THE IMPACT OF VECTOR CONTROL MEASURES ON MALARIA EPIDEMIOLOGY IN DAR ES SALAAM

BY

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ABSTRACT

A study on the impact of vector control measures on malaria epidemiology, before and after intervention measures were applied, was conducted in Magomeni in Dar-es-Salaam between October 1988 and April 1989. The study involved determining the prevalence rate of malaria by parasite and spleen rates, using children aged between 2-9 years old living in the study area, and comparing it with that of a control area.

The main objective of the study was to determine the prevalence of malaria before and after intervention and the effectiveness of the anti-vector measures of the malaria control programme in Magomeni.

The study revealed that the prevalence of malaria in the study area was 20% before intervention and 19.7% six months after intervention. There was no statistically significant decrease in malaria prevalence six months after intervention measures were instituted.

The spleen rate was not found to have significantly decreased after intervention. It was also found that Anopheles larval densities in the breeding sites in the study area were still high despite the application of the larvicide, 50% (EC) Fenitrothion. However, it was observed that there was a gradual decrease in larval densities over the six month period in both the study and comparison areas.

Clinical malaria patients who were attending treatment in the health institutions in the study area before intervention constituted 18% of all out-patient attendances but six months later after intervention, the number decreased to 16%. However, the drop was not statistically significant. Despite this drop, malaria still constituted the highest percentage of out-patients.

Therefore the study revealed that the malaria vector control measures that were carried out in the Magomeni area of Dar-es-Salaam over a period of six months had no significant impact on the epidemiology of malaria. The study, therefore, failed to support the Null-hypothesis that the prevalence of malaria would drop from a higher level of endemicity to the next lower level after six months of anti-vector operations.

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DECLARATION

I hereby declare that this dissertation is my original work and has never been submitted for a diploma or degree in any other University.

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INTRODUCTION

Malaria has been the most prevalent infection of man since ancient times and yet there is no doubt that it has been one of the most important preventable diseases in the world. Throughout the tropics and subtropics malaria adds, enormously to the tasks of civil servants, peasants and merchants just as it has been doing for centuries, (Russel et. al.,1946). It has undermined the welfare of many countries. By reason of their characteristic periodicity, the intermittent fevers (now grouped as Malaria) are among the oldest recorded diseases. They may be recognized for example in Chinese and Hindu texts written many years before Christ (BC). The Chinese mythology described three malaria demons one with a hammer, another with a pail of cold water, and the third with a stove. These devils were said to be responsible for the characteristic headache, chills and fevers of malaria respectively, (Russel et. al., 1946).

Efforts of man in fighting against malaria have been taking place all the time. For centuries man has been learning how to combat malaria but the recognized fight was initiated in the 1950's when the WHO endorsed the concept of malaria eradication. The introduction of residual insecticides and of the use of chemotherapy, with chloroquine as the mainstay in malaria eradication, brought about a dramatic disappearance of malaria in North America and Europe.

However, in the tropics, especially Sub-Sahara Africa, the malaria situation has remained much the same and there appears to be no prospects for overcoming this disease in the near future.

The intensity of malaria transmission, although not uniform all over the continent, has been considered to be the main obstacle to any control of the disease for some years. Malaria continues to be a major health problem of tropical developing countries and the recent years have been seeing its return to areas freed from it in the 1960's (Bruce-Chwatt, 1980).

In Tanzania, malaria is probably the most widespread infection causing considerable morbidity and mortality. Malaria is highly endemic and by mid 1960's malaria had been mapped showing that about 75% of the country consisted of hyperendemic to holoendemic malaria (Clyde, 1967). In a recent report, the epidemiology of malaria has been observed to be changing with high numbers of cases being observed for the first time in high altitude areas of Iringa, Arusha and Kilimanjaro where malaria transmission had not been occurring before (Dahoma, 1983). Transmission occurs in most areas of the country throughout the year but highest intensity is seen following the rainy seasons and is influenced by temperature and relative humidity with the low-lying coastal belt and shores of Lake Victoria having the highest transmission. The disease

vectors commonly found in Tanzania are Anopheles gambiae(S.l) and Anopheles funestus, both of which are well known for their efficiency in transmission of malaria as well as for their longevity. All four species of malaria parasites occur in the country, but predominantly Plasmodium falciparum consists of 90%, while Plasmodium malariae is found in 10-20% of infections. P. ovale and P. vivax share the remaining 5% (Clyde, 1967; Irare et. al., 1989).

A classification has been made of malaria endemicity in Africa according to grades that are related to immunity which have been described by Wilson, (1949). Classification of endemicity of malaria has been adopted by the WHO on the basis of spleen rate determination on a statistically significant sample of the population involved. These degrees of endemicity are as follows:-

i. Hypoendemic malaria: Spleen rate in children (2-9 years) not exceeding 10%.

ii. Mesoendemic malaria: Spleen rate in children (2-9 years) between 11% and 50%.

iii. Hyperendemic malaria: Spleen rate in children (2-9 years) constantly over 50%. Spleen rate in adults is also high; over 25%.

iv. Holoendemic malaria: Spleen rate in children (2-9 years) constantly over 75% but spleen rate in adult is low. An alternative method of classification

of endemicity has been proposed using the same ranges of percentages for parasite rate (less than 10%, 11-50%, 50-75%, and over 75%) as parameters of the four classes of endemicity of malaria as classified by the spleen rate.

In Dar-es-Salaam, prior to the introduction of effective mosquito control measures, malaria transmission continued at a high level throughout the year with some accentuation during the months of March to May and to a lesser extent in October to December. These two peaks closely followed the long rains and short rains respectively. Malaria control activities in Tanzania began during the German colonial rule. Two methods were employed for malaria control. One was Robert Koch's recommendation of Mass Quinine treatment of people to destroy the parasite directly which commenced in Dar-es-Salaam, Kilwa and Tanga at the end of 1901. The other method was Ross' method of destroying the mosquitoes to interrupt the malaria cycle by destruction of larvae, (Clyde, 1961). This made malaria prevalence among immune population to decline from 45% in 1903 to 30% in 1907. In 1913 Koch's method was rejected and environmental manipulation was advocated instead through construction of drainage canals and filling up of innumerable ponds and applying larvicidal oiling.

Tanganyika malaria service was established in 1951 and was primarily involved in supervision of anti-malaria measures in all urban areas. Although over the years, especially after 2nd World War, larviciding seemed to be the main mosquito control activity in urban areas. Source reduction, particularly draining and other engineering works, constituted the major measures of urban mosquito control. Indeed such activities preceeded the settlement of surveyed urban areas and chemical control was only employed as a back-up measure.

During the past decade, there has been a growing concern about the effects of urbanization on mosquito-borne diseases in Africa (White, 1971). Urbanization, with its drastic changes in environment, produces many problems in community health. Man finds himself in overcrowded environment, slums occur almost overnight and frequently the influx of human population a outpaces the health budget of the government. There is a close relationship between urbanization and changes in adult population densities of anopheline mosquitoes in Tanzania (Bang et. al., 1973).

From 1951 onwards, the urban mosquito control programme became increasingly effective. Drainage and larviciding accompanied by residual spraying in selected peripheral parts of the city reduced transmission very considerably. DDT and dieldrin were

being applied as larvicidal airspray and routinely as residual imagocides. These methods slackened down after government decentralization in 1972 where malaria control programme was not given equal weight as other disease control programmes (Tarimo, 1976). Furthermore in 1966 the government started the medicated salt scheme in Mto wa Mbu settlement near Lake Manyara, Arusha region. It was evaluated in 1981 and it became clear that it could not be continued due to growing malaria parasite resistance to Amodiaquine used in the scheme (MOH, 1988). So the hope of country-wide malaria control through medicated salt died with the scheme.

Therefore, this study has been prompted by the introduction of the malaria control project in Dar-es-Salaam and Tanga vector Control measures. A malaria control project is currently being conducted in Dar-es-Salaam and Tanga Municipality by the Tanzania Government with Japanese Government assistance through the Japanese International Cooperation Agency (JICA) in Dar-es-Salaam. The project started in July 1988, but it came to full swing operation in October 1988. It focuses on malaria vector control by application of the insecticide Fenitrothion (Sumithion). The chemical has lethal action on adult and immature stages of mosquitoes and stops the transmission of the disease.

Fenitrothion is a residually acting organophosphorous compound already approved by WHO (OMS 43) for vector control in the field of public health. This compound is an ester of phosphorothioc acid and has alternative commercial names, e.g. Sumithion, Folithion, Donathion, Accothion, Metathion and Norathion. Sumithion was first manufactured by Sumitomo Company of Japan in 1959, it was later produced by German and American companies separately. In Tanzania, Fenitrothion is used in different preparations. e.g. 50% emulsion concentrate (E.C), 40% wettable powder (wpd), 98% technical grade used in vegetable pests and locusts control and 80% (EC). However the 40% (wpd) and 80% (EC) were used for indoor residual spraying in mud and plastered houses respectively. The indoor house spraying insecticide has a residual effect of up to six months.

In the Dar-es-Salaam malaria control programme, there were two phases of spraying within the first year of the programme. Fenitrothion 50% (E.C) has an action on the mosquito larvae of both anopheline and culicine species and the insecticide was applied in all possible breeding sites for mosquitoes. The effects last for three weeks. Ultra low volume (ULV) spray and larviciding was considered a necessary adjunct to house spraying where the vectors were largely exophilic and was prefered in the urban areas where breeding sites were relatively few and accessible.

Environmental modification and manipulation was also included in the vector control project and numbers of antimalaria drains were constructed, repaired and maintained. Large water ponds were either drained off or filled up with soil and sand.

Organophosphorous compounds, e.g. Fenitrothion are being used with increased frequency for malaria control following resistance to organochlorides, e.g. DDT and Dieldrin (Davidson, 1958; Bruce-Chwatt et. al., 1984; Gandahusada et. al., 1984). Besides the vector resistance to organochloride, these compounds introduced other problems to the users, namely, environmental pollution. The objective of the mosquito control programme in Dar-es-Salaam was to reduce both morbidity and mortality due to malaria among city dwellers living in at risk areas. The programme was based on residual house spraying, larviciding, ultra low volume (ULV) spray and source reduction using environmental manipulation and modification.

The urban vector control measures has been practiced in Tanzania for many years with the hope that the malaria burden will be reduced. These methods slackened down after government decentralization in 1972 where malaria control programme was not given priority as other disease control programmes (Tarimo, 1976). The recent introduction of malaria control project in Dar-es-Salaam and Tanga using anti-vector

measures will probably reduce malaria prevalence in these two areas.

Although the vector control measures started many years ago, no evaluation programme has yet been done to ascertain the efficacy of these methods and hence reducing malaria prevalence in Dar-es-Salaam. It is against this background that this study has been introduced to investigate the effectiveness of anti-vector measures six months after their execution was planned in the Magomeni area of Dar-es-Salaam.

2. REVIEW OF LITERATURE

2.1 The Global Situation of Malaria

Before World War II approximately 2/3 of the World's population was at risk of suffering from malaria. After remarkable initial success of DDT spraying in controlling transmission of the disease, the WHO initiated the Global Malaria Eradication programme in the late 1950's. Large scale spraying of insecticides, the mainstay of the programme, contributed to the subsequent elimination of malaria for an estimated population of 400 million people and eradicated the disease in most temperate regions (Noguer, 1976). Malaria still poses as a major challenge to public health in the world today. Due to its disabling ill effects on human population, it has been blamed for African under-development (Beausoleil, 1984). Despite the advent of modern technological advances currently available for effective action against malaria, this disease still affects quite a substantial number of people in the world. It is reported that there are some 100 countries which have indigenous malaria (WHO, 1987).The number of clinical cases of malaria occurring on a global scale is estimated to be in the order of 250 million annually with over 2.5 million deaths occurring annually mainly in children (WHO, 1988).

Clinical cases of malaria occurring in Africa south of the Sahara alone are in the order of 80 million (WHO, 1987). It is very discouraging to note that although the overall situation of malaria has been said to have remained static over the recent years in endemic areas, there are countries whose malaria situation has actually been worsening (WHO, 1987). The countries whose malaria situation has been deteriorating include African countries south of the Sahara which also, unfortunately, happen to be under high intensity of transmission rendering control measures applied to be costly and ineffective (WHO, 1987). The ecological privilege enjoyed by malaria vectors in Africa makes the control of malaria in the region quite a dreadful task and unattainable objective in terms of technical operation, administrative and financial constraints (WHO, 1983; WHO, 1987). As a consequence minimal malaria control activities are being carried out in Tropical Africa, where some 150 million people are estimated to be chronically infected and approximately one million infants and young children die per year from Plasmodium falciparum malaria (Duale, 1984; WHO, 1975). Malaria probably causes more deaths in the world than any other infectious disease, and throughout history malaria has been a more important cause of death than any war (Paul, 1964; Russel et. al., 1946).

Even at the present time there are millions of cases of malaria and hundreds of thousands of deaths occurring. Thus in spite of a fairly complete knowledge of the epidemiology of the disease and with adequate and efficient methods of malaria control at our disposal, the disease continues to exert an immense toll of human life especially on the continent of Africa (Paul, 1964). Malaria affects the agricultural workers more profoundly than the urban dwellers (Paul, 1964). The physical fitness of the workers is undermined and their effective working hours reduced during the harvest time.

The foregoing exposition at least briefly throws some light on the public health importance of malaria facing mankind which needs urgent and efficient control measures if the health status of the community is to be improved. The theoretical approach to malaria control appears simple but in actual practice the approach is hard to put into practice due to the problems already mentioned. Thus research is needed so as to find solutions to the problems or some ways of going round the problem (WHO, 1983). At global level it is envisaged that improvement in malaria control and hence health status will result in substantial increase in World food supplies due to increase production in world food crops and thus improve the world food reserve (Paul, 1964). This ultimate goal of malaria control will enable the community to live a socially acceptable

and productive life. The only rationale and logical way of achieving this noble goal is thought to be through the Primary Health Care (PHC) approach (WHO,1978; WHO, 1984).

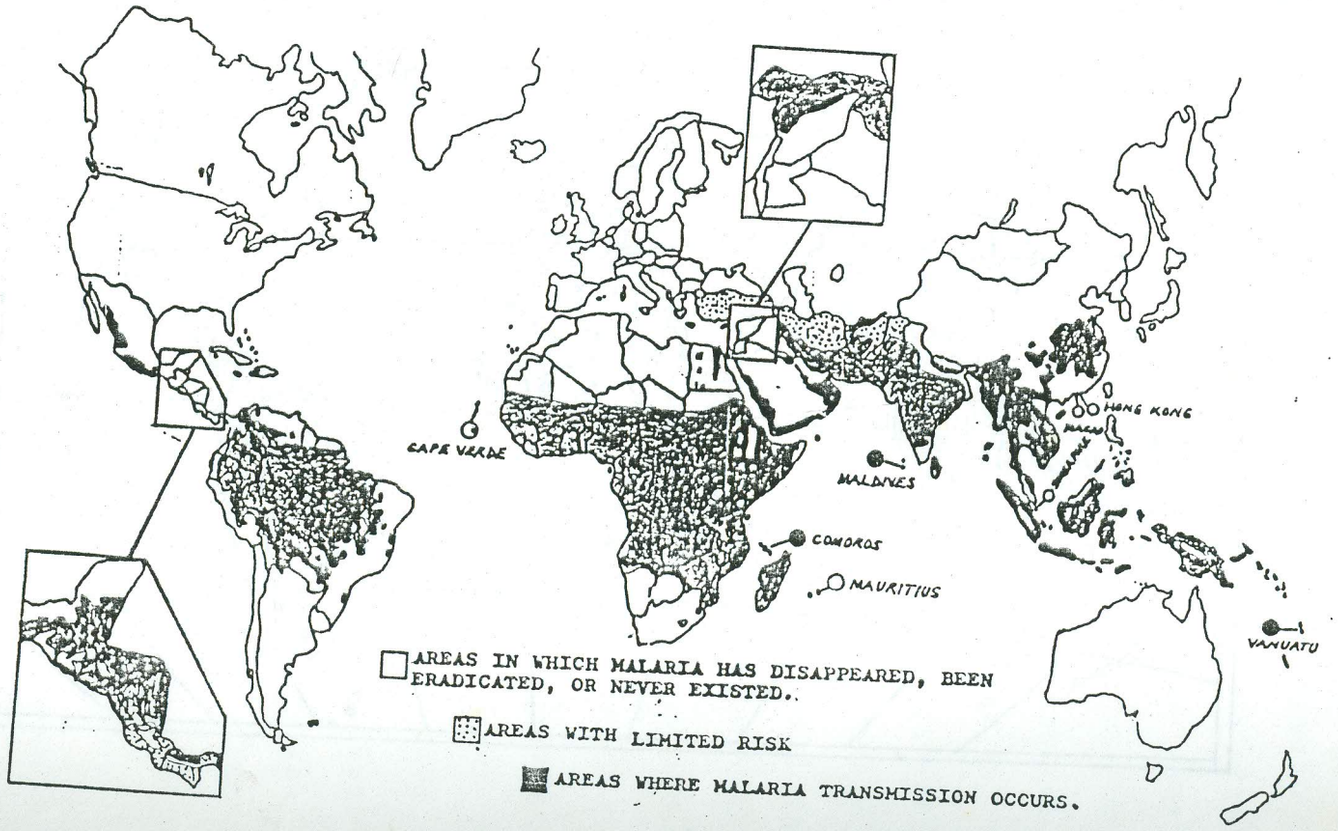
2.2 Malaria problem in Tanzania

Among the communicable diseases occurring in Tanzania, malaria is by far the commonest and of greatest public health importance. It causes much ill-health and is one of the top ten causes of deaths (USAID, 1979). Unrepresentative as they are, hospital-based data show that malaria is the leading cause of out-patient hospital attendances and ranks very high as a cause of hospital admissions in the country (USAID, 1979; WHO/MOH, 1984). Malaria is also one of the leading causes of mortality. These figures places malaria on the top of the list of causes of ill-health among patients receiving treatment in the health institutions in the country and in this regard malaria is only surpassed by acute pneumonias and diarrhoea (USAID, 1979; WHO/MOH, 1984).

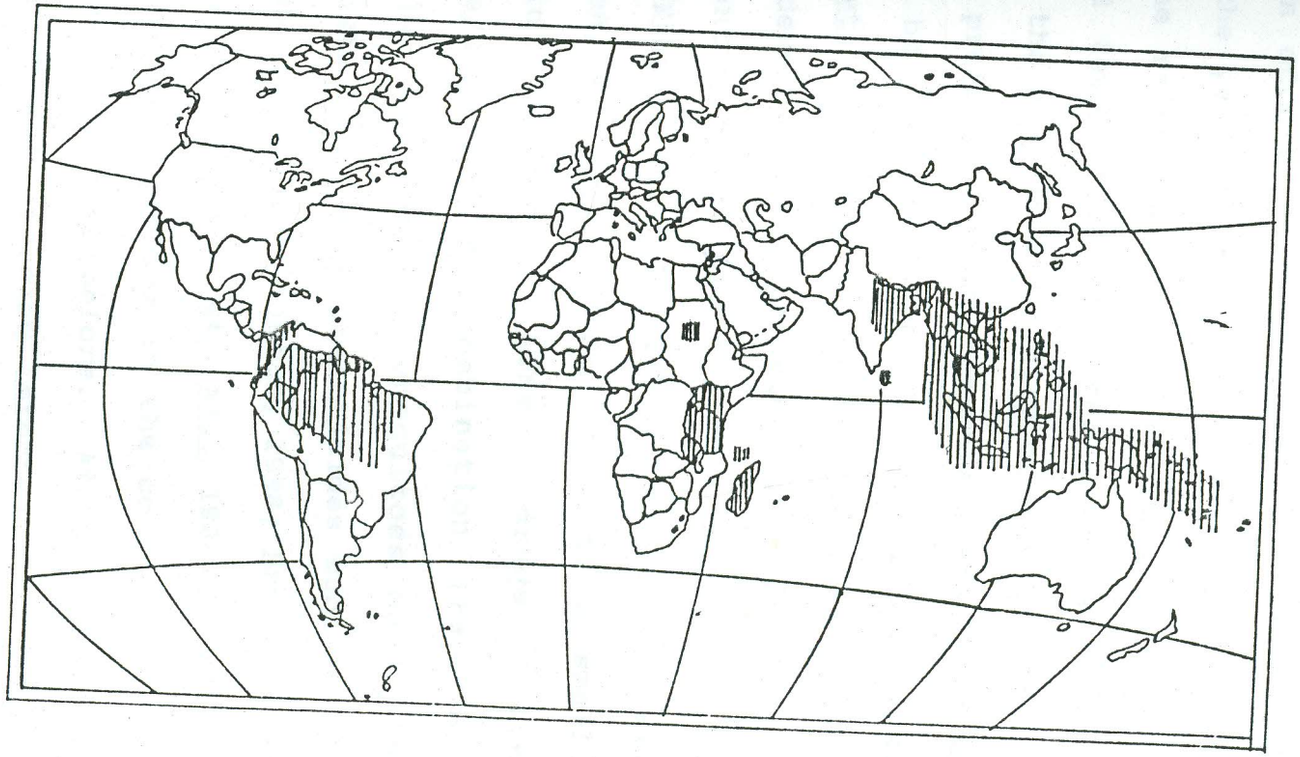
The disease is particularly dangerous in children and pregnant women due to physiological reasons related to body immunity. It is estimated that 10-15% of all childhood mortality during the first five years of life in malaria endemic areas is directly due to malaria (Clyde, 1967; WHO/MOH, 1984). The principal vectors are A. gambiae (S.l) and A. funestus (group) (Minjas,

MAP: i : SHOWING EPIDEMIOLOGICAL ASSESSMENT OF STATUS OF MALARIA.

SOURCE: (WORLD HEALTH STATISTICS QUARTERLY, 1987)



MAP. ii : SHOWING DISTRIBUTION OF CHLOROQUINE RESISTANT P. FALCIPARUM IN THE WORLD [STATUS AS AT 30TH APRIL 1983]. SOURCE WHO TRS 711 [1984]



1984) both of which are not easily amenable to control. Malaria is highly endemic in most parts of Tanzania and hence very few areas todate are free from malaria. Transmission occurs in most areas of the country throughout the year. The heaviest intensity is seen following the rainy seasons and it is influenced by humidity and temperature with the low-lying coastal areas having the highest endemicity of the disease.

Malaria prevalence in Dar-es-Salaam and Tanga was found to be 48.9% and 32.1% respectively (Ng'weshemi et. al., 1986). Malaria problem has been worsened by development of parasite resistance to the first line antimalarial drugs i.e. Chloroquine and Amodiaquine (Kihamia and Gill, 1982; Campbell et. al., 1983; Joatinen, et. al., 1984) and, to a smaller extent, to second line drugs i.e. Pyrimethamine/Sulphadoxine combination (Fansidar) (Duale, 1984). Furthermore, mosquitoes have also developed resistance to some insecticides such as the organochlorides, e.g. DDT (Davidson, 1958; Bruce-Chwatt et. al., 1984; Gandahusada et. al., 1984). All it means is that malaria problem in the country is even more challenging than ever before. At any rate, all Tanzanians are at risk of being infected with malaria because even those who live in high altitude areas are apt to contract malaria when they visit low-lying areas.

2.3 Malaria Morbidity and Mortality

The importance of malaria in Public Health as has already been seen, cannot be over emphasized because the disease affects many people in the World and causes considerable amount of morbidity and mortality. The clinical effect of malaria in vulnerable groups like pregnant women and young children in endemic areas are well known. Malaria is capable of causing severe anaemia, a complement mediated haemolytic anaemia crisis, and mild bone marrow depression (Woodraff et. al., 1979; Weatheral, 1982). Anaemia resulting from such a malaria attack especially in children and pregnant women in their last trimester, can lead to heart failure and death if not treated in time. Other notable complications of malaria include renal failure, liver failure, disseminated intravascular coagulopathy (DIC) and disturbance of body fluid balance (Gilles, 1982). Nephrotic syndrome has been associated with malaria (McGregor, 1972; Oyediran, 1987). It is reported that 60% of pregnant mothers with malaria become anaemic (Gillies, 1969). Malaria attack in pregnancy causes hyperpyrexia, abortion, and advanced pregnancy foetal death (Lawson, 1967).

Placental malaria parasitization is associated with intra-uterine foetal growth retardation because of placental insufficiency which results from blockage of intervillous spaces which in turn cut off maternal

circulation to the foetus (Lawson, 1967). Kortman (1972) did study malaria in pregnancy in Tanzania and his findings were similar to the ones above. As a result of placental parasitization, the incidence of low birth weight (LBW) is considerably increased and since babies of LBW are generally considered to be at greatest risk of reduced survival especially during the neonatal period, placental malaria may lead to high neonatal death rate in malarious areas (McGregor, 1983).

There are, however, important findings which have been shown clearly in respect of malaria morbidity in pregnancy. Placental parasitization was common in primigravidae than multigravida women (Jeliffe, 1968; Brabin, 1983; McGregor, 1983,1984). A study done in Zambia revealed that anaemia was more severe in primigravidae than multigravida and that more malaria parasites were found in the placenta of primigravidae than multigravida (Van-dongen, 1983; McGregor, 1984). In addition malaria is responsible for much school absenteeism and loss of working days among the economically productive population (Kilama, 1985). In order to appreciate the total burden due to malaria, consideration must be given to the costs of drugs, hospital beds, medical personnel and total economic loss resulting from reduced work output which amounts to thousands of Tanzania shillings per annum.

2.4 Malaria Vectors

There are about 400 species of Anopheles mosquitoes throughout the World, but only 60 species are vectors of malaria under natural conditions. Of these, 30 species are of major importance. Anopheles mosquitoes are most frequent in tropical and sub-tropical regions, they are found in temperate climate in arctic during summer. As a rule mosquitoes are not found at altitude above 2000 - 2500 metres above sea level.

Anopheles gambiae (S.l) and Anopheles funestus (type form) are the only known primary vectors of malaria in East Africa. The Anopheles gambiae comprises cryptic or siblings namely A. merus, salt water breeding species, confined to East Africa, A. melas salt water breeding species confined to West Africa, A. arabiensis B which is a fresh water breeding species distributed over most of the African continent and its associated Islands, and A. gambiae D, so far only for Semliki forest areas of Uganda/Zaire boarder where breeding is confined to mineral water swamp (Paterson et. al., 1963; Davidson, 1964; Coluzzi, 1984). The most typical breeding site for A. gambiae (S.l.) is shallow open sunslit pools with unpolluted water. Flooded rice fields have been found quite favourable especially if they are recently flooded and when the rice is low (Chandler et. al., 1975; Coluzzi,

1984). A. merus the East Africa salt water breeding sibling species of A. gambiae complex, is commonly found breeding in brackish lagoons, swamps, pools and puddles that are flooded at spring tides and subsequently diluted by rainfall or seepage from the land. Anopheles funestus group consists of 6 recognized members, namely A. funestus, (Giles). Anopheles confusus, A. leesoni (Evans), A. rivulorum (Leeson), A. aruni (Sobti)and A. brucei. These subspecies are identified by their larval and adult morphological characteristics (Gillies and de Meillon, 1969). Characteristically, A. funestus group breeds in bodies of clear water with emergent vegetation. This species normally requires a second blood meal before laying eggs.

As with A. gambiae, A. funestus feeds mainly indoors at night, but has greater tendency to bite during the day time (Smith, 1955; Hanney, 1960). In East Africa very few A. funestus leave houses the same night as they fed (Draper and Smith 1957; Smith and Draper 1959; Gillies, 1954). A. funestus is highly anthropophilic, precipitin tests have shown between 78% and 95% human blood index in catches from East Africa (Bruce-Chwatt and Cockel, 1960; White, 1971; Chandler et. al., 1975). Anopheles gambiae (S.l) and A. funestus group are important vectors of malaria and they are well known for their rapid reproduction

especially after the rains when hot humid condition are favourable. In addition their efficiency in malaria transmission is enhanced by their long life span. A. gambiae (S.l) is associated with highest degree of anthropophily particularly on the East African coast where cattle are few (Davidson and Draper, 1953; Gillies, 1964). They bite mainly indoors at night and in Africa they are most active between midnight and 04.00 hours (Haddow, 1945; Gillies, 1957). Some observers suggest that the house entry is earlier than actual activity, indicating a period of rest indoors before the host is attacked (Haddow, 1942; Gillies, 1957).

2.5 Vector Control

Malaria control with a vector control component has a long history in the African region. Prior to the 2nd World War, control was based mainly on anti-larval measures including source reduction while pyrethrum spray as an imagocide was tried on a small scale in certain areas with variable reduction. During the late 1940's when organochloride insecticides became available, malaria control by house spraying was initiated on a small scale in certain countries.

When the global malaria eradication programme was established in 1955, the World Health Organization (WHO) African region was excluded because of the problem of intense transmission of P. falciparum by the

most efficient vector Anopheles gambiae (S.l) assisted by A. funestus. In the hope of overcoming this problem, a reorientation of malaria control activities was undertaken in certain countries and Islands and malaria eradication pilots projects were established in circumscribed area in several countries. These projects aimed at complete interruption of transmission as a pre-requisite for malaria eradication (Zahar, 1984).

At one time it seemed as though the control and eventually eradication of malaria in Africa would prove to be an easy exercise. This belief was based on the knowledge that the relationship between the Plasmodium, the vector, and man was clearly understood, that effective chemotherapeutic and chemoprophylatic agents were available and that modern insecticides held a great promise for vector control. Unfortunately, decades later and after several pilot projects, reviews and revisions of strategies and various attempts at control, malaria still remains an insidious scourge with serious public health, social and economic consequences that constitute serious obstacle to development especially in the rural areas. Chief among the factors responsible for this gloomy and exasperating situation are the climatic and ecological characteristics that favour survival of the vectors and transmission of the disease. The malaria problem is

made worse by the bionomics of the principal vectors, the A. gambiae complex and A. funestus, and to the very high intensity of transmission in savanna areas as well as in the rain forests. There were also some administrative and operational problems due to lack of trained personnel at all levels and inadequate development of the infrastructure that is required to support a properly organized malaria control (Beausoleil, 1984). In the light of these frustrations, it is no wonder that African countries lag behind other areas of the world in the global battle against malaria (Beausoleil, 1984).

Undoubtedly, a great volume of work has been done on vector control methods throughout the years either experimentally or on an operational scale. For chemical control, only the outcome of epidemiologically assessed large scale trials of operations, mainly house spraying, is considered. The latest report of WHO Expert Committee on vector biology and control (WHO, 1983) noted that in the African region, malaria vector control operations on the mainland are largely confined to urban and peri-urban areas. In islands more comprehensive malaria eradication programmes have been carried out as in Cape-Verde, Mayotte, and Sao Tome and Principe, where malaria control activities have led to a spectacular drop in parasite rate and malaria incidence (WHO, 1983).

In Sao Tome and Principe, DDT alone was applied while in Mayotte, DDT was alternated with Malathion. It appears that house spraying has not been employed as a principal measure for malaria control in the majority of the countries of the mainland in conformity to the recently adopted malaria control strategy. However, some limited spraying is probably applied around urban areas or selectively in some rural areas as in Ethiopia and Somalia, but no recent information could be obtained on epidemiological assessment of such operations (Beausoleil, 1984). In West Africa past experience with DDT house spraying in savanna areas showed house spraying to be incapable of interrupting malaria transmission owing mainly to the increased exophily of A. gambiae (S.l) and A. funestus. Also, more complications have been added by the appearance of DDT resistance in A. gambiae (S.l). In Guinea savanna of Togo, a malaria control demonstration zone was sprayed with two rounds of DDT (WHO, 1975). A spectacular reduction in A. gambiae (S.l.) man-biting density occurred and A. funestus almost disappeared following the DDT spraying. Parasitologically, the effect of this was clearly demonstrated by considerable reduction in the infant parasite rate which reached almost zero. In the dry savanna of Northern Nigeria, a trial of DDT spraying combined with Mass Drug Administration (MDA) was reported by Najera, (1974). The trial was designed

according to expectations of a mathematical model. Control operations continued for two years but did not achieve interruption of malaria transmission and malaria prevalence returned to its pre-operational level after duration of one and half years (Najera, 1974). However, the parasitological findings indicated that during the dry seasons, malaria prevalence greatly decreased, probably because the MDA had reduced the reservoir of infective cases. However, there was a big increase in prevalence during the main transmission season of the wet period of the year; thus under such conditions, MDA was unable to check the increase in parasite reservoir.

Even the use of most powerful insecticides could not lead to interruption of malaria transmission in the dry savanna of West Africa. This was demonstrated in the Garki Project in Northern Nigeria by Molineaux et. al. (1986), confirming the other experiences in West Africa. Propoxur spraying was applied in an area which was divided into 3 sectors, where the impact of spraying alone, as supplemented by high or low frequency MDA was assessed. Propoxur alone produced very limited impact on malaria, the vectorial capacity remained well above the critical level to maintain P. falciparum transmission and entomological inoculation remained at measurable level. Despite 90% reduction in the vectorial capacity the prevalence of P. falciparum

was reduced to about 25% (Molineaux et. al., 1980). Propoxur combined with MDA also failed to interrupt malaria transmission even with high drug frequency. However, with high frequency MDA, child morbidity was reduced. The conclusion drawn from the effect of propoxur spraying combined with MDA is that despite giving high level of control, it is too expensive to be applied on a large scale for a long time.

In East Africa, the most recent house spraying trial was conducted during 1972-1976 with Fenitrothion (Sumithion) near Kisumu Kenya, being the final stages of evaluating this insecticide under previous WHO programme for evaluating and testing new insecticides as reported by Fontaine et. al., (1978). The trial was carried out in an area where malaria is known to be hyper- to holoendemic and A. gambiae (S.l) and A. funestus were the major vectors. Fenitrothion was applied at the target dosage of $2gm/m^2$ for a total of 8 consecutive spray rounds. The indoor and outdoor mosquito population density was reduced to a negligible level (Fontaine et. al., 1978). However, A. gambiae (S.l) reappeared during the main wet season at density sufficiently high to re-establish a low level of transmission. In general, spraying produced a marked and rapid reduction in both the incidence and prevalence of malaria. Prevalence in the evaluation zone fell from 58.8% to 17.2%, whereas in the untreated

area it remained 46-49% (Fontaine et. al, 1978). Fontaine et. al. (1978), concluded that despite the general reduction in malaria prevalence without supplementary measures, fenitrothion was incapable of containing the explosive increase in the vector population during the most favourable period of the year. Furthermore, an operational scale trial again using fenitrothion for controlling malaria was carried out in Central Java, Indonesia by Gandahusada et. al. (1984). Two areas were treated with fenitrothion 40 wdp for 3 cycles at 6 months intervals. One area was treated with full coverage i.e. the interiors of houses and cattle shelters were sprayed. The other areas were treated with only selective coverage. While both treatment methods reduced malaria prevalence rates and vector population to very low levels, the full coverage was more effective and it also reduced the Plasmodium index (Gandahusada et. al., 1984).

In another trial of fenitrothion efficacy, conducted in Tanzania at a village scale, in Mvuti and Chanika villages in Ilala District Dar-es-Salaam by Marijani et. al. (1986), results indicated that a satisfactory control of the two malaria vectors i.e A. gambiae and A. funestus was achieved. Mosquito room densities were kept low throughout the trial period and there was an appreciable decrease in crude parasite rate in the area (Marijani et. al., 1986). Pant et.

al. (1974), carried out a large scale field trial of ULV fenitrothion applied by portable mist blower for the control of A. aegypti in Thailand. The insecticide mist and aerosols produced an immediate reduction of population of A. aegypti and also produced residual effect that prevented oviposition for a period. No large scale space spraying seems to have been undertaken in rural areas, but information on a village-scale trial is available from Nigeria. Brown et. al. (1981), reported the results of a ULV malathion trial carried out during 1978 by the former WHO Arbovirus Unit at a village, involving 582 houses with about 1700 people from Enugu. The application was made indoors and outdoors around each house.

Two consecutive applications were applied with a one week interval between. The target species were Anopheles gambiae (S.l), A. funestus, Aedes aegypti and other Aedes species. The trial was assessed entomologically by landing catches on man and by pyrethrum spray catch before and after spraying and in an unsprayed comparison village, as well as by bioassays. The sequential applications gave good control of Anopheles and Aedes species. The highest percentage reduction was against A. gambiae (S.l) and A. funestus.

Concerning antilarval measures, there is very little recently published data on the assessment of antilarval operations currently being carried in urban

areas in the African region, whether for malaria control or as part of general mosquito control. An example of assessment of larval vector control operations has been provided by studies in Ghana by (Chinery, 1969, 1970, 1979). Longitudinal larval and adult house resting mosquito surveys were conducted at a monthly intervals. Antilarval measures consisted of mechanical source reduction as well as larviciding with diesel oil. Satisfactory control was noted, but expansion of breeding with marked increase in adult densities was observed during the rainy season.

From the above reviews of various well performed and carefully assessed trials, residual house spraying cannot be considered as a principal tool for long term malaria control in tropical Africa. Indeed, as expressed by Bruce-Chwatt, (1979), the days of the magic words "Let us spray" are over. Apart from technical, administrative and logistic problems, there are now the added problems of the increasing incidence of double resistance to organochloride compounds and alternative insecticides (Davidson, 1958; Gandahusada et. al., (1984). Other problems include the rapidly increasing cost of alternative insecticides, the remoteness of the hope of developing new effective, safe and cheap compounds and the greatly increased concern about environmental safety.

Yet, residual house spraying for malaria control has its own advocates. Kouznestov (1977) noted that despite failure of malaria control or eradication projects to interrupt malaria transmission in tropical Africa, there had been considerable reduction in Malaria prevalence, but few systematic attempts had been made to assess the beneficial effects of this reduction. Kouznetsov (1977), endorsed the view that in highly malarious endemic rural areas in Africa although house spraying does not interrupt malaria transmission, it will make a considerable contribution to an improvement in health. House spraying cannot be accepted for long term malaria control, it may be considered as an interim measure in an integrated control programme for initial reduction of malaria prevalence.

It is well known that development in Africa has been progressing rapidly, involving the construction of dams for hydroelectric schemes or for the expansion of irrigated land for agriculture, progress in mining and industrialization, and increasing urbanization as well as construction of the necessary roads. The question may be asked whether chemotherapy and chemoprophylaxis can cope with all these situations. It seems unlikely, except perhaps among migrant labour groups. For settled communities permanent vector control measures are indispensable to ensure health

improvement. It has been shown that residual house spraying cannot be relied upon as a permanent measure. It has been repeatedly recommended that the answer is the integrated control whether for Africa or for other parts of the world. The latest report of WHO Expert committee on vector biology and control (WHO, 1983) defined the principles of integrated control and its implementation through community participation in association with primary health care in a planned programme of control of vector-borne diseases. In an integrated control programme, residual house spraying may be used as an interim measure for reducing malaria prevalence for a "relief" period during which non-chemical methods can be developed and assessed to ensure that they can reliably maintain the designated acceptable or tolerable target of malaria control.

Therefore, this study will try to gather some necessary information which will be useful in the malaria vector control programme when launching the programme nationally.

3. RATIONALE OF THE STUDY

The malaria situation in Tanzania is grave and with the lack of vector control measures reliance has been placed upon anti-parasite measures through the use of Chloroquine and Amodiaquine. Although resistance of the local strains of P. falciparum has been reported, complete mapping of the spread of this resistance in Tanzania has not been possible to date. The problem has been worsened by the development of parasite resistance to the first line antimalaria drugs, Chloroquine and Amodiaquine (Kihamia and Gill, 1982, Campbell et. al., 1983; Schwartz et. al., 1983), and, to a smaller extent, to the second line drugs, e.g. Pyrimethamine/Sulfadoxine combination (Duale, 1984).

Malaria is highly endemic in Tanzania and by 1960's malaria had been mapped and shown that about 75% of the country consisted of hyper-endemic to holo-endemic malaria (Clyde, 1967). Malaria accounts for a large proportion of the out-patient attendances and admissions to our hospitals and is among the top ten causes of death especially in children in our country (USAID, 1979; WHO/MOH, 1984; MOH, 1983). The burden of malaria includes school absenteeism, loss of working days among economically productive adult population (Kilama, 1985) and the cost of drugs, hospital beds, medical personnel and economic loss resulting from reduced work out-put. Given this situation where malaria is a major public health problem in Tanzania

particularly affecting the underfives and pregnant women and also given the natural ability of malaria parasite and their insect vectors to acquire resistance to chemicals used against them and the meagre budget of the Ministry of Health, a well organized malaria vector control programme will be the answer to our problem as prevention is better than cure. The urban vector control measures have been practised in Tanzania for many years, with the hope that the malaria burden will be reduced. These control measures slackened down after government decentralization in 1972 where malaria control was not given priority (Tarimo, 1976).

Although vector control measures have been in operation for many years, a well organized evaluation has not been done to ascertain their efficacy in reducing the mosquito population.

It is against this background that the investigator took up this problem of not having a well organized vector control measures and its evaluation in the country, for research as one of the priority areas. It is envisaged that the knowledge gained from this study will provide the necessary experience, which is very essential to all levels of the health system when extending the malaria vector control measures to the rest of the country, bearing in mind that this is the first study of its kind to be conducted in the country.

4. OBJECTIVES

4.1 Broad objective

To determine the prevalence of malaria and the effectiveness of intervention measures of mosquito control programme in Magomeni area of Dar-es-Salaam.

4.2 Specific Objectives

4.2.1 To determine the pre-intervention prevalence of malaria in Dar-es-Salaam using parasite and spleen rates of children aged 2-9 years living in Magomeni area.

4.2.2 To determine the post-intervention prevalence of malaria using parasite and spleen rates as above.

4.2.3 To determine the reduction of malaria morbidity (cases) in Magomeni health facilities, pre- and post-intervention.

4.2.4 To determine the Anopheles mosquito larval density before and after intervention measures using larval searching technique in Magomeni area.

4.2.5 To determine the same parameters (4.2.1-4.2.4) in a comparison area (Pugu-Kajiungeni).

5. METHODOLOGY

5.1 Study Area

5.1.1 Description of the Study area

The study was conducted in Magomeni which is located within Dar- es-Salaam city. The Malaria Control programme covered an area of about 442 sq. km. of the city mainly the urban city areas. The periphery remained as the control areas. Dar-es-Salaam is the largest city in Tanzania with a total population of 1.5 million (1988 National Population Census). It was the capital city before the government transferred its headquarters to Dodoma in 1975. The city has thus remained as the largest commercial centre in Tanzania. Since the city of Dar-es-Salaam is the largest commercial centre, it is not surprising to find that all the tribes in the country are represented here. Although the indigenous tribes are Wazaramo, Wandengereko and Wamatumbi, the bulk of the city population is made up of tribes from up-country regions which have migrated in search for employment or is engaged in some business.

Dar-es-Salaam by itself is a region and was accorded this status in 1972. It has a Regional Administrative structure and is divided into three administrative districts,i.e., Kinondoni, Ilala and Temeke. All are headed by District Commissioners (D.C). In local government terms Dar-es-Salaam has a

City Council Authority (D.C.C.) with its own functional administrative structure. This does not include the entire region.

It has an elevation of about 4.5 - 30.5 m. above the sea level and the soil is generally sandy and porous, but some patches of clay and stone rocks may be found. Two areas in Dar-es-Salaam were selected for the study. Magomeni was taken as the study area while Pugu-Kajiungeni served as a comparison or control area. The mosquito breeding habitats and the climate in both areas are similar, except, that the population density and ethnic characteristics of both communities differ. Both areas are situated in a malaria transmission zone of high endemicity.

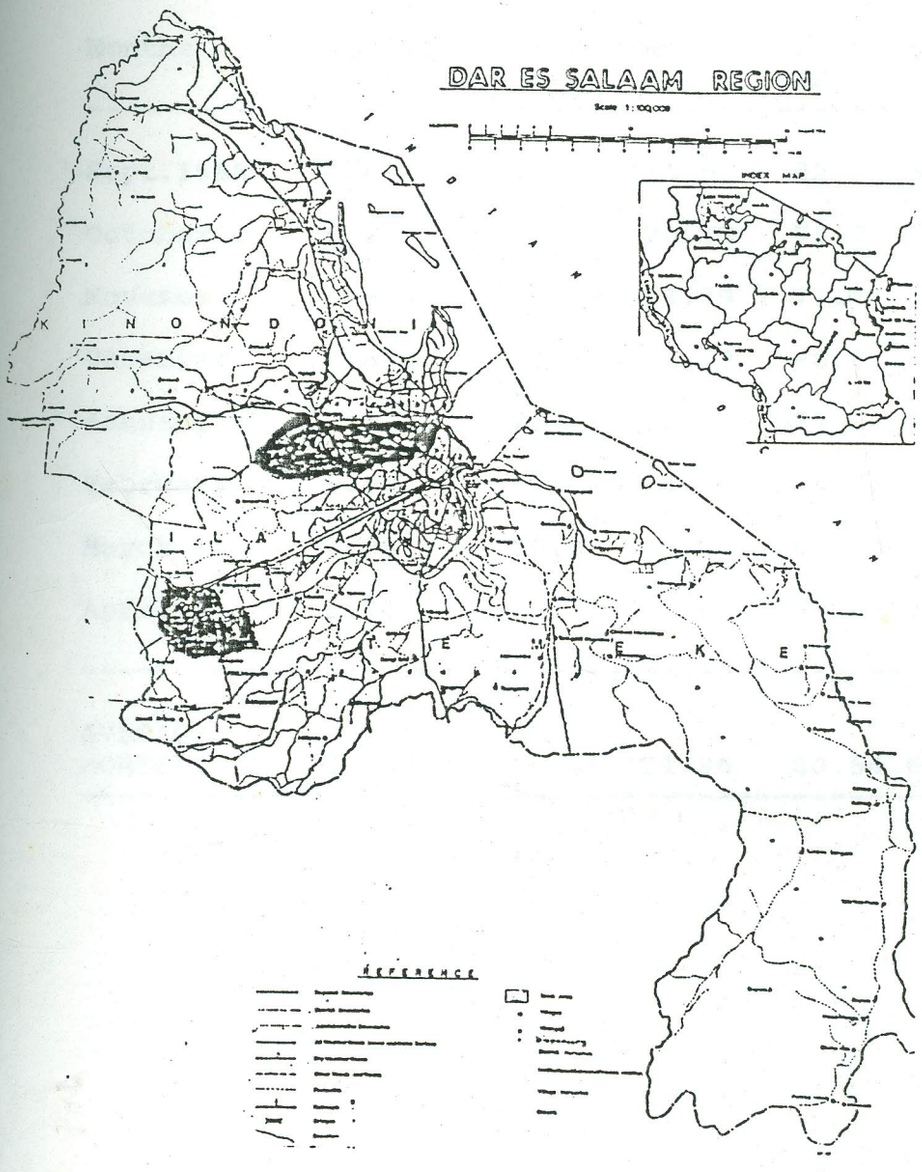
5.1.2 **Climate**

The climatic condition of Dar-es-Salaam can be summarized as being hot and humid throughout the year. (See Table I and Figure I) which shows the mean monthly rainfall and relative humidity as collected from the Department of Meteorology in Dar-es-Salaam, from the month of September, 1988 to April, 1989.

During this period the minimum and maximum temperatures were recorded, and the mean monthly average was 21.9°C and 30°C respectively. The minimum and maximum relative humidity was recorded and it was 64.7% and 80.6% respectively. The relative humidity is high throughout the year but it varies from 54-85% in

the dry months of June and September and 63% -85% during rainy seasons. There are two rainy seasons that is "Masika" or long rains from March to May and "Vuli" or short rains from October to December.

Map.iii Map of Dar es Salaam Region showing the location of study and comparison areas.

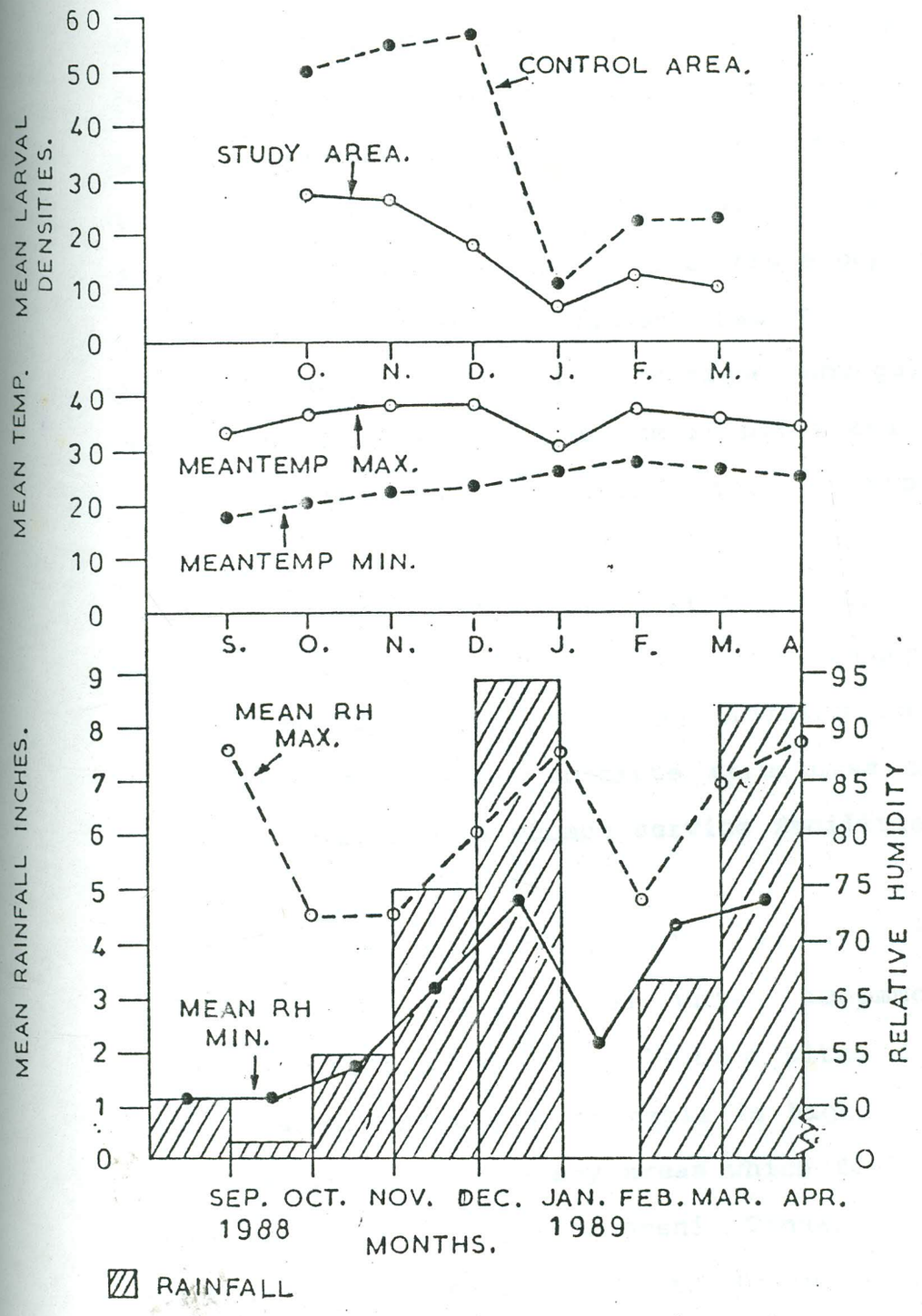


Source Malaria Control Project of Dar es Salaam

TABLE I: Weather data of 1988/89 taken from Meteorological Directorate of Dar-Es-Salaam

Months	Rainfall in inches	Mean temp. Max.	Mean temp. Min.	Mean RH% Max	Mean RH% Min.	No.of wet days
Sept.1988	1.03	30.15	19.57	82	54.9	8
October	0.258	30.52	20.12	73.7	54.0	4
November	1.933	31.69	21.79	73.5	59.9	6
December	4.890	31.2	21.72	80.8	67.7	22
January 89	8.64	29.69	23.3	87.8	74.3	17
February	0.00	31.77	24.1	74.96	61.5	0
March	3.06	30.0	22.96	84.13	72.7	12
April	8.246	28.68	21.69	88.2	72.9	17
AVERAGE MONTHLY	3.600	30.46	21.96	80.64	64.7	11

FIG.1: RELATIONSHIP OF RAINFALL, TEMPERATURE, AND HUMIDITY. OF D.S.M. WEATHER DATA OF 1988 / 89 TAKEN FROM METEOROLOGICAL DIRECTORATE



5.1.3 Magomeni

Magomeni is an area situated on the western part of Dar-es-Salaam about 4 km from the city centre. It is part of Kinondoni District. Kinondoni district has a population of about 500,000 people (1988 National Population Census). Magomeni itself has a population of about 150,000 people. Magomeni has 8 wards namely Magomeni, Ndugumbi, Makurumla, Manzese, Ubungo, Kigogo, Mabibo and Tandale. It has one hospital and an urban dispensary at Tandale. Medical care is provided in these health facilities and also in some voluntary agency private clinics. The area is densely populated by residents of low and middle income occupations in and around Dar-es-Salaam. The housing consist of traditional six roomed concrete structures shared by several families with common service facilities in the backyard.

The soil consists of clay subsoil lying on unevenly distributed coral which accommodates a numerous number of water collection sites during the rainy season, and the water table is high. This fits with the eruption of marshy areas which form permanent water bodies e.g. lakes Magomeni, Tandale, Minyonyoni and Makurumla and river Msimbazi. Drainage is poor due to ill-maintained furrows on the eastern side of Magomeni which lead towards the Msimbazi creek into the Indian Ocean.

The basic health infrastructure of the area is inadequately developed for maintaining an adequate sanitation for such densely populated area. Most of the houses are provided with pit latrines while few have septic tanks and cesspools which require frequent emptying. Slackening of the vector control activities during the past decades has led the malaria vectors (Anopheles mosquitoes) to multiply in the numerous breeding sites as well as the multiplication of great numbers of Culex mosquitoes in pit latrines and septic tanks as these contain organically polluted water.

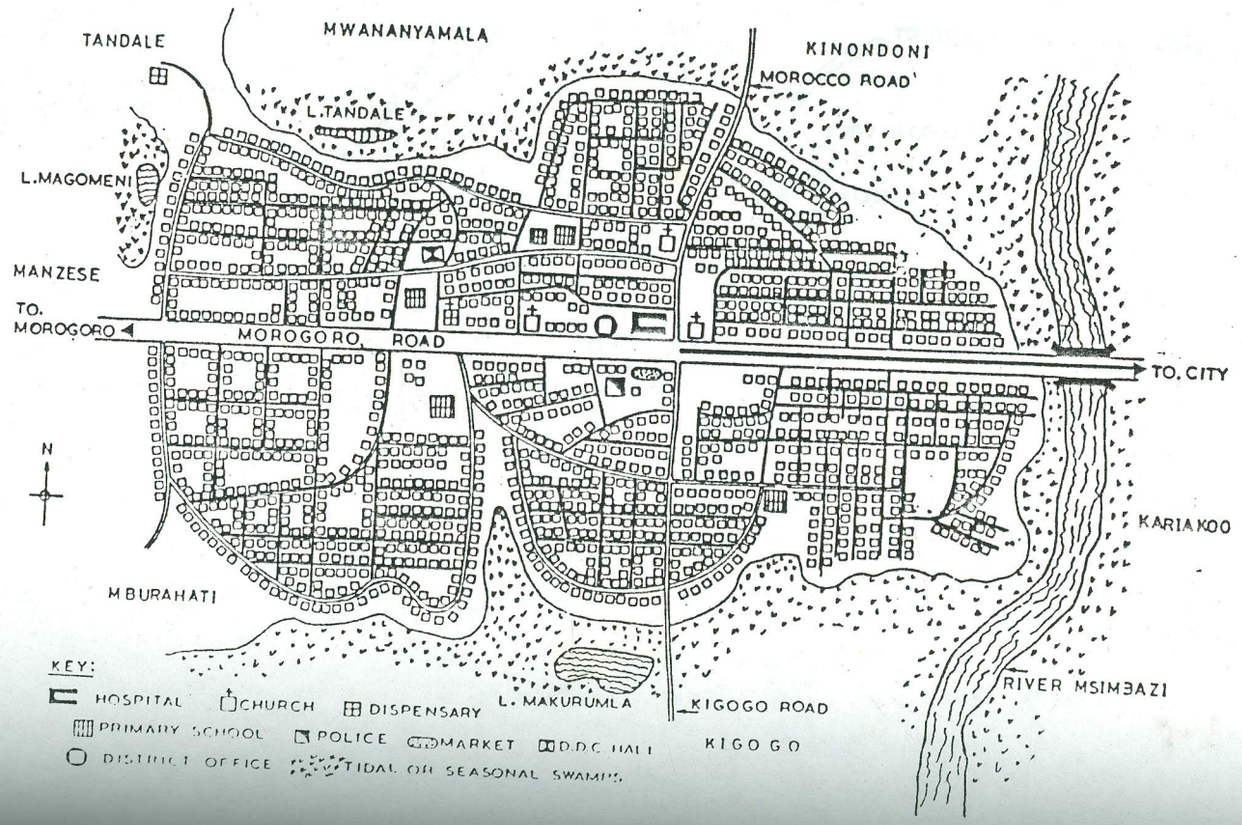
5.1.4 Pugu-Kajiungeni (Comparison Area)

Pugu-Kajiungeni served as the control area in the study. It is located on the southern part of Dar-es-Salaam about 10 km from the city centre. It is part of Ilala District. Ilala District has a population of about 450,000 (1988 National Population Census). Pugu itself consists of three villages, namely Pugu-Kajiungeni, Mwakanga and Pugu station. It has a population of about 3200 people (1988 National Population Census) Most of the inhabitants of this area are indigenous to the region i.e. Wazaramo and Wandengereko.

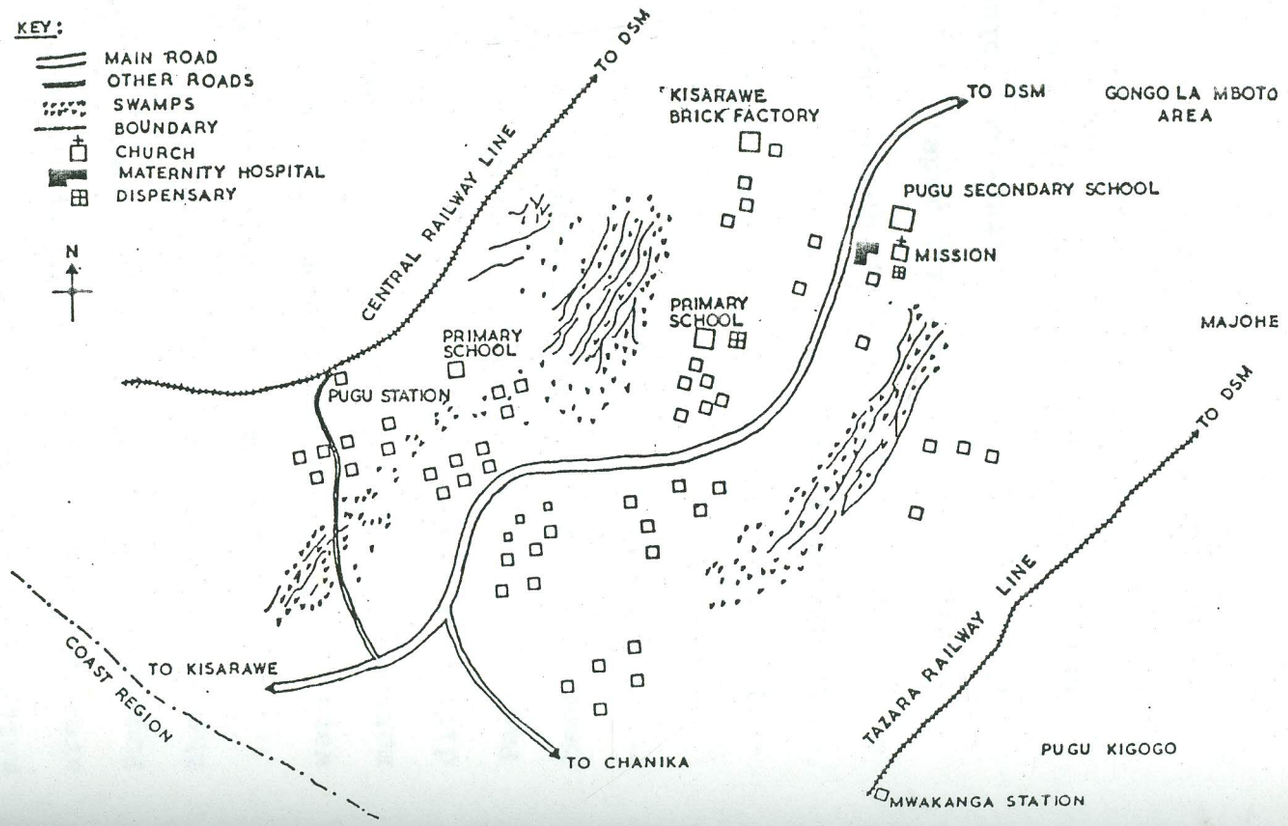
5.2 Selection of Study Area

Dar-es-Salaam was selected because malaria control programme was being carried out here, therefore no statistical methods were used to select it. The

MAP. IV: SHOWING SKETCH MAP OF MAGOMENI



MAP. V: SHOWING SKETCH MAP OF PUGU-KAJIUNGENI



malaria control areas covers the urban part of the city area leaving out the periphery as the control zones. Pugu-Kajiungeni is on the periphery, so it was taken as the comparison area for this study.

The control methods used in the control programme were not uniform throughout the city, but different methods, or a combination of methods, were applied in different areas (See appendix A Page (105) and Map vi Page (108). Magomeni was selected as the study area because of the following reasons:

- Malaria control programme is being conducted in this area.
- It consists of urban and peri-urban densely populated area.
- It has malaria depot, where supervision of the programme could be easily made.
- Both larviciding and ultra-low volume (ULV) spray using cold fog containing fenitrothion concentration on open space to reduce the adult mosquito population was being carried out.

5.3 Target and Study Population

The target population consisted of all children aged between 2 - 9 years living in Magomeni area, during the study period. The study population was obtained by systematically examining children from the randomly selected households of Magomeni area as study area and Pugu-Kajiungeni as comparison area. The office of Divisional Secretary was consulted and clearance was given. All of the Ten-cell leaders ("Balozis") of Magomeni with their respective household leaders were listed. The reasons for selecting this age group of 2--9 years in the study were as follows:

- This is a high risk group for malaria and prevalence of malaria could be studied easily
- This is the age group commonly used for spleen examination in most malaria studies as it best indicates malaria related splenomegaly.

5.4 Sampling Method:

The study population was obtained by simple random sampling technique in order to avoid bias in the selection procedure. The sampling frame consisted of 178 ten-cell leaders of Magomeni area. Random sampling technique was used to select 10, ten-cell leaders ("Balozis") from the total number of ten-cell leaders of Magomeni. Each "balozi" has not less than 10 households. Therefore a total of 100 households were included in the study and through recording the names of all households in the selected "balozi" a house to house visit was made and every child between the age of

2 - 9 years old was examined. The same procedure was applied in Pugu-Kajiungeni, the comparison area. These children were identified and examined in their homes. The first examination was done during the month of October, 1988 and repeated examination six months later was done in the month of April, 1989. All children from the selected households had opportunity to be studied. The study was completed in April, 1989.

5.5 Sample Size

Based on the prevalence rate of Malaria in Dar-es-Salaam as reported earlier by Ng'weshemi et. al. (1985), the sample size required was calculated using the formula described by Handerson et. al., (1982).

$$N = \frac{Z^2PQ}{d^2}$$

where N = Number of persons required to be studied (sample size)

d = Desired precision

Z = The standard normal deviation

P = Proportion of persons in the population having malaria

Q = Proportion of persons in the population not having malaria.

The sample size required was obtained by substituting the following figures:

Taking d = 0.1 and P = 49% then

$$N = \frac{1.96^2 \times 0.49 \times 0.51}{0.1^2} = 99.96\ (100)$$

Therefore about 100 children were required in the study area and 100 children in the control area. As the nature of this study required a follow up of the children six months apart, a total of 400 was taken in order to detect an estimation of true prevalence rates. Also the significant results depended mainly on shifting of one malaria endemicity from one level to a lower level of endemicity. Therefore 400 children were the minimum number of cases which was supposed to be taken into consideration for significant results. But for the purpose of the study a much larger sample size was taken to minimize the sampling variation. A total of 283 children were examined during the pre-intervention period and 291 during the post-intervention period making a total of 574 children studied.

5.6 Epidemiological Survey

5.6.1 Parasite count

The prevalence of malaria among children aged 2-9 years in Magomeni and Pugu-Kajiungeni was determined first in the month of October, 1988 and the second time in April, 1989 over a period of six months apart. Prevalence of the disease was carried out prior to the introduction of control measures and six months later after intervention. For all children who were included

in the study; thick and thin blood smears were made on the same slide, dried and stained with giemsa. Parasite positivity, density and species were determined during the pre- and post-intervention phases i.e during the month of October, 1988 and April, 1989. Results were recorded in special designed recording form (see Appendix B page (109).

5.6.2 **Physical examination**

Children from whom blood smears were taken were also examined by the author for spleen enlargement. The spleen was palpated while the child was standing. The hand was pressed gently against the left anterior abdominal wall until the spleen was felt or not felt. Measurements of the enlargement were recorded in the recording form and based upon the Hackett's method.

Class of spleen Age 2 - 9 years

0 - Not palpable

1 - Spleen palpable below the left costal margin usually on deep inspiration.

2 - Spleen palpable below the left costal margin but not beyond horizontal line half way between the costal margin and umbilicus measured along a line dropped vertically from the left nipple.

3 - Spleen with lowest palpable point projected more than half way to umbilicus but not below a line drawn horizontally through it.

4 - Spleen with lowest palpable point below the umbilicus level but not projected beyond a horizontal line situated half way between the umbilicus and symphysis pubis.

5 - Spleen will be recorded as indicated beyond the lower limit of class 4.

5.6.4 Detection of Malaria diagnosed cases

Cases of clinical malaria in Magomeni health facilities (Tandale Dispensary) before intervention and six months after intervention was recorded. All those cases which were visited in October, 1988 were recorded. Thereafter follow-up of malaria cases was done monthly starting from October, 1988 till April, 1989, in both study and comparison areas. Results were recorded in special recording forms (See appendix D Page 112).

5.7 Entomological Survey

Sampling of Mosquito larvae from breeding sites

All breeding sites which could support the development of **Anopheles** larvae were surveyed and mapped between August and September, 1988. For the purpose of this study the sites were selected based upon the nature of the breeding site and mainly the permanent water collections suitable for breeding Anopheles species. These areas were identified and given some numerical numbers. Random sampling technique was used and 10 breeding sites were selected from each area; the study and comparison areas. These

areas were visited once every month with the assistance of two malaria assistants beginning from October, 1988. An estimation of the relative abundance of the **Anopheles** species larvae was made by dipping at several points of the pool. Dipping was done with a ladle having the capacity of 100 mls and the contents of 5 dips in each breeding site were emptied into a white enamel tray. Using a pipette, larvae of different stages were picked up, identified and counted. The identification was done on the spot by using an identification key.

Anopheles larvae are small with distinct head, thorax and abdomen. They have palmate hairs (floating hairs). At their breeding sites the larvae lie flat on the water surface and have no breathing syphon. They have two spiracular openings leading to the trachea. Live larvae were kept in a collecting jar half filled with water and not exposed to sunlight and brought to the laboratory for correct identification and counting by the laboratory technician in the Insectorium of the Muhimbili Medical Centre (MMC). Anopheles larvae of both A. gambiae and A. funestus were recorded in the recording forms (See attached appendix No.C page 111).

5.8 **Study Duration**

The study took a duration of six months from October, 1988 to April 1989.

5.9 **Study Design**

This was a prospective longitudinal study whereby two cross-sectional studies were done six months apart.

5.10 **Data Analysis** Data were analyzed using a Computer programme and a battery operated calculator (Scientific Calculator Casio Fx-180P). Standard statistical techniques in testing significance were used and results were deemed significant at p value of less than 0.1 ($P<0.1$).

5.11 **Field and Laboratory Logistics Formalities**

The following local formalities had to be accomplished before conducting the study. Research permit was obtained from the Director General's Office and City Council authorities. Also an introductory letter to the city officials including City Medical Officer, District Medical Officers of Ilala and Kinondoni Districts. Also the Divisional and Ward secretaries of Magomeni and Pugu-Kajiungeni were approached.

5.11.1 **Drugs**

Chloroquine and Aspirin tablets were required for treating children who were found to have malaria parasites. Therefore the author received some assistance from the Muhimbili Medical Centre Pharmacy Department.

5.11.2 **Survey**

Record forms were specifically designed for this study (See appendices B, C, and D.). A pre-coded one page record form was developed in English and there was no need of translating it to Kiswahili as the author was himself using it. The form consisted of 3 parts:

a) Parasitological and spleen survey

b) Morbidity data collection

c) Larval density

5.11.3 **Laboratory Procedure**

Blood slides were taken in the field and examined to determine the presence of malaria parasites and density in the Parasitology and Entomology laboratory of Muhimbili Medical Centre. The work was done by the author assisted by qualified and competent laboratory technicians who examined the blood slides for positivity and negativity as well as for parasite density. At the end of each working day in the field, the slides were packed in the appropriate glass slide boxes and transferred to the above mentioned laboratory.

5.11.4 **Giemsa Staining**

The stock solution of Giemsa was prepared by using the following ingredients:-

- Giemsa powder 3.8 g
- Glycerol pure 250 ml

Alcohol and Glycerol were mixed together before gradually adding small quantities of the powder in a mortar and grinding until dissolved. The solution was then filtered and bottled in a special (brown) bottle. Staining of thick and thin blood smears was done using Giemsa staining diluted 1:50 in a buffered water (pH 7.2). The solution was poured on the horizontally placed blood smears suspended on the staining rack over

a water sink and allowed to stain for 30 mins before being flushed with tap water. They were then positioned upright to dry.

5.12 Problems encountered

The following were the main problems encountered during the course of study.

5.12.1 Transport

It was not possible to obtain a specific vehicle for the study. As a result the investigator and his assistants had to use the limited resources in hiring taxis to Magomeni and Pugu-Kajiungeni on several occasions. This was a very costly form of transport but the good offices of the Director General of Muhimbili Medical Centre made it possible to obtain extra funds to facilitate transportation to the study areas.

5.12.2 Heavy rains

During entomological survey, some of the breeding sites could not be reached easily due to heavy rainfall creating large pools of water. This problem was overcome by borrowing rain coats and gun boots from Malaria Control project which enabled the work to be done.

5.12.3 Cooperation of the parents

Some of the parents at Magomeni and Pugu-Kajiungeni were reluctant to allow their children to be bled for parasite examination because they thought

probably blood was being taken for sale. This problem was solved by using the ten-cell leaders ("Balozi") and CCM village chairman who assured them that these children were being examined for malaria parasites and those who will be found to have malaria parasites will be treated.

5.13 Work Organization and Administration

Studies on the transmission and control of **Anopheles** species and epidemiology of malaria were divided into phases.

1(a) September 1988 - Preliminary studies for the purpose of selecting study area and mapping.

1(b) October, 1988 - Parasitological survey and clinical examination of children in the study and comparison areas.

Entomological studies continued every month up to April 1989.

2. April 1989, Post-intervention parasitological survey and clinical examination of children in the study and comparison areas.

5.14 Abbreviations and Definitions

5.14.1 Abbreviations

CCM	=	Chama cha Mapinduzi (The Ruling Political Party of Tanzania)
UNICEF	=	United Nations Children's Fund
USAID	=	United States Aid for International Development
ULV	=	Ultra low Volume
JICA	=	Japanese International Cooperation Agency
SE	=	Standard Error

CL = Confidence Limit

WBC = White Blood Cells

PDI = Parasite Density Index

MOH = Ministry of Health

MMC = Muhimbili Medical Centre

S.l. = Sensu lato

5.14.2 **Definitions**

(i) **Parasite Density Index (PDI)**

Defined as proportion of field positive for **P. falciparum** asexual stages, **P. falciparum** gametocytes, **P. malariae** and **P. ovale** respectively out of the fields examined in a given population (Bruce-Chwatt, 1980)

(ii) **Parasite Rate (PR)**

Defined as the proportion (percentage) of persons positive for **P. falciparum** (any form) **P. vivax, P. Ovale,** or **P. malariae** respectively by examination of 200 microscope fields of thick film.

(iii) **Environmental Manipulation**

A form of environmental management consisting in any planned recurrent activity aimed at producing temporary conditions unfavourable to the breeding of vectors in their habitats.

(iv) **Environmental Modification**

A form of environmental management consisting in any physical transformation that is permanent or

long lasting of land and vegetations aimed at preventing, eliminating or reducing the habitats or vectors without causing undue adverse effects on the quality of human environment.

(v) **Clinical Malaria**

A patient presenting with symptoms of malaria and treated with antimalarials without being tested for malaria parasitaemia.

6.0 RESULTS

A total of 574 children in the study and comparison areas were examined, 283 during pre-intervention phase and 291 during the post-intervention phase. A corresponding number of 574 special recording forms were filled. Therefore these results were based on the 574 special recording forms that were analysed.

Table 2(a) shows the age and sex distribution of the studied sample examined for malaria parasites and spleen enlargement during the period of October, 1988 in the study area (Magomeni) before intervention. The table shows that about 60% of all children studied were in the age group 6 - 7 years. The male:female ratio was 1:1.

Table 2(b) shows the age and sex distribution of the studied sample in the study area after intervention measures were instituted. The table shows that about 44.2% of all children studied were in the age group of 4-5 years and male:female ratio was 1:1.

Table 2(c) and 2(d) shows the age and sex distribution of the studied sample in the comparison area before and after intervention. About 54.3% were in the age group 8-9 years before intervention and 55.6% after intervention.

Table 2a **Age and Sex distribution of the study sample before intervention in Magomeni area**

N=145

Age Group	Male	%	Female	%	Total	%
2-3	4	5.1	4	6	8	5.5
4-5	18	22.8	24	36.5	42	29
6-7	51	64.5	36	54.5	87	60
8-9	6	7.6	2	3	8	5.5
Total	79	54.5	66	45.5	145	100

Table 2b **Age and Sex distribution of the study sample after intervention in Magomeni area**

N=147

Age Group	Male	%	Female	%	Total	%
2-3	9	12.2	12	16.4	21	14.3
4-5	36	48.6	29	39.7	65	44.2
6-7	29	39.2	32	43.5	61	41.5
Total	74	50.3	73	49.7	147	100

Table 2c **Age and Sex distribution of the study sample in Pugu-Kajiungeni area before intervention.**

N=138

Age Group	Male	%	Female	%	Total	%
2-3	14	23.7	8	10.1	22	15.9
4-5	7	11.9	12	15.2	19	13.8
6-7	12	20.4	10	12.7	22	15.9
8-9	26	44	49	62	75	54.3
Total	59	42.8	79	57.2	138	100.0

Table 2d **Age and Sex distribution of the study sample in Pugu-Kajiungeni after intervention**

N=144

Age Group	Male	%	Female	%	Total	%
2-3	13	18.3	13	17.8	26	18.1
4-5	5	7.1	5	6.8	10	6.9
6-7	12	16.9	16	21.9	28	19.4
8-9	41	57.7	39	53.4	80	55.6
Total	71	49.3	73	50.7	144	100

Table 3(a) and 3(b) shows the prevalence rate of malaria among children aged between 2-9 years in the study area (Magomeni) by age group before and after intervention.

Out of 145 children who were examined for malaria parasites before intervention 29 (20%) had their blood slides positive for malaria. The majority of them were in the age group of 6-7 years. Table 3(b) shows the prevalence of malaria six months after intervention on the same area. Out of 147 children who were examined 29(19.7%) were having malaria parasitaemia. The pattern of distribution was not similar as shown in table 3 (a). Age group 8-9 years had no children who were included in the study.

Table 4(a) and 4(b) shows the prevalence of malaria in the comparison area (Pugu-Kajiungeni) by age group before and after intervention. Out of 138 children examined 67(48.6%) had malaria parasitaemia

before intervention. On the other hand, the post-intervention prevalence was 34.7%. Majority of children who were positive for malaria before and after intervention were on the age group of 8-9years.

All malaria parasites identified were of species of Plasmodium falciparum. Thus from the results, malaria prevalence after intervention in the study area (Magomeni) showed no statistically significant difference (X^2 = 8.29 P< 0.012). However, there was no statistically significant decrease in malaria prevalence six months after intervention measures were instituted.

Table 3a **Prevalence of malaria in children studied by age group in the study area (Magomeni) before intervention (Oct, 1988)**

N=145

Age Group	Malaria Positive	%	Malaria Negative	%	Total	%
2-3	3	37.5	5	62.5	8	100
4-5	8	19	34	81	42	100
6-7	16	18.4	71	81.6	87	100
8-9	2	25	6	75	8	100
Total	29	20	116	80	145	100

$X^2_{(3)}$ = 1.82 P = 0.61

Table 3b **Prevalence of malaria in children studied by age group in the study area (Magomeni) after intervention (April, 1989)**

N=147

Age Group	Malaria Positive	%	Malaria Negative	%	Total	%
2-3	9	42.9	12	57.1	21	100
4-5	10	15.4	55	84.6	65	100
6-7	10	16.4	51	83.6	61	100
Total	29	19.7	118	80.3	147	100

X^2 = 8.29 P< 0.012
(2)

Table 4a **Prevalence of malaria in children studied by age group in the comparison area (Pugu-Kajiungeni) (October, 1988)**

N=138

Age Group	Malaria Positive	%	Malaria Negative	%	Total	%
2-3	13	59.1	9	40.9	22	100
4-5	8	42.1	11	57.9	19	100
6-7	10	45.5	12	54.5	22	100
8-9	36	48	39	52	75	100
Total	67	48.6	71	51.4	138	100

X^2 = 1.38 P<0.708
(3)

Table 4b **Prevalence of malaria in children studied by age group in the comparison area (Pugu-Kajiungeni) (April, 1989)**

N=144

Age Group	Malaria Positive	%	Malaria Negative	%	Total	%
2-3	11	42.3	15	57.7	26	100
4-5	3	30	7	70	10	100
6-7	12	42.9	16	57.1	28	100
8-9	24	30	56	70	80	100
Total	50	34.7	94	65.3	144	100

X^2 = 2.36 P< 0.5
(3)

Table 5a **Distribution of children with malaria parasite count as described by (Bruce-Chwatt, 1958) in both study and comparison areas pre-intervention**

Parasite Count Per Class MM^3/ul	Number of Children examined		Class Frequency	
	Magomeni	Pugu-Kajiungeni	Magomeni	Pugu-Kajiungeni
< 100	1	29	62	29	62
101-200	2	0	2	0	4
201-400	3	0	3	0	9
Total		29	67	29	75
Parasite Rate		20	48.6		
Parasite Density Index		1.00	1.12		

* See calculation on page 65.

Table 5b **Distribution of children with malaria parasite count as described by (Bruce-Chwatt, 1958) in both study and comparison areas post-intervention**

Parasite Count Per MM^3/ul	Class	Number of Children examined		Class Frequency	
		Magomeni	Pugu-Kajiu-ngeni	Magomeni	Pugu-Kajiu-ngeni
< 100	1	25	42	25	42
101-200	2	4	5	8	10
201-400	3	0	3	0	9
Total		29	50	33	61
Parasite Rate		19.7	34.7		
Parasite Density Index		1.13	1.22		

* See See calculation on page 65.

Calculations of parasite rate and parasite density index

Crude parasite rate was calculated by taking number of malaria positive in studied children x 100 divide by the total number children examined:

Therefore Parasite rate (PR) for

Magomeni before intervention $= \frac{29 \times 100}{145} = 20\%$

PR for Pugu-Kajiungeni before intervention $= \frac{29 \times 100}{147} = 19.7\%$

PR for Pugu-Kajiungeni after intervention $= \frac{50 \times 100}{144}$

Parasite density index was calculated by multiplying number of each individual in each class and its total then divided by Total positive for malaria.

Parasite density index (P.D.I) for Magomeni before intervention $= \frac{29}{29} = 1.0$

Parasite density index for Pugu-Kajiungeni before intervention $= \frac{75}{67} = 1.12$

PDI for Magomeni after intervention $= \frac{33}{29} = 1.13$

PDI for Pugu-kajiungeni after $= \frac{61}{50} = 1.22$

Table 6 **Distribution of children with splenomegaly before and after intervention in the study area (Magomeni) and Comparison area (Pugu-Kajiungeni)**

Study Area

	Number examined	Number positive	%
Pre-intervention	145	41	28.3
Post-intervention	147	29	19.7
Total	292	70	24

$X^2_{(2)} = 3.29$ P<0.07

Comparison area

	Number examined	Number positive	%
Pre-intervention	138	51	36.9
Post-intervention	144	35	24.3
Total	282	86	30.5

$X^2_{(2)} = 8.31$ P<0.01

Table 5(a) and 5(b) shows the distribution of children with malaria parasites according to parasite count pre- and post-intervention in the study and comparison areas respectively. The parasite rate of both study and comparison areas was 20% and 48.6% respectively. Six months later after intervention measures were applied in the study area, the parasite rate was 19.7% while the comparison area was 34.7%.

Similarly the parasite density index before intervention was 1.0 whereas after intervention it was 1.13 in the study area. The comparison area had parasite density index (PDI) of 1.12 and 1.22 before and after intervention respectively.

Table 6 shows the distribution of children with splenomegaly before and after intervention. Among the children examined for palpable spleen according to Hackett's classification in the study area, 41 out of 145 (28.3%) had splenomegaly before intervention. In the comparison area 51 out of 138 (36.5%) had palpable spleens. Similarly after intervention measures were applied 29(19.7%) of children examined in the study area had enlarged spleens. In the comparison area, out of 144 children examined 35(24.3%) had enlarged spleens. However, there was no statistically significant difference in spleen rate decrease before and after intervention ($X^2 = 3.29$ $P<0.07$). The overall spleen rate was 24% in the study area and 30.5% in the comparison area.

Table 7(a) and Fig 2 show the relationship between splenomegaly and malaria parasites among children studied before intervention.

Out of 145 children examined for spleen enlargement 38 had palpable spleens falling under classification number one. Out of the 38 who had enlarged spleens 10(26.3%) also had malaria parasitaemia. In the

comparison area Table (7b and Fig.2) 42 children had palpable spleens, also under classification number one and among them 23(54.8%) had malaria parasitaemia.

The relationship between splenomegaly and malaria parasitaemia after intervention in the study area is shown in Table 7(c) and Fig 3. Twenty five children were found to have palpable spleens in the study area and out of them 18(72%) had malaria parasites in their blood. In the comparison area (Table 7(d), 27 children had splenomegaly of whom 12(44%) had malaria parasites. Therefore, when these results were compared before and after intervention in the study area, there was no statistically significant difference in splenomegaly and malaria parasitaemia (X^2 = 16.6 P<0.0002).

Table 7(a) Relationship between splenomegaly and malaria parasites before intervention in the study area (Magomeni).

Spleen Classification	Number Examined	Malaria Positive	%
0	104	17	16.3
1	38	10	26.3
2	3	2	66.6
Total	145	29	20

$X^2_{(2)}$ = 3.94; P= 0.268

Table 7(b) **Relationship between splenomegaly and malaria parasites before intervention in the Comparison area (Pugu-Kajiungeni).**

Spleen Classification	Number Examined	Malaria Positive	%
0	87	36	41.4
1	42	23	54.8
2	6	6	100
3	2	2	100
4	1	0	0
Total	138	67	48.5

X^2 = 2.47; P< 0.48
(3)

Table 7c **Relationship between splenomegaly and malaria parasites after intervention in Study area (Magomeni)**

Spleen Classification	Number Examined	Malaria Positive	%
0	118	19	16.1
1	25	18	72
2	4	2	50
Total	147	29	19.7

X^2 16.6 P<0.0002
(2)

Table 7d **Relationship between splenomegaly and malaria parasites after intervention in Pugu Kajiungeni (Comparison area)**

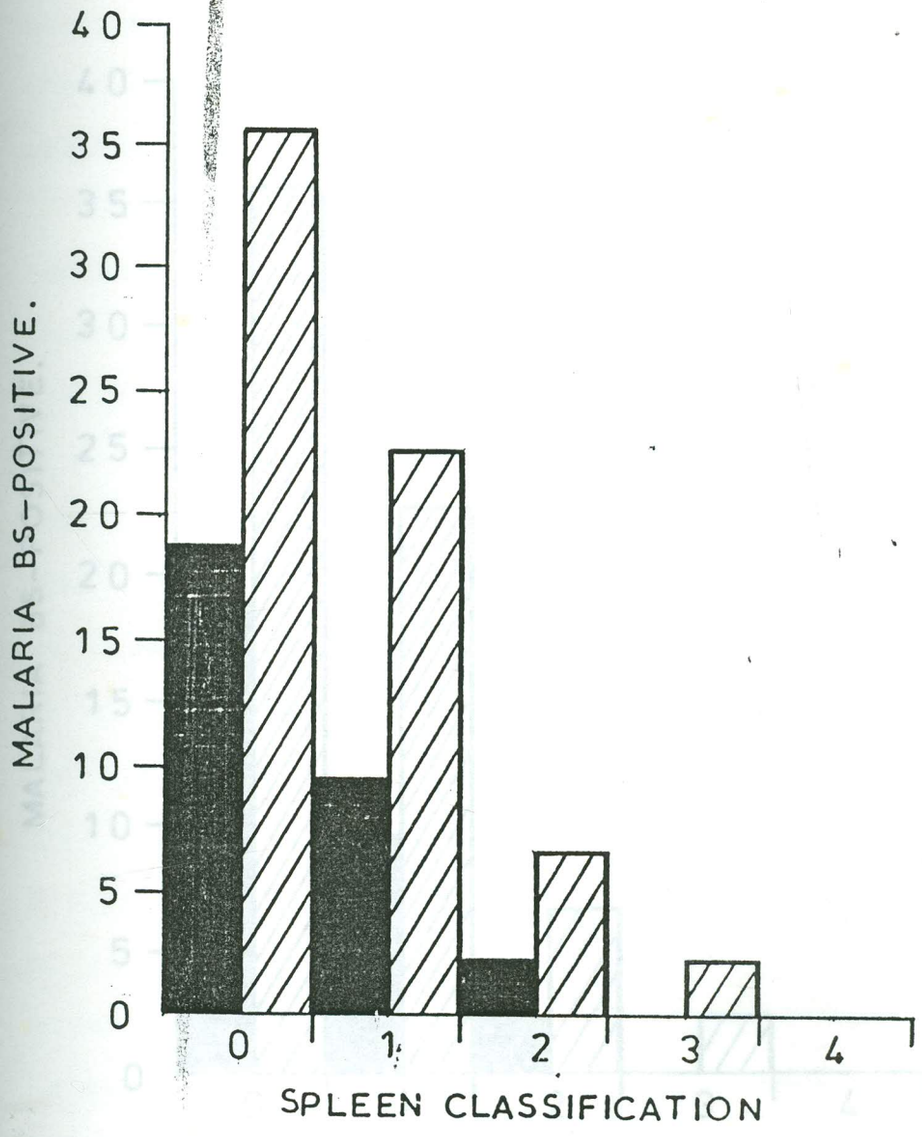
Spleen Classification	Number Examined	Malaria Positive	%
0	109	32	29.4
1	27	12	44.4
2	3	2	66.7
3	4	3	75
4	1	1	100
Total	144	50	34.7

$X^2_{(1)} = 0.418$ P = 0.518

Table 8(a) shows the distribution of clinical malaria in Magomeni health unit six months before intervention and six months after intervention. There was a total of 111,986 patients seen at the outpatient department (OPD) from April to September 1988. Out of whom 20,878 were patients of clinical malaria. Six months later, total OPD patients were 104,847 of whom 17,813 were patients of clinical malaria. Clinical malaria comprised a higher number of all patients who attended treatment in Magomeni before and after intervention.

These results were compared with those obtained from comparison area. Table 8(b) shows the clinical malaria patients in the comparison area (Pugu-Kajiungeni) where there was no malaria intervention

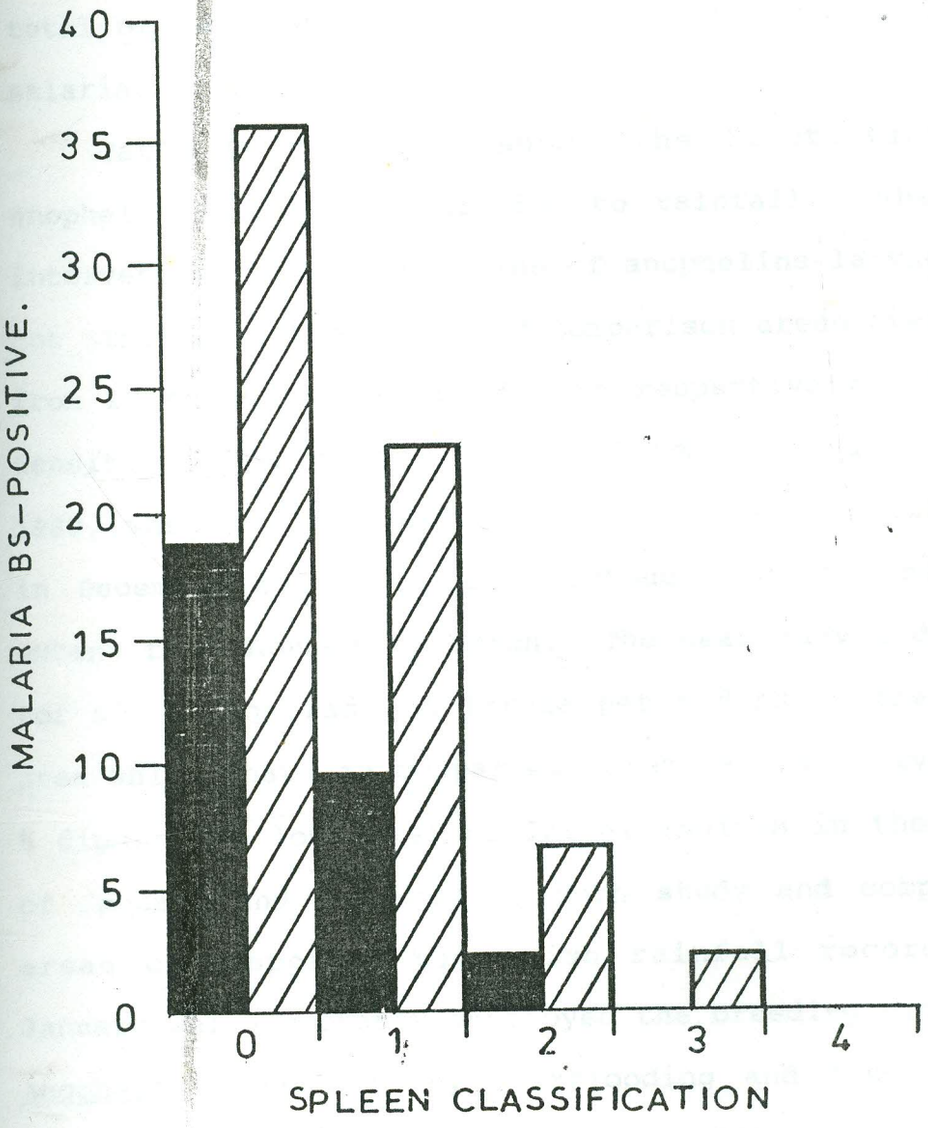
FIG.2: RELATIONSHIP BETWEEN MALARIA PARASITAEMIA AND SPLENOMEGALY IN THE STUDY AND COMPARISON AREAS BEFORE INTERVETION



■ MALARIA PARASITAEMIA IN MAGOMENI STUDY AREA

▨ MALARIA PARASITAEMIA IN PUGU COMPARISON AREA

FIG.2: RELATIONSHIP BETWEEN MALARIA PARASITAEMIA AND SPLENOMEGALY IN THE STUDY AND COMPARISON AREAS BEFORE INTERVETION



■ MALARIA PARASITAEMIA IN MAGOMENI STUDY AREA

▨ MALARIA PARASITAEMIA IN PUGU COMPARISON AREA

measures. The total number of patients seen in the health unit was 7,355 six months before the study started. Out of whom 1274 were patients of clinical malaria. Between October and March 1989 there was a total of 6637 OPD patients of whom 1230 were clinical malaria.

Table 9 and Fig 4 show the fluctuations of anopheline larvae in relation to rainfall. The pre-intervention larval densities of anopheline larvae were not similar in the study and comparison areas averaging from 26 to 50 larvae per 5 dips respectively. Larval densities kept on falling in Magomeni from December 1988, whereas in Pugu-Kajiungeni they were still high in December but also fell although not to the same extent from January to March. The mean larval density for six months was 15 larvae per 5 dips in the study area while that in comparison area was 40 larvae per 5 dips. The low level of larval indices in the month of January and February in both study and comparison areas corresponded with high rainfall recorded in January which probably destroyed the breeding sites for Anopheles mosquitoes by overflooding and also by the drought period reported in February 1989.

Table 8(a) Comparison of clinical malaria diagnosed in Magomeni health unit within six months before and after intervention

Pre-intervention

Months	Total Patient	Malaria	%
April 1988	18,741	4166	22.2
May	21,781	4050	18.6
June	18,684	3539	18.9
July	18,190	3843	21.1
August	17,295	1640	9.5
September	17,295	3640	21
Total	111,986	20878	18.6

Post-intervention

Months	Total Patient	Malaria	%
October 1988	17,694	2828	15.9
November	20,351	2959	14.3
December	16,374	2914	17.8
January 1989	18,183	2854	15.7
February	15,162	3071	20.7
March	17,083	3187	18.7
Total	104,847	17813	16.9

Table 8(b) Comparison of clinical malaria diagnosed in Pugu-Kajiungeni health unit within six months before and after the study period

Pre-Intervention

Months	Total Patient	Malaria	%
April 1988	1,035	180	17.4
May	1,577	242	15.3
June	1,266	241	16.9
July	979	195	19.9
August	1,197	198	16.5
September	1,301	245	18.8
Total	7,355	1,248	17.3

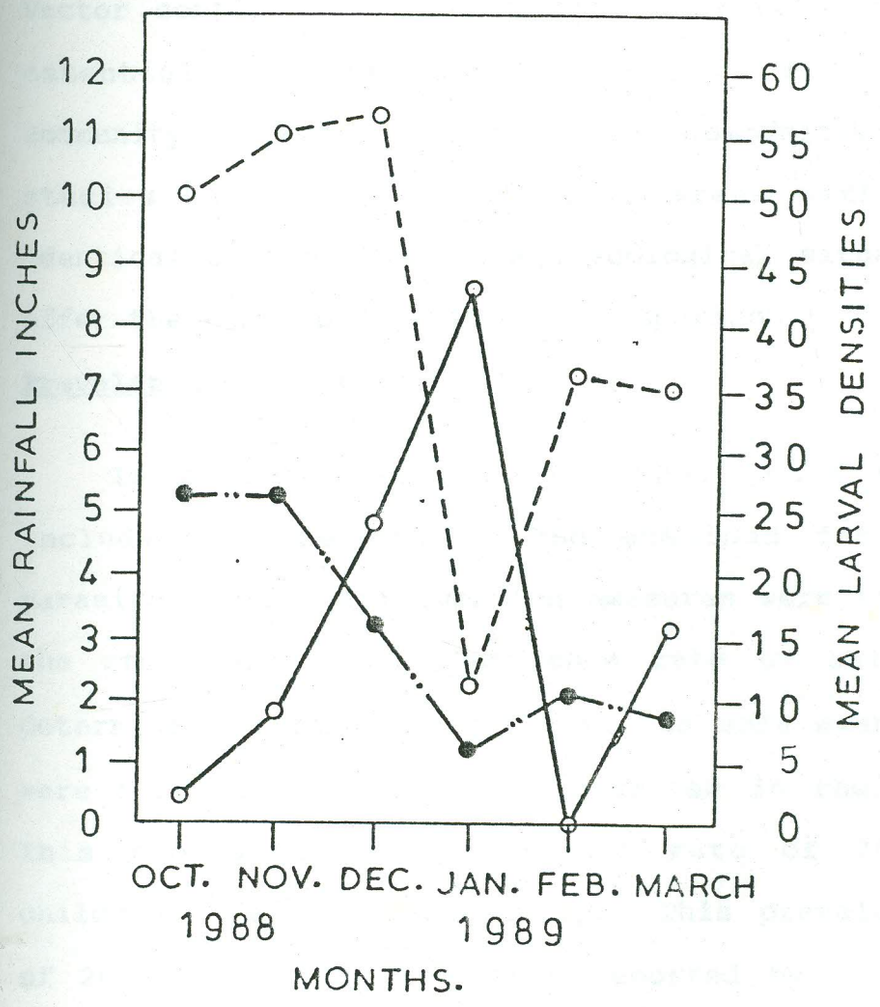
Post-intervention

Months	Total Patient	Malaria	%
October 1988	1,048	203	19.4
November	1,180	195	16.5
December	836	170	20.3
January 1989	909	186	20.3
February	1,325	226	17.1
March	1,259	250	19.9
Total	6,637	1,230	18.5

Table 9 **Relationship between larval densities and rainfall in Magomeni and Pugu-Kajiungeni**

Months	Mean Rainfall in inches	Mean larval density count Per 5 counts Magomeni	Mean larval density count Per 5 counts Pugu-Kajiungeni
Oct. 1988	0.258	26	50
November	1.933	26	55
December	4.890	16	57
Jan. 1989	8.640	6	12
February	0.000	11	36
March	3.060	9	35
Average	3.13	15.6	40.8

FIG.4: RELATIONSHIP BETWEEN RAINFALL AND LARVAL DENSITIES IN THE STUDY AND COMPARISON AREAS.



o--o COMPARISON AREA

●-··-● STUDY AREA

o——o MEAN RAINFALL IN INCHES

7 DISCUSSION

The present study which was designed to delineate the impact of vector control measures on malaria epidemiology in Dar-es-Salaam was conducted in an area of hyper-endemic to holo-endemic malaria situation. Vector control measures in this area were absolutely essential for effectively combating malaria in the community especially in the urban communities. Other studies have been conducted in areas with perhaps identical epidemiological and ecological situation and offer the best opportunity for comparison.

Prevalence of Malaria

In children aged between 2-9 years who were included in the study and examined for malaria parasites before intervention measures were applied in the study area, the prevalence rate of malaria was determined. Among the children who were examined 20% were found to have malaria parasites in their blood. This represented a prevalence rate of 20% among children in Magomeni community. This prevalence rate of 20% was similar to that reported by Temu (1984) among pregnant women attending MCH clinics in Dar-es-Salaam.

The prevalence rate revealed by this study was however, significantly lower than 48.9% reported previously by Ng'weshemi et. al. (1985) among the general population in Dar-es-Salaam and was also

significantly lower than the 60.3% reported by Kouznestov et. al. (1979) in North East Tanzania. In their observation, the study population consisted of children between 5-14 years old at the end of malaria transmission season while the study by Temu (1984) was on pregnant women who were on chloroquine prophylaxis. Matola et. al. (1982), found the prevalence rate of malaria among pregnant women and children under five years of age to be 60.4% in Muheza district, Tanga region. These results resemble those by Kouznestov et. al. (1979), and were much higher than those reported by Ng'weshemi et. al., (1985).

Furthermore in the study, similar children from the same area were followed up six months after intervention and their blood slides were taken and examined for malaria parasitaemia (Table (3b). Among the children examined 19.7% had malaria parasites in their blood. The comparison area is shown in (Table 4(a) and 4(b). The difference between the pre- and post-intervention prevalence rate of malaria is negligible and it was not statistically significant decrease (x^2 = 8.29 P = 0.012). The comparison group had a lower prevalence rate of malaria after a period of six months (Table 4(a) and 4 (b). This shows that there was a decrease in prevalence in the comparison group, although there were no intervention mesures applied.

There was no statistically significant fall in the prevalence of malaria six months after intervention

indicating that the reduction in malaria prevalence was not different after intervention.

The probable reasons for such results could be:

- Insufficient coverage either in space (too many houses left unsprayed) or time delay of spraying in between rounds, or too long intervals between rounds.
- Ineffectiveness of the insecticide applied either due to expiry or due to the use of low dose.
- Migration of both vectors and people from unsprayed area to the sprayed areas.
- Lack of proper supervision during the implementation of the project, this could have resulted in poor performance of the project.

The post-intervention prevalence of malaria obtained by this study six months after intervention when compared with other studies was different. Fontaine et. al. (1978), while evaluating Fenitrothion efficacy in Kisumu Kenya, reported the infant malaria prevalence rate of 53.3% before spray phase in the evaluating zone, and eventually the prevalence fell successfully to 19.9% three months later after the first spray, and later to 8.1% in six months and 4.7% in 9 months. This was statistically significant drop which indicated that there was a downward shift of one level of malaria endemicity to another. In his study, the population studied consisted of the general population and infants of the age between 0-11 months.

The results by Marijani et. al. (1986), revealed a crude parasite rate of malaria of 49.5% before Sumithion spray in two villages in Dar-es-Salaam region. After four spraying operations using Sumithion the prevalence dropped to 12.7%. Such a drastic fall in malaria prevalence could not only be attributed to the insecticide alone but also to some other factors which might have played a role. This could be substantiated by observing the results obtained from the control group, there was also prevalence rate fall although the area was not under spray. The initial malaria prevalence rate in the control area was 48% at baseline and 29% some months later. Climatic changes are thought to account for this difference.

Gandahusada et. al. (1984), on the other hand had results much lower than the ones revealed by this study. He observed an operational scale trial using fenitrothion in Java, Indonesia the vector population was reduced from 6.5% in January 1981 to 0.04% in September, 1982 in a period of about 18 months. He also noted that the Plasmodium index was reduced from 35.8% to 0% and was maintained at zero for 3 months. ($P<0.05$).

This study has also shown that parasite rate and parasite density index was high in both study and comparison groups before and after intervention as shown in (Table 5(a) and 5(b). The parasite rate of 20% and 48.6% was observed in the study and comparison

group respectively before intervention and 19.7% and 34.7% after intervention. The findings are much lower, than those reported by Matola et. al. (1983), while establishing the baseline data on the impact of Stiergler's Gorge Project on Malaria in Rufiji Basin. He found parasite rates of 60%, 70.8% and 54% during January/February and July/August 1981 and January/February 1982, respectively. The probable reasons why there was so much difference between results of this study and those of the Rufiji Basin Project could be that, this study was conducted in urban and semi-urban areas where the community living in these areas could have been using some methods to protect themselves from being bitten by mosquitoes, e.g.: use of mosquito nets, mosquito coils and screening their houses by mosquito gauze. Matola et. al. (1982), conducted their study in a typical rural area of Rufiji, which provide suitable habitats for mosquito breeding. Rufiji basin is well known for rice fields and flooded rice fields have been found to be suitable for breeding **Anopheles gambiae** especially if they are recently flooded and when the rice is low (Chandler et. al., 1975; Coluzzi, 1984).

Moreover, the parasite density index revealed by this study was much lower than the one reported by Matola et. al. (1983). Clyde (1961), found a malaria prevalence of 65.8% and a Parasite Density Index (PDI)

of 3.8 at the end of unusually dry season in the island of Mafia. This study showed the parasite density index of 1.00 and 1.12 before intervention in both study and comparison areas respectively. When these were compared with the post-intervention, parasite density index of 1.13 and 1.22 in both study and comparison area the difference is negligible. The differences in the results of this study and those of other workers could be explained by the difference in the study area and the population studied.

Interestingly, however, the results obtained from this study do not differ much from those observed in the Garki Project in West Africa by Molineaux et. al., (1980) and that of Najera (1974) also in West Africa. The study of Molineaux et. al. (1980), intended to demonstrate the powerful insecticide (Propoxur, (OMS_{33}) in interrupting malaria transmission in the dry savanna of West Africa. The insecticide was applied in an area and the area was divided into 3 sectors when the impact of spraying alone, or as supplemented by high and low frequency Mass Drug Administration (MDA) was assessed. Propoxur alone produced very limited impact on malaria, the vectorial capacity remained well above the critical level to maintain **P. falciparum** transmission and entomological inoculation rate remained at a measurable level. While Najera (1974) also demonstrated that

there was no interruption of malaria transmission or reduction of prevalence while using DDT spray in controlling malaria vectors in Northern Nigeria.

The present study has also revealed, with regards to splenometric indices, the spleen rate in the study area of 28.3% while comparison area had spleen rate of 36.9% before intervention. When these children were examined again six months later after intervention measures were instituted in the study area the spleen rates of both study and comparison groups dropped to 19.7% and 24.3% respectively. Although there was a decrease in the spleen rate after intervention was applied in the study area there was no statistically significant difference, before (X^2 = 3.29 $P<0.07$). Moreover, the study done by Matola et. al. (1983), revealed an overall spleen rate of 15.8% which happened to remain almost the same during all surveys in Rufiji basin. They observed that the age group of 12 - 13 months old showed the highest spleen rate which decreased with increased age. In the present study, this age group was not included, instead children between 2 - 9 years were studied. It has been observed that this is a high risk group for malaria that could be studied. Moreover this is the age group commonly used for spleen examination in most malaria studies as it best indicates malaria-related splenomegaly (Bruce-Chwatt, 1985).

In another study by Bryceson et. al. (1976), on splenomegaly in Northern Nigeria, people with enlarged spleens were investigated to establish the cause of splenomegaly. Tropical splenomegaly Syndrome (TSS) was found to be predominantly a disease of Fulani females in Nigeria. Its essential characteristics were splenomegaly in the presence of acquired immunity to malaria. In the present study, the author observed that out of those children who were found to have splenomegaly, before intervention in the study area a good proportion of them had malaria parasitaemia (table 7 (a, b, c, d) in both study and comparison groups. These results do not differ much from those reported by Fleming et. al. (1976), who observed that of the 22% of pregnant women who had splenomegaly in Nigeria 15% had malaria parasitaemia ($P<0.01$). This could be explained by the fact that heavy and repeated malaria infections, could cause splenomegaly (Fleming et. al., 1976; Matola et. al., 1983).

Entomological Survey

The entomological parameters evaluated in this study included the larval densities of **Anopheles** mosquitoes. Due to shortage of manpower and time constraints, the use of other entomological parameters such as window traps, spray catch, and human bait catches were not included in the study. However, other authors had made some observations using the

above parameters. In this study the author observed some changes in larval density in random selected breeding sites for **Anopheles** mosquitoes. It was found that larval density kept on falling in Magomeni from December, 1988, whereas in Pugu-Kajiungeni it was still high in December but also fell although not to the same extent from January to March. The expectation of the larviciding programme at Magomeni was to clear all the immature **Anopheles** mosquitoes in the breeding sites if the insecticide were effective and properly applied. Chinery (1969, 1970 and 1979) conducted longitudinal larval and adult house resting mosquito surveys in Ghana. The anti-larval measures he conducted of mechanical source reduction as well as larviciding using diesel oil. Results he obtained showed satisfactory control but there was expansion of breeding sites with marked increase in adult densities during rainy season. Fontaine et. al. (1979), in their finding in Kenya where Fenitrothion (Sumithion) 40% (E.C) larvicide was used as in Dar-es-Salaam control project observed a drastic change in larval densities of both **Anopheles gambiae** and **Anopheles funestus** adult population, and adult mosquito densities were virtually nil after the first round of spray.

In the Garki Project in West Africa where propoxur (OMS 33) was used as insecticide, it was observed that in the sprayed village there was a drastic reduction in the vector capacity (Molineaux, et. al., 1980).

In this study, larval densities were observed to gradually decrease in the study area but not to the same extent as in the other studies mentioned above. Information which was gathered during the course of study was that some of the breeding sites were not treated with larvicide which was supposed to be applied once every two weeks, as a result some breeding sites when surveyed were found to have a lot of larvae while others did not. These findings were later confirmed by the Project Manager (Personal Communication). He said that due to shortage of manpower and transport some areas were not treated with the larvicide, thus rendering the coverage to remain very poor.

More importantly in this study, the author made some observations which revealed some defects in management and supervision of the spraying operation as the possible cause of low coverage. Lack of health education and failure of spraymen to develop good relationship with city community were some of the weaknesses which were noted.

It was also noted that many city residents were not well informed about the whole project as a result there was very minimal cooperation between city residents and the project staff, during the implementation of the vector control project in Dar es Salaam. This could explain possible reasons why some of these results were not satisfactory. This statement

could be qualified by citing the results of Thavitong et. al. (1982), who investigated factors affecting public cooperation in DDT house spraying in which it was important in malaria control measures in Thailand. They noted that emphasis was placed on operational practice of spraying team and villagers were left without being incorporated, as a result the impact was not very much convincing.

Malaria Morbidity

On malaria morbidity pattern in Dar-es-Salaam, the author also investigated whether there was any change in the clinical malaria cases attending the health institutions in the study and comparison area. He noted that clinical malaria cases comprised 18.6% of all patients attending the outpatient treatment in this study before intervention, and six months later after intervention malaria cases constituted 16.9%. Although these results show some decrease in percentage, the decrease was not statistically significant. Therefore clinical malaria cases in these two areas did not differ much with other results available in the country (USAID, 1979; WHO/MOH, 1984; MOH, 1983).

The data available in the country are hospital-based but show that malaria is the leading cause of outpatient attendance and ranks very high as a cause of admission in the country. The number of clinical malaria cases observed in this study could have been

much higher than the observed ones, but other factors might have played a role rather than vector control measures. Such measures include Malaria chemoprophylaxis using chloroquine and amodiaquine by the vulnerable groups and use of protective measures such as mosquito coils, nets and gauze.

8. CONCLUSIONS AND RECOMMENDATIONS

This study has shown that the post-intervention prevalence of malaria in the study area in Dar-es-Salaam was 19.7% while the pre-intervention prevalence was 20%. However, the study has failed to find evidence to support the Null-hypothesis which expected prevalence rate reduction from one level of endemicity to a lower level of malaria endemicity. Unlike Fontaine et. al. (1979), who reported the infant malaria prevalence rate of 53.3% before spraying and then 19.9% three months after first spraying.

It has been demonstrated in this study that spleen rates of children aged 2 - 9 years who were included in the study, before and after intervention did not show any statistically significant difference.

This was compared with the finding of the comparison group which showed a similar picture.

Another important finding seen in this study was that larval densities after application of 50% (EC) in all possible breeding habitats for **Anopheles** mosquitoes kept on falling in Magomeni from December 1988, whereas in Pugu-kajiungeni it was still high in December but also fell although not to the same extent from December to March.

The study has also not been able to show that the number of patients who were diagnosed as cases of clinical malaria in study area after intervention were

fewer than before intervention. Malaria constituted a high proportion of all outpatient attendances. Thus if malaria constitutes such high percentage, then it is obvious that malaria is a major public health problem in Tanzania.

Recommendations

1. Malaria Control project in Dar-es-Salaam will take a period of five (5) years initially, therefore, similar study should be repeated after every two years with probably much bigger sample size so that results obtained can be compared before introducing the vector control measures nationally.
2. Longitudinal or a cohort study should be done rather than two cross-sectional studies. This will enable the same children to be followed up for a certain period of time and see whether there will be a significant changes in malaria prevalence.
3. Community awareness about the vector control measures should be encouraged through intensive health education campaigns using mass media, adult education classes and schools.

4. Research into social and administrative factors which have contributed to the failure of the programme should be conducted so that such factors can be identified and rectified.

5. The efficacy of the larvicide (50% Fenitrothion) used in the control of immature stages of Anopheles mosquitoes should be tested in order to certify its chemical potency. This is necessary as it has been shown that the chemical has proved to be effective elsewhere.

6. Vector control measures using insecticides should go hand in hand with other methods of control e.g. environmental modification and manipulation. These methods were not given equal priority in the programme.

9. SUMMARY

The study on the impact of vector control measures on epidemiology was conducted in Magomeni area in Dar-es-Salaam between the months of October, 1988 and April 1989. The main objective of the study was to determine the prevalence of malaria before and after the introduction of the vector control measures and the effectiveness of these intervention measures of the malaria control programmé at Magomeni.

The study involved determining the prevalence rate of malaria by parasite and spleen rates is children aged between 2 - 9 years old, living in the study area (Magomeni) and comparing it to the control area (Pugu-Kajiungeni). The pre-intervention and post-intervention prevalence was determined in October, 1988 and April, 1989 respectively, a period of six months apart.

The study revealed that the overall malaria prevalence in Dar-es-Salaam was 30%, while the prevalence rate in the study area before intervention was 20%. Six months later, after intervention, the prevalence was 19.7%.

The comparison area had baseline prevalence of 48.6% while six month later the prevalence was 34.7%. The study also revealed that the overall spleen rate was 24% in the study area and 30.5% in the comparison

area. As for the spleen rates of children living in the study area, this was 28.3% before intervention and 19.7% six months later, i.e. after intervention. In the comparison area the spleen rate was slightly higher.

There was a relationship between those children found with splenomegaly and malaria parasitaemia. Out of those with splenomegaly 72% had also malaria parasitaemia.

Most of the children who had splenomegaly were falling under classification number one, according to Hackett's classification.

Malaria parasite species observed was that of **Plasmodium falciparum** in both the study and comparison areas.

The study showed that clinical malaria patients who were attending the outpatient treatment in the health institution in the study area and comparison areas constituted the highest percentage of the out-patients.

However, the study showed that **Anopheles** larval densities in the breeding sites in the study area were still high although there was an application of 50% (EC) fenitrothion as larvicide.

The study, therefore failed to support the Null-hypothesis that the prevalence of malaria would drop from a higher level of malaria endemicity to the next lower level after six months of anti-vector operations.

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