TITLE: ESTIMATING THE LEVEL OF MALARIA TRANSMISSION IN NAIROBI AMONGST THE PAEDIATRIC AGE GROUP

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DECLARATION

I hereby certify that this dissertation is my own original work and has not been presented for a degree in any university

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DEDICATION

To my parents:

Aaron K.Kamoing and Rebecca C. Kamoing

To my sisters and brother

Caroline Chepkemoi, Susan Chepkirui and Eric Kipngetich.

ACKNOWLEDGEMENT

1. To my supervisors who were a great inspiration to me.
2. To the Kenyatta Hospital, Mbagathi Hospital and City Council.
3. To the Walter Reed Project and the Laboratory staff.
4. To my assistants Irene Mbugua Wambui and Joseph Wambui Gatura who worked selflessly to see to the completion of the study.
5. To Florence Wamucii, Naima Wangare and Dan Korir for their handy assistance.
6. To Judy Omumbo using Map-info software provided the maps in the appendix.
7. To all the others who in one way assisted and are not mentioned above.

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SUMMARY

AIM OF STUDY: To estimate the level of transmission of malaria in Nairobi by using the malaria parasite rate in children, presenting with fever or history of fever. Nairobi is classified as 'malaria-free' but anecdotal reports have suggested that malaria transmission was occurring in Nairobi.

PERIOD OF STUDY: November 17,1998 - January 18,1999.

STUDY SITE: All government health centers offering curative services in Nairobi

METHODOLOGY: This was a cross sectional study. 1481 children, aged 0-13 years, presenting to the study health facilities with fever (temperature τ 37.5 degrees centigrade) or history of fever were recruited. Unaccompanied children were excluded. The parent or guardian was interviewed using standard questionnaire that collected information on age, sex, tribe, residence, travels and blood transfusions. Blood smears for malaria parasites were made and slide reading was done by two independent malaria slide readers at the Walter Reed Projects in Nairobi and Kisumu. Children with non-travel outside Nairobi in the three months pr or to the interview were considered to have acquired malaria in Nairobi if the blood smear results were positive. Children with no history of travel outside Nairobi in their lifetime provided stronger evidence for malaria transmission in Nairobi.

RESULTS: The overall prevalence of malaria was 11.2%. Fifty-six (33.7%) of the 166 cases of malaria were seen in children with no history of travel in the past three months. Thirty one (18.7%) of the malaria cases were seen in children with no travel in the past one-year. Twenty-three (13.9%) of the malaria cases were seen in children with no history of travel in their lifetime. The parasite rates calculated using children with non-travel in the previous three months, one-year and lifetime was 6.2%, 4.8% and 4.4% respectively. There was a strong association between travel outside Nairobi in the previous three months and malaria. The risk ratio being 3.02 for an outcome of positive malaria slides if there was travel in the past three months. Age differences were noted in the parasite rates for children with no travel in the past three months with peak prevalence in the 5-10 years age group (13.2%). No statistically significant differences were noted in the parasite rates for the different divisions of Nairobi for children with non-travel in the past three months, past year or lifetime. Certain divisions, however

showed higher prevalence of malaria compared to others e.g. Kibera (9.5%),Dagoretti (8.2%) and Central division (0%).

CONCLUSION AND RECOMMENDATION: There is evidence for hypoendemic malaria transmission in Nairobi with possible differences in transmission for the different Divisions in Nairobi. There is need for malaria survey in Nairobi to include entomological survey to quantify malaria transmission and plan malaria control efforts.

INTRODUCTION AND LITERATURE REVIEW

Malaria is an important parasitic infection caused by protozoa of the species *plasmodia*. It kills one to two million children per year (1). There has been a 2-3-fold increase in malaria cases in the past 10 years and presently there are 150-300 million cases of malaria per year in the world (1,2).

The outpatient morbidity data for 1995 in Kenya showed that malaria was among the leading causes of the outpatient morbidity and mortality, accounting for 29.35% of all new diagnoses. Malaria is the single most common condition among reported causes of hospitalization contributing to 18.5% of the total hospitalization. Regional differences occur in the epidemiology of malaria in Kenya (3-6).

Statistics from Kenyatta National Hospital Records Department for the year 1997 show that 1,146 cases of malaria were diagnosed in children aged 0-15 years. Of these a total of 146 patients died giving a case fatality rate of 12.7 % (7). Some cases were diagnosed clinically and some were proven by blood slide examinations though the exact proportions were not evident from the data provided.

Losses attributable to malaria are not easily quantifiable but may be significant. These losses include death and recurrent poor health leading to decreased growth, poor concentration and frequent school absences for children. Parental absence from their work place leads to a loss of income as the parent is forced to care for the sick child.

The serious forms of malaria (e.g. cerebral malaria) have a mortality that has not changed in the past thirty years. Drug resistance has been noted for all available anti-malarials in Kenya with varying proportions (8). The levels of resistance vary from 13% for *Pyrimethamine/sulfadoxine* combination and up to 80% for *Chloroquine* in various parts of the country ((9).

Nairobi is the capital city of Kenya and is situated in the edge of the East African highlands at 1^0 16' 43" South latitude and $36^0$50" East longitude. It has approximately 2.1 million inhabitants' (2). Children under 15 comprise 38.3% of the population.

At an altitude of 1,650-1,750 meters above sea level, the temperatures vary from 18 –25° C with a mean of 23 degrees centigrade. The average annual rainfall is 800 mm of rainfall with a relative humidity of 60 –70 % (12).

More than half of Nairobi is low lying and generally has poor drainage. The main river is the Nairobi River, which passes through the city, and other numerous streams are to be found. Numerous slum dwellings are found that house more than half of the city population.

Traditionally in Kenya, malaria has been associated with the Coastal and Lake Basin region. Patterns of malaria transmission may be changing (10-13). Many highland areas, which were found to be free of malaria when early Europeans settled in Kenya, are now reporting regular epidemics (14-17). Malaria transmission in Nairobi has been reported to occur in epidemic pattern but this may also be changing (18).

Nairobi is classified as malaria–free (19,68), being excluded from malaria transmission because of the lack of fringe holoendemic areas, its high altitude and low mean temperatures associated with it (16,20). The upper altitude limit for malaria varies for different parts of Africa. The upper limit is thought to be 1500 meters above sea level in Kenya (21-24).

Residents of Nairobi could be susceptible to malaria because of the following reasons

- There are a large number of non-immune children (25,26).
- The rural to urban migration that has increased the number of infective reservoirs (the immigrants) who may be asymptomatic and yet carrying highly infective gametocytes in their blood (17,27).
- Given the sufficient rainfall for the production of vectors, it is accepted that atmospheric conditions necessary for the transmission of malaria in Nairobi are

nearly always satisfied (28). The life cycle of all species of malaria parasites is similar (29). The essential atmospheric conditions for transmission of malaria is, a relative humidity of at least 60% and temperatures not lower than 18° centigrade (12). Microclimates such as those found in houses, rocks, crevices, and vegetation clumps are important in providing more favorable temperatures and humidity during periods of adverse weather for sporogonic development (29).

- Climatic changes such as global warming and the El Nino phenomenon, which have affected Nairobi favor vector breeding and malaria transmission (3,33-40)
- Increased deforestation and other agro-forestry developments that increase breeding sites for Mosquitoes has occurred (30-33).

Determining the occurrence of malaria transmission may be difficult. Transmission is proved when parasites that develop in a female anopheles are found to cause malaria in the human host. This has been shown in western Kenya where studies involving overnight capture of mosquitoes that have bitten volunteers are then dissected to evaluate the DNA sequence in the sporozoites on the mosquito's salivary gland. Two weeks later when the human host develops malaria the trophozoites are then sequenced genetically to match those isolated from the mosquito (29).

Malaria survey, involve the evaluation of the amount and conditions of transmission of malaria. This precedes any attempts to control malaria in a given area. The malaria survey proper involves investigation under the following headings:

- Collection of existing environment and epidemiological data.
- Investigations relating to the human host.
- Investigations relating to the insect vector.

To obtain general knowledge of the epidemiological situation, information is acquired regarding morbidity and mortality, vital statistics, meteorological, topographical and other relevant features.

Investigations relating to the human host require

- *Spleen examination*: The spleen rate is the proportion of enlarged spleens in the indigenous population. This is a crude measure that is not useful where there is widespread use of anti-malarials by the community. It also applies to populations that have been resident in a particular area for prolonged periods and is measured in children aged 2-10 years. It generally does not give useful information in an urban setting.
- *Blood examination*: The parasite rate is the proportion of blood films positive for malaria parasites in the indigenous population. In high transmission areas the morbidity contributed by malaria to febrile illnesses is higher than 75% whereas in areas of low transmission, malaria contributes to less than 10% of the febrile illness. This provides an indirect measure to the level of malaria transmission.

The following age grouping is the one recommended by WHO (1964) in classifying malaria endemicity.

Group	**Description**
0-11 months	Infants
12-23 months	Toddlers
2-4 years	Small children
5-9 years	Juveniles
10-14 years	Adolescents
15 years and over	Adults

The infant parasite rate is of special importance as it is a good indicator of recent transmission (69).

The maximum prevalence of malaria is usually reached fairly quickly during childhood – before the age of two years in holoendemic areas, between two to four years in hyperendemic areas and between five and nine years in the mesoendemic and hypoendemic areas. The only acknowledged exception is epidemic malaria where classically all age groups are uniformly affected. Even in this case it is not rare to find higher prevalence in children (70).

A proposed classification of malaria endemicity involves using parasite rates of the indigenous population (69-74).

Degree of endemicity	**Range of parasite rate**
Hypoendemic malaria	less than 10%
Mesoendemic malaria	11-50%
Hyperendemic malaria	50-75%
Holoendemic malaria	over 75%

There is no fully satisfactory method of expressing in an arbitrary way the dynamics of malaria transmission. Quantitative methods, which estimate the vectorial capacity and the subsequent risk of infection, come closest to such an appraisal. These are carried out in entomologic studies, which are expensive and require evidence that suggests malaria transmission is occurring in given area before they can be carried out (69).

More complex methodologies have been used to study malaria transmission. This has included satellite observations and mathematical models used to predict malaria transmission based on climatic patterns. All these have been in an attempt to understand malaria transmission patterns. The data obtained are more useful in preparing for larger scale malaria eradication or reduction programs (43-46).

It is therefore difficult to prove malaria transmission, but investigations outlined earlier relating to the human host may provide evidence that suggests transmission of malaria in a given area.

Urban malaria is characterized by autochthonous (locally transmitted) and imported malaria because of the high mobility of urban populations. Many of the malaria cases seen in Nairobi are those acquired most likely from the high malaria transmission areas of the country as noted by Rapuoda (42,51).

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The geographical site of malaria transmission in the human host may be difficult to determine. The available tool is the history of travel. This takes into account the incubation period of malaria after an infective bite. The minimum incubation period for *P falciparum* is 9-14 days, *P malariae* 18-40 days *P vivax* 12-17 days and *P ovale* 16-18 days (13). Non-travel for duration of three months is considered adequate for malaria symptoms to develop in all infected individuals this implies that malaria transmission has most likely occurred locally in Nairobi if there is non-travel in the three months prior to obtaining a smear for malaria parasites in the patient. Noted exceptions occur when malaria is caused by *P vivax* in which relapses of malaria occur, when ineffective anti-malarials are used prolonging the incubation or appearing as recrudescence and when immune children harbour parasites and the child is asymptomatic (26). Parasite rates in children with non-travel in previous three months will give a close estimate of the true prevalence of malaria in the indigenous population (26,27).

Anopheles mosquitoes are not usually found more than 2-3 km from their breeding places in large numbers. However strong winds may carry anopheles upto 30km or more. Dispersal is either active by flying or passive by carriage of the mosquito by any other means other than insect wings e.g. planes, trains e.t.c and result in the anopheles being found far from their place of origin (47,48). These may contribute to a series of cases of imported malaria in the city.

There is anecdotal evidence of malaria transmission in areas that surround Nairobi e.g. Thika, Athi River, Ongata Rongai and Ngong townships. Mapping the distribution of documented cases will be of value in attempting to determine the source of malaria.

STUDY JUSTIFICATION

The magnitude of malaria transmission in Nairobi's children is not clear. Malaria cases seen in Nairobi are largely believed to be acquired outside Nairobi in malaria endemic areas. Malaria remains a leading cause of morbidity and mortality in Nairobi (52).

There is anecdotal evidence of increased cases of malaria in children in Nairobi who have not traveled out of Nairobi in the previous six months though Nairobi is classified as malaria -free. It is clear that active malaria vector eradication programs have largely stalled and breeding grounds of the vector in Nairobi have increased e.g. stagnant waters in quarries, pools of water, e.t.c. The housing in Nairobi has encouraged a lot of slum dwellings and households that are not well aerated and are suitable for the vector during its resting period.[7]

Weather patterns have changed as evidenced by the recent El Nino rains and global warming has occurred. This has led to suggestions that malaria is now being transmitted in Nairobi because climatic conditions in Nairobi appear to be satisfactory for the transmission of malaria through most of the year.

This study aims at determining whether or not transmission of malaria occurs in Nairobi and if so, of what magnitude. This information will be vital in establishing whether or not malaria control programs need to be intensified and whether prevention should be recommended to travelers entering the city.

The outcome of the study may also affect the management of fevers seen in children in Nairobi. If there is evidence for malaria transmission in Nairobi then malaria should be considered a differential diagnosis in children who are considered to have no risk factor of having traveled to a malaria-endemic area.

AIMS AND OBJECTIVES

1. To determine what proportion of children presenting with fever or history of fever to the government health facilities offering curative services have malaria.
2. To determine what proportion of these malaria cases were acquired in Nairobi.

SPECIFIC OBJECTIVES

1. To describe age and sex distribution of children studied.
2. To describe the origin (residential area) and the tribes of the study subjects.
3. To determine the parasite rate for the different age groups in children who have not traveled in the past three months.
4. To compare the parasite rates in children who have not traveled outside Nairobi in the past three months, past one year and in their lifetime

MATERIALS AND METHODOLOGY

STUDY DESIGN:
This was cross sectional study.

PERIOD OF STUDY
The study was conducted between 17th November 1998 and 18th January 1999.

STUDY AREA:
Kenyatta National Hospital, Mbagathi District Hospital and all the City Council health centers offering curative services at the time of the study

SOURCE POPULATION:
The estimated population of Nairobi is 2.1 million with 38% aged less than 15 years. 48.3% of the population live in urban slums. The study subjects were drawn from the patients aged 0-13 years attending the above health institutions in Nairobi.

STUDY POPULATION:

Inclusion Criteria:

1. Children presenting to the study health facilities with fever (temperature τ 37.5 degrees centigrade) or a history of fever.

2. Children aged 0-13 years whose parents gave informed consent for their inclusion in the study.

Exclusion criteria:

1. Unaccompanied children.
2. Where parental consent was not given.

A Malaria case was defined as a child with at least one positive blood slide for malaria presenting with fever or a history of fever. Six negative slides were required to declare child malaria negative.

For the purposes of this study a child with malaria and no travel outside Nairobi three months prior to the time of interview was considered to have acquired the infection in Nairobi. Whereas children who had history of travel outside Nairobi in the three months prior to being interviewed were considered to possibly have acquired the malaria infection outside Nairobi.

SAMPLE SIZE CALCULATIONS

A large sample was obtained for statistical inference. The assumptions made were

1. A prevalence of malaria of 14.2% as found by Kamiya in a cross-sectional survey of malaria in children under 5 years in Kibera, Nairobi
2. A 95% confidence level.
3. Power of 80%, in a cross-sectional survey where the exposed to the unexposed was taken in a 1:1 ratio. The exposure being travel outside Nairobi in the three months prior to the interview.
4. Odds ratio = 1.5

The minimum sample calculated using EPI INFO version 6.04C.was 1440.

ETHICAL CONSIDERATIONS:

Taking blood samples for malaria parasites is an invasive procedure. Informed consent was obtained from the participants before recruiting them into the study. Approval to carry out the study was obtained from the Kenyatta National Hospital ethical committee, The office of the president research division and the office of the Medical officer of health in the City Council

Clinical management of these patients was the responsibility of the attending clinician. Results of the blood slides and of the study were relayed back to the patients and the health facility.

STUDY TOOLS

These included a questionnaire that obtained the social and demographic information and relevant clinical information, consent forms, gloves, glass slides, transport medium sterile lancets sharps disposable containers.

PROCEDURE

A list of all the health centers offering curative services was obtained from the Assistant Medical officers of heath, Nairobi city council. The investigator then drew a rotational roster of visiting the health centers to include the two other government hospitals in the city i.e. Kenyatta Hospital and Mbagathi District Hospital offering curative services. The rest of the city council facilities were dispensaries offering mainly maternal and child health services. Many health centers had been closed for renovation purposes.

The investigator and research assistant handled one health facility daily. Every weekday between 8:00 am and 1:00 p.m., they carried out the data collection. The parents of the first ten children on the queue were interviewed and recruited. These were the first 10 who gave consent and fulfilled the inclusion criteria. Using a pre-tested questionnaire the parent was interviewed this child's temperature taken and a finger prick made on the 2nd or 3rd fingers of the left hand. Six thick and thin blood films were then prepared and allowed to air dry.

The prepared blood films were taken to the Walter Reed Army laboratory-KEMRI in the afternoon of the same day for reading.

The results were collected either in the evening or the next day and returned to the health facility.

The parents /guardian of the child had been instructed to come for the results the following day. When the child required referral to another center, then the results were forwarded to that center. The responsibility of the management of the patients was left to the attending clinician.

The slides were sent for the second slide reading at the Walter Reed Laboratories in Kisumu. This was done to provide a quality control of the slide reading done in Nairobi.

A definite diagnosis of malaria was established on finding malaria parasites in blood. The malaria case was defined as a child with a positive blood slide for malaria parasites and having fever of greater than 37.5°C. The six thick and thin blood films were made on clean slides.

Thick films were stained with Field's stain and the thin smears were stained with Leishman's stains. The value of the thick film was its high sensitivity, while that of the thin film will lie in the identification of the parasite species. The films were examined quantitatively and 200 fields examined before declaring a malaria slide as negative.

Microscopic diagnosis is only as reliable as the competence of the workers who prepare and examine the films. Thus the films were prepared and examined by two technologists at each location in Nairobi and Kisumu. They are full time malaria slide readers and between them, they have at least ten years experience. They read up to 1200 slides for malaria parasites per month and are subjected to an aptitude test every six months. They are aware that some of the slides they read are sent for a second read.

As a means of quality control, all the slides were read in Nairobi and Kisumu conflicting were read by a third slide reader aware of the conflicting results and who's verdict was taken as final.

DATA MANAGEMENT

Data was entered into a computer and analyzed using EPI INFO VERSION 6.04C software. Frequencies of various parameters were obtained. These included socio-

demographic characteristics, the prevalence of malaria in febrile children or those with history of fever presenting to the government health facilities offering curative services in Nairobi and Nairobi acquired malaria. Significance of travel to the contribution of malaria cases seen in the city was assessed. Tests of significance were done using chi-square or Fischer's exact tests as appropriate. Results are presented in pictorial charts and graphs and tables.

STUDY LIMITATION

1. The travel history was based on recall. Recall bias was therefore difficult to eliminate completely.
2. Not all city council clinics offering curative services were open hence selection bias was not eliminated.

RESULTS

A total number of 1481 children were recruited into the study of whom 682 (46.0%) were girls and 799(54.0%) were boys.

Five hundred and forty five (36.8%) of the children were febrile at the time of the interview but all volunteered a history of fever ranging from one day to two weeks with a mean of 4 days duration.

The number of children studied from each of the health facility visited is shown in table 1

TABLE 1. The number of children studied from the health facilities visited.

HEALTH FACILITY	SUBJECTS	PERCENT OF TOTAL
DANDORA HEALTH CENTER	148	10.0%
JERICHO HEALTH CENTER	125	8.4%
KAHAWA HEATH CENTER	138	9.3%
KANGEMI HEALTH CENTER	129	8.7%
KENYATTA HOSPITAL	123	8.3%
LANGATA HEALTH CENTER	119	8.0%
MATHARE HEALTH CENTER	113	7.6%
MBAGATHI DISTRICT HOSPITAL	131	8.8%
NGAIRA HEALTH CENTER	116	7.8%
PUMWANI HEALTH CENTER	119	8.0%
RIRUTA HEALTH CENTER	104	7.0%
UMOJA HEALTH CENTER	116	7.8%
OVERALL TOTAL	**1481**	**100%**

The ages of the children were regrouped into the infants (0-1 years), toddlers (1-2 years), young children (2-5 years), juveniles (5-10 years), and the adolescents (10-14 years)

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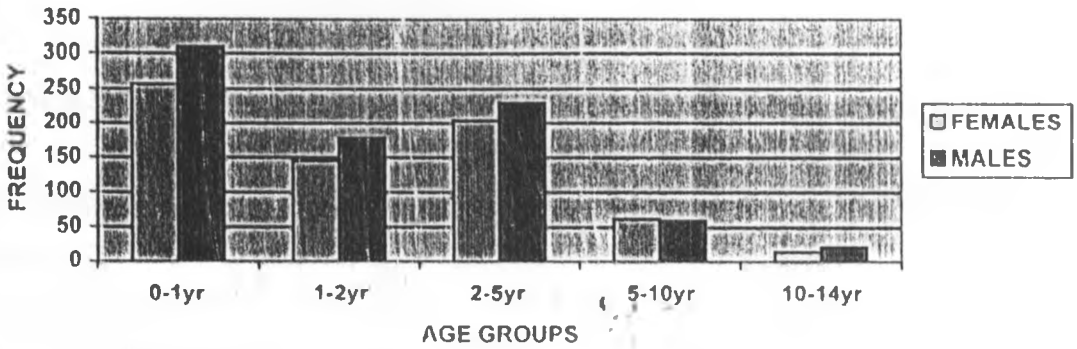
according to the WHO recommendation (1963) for the purposes of a malaria survey. This was done for the purposes of calculating age specific parasite rates and obtaining the infant parasite rate an indicator of a recent malaria infection. The age distribution amongst the two sexes was similar. The age, sex differences were not significant (chi-square = 2.01 d.f =4 p=0.73). The age and sex distribution of the study subjects is shown in figure 1.

Figure 1: The age and sex distribution of the children studied



More than 90% of the children studied were children from the Kikuyu, Luo, Luhyia and Kamba ethnic groups. The distribution by tribe is presented in table 2.

TABLE 2. Distribution of the children studied by tribe.

TRIBE	SUBJECTS	PERCENT OF TOTAL
KIKUYU	465	31.4%
LUO	407	27.5%
LUHYIA	298	20.1%
KAMBA	170	11.5%
KISII	55	3.3%
OTHERS	86	5.8%
OVERALL	1481	100%

The origin of the children by residential area were then regrouped into their origin by sublocation which is the smallest administrative unit. Their origin by sublocation was subsequently regrouped into origin by division. This was done because the numbers of children regrouped by origin of sublocation and location were too few for any meaningful analysis and the differences in the ecology of the divisions was felt sufficient to give an estimate for the areas studied. Mapping by division also facilitates possible future malaria surveys and other administrative action. The origin by division is shown in table 3.

TABLE 3 Residential area of the children studied by division

DIVISION	SUBJECTS	PERCENT OF TOTAL
CENTRAL	30	2.0%
DAGORETTI	215	14.5%
EMBAKASI	306	20.7%
KASARANI	309	20.9%
KIBERA	254	17.2%
MAKADARA	127	8.6%
PARKLANDS	60	4.1%
PUMWANI	180	12.2%
OVERALL TOTAL	**1481**	**100%**

Travel history indicated that 1057 (71.4%) of the 1481 children had not traveled outside of Nairobi in the one-month prior to the interview. Eight hundred and ninety-nine (60.7%) had not traveled outside the city the three months prior to the interview, 648 (43.8%) had not traveled outside the city in the past 1 year prior to the interview and 528 (35.7%) had never traveled outside the city in their lifetime.

One hundred and forty four (9.7%) of the parents volunteered information that they had given their children an anti-malarial medication in the month prior to the interview.

Thirty-five (2.4%) children had received a blood transfusion at any time in their lifetime. All except one child had received a blood transfusion five months or more from the time of interview. The one child had received the blood transfusion during the same month of the interview

The overall prevalence of malaria (smear positive) amongst the children presenting with fever or a history of fever was 11.2%(166/1481) with a gametocyte rate of 7.2%(12/166) in the smear positive cases

P. falciparum was seen in 163(98.2%)of the 166 smear positive cases, *P. malariae* in 2 (1.2%) of the cases and a mixed infection of *P. falciparum* and *P.malariae* was seen in 1 (0.6%) of the cases.

The malaria slides read in KEMRI-Nairobi found that 168 slide were smear positive for malaria parasites whereas those read in KEMRI-Kisumu found 165 of the slides were smear positive. The three slides that were conflicting were referred to a third slide reader also employed by the Walter Reed Army whose decision was considered final. Two of the slides read in KEMRI-Nairobi were reported to be artifacts and were reported as negative.

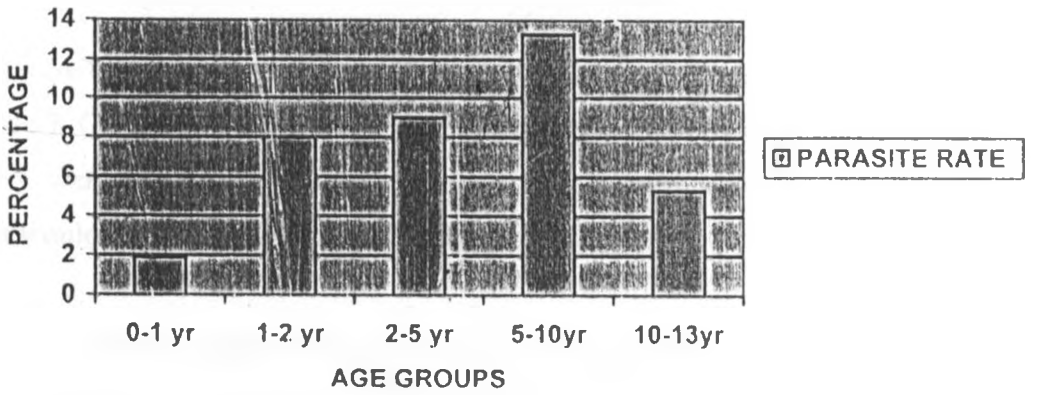
For the purposes of the study, the 899 children with no history of travel outside Nairobi in the three months prior to the interview were considered to have acquired the malaria infection in Nairobi if the malaria smear turned out to be positive. Parasite rates, for the different age groups, and residential origin by division in this subgroup were analyzed.

The parasite rate for children with no travel in the past three months was 6.2% (56/899). 32 (57.1%) of the malaria cases in this subgroup occurred in the females. There was no significant difference in the parasite rates among the two sexes (chi-square=2.33 OR =1.53 95% Confidence limits 0.89< OR <2.74 P=0.12)

The parasite rates in the different age groups was 1.9% (7/365) in infants, 8.0% (14/174) in toddlers, 9.0% (24/266) in young children, 13.3% (10/75) in juveniles and 5.3% in adolescents. An increase in parasite rate was noted with an increase in age in a linear fashion up to the age group 5-10 years, followed by a sharp decline in the 10-14 years age group, as shown in figure 2. The highest parasite rate being 13.3% in the 5-10 years bracket. The infant parasite rate was 1.9%. This was the lowest parasite rate among the different age groups. There were significant differences in the parasite rate among the 5 different age groups (chi square = 21.39 d.f =4 $p<0.001$).

The parasite rate in the different age categories is indicated in figure 2.

Figure 2: Parasite rates for the different age groups in children with no travel outside Nairobi in the past three months



When the origin of the children by division was considered in this subgroup, there were no significant differences in the parasite rates for the different Divisions of origin (chi-square = 9.51 d.f. = 7 $p=0.21$). The highest parasite rates were recorded in Kibera and Dagorretti divisions with parasite rates of 9.5% and 8.2% respectively, whereas, no cases were recorded in central division. Most of the divisions had a parasite rate of around 5-7%. The parasite rates for the different divisions are given in table 5.

The parasite rates in the different age groups was 1.9% (7/365) in infants, 8.0% (14/174) in toddlers, 9.0% (24/266) in young children, 13.3% (10/75) in juveniles and 5.3% in adolescents. An increase in parasite rate was noted with an increase in age in a linear fashion up to the age group 5-10 years, followed by a sharp decline in the 10-14 years age group, as shown in figure 2. The highest parasite rate being 13.3% in the 5-10 years bracket. The infant parasite rate was 1.9%. This was the lowest parasite rate among the different age groups. There were significant differences in the parasite rate among the 5 different age groups (chi square = 21.39 d.f =4 $p<0.001$).

The parasite rate in the different age categories is indicated in figure 2.

Figure 2: Parasite rates for the different age groups in children with no travel outside Nairobi in the past three months

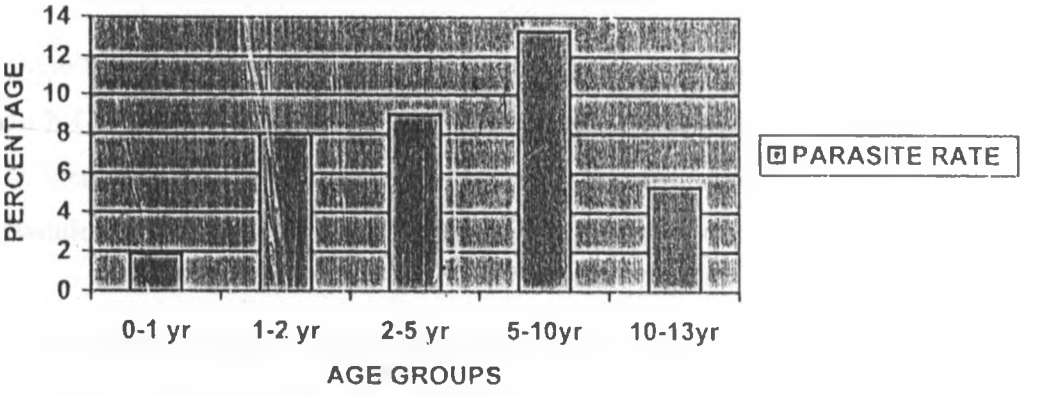


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TABLE 5 Parasite rates by Division of origin in children with no travel in past three months.

ORIGIN BY DIVISION	SUBJECTS	PARASITE RATE
CENTRAL	21	0.0%
DAGORETTI	134	8.2%
EMBAKASI	169	2.4%
KASARANI	209	6.7%
KIBERA	148	9.5%
MAKADARA	68	5.9%
PARKLANDS	42	4.8%
PUMWANI	108	6.5%
P value Division VS Results		P = 0.21
OVERALL TOTAL	**899**	**6.2%**

Parasite rates were then calculated for the different divisions on the basis of travel. This is shown in Table 7. Children with similar histories of travel were compared. This was done to see if there were any significant differences in the parasite rates for the different divisions that would imply probable foci of higher transmission.

For all the 1481 children studied, without considering travel, the highest parasite rates were seen in children from the Kibera and Makadara divisions where parasite rates recorded were 18.4% and 14.2% respectively. The lowest parasite rates were seen in the central division where no cases of malaria were recorded. There was a significant difference in the parasite rate for the different divisions of origin of the child in this group (chi square = 23.57 d.f =7, $p<0.001$).

It was observed that the parasite rates for all the divisions' fell to lower than 10% for all the divisions of Nairobi when children who had traveled outside Nairobi between the time of interview and the three months preceding the interview were excluded. There was no significant difference in parasite rates for the different divisions for children with no travel in the past three months, past one-year and their lifetime (chi-square = 9.51, d.f. =

7, p=0.21: chi-square = 8.21 d.f. =7 p=0.31 and chi-square = 11.97 d.f =7 p=0.1 respectively).

Parasite rates were then calculated for the children with different categories of travel as shown in table 8. This was done to see if malaria was associated with travel and to obtain the different parasite rates for children with no travel outside Nairobi in the different categories of travel inquired. The parasite rates obtained would be compared to see if a wide variation existed for children in whom travel history indicated that the malaria was acquired in Nairobi i.e. those who had not traveled outside Nairobi in the previous three months, past year or in their lifetime.

TABLE 7 Parasite rates by history of travel.

DIVISION	OVERALL	NO TRAVEL PAST THREE MONTHS	NO TRAVEL PAST ONE YEAR	NO TRAVEL OVER LIFETIME
CENTRAL	0%(0/30)	0%(0/21)	0%(0/16)	0%(0/14)
DAGORETTI	11.6%(25/215)	8.2%(11/134)	8.6%(9/105)	8.2%(7/85)
EMBAKASI	8.5%(26/306)	2.4%(4/169)	0.6%(1/113)	0.9%(1/106)
KASARANI	8.4%(26/309)	6.7%(14/209)	5.3%(9/170)	6.5%(9/138)
KIBERA	18.4%(47/254)	9.5%(14/148)	5.4%(5/92)	1.5%(1/67)
MAKADARA	14.2%(18/127)	5.9%(4/68)	4.4%(2/45)	0%(0/33)
PARKLANDS	10.0%(6/60)	4.8%(2/42)	3.4%(1/29)	3.7%(1/27)
PUMWANI	10.0%(18/180)	6.5%(7/108)	5.1%(4/78)	6.9%(4/58)
P value Division VS Results	P = 0.001	P =0.21	P = 0.31	P = 0.1
TOTAL AV.	**11.2%(166/1481)**	**6.2%(56/899)**	**4.8%(31/648)**	**4.4%(23/523)**

TABLE 8 Parasite rates for the children with different categories of travel

TRAVEL	YES	NO
PAST MONTH	21.5% (91/424)	7.1% (75/1057)
PAST THREE MONTHS	18.9% (10/582)	6.2% (56/899)
PAST YEAR	16.2% (135/833)	4.8% (31/648)
LIFETIME	15.0% (143/953)	4.4%(23/528)

It was observed that the highest parasite rates were seen in children who had traveled outside Nairobi one month prior to the interview 21.5 % (91/424). Travel outside Nairobi in the previous one month was associated with a higher likelihood of a positive smear for malaria. Significant differences were noted in the parasite rates between children who had traveled outside Nairobi in the past month compared to those who had not (odds ratio =3.58 95% confidence limits 2.53<OR>5.06 p<0.001). The parasite rates for children with non-travel outside Nairobi in the past three months, past year and in their lifetime did not vary widely and was 6.2% (56/899), 4.8% (31/648), and 4.4% (23/528) respectively.

Twenty-three (13.9%) of the 166 malaria cases were seen in children with no history of travel outside Nairobi in their lifetime. Thirty-one (18.7%) and 56 (33.7%) of the malaria cases was seen in children with no travel outside Nairobi in the previous one year and previous three months respectively.

One child (0.6%) of the 166 children with malaria parasites had received a blood transfusion in the same month of the interview.

The mapping of the cases is shown in the appendix D-G.

DISCUSSION

In this study the overall malaria parasite rate was 11.2% for children presenting with fever or history of fever to the government health facilities offering curative services in Nairobi. Kamiya, in a malaria prevalence study carried out in Kibera (Nairobi) involving children under five years irrespective of their health, found a parasite rate of 14.2% (50). Rapuoda, however, found a parasite rate of 3.9% in a study that involved adults irrespective of their health status (51). This may reflect the different subjects and methodologies used in the studies, though both were malaria prevalence studies using parasite rate. The figures in these studies are far below those reported in the annual morbidity reports in Nairobi of the Health Information Systems, Ministry of health which is based on reported cases but nonetheless indicate importance of malaria in the febrile childhood diseases in Nairobi (52).

Of all the children with malaria studied, about one third appear to have acquired the malaria infection in Nairobi by virtue of having no travel history outside the city in the three months prior to the interview. Thirty-one (18.7%) of the malaria cases were seen in children with no history of travel outside Nairobi in the past one-year. Twenty-three (13.9%) children were found to have parasites in their blood yet they had never traveled outside Nairobi in their lifetime. This indicates that the contribution of Nairobi acquired malaria, (which for purposes of this study was taken to be children with no travel outside Nairobi in the three months prior to the interview), to the total number of cases of malaria seen in Nairobi is significant. Rapuoda found that 14.2% of the malaria cases in a prevalence study of malaria in Nairobi occurred in persons who had not traveled outside Nairobi, though, she did not indicate the specific duration of non-travel (51).

The parasite rates of children with no travel outside Nairobi in the three months prior to the interview were analyzed, according to age, and division of origin. These were the 899 children who had no travel in the three months prior to the interview. The parasite rate for these children with non-travel in the three months prior to the survey was 6.2%. This rate is below 10% and is probably close to the true prevalence of malaria in children presenting with fever or history of fever to government health facilities when the

contribution of malaria cases from children with travel outside Nairobi is excluded. According to the proposed classification using parasite rate in children, Nairobi would be classified as an area with hypoendemic malaria transmission.

Using children with no travel outside Nairobi in the past year and those with non-travel in their lifetime, the parasite rates were found to be 4.8% and 4.4% respectively. The parasite rates were still below 10% for these two groups of children who have stronger evidence of having Nairobi-acquired malaria. This is by virtue of the fact that incubation periods for all the malaria species are usually less than one month and are very unlikely to be longer than one-year (30). The exception is *P.vivax* malaria where recrudescence may occur because of the persistence of the parasites in the hypnozoite stage. However no cases of P vivax were seen in the children studied. For those with no travel in their lifetime, they definitely acquired malaria infection in Nairobi unless the travel history was inaccurate. It may be tempting to use parasite rates of children with non-travel in the previous one-year or lifetime to give a closer estimate of the true parasite rate of Nairobi acquired malaria amongst children because in these groups evidence of malaria being transmitted in Nairobi is stronger. The shortcomings are those parasite rates for children with no travel in the previous one-year exclude infants because the history would not include these children. The parasite rate for children with non-travel in their lifetime would be biased to the younger children because the majority of older children have traveled outside Nairobi at some point in their lifetime.

Further evidence to suggest that malaria transmission in Nairobi may be hypoendemic was noted by the increase in the parasite rate with age up to the age group 5-10 years and sharp decline in 10-14 years. The peak prevalence was seen in the 5-10 years age group. This is similar to those reported earlier in Tanzania (16) where peak parasite rates were found in the age groups of 5-9 years respectively. This finding is consistent with malaria transmission in the hypoendemic class as described by Boyd. Only in epidemic situations, are the parasite rates for the different age groups found to be similar.

To look for evidence of differences in malaria transmission in Nairobi, parasite rates for the different divisions was calculated using children with no travel in the three months

prior to the interview. It was noted that parasite rates were different for the different Divisions in Nairobi. There appeared to be a higher prevalence of Nairobi-acquired malaria in Kibera (9.5%) and Dagoretti (8.2%) divisions of Nairobi whereas no cases of malaria were recorded in the Central Division (0%) of Nairobi, though statistical differences were not significant by chi-square. This may suggest higher malaria transmission in the two divisions. Perhaps a larger sample would more clearly demonstrate this. Malaria endemicity has been found to be lower in the urbanized areas compared to the immediate surrounding areas in several cities e.g. Brazaville, Lagos, Ougadougou and in the Gambia. Various factors are attributed to this including less breeding sites for the mosquitoes and to the use of anti-malaria medications (57,63-65).

The travel history revealed a strong association between malaria and travel outside the Nairobi. This is probably explained by fact that areas outside Nairobi in Kenya have higher malaria transmission rates than Nairobi as seen in the malaria epidemiology map of Kenya (appendix). It does not prove that malaria in these cases was transmitted outside Nairobi but explains the association of malaria and travel outside Nairobi as known to many clinicians in Nairobi (51).

One child presenting with malaria had received a blood transfusion within the same month of the interview. It was difficult to find out if malaria in this case was attributable to the transfusion or the child had been transfused as a consequence of malaria related anemia and therefore the positive smear representing inadequately treated malaria or a recrudescence.

The results indicate that there is hypoendemic malaria transmission in Nairobi with variation between the Divisions.

This suggests that it is no longer tenable to classify Nairobi as malaria-free. To obtain a clearer picture of the extent of transmission of malaria in Nairobi entomologic studies need to be done because, though several studies have shown concordance with parasite rates studies, wide variations have sosmetimes been noted in the actual levels in transmission as shown in the Brazaville (15).

Studying the factors that may be associated with malaria prevalence in a certain area and showing causality are difficult (15) and went beyond the scope of this study.

Personal and environmental activities are known to have eliminated the transmission of malaria in some parts of Columbia (25). Nairobi may eventually become a malaria endemic area if the rapid environmental degradation continues and if the concerned authorities remain complacent about the risk malaria poses as has happened in some parts of Tanzania (25).

CONCLUSIONS

1. The overall prevalence of malaria in children presenting with fever or history of fever to government facilities offering curative services in Nairobi was 11.2%

2. 33.7% of the malaria cases seen in this study were transmitted in Nairobi based on non-travel of these children outside Nairobi in the three months prior to the study.

3. The study gives evidence for a hypoendemic malaria transmission in Nairobi with possible differences in transmission for the different Divisions in Nairobi.

RECOMMENDATIONS

1. This study indicates the need for a malaria survey to include entomological surveys for purposes of quantifying malaria transmission and planning malaria control efforts.

2. Diagnosis of malaria should be considered in a child resident in Nairobi who presents with fever and has no history of travel outside Nairobi.
3. Anti-malaria efforts both environmental and personal should be intensified to prevent Nairobi's development into a malaria endemic area.

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APPENDICES

Appendix A: Map showing the malaria transmission in Kenya

Appendix B: Map showing the sublocations ir Nairobi

Appendix C: List of the Divisions in Nairobi and the sublocations found in the Divisions

Appendix D: Map showing the distribution of origin of all the children interviewed and sublocation of origin of those with malaria

Appendix E: Map showing the distribution of children with non-travel in the month preceding the interview and sublocation of origin of those with malaria in this group.

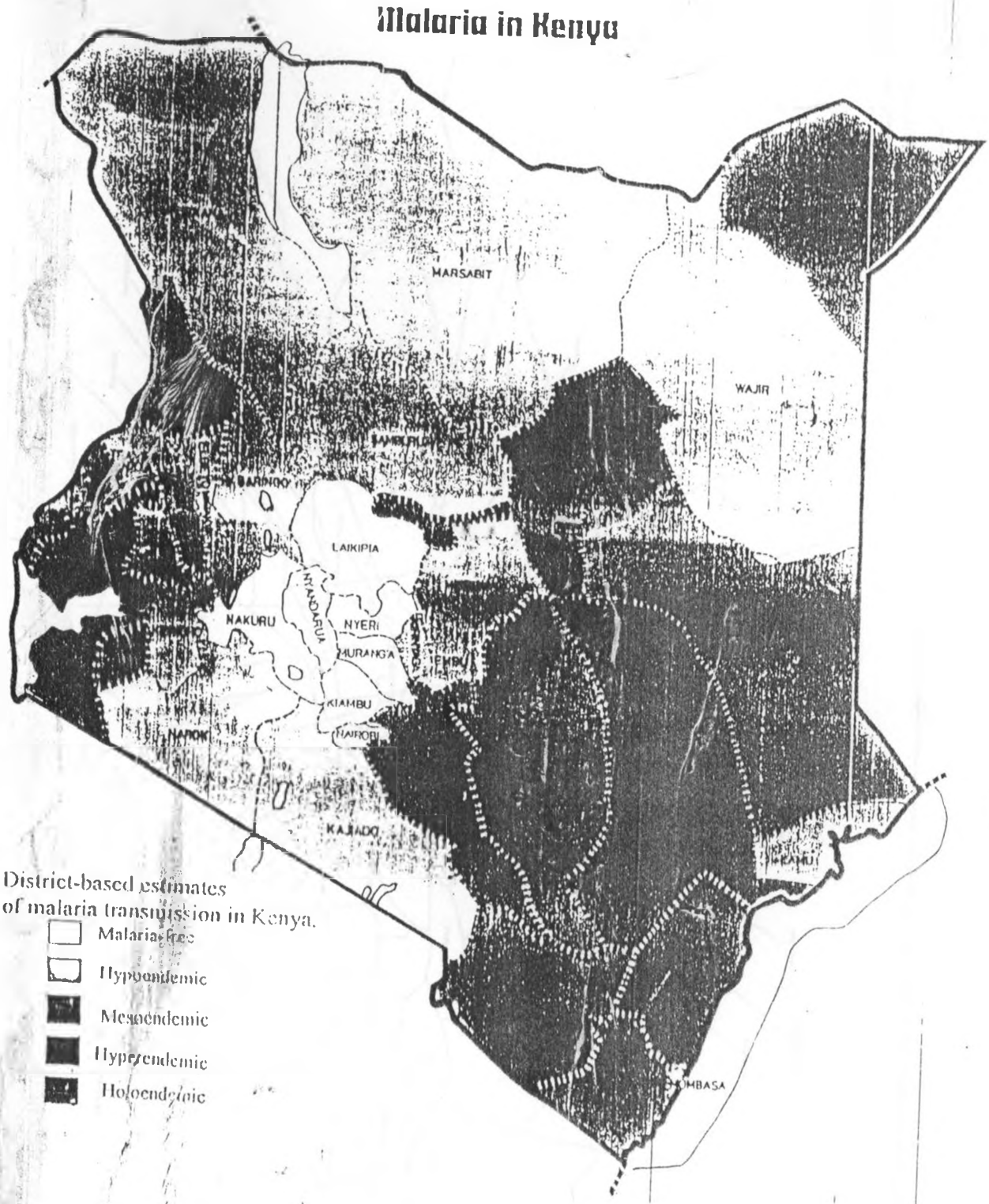
Appendix F: Map showing the distribution of children with non-travel in the year preceding the interview and sublocation of origin for those with malaria in this group.

Appendix G: Map showing the distribution of children with non-travel in their lifetime and sublocation of origin of those with malaria in this group.

Appendix H: Questionnaire

Appendix I: Consent form

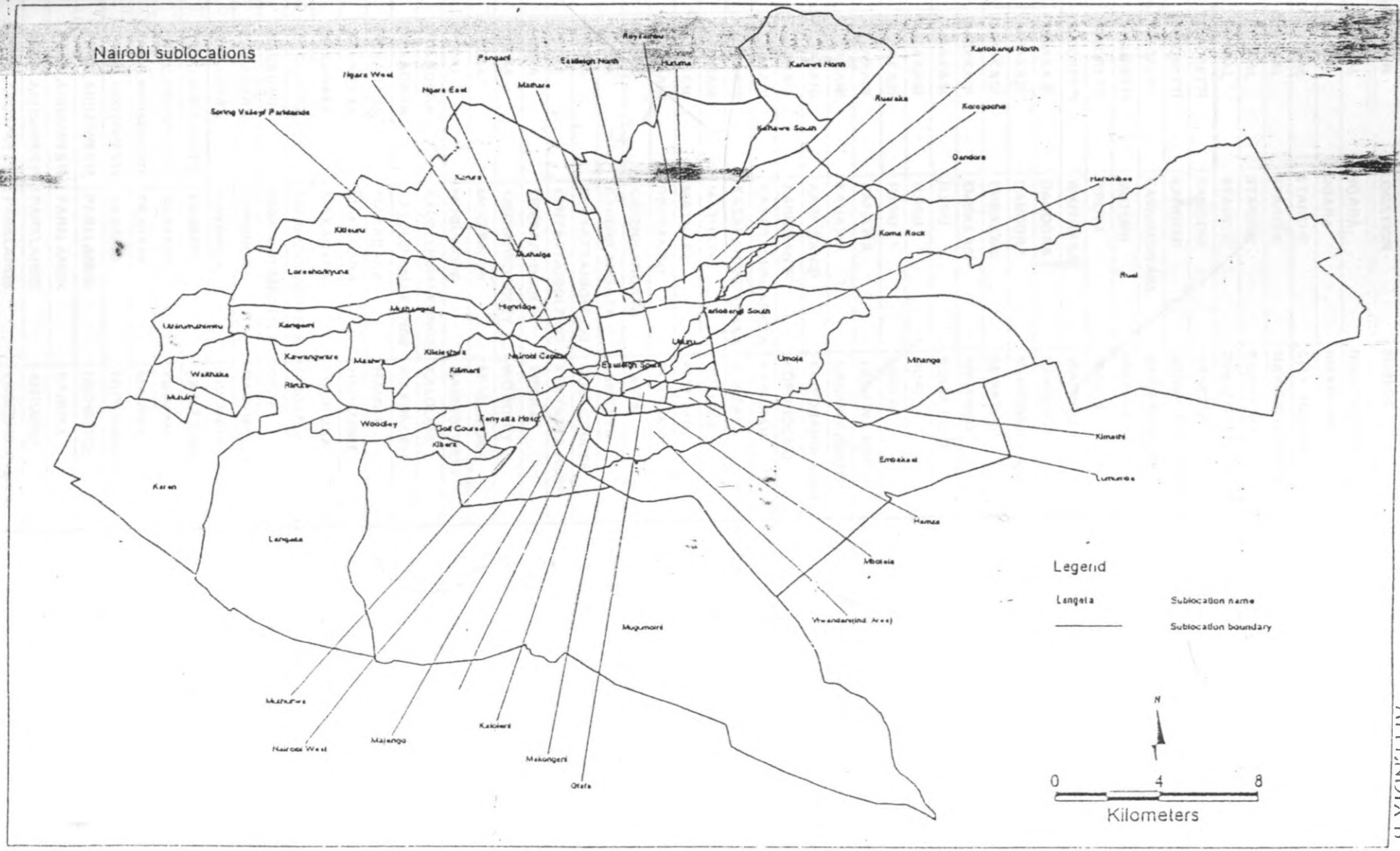
Malaria in Kenya



District-based estimates of malaria transmission in Kenya.

- Malaria-free
- Hypoendemic
- Mesoendemic
- Hyperendemic
- Holoendemic

Source: Kenya Medical Research Institute (KEMRI), Medical illustration unit, 1999

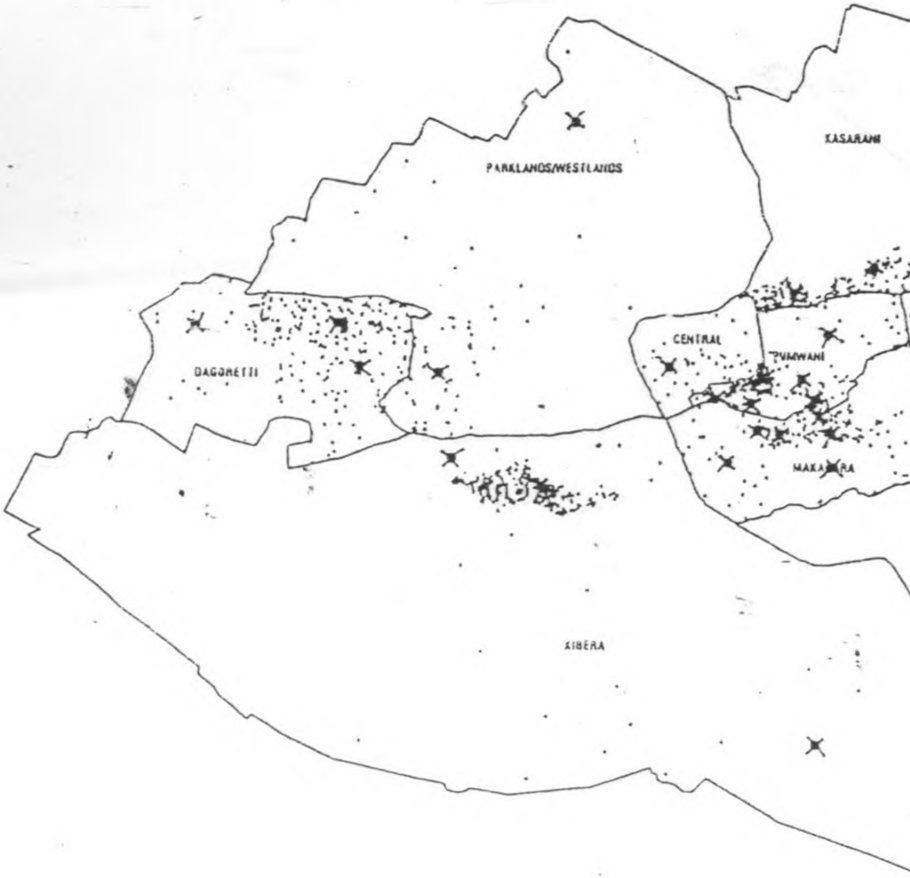

Nairobi sublocations
Ngara West
Ngara East
Pangani
Eastleigh North
Huruma
Kariobangi North
Kaheawa North
Mathare
Riverside
Korogocho
Kaheawa South
Starling Valley/ Parklands
Kariobangi South
Umoja
Mihango
Kimathi
Lumumba
Embakasi
Hamza
Mbotela
Woodley
Golf Course
Kibera
Karen
Langata
Mugumoini
Mutuini
Nairobi West
Maiango
Kaloleni
Mabongeni
Ofafa
Legend
Langata
Sublocation name
Sublocation boundary
N
0
4
8
Kilometers

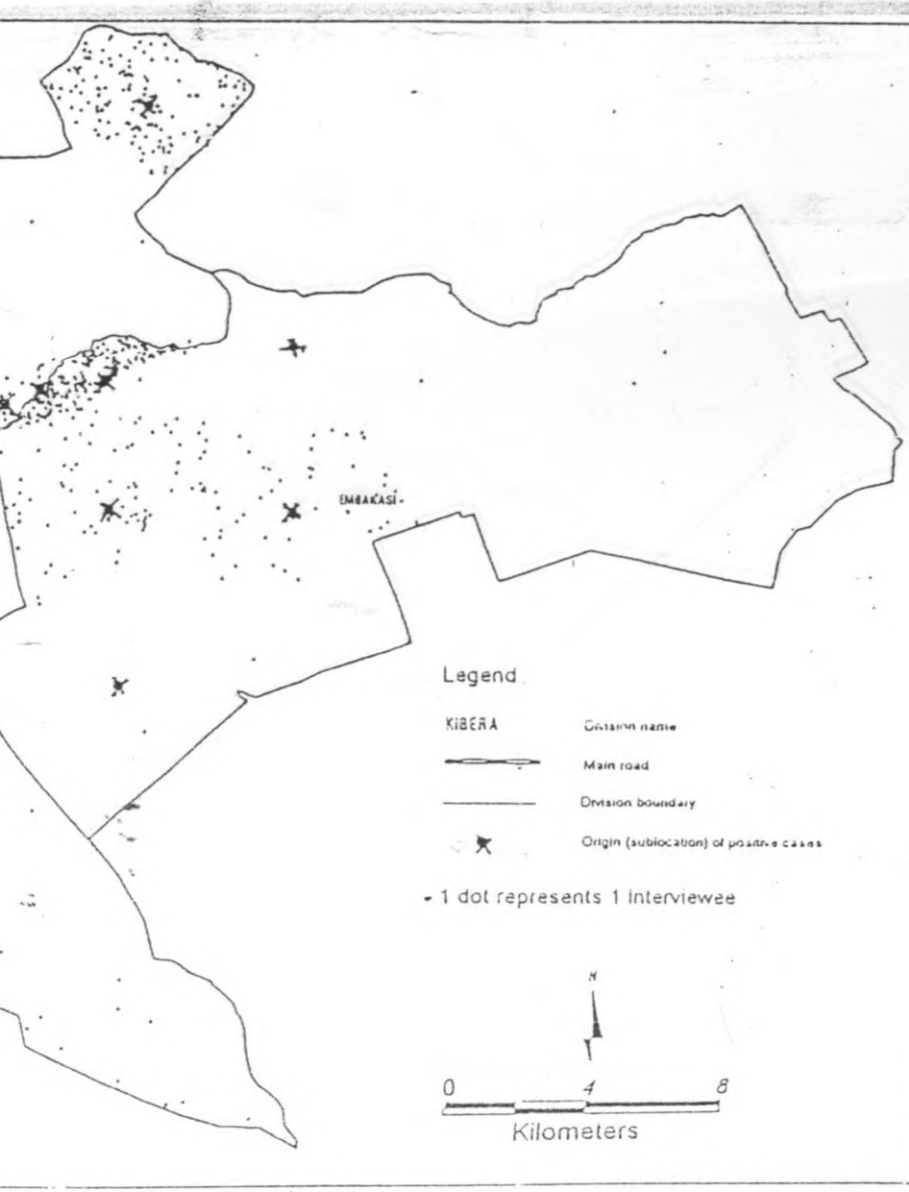
APPENDIX 13

DISTRICT	DIVISION	LOCATION	SUBLOC
NAIROBI	CENTRAL	NGARA	NGARA EAST
NAIROBI	CENTRAL	NGARA	NGARA WEST
NAIROBI	CENTRAL	STAREHE	CITY SQUARE
NAIROBI	CENTRAL	STAREHE	NAIROBI CENTRAL
NAIROBI	CENTRAL	STAREHE	PANGANI
NAIROBI	CENTRAL	STAREHE	ZIWANI/STAREHE/K
NAIROBI	DAGORETTI	KANGEMI	KANGEMI
NAIROBI	DAGORETTI	KANGEMI	UTHIRU/RUTHIMITU
NAIROBI	DAGORETTI	KAWANGWARE	KAWANGWARE
NAIROBI	DAGORETTI	MUTUINI	MUTUINI
NAIROBI	DAGORETTI	RIRUTA	RIRUTA
NAIROBI	DAGORETTI	WAITHAKA	WAITHAKA
NAIROBI	EMBAKASI	DANDORA	DANDORA
NAIROBI	EMBAKASI	DANDORA	KARIOBANGI SOUT
NAIROBI	EMBAKASI	EMBAKASI	EMBAKASI
NAIROBI	EMBAKASI	EMBAKASI	MIHANGO
NAIROBI	EMBAKASI	NJIRU	KOMA ROCK
NAIROBI	EMBAKASI	NJIRU	RUAI
NAIROBI	EMBAKASI	NJIRU	UMOJA
NAIROBI	KASARANI	KAHAWA	KAHAWA NORTH
NAIROBI	KASARANI	KAHAWA	KAHAWA SOUTH
NAIROBI	KASARANI	KARIOBANGI	KARIOBANGI NORT
NAIROBI	KASARANI	KARIOBANGI	KOROGOCHO
NAIROBI	KASARANI	KASARANI(RUARAKA	KASARANI
NAIROBI	KASARANI	KASARANI(RUARAKA	RUARAKA
NAIROBI	KASARANI	MATHARE	HURUMA
NAIROBI	KASARANI	MATHARE	MATHARE
NAIROBI	KASARANI	ROYSAMBU	ROYSAMBU
NAIROBI	KIBERA	KAREN/LANGATA	KAREN
NAIROBI	KIBERA	KAREN/LANGATA	LANGATA
NAIROBI	KIBERA	KENYATTA/GOLF CO	GOLF COURSE
NAIROBI	KIBERA	KENYATTA/GOLF CO	KENYATTA HOSP.
NAIROBI	KIBERA	KIBERA/WOODLEY	KIBERA
NAIROBI	KIBERA	KIBERA/WOODLEY	WOODLEY
NAIROBI	KIBERA	MUGUMOINI	MUGUMOINI
NAIROBI	KIBERA	MUGUMOINI	NAIROBI WEST
NAIROBI	MAKADARA	KALOLENI/MAKONGE	KALOLENI
NAIROBI	MAKADARA	KALOLENI/MAKONGE	MAKONGENI
NAIROBI	MAKADARA	MAKADARA	HAMZA
NAIROBI	MAKADARA	MAKADARA	HARAMBEE
NAIROBI	MAKADARA	MAKADARA	LUMUMBA
NAIROBI	MAKADARA	MARINGO/MBOTELA	MBOTELA
NAIROBI	MAKADARA	MARINGO/MBOTELA	OFAFA
NAIROBI	MAKADARA	VIWANDA	NAIROBI SOUTH
NAIROBI	MAKADARA	VIWANDA	VIWANDANI(IND. A
NAIROBI	PARKLANDS/WESTL	KILIMANI	KILELESHWA
NAIROBI	PARKLANDS/WESTL	KILIMANI	KILIMANI
NAIROBI	PARKLANDS/WESTL	KILIMANI	MASIWA
NAIROBI	PARKLANDS/WESTL	KILIMANI	MUTHANGARI
NAIROBI	PARKLANDS/WESTL	PARKLANDS	HIGHRIDGE
NAIROBI	PARKLANDS/WESTL	PARKLANDS	KARURA
NAIROBI	PARKLANDS/WESTL	PARKLANDS	KITISURU
NAIROBI	PARKLANDS/WESTL	PARKLANDS	LORESHO/KYUNA
NAIROBI	PARKLANDS/WESTL	PARKLANDS	MUTHAIGA
NAIROBI	PARKLANDS/WESTL	PARKLANDS	SP. VALLEY/U.PARK
NAIROBI	PUMWANI	BAHATI	KIMATHI

DISTRICT	DIVISION	LOCATION	SUBLOC
NAIROBI	PUMWANI	BAHATI	UHURU
NAIROBI	PUMWANI	EASTLEIGH	EASTLEIGH NORTH
NAIROBI	PUMWANI	EASTLEIGH	EASTLEIGH SOUTH
NAIROBI	PUMWANI	KAMUKUNJI	MUTHURWA
NAIROBI	PUMWANI	KAMUKUNJI	SHAURI MOYO/KAM
NAIROBI	PUMWANI	PUMWANI	MAJENGO

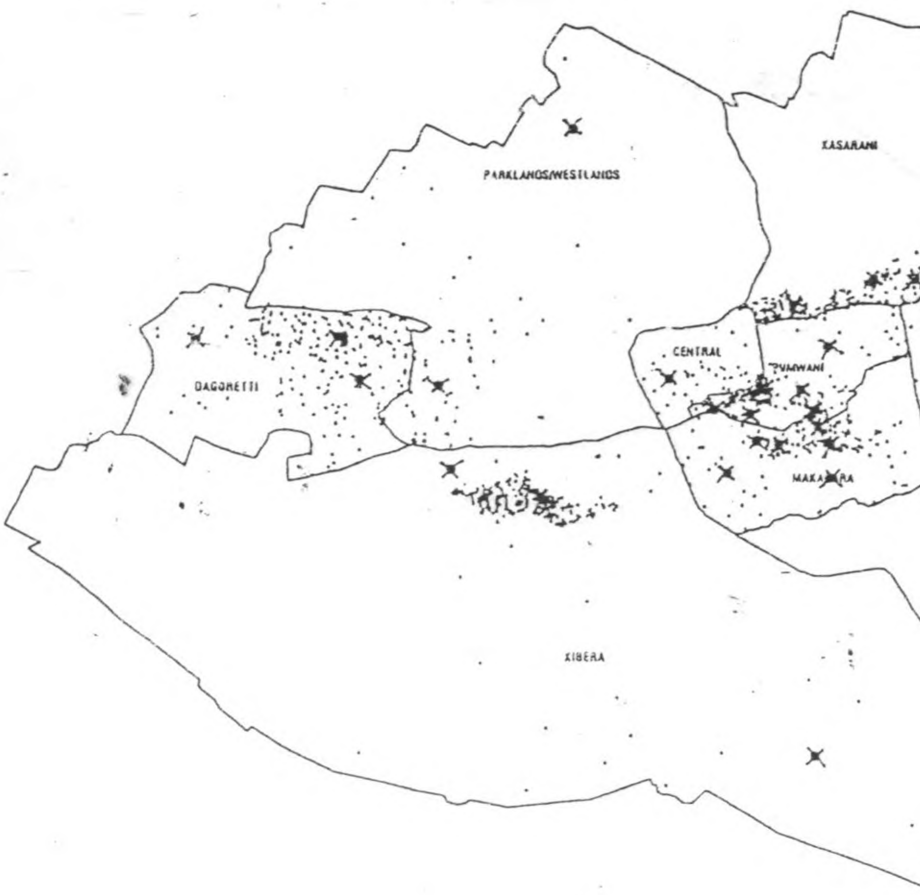
Distribution of malaria cases by sublocation

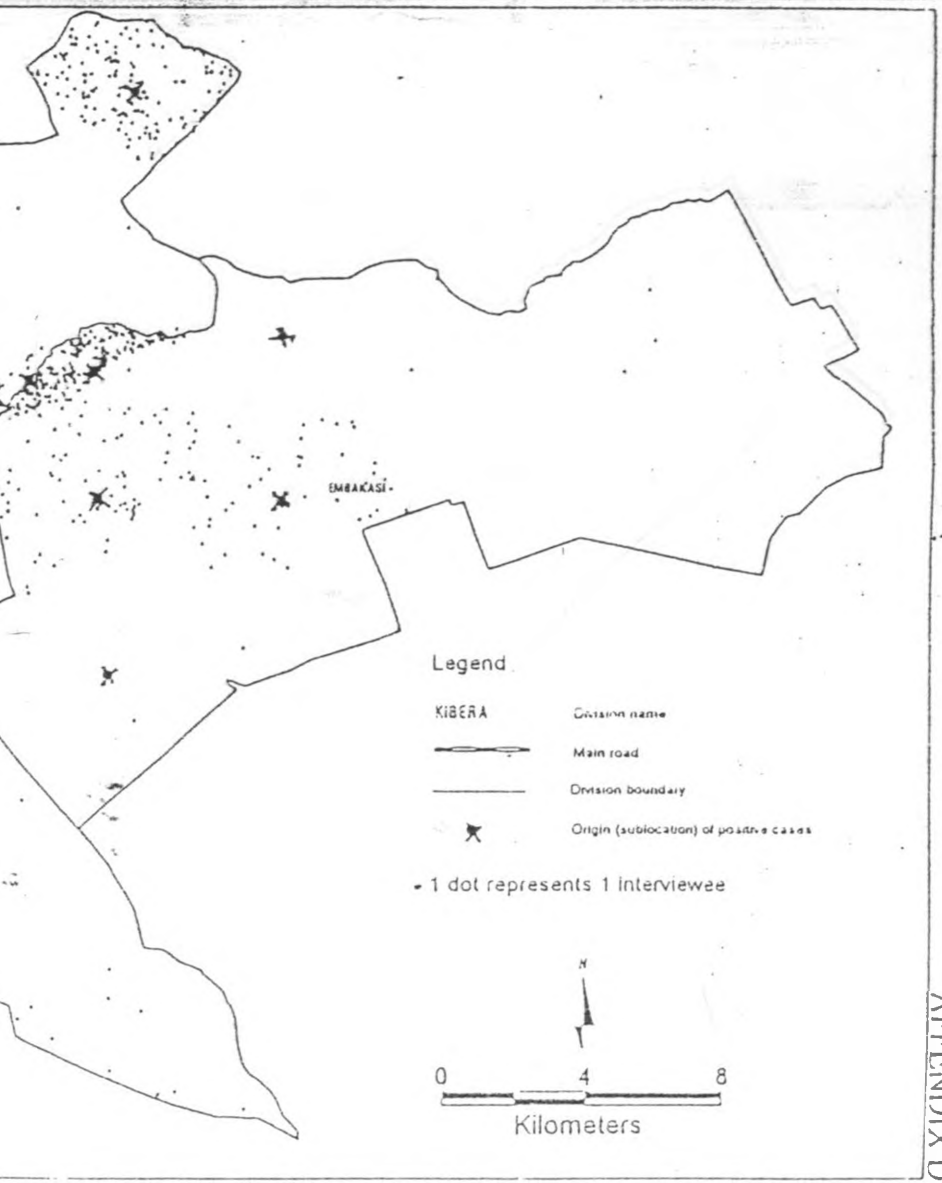



EMBAKASI
Legend
KIBERA
Division name
Main road
Division boundary
Origin (sublocation) of positive cases
- 1 dot represents 1 interviewee
N
0
4
8
Kilometers

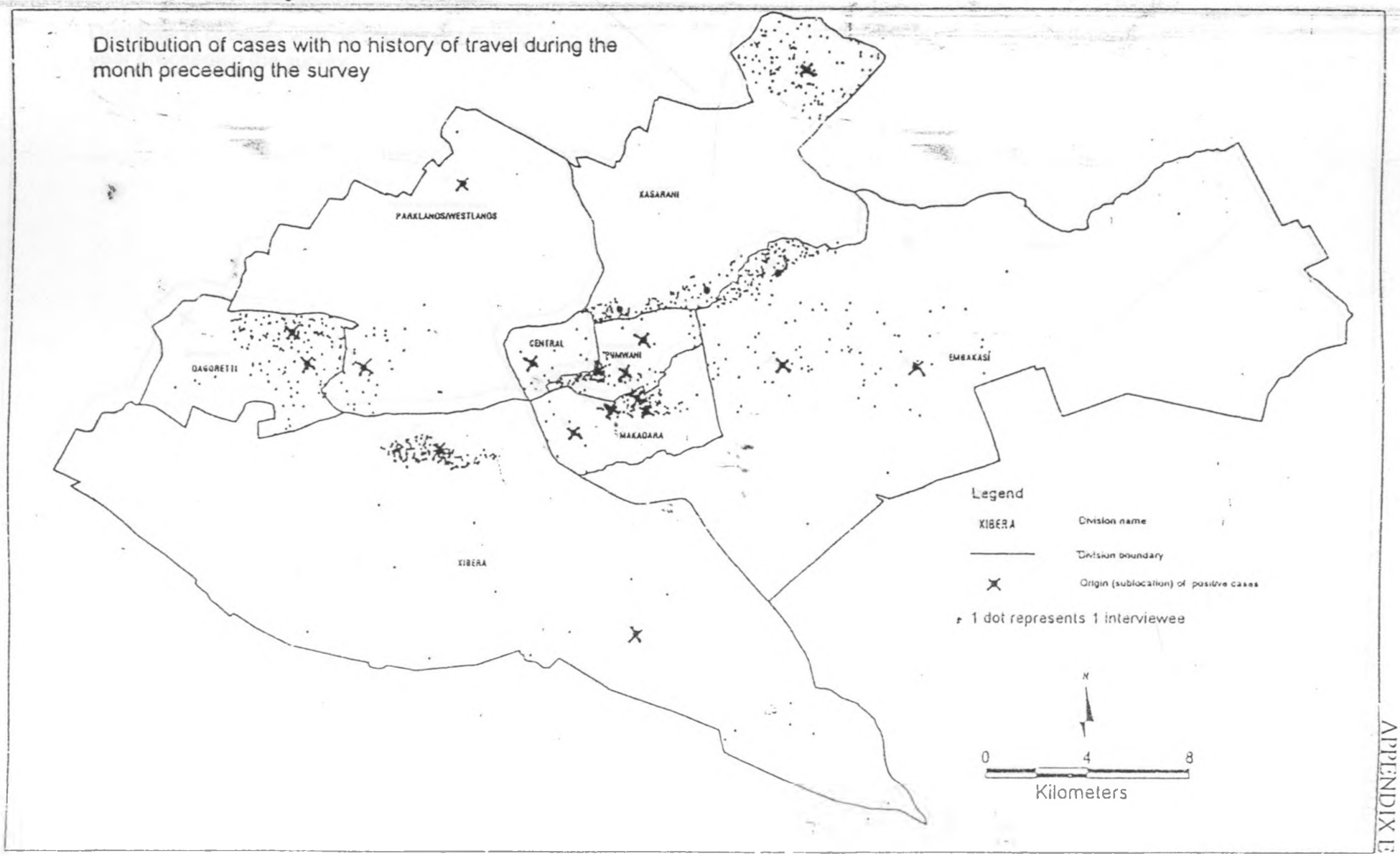
APPENDIX D

Distribution of malaria cases by sublocation



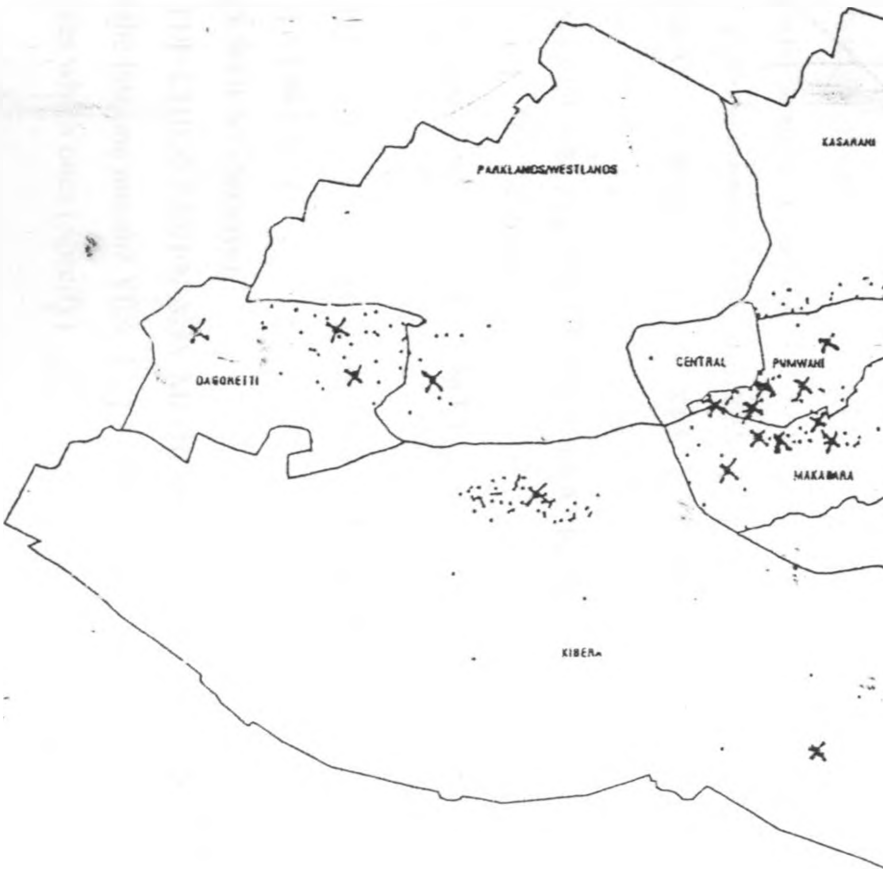

EMBAKASI
Legend
KIBERA
Division name
Main road
Division boundary
Origin (sublocation) of positive cases
- 1 dot represents 1 interviewee
N
0
4
8
Kilometers

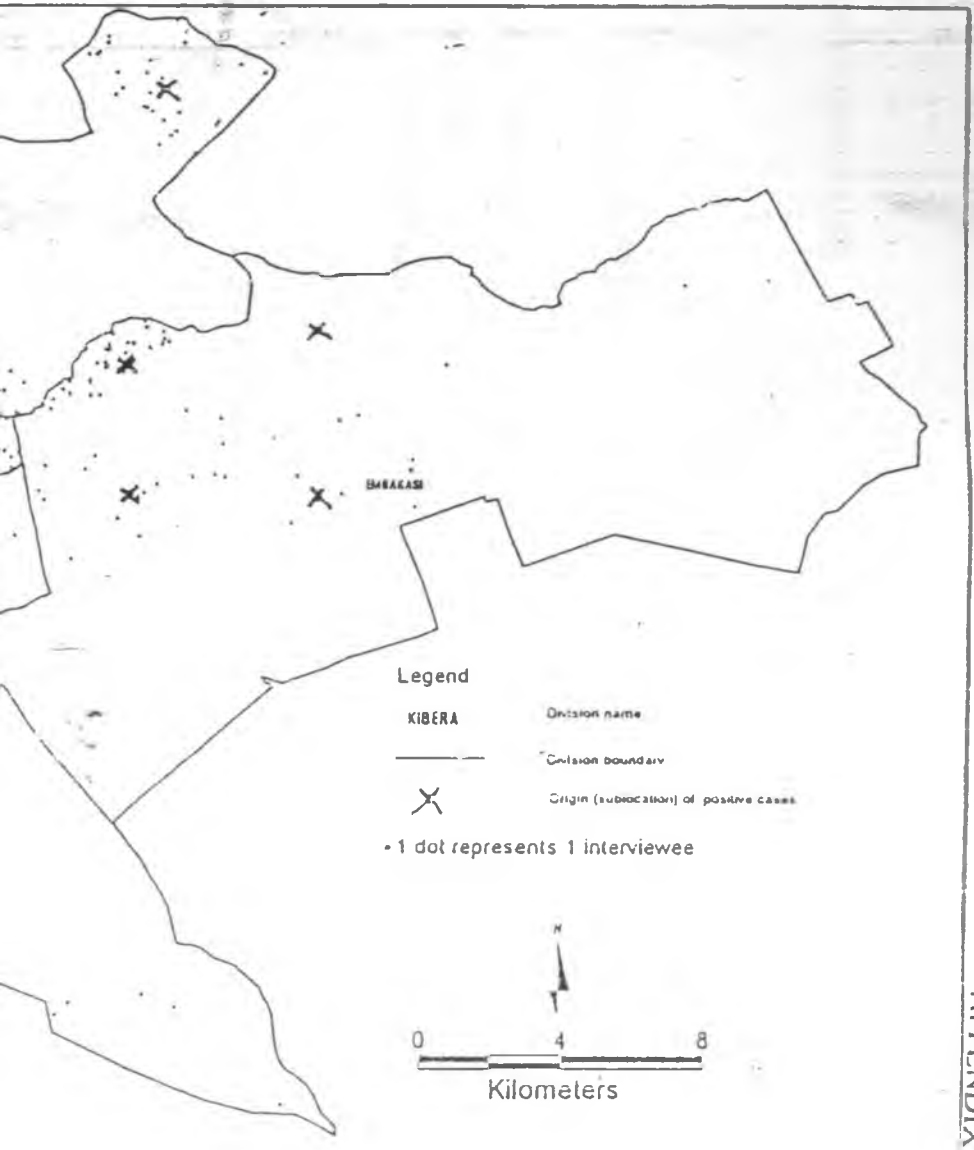
APPENDIX D


Distribution of cases with no history of travel during the month preceeding the survey
PARKLANDS/WESTLANDS
KASARANI
DAGORETTI
CENTRAL
PUMWANI
EMBAKASI
MAKADARA
XIBERA
Legend
XIBERA
Division name
Division boundary
Origin (sublocation) of positive cases
1 dot represents 1 interviewee
N
0
4
8
Kilometers

APPENDIX E

Distribution of cases with no history of travel during the year preceeding the survey




SARAKASI
Legend
KIBERA
Division name
Division boundary
Origin (sublocation) of positive cases
• 1 dot represents 1 interviewee
N
0
4
8
Kilometers

APPENDIX I

QUESTIONNAIRE

Divisions code no _____

Slide Serial no _____

1. VITAL STATISTICS:

Name: _____ Tribe: _____

Age: _____ Sex _____

Residential area: _____ Address: _____

2. PRESENTING COMPLAINTS

a) Fever Duration _____ days Temperature

3. HAS CHILD TRAVELED OUTSIDE NAIROBI? Y/N IF YES SPECIFY WHERE

- In the last one month YES [ ] NO [ ] _____
- In the last one to three months YES [ ] NO [ ] _____
- In the last three months to one year YES [ ] NO [ ] _____
- In the child's life time YES [ ] NO [ ] _____

4. HAS ANY HOUSEHOLD CONTACT TRAVELED OUTSIDE NAIROBI IN THE

IF YES SPECIFY WHERE

In the last one-month YES [ ] NO [ ]

5. HAS THE CHILD EVER RECEIVED BLOOD TRANSFUSION?

YES [ ] NO [ ]

IF YES WHEN? (Specify) _____

6. HAS THE CHILD TAKEN ANY MEDICINES?

- In the last one month? YES [ ] NO [ ]

If yes which ones (Specify) _____

QUESTIONNAIRE

Divisions code no _____

Slide Serial no. _____

1. VITAL STATISTICS:

Name: _____ Tribe: _____

Age: _____ Sex: _____

Residential area: _____ Address: _____

2. PRESENTING COMPLAINTS

a) Fever Duration _____ days Temperature _____

3. HAS CHILD TRAVELED OUTSIDE NAIROBI? Y/N IF YES SPECIFY WHERE

- In the last one month YES [ ] NO [ ] _____
- In the last one to three months YES [ ] NO [ ] _____
- In the last three months to one year YES [ ] NO [ ] _____
- In the child's life time YES [ ] NO [ ] _____

4. HAS ANY HOUSEHOLD CONTACT TRAVELED OUTSIDE NAIROBI IN THE

IF YES SPECIFY WHERE

In the last one-month YES [ ] NO [ ]

5. HAS THE CHILD EVER RECEIVED BLOOD TRANSFUSION?

YES [ ] NO [ ]

IF YES WHEN? (Specify)

6. HAS THE CHILD TAKEN ANY MEDICINES?

- In the last one month? YES [ ] NO [ ]

If yes which ones (Specify) _____

CONSENT FORM

I _____ (parent/guardian's name) do accept to have a blood sample taken from my child _____(child's name) for the preparation of a malaria slide. I has been explained to me that the child is being recruited into a study to determine whether malaria transmission occurs in Nairobi. The results will be returned to me within 72 hours. The findings of the study will be available to me at the clinic where the child was seen.

Signed: _____(parents/guardians signature)

Date: _____

Signed: _____(investigator's signature)