision of control materials like filters and "Abate" larvicides for water treatment and other modern amenities (Hopkins, 1988).

The impulse, momentum and commitment to eradicate dracunculiasis emerged in 1981 when the steering committee of international drinking water supply and sanitation decade (1981-1990) adopted the eradication of guinea worm disease as a sub goal of the decade.

About a year after the historic national conference on dracunculiasis (the first of its kind) was held in Ilorin, Kwara state, Nigeria in March 1985; the World Health Assembly (WHA) in May 1986 passed a resolution targeting dracunculiasis for global eradication. About two years after the WHA's resolution, the first African regional conference was held in Niamey, Niger republic, from July 1-3, 1988. Thereafter, in rapid successions, the African health ministers and WHO in 1988 and 1991 respectively, set December 1995 as the target date for eradication of the disease globally (Edungbola and Ologe, 1995).

Nigeria signed an agreement with the Bank of Credit and Commerce International and former US President Jimmy Carter, now the Chairman of The Carter Centre/Global 2000, on March 13 1988, to eradicate Guinea worm disease in Nigeria by 1995. In 1988, Nigeria formally inaugurated a Guinea Worm Eradication Programme in conformity with the resolution of African Health Ministers at the World Health Assembly of 1986. For this purpose, the country has been divided into 5 Global 2000 zones (Figure 2). A national task force was established with the mandate to eradicate guinea worm disease by December 1995 with a National Plan of Action prepared to guide the implementation of the objective (Nwobi, 1996). All the 30 states in the country, which were subdivided administratively into 589 (then) local government areas (LGA) plus the Federal Capital Territory (FCT) were actively engaged in this national campaign. Nigeria was mobilized to attack this disease through four distinct overlapping phases namely documentation, demonstration, mobilization and implementation.

Phase one: Documentation (1980-1983)

Starting from the pioneering work of Professor S.D. Onabamiro, who studied and classified the copepod vectors of dracunculiasis in Nigeria in the early 1950's, many other university- based researchers have contributed to the knowledge of the clinical and public health aspects of the disease in Nigeria. These contributions increased during the 1980's. Major ones relevant to this report include the extent and epidemiology of dracunculiasis in Nigeria (Kale 1977, Abolarin, 1981; Nwosu et al*.* 1982; Edungbola, 1983 and 1984; Edungbola and Watts, 1984 and 1985; Osisanya, 1986; Edungbola et al*.* 1987; Onwuliri et al. 1988-1990 a and b; Braide et al. 1989; Ugwu and Nwaorgu 1988- 1990; Suleiman and Abdullahi, 1988- 1990); its impact on school attendance(Kale, 1977; Edungbola, 1984; Edungbola and Watts, 1984; Ilegbodu et al. 1986; Nwosu et al. 1982); the duration and frequency of associated disability (Smith et al. 1989), the relevance of dracunculiasis to

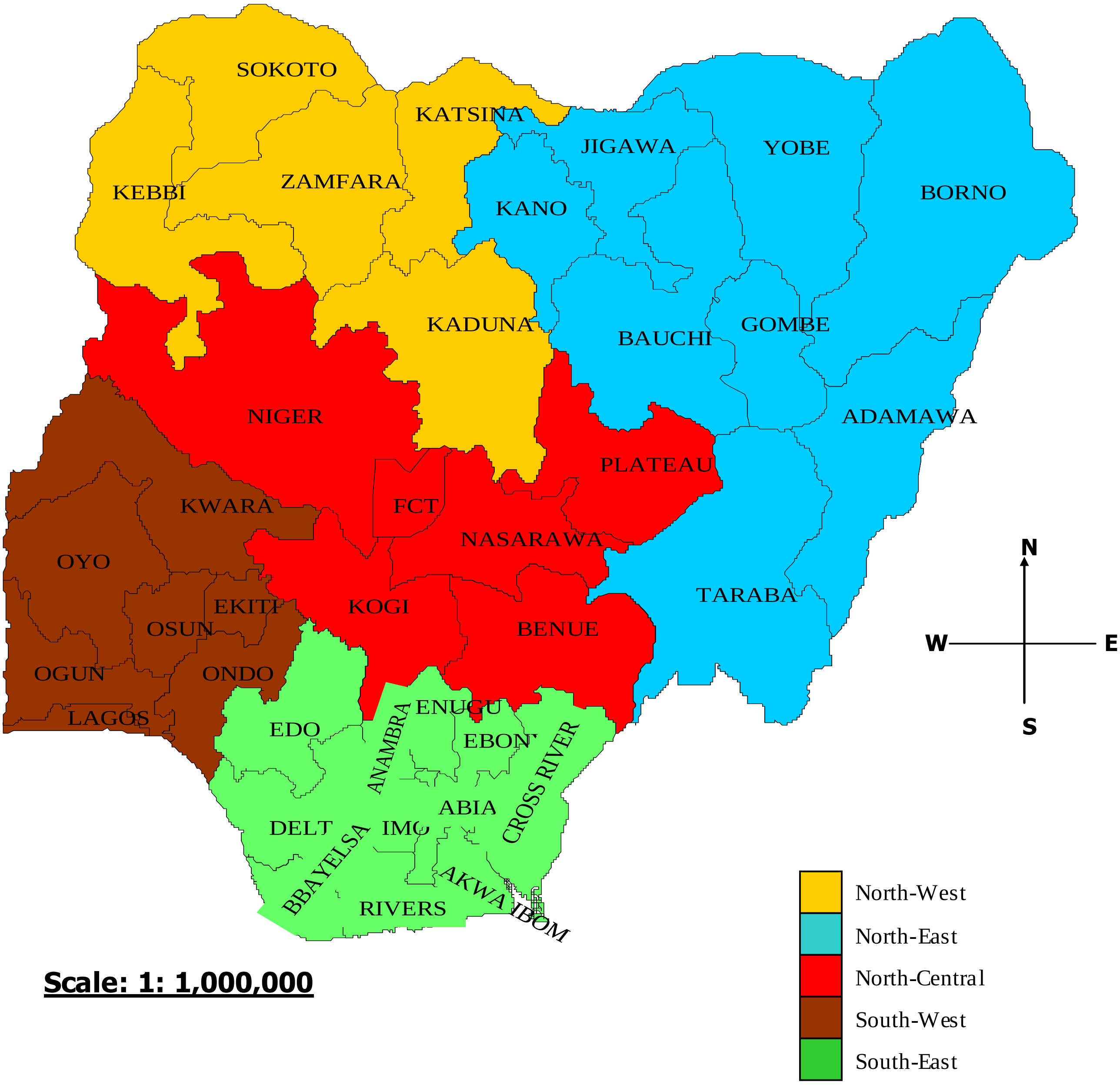

Figure 2: Map of Nigeria Showing Global 2000 Zones
Source: Nigeria Guinea Worm Eradication Programme, 1991.

maternal and child health (Yacoob et al. 1989; Watts et al., 1989, Brieger et al. 1989a); and its impact on agriculture (Edungbola et al. 1987; Nwosu, 1989). These and other studies developed the scientific basis for a fuller understanding of the effects of guinea worm disease on health, education and agriculture in Nigeria and in other endemic countries.

One of the most important features of the documentation phase was ascertaining the full extent and distribution of dracunculiasis throughout the country. Guinea worm disease was not an officially noticeable disease in Nigeria, which reported only a few cases annually to the WHO in the early 1980's. Although some surveys of state ministries of health were made in 1984, the first comprehensive information on the nationwide status of the disease was obtained in the compilation of reports presented to the first national conference on dracunculiasis in Nigeria in March 1985, (Edungbola et al. 1985, WHO 1985, Edungbola et al. 1986). Even though these data were crude and qualitative, indicating the location and level of endemicity of affected status by LGA's, it confirmed for the first time that guinea worm disease occurred in every state in Nigeria. This information, plus the estimate that Nigeria had approximately 25% of the cases of dracunculiasis remaining in the world, had a significant impact that was only superseded when the results of the first national search for cases became available in 1989.

Most of the financial support for activities in this phase prior to 1986 was provided by University Research Grants, the Federal Ministry of Science and Technology and the United Nations Children's Fund (UNICEF). The UNICEF-funded study of the impact of guinea worm disease on rice production in a fertile area of South Eastern Nigeria in late 1987, (which cost about ₦110, 000) and the report of the first national conference were the two most influential early documents for mobilizing national leaders.

Phase Two: Demonstration (1983-1986)

The second major thrust of the early years was to demonstrate that guinea worm disease is vulnerable to intervention (Hopkins, 1982, Edungbola et al. 1988) and show that effective action against the disease was possible in Nigeria. The main part of this phase may be dated as starting in 1983, when Richard Reid, the UNICEF representative in Nigeria, in collaboration with the Nigerian government agreed to an indicator of the efficacy of an extensive rural water supply project that UNICEF and The Federal Government of Nigeria were beginning to expand to several states starting in Kwara, Imo, and Gongola states (Edungbola et al. 1988; WHO, 1984); the disease was also used for prioritizing endemic villages for participating in the project.

During this phase, Luke D. Edungbola assumed a leading role in planning and evaluating the impact of the UNICEF- assisted water and sanitation project in Kwara state. In the first targeted LGA, the project subsequently reduced the overall prevalence of guinea worm disease in 20 villages from 59.6% during the 1983-1984 seasons to 11.3% during the 1986-1987 seasons. Three of these villages had their prevalence rates reduced from 62%, 52.7% and 44.8% to zero (Edungbola et al. 1988). Similar dramatic results were seen in Imo state, thus demonstrating the reproducibility of this approach.

Phase Three: Mobilization (1986-1988)

Early in 1986, professor A.B.C Nwosu, a university-based parasitologist and researcher on guinea worm disease, became the commissioner for health in Anambra state. He immediately began an aggressive campaign to eliminate dracunculiasis in Anambra state, making full use of his official position and budget. His new position and efforts greatly strengthened the mobilization of the eradication of dracunculiasis in Nigeria.

Anambra state inaugurated a task force on guinea worm eradication with great fanfare in 1986. Other states followed by forming their own taskforces starting in 1988. With the full backing of the then Military Governor of Anambra State, Col. Robert Nnaemeka Akonobi, the Commissioner for Health successfully solicited external assistance from the Government of Japan and UNICEF for rural water supply projects targeted specifically to highly endemic villages in Anambra, from Rotary international for construction of cisterns for rainwater catchments in some endemic communities, from global 2000, which helped arrange a donation of the larvicide, temephos (abate) from the American Cyanamid company, from the United States Agency for International Development which financed two consultants for training local personnel in temephos usage, and from the Federal Ministry of Health Nigeria, which provided funds for logistics.

To promote an effective public awareness campaign and to mobilize community participation, the Anambra state ministry of health used traditional town criers, posters and radio jingles, and they also developed a video documentary for the State Television. A highly successful movie, "Guinea worm, the fiery serpent", was filmed in Anambra state in 1988 by the US Center for Disease Control, Global 2000, UNICEF, and the United Nations Development Programme for local and international uses. Several of the other state task forces also prepared video documentaries on the disease that were aired on their State Television Stations. In addition to increasing public awareness and helping to generate political support at LGA, State and National levels, these mobilization activities were intended to help inform villagers on how to help themselves, by keeping infected people out of drinking water sources and by supporting other interventions such as drilling or digging of wells.

In August 1987, the African Concord published a heavily illustrated 13-paged cover story detailing the horrors and shame of guinea worm disease in Nigeria. Mass media attention to the problem reached its peak when former US President, Jimmy Carter, visited Nigeria to sign a memorandum of understanding with the Federal Ministry of Health, in which the Global 2000 project of the Carter Center agreed to assist the Government of Nigeria in its battle to eradicate guinea worm disease. Carter's visit resulted in numerous articles about guinea worm disease and the new eradication programme in Nigerian Newspapers and Magazines, including front-page feature stories, editorials, cartoons and letters to Editors. The mass media had another flood of coverage in July, 1989, when former President Babangida of Nigeria, former US President, Jimmy Carter and Alhaji Dasuki, the sultan of Sokoto, led several other dignitaries to the International Donor's Conference that was held in Lagos for the Global Guinea Worm Disease Eradication Initiative.

By the middle of 1988, the National Council of Health, which is the highest policy-making body for health in the country, declared guinea worm disease to be an officially reportable disease, adopted the goal of eradicating dracunculiasis from Nigeria by the end of 1995, and took several other steps to launch an effective nationwide eradication programme. By the end of 1988, all the 21 States in Nigeria and the Federal Capital Territory had established State Task Forces for guinea worm eradication, and the first national search for cases, which began in August 1988, was almost completed.

The successful conclusion of the first national village-by-village search for cases of dracunculiasis in March 1989 was another very important milestone in mobilizing the Nation. This first search enumerated over 650,000 cases of dracunculiasis in about 6,000 endemic Nigerian villages (WHO, 1989; Withers, 1989). These totals were higher than had ever been reported to health authorities. Moreover, these results gave an unprecedented specificity to the problem of guinea worm disease in Nigeria, namely lists of affected villages and the numbers of victims therein. These results were released during the second National Conference on dracunculiasis in Nigeria, which met in Lagos in March 1989 (Edungbola and watts, 1989)

Phase four: Implementation (1988)

The first major bench work in this phase was the initial national search for dracunculiasis cases, which was completed in early 1989. This provided for the first time a firm basis for quantifying the scope of the problem and hence of the effort needed to eradicate the disease in Nigeria. Standard forms and training procedures developed by the National Task Force were used in this and subsequent case searches to help assure uniformity of methods and comparability of results. All case searches used the standard WHO case definition: "an individual exhibiting or having a recent (about one year) history of a skin lesion with emergence of a guinea worm".

Financial support for the searches came from cost sharing by LGA's, State and Federal Government, Global 2000, UNICEF and other international or private donors. Substantial support "in kind" was provided by villagers themselves and the other levels of government as well as by other non-Governmental Organizations (example local rotary clubs). (The cost of the first search was approximately $100,000 that was donated by all sources, Edungbola et al. 1992). The data from the first search were used to prepare a national plan of action, which was presented at the Second National conference in 1989, when in a speech, read on behalf of the federal government by a representative of Nigeria's Vice-President, it was announced that from thence, all nationally and internationally supported rural water supply projects were to give priority to villages where guinea worm disease was endemic. Nigeria Guinea Worm Eradication Programme (NIGEP) now commemorate the day of that momentous announcement, March 20, as National Guinea Worm Day, to continue to educate the public about the disease and maintain public support for its eradication. On March 20, 1991, the vice-president of Nigeria, Augustus Aikhomu, presided at the issuing of three commemorative postage stamps as a part of ceremonies marking the second observance of national guinea worm day.

After the establishment of the national task force in 1988, a zonal facilitator was appointed to oversee operations in each of the country's four established primary health care quadrants, each of which included 5-6 states at that time. This arrangement facilitated the integration of NIGEP activities into the existing primary health care structure of the country as well as the effective identification training and supervision of village-based health workers in endemic villages.

The results of the second and third national searches were announced at the third and fourth national conferences on dracunculiasis, which were convened in 1990 and 1991 respectively (WHO, 1991a; Brieger, 1989)

Multiple spot checks by NIGEP supervisors and an evaluation of the search by a team of person's not involved in the programme were conducted after each of the first two searches, which between them reached an estimated 90% of the target population at least once. During the third national search for cases, which was limited to the known endemic villages identified during the previous two searches and other suspect villages reported since then, concomitant health education efforts and some treated cases were conducted in many areas to mark the beginning of full-scale implementation of interventions. Data from the third case search were used to prepare a map showing LGA-specific incidence levels for the first time.

Some intervention strategies for example health education (which involved placement of posters, demonstration of the use of cloth filters); provision of safe drinking water, topical treatment of cases otherwise known as case containment, were being conducted by some agencies such as UNICEF, State Ministries of Health and Water Boards and the Directorate of

Food, Roads, and Rural Infrastructure, even before the NIGEP was formed but such efforts were sporadic and uncoordinated nationally. Even during the first two case searches and on other occasions, the search teams and accompanying primary health care workers conducted some health education. However, systemic extension of the interventions to eventually include all known endemic villages began with the third case search.

The role of WHO in the Guinea Worm Eradication Programme is to provide technical advice and to certify countries that have eliminated the disease. Eradication deadlines have been missed repeatedly. The first was set for 1995, the second 2000 and the third 2005. WHO now hopes to certify eradication by 2009 (Hopkins et al. 2005).

The objectives of NIGEP in eradication programme are to collect, analyze, interpret and disseminate information that will help to realize the goal of disease eradication (Nwobi, et al. 1996).

NIGEP started its activities to ensure eradication of guinea worm disease from the North-East zone comprising Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Nasarawa, Plateau, Taraba, and Yobe in 1988 with a case search which reported 43,662 cases from 1,189 villages. Interventions to disrupt the life cycle and break the disease transmission started in 1991 when NIGEP/Global 2000 established its Northeast zone with the office in Jos (Figure 2). The intervention strategies put in place include provision of portable water through drilling of boreholes, sinking wells or Hand-Dug Wells (HDWs), Intensive Health Education on the need to filter or boil all drinking waters through provision of Monofilament Nylon Filters, protection of drinking water sources and case containments/detection and management, introduction of vector control through the application of temephos (abate) to sources of drinking water (Hopkins 1998). Case containment strategy implies the complete management of each identified case within 24hours of worm emergence in such a manner as to forestall any further possible transmission of the disease by that infected person (Nwobi et al. 1996). WHO (2003) stated that guinea worm disease is said to be contained if all of the following conditions are met:

i. The patient is detected before or within 24hours of worm emergence
ii. The patient has not entered any water source since the worm emerged.
iii. The village volunteer has properly managed the case by cleaning and bandaging until the worm is fully removed, and by giving health education to discourage the patient from contaminating any water source (if two or more emerging worms are present, the case is not contained until the last worm is pulled out and
iv. The containment process, including verification that it is a case of guinea worm disease, is validated by a supervisor within 7days of the emergence of the worm.

But Ukoli (1990) has maintained that the installation of control materials has had disastrous consequences simply because of poor maintenance which fails to keep the materials beyond a time limit. In most places, it was not seen as suitable for the traditional practices. Furthermore, while these measures could help to prevent infection of the majority of the people, they do not take care of the interest of these farmers and fishermen whose occupational needs make daily water contact inevitable.

In any eradication programme, the following steps are necessary and must be incorporated.

i. Problem diagnosis and adequate definition of objectives
ii. Careful selection of intervention strategies/implementation
iii. Evaluation of project success which leads to
iv. Modifications

1.4 AIM AND OBJECTIVES

This study has assessed and evaluated the successes and impact of each of the ongoing intervention strategies in dracunculiasis eradication programme in Borno State. The study has:

1. Reviewed cases of dracunculiasis in Nigeria, Northeast zone and Borno state from 1995-2002.
2. Identified and ascertained the various interventions put in place in the various endemic villages, their cost implications and the impediments in the implementation of the interventions.
3. Determined the current status of the disease and its vector in the various endemic communities
4. Assessed the impact of knowledge, attitude, practices and beliefs (KAP) of the sampled individuals on the disease and on the interventions with regards to sustainability of the Eradication Programme.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION AND HISTORICAL ACCOUNTS

Guinea worm disease, also known as dracunculiasis is a long-established human infection which has been with man on earth since ancient times. This was clearly referred to by various authors from India, Greece, and the Middle East. In antiquity, interesting historical accounts of dracunculiasis have been given by several authors (Castiglioni, 1947; Hughes 1967; Muller 1967; Geoneratne, 1969) and female worms have been seen in Egyptian mummies (Adamson, 1988; Watts, 1998). James Africanus Horton, the first West African to be trained in Europe as a medical doctor wrote a book about the disease (cited by Cairncross 2002) mistakenly supposing that it was transmitted through the soles of the feet. The physician, Galen first named the condition "dracontiasis" a little over 100 years before the birth of Christ, although Galen himself saw no case of this disease in his practice in Rome. Among the early pioneers who contributed to the knowledge of the disease are Rhazes, (865-925), an Arabic physician, who first attributed the cause of a typical guinea worm swelling to a parasite; Avicenna (980-1037),a Persian Philosopher, gave detailed clinical presentations of "medina sickness", so-called because it was prevalent in Medina from where it was believed to have spread to other parts of the world through pilgrimage routes (Hopkins, 1983); and Bastian (1863) described the morphology of the parasite.

The connection of infection with water sources was recognized early and it is probable that if the prepatent period were not so long, the mode of infection would have been obvious many years earlier. This was determined in 1870 by a Russian scientist, Alexei Fedchenko, who found that larvae expelled from emerging female worms in the limbs of sufferers developed in freshwater micro crustaceans (cyclops) living in ponds which were then ingested in drinking water (Fedchenko, 1971). This was the first time an invertebrate host was implicated in the transmission of a medically important disease.

2.2 THE ZOONOTIC ASPECTS

The sole cause of this disease in man is *D. medinensis* (Linnaeus, 1758 as cited by Cairncross et al. 2002; Onabamiro, 1951). There is no evidence that animals act or have ever acted as reservoir hosts of human guinea worm infection (Hopkins et al. 1997) and the theoretical possibility that they could do so has been conclusively disproved. Studies of animal infection in areas where dracunculiasis has been recently eliminated but without much improvement in drinking water sources may provide useful information regarding this question (Cairncross et al. 2002).

Emerging female worms are recovered sporadically from a wide range of mammals from both endemic and non endemic parts of the world, (Ghensis, 1972; Lalitha and Anandan, 1980; Hsu and Li, 1981; Batliwada, 1983; Davidson et al. 1992; Keeling et al. 1993; Richardson et al. 1993; Seville and Addison, 1995; Fu et al. 1999). Unfortunately, in almost all cases only a portion of a female worm is recovered usually in a flaccid state after the enclosed larvae have been ejected, and identification with regard to species is impossible (Cairncross et al. 2002). In general, worms in mammals are regarded as *D. medinensis* in the old world and South Americas and as *D. isignis* in North America. *Dracunculus* has a very short patent period, at most a few weeks, and an emerging worm is not easily seen in fur – bearing carnivores. So it is likely that infection is much more common in many countries than currently recognized.

An isolated autochthonous human case of dracunculiasis has been reported from Japan (Kobayashi et al. 1986); Indonesia (Heutsz, 1926 cited by Cairncross et al. 2002), and Korea (Hashikura, 1927 cited by Cairncross et al. *2002; WHO, 1996*). In all of these presumably zoonotic cases, there was the possibility that infection was contracted from ingesting raw fresh water fishes as paratenic hosts (in which the immature parasites ingested in cyclops can survive but do not develop) rather than from drinking water. Crichton and Beverly-Burton (1977); Eberhard and Brandt (1995) have shown that *Dracunculus* in North America can be transmitted experimentally by amphibians.

The infections in domestic animals reported from areas of endemicity are possibly of human origin (Cairncross et al. 2002). This supposition is supported by the higher prevalence found in surveys of the human population than by the dissection of dogs culled during the 1920s in Uzbekistan. However, worms are still found in dogs in the former areas of endemicity of Uzbekistan and Tamil Nadu (Lalitha and Anandan, 1980), and in dogs also and cats in the areas of Kazakhstan and Turkmenia where the disease is not endemic (Ghensis, 1972; Velikanov, 1984 cited by Cairncross et al.*2002*).

It is very likely that in many parts of the world there is widespread but under-reported animal cycles completely independent of human infection. For example, there was a recent report from China of infection with *D. medinensis* in a cat (Fu et al. 1999).

Animal infections are however, unlikely to pose a human public health problem once complete eradication of the human diseases has been achieved, particularly if safe water sources are provided.

2.3 GEOGRAPHICAL DISTRIBUTION

In historical times, infection occurred in Algeria and Egypt (Watts, 1998); Gambia, Guinea Conakry, Iraq, Brazil and the West Indies (Watts, 2000) but died out spontaneously in those countries and was eliminated from Uzbekistan in 1932 and from Southern Iran in 1972 (WHO, 2000b).

Muller (1971) updated a list of global distribution of dracunculiasis earlier on made by Stiles and Hassel in 1920. The disease was widely distributed in West and Central Africa, India, Pakistan, Middle East and Asia (Ramsay, 1935; Onabamiro, 1952; Raffier, 1966). The World Health Organization (WHO, 1987, 1991a) reported that up to 120 million people were affected from its African countries including Nigeria and about 10 million others from Pakistan and India. Other endemic areas included Yemen, Iran, and Saudi Arabia (Hopkins, 1985).

In 1989, WHO received reports from fourteen countries on the disease with a total of 845, 143 cases (>98%) of these coming from Africa (WHO, 1990a, 1990b). A breakdown of this figure showed that the largest number of cases occurred in the West African sub-region with a large proportion coming from Nigeria. WHO (1985) had earlier estimated that 2.5 million cases occurred annually in Nigeria alone. Ramsay (1935), Raffier (1966), Muller (1971), and Belcher et al. (1975) among others had noted that the disease was endemic in West Africa. Ramsay (1935), found the disease common in different parts of Nigeria especially in the north. The disease had been shown to be endemic in the South West of Nigeria (Onabamiro, 1950; 1951; 1952; Edungbola, 1983; and also in the South East (Nwosu et al. 1982, Udonsi, 1987b; Braide et al. 1991; Okoye et al. 1995; Anosike et al. 2000; Onwuliri et al. 2005), other parts of the north (Thompson, 1956; Suleiman and Abdullahi, 1988 - 90); Bauchi, Sokoto, Plateau, Benue and Nasarawa (Fabiyi, 1991; Osisanya et al. 1986; Onwuliri 1982; Onwuliri et al. *1988* - 1990a and b). Thus the disease had long been recognized as a public health problem in Nigeria.

Recent reports have shown that it has been eradicated from Pakistan, India and Yemen (Hopkins et al. 1995, WHO, 1996b). It is also being rapidly eradicated in many African villages (Edungbola and Ologe, 1995). The disease is now found in 5 countries including Nigeria where 73 cases were reported in 2007 from four villages (NIGEP, 2007). All the 100% of reported cases occur on the African continent with Sudan having the highest number of cases of 5,074 followed by Ghana with 3191 (Figure 3).

2.4 THE VECTORS

The vectors of the disease are cyclopoid copepods that inhabit stagnant ponds and the disease is prevalent in rural villages among people who obtain their drinking water from such ponds.

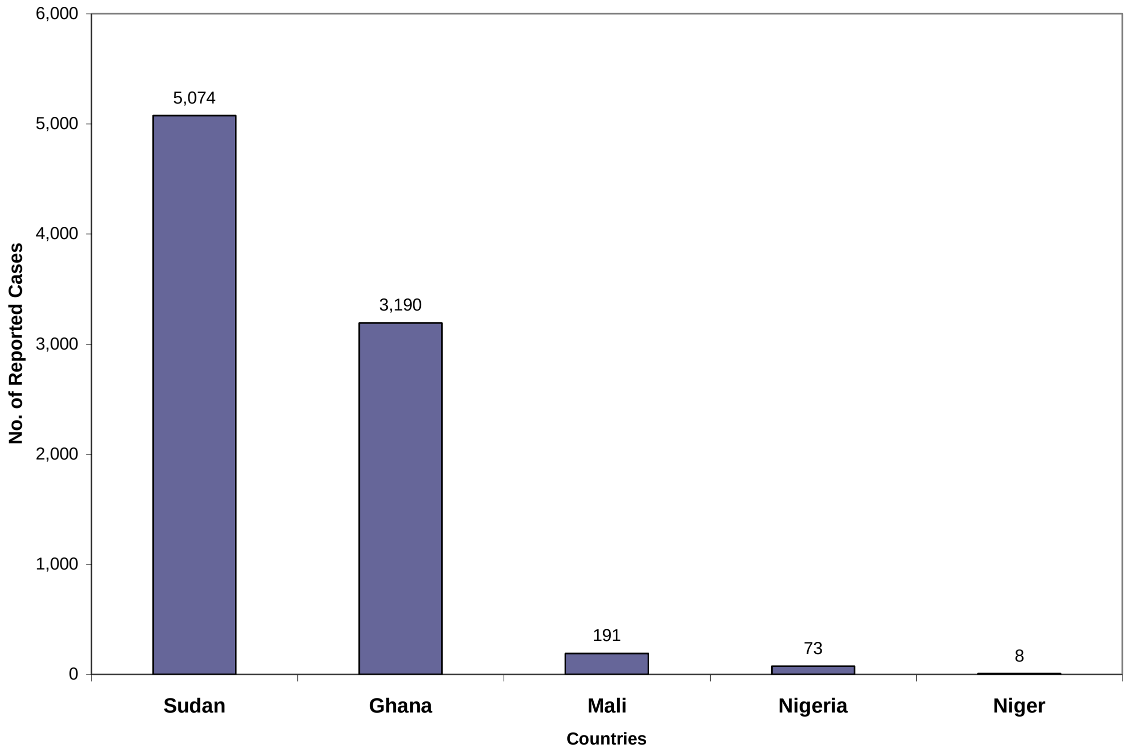

Figure 3: Current Endemic African Countries and Their Cases (2007)
Source: World Health Organization, 2007.

Until a few years ago, these were all included in the single genus *Cyclops*, but this has now been subdivided and the most important intermediate hosts belong to the genera *Mesocyclops (M. aequatorialis)* and *M. kieferi); Metacyclops (M. margaretae)* and *Thermocyclops* (*Th. crassus, Th. incisus, Th. inopinus* and *Th. oblongatus* (Muller, 1991).

The development of the larvae in cyclops was observed by the Russian scientist, Fedchenko in 1870 (Moorthy, 1938; Fedchenko, 1971). He found out that only one infective larva is found in naturally infected cyclops hosts. Further investigations revealed that infected adult cyclops might carry up to five larvae, although their immature stages have only one larva (Onabamiro, 1956, Onwuliri et al. 1991). These cyclops are mainly distributed in ponds in endemic foci of the disease, where the availability of food and some immunological conditions (varying seasons, rainfall, temperature,) affect their growth, population density, reproduction and infectivity (Muller, 1971; Onwuliri et al. 1991).

The density of cyclops however does not determine the rate of infection. In an experiment, Onabamiro (1954) observed only approximately 5% larval infection out of 152 cyclops. Lyons (1972) found a much lower density of cyclops in Wa district of Ghana. It has been observed that the population density of cyclops increases during the dry months, but decreases drastically with the approach of the rains. Rainfall, temperature, dissolved oxygen concentration; pH , salinity and bicarbonate alkalinity generally affect the population density and infectivity of the cyclopoid copepods. Low dissolved oxygen in ponds influences a higher density of cyclops and most studied cyclops prefer a pH range of 5.8- 6.8 (Onwuliri et al. 1991). Onabamiro (1951); Boxshall and Braide (1991), described the cyclops fauna of Nigeria but restricted themselves to species from southern parts. Onwuliri et al. (1991) first documented Northern Nigerian cyclops species and implicated some species in the transmission of dracunculiasis. No other comprehensive work on Northern Nigerian cyclops fauna has been documented.

Dracunculus medinensis exhibits a high degree of host-specificity. Onwuliri et al. (1991) observed that out of the five species of cyclops, *Thermocyclops nigerianus, Mesocyclops aequatorialis, Microcyclops linjanticus, Tropocyclops confines*, and *Platycyclops phaleratus*; only *Th. nigerianus* was found to have been significantly more infected than *M. aequatorialis*. Of the over 40 different species of cyclopoid copepods identified in Nigeria, only six are implicated as vectors of guinea worm in nature, and in the laboratory (Boxshall and Braide, 1991; Onwuliri et al. 1991). Onabamiro, whose work in the early 50s remains the only definitive work on the biology, distribution and ecology of cyclops in ponds in West Africa, showed that, of the 30 species and sub-species of cyclops identified in Nigerian ponds and streams, only *Th. nigerianus* and *M. leukarti* were found to be naturally infected with *D. medinensis*. However, it has been established that *M. leukarti* does not even occur in Africa and India where it had been widely implicated to be a vector of guinea worm disease (Van de velde, 1984). Attempts by Boxshall and Braide (1991) to verify what Onabamiro (1951) identified as *M.*

leukarti was unsuccessful as the British Museum of Natural History does not have the specimen any longer.

Onwuliri et al. (1991) showed that *M. aequatorialis* could be infected experimentally in the laboratory. He further confirmed the assertion of Muller (1972) that infection of cyclops is limited to tropical and sub-tropical regions because the larvae of *D. medinensis* develop best between 25^0C and 30^0c and do not develop below 19^0C.

2.5 CLINICAL MANIFESTATIONS

A number of clinical manifestations due to the disease are varied. Pre-emergent female worms can move easily through the connective tissues but when they are about to emerge to the surface, a few larvae are released into the sub-dermis through a rupture at the anterior end. The host reaction results in the formation of a burning, painful blister. The first symptoms appear simultaneously with the beginning of a blister formation and consist of nausea, vomiting, diarrhoea, giddiness and fainting. Some or all of these symptoms may be present (Edungbola, 1983).

Muller (1979) believes that they are due to the absorption of the toxins employed by the worm to form the blister. According to him, they are intense inflammatory reactions along the entire length of the worm with cells closely adhering to the worm and preventing its removal. The blister bursts in a few days to give a shallow ulcer. The bacteriologically sterile blister fluid contains larvae surrounded principally by polymorphonuclear neutrophils with macrophages, lymphocytes, and eosinophils (Muller, 1976). After the expulsion of thousands of larvae, the end of the worm dries up and this process is repeated a few times in a few weeks. The lesion then resolves quickly. Unfortunately, the tract of the worm becomes secondarily infected in about half of all cases and patients become severely incapacitated (Smith et al. 1989; Hours and Cairncross, 1994). Muller (1971) and Kale (1977) reported that over 90% of the ulcers were infected by bacteria. In another study in Benin, there was 0.3% mortality from tetanus and septicaemia (blood poisoning) (Chippaux and Massougbodji, 1991 cited by Cairncross et al. 2002).

Female worms sometimes burst in the tissue, resulting in a very large pus-filled abscess and severe cellulites. Infertile females or males elicit a slight inflammatory reaction and sometimes calcify, showing up on a roentgenogram (x-ray). Dracunculiasis is unusual among parasitic infections in that there is little evidence of acquired immunity and the same individual can be re-infected many times.

2.6 COMPLICATIONS

The complications of dracunculiasis result in the discomfort of the patient. Larvae released provide abscesses which can lead to chronic ulcerations. When the worm bursts deep in the subcutaneous tissue, it provides abscesses which can lead to chronic ulcerations. Such abscesses can be secondarily infected by bacteria along the tract of the worm especially if it damages the tissue or if it retracts into the body. These conditions give rise to serious disabilities and when there is involvement of the joints of the legs, they produce fibrous ankylosis, contracture of the tendons, septic and aseptic arthritis (Reddy et al. 1968; Muller, 1979; Ukoli, 1990). Cases of dracunculiasis abscesses in extra-dural space of the spinal canal resulting in paraplegia and motor weakness of the legs have been reported, (Mitra and Haddock, 1970).

Sometimes worms which do not emerge die and become calcified near the joints like the pelvis and the knee. It is possible that such worms contribute to arthritis observed in such patients. Over 90% of the blisters/ulcers marking the site of emergence of the worms are located in the lower limbs particularly the ankles and feet (Onabamiro, 1951 and 1952) while the abdomen, upper limbs, head and neck account for less. Some of the unusual sites include the urinogenital system, scrotum, vulva, penis, buttocks, and chin. Guinea worm ulcer is one of the commonest sites of entry of tetanus spores so the risk of tetanus as a complication of dracunculiasis infection is very high. The ulcers sometimes may become so severe that amputation of the affected limb may become necessary, or may cause fatal blood poisoning (Muller, 1979). The disease is also known to cause habitual abortion in pregnant women (George, 1975), adverse effects on health (WHO, 1991c), allergic reactions including urticaria, fever, nausea, giddiness, asthma, vomiting, and severe inflammation due to damage to worms in the skin (Reddy et al. 1969). The disease also causes bleb or blisters (Reddy et al. 1969; Fairley and Liston, 1924b); giddiness, gastrointestinal symptoms, intra-orbital oedema (Fairley, 1924a), allergic pruritis (Hodgson and Barret, 1964), constructive pericarditis due to worm presence in the thoracic cavity

(Kinare et al. 1962), urinogenital disease (Pendse et al. 1987; Raffi and Dutz, 1967).

Guinea worm disease is a painful disabling and incapacitating affliction (WHO, 1982, 1991a), causing human misery and extensive suffering (Lyons, 1972; Belcher et al. 1975). The painful lesions caused by emerging worms cripple up to 40% or more of the children and adults in affected rural areas for weeks or months (Wurapa et al., 1975; Ukoli, 1990).

2.7 DIAGNOSIS

Patients in an area of endemicity have no doubt about the diagnosis. When or just before the blister forms, there is localized itching then sharp pain and often general allergic symptoms, including urticaria, follow. Once the blister has burst, cold water will encourage the release of larvae, which can be seen microscopically under low power. Immunodiagnostic methods are not useful in practice because it has not been proved that they can detect prepatent infections, mainly because of the lack of prepatent serum samples.

2.8 TREATMENT

Despite the fact that extensive work has been done in the area of chemotherapeutic treatment of guinea worm, its treatment has continued to pose a serious challenge to man. Muller (1971) cited some of the earlier works in this area. Trewn (1937) and Shastry (1946) reported the efficacy of tartaremetic but this was disputed by Fairley and Liston (1924). Guinea worms are easily expelled from the skin tissue by injection of Trimelarsanmel-W or Phenothiazine emulsion (Elliot, 1942). The worms are normally mechanically extracted by carefully winding the emergent worms around a small stick, a few centimetres a day, for as long as it can be completely removed. This method has been practised since antiquity and is still useful, particularly when combined with a clean dressing and antibiotics to prevent secondary bacteria infection (Magnussen et al. 1994).

Many antihelminthic drugs have been tested. These include: Thiabendazole, Mentazole and Cambendazole (Merck, Sharp & Dohme, Ltd.). Others include Methyridine (Prometic Imperial Chemical Ltd.), Metronidazole (Flagyl – May and Baker Ltd.). Muller (1979) estimated that about 20 clinical drug trials have been made in West Africa alone. Rousset (1952) found Hetrazan can give 50% cure in Sudan. He also observed that large oral doses of Diethyl Carbamazine, (DEC), would kill the adults and in prophylactic amount kill the larvae. The systemic side effects of this drug, according to him, can be relieved by epinephrine or anti-histamine drugs. Following these clues, Onabamiro (1956) tested hetrazan on the worm since Rousset's experiment could not show how the worms were destroyed. He observed that the drug even in strong concentrations had only a very slow effect on freshly discharged larvae. He explained that it is possible due to toxic effect of the waste products of the cyclops. In a previous investigation, he had found that cyclops with infective larval stage died off in large numbers.

This however led to his suggestion of a possible prophylactic use of hetrazan by travellers journeying through guinea worm endemic areas. The drug was confirmed safe at correct dose for two weeks. Onabamiro (1956) confirmed the prophylactic efficacy of DEC against larval guinea worm inside cyclops. Raffier (1966), Oduntan et al. (1967), and Antani et al. (1970), have respectively tested the efficacy against guinea worm of such drugs as niridazole, commonly called ambilhar, (containing 1-C5-nitro-2-thrizolyl), thiabendazole of the trade name mintezol, and metronidazole known by the commercial name as flagyl.

Shafel (1976) worked on the preliminary report of the therapeutic effects of dracunculiasis and discovered that mebendazole proved to be an efficient drug of choice for the treatment. His findings indicated that mebendazole affected mature adult worms especially after discharge of larval content of the uterus, but the appearance of fresh lesions after healing of the original lesions indicated that mebendazole did not have a full effect on relatively premature worms. Wurapa et al. (1975) in a similar study found that allergic swellings of the limbs before appearance of the guinea worm under the skin subsided with thiabendazole or metronidazole treatment but this was considered to be an anti-inflammatory effect only as the worms were not killed or readily expelled.

Muller (1979) in a study of 20 clinical trials carried out with some of these drugs in West Africa, discovered that the effects of these drugs have always been very similar and that the drugs have no effects on pre-emergent female worms which discharged the load of larvae that were infective in the usual way. It appears likely that in man these compounds act against the host inflammation reaction rather than on the worms themselves (Lyons, 1972; Muller, 1979) a role which can better be served by local treatment with hydrocortisone cream containing an antibiotic (Muller, 1979). Nwoke (1992) observed that there was no evidence that any chemotherapeutic agent has a direct action against guinea worm, although various benzidamizoles may have an anti-inflammatory action, aiding elimination. Chippaux (1991) found that treatment with mebendazole was associated with aberrant migration of worms which were more likely than usual to emerge at places other than the lower limbs.

Widely reported chemotherapeutic failures in guinea worm treatment have been confirmed by Kale (1974; 1975), and Belcher et al. (1975). More so infection due to dracunculiasis provoked no immunity so people are infected year after year (Hopkins, 1987). This means that even if tested drugs were effective, previously cured patients will not be prevented from re-infection if re-exposed. The need for drug of chemotherapeutic value is important and according to Muller (1979) there is hope in the evidence that some chemotherapeutic agents are active against developing guinea worm parasites.

As none of the drugs had a prophylactic effect, so infection can always re-occur after infection (Onabamiro, 1956), efforts were then shifted to traditional African medicine (herbal). Before this time, these herbs were acknowledged as having varying degrees of cure (Muller, 1971). *Combretum mucronatum*, long prescribed by herbalists produced 97.7% cure with extrusion of the worms and reduction in inflammation around the ulcer and healing of the ulcer in two weeks following the application of sterile palm oil (Ampofo, 1977). In other trials, *Mitrogyna stipulosa* gave 52.2%; leaves of *Elaceophobia drupitera* and *Hellaria latifolia*, taken in palm oil soup were effective against dracunculiasis. The major shortcomings of herbs are the unquantifiable dosages and the refusal of local herbalists to disclose the combination of herbs for scientific evaluation.

As success through chemotherapeutic means was not forth coming, Muller (1979) observed that the most urgent need was for carefully monitored control scheme capable of reducing or eliminating infection in the locality be put in place.

However, of recent, Anosike et al. (2006), working on the treatment of *Dracunculus medinensis* infection with cotrimoxale in endemic population of Ebonyi South Eastern Nigeria, observed that inflammation signs subsided within the first 2 – 4 days of treatment. Specifically, symptoms were more pronounced in the untreated than in the treated groups. The drug enhanced healing of septic wounds and reduced both swollen legs and pains in over 67% of the cases.

2.9 SOCIO-ECONOMIC IMPACT

In recent years, the understanding has grown that biological, technical feasibility costs and benefits are the criteria to consider before launching an eradication programme (Dowdle and Hopkins, 1998 cited by Cairncross et al. 2002). The benefits of dracunculiasis eradication will occur almost exclusively to the population in which the disease is endemic (Aylward et al. 2000). In the past, most cases of dracunculiasis went unreported for a number of reasons. Most health centres had little to offer the patient besides palliative treatment; most patients lived in poor, remote rural areas and were hindered by their disease from walking to a health facility, and most recovered spontaneously after expulsion of the worm. Since few cases were reported, the disease was often considered an exotic curiosity rather than a major public health problem. However, in areas of endemicity, its social, economic, nutritional and educational consequences and the costs incurred by the individuals, households and communities that suffer from it, can be substantial (Caincross et al. 2002).

2.9.1 Disability

Human infection with guinea worm is rarely fatal but causes much incapacitation. Studies in India based on medical records suggested a case fatality rate of 0.1% or less, and this was probably a generous estimate because only persons with severe complications usually seek treatment from health facilities (Adeyeba, 1985). The proportion of patients permanently disabled by the disease is also small. A number of studies have found it to be less than 10% (Singh and Raghavan, 1957; Rao and Reddy, 1965; Imtiaz et al. 1990).

The social aspects of the disease are attributable to the temporary disability suffered by the patient. Two studies in Nigeria, (Adeyeba and Kale, 1991; Smith et al. 1989); found that 58 to 76% of patients were unable to leave their beds for appropriately a month during and after emergence of the worm. The more severe and protracted disability is associated with secondary infection of the lesion; this occurs in roughly half the cases (Wurapa et al. 1975; Nwosu et al. 1982). The impact of this temporary disability is reinforced by the seasonal pattern of worm emergence, often peaking at stages of the agricultural year where labour is in maximum demand. There is seasonal variation in agricultural activity peaking in the dry season (South zone) and some in the wet season (North zone). *Dracunculus* cases also peak at the same periods (Muller, 1976, 1979). The one for the south zone also corresponds with the period of yam and rice harvesting (Smith et al. 1989). This seasonality means that a whole community can be laid prostrate simultaneously and household members can be prevented from substituting for one another in agricultural and other tasks (Belcher et al. 1975).

Indeed, the Dogon people in Mali refer to the infection as "the disease of the empty granary" (WHO, 1998c). The impact of guinea worm disease does not end when the worm is out and the sufferer returns to work. A study in Ghana by Hours and Caincross (1994) found that between 12 and 18 months after emergence of a worm, 34% of patients still had some difficulty performing everyday activities, usually due to pain attributable to its location and the date of onset of the episode of dracunculiasis. While the disability is not necessarily permanent, it extends beyond the incapacity occurring during worm emergence. Osaba et al. (1977) observed that joints in some cases when involved, lead to permanent deformities.

2.9.2 Economic Impact

Some attempts to estimate the economic impact of dracunculiasis have simply multiplied the number of days of labour lost by the mean value of production per day or by the wage rate. From this, it is easy to calculate the loss per household to derive an estimated cost for a whole region. In a study carried out by de Rooy and Edungbola (1988 cited by cairncross et.al. 2002) based on a survey of 87 households, estimated that rice-growing areas in three states of southern Nigeria sustained an annual loss of $20 million due to guinea worm disease. This argument was extremely effective in mobilizing the support of senior politicians in Nigeria for the eradication of the disease (Edungbola et al. 1992). Adeiyongo(2004) in a research carried out in Central Nigeria observed that quantity of rice and yams output lost as a result of guinea worm infection for the 1999 cropping season was 27.1 metric tonnes of rice and 225,785 tubers of yams valued at N406,200.00 and N5,644,618.25 respectively. It has been argued that this method of calculation uses an over simplified field approach and is likely to over estimate the cost (Paul, 1988 cited by Cairncross et al. *2002*) as it does not allow for the various coping strategies by which households respond to illness (such as abandoning other tasks and using additional labour) which qualitative studies have found to be common in peasant farming (Brieger et al. 1989; Chippaux et al. 1992). A more sophisticated approach is to examine the impact on actual production (Brieger and Guyer, 1990) or even to include the incidence and duration of dracunculus-induced disability as predictive variables in an agricultural production function. Audibert (1993 cited by Cairncross et al. 2002) used this method and approach in a setting in northeast Mali where the incidence of guinea worm disease was relatively low (3-33% in the villages studied) to show that temporary disability accounted for a reduction of 5% in the overall production of two important subsistence crops, sorghum, mainly grown by men, and peanuts, cultivated by women. There is also a cost to the coping strategies which cannot be measured using this approach. Mutual assistance, (Watts et al. 1989), simply transfers the cost of the disease to other households and is of little help to wage labourers (Chippaux, 1992).

2.9.3 Nutrition, Education and Perpetual Benefits

There is an unequal distribution of costs within the family and the way in which disease, by impacting more on the production of some crops than others (Brieger and Guyer, 1990) can have a disproportionate effect or nutritional status. A survey in south Kordofan, Sudan (Tayeh and Cairncross, 1996) found that in households where more than half the adult members had suffered from dracunculiasis in the previous year, the children under 6 years of age were nearly three times as likely to be malnourished as indicated by wasting.

Children also suffer in other ways from guinea worm disease in their families. The disease affects the mental development of the children as well. They miss school when they have no substitute for their ill parents in doing agricultural work and other household tasks. As a result, school attendance suffers during the peak season (Nwosu et al. 1982; Brieger et al. 1983; Edungbola and Watts 1985; Ilegbodu et al. 1986; Edungbola et al. 1988) and schools in areas of endemicity often have to close for one month in each year as a result of this. This school absenteeism often leads to poor academic performance leading finally to drop out from school (Lyons 1972, Belcher et al. 1975; WHO, 1982; Edungbola, 1983).

Guinea worm disease is of special interest to economist not only because of its direct and measurable impact on production but also because of the singular ability of disease eradication to produce a perpetual stream of benefits at no ongoing cost. It is therefore surprising that recent cost-benefits analysis of the eradication effort by the World Bank considers only the benefits from incidence reduction during the campaign, which they estimate to have cost more than $90 million to date is certainly pessimistic (Cairncross and Muller, 2002).

2.10 EPIDEMIOLOGY

2.10.1 Water Sources

Dracunculus larvae need a period of 12-14 days to develop in the cyclops and become infective; therefore, dracunculiasis is not normally caught from flowing water sources such as rivers and streams. Deep wells are rarely implicated in transmission (Cairncross and Tayeh, 1988; Muller, 1979) few cyclops are found in them, probably because the lack of light at the bottom constrains the population of zooplankton, which are the cyclops' natural diet. Thus, ponds and sometimes shallow or step wells are the main sources of the disease and the epidemiology of dracunculiasis is chiefly determined by the use of such sources for drinking water. Numerous studies have illustrated the predominant role of ponds in dracunculiasis transmission in various parts of Nigeria (Kale 1977; Edungbola, 1980, 1983; Edungbola and Watts, 1984, 1985, 1990; Osisanya et al. 1986); Ghana (Scott 1960, Lyons 1972); Pakistan (Hopkins et al. 1995); India (Johnson and Joshi, 1982) and Uzbekistan (WHO, 1998a).

Most of the ponds involved in transmission are human-made. Steib and Mayer (1988) while working in a village in North east Burkina Faso demonstrated large numbers of ponds which can be found in a single village, even in semi and Sahelian setting, and the degree to which relatively few human-made ponds with specific characteristics play a significant role in transmission. Other types of human-made ponds implicated elsewhere include 'boullies' which are large dew ponds excavated for community water storage on the Mossi Plateau of central Burkina Faso (Kambire et al. 1993); small dams in northern Ghana (Tayeh and Cairncross, 1998); "ataparas" or valley tanks which are similar reservoirs in northern Uganda (Henderson et al. 1988); hundreds of drinking water-ponds recently built in Anambra State Nigeria (Cairncross et al. 2002); "hafirs" built to store water from empheral streams in Sudan (Cairncross and Tayeh, 1988); and municipal ponds in old Bukhara, Uzbekistan (Cairncross et al. 2002). Outbreaks of guinea worm disease blamed on dam construction are as a result of the use of ponds left by the receding water during drawdown of the water level (Adekolu-John, 1983; Edungbola and Watts, 1984).

Various types of wells and storage tanks have been known to become sources of the disease. Rectangular masonry-lined step wells were the principal sources of infection in Rajasthan, India (Singh and Raghavan, 1957). Shallow wells have been implicated in Mali (Ranque et al., 1979 cited by Cairncross et al. 2002). Scoop wells dug in sandy riverbeds can also be a source but if the drawing of water each day exhausts the water holes, no cyclops population can be sustained in them and so transmission cannot occur

(Cairncross and Tayeh, 1988). In Iran, "berkeh" – traditionally covered water storage cisterns with a diameter of over 10 metres were implicated (Sahba et al. 1973).

Transmission has also occurred from rainwater storage reservoirs used by individual households such as the "karkour" of the Nuba mountains of Sudan (Cairncross and Tayeh, 1988) and in isolated incident in 1993 in El Rohaibat, Libya, from a buried reservoir filled from a farm tank which an infected migrant worker had contaminated (Karam and Tayeh, 1999). Few cases are caused in this way, because there must be an index case in the household to contaminate the reservoir, but when they do occur, transmission is more intense than usual because the infected cyclops are contained in a smaller volume of water and this is reflected in a higher average number of worms per patient (Cairncross and Tayeh, 1989).

2.10.2 Villages of Endemicity

Dracunculiasis occurs only in a limited number of so-called "villages of endemicity", on which eradication activities can focus. For example, in 1980 the National Case Search conducted in all 8,068 villages in Burkina Faso found cases in only 2,621 (Kambire et al. 1993). Local health staff in Bam province found that villages known to have ponds were twice as likely as others to be among these villages of endemicity. There has been a tendency in some countries for the list of villages of endemicity to "drift" by some 30% per year and sometimes even twice this but, the appearance of a large proportion of new villages seems to be largely the consequences of cases reappearing in villages removed prematurely from the endemicity list rather than a change in the set of villages susceptible to the disease. A period of one year without cases is insufficient evidence that transmission has been interrupted as the full cycle from emergence of a worm in the index case to detection of a secondary case can take up to 16 months.

2.10.3 Seasonality

Dracunculiasis takes roughly a year from ingestion of an infected cyclops by the human host to emergence of an adult worm. This makes it well suited for environments in which transmission can occur only at a particular time of the year. As a result, there is a strong seasonal peak in incidence rates in most communities of endemicity. Two broad patterns of seasonality are found in the African areas of endemicity, depending on climatic factors. In some countries, both patterns occur each in a different climatic zone. To the North in the Sahelian zone, transmission of dracunculiasis is generally limited to the rainy season from May to August with a peak in June and July (Guiguemde, 1985). Steib and Mayer (1988) attributed this pattern to the presence of *Thermocyclops inpinus* in the surface and shallow water used for drinking. Others however have found it more difficult to correlate occurrence of cyclopoids in the local water sources with the prevalence of infection among the people using them (Yelifari et al. 1997). More fundamentally, many water sources involved dry up and hand pumps are repaired in the dry season, so that the population turns to safe ground water sources (Curtis et al. 1993 cited by Cairncross et.al. 2002)).

Further south in the humid savannah and forest zone, the opposite pattern is found, with the peak in the dry season. This may be the early dry season (September-January) as in some parts of Oyo state, Nigeria (Edungbola and Watts 1990; Kale, 1977); and south Togo, particularly in villages with shallow ponds which usually dry up by January. The disease often occurs or continues towards the end of the dry season (January- May) in Ghana (Scott, 1960; Lyons, 1972; Belcher et al. 1975) southern Benin (Chippaux and Massougboji, 1991 cited by Cairncross et al. 2002), Kwara and Anambra states in Nigeria (Abolarin, 1981; Nwosu et al. 1982; Edungbola, 1983; Edungbola and Watts, 1985;), and Uganda (Henderson et al. 1988). This dry season transmission is often associated with the consumption of water from ponds or water holes formed or dug in the beds of seasonal rivers when flow has ceased (McPherson, 1981; Chippaux et al. 1992). Chippaux and Massougbodj, (1991 cited by Cairncross et al. 2002) suggested that transmission does not occur when there is less than one susceptible cyclopoid per litre in the pond and that this accounts for seasonal variations in incidence.

There are local variations in these patterns. The duration and intensity of transmission in particular villages often depend on whether and when the local dams or ponds dried up the previous year (Tayeh and Cairncross, 1998) and some villages have very different seasonal peaks from those of the surrounding areas because of local circumstances. For example in some villages along the banks of the Niger and Volta rivers the incidence peaks when the river level falls and water is taken from holes dug in the river bed (Cairncross et al. 2002).

2.10.4 Individual Risk Factors

The incidence of the disease has been found to vary with age and sex in different ways, but these can generally be understood from the way that people of different ages and genders behave with regard to their sources of drinking water. For example, a significantly higher prevalence has been found in women in Ethiopia (Jamaneh and Taticheff, 1993) and in men in India (Johnson and Joshi; 1982) and sometimes in west Africa (Adekolu-John, 1983; Chippaux et al. 1991 in Cairncross et al. 2002; Nwoke, 1992), however when behavioural risk factors (such as work in the fields or collection of water) are taken into account, the difference between the sexes is not significant (Tayeh et al. 1993).

Cairncross and Tayeh (1989) in Sudan discovered two possible age prevalence profiles. One for high-prevalence villages each with an infected water source, showing similar prevalence in children and in adults. Two for 23 villages showing a lower prevalence in all ages but significantly less in children than in adults. The first is characteristic of communities where the water carried home is infected, while the latter is indicative of an association with mobility where infection is acquired from water sources outside the community.

Other important individual risk factors are those associated with mobility (Watts, 1984), however the strongest of all is infection in the previous year. A minority of people suffer recurrent infection in spite of drinking from the same water sources as the rest of the populations reflecting the variability in individuals' susceptibility to the disease (Lyons, 1972; Tayeh et al. 1993).

2.11 THE ERADICATION INITIATIVE

Muller (1979) pointed out that guinea worm disease is a promising candidate for successful eradication. The cyclops is not a mobile vector like a mosquito, and the carrier state in both the cyclops and human hosts is of limited duration. Diagnosis is easy and unambiguous, cheap and effective measures are available to prevent transmission. The disease has a limited geographical distribution and even within this area it is found only in certain communities of endemicity. Its markedly seasonal distribution in time also permits a more intense focus on its prevention in seasonal campaign and transmission from animals to people is practically unknown. Therefore the suggestion that dracunculiasis might be eradicable fell on fertile grounds.

Choosing a target was easy, however compared with the task of mobilizing the resources for the battle much of the credit for that achievement goes to members and former members of the staff of the Centres for Disease Control and Prevention (CDCP), who through an advocacy campaign beginning in 1980 and sustained over more than a decade (Hopkins, 1983;1985b; 1987; 1990 and 1993) succeeded in convincing former U.S. President, Jimmy Carter, the United Nations Children's Fund, (UNICEF), Executive board, the 1989 African regional committee of the WHO and the 1990 World Summit for children to take up the challenge. In 1991 World Health Assembly declared "its commitment to the goal of eradicating dracunculiasis by the end of 1995, this date being technically feasible given appropriate political, social and economic support". The target date was set in order to enhance the advocacy effort at the international level and in the countries of endemicity as well. This advocacy effort needed to be replicated in each country to get a national programme established (Edungbola et al. 1992). In 1982, India was the first to initiate a national eradication campaign. By 1990, four other countries followed namely Pakistan, Ghana, Nigeria, and Cameroon. In the following five years, all the other known countries of endemicity also established national eradication programmes and substantial and progressive reductions in disease incidence were recorded each year, particularly at the beginning of the campaign.

The advocacy needed to be maintained as the initiative advanced. This was, on the other hand, to kindle and sustain the interest of donor agencies, which supported water supply programmes, technical assistance, vehicles, cloth filter, Temephos, training of staff and volunteers, and field allowances. On the other hand, it was aimed at keeping up the commitment of government of countries of endemicity and the enthusiasm of programme staff, an essential function, since the bulk of the staff engaged in the initiative were health workers whose salaries were supported from the budgets of National Ministries of Health (Cairncross et al. 2002).

An important means to this end has been the series of regional conferences and meetings of national programme coordinators, together with programme review meetings. Donor involvement and coordination were also supported by regular inter agency meetings, usually held in the United States of America and attended by representatives of the carter centre, UNICEF, the U.S. Agency for International Development, the World Bank, WHO, and other agencies. High-level advocacy was also supported by the continuing involvement of Jimmy Carter and two former African Heads of State whom he persuaded to play a similar role, A.T. Toure of Mali and Yakubu Gowon of Nigeria (Cairncross et al. 2002).

The principal international stakeholders in the programme have been relatively few in number. The Cater Centre, UNICEF, the World Bank and WHO. Other major supporters include Bill and Melinda Gates foundation and the British and Japanese bilateral aid programmes and have channelled their funding through these agencies (Cairncross et al. 2002). The major players liaise periodically to identify major gaps in the funding of national programmes and in most countries of endemicity, one of them has, by consensus, taken the leading role.

From 1992 to 1996, when National Eradication Programmes were being established, UNICEF and WHO maintained a joint technical team based in Ouagadougou, Burkina Faso, to provide technical support to national programme coordinators in the region and external support agencies. The Carter centre also seconded one of its staff to this team in 1994 (Cairncross et al. 2002).

The out come of all this effort has been a remarkable reduction in the number of cases, from an estimated 3.3million world wide in 1986 (Watts, 1987) to 75,223 (WHO 2001). Only 14 countries, including Nigeria, all on the African continent, reported indigenous cases in 2000 (WHO, 2001).

2.12 INTERVENTIONS

Given the transmission cycle of the parasite and the absence of an effective vaccine, a number of interventions seemed a priority to be worth considering.

i. Filtration of one's drinking water to remove cyclops.
ii. Provision of safe water supplys
iii. Searching for patients with active cases and proper management of the cases
iv. Ensuring that patients avoid contact with ponds/case containment
v. Killing or removing cyclops in ponds using Temephos (Abate)

2.12.1 Filtration of Drinking Water

The adult cyclops is over 1mm long and therefore it can easily be removed by filtering the water through an ordinary cloth. The filtration may be easy but convincing the people to do it is another problem. For millions of poor and mostly illiterate villagers, living in thousands of remote and frequently inaccessible communities and speaking hundreds of different languages, to change their behaviour in this way is by any standard a major challenge to health education planning.

As the National Eradication Programme took shape during the early 1990s, it became clear that it would rely largely on health education to promote the use of cloth filters. Early eradication programmes distributed cotton cloth, but this was sometimes used as clothing or for decoration, and homemakers also complained that it soon became clogged with sediments in the water so that too much time was needed to do the family's filtering. The right type of filter cloth was then introduced in the early 1990s, the cotton cloth was replaced by a monofilament nylon cloth, which was donated in huge quantities by Precision Fabrics Group through the Carter Centre and which is less susceptible to clogging (Duke, 1984). More recently, a somewhat cheaper polyester fabric has been found to be equally effective and acceptable (Olsen et al. 1997).

Several hundred thousand square metres of this cloth were donated during the 1990s; at the cost price of the fabric, this represents a donation of over US$14million (Carter, 1999). A study in Pakistan (Imtiaz et al. 1990) found the filters in satisfactory condition after 12-15 months of use. Unfortunately it gradually became clear that in Africa the cloth could not be expected to last for more than a year particularly when people washed it regularly, with the vigour that they customarily used on other items of domestic laundry. This meant that filters had to be replaced regularly (Cairncross et al. 2002). The fabric donation ended in 1998 and since then national programmes have had to distribute cotton cloth or to find the funding to purchase monofilament fabric at US$4 per square metre. The cost of the cloth has encouraged national programmes to find more economical ways of using it, such as stitching a patch of it into a hole made in a larger piece of ordinary cotton cloth. One other cost effective use of the material is to fix it over the end of a piece of 10-20mm diameter plastic pipe, 100-200mm long. This "straw" filter can then be taken on journeys or to the fields and used to drink from ponds. A hole can be drilled through the pipe so that it can be hung around the neck from a string. First introduced with successes by the Mauritanian Programme, it has been used in Niger, southern Sudan and Nigeria especially in the North West and North East zones (Cairncross et al. 2002, Hopkins and Withers, 2002).

When the nylon cloth was being donated, some National Programmes, especially Burkina Faso and Togo, sold the filters for a nominal sum. This was to help pay for the cost of making up the cloth into a handy form and also seen as ensuring that those who acquired the filters would value them. Ironically, now that the National Programmes have to purchase the filter cloth, all of them have decided to distribute filters free of charge in communities of endemicity, with a view to ensuring complete coverage.

2.12.2 Safe Water Supply

In the early strategies for eradication of dracunculiasis provision of safe water supply was generally seen as the intervention of choice although water supplies are built and maintained for many other reasons besides the prevention of guinea worm disease. The eradication goal was originally proposed as a target for the international water decade (Hopkins, 1983; 1984). Early eradication efforts in Nigeria (Edungbola et al. 1988; Edungbola and Watts, 1990; Huttly et al. 1990) and Benin invested the major part of their budgets in water supply construction. The former vice president of Nigeria, Augustus Aikhomu, while declaring open the second national guinea worm conference in March 1989, directed all water providers including the governments Directorate of Food, Roads and Rural Infrastructures (DFRRI) to give priority to villages with guinea worm in their water projects.

There is a lot of evidence on the success story of the impact of water supplies on dracunculiasis (Reddy et al. 1969; Lyons, 1972; Bhatt and Palan, 1978; Johnson and Joshi, 1982; Udonsi, 1987a; Cairncross and Tayeh, 1988; Edungbola et al. 1988; Henderson et al. 1988). India's rural water supply programme gave priority to villages of endemicity and by the time the National Eradication Programme was concluded, had provided water supply to every village of endemicity in the country. This was an important contribution to that country's successful elimination of the disease in 1997. There are however some important limitations to the effectiveness of water supply as a preventive intervention.

i. Water supplies cannot function without proper maintenance. Many water systems in Africa have fallen into disuse for this reason within a few years of construction and in some cases the resulting reversion to unprotected water sources have allowed the disease to persist (Bhatt and Palan, 1978, Steib and Mayer, 1988) or in peri- urban settings, to develop in epidemic form (Edungbola, 1980; Brieger et al. 1982).

ii. The provision of water supply to every village and hamlet is not always feasible. Studies carried out by Tempalski (1991 cited by Cairncross et al. 2002) in a Benin project revealed that the prevalence of guinea worm disease in the villages of endemicity with fewer than 150 inhabitants was four times that in the largest villages, but they were specifically excluded from the borehole programme as they were considered too small to justify the cost of drilling and maintaining a hand pump sustainably (Yellott, 1990 cited by Cairncross et al. 2002).

iii. A functioning water supply will still be ineffective if it is not used. It has been shown that the most common cause of non-use is that the supply is not close enough to people's homes (Cairncross et al. 2002). In the countries of endemicity of the Sahel, a hand pump may be the only source of water for miles around in the dry season; however, guinea worm transmission peaks during the rains, when people are often infected from the many ephemeral ponds which are within a few hundred yards of their houses.

iv. Much of the population in the rural Sahel migrates. In addition to the movement of the nomadic pastoral population, it is common practice in countries such as Burkina Faso and Niger for a village to disperse during the growing season (which is also the peak of dracunculiasis transmission season) to a number of small and seasonally occupied hamlets, some of which may be in other districts, or even to sow their crops in several different areas and tend those where the region's unpredictable rainfall turns out to be most plentiful. When a borehole can cost as much as US$10,000, it is not a cost effective option to provide one for every such hamlet (Cairncross et al. 2002).

v. Water supplies alone cannot eliminate dracunculiasis if they are not used exclusively. Guinea worm infection is often acquired through casual use of unprotected sources when people are away from home, especially when they are working on the fields. The findings of Belcher et al. (1975) and Cairncross and Tayeh (1988) have confirmed this where adults, particularly farmers were more commonly infected than were children and that people travelling away from their villages were at greater risk (Tayeh et al. 1993).

vi. Water supplies are very expensive. WHO (1992a) has shown that typical rural water supplies in sub-Saharan Africa have a median capital cost of US$40 per person served with an additional recurrent maintenance cost. This however, does not mean water has no role to play, in some cases, particularly in the few urban foci of dracunculiasis, it has been decisive, but its impact must be assessed realistically. It can be seen as transforming a high prevalence community where all water is contaminated to a low prevalence community where only those who use unprotected sources are at risk.

2.12.3 Case Management

Surgical extraction of the worm was first recommended by Avicenna (980 to 1037) and was practiced by traditional healers in Iran and in what is now Uzbekistan (WHO, 1998). Great skill is required to avoid breaking the worm, which is sometimes caught around joints or tendons. Extraction before emergence avoids the pain and suffering caused as the worm emerges and also contains the case by preventing contamination of water sources. B.L. Sharma, an ayurvedic practitioner supported by UNICEF refined this technique and applied it in India, and with this, a further advantage was apparent in that people could come from far and wide to have their worms extracted, greatly improving the effectiveness of case detection and hence of case containment (Rohde et al. 1993). Although the technique was an important component of the eradication programme, the measures were never accepted by the Indian medical profession or adopted by the National Eradication Programme. Ghana was the only African country to include this intervention in its dracunculiasis eradication programme but abandoned it in the early 2000; this was because the measure distracted the attention of health workers who received a reward for each worm extracted, from the implementation and supervision of the basic community-based interventions (Cairncross et al. 2002).

A more widely used form of case management is to apply an occlusive bandage to the lesion where the worm is emerging. This does not prevent the larvae from being released into the environment but it does discourage the patient from immersing the affected part in a pond; immersion transforms a neat bandage into a soggy mass of wet cotton wool which is likely to fall off. There are also other palliative treatments by the village health worker, example, "controlled emersion" of lesion in a bucket of water, disinfection of the lesion by topical application of emollient creams and even antibiotic ointment (WHO, 1990b), bandaging by a VBHW has been used to promote early self-reporting of cases.

2.12.4 Preventing Patients' Contact with Ponds

Preventing patients' contact with ponds was an important component of the world's first endeavour at dracunculiasis elimination conducted in the old city of Bukhara, Uzbekistan, in the 1920s (WHO, 1998a). Efforts were made to identify patients early and keep them under observation during the two weeks following initial emergence of their worms, and Muslim worshippers were prevented from approaching the main ponds in the town to perform their ablutions.

In the early stages of the worldwide eradication campaigns, however, such measures were ruled out as impractical in a rural context where case detection within even a month of emergence could be considered an impressive achievement. Instead, the message that patients should not contaminate ponds was usually a secondary one in the general health education materials. As a result, people were far more aware of how one catches the disease than of how one passes it on. Example, an evaluation survey by Cairncross in 1994 of 26 villages in Niger showed that while 54% of householders knew that dracunculiasis is transmitted in drinking water, only 13% could say how ponds became infected with it (Cairncross, 1995).

More recently, it has become clear that people sometimes respond so well to this message that it can have a significant effect on transmission in the complete absence of filter cloth (Cairncross et al. 2002).

2.12.5 Killing or Removing of Cyclops

The intervention of killing or removing cyclops has also been tried since the earliest efforts to control transmission of the disease. Leiper (1911) used steam to kill cyclops in Indian step wells and Turkhud (1914) used potassium permanganate. Ten years later, when Isaeu tried to apply their methods to the ponds of old Bukhara, he found them impractical, an average pond required 300kg of disinfectant, and the water became undrinkable (Isaev, 1956).

In more recent times, Temephos (Abate), an organophosphate insecticide safe for use in drinking water sources, has been used in many countries of endemicity and $2million worth has been donated to the campaign by its manufacturer (Carter, 1999). Cyclopicide played a prominent role in the eradication programmes launched in the 1980s in India, Pakistan and Cameroon. All these programmes have successfully achieved elimination but this took many years.

In Africa, vector control has not proved as easy as initially anticipated, in spite of their being fewer ponds per person than there were step ponds in India. Chemical treatment of African ponds, even by highly qualified research teams has been found on a number of occasions to be of questionable effectiveness (Guiguemde et al. 1990, Sullivan, 1991 as cited by Cairncross et al. 2002). When the treatment is not fully effective, there is an increased risk of cyclops developing resistance to the cyclopicide. Even treatment, which successfully removes the cyclops from the pond, does not always eliminate guinea worm disease, as other contaminated water sources are often in use (Lyons, 1973).

Transmission is most intense in ponds which are in the final stages of drying up (Belcher et al. 1975; Tayeh and Cairncross, 1998) and which therefore may be missed by the treatment team. This is because the infected cyclops which tend to sink to the bottom are increasingly likely to be scooped up as the pond became a shallow puddle (Nugent et al. 1955; Onabamiro, 1954).

Treatment of ponds can also consume substantial resources, particularly in terms of trained staff. It is harder to calculate the volume of an irregular pond than of a rectangular Indian step well, although this is essential in order to estimate the dose of insecticide required (Centre for Disease Control, 1989). Faced with these difficulties, the health technicians usually take almost half a day to measure the volume of some ponds.

The pond volume also varies with time; if rainfall after the treatment does not dilute the insecticide to harmless levels, the pond may still need to be re-measured the following month, although a solution used in India to avoid continued measurement of the volume is to insert a calibrated scale in the pond. Treatment has to be applied at least monthly to be effective, and there is evidence to suggest that an even shorter treatment interval is required. With as many as 10 ponds to treat per village it becomes a very labour-intensive activity. There is some evidence that it has diverted staff from other more important activities (Cairncross, 1995).

Some exceptional cases were found in northern Ghana where in 1997, the eradication programme staff found that most of their cases came from only four district towns each of which used water from a dam. The dams were nearly ten times the maximum size recommended for treatment (Centre for Disease Control and Prevention 1989). Nevertheless, after some experimentation they found that cyclopicides could be applied very effectively to these dams (Cairncross et al. 1999).

2.12.6 Case Containment

By the middle of the 1990s as case numbers began to drop, there was increased enthusiasm to step up the level of intervention and move towards "case containment". This involves a shift of emphasis from helping individuals to protect their own health by avoidance or filtration of infected water towards the protection of ponds and the community at large from contamination by infected people.

If this is to be effective, it requires detection of each case before or immediately after the emergence of the worm and measures to ensure that it could give rise to no subsequent case. Case containment helps to encourage self-reporting of cases, essential if the cases are to be detected in time and also discourage patients from immersing their lesions in water. Patients and their families are urged to keep out of water sources until the worms have completely emerged and are also interviewed to ascertain whether they have already contaminated any ponds. If so, remedial measures are taken, such as alerting the community to this possibility, treatment of the affected ponds with cyclopicide and checking that every household in the village has a cloth filter in good condition and knows how to use it. To ensure the effective implementation of case containment each case should be reported to the supervisor of the village health worker within seven days, and the supervisor should visit to verify the diagnosis and ensure that all necessary measures have been taken.

These measures require substantial additional resources (Greer et al.1994). The cost per village is probably at least double the cost of the conventional approach (Cairncross et al. 1996). Some of the principal international agencies involved expressed concern that these resources should be deployed effectively, so in 1994 at a meeting organised in Nairobi, Kenya, technical standards for effective case containment were defined and agreed on (Anonymous, 1994, cited by Caincross et al. 2002). According to these criteria, a case is considered to have been successfully contained only if:

i. it was detected before or within 24 hours of worm emergence
ii. the patient has not entered any water source since the worm emerged or if so, the source has been treated in time to prevent transmission
iii. the case has been properly managed by cleaning and bandaging until the worm is fully removed, and the patient has been discouraged from contaminating any water source
iv. the diagnosis and containment of the case have been verified by a supervisor within seven days of worm emergence.

The implication of this is that eradication programmes where the resources did not permit a supervisor to visit each village of endemicity more than once a month could not be considered to be implementing case containment even if the village health worker did carry out some containment activities. The Nairobi participants referred to this as "intensified case management". It has taken several years for all the countries of endemicity to adopt these standards. For example, Niger maintained that a case had been contained if the case was detected in a week. Even now, a number of countries do not confirm the diagnosis and containment within a week (Cairncross et al. 2002).

2.12.7 Village-Based Health Workers (VBHWs)

The annual case search for 1990/91 was the last, and in 1992, the programme emphasis was shifted from case reduction to case containment. Village-based health workers (VBHWs) were trained to assist with monthly surveillance and intervention activities which commenced in January 1992 have been in operation to date. The collection and management of surveillance and intervention data are now ongoing activities and form an integral part of the eradication programme involving communities, Local Government Areas, States, Federal Government and supporting agencies.

In Nigeria, government launched a village-level guinea worm eradication initiative after four successive National case searches. In this regard, VBHWs nominated by the village health committee and leaders were trained and given flip charts as aids in educating villagers on the benefits and practical use of filtering water. The over 6000 unpaid village-based health workers, apart from engaging in filter distribution and health education, undertake surveillance activities by counting number of guinea worm cases in each household and taking stock of sources of drinking water in the communities. WHO assisted in the logistics with the provision of bicycles.

The surveillance and intervention strategies were also supported not only by the VBHWs but also by about 94 National Youth Corp Members (NYSC) who were recruited, trained and assigned to the then 86 most highly endemic Local Government Areas in the country. Other support manpower resources include American Peace Corp Volunteers and Canadian Co-operants, LGA guinea worm coordinators, State task force members, zonal facilitators and the staff of the Federal Ministry of Health and Social services which, in collaboration with Global 2000, sends directives to all the States and the LGAs.

2.13 CURRENT ISSUES ON GUINEA WORM

2.13.1 The Integration Debate

The strategy followed by most endemic countries as they set up eradication programmes during the 1990s was built on the experience of Pakistan, Ghana, and Nigeria (Hopkins and Ruiz-Tiben, 1991). Volunteer VBHWs, providing health education, distributing cloth filters, and carrying out surveillance, were central to the strategy. It was foreseen that they would cover more villages in less time than the provision of safe water supplies required. It was proposed that where Primary Health Care (PHC) workers already exist, they should be used. But where they do not exist, an appropriate villager should be designated (who may later be incorporated into the country's PHC programme).

In the ensuing years, the networks of villager volunteers which were being established proved remarkably effective in carrying out surveillance and health education (Cairncross *et al.,* 1996). However, the degree of their integration into the PHC programme was a subject of intensive debate. Their success led some stakeholders in the global campaign to advocate that they should be used to monitor conditions other than dracunculiasis, such as immunization status and acute flaccid paralysis as a marker for possible polio epidemics. As they saw it, the cost of establishing the network was an investment which should serve health objectives.

The main item in such a network is the salaries of those who supervise the volunteers and in most countries these are met from the general health budget and not from funds earmarked for guinea worm eradication. The other major items are the cost of annual retraining for the volunteers and occasional gifts- in- kind to motivate them such as T-shirts or the salt and soap given to the volunteers in South Sudan (Cairncross *et al.,* 2002).

Others doubted the wisdom of integration wary of putting the eradication effort at the mercy of an often-weak PHC system and dissipating eradication resources on other activities (Hopkins, 1998). Prior experience of inappropriate "integration of smallpox eradication with measles control and yaws control in Ghana (Hopkins, 1985a) influenced their thinking.

The danger of over-burdening the volunteers, though a recent field assessment of integration surveillance in Northern Ghana found no objective evidence that the surveillance activities were interfering with health workers' ability to effectively carry out the work on eradication (Zucker, 1998 cited by Cairncross *et al.,* 2002). Another source of unease with some justification was that the collection of surveillance data is useless if, as has occurred in a number of countries of endemicity, it is not used for any action.

However, the integration debate led to a joint statement in favour of the integrated surveillance by the four principal agencies involved in the eradication effort, WHO, UNICEF, Global 2000 and WHO Collaborating centre at Centre for Disease Control (WHO, 1993). But the question of whether to "integrate, or not to integrate" does not have a universal answer; the answer can only be worked out on the ground in each specific context. Moreover, surveillance is only one component of a public health system, and others may benefit from a degree of integration. There have been substantial synergies from combining dracunculiasis eradication activities with others in a number of cases. Both dracunculiasis eradication and the wider health agenda can benefit as long as the combination is opportune and has been made judiciously. Examples:

i. The integration surveillance for guinea worm, immunization, yellow fever, and cerebrospinal meningitis in the 3,743 villages of Northern region, Ghana (Zucker, 1998 cited by Cairncross *et.al.,* 2002) where initial difficulties in harmonizing case definitions were ironed out during the first year of operation.
ii. The mobilization of underused government field staff to supervise the village health workers in Mopti Region, Mali (Cairncross *et al.,* 1997) while also supporting their work to promote latrine construction and better agriculture.
iii. The use of guinea worm surveillance system for implementation and monitoring of trachoma (a chronic contagious disease of the eye

caused by *Chlamydia trachomatis)* infection elimination activities in Zinder Region, Niger.

iv. Also in southern Sudan, the use of Guinea worm programmes training and supervision system for a pilot programme in which village health volunteer in remote villages were trained to identify and treat fever and malaria, cough and difficult breathing, and dehydration due to diarrhoea.

v. The use of the Polio national immunization days to detect 400 new villages of endemicity in southern Sudan during the first campaign in this area in 1998 (WHO, 1999a) where the same process in the following 2 years led to the detection of a further 350 villages of endemicity.

2.13.2 Geographic Information System

The use of Geographic Information System (GIS) is another area where dracunculiasis eradication has interacted positively with other public health activities. The dracunculiasis eradication campaign was the first global public health initiative to pioneer the use of GIS as a planning tool.

The application of GIS had its origin in the link between water and health sectors from the beginning of the campaign. Rural water supply programmes in the countries of endemicity of West Africa are largely based on boreholes with hand pumps. Rural water projects in a number of countries supported by the Cooperation Francaise and United Nations Development Programme were developing computer databases of the boreholes drilled, for purposes of asset management and geohydrological analysis. These databases naturally included data on the borehole positions and maps could be drawn from them by using GIS software. From this it was a small step to using this software to map other items of rural infrastructure such as schools, health posts, and the presence of VBHWs and also guinea worm surveillance data. Thus, villages of endemicity and safe water points were plotted on digitised maps early in the 1990s by UNICEF water sector in most of the countries of endemicity of Francophone Africa (Clarke *et al.,* 1991). In the Anglophone countries of endemicity such as Ghana, Nigeria, and Uganda, a specific mapping exercise was yet to be acquired to enhance dracunculiasis elimination programme. GIS was not used in Pakistan and India before the disease was eliminated from these countries although other computer databases were set up to manage the surveillance data (Cairncross *et al.,* 2002).

In 1993, the WHO-UNICEF Joint Programme on Data Management and Mapping, called Health map was established at WHO headquarters in order to implement and maintain a GIS for the guinea worm eradication programme at global, national, and local levels. Commercial software was used at international and national levels to enter, store, and maintain data on over 80, 000 geo-referenced villages in Sub-Saharan Africa, such as village populations and schools, health, and water supply infrastructure in addition to the epidemiological information on guinea worm disease.

In 1997, it was felt necessary to develop dedicated software, adapted to the specific needs of dracunculiasis eradication as well as other public health initiatives which can be easily used by technical staff at national and sub-national levels in the countries of endemicity. The health mapper software was therefore developed by the Health Map Unit. It contains a standardized geo-referenced database of country, regional, district, and sub-district boundaries with rivers, roads, villages, and water health and social infrastructure. The system also comprises a user-friendly mapping interface and a database management facility (WHO, 1999b). The main users have been involved in the refinement of this software and in several workshops held to ensure that they can use it to enter, update, and analyse their epidemiological and programme data and to show the data and analytical results in map form.

The costs of the development of GIS database and the software to manage them have largely been borne by International Agencies. The national staff that maintains them would in any case be required to collate and analyse surveillance data, so that the opportunity cost to the countries concerned is very small. The databases have begun to prove their worth. For example, the requirements to maintain them have proved to be a powerful means of encouraging programme staff to continue maintaining the status of villages which, for a lack of dracunculiasis cases would otherwise be dropped from surveillance.

These databases would also prove their worth in establishing the completeness of the surveillance arrangements for the certification of eradication. The International Commission for the Certification of Dracunculiasis Eradication (ICCDE) has determined that at least 9 out of 12 monthly reports must be received from all villages of endemicity (''acceptable'' surveillance) or all 12 from at least 85% of villages of endemicity ("effective" surveillance) for the surveillance results to be used for certification purposes (WHO, 1996a). Functions have been added to the GIS software to permit these indicators to be shown by village or by administrative division.

The positive experience of using GIS for dracunculiasis eradication formed the bases on which the same team has subsequently developed GIS software to support elimination control programmes for other diseases, particularly leprosy, lymphatic filariasis, and onchocerciasis.

2.13.3 The Certification of Dracunculiasis Eradication

In 1991, the World Health Assembly (WHA) urged the WHO Director general to:

> Immediately initiate country-by-country certification of elimination so that the certification process can be completed by the 1990s

In May 1995, the International Commission for the Certification of Dracunculiasis Eradication (ICCDE) was established to verify and confirm information from countries claiming the absence of indigenous dracunculiasis. The Commission is made up of 12 independent public health experts from all regions of the world (WHO, 1996). The criteria for the certification of dracunculiasis eradication were developed by WHO in consultation with the main partners and were given their final revision and endorsement at the first meeting of the ICCDE held in Geneva, Switzerland, in March 1996. They are complemented by number of explanatory documents and guidelines (WHO, 1996b and 2000b).

All the countries with dracunculiasis transmission after 1980 are required to maintain active surveillance for at least 3 years after achieving interruption of transmission. In addition, a country report needs to be submitted to the ICCDE through WHO, describing the procedures undertaken and providing evidence of the reliability of the surveillance system and its ability to detect any case of dracunculiasis, even in the most remote areas of the country. A panel of specialists has been created and the members have been assigned to the International Certification Teams (ICTS). The visits of the ICTS are necessary in all countries of previous endemicity in order to assess the reliability of the surveillance system in the field and to review and document the overall process which led to the interruption of transmission.

After its first meeting in March 1996, the ICCDE met again in January 1997, February 1998, and February 2000. International Certification Teams have visited Iran, Pakistan, Egypt, India and Libya. On the basis of the recommendations produced by the ICCDE 151 countries and territories have so far been certified as free of dracunculiasis transmission by WHO (WHO, 1998b and 2000b).

Among these countries, Pakistan and India achieved interruption of transmission after the beginning of the global eradication campaign in the 1980s. Kenya, Cameroon, and Senegal have also achieved interruption of transmission, reporting zero case for more than 3 years (WHO, 2003). They are now in the pre-certification phase during which active surveillance needs to be maintained for at least 3 consecutive years with no cases reported. Countries bordering countries of high endemicity like Sudan cannot be certified unless interruption of transmission is also achieved in the cross-border areas. This means that the pre-certification phase will last longer than 3 years for Kenya and probably Uganda, Ethiopia and Central African Republic despite the fact that interruption of transmission may have been or may be achieved in these last three countries during 2001 or 2002.

The ICCDE has been useful not only for the certification process but also some of its recommendations have focused on critical aspects of the eradication campaigns, like the surveillance systems and their implication for the certification criteria or the revision of guidelines and tools for the production of country reports and the ICTS visits.

For countries approaching the target of elimination at the national level, vigilance must be maintained and not limited to the formerly known areas of endemicity. Several types of surveillance activity, for example, the collection and prompt investigation of rumours and the offering of rewards for confirmed indigenous cases are needed to complement official notifiability and specific community-based surveillance and to give wider geographic coverage. Also at the final phase of the campaign, it is becoming more important to link the work of the ICCDE to the context of the countries where dracunculiasis is still endemic, which represent the most difficult areas in which to interrupt transmission. Nomadism and transhumance are also common in areas of endemicity. There is a need for innovative strategies to conduct preventive interventions as well as to maintain active surveillance in these very difficult areas.