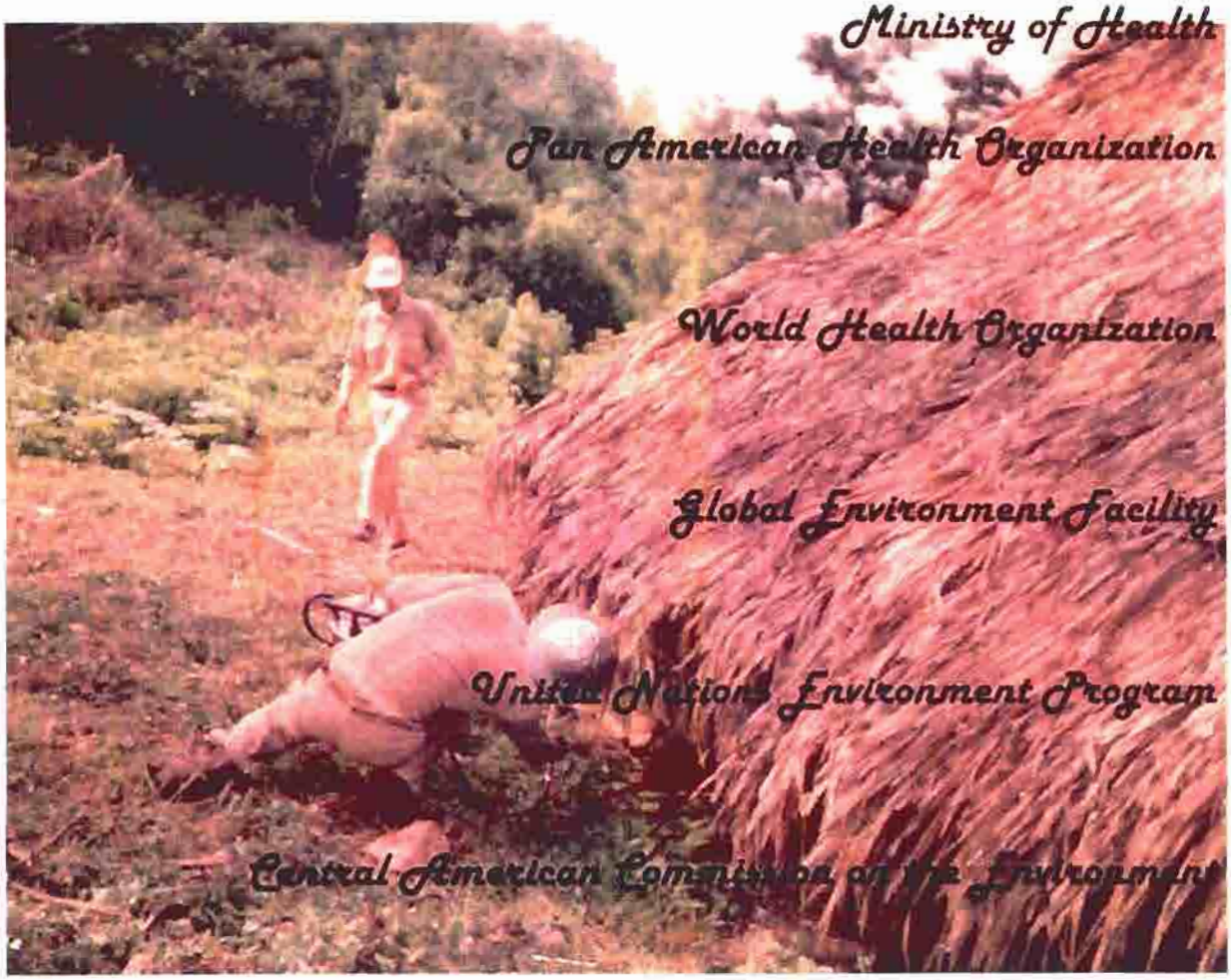
DIAGNOSTIC SITUATION ON THE USE OF DDT AND THE CONTROL AND PREVENTION OF MALARIA IN BELIZE



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DIAGNOSTIC SITUATION ON THE USE OF DDT AND THE CONTROL AND PREVENTION OF MALARIA IN BELIZE

Ministry of Health

Pan American Health Organization

World Health Organization

Global Environment Facility

United Nations Environment Program

Central American Commission on the Environment

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ACKNOWLEDGEMENT

This report was carried out in fulfillment of a contractual service agreement between the Pan American Health Organization and Mario Fernandez to conduct a study titled ***Diagnostic Assessment of the Use of DDT in the Control and Prevention of Malaria in Belize***. The Vector Control Unit of the Ministry of Health was chosen as the counterpart Government Agency to coordinate this project. My appreciation goes out to the following persons and institutions whose invaluable assistance allowed for the implementation and completion of this project.

Special thanks to the coordinators, Rony Maza, PAHO Consultant and Francis Westby, Director of the Malaria Control Program, Ministry of Health. Our gratitude goes out to the interviewers, Patricio Mena, Angel Tzec, Eugene Lisbey, Steven Rivers, Conrad Thomas, Orlando Chan, and Dunninger Duhaney. To Nurses Gloria Vialta, Glendora Gordon and Martha Sosa, who assisted in the collection of breast milk samples, Donna Dougal who collected and prepared the blood samples and Marlon Fernandez who collected the sediment and soil samples. We also extend our gratitude to Albert Roches of the Department of the Environment for providing camera equipment. . We would like to thank the communities that were interviewed as well as those persons who willingly agreed to partake in the pesticide residue-monitoring program and who donated biological samples for analysis.

Prepared by

MARIO FERNANDEZ

Belize
July, 2001

ABBREVIATIONS

DDT	Dichlorodiphenyltrichloroethane
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenylethane
PCB	Pesticides Control Board
NMES	National Malaria Eradication Service
VC	Voluntary Collaborator
CNA	Community Nurses Aide
PAHO	Pan American Health Organization
WHO	World Health Organization
EHD	Environmental Health Division
VCU	Vector Control Unit
DOE	Department of the Environment

SUMMARY

The Pan American Health Organization has contracted with Mario Fernandez to conduct a Diagnostic Assessment of the use of DDT in the Control of Malaria in Belize. Working with various Governmental, Non Governmental agencies and communities the consultant prepared this document titled "***DIAGNOSTIC SITUATION ON THE USE OF DDT AND THE CONTROL AND PREVENTION OF MALARIA IN BELIZE***". This study was coordinated by the Vector Control Unit (VCU) of the Ministry of Health.

The terms of reference required that the consultant carry out a field study of the use of DDT in Belize along wit the methods employed to control Malaria in Belize. Specific objectives include; preparing an assessment of the VCU use of DDT to control Malaria and the present incidence of Malaria, conduct a community survey to determine the impact that DDT use has had on these communities, and carry out an initial investigation on the levels of DDT residue present in biological and environmental samples. A report was to be submitted to PAHO for approval.

The study found that DDT is no longer being used by the VCU for the control of malaria. As a result a total of approximately 13 tons of DDT remains in storage. The disposal of this DDT is one of the main concerns of the VCU. There is a lack of manpower and equipment to carry out any effective epidemiological and entomological monitoring. At the same time however the malaria incidence rate has decreased over the last five years with Toledo District having a high incidence rate, Cayo and Stann Creek Districts having a medium incidence rate and Corozal, Orange Walk and Belize District having a low incidence rate.

Results from a recently concluded DDT residue-monitoring program show that DDT was present in all the samples tested. Average residue levels are 0.08 ppm for blood samples, 0.45 ppm for breast milk, 0.26 ppm for soil, and 4.16 ppm for sediment samples. The elevated levels in sediment samples as compared to the other samples suggest that a lot of the DDT used eventually washes out into rivers and finally into the sea. Those seaside communities whose diets include fish and other marine life may show higher levels of DDT residue than inland communities.

Recommendations as a result of this report include:

-Use of alternative chemicals to replace or use in conjunction with DDT.
- Prohibiting use of DDT except for use as an emergency application
- Sanitation and construction of drains to reduce the number of available breeding sites
- Building codes to ensure that; drums, vats and other such receptacles for the storage of water are properly covered.
- Public awareness program to educate the public on the prevention and control of malaria and their role in its prevention.
- Epidemiological monitoring program to assess effectiveness of program and strategies for better control of malaria

INTRODUCTION

Belize is an independent nation since 1981, with a democratically elected parliamentary government and is also a member of the British Commonwealth of Nations. Named by the British as British Honduras, it was renamed Belize in 1973. Belize covers an area of only 8,866 square miles and is situated on the east coast of Central America on the Caribbean Sea. Belize is bordered by Mexico to the north, and Guatemala to the west and south. Approximately 40% of Belize's total land mass is dedicated as nature reserves. The population is estimated at about 250,000 in 2000, of which 49% are rural and 51% urban. The country's labor force is estimated at over 82,000. Main population centers are Belize City, Belmopan, Corozal, Dangriga, Orange Walk, Punta Gorda, and San Ignacio. Main seaports are Belize City and Big Creek.

The climate is considered tropical with temperatures ranging from 20^0 C to 40^0 C, with a mean temperature of 32^0 C. The main industries are agriculture, fisheries and eco-tourism.

Belize is a member of the Organization of Caribbean States (OCS), the Organization of American States (OAS), the Caribbean Community (CARICOM) and the Central American System for Integration (SICA).

The economy achieved a real Gross Domestic Product (GDP) growth rate of 1.4% in 1998, when the GDP was US$2,235 per capita. In 1998, the major exports of Belize were sugar, citrus, bananas, and shrimp, which together were valued at US $50.63 million. The major imports were fuel and finished goods valued at US $135.82 million. Most of the exports are to USA, United Kingdom, Canada and CARICOM. Major imports are also from the same countries.

DDT has been used in Belize strictly for the control and prevention of Malaria. Its use has been restricted to the Ministry of Health personnel ad at the moment its stewardship is the responsibility of the VCU.

Pesticides of natural origin have been used by man for many centuries. Some inorganic compounds, such as sulphur and arsenicals, are probably the oldest pesticides in use both in Europe and in Asia. In the 10th century, arsenic sulphide was used as an insecticide. Copper compounds were used in the 19th century as fungicides. The Egyptians and the Romans knew the toxic properties of hydrocyanic acid, and the compound was used, as was carbon disulphide, as a fumigant more that a hundred years ago. In the 19th century pyrethrins obtained from pyrethrum flowers were used in Asia against body lice. Tobacco and Nicotine have been widely used in Europe since the 17th century as insecticides.

The history of modern, synthetic pesticide may be said to begin in the 1930s, when the insecticidal properties of dichlorodiphenyltricchloroethane (DDT) were discovered by Nobel Prize winner Paul Muller. In the years following, DDT was used extensively for the control of Mosquito and lice. Its effectiveness, low cost, and chemical stability made it ideal for use during World War II. In its campaign to eradicate malaria, the WHO promoted the use of DDT as part of its anti-malarial program. In 1957 Belize commenced the use of DDT for the eradication of malaria. For the last forty years this has been the principal pesticide used in the control and prevention of malaria. In recent years alternative pesticides have been identified and are being tested.

1. PRODUCTION AND USE OF DDT IN BELIZE

DDT use in Belize for the control of mosquito was started in 1957. The initial program involved spraying all the households throughout the entire country with DDT. This formed the basis for the control of malaria up until recently when other alternative pesticides have been employed.

1.1 Use of DDT in Public Health

In 1957 the National Malaria Eradication Service (NMES) was established within the Ministry of Health. This was as a direct result of the worldwide malaria eradication program promoted by the World Health Organization (WHO) and the Pan American Health Organization (PAHO). At that time it was the general consensus that malaria could be eradicated within five years if a program of spraying using residual pesticides such as DDT was initiated along with treatment using anti-malarial drugs such as Chloroquine.

DDT was quickly accepted by the population. Its effect on reducing the mosquito population as well as secondary effects such as control of roaches, spiders, tarantulas, scorpions and other insect made it easily acceptable by the population. Its low cost, prolonged active period of six months, stability to light and water, ease of use by the applicators, and low acute toxicity to mammals made it ideal for use by the NMES.

Very good results were obtained at the beginning of the program so that by 1963 the Consolidation Phase of the Eradication Program was commenced. In 1965 due to program difficulties spraying was again continued countrywide with the exception of the Belize District. There was a decrease in spraying observed during the period 1974-1979. In 1976 the total number of reported malaria cases was only 199. By 1982 the number of cases had risen to 3,868 with over half the localities in the country reporting at least one case of malaria. In 1983 there were 4595 cases of malaria recorded and in 1984 even higher numbers were recorded[1]. Reasons for this rise in malaria was attributed to a small budget for the NMES as well as migration of refugees from Central America who brought the malaria into Belize.

Given the disparity in the types of dwelling constructed throughout the country no data is available on the average size of houses. However it has been established that in 1980 the average number of houses sprayed was nine houses per sprayman, which fell to eight houses per sprayman in 1999. A total of twenty-four spraymen have been employed by the NMES annually for the spray program.

There are two formulations of DDT employed in the spraying of homes. The 75%WP is a wettable powder formulation. It is mixed with water in a ratio of 28 ounces DDT to 3 gallons of water. This solution is used for spraying unpainted surfaces of any type of material. The 100%E is an emulsifiable concentrate solution. This formulation is mixed in a ratio of 28 pounds DDT to 54 gallons of kerosene and used on all painted surfaces. Spraying is done using a Hudson X-Pert spray pump, which is easy to use and maintain.

The insecticidal properties of DDT last on average for six months. It is thus necessary to spray each house twice a year. The entire house is sprayed including the walls, and eaves of the hall, kitchen, bedrooms, and bathrooms. For those houses where the kitchen and toilet are separate from the main house these are also sprayed. Before spraying is done the homeowners are notified a day or two before that spraying will be done. All belongings are either placed outside or in the middle of the room. Food and cooking utensils have to be covered so as not to be contaminated. All occupants of the house have to remain outside until after the spraying is finished. It is recommended that occupants should not enter the house until at least an hour has elapsed. This allows the spray to dry on to the surfaces.

During the initial stages of the eradication program all houses were sprayed in the country. Over a period of time spraying was discontinued in the urban areas such as Belize City and the District Towns. The decrease in the number of malaria cases also further reduced the number of localities sprayed. At the same time the resources assigned to the NMES became more limited as the importance of malaria as one of the important diseases decreased. It is important to note that up until 1985 when the Pesticides Control Act was passed into law that the environmental effect of

DDT was not an issue in its use for public health purpose. At present spraying is limited to the ten localities in each district with the highest malaria incidence (fig. 1).

In the latter part of the 1980's the damaging effect of DDT on the environment, especially bioaccumulation along the food chain, caused concern about the use of DDT. This was followed by various organizations calling for its discontinued use. In 1994 the Pesticides Control Board for the first time was refusing the importation of DDT. Ministerial intervention was required for it to be imported. At the same time the National Malaria Service (NMS) as it is now called drastically reduced the use of DDT for mosquito control. Spraying was restricted to the border region between Belize and Mexico. As a result of no spraying being done the number of cases of malaria increased so that in 1995 DDT was once again used to control the mosquito population. Around this time the NMS was experimenting with using alternative chemicals for the control of malaria including the use of Deltamethrin, a pyrethrin. This change in control method allowed for DDT use to be discontinued in 1997. At present it has not been used for the last three years.

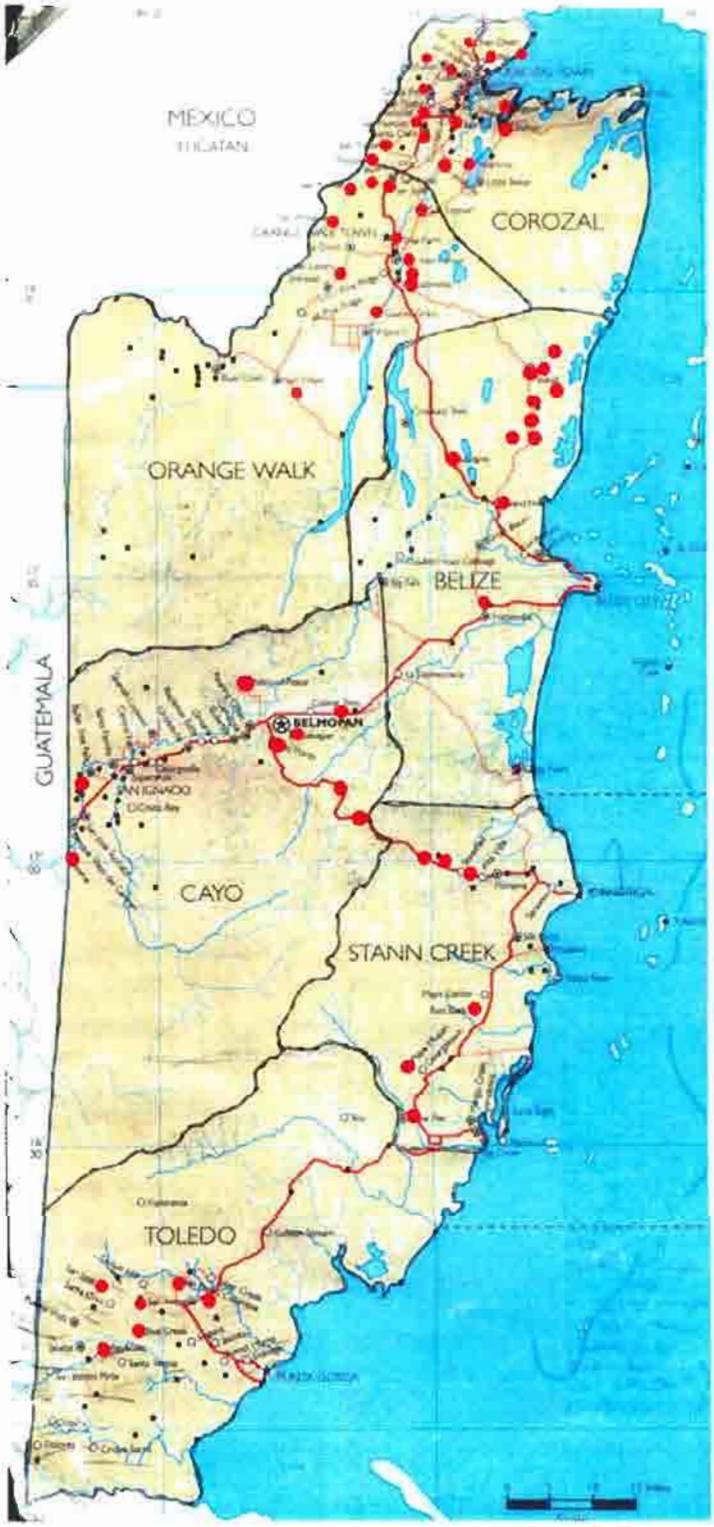
1.2 OTHER USES

DDT is not registered for other uses in Belize other than for vector control purposes. However, undocumented cases point to isolated instances where DDT was used as an agricultural insecticide. The only Agency authorized to import or handle DDT is the Ministry of Health. All importation is done strictly by this Ministry, so that any DDT that may be used for other purposes originates from that Ministry.

1.3 PRODUCTION OF DDT IN BELIZE

Belize does not manufacture any pesticide. Belize imports all of its pesticide in a state ready for use. Data obtained from the Pesticides Control Board shows that annually approximately 2.5 million pounds[2] of pesticides are imported at a value of US$5 million.

Figure 1. Localites where spraying is presently conducted



1.4 IMPORT AND EXPORT OF DDT

DDT was imported mainly from Mexico. There are no available figures to show how much DDT has been imported over the years. Based on the number of houses sprayed an estimate can be made of how much DDT was needed. During the period 1984 -1988 the work plan called for 17,500 to be sprayed with DDT. If an average of 28 oz. of DDT were used per house it would then require an average of 15.5 tons of DDT. Under a Tri-national Agreement between Mexico, Belize and Guatemala, Mexico has assisted Belize by donating DDT to the Malaria Control Program. The DDT was obtained from the Ministry of Health in Chetumal, Quintana Roo, Mexico. A small amount of DDT was also obtained from France in 1984. The flakes however were difficult to dissolve and as a result no further amount was obtained from this source.

On occasions the Belize Government has assisted the border Town of Melchor de Mencos in Peten, Guatemala. This assistance is in the form of ULV spraying through the entire town. Spraying is also done in the entire village of Arenal. Arenal is a village, which straddles the Belize/Guatemala border. In 1985 a contract was signed between the Ministry of Health and the United States Agency for International Development (USAID) to provide assistance in improving the health and population of the Belizean population. One of its components was to provide assistance for the control of malaria and dengue fever over a five-year period commencing 1985 to 1989. This assistance included institutional strengthening of the VCU, purchase of vehicles and acquisition of application equipment such as foggers and pumps.

1.5 QUANTITIES OF DDT PRESENTLY AVAILABLE

The DDT inventory is presently stored at two sites. Ten tons of combined 75%WP and 100% EC DDT is stored in a 20-foot container at the Belmopan Hospital grounds. It is estimated that as much as 40% of this stock may be in a usable state. An additional amount of approximately 3 tons is stored in a container at the Public Health Compound in San Ignacio, Cayo. Most of this is unusable contaminated DDT. The other operational centers do not have any DDT in stock.

1.6 NATIONAL CAPACITY TO DISPOSE OF EXISTING DDT

There is no central depository for the storage of DDT. The storage areas mentioned above do not count with the proper installations to properly safeguard the DDT stored. The Belmopan storage container, although fenced in with chain link fencing is nonetheless susceptible to theft as well as damage by climatic conditions. The San Ignacio storage site lies on an incline (fig.2). The metal container also shows signs of corrosion.

Figure 2. DDT Storage Container at San Ignacio Hospital (top) and Belmopan Hospital (bottom)

Disposal of this DDT would require exportation to another country, or binding with cement and burial at a designated disposal site. The cost of exportation ranges from US$4.00 to US$6.00 per kilogram. For the 13,000 Kg presently stored this would cost US$78,000.00. Burial at a local site needs to be carefully considered before any action is taken. Discussion have been held between the PCB, DOE, and MOH to find a viable solution for the disposal of DDT presently in the country.

1.7 REGISTRATION STATUS OF DDT

In 1995 the Pesticides (Registration of Pesticides) Regulations came into effect. All pesticides previously registered were canceled and had to be re-registered. Previously pesticides were registered by active ingredient only. Any formulation with that active ingredient was automatically registered and could be imported into the country. The new regulations require that pesticides are registered based on their formulations instead of active ingredient. A registration is valid for one formulation only, for a period of five years. The Pesticides Control Board has issued a manual titled "The Belize Pesticides Manual" which contains all pesticides registered to date[3].

The Ministry of Health for Public Health purpose originally classified DDT as a restricted use pesticide for use. After the Registration Regulations came into effect registration for DDT was not sought and at present it remains as an unregistered pesticide. It has, however, not been placed on the list of prohibited pesticides. The present Board of Directors of the PCB has indicated that they will be recommending that DDT be classified as a prohibited pesticide. Any importation of DDT requires cabinet approval as the PCB has decided that they will not grant approval for its importation. The PCB's efforts to discontinue the use of DDT depend on the identification of suitable alternative replacements.

2. PROBLEMS OF HUMAN AND ENVIRONMENTAL HEALTH ASSOCIATED WITH THE USE OF DDT

The use of DDT increased dramatically on a worldwide basis after World War II, primarily because of its effectiveness against the mosquito that spread malaria and lice that carry typhus. DDT seemed to be the ideal insecticide because it is cheap and of relative low toxicity to mammals **(oral LD_{50} is 300 to 500 mg/kg)**. However, problems related to extensive use of DDT began to appear in the late 1940's. Many species of insects developed resistance to DDT, and DDT was also discovered to have a high toxicity toward fish. The eggs of the sea birds are valuable indicators on environmental contaminators, because sea birds are located in a high biological scale. Since the late sixties, a correlation between DDT content and eggshell thinning has been postulated.

The chemical stability of DDT and its fat solubility compounded the problem. Animals do not metabolize DDT very rapidly; instead, it is deposited and stored in fatty tissues. The biological half-life of DDT is about 8 years, that is, it takes about eight years for an animal to metabolize half of the amount it assimilates. If ingestion continues at a steady rate, DDT builds up within over time.

There are no reports of any study being done to evaluate any correlation between exposure to DDT and health of workers in Belize. Lacking also are epidemiological studies on populations

exposed to DDT. As a result it is unlikely that any death can be attributed to DDT or its use. At the very least, however, it may be worth monitoring the health of these spraymen to look for any pattern, which may suggest an association with exposure to DDT.

2.1 OCCUPATIONAL EXPOSURE OF THE PERSONNEL OF THE MALARIA CONTROL PROGRAM TO DDT

When the NMES was established it was generally agreed that eradication of malaria could be done within five years. Initially spraying was done countrywide in all localities. Spraymen were employed year round. Most of these spraymen remained within the service for at least ten years. Initially there were three squads of spraymen made up of eight sprayers and one squad leader for a total of twenty-seven persons. Today there are eight sprayers with one of the spraymen acting as the squad leader.

To date no studies on human exposure to DDT have been conducted on the spraymen previously or presently working with the program. During their tenure however there have been no reported cases of fatalities as a result of exposure to DDT. In the present situation the spraymen are employed for 36 weeks of the year. In the ensuing year because it is a contract work not all of them return to work. Thus their employment time has generally been much shorter so that their exposure to DDT is also decreased.

For the rest of the personnel of the NMES exposure has been limited principally to issuing of DDT to the spray team. Occasionally workers have had to go to Mexico to receive a shipment of DDT. In San Ignacio the DDT is stored in a container adjacent to the offices occupied by the VCU.

2.2 DDT IN THE BELIZE ENVIRONMENT

To date few studies have been done involving DDT residues in environmental samples from Belize. Alegria[4] tested air samples around Belize City and Belmopan for DDT residue samples during 1995-96. Average total DDT levels were 992 pg/M^3 for Belmopan and 216 pg/M^3 for

Belize City. There does not exist data of other studies that have been done on DDT residue levels.

2.3 DDT RESIDUE LEVELS IN ENVIRONMENTAL AND BIOLOGICAL SAMPLES

In Belize, DDT was used solely for the control of mosquito as opposed to the Central American countries where it was also used for agricultural purposes. DDT was restricted for use indoors and as such it would be expected that residue levels might be higher in samples taken from areas close to dwellings. DDT as an agricultural pesticide was limited to isolated cases where farmers got the product illegally and used it on their crops. This seems to have been the exception so that few such cases have been reported. As part of this Study, testing of environmental and biological samples was conducted on biological and environmental samples from selected communities in the Cayo District. It has been discovered that DDT was present in all samples tested. When compared to the rest of Central America, DDT residue levels are generally low with the exception of sediment samples.

2.3.1 DDT RESIDUES IN BLOOD SAMPLES

Blood samples showed an average of 0.08 ppm total DDT (fig. 3). Total DDT includes DDT as DDT, DDE or DDD. There is no correlation between locality and residue levels, however the highest residue level was found in a sample from San Martin, Belmopan (0.20 ppm) while the lowest was found in a sample from Calla Creek (0.012 ppm). The blood residue level is generally low and points to low exposure to DDT.

2.3.2 DDT RESIDUE IN BREASTMILK SAMPLES

Breast milk samples showed an average of 0.15 ppm, which was nearly twice that for blood samples. Residue levels ranged from 0.27 ppm for a sample from San Ignacio Town to 0.07 for a sample from Los Tambos, Cayo. Samples taken from the urban area showed levels about twice that of those taken from rural areas.

2.3.3 DDT RESIDUE IN SOIL AND SEDIMENT SAMPLES

Soil samples showed a value of 0.26 ppm while sediment samples showed an average of 4.16 ppm. Sediment samples ranged from 5.38 ppm for a sample from the mouth of the Haulover Creek, Belize City to 3.35 ppm from a sample taken on the upper Macal River near Chaa Creek, Cayo (figure 3a). DDT residue levels are about 16 times higher in sediment than in the other samples tested. For those populations whose diet may significantly include shellfish and other seafood that live or feed on sediment detritus, this could pose a health risk. Future testing may take into account these high levels as a reason to target fishing communities for sampling.

Figure 3. Average DDT residue levels in biological and environmental samples in Belize

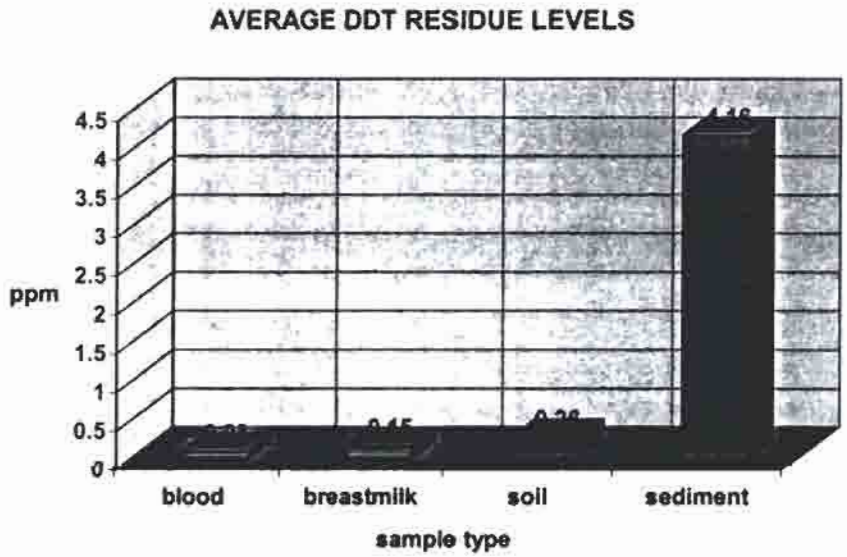
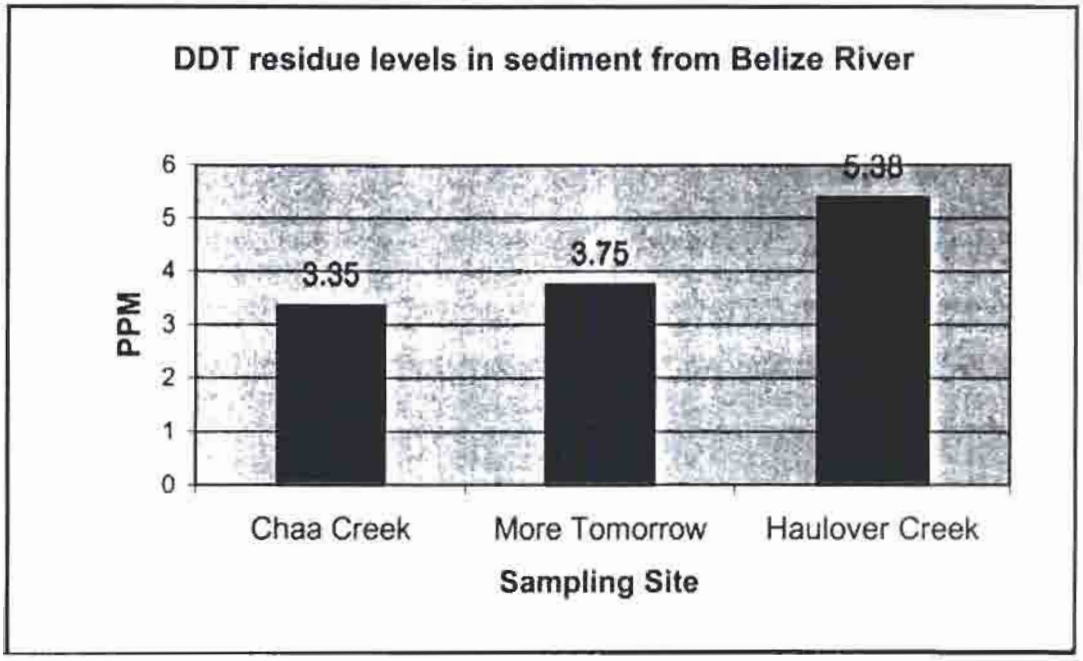


Figure 3a. DDT residue levels in sediment samples taken from the Belize River



3. THE MALARIA CONTROL AND PREVENTION PROGRAM

3.1 A GLOBAL HISTORICAL PERSPECTIVE

The battle initially won and later lost against malaria has brought to a sharp focus many subtle aspects of vector biology, which still defy understanding. Fortunately, it is known that most arthropod borne disease agents perpetuate themselves in wild vertebrate-arthropod cycles without causing any infection to man unless the latter transgresses into the orbit of the wildlife and trigger ecological disturbances. Deforestation for land reclamation and impounding of river water in huge reservoirs for irrigation of agricultural land are two of the developmental activities with the highest potential to set in motion ecological imbalance in forest ecosystems and transform such vectors into actual harbingers of epidemics[5].

Vectors that carry disease pathogens are spread globally and modern transportation methods have rendered their migration very easily. Altogether even deploying all the deadly chemicals weapons at our disposal cannot eliminate the epidemics associated with such disturbances. Disease agents transmissible directly from man to man via an arthropod vector are theoretically more amenable to containment by a combination of strategies of which use of insecticides is one. In actual practice, however, the pressure exerted on disease vectors by agricultural pesticides has resulted in the emergence of large-scale resistance of anthropoid vectors in Asia, Africa, and Latin America.

Malaria is an infectious disease caused by the parasite Plasmodia. There are four identified species of this parasite causing human malaria, namely, *Plasmodium vivax, P. falciparum, P. ovale and P. malariae*. It is transmitted by the female anopheles mosquito. It is a disease that can be treated in just 48 hours, yet it can cause fatal complications if the diagnosis and treatment are delayed. It is re-emerging as the number one Infectious Killer and it is the Number one Priority Tropical Disease of the World Health Organization.

Malaria affects more than 2400 million people, over 40% of the world's population, in more than 100 countries in the tropics from South America to the Indian peninsula. The tropics provide ideal breeding and living conditions for the anopheles mosquito, and hence this distribution. Every year 300 million to 500 million people suffer from this disease (90% of them in sub-Saharan Africa, two thirds of the remaining cases occur in six countries- India, Brazil, Sri Lanka, Vietnam, Colombia and Solomon Islands). WHO forecasts a 16% growth in malaria cases annually. About 1.5 million to 3 million people die of malaria every year (85% of these occur in Africa), accounting for about 4-5% of all fatalities in the world. One child dies of malaria somewhere in Africa every 20 sec., and there is one malarial death every 12 seconds somewhere in the world. Malaria kills in 1 year what AIDS killed in 15 years. In 15 years, if 5 million have died of AIDS, 50 million have died of malaria. Malaria ranks third among the major infectious diseases in causing deaths- after pneumococcal acute respiratory infections and tuberculosis. The estimated global annual cost in 1995 for malaria was US$ 2 billion (direct and indirect costs, including loss of labor).

Malaria was nearly eradicated from most parts of the world by the early 60's, owing largely to concerted anti malarial campaigns world over under the guidance of the World Health Organization. In recent years it has seen resurgence especially in Sub-Saharan Africa. Some of the reasons for the resurgence of malaria include complacency and laxity in anti malarial campaigns, conflicts and wars, migrations, deteriorating health systems, poverty, drug resistance by parasite, vector insecticide resistance, ban on DDT, global warming - increased breeding and life span of the insect vector, Jet Age - increased travel to endemic areas, and a shrinking world - spread of malaria from endemic areas to all other parts of the world.

3.2 MALARIA AS A PUBLIC HEALTH PROBLEM IN BELIZE EPIDEMIOLOGICAL PROFILE

THE PARASITE

Of the four species of *Plasmodium* that cause sickness in humans, only three have been found in Belize. These are *P. vivax, P. falciparum*, and *P. malarie. P. vivax* is the most common species accounting for about 95% of cases (TableV). Both *P. vivax* and *P. falciparum* are found countrywide. The last case of *P. malarie* was recorded in the Belize District in 1996 and is considered practically non-existent.

THE VECTOR

Entomological studies show the presence of at least three species of anopheline mosquitoes in Belize. The primary vectors for malaria are *A. albimanus* accounting for over 99% of malaria cases. *A. darlingi* has been found in the Stann Creek District while A. *vestitipennis* has been found in the Stann Creek and Toledo District.

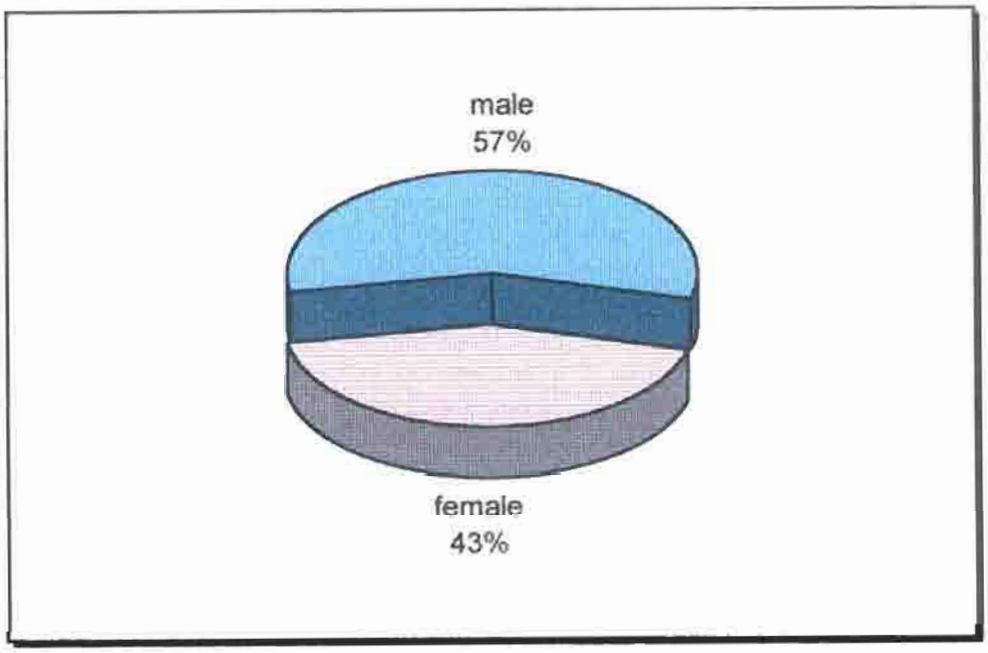
TABLE 1: Area of Country with low medium and high Malaria risk (1999)

DISTRICT	POPULATION	NO. MALARIA CASES	RATE PER 1OOO	RISK
COROZAL		105	3	Medium
ORANGE WALK		85	2	Medium
BELIZE		71	1	Low
CAYO		753	15	High
STANN CREEK		287	12	High
TOLEDO		691	30.5	High

example in the Cayo District the ten localities with high levels of malaria cases are all communities with large immigrant populations. Geographically the three southern Districts (Cayo, Stann Creek and Toledo) account for approximately 90% of malaria cases(figure I) and are considered high risk areas(table 1a). Corozal and Orange Walk Districts are medium risk areas and Belize District is a low risk area.

Most of the malaria cases occur in rural areas with poor hygiene and sanitation conditions. In these communities the majority of houses lack protective barriers such as window and door screens. In Mayan communities the houses consist of one large room with thatch roofs and few if any windows. These form excellent breeding grounds for mosquitoes. Breeding grounds are abundant as there are no proper drainage in these localities.

Figure 4. Malaria cases in Belize by sex (1999)



More males contract malaria than do females (figure 4). The population between 15 and 44 years account for 41% of cases. The group 5 to 14 years account for 31% while from 1 to 4 years account for 17% (figure 5).

There are two periods when the levels of malaria go up. These are February to April and August to October (Fig 5a). In Toledo malaria cases go up after the rainy season. During this time the rivers become sluggish and pools of water remain behind which form breeding sites for the mosquito.

Fig 5. Incidence of Malaria in Belize by age distribution (2000)

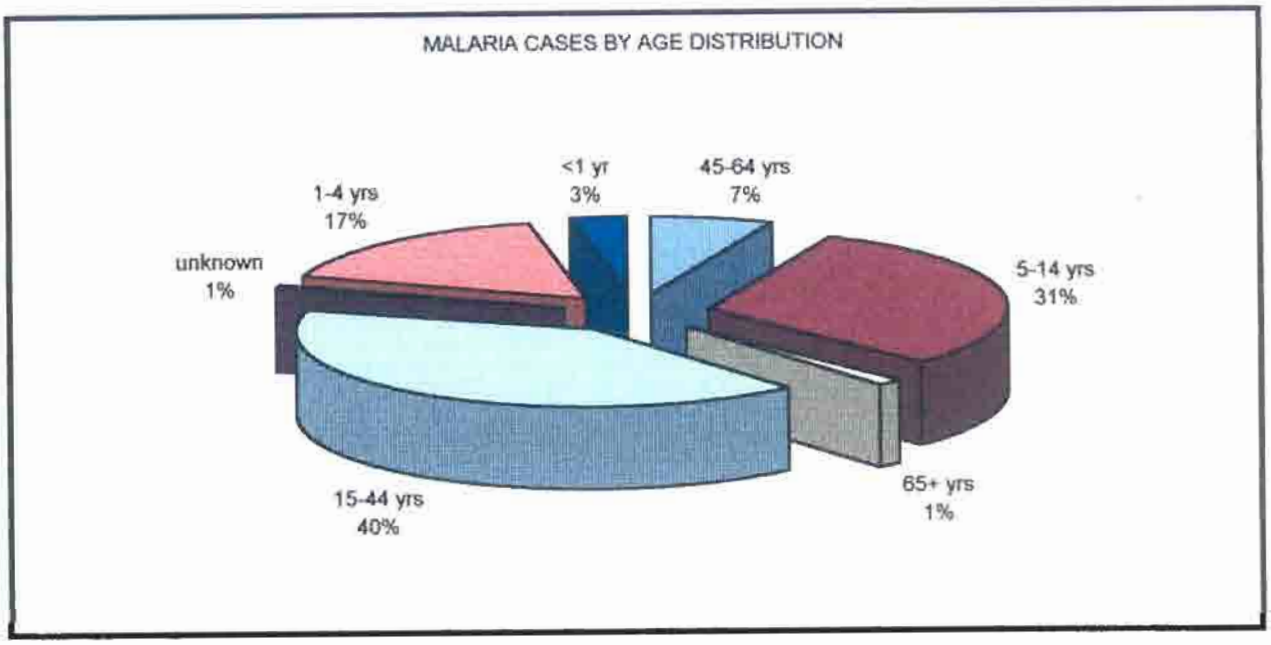
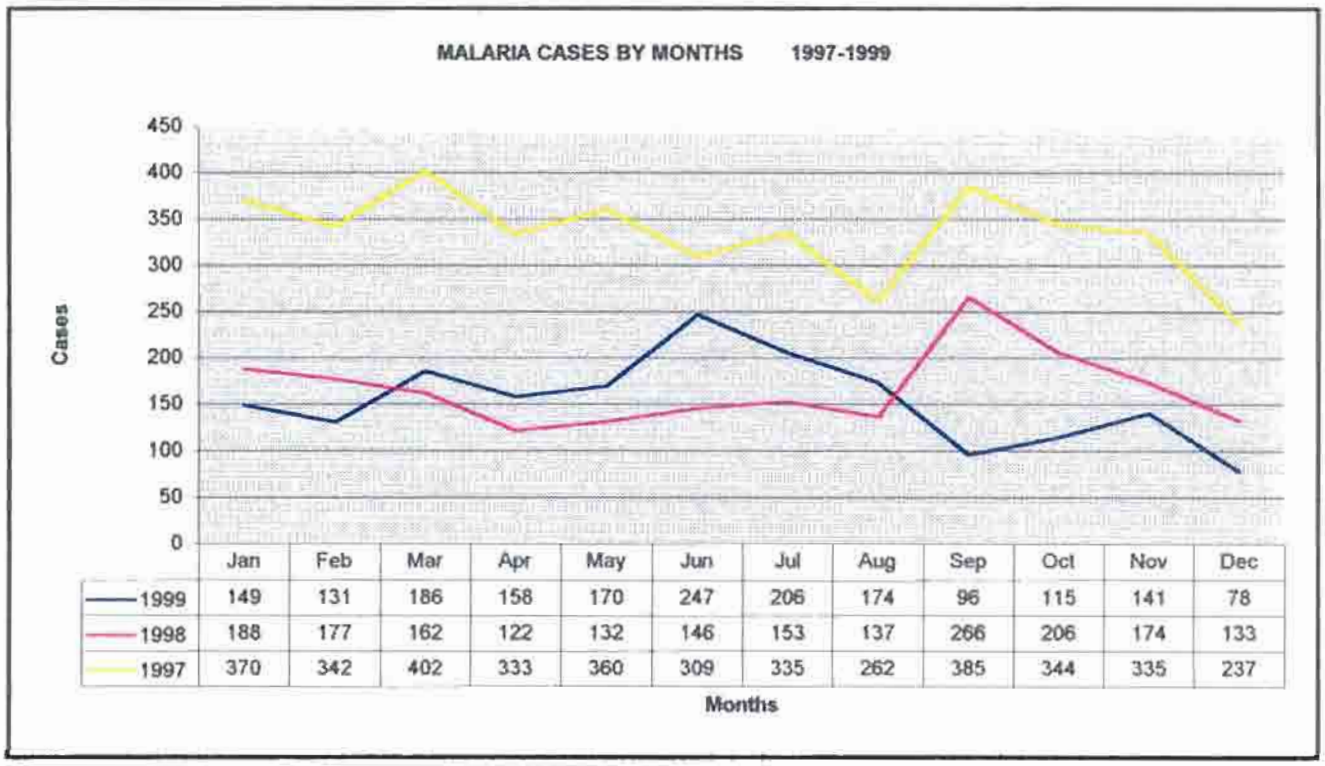


Figure 5a Malaria cases by month for the period 1997-1999.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999	149	131	186	158	170	247	206	174	96	115	141	78
1998	188	177	162	122	132	146	153	137	266	206	174	133
1997	370	342	402	333	360	309	335	262	385	344	335	237

4. ACTUAL SITUATION AT THE GLOBAL AND REGIONAL LEVEL

The Pan American Health Organization has registered malaria cases in 21 of its 37 member countries. In 1997 the population of these countries was 794 million of which 307 million (38%) lived in areas with malaria risk. In that same year one million thirty five thousand malaria cases were diagnosed.

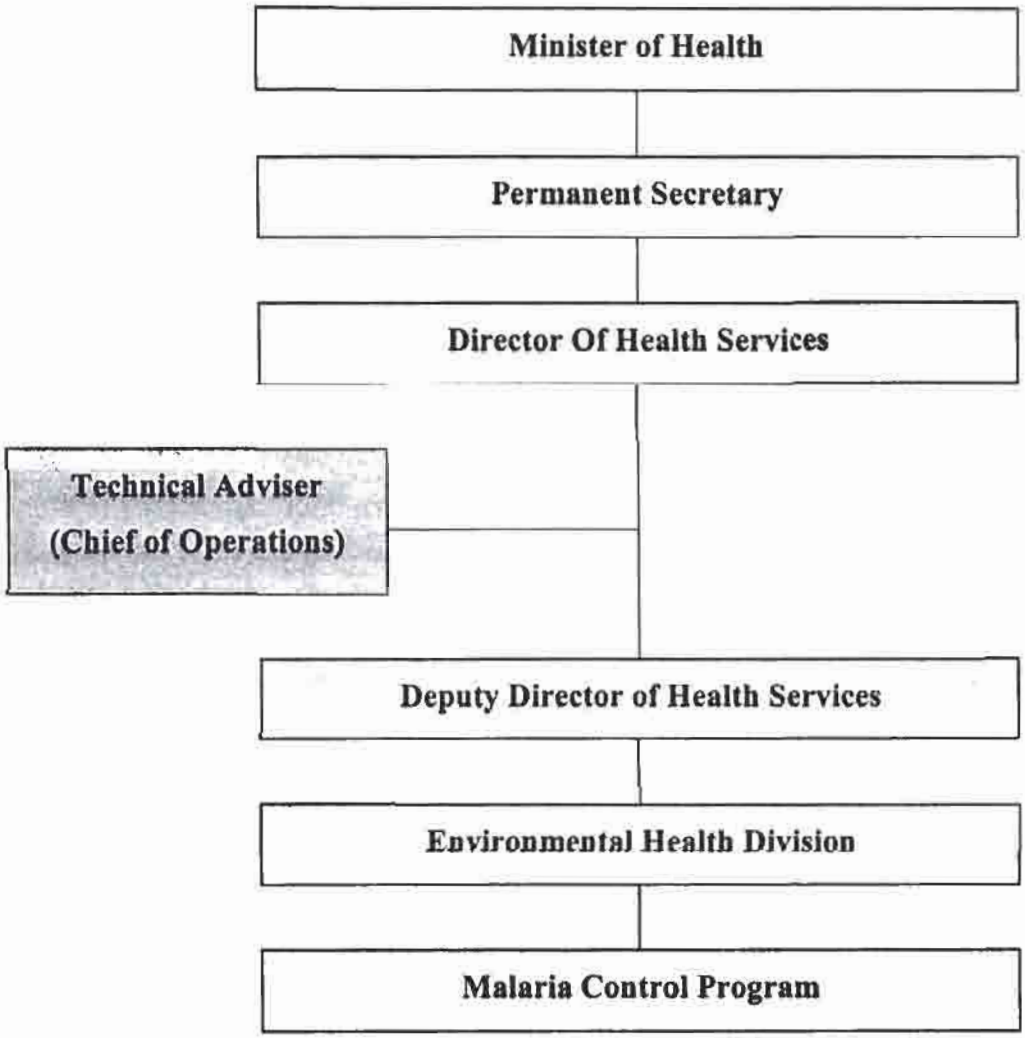
Within the PAHO countries, Belize represents only a small fraction of total malaria cases (0.2%). Because of its small and widely dispersed population, malaria cases are low but will continue to persist.

4.1 ACTUAL SITUATION

The Ministry of Health is responsible for all matters dealing with the control, prevention and cure of all diseases, including malaria. The Vector Control Unit (VCU) is established as a Department of this Ministry and is under the supervision of the Director of Health Services. The VCU is comprised of two sections, the Malaria Control Program and the Aedes Aegypti Control Program. The Malaria Control Program has a total of 31 persons altogether (table XIV). Additionally there are also 24 spraymen who are contracted on a part time basis as spraying is not done continuously. These spraymen are divided into three squads of eight, each squad being responsible for spraying localities in two Districts per squad.

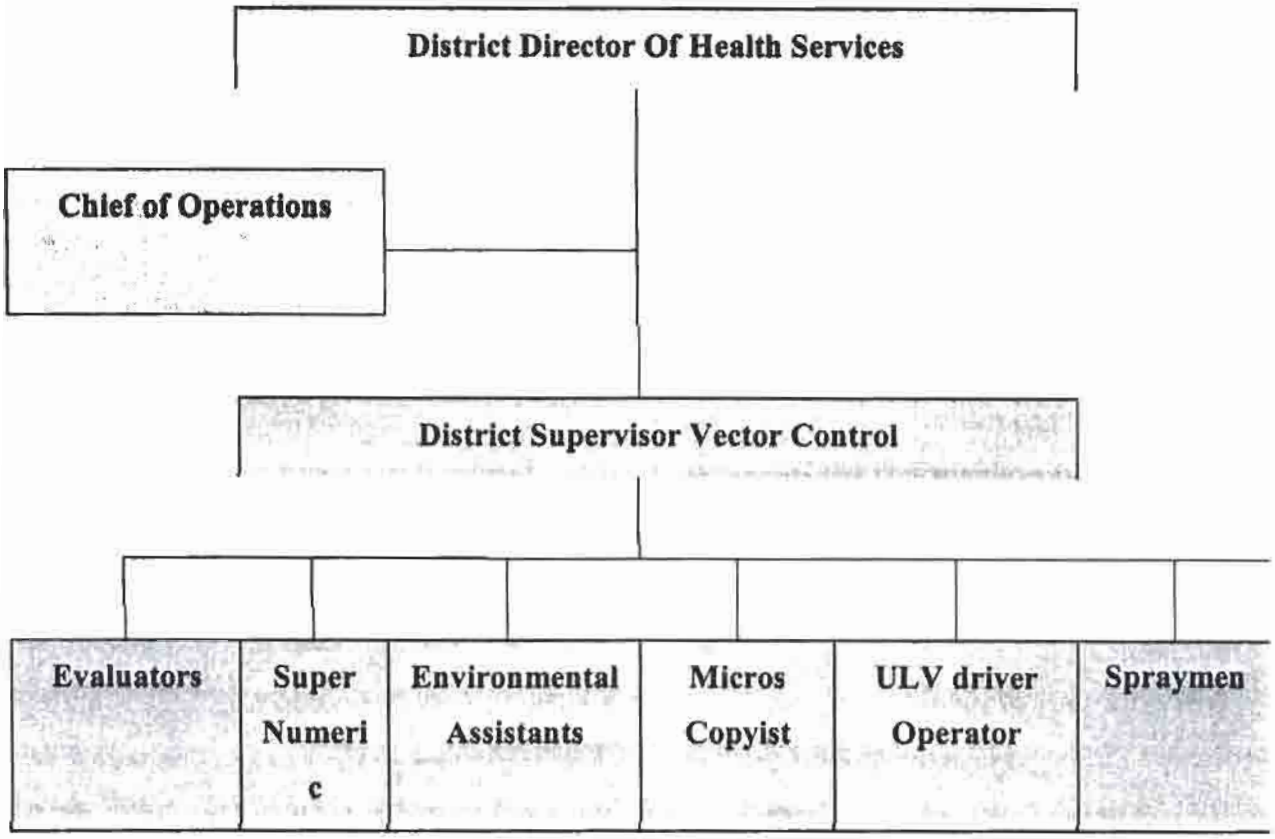
A very important component of the Malaria Control Program is the use of Voluntary Collaborators (VC=s) and Community Nurses Aide (CAN). Initially VC=s were recruited to assist with identifying malaria cases at the village level. These VC=s are trained to collect blood samples, which are then sent to the nearest Vector Control Office for confirmation. The VC's also administer a single dosage of chloroquinne as a preventive dosage to anyone suffering from a fever or chills. VC=s are generally unpaid as opposed to CAN's who receive a stipend. The CNA is trained to perform other jobs apart from obtaining blood samples. As such their work is more general. A village may have either a VC or a CNA or may have both of them. It is expected that eventually all the VC=s will be trained to become CNA=s.

. Figure 6: Organizational Chart, Ministry of Health



There is presently an ongoing process of decentralization of the Health Services. Under this decentralization, Regional Administrative Centers will be established. These will include the Northern, Central, Western, and Southern Regional Administrative Centers. All health related activities would be under the control and supervision of these administrative centers. The Malaria Control Program will constitute a unit of the Environmental Health Division and will be supervised by a Deputy Director of Health Service (figure 6). At the district level the Unit will be under the control of the District Director of Health Services (figure 7).

. Figure 7: District Organizational Chart, Ministry of Health



4.2 MALARIA CONTROL IN BELIZE

Table V shows the number of malaria cases for the last ten years. The increased cases of malaria coincided with a halt of the spray program. In 1995 after malaria cases went above 10,000 cases DDT was used again to control the mosquito population. By 1997 with a decline in malaria cases Deltamethrin was introduced as an alternative control chemical. This has continued to be used and for the present DDT is not being used. The number of total malaria cases has gone down to less than 1500. The use of Deltamethrin poses a problem for the program because of its relatively high cost compared to DDT and its growing non-acceptance by the public. An integrated approach has to be introduced which will place heavy emphasis on hygiene, sanitation and destruction of breeding grounds.

5. IDENTIFICATION OF BARRIERS THAT HINDER THE APPLICATION OF NEW PRACTICES.

5.1 ECONOMIC FACTORS

The budget of the Vector Control Unit has been decreasing steadily over the last few years (table XV). Added to this is the fact that while DDT was obtained freely from Mexico, other chemicals have had to be bought. PAHO has been assisting the VCU by donating quantities of Deltamethrin and Malathion. At present the cost of Deltamethrin (BZE $200.00 per Kg) is high compared to DDT. The use of this product as a replacement for DDT will depend on the ability of the VCU to buy or acquire this product. The high cost of the Deltamethrin may also restrict the number of localities that the VCU can spray.

5.2 SOCIAL FACTORS

During a recent survey done in various high-risk localities throughout Belize, a number of interesting observations were made. Of much importance is the attitude of people to the use of Deltamethrin. The survey showed that a number of people reporting some form of allergic reaction to the Deltamethrin. They were concerned about the safety of this product. This has lead to more people refusing to have their house sprayed, which ultimately will lead to a breakdown in the effectiveness of the spray program. This is especially true of Mayan communities in Toledo who reported a much higher incidence of burning of skin, rashes, and headaches than did other areas of the country. This may be due to their mode of construction. The house has one big room and the people may both sit on the floor and lean their back against the wall so that there is contact between the freshly sprayed walls and the individual. It is interesting to note that in areas where the houses are painted that the level of allergic reaction is minimal.

5.3 EMPLOYMENT FACTORS

A large percentage of laborers in Belize are seasonal workers. In the Northern Districts the sugarcane season lasts for about eight months. During this time there is a lot of movement of workers from one cane field to another. In Stann Creek and Cayo District harvesting of orange

also leads to movement of workers from one area to another. A huge proportion of these workers are migrant workers who either live on the farms where they are harvesting fruits or travel from neighboring Guatemala and Mexico into Belize. In various occasions malaria cases have been traced as originating outside of Belize. Given the present unemployment conditions this situation is not likely to change in the near future.

In Toledo rice planting is either by flood irrigation or upland rice planting. Both methods require large amounts of water, which form breeding grounds for the mosquitoes. Places like Big Falls and Columbia have a high incidence of malaria.

5.4 PERCEPTION AND ACCEPTANCE

Within the VCU there is a lot of support for the continued use of DDT. This may be due to the fact there is a higher refusal rate with use of Deltamethrin. Even among households it is felt that DDT is better to use than Deltamethrin. A large majority of the persons surveyed were not aware of what was being sprayed on their houses. At the same time a lot of opposition has come from environmental groups to discontinue the use of DDT. As these groups become more organized and more vocal it will become more difficult to justify the use of DDT to control malaria rather than other chemical means.

5.5 DECENTRALIZATION

The Ministry of Health is presently going through a process of decentralization. The operation of various departments and programs will be affected including the Vector Control Unit. The VCU will now form a part of the Environmental Health Division (EHD), which includes other areas such as Public Health. The EHD is under the supervision of a Deputy Director of Health Services (figure 4). The Budget of the VCU will now be a part of the EHD budget and will have less control on how much funding it ultimately receives, especially Capital II funding. Additionally it is being suggested that the personnel of the Program be given a new terms of reference, which include doing other duties within the EHD.

6. STRATEGY FOR THE PROGRESSIVE ELIMINATION OF THE USE OF DDT

The growing Belize population, which has seen a rapid growth in the last couple of years, is placing a strain on the government to provide land for agriculture as well as for housing. New settlements are being established in areas, which are natural habitats for mosquitoes. As this happens these new areas will become focal points for transmission of malaria. At the same time localities that presently have high incidences of malaria should develop the necessary infrastructure, which will reduce the number of malaria cases. A strategy for the elimination of the use of DDT should include alternative chemicals, restriction on use of DDT, a sanitation program, construction of drain, enforcement of building codes, a public awareness program, and an epidemiological monitoring program to restructure the spray program.

6.1 ALTERNATIVE CHEMICALS

Deltamethrin will be the basic tool used to control malaria for the foreseeable future. Its use has to be properly regulated in terms of cost efficiency, public acceptance and vector resistance. There will be the need to address other socioeconomic conditions in these localities that favor transmission. A concerted effort has to be done to provide proper drainage in these localities as well as to adapt lifestyles that will reduce the vector population. In areas like Las Flores and Salvapan which are adjacent to Belmopan building codes have to be enforced which will require that construction of houses are done as per the building codes in force in that municipality. Over a period of time sanitary conditions in these areas will become better.

6.2 PROHIBITING USE OF DDT

Should the PCB place DDT on the prohibited list it will become even more difficult to use DDT on any large scale. The PCB has requested the Ministry of Health to dialogue on ways to phase out the use of this product.

6.3 SANITATION AND CONSTRUCTION OF DRAINS

A critical part of controlling malaria will be the involvement of the community. A sanitation program has to be put in place including factors such as a water supply system, establishing a

garbage disposal site away from the community, opening drains to remove excess water, and enforcing the public health regulations. These infrastructure developments can be done through funding agencies such as the Basic Needs Trust Fund.

6.4 BUILDING CODES

In areas close to the major towns it is necessary to enforce the building codes. In rural areas an effort has to be made to standardizing the types of structures to be built. This would include parameters such as ensuring that drums, which hold water, are properly covered.

6.5 PUBLIC AWARENESS PROGRAM

Emphasis needs to be placed on making the public aware of alternative ways of controlling malaria. This may be more difficult in areas where movement of people is the norm for example, in the banana belt. Talk shows on the radio and television, and presentations at the village levels directed at removal of debris and potential breeding sites around the house may prove more beneficial. An example is the television commercial presently being aired featuring sanitation for control of the aedes aegypti mosquito.

6.6 EPIDEMIOLOGICAL MONITORING PROGRAM

Decentralization of the Ministry of Health will place the Malaria program as a component of the services offered by the Regional Health Services. It has been suggested that present workers within the program will be integrated into a larger unit, which will then be responsible for public health duties including vector control. An epidemiological monitoring program can be established under the EHD to cover not only malaria cases but other diseases as well. With the expanded staff available under the EHD this is a more feasible and practical function to undertake.

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3 - The Belize Pesticides Manual 97, Belize Pesticides Control Board, 1997

4- Alegria, Henry A.; et al; organochlorine pesticides in ambient air of Belize, Central America, Environ. Sci. Technol. 2000, 1953-1958

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6- Report of Tri-national Meeting, Mexico-Belize-Guatemala; Vector Control Program, Ministry of Health, March, 1993.

TABLE III: Quantity of DDT in storage by the Ministry of Health

DATE (a)	WAREHOUSE (b)	FORMULATION (c)	QUANTITY (d)	PRESENTATION (e)	OBSERVATIONS (j)
March 2001	Belmopan Hospital	mixed	10 tons	bags, carton barrels	about 60% in good state
March 2001	San Ignacio Hospital	mixed	3 tons	Bags, carton, barrels	About 20% in good state

TABLE IV: Annual Malariometric Data

SPRAYED DOMICILE		ANTILARVAL SPRAYING		SPATIAL SPRAYING	
HOUSES (a)	PRODUCT (b)	SURFACE (c)	PRODUCT (d)	SURFACE (e)	PRODUCT (f)
6777 (2000)	Deltamethrin	no data	abate	no data	malathion
1485 (1998)	186 lbs Deltamethrin				
4158 (1997)	140 lbs Deltamethrin 170 lbs DDT				

TABLE V: Annual Malariometric Data (CONT.)

YEAR (a)	TOTAL POPULATION (b)	POPULATION AT RISK (c)	TOTAL LOCALITIES (f)	POSITIVE LOCALITIES (g)	SAMPLES EXAMINED (h)	POSITIVE SAMPLES (i)	*P. vivax* (j)	*P. falciparum* (k)	OTHER SPECIES (l)
2000					18559	1484	1464	20	0
1999					19375	1853	1801	52	0
1998					20664	1936	1767	169	0
1997					26600	4014	3888	126	0
1996					35113	6605	6149	456	0
1995					37267	9413	8885	528	0
1994						10411	9991	420	0
1993						8671	8357	274	0
1992						5199	5031	168	0
1991						3043	2997	46	0

TABLE VI: Malarimetric Indices and Measurements

YEAR (a)	ILP (b)	IAES (c)	IPA (d)	IAF (e)	IAV (f)	IACA (g)	TVA (h)
2000	8.00			1.35	98.65	0	
1999	9.56			2.81	97.19	0	
1998	9.37			8.73	91.27	0	
1997	15.09			3.14	96.86	0	
1996	18.81			6.90	93.1	0	
1995	25.26			5.61	94.39	0	
1994				4.03	95.97	0	
1993				3.16	96.84	0	
1992				3.23	96.77	0	
1991				1.51	98.49	0	

TABLE VII: Equipment available for the NMES (furniture)

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
Desks	33		
Chairs	48		
Tables	14		
Cabinets	12		
Copier	1		

TABLE VIII: EQUIPMENT AVAILABLE FOR THE NMES (VEHICLES)

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
Toyota Hilux	1		
1990 Jeep Wrangler	1		
Ford 150 pickup	3		
boat with engine	2		
2001 Mazda pickup	1		
2001 chevy pickup	1		
motor cycle	12		

TABLE IX: Equipment available for the NMES equipment for application of insecticides

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
spray tank	52		
Solo mistblower	16		
swing fogger	3		
small swing fogger	1		
ulv fogger	15		
compressor sprayer	7		
hand fogger	11		

TABLE X: equipment available for the NMES (equipment for personal protection)

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
overall	54		
gloves	15		
respirator	15		
goggles	8		
boots	15		
Helmet	15		

TABLE XI: Equipment available for the NMES(insecticides in stock)

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
97% Malathion technical grade	17 drums		
Deltamethrin 5WP	49 drums of 25 kg ea.		
temephos 1%	102 sacks of 25 kg each		
Malathion wettable	12 barrels of 15 lb ea.		

TABLE XII: Equipment available for the NMES (medication available)

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
chloroquinne 150 mg	3600 box / 1000 tab. Per box		
Primaquinne 5 mg	6 box / 12000 tab. Per box		
Primaquinne 15 mg	5 box / 12000 tab. Per box		

TABLE XIII: Equipment available for the NMES (other resources available)

DESCRIPTION (a)	QUANTITY (b)	SUPPORT TO OTHER PROGRAMS (c)	
		PROGRAM	%
Computer	2	Dengue Control	50
Copier	1	Dengue Control	50
Refrigerator	1		
Microscope	3		

TABLE XIV: Financial and Monetary resources for the NMES

DATE	AMOUNT (US Dollars)
1999 – 2000	**$40,721.00**
1998 – 1999	**$51,598.00**
1996 – 1997	**$37,500.00**
1995 – 1996	**$50,000.00**
1993 – 1994	**$139, 232.00**

TABLE XV: Human resources available to the NMES

DESCRIPTION	COROZAL	O. WALK	BELIZE	CAYO	STANN CREEK	TOLEDO
DISTRICT LEADERS	1		1 Chief of Operations	1	1	1
SPRAYERS	8		8		8	
VOLUNTEERS	40	40	28	60	42	57
EVALUATORS	1	2	2	2	1	1
ENVIRONMENTAL ASSISTANTS	4	2	4	4		3
SUPERNUMARY		1	1	1	1	1
LAB TECHNICIAN			2	2	1	1

Belize City also has a Secretary and a Statistical Officer