ENVIRONMENTAL HEALTH PROJECT

Activity Report 144

Eritrea: Malaria Surveillance, Epidemic Preparedness, and Control Program Strengthening

Patricia M. Graves

October 2004

Prepared under EHP Project 26568/E.X.ER4.PUBS

Environmental Health Project
Contract HRN-I-00-99-00011-00
is sponsored by the
Office of Health, Infectious Diseases and Nutrition
Bureau for Global Health
U.S. Agency for International Development
Washington, DC 20523

Contents

Abbreviations

ADDAPIX	FAO software for analyzing spatial data
DDT	Dichlorodiethyl trichloroethane
DHS	Demographic Health Survey
DK	Debubawi Keyhi Bahri (Southern Red Sea zoba)
EHP	Environmental Health Project
FAO	Food and Agriculture Organization
FEWS	Famine Early Warning System
GIS	Geographic Information System
GPS	Global Positioning System
HAMSET	HIV/AIDS, Malaria, Sexually Transmitted Diseases, and Tuberculosis Control Project
IDP	Internally Displaced Person
IDSR	Infectious Disease Surveillance and Response
IRI	International Research Institute for Climate Prediction (Earth Institute at Columbia University)
JSI	John Snow International
Kg	Kilogram
MARA	Mapping Malaria Risk in Africa
MOA	Ministry of Agriculture
MOH	Ministry of Health
mm	Millimeter
NFIS	National Food Information System
NGO	Nongovernmental organization
NHMIS	National Health Management Information System
NMCP	National Malaria Control Program
NSEO	National Statistics Evaluation Office
NRS	Northern Red Sea zoba (also known as SK, see below)
NVDI	Normalized vegetation data index
OCHA	Office for Coordination of Humanitarian Affairs (an office of the United Nations)
RBM	Roll Back Malaria
RFE	Rainfall estimate

SEMISH	State of Eritrea Management Information System for Health (Now NHMIS, but still frequently used)
SK	Semenawi Keyhi Bahri (Northern Red Sea zoba)
Sq Km	Square kilometer
SRS	Southern Red Sea zoba (also known as DK, see above)
TASC	Technical Assistance and Support Contract (USAID)
UNFPA	United Nations Family Planning Association
USAID	United States Agency for International Development
USCDC	U.S. Centers for Disease Control and Surveillance
USGS	United States Geological Survey
UTM	Universal Transverse Mercator (projection used in GIS)
WHO	World Health Organization
WINDISP	FAO software for viewing GIS data

Acknowledgments

First of all, I thank the Minister of Health, Mr. Seleh Meky, and the Director General of Health, Mr. Berhane G. Tensae, for their support for this work. The permission, support, advice, and assistance of Dr. Tewolde G. Meskel, Head of the National Malaria Control Program (NMCP), and Dr. Goitom Mebrahtu, Head of Disease Prevention and Control, were invaluable.

I am extremely grateful to the following people at the National Malaria Control Program: Mehari Zerom, David Sintasath, Dr. Josephat Shililu, Asmelash Gegziabher, Solomon Mengistu, Yohannes Bein, Helen Fekadu, Fyori Hagos, Zifan Tesfai, and Fessehaye Seulu at the NMCP head office; Endemariam W. Micael (Northern Red Sea zoba (NRS)), Afewerki Araya, and Ferezgi (Gash Barka), Kiros Sereke (Anseba), Solomon Neguse, Tekle Berhane, Ghirmai Woredel, and Lemlem (Debub), Meles G/Yesus (Maekel), and Asrat G/Lul (Southern Red Sea zoba (SRS)).

I thank Embaye Asfaha, Fikremariam Ghilamichael, and Tadase Fessehaye of the Infectious Disease Surveillance and Response (IDSR) System for their cooperation and help, as well as consultants Monali Varia and Dr. Mac Otten from the U.S. Centers for Disease Control and Surveillance (CDC).

Grateful appreciation is due to Dr. Andom Ogbamariam, Sr. Shashu G/Sellasie, Ezra Kidane, Amanuel Kifle, and Samuel Goitom for assistance with the National Health Management Information System (NHMIS), as well as to Mike Edwards of John Snow International (JSI).

The Meteorological Office of the Civil Aviation Department provided rainfall gauge data, through the cooperation of Mr. Asefau, Mr. Asefau, Issac Fesseha, Hadgu Kibreab, and Tsehaye Tseghe. At the Ministry of Agriculture, Yemane T. Yohannes, Tekeste Weldegabriel, Yergalem Beraki at the FEWS (Famine Early Warning System) Eritrea office, and Byron Ponce-Segura of the National Food Information System (NFIS) have been extremely helpful.

Yemane Yohannes, Kibrom Tuum, Tirhas G. Yohannes, Semir, and Almas at the National Statistics Evaluation Office contributed cartographic information and much assistance in interpreting it. Gebremicael Hagos, Yohannes Michael and Michael Abraha of the Ministry of Land, Water, and Environment generously gave other Geographic Information System (GIS) help.

At the International Research Institute for Climate Prediction (IRI), I thank Madeleine Thomson, John del Corral, and Steve Connor for collaboration and assistance. Rainfall estimates and other geographic and climate data could not have been obtained without Malanding Jaiteh, Benno Blumenthal, Tsegay Woldegeogis, Marc Levy, Michael Bell, Alessandra Giannini, Tony Barnston, and Lisa Lukang, who also assisted with data analysis and interpretation.

Other people who provided advice or technical assistance were Kate MacIntyre of Tulane University, John Gless of Geopraxis, Doug Brown, UNFPA (United Nations Family Planning Association) consultant and Jason Weisfeld, JSI consultant. The original Excel epidemic threshold calculation spreadsheet was greatly improved by addition of ideas from the World Health Organization (WHO) draft manual, “Field Guide for Malaria Epidemic Assessment and Reporting,” WHO/HTM/MAL/2004.1097, written by Dr. Christa Hook.

Last but not least, I thank Gene Brantly, Matt Lynch, Eckhard Kleinau, and Cheri Alexander of the Environmental Health Project (EHP) for advice and logistical support, as well as Linda Lou Kelley, Semere G. Giorgis and Kris Lantis of the United States Agency for International Development (USAID) and Mr. Mesfin of TASC for arrangements in Eritrea.

Executive Summary

This report describes the results of efforts to improve malaria surveillance in Eritrea in ways that will increase preparedness for epidemics as well as strengthen the control program in general. This involved describing the current malaria situation, gathering detailed data on the epidemiology of malaria in the past eight years, and analyzing this data to understand the reasons for the recent decline in malaria cases, as well as to develop methods to detect or preferably prevent a reversal of this declining trend.

To achieve this aim, there were four specific objectives:

1. Gather historical data and develop computerized databases
2. Analyze historical data
3. Identify potential improvements in malaria control operations
4. Develop epidemic prediction tools.

The first objective underpins all the others. The first database, CASES, comprises monthly records on clinical malaria outpatients, inpatients and deaths from all health facilities reporting monthly to the National Malaria Control Program (1996–97) or to the National Health Management Information System (1998–2003). Extraction of information from the second source provided an opportunity to develop procedures for doing this on a regular basis and improved the information sources available to the NMCP and its staff at the *zoba* (district) level. Secondly, an INTERVENTION dataset, structured by subzoba and month, was compiled from all available records of malaria control activities performed from 1998 to 2003; earlier years were unavailable. Activities included indoor residual spraying with DDT and malathion in three zobas, provision and retreatment of permethrin-impregnated mosquito nets in all malarious areas, control of breeding sites by larviciding or elimination, and prompt provision of malaria treatment by village health aides. Finally a METEOROLOGICAL dataset was compiled, also by subzoba area and month; at present it consists mostly of rainfall estimates with other climate data still being added. Rainfall estimates from all available ground stations and from satellites were obtained, the latter being more comprehensive than the gauge data.

Detailed descriptive analysis of the cases' data, described under Objective 2, revealed patterns of seasonality and transmission intensity in the country, which have been useful in geographic stratification and for assessing the relationship between rainfall and malaria cases. Regression analysis showed that the strongest association was between malaria cases and rain occurring two to three months previously, but rainfall in the current month and up to four months previously affected the number of cases.

The declining number of malaria cases over the years 1998 to 2003 is clear, although a flattening of the decline between 2002 and 2003 is a cause for concern. Trends in two other diseases and in total diagnoses reported by the same mechanism did not show similar declines. The question is whether the decline has been due to rainfall, other climate factors, the activities of the control program, or other reasons.

More than half a million impregnated nets have been distributed in Eritrea since 2000, with up to two per household being issued in all malarious areas. The amount of indoor residual spraying varies greatly from year to year, but has been increasing steadily from 2000 to 2003, as has the use of the temephos larvicide. Provision of treatment by village health agents is a longstanding feature of the program but was given a boost in 2002 with change of the first line treatment from chloroquine to Fansidar plus chloroquine, involving extensive retraining.

Cross-sectional, time-series regression analysis was used to investigate the relative role of these different interventions. At present, the analysis has been done only for Gash Barka and Anseba. The results greatly strengthen the evidence that the net impregnation program has been an important factor in the success of Eritrea's program because the analysis takes into account rainfall by subzoba. Therefore, decline in rainfall can be discounted as the main explanation for the decrease in malaria cases in Eritrea from 1998 to 2003. Larval control also appeared to be contributing to decreased cases in Anseba.

A type of regression known as instrumental variable, time-series regression was done to account for "endogeneity" in the DDT spraying variable, i.e., the fact that spraying was targeted to places where malaria case numbers are highest. However, even after adjusting for endogeneity, there was no evidence that DDT spraying as presently done was negatively associated with case numbers in Gash Barka. If this is borne out by the results in Debub, then either the method has to be improved in its implementation or stopped, with the resources directed elsewhere.

Potential improvements to the program are described in the third section of the report, in terms of the mix of interventions, targeting, timing and monitoring. Concerning the mix of activities performed none can be dropped immediately, although spraying still has to prove itself. In the meantime, assessment of the spraying coverage and malaria incidence by subzoba in Gash Barka indicated that there is definitely scope for improvement in both the spraying timing and targeting. Prioritization of spraying by subzoba is now much more feasible with better past data and the improvement in geographic stratification. Starting spraying two months earlier may improve control and help to keep pushing incidence down by eliminating dry season reservoirs of cases. Creative new ways to attack the difficult-to-control preferred breeding sites of *Anopheles arabiensis* must be developed. Monitoring and reporting of all malaria control activities, but especially the amount of effort on larval control, needs to be streamlined and improved. Effectiveness of interventions cannot be evaluated or improved if it is not known whether they were applied properly.

Finally, under the fourth objective, past malaria epidemics were studied to improve detection and future prevention of epidemics. The usefulness of different epidemic definitions was assessed, with the mean plus 1 standard deviation emerging as the most practical. Using five of the eight years as baseline, each month in the other three years (1997, 1998, and 2003) was defined as "epidemic" or not based on this threshold. The results showed that February 1998 was the month when the greatest number of subzobas had cases exceeding the threshold. If this had been known at the time, it could have given warning of the severe epidemic that was to occur later that year over most of the country. The tools are now available to help prevent this happening again.

Introduction

This report covers work conducted in Eritrea from January 2003 to September 2004, including four visits to the country each lasting two to three weeks.

The work had four major objectives, as follows:

1. Gather historical data and develop computerized databases
2. Analyze historical data
3. Identify potential improvements in malaria control operations
4. Develop epidemic prediction tools

This report covers these four objectives essentially within this framework and in this order, although since the objectives are all related, there will be some crosscutting discussion between them in the text. This report attempts to synthesize routinely collected data on malaria, interventions, and climate for the last six to eight years to assess the success of the malaria control program. The number of malaria cases will be used to measure control program effectiveness, after adjusting for variation in rainfall.

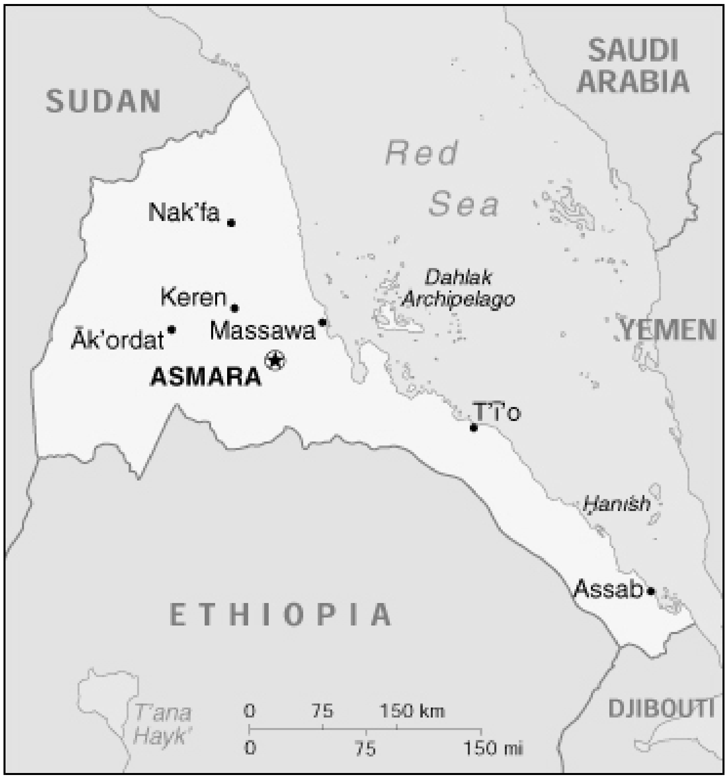
Some analysis of the databases is still in progress as is the development of improved malaria stratification maps. However, many illuminating details have already emerged, which it is hoped will assist the control program to continue their excellent progress and prevent future epidemics.

Country Background

Eritrea is one of the poorest nations in Africa with a GNP of about $200 per capita (World Bank 1998). The country is situated in the Horn of Africa and covers an area of approximately 124,000 square kilometers (sq km) (Figure 1). Most of this is defined as semi-arid tropical convergence zone, indicating low, sporadic rainfall, ranging between 250 millimeters (mm) annually in the lowland areas and 500 mm in the highland region. Eritrea regained its independence in 1991 (ratified by a referendum in 1993) following a 30-year war with Ethiopia. This extended war, combined with the recent border conflict, which caused the temporary dispersal of tens of thousands of people, continues to imperil the development of the economy, health and other social sectors, and the overall quality of life.

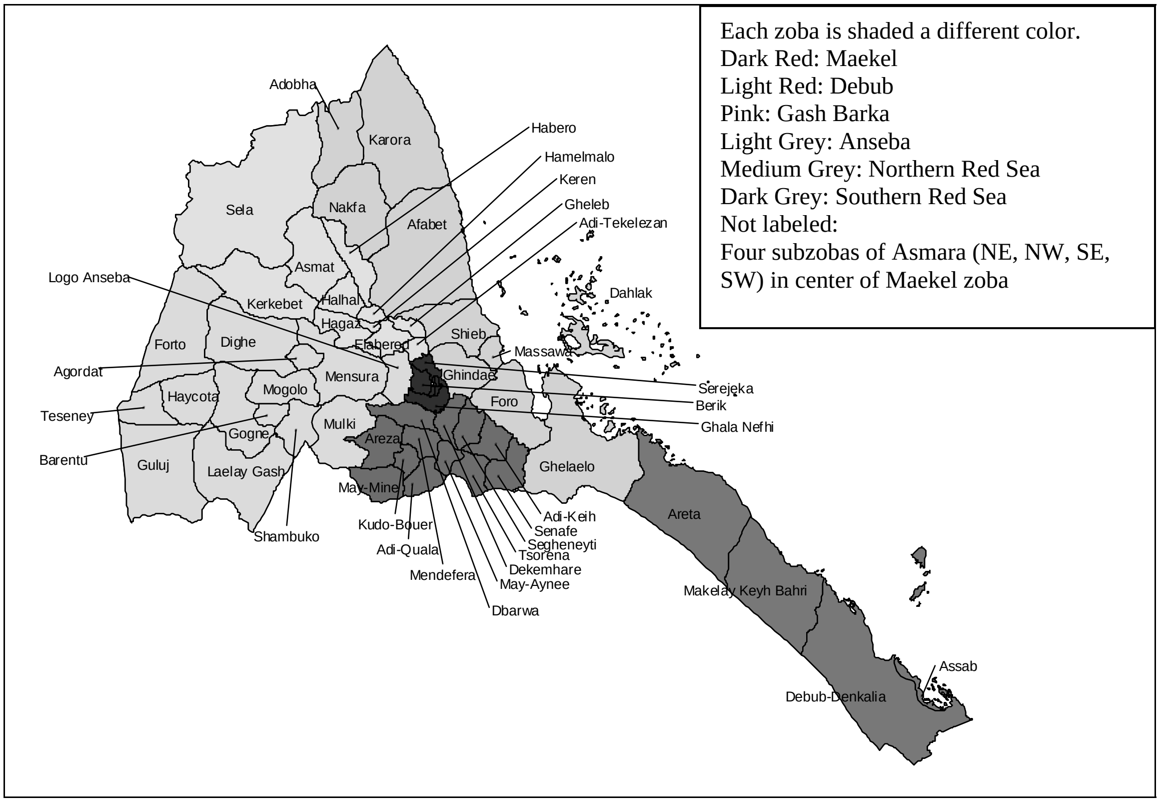
Eritrea is home to a culturally and linguistically diverse population of nearly 4 million (World Bank 1999), and it remains largely rural (more than 90%). There are three official languages (Tigrinya, English, and Arabic) and nine major ethnic groups. The most recent Demographic and Health Survey (DHS 2002) produced the following estimates: crude birth rate = 32/1000; infant mortality rate = 48/1000, and under-five mortality rate = 93/1000. These place the country in the pre-health transition stage, with a life expectancy of 51 years (World Bank 1999). Literacy is estimated to be only 10% for women and 20% for men.

Figure 1. Location of Eritrea



Since 1996, the country has been divided into six administrative zobas (zones). It is further divided into subzobas (subzones), kebabis (groups of villages) and adis (villages), with an estimated 1,500 villages overall. Currently there are 58 subzobas. The zoba and subzoba boundaries and locations are shown in Figure 2 and listed with their estimated populations in Appendix 1. Also in Appendix 1 are the codes used by the NHMIS and the Ministry of Health (MOH) in their databases.

Figure 2. Subzobas of Eritrea



Eritrea's Health System

In 2002 there were 330 health facilities of various types in the country, and the number has increased since then. Hospitals, mini-hospitals, health centers, and health stations managed by the Ministry of Health, Christian missions, or nongovernmental organizations (NGOs) comprise about two-thirds of the health facilities; the rest consist of private clinics, industry clinics, or other specialized facilities such as maternal and child health clinics and eye clinics. There is a hospital in each zoba and at least one mini-hospital or health center in each subzoba. Several health stations operate under the direction of each health center or mini-hospital.

In addition to the formal clinics, many people obtain treatment from licensed pharmacies or rural drug vendors in the cities and towns. Community workers (village health agents) work from their own houses to treat fever cases during the peak malaria transmission months. The National Malaria Control Program gives annual training to the village health agents, and the Ministry of Health provides drugs.

All health facilities at health center level and above have diagnostic laboratories. A WHO/Roll Back Malaria (RBM) survey showed that in 2001 more than half of all health facilities had malaria diagnostic capacity. The Malaria Control Program is currently providing the Optimal rapid test to health facilities in malarious areas that do not have microscopists.

Malaria Transmission in Eritrea

Eritrea is at the northern limit of malaria transmission in sub-Saharan Africa, and lengthy dry periods limit the intensity of transmission. Large differences in altitude across the country contribute to the complex transmission picture. Transmission is usually described as highly seasonal and unstable, although this generalization masks a high variability. There are three distinct climate systems affecting the rainfall and hence malaria in Eritrea: the *Azmera* (March-May) short rains, which fall mainly in the Eritrean highlands, the *Kremti* (July-October) rains, which usually bring heavy rains to the south-west of the country including the western escarpments, and the *Bahri* (December to February) rains that occur mainly in the eastern lowlands and escarpments.

Following these rainfall patterns, transmission in the south and western areas of the country usually peaks in the months of September through November, while in the eastern coastal zones transmission is highest in the months of January through April. The March to May Azmera rains do not have a large influence on malaria in the central highlands because these rains are generally light and fall mostly at altitudes too high for transmission. However, they do affect the transmission pattern in some escarpment areas such as subzoba Ghinda.

The vector is almost exclusively *Anopheles arabiensis* (Shililu 2003). Despite lengthy dry periods even in the south and west, year-round transmission nevertheless occurs in some areas. This may partly be due to persistence of manmade water sources (Shililu et al. 2003).

In 1999, malaria accounted for one-fifth of all hospitalizations and one-tenth of all outpatient visits, and until recently it was counted as the leading cause of mortality for those aged 5 and older. The maternal mortality rate is high and much of this is attributed to malarial anemia during and after pregnancy. Nevertheless, malaria incidence in Eritrea is relatively low compared to countries further south in Africa. From the data available, the annual incidence of suspected malaria cases seen by health workers (including village health agents) in the years 2000–01 for the whole country appeared to be in the range 60–90 per 1,000 population. If a ratio of about 5:1 is assumed for suspected to confirmed cases, the incidence of confirmed cases would be about 12–18 per 1,000 persons per year.

Incidence in recent years peaked in 1998 and has been declining since. The great majority of confirmed cases seen at health facilities are due to *P.falciparum* (89% in 2000 and 93% in 2001). In the past, the proportion of *P.vivax* cases was higher, but it is unclear whether this change has occurred because of decline in *P.vivax* incidence, an increase of *P.falciparum* incidence, or a combination of the two.

A comprehensive prevalence survey was conducted in 2000–01 using Optimal rapid diagnostic tests to estimate the point prevalence of malaria infection in five out the six zobas (Sintasath et al. submitted). At the time of the survey, point prevalence ranged from 0.1% in Maekel zone (only one positive recorded) to 7.0% in Gash Barka, with an overall prevalence of 2.2% in the country as a whole. There was little difference in the prevalence of malaria infection by age group. The study showed that after adjusting for altitude and rainfall, the type of housing affects malaria risk, with mud walls being associated with higher risk.

Malaria Control Program

The National Malaria Control Program formulated clear guidelines, policies, and targets based on a five-year plan for control of the disease developed at a 1999 meeting in Mendefera. The NMCP set out ambitious goals for percentage reduction of malaria proportional morbidity and mortality rates and incidence of epidemics. The target is an 80% reduction in both morbidity and mortality by the end of 2005, or an average of a 20% reduction each year. The program has been meeting these targets.

The strategies in use include:

1. Early diagnosis and prompt treatment at health facility and community levels
2. Proper management of severe malaria at zoba/subzoba level
3. Reduction of man-mosquito contact through provision of insecticide impregnated bednets to communities in all zones
4. Increase in community awareness in controlling malaria and health-seeking behavior through the promotion of information, education, and communication
5. Environmental management through community participation and prevention and control of malaria outbreaks

Indoor residual spraying is not specifically mentioned in this list of priorities, but is done in selected malaria risk areas or villages in three zobas. Spraying may be covered under Strategy 3 (reduction of human-mosquito contact) and Strategy 5 (control of malaria outbreaks).

Until 2002, the first line treatment for malaria was chloroquine, with sulfadoxine-pyrimethamine (Fansidar) as second line, and quinine reserved for severe and complicated cases. The MOH/NMCP changed the malaria treatment policy in June 2002, based on accumulating evidence of widespread chloroquine resistance. First line treatment is now chloroquine plus Fansidar. It is predicted that a further change will take place within a few years to a combination of artesunate and another drug, possibly amodiaquine. Drug resistance is monitored every year, but so far is at a low level.

Impregnated bednets have been used in the country since the mid-1990s, but have been introduced more rapidly in some zobas more than others. Nets are issued and reimpregnated annually by malaria program staff together with health facility staff, based on household registration at the administration offices of the kebabi level. There was a large scaling-up of the program in 2000 as well as a huge increase in the reimpregnation rate. By 2003, more than half a million impregnated nets had been distributed, and a large network of re-impregnation sites established. Until 2002, a small payment per net was required, but now nets are issued free in "high-risk" areas at one per household in some zobas and up to two per household in others. Nets have been free to pregnant women since 2001.

Indoor residual spraying using DDT or malathion is done as routine practice in two zobas (Gash Barka and Debub). It was also done in Northern Red Sea zoba until 2000. The amount of spraying done varies by year according to the chemical available and the discretion of the zoba manager. Transport availability is also a limiting factor, since each spray team requires constant use of a vehicle for several months. The spraying rounds are organized early in the year and are hard to vary once under way. Therefore spraying is not a feasible method of responding to epidemics.

The Environmental Health Project has been evaluating the effectiveness of larval control by environmental management and the use of biological insecticides for malaria control in Eritrea. This is carried out at all levels in the community and health system, including the village health agents who are responsible for community mobilization and action. The larvicide Temephos (Abate) is also used widely in towns during the rainy season, during which it is applied weekly to larval habitats found.

Monitoring of control program activities needs improvement and makes it hard to evaluate the relative effectiveness of the different activities. While the program generally functions well, a few areas have been neglected. Two examples are improving control of malaria in pregnancy and increasing rapid access to treatment, which are both now being addressed.

1. Compilation of Past Data

There are three aspects to understanding the malaria situation in Eritrea. The first task is to document the malaria cases for the past few years. The second task is to understand what the control program has been doing over the same time period. Third, it is crucial to document the climate to try and understand its influences on the amount of malaria. Only then can one understand the following:

1. What the control program is up against
2. How effective it has been in the past
3. The relative impact of climate and control measures on malaria transmission

In addition, only by understanding past epidemics and looking for prior warning signs will Eritrea be able to predict and prevent future calamitous epidemics.

A critical factor in this process is to choose appropriate time and space units for documenting and analyzing these three key topics. A general overview can be gained by synthesizing data over the whole country, but this masks important variation in a country as variable in terrain and climate as Eritrea. On the other hand, choosing too small a geographic unit leads to data overload and is not useful for managing and improving a program. The first analysis is done using datasets organized by subzoba and month as the geographic and time units of analysis.

Recognizing that data from health facilities only includes the people who access care. From there, malaria information by health facility and month from the NHMIS was selected as the core of this investigation. NMCP data for earlier years was added, as was the NMCP information on malaria control activities performed.

Limitations of routine disease surveillance systems are well known and include missing data, poor training and supervision, and insufficient data cleaning and checking. Lack of use of routine data contributes to these problems, since staff will cease to care about maintaining data quality if no one is using the data or noticing inconsistencies. One of the best ways to improve the quality of routine data is to make use of it. For certain types of information, for example, bednet use, rigorously conducted sample surveys will always be necessary. However, if large-scale longitudinal data from countries such as Eritrea where malaria transmission is at a relatively low level, but is ill defined and heterogeneous, “large scale” means the whole country.

This section describes the data collected to form three datasets known as the CASES, INTERVENTION, and METEOROLOGY datasets, based on a time series of subzoba and month. These datasets are later merged for analysis, which is described in Section 2, below.

When compiling past data, the coverage and availability of records are limited to those collected and kept. In epidemiological data, the constraints are the age-groupings and case definitions used, which have changed over time. In the early 1990s, the malaria program reported data by five age groups and separately by sex. When the NHMIS was introduced in 1998, the number of age groups was reduced to only two (under-five years and all others) and cases by sex were not reported separately. The NHMIS also introduced new ways of reporting particular diagnoses using ICD-9 codes. However, “clinical malaria” is still a reportable diagnosis, and it is unlikely that clinical judgment changed dramatically as a result of the new reporting system.

In addition to changes in data categories, adequacy of staff training, consistency of effort, and accuracy of reporting have to be considered. Possible biases in case definitions and reporting must always be kept in mind, even if their extent is unknown. A particular problem in all the datasets, but especially the intervention activities, is distinguishing “zeros” (no malaria cases, no rainfall, or no control activities were done in that particular month) from “missing records” (no report for that month). By assigning all the missing values to “zero” in the INTERVENTION dataset, is a conservative approach since it would tend to minimize the effects of the interventions. Missing values in the CASES dataset were handled by either: 1) restricting the data to health facilities with good reporting rates; or 2) imputation from existing data, which is described in the report by Thomson et al.

Despite all these caveats and provided biases that exist are reasonably consistent, selected variables in large datasets prepared from routinely collected data can be used with confidence to examine long-term trends over time and space and to assess the effectiveness of malaria control interventions.

1.1. Malaria Cases

Reporting system

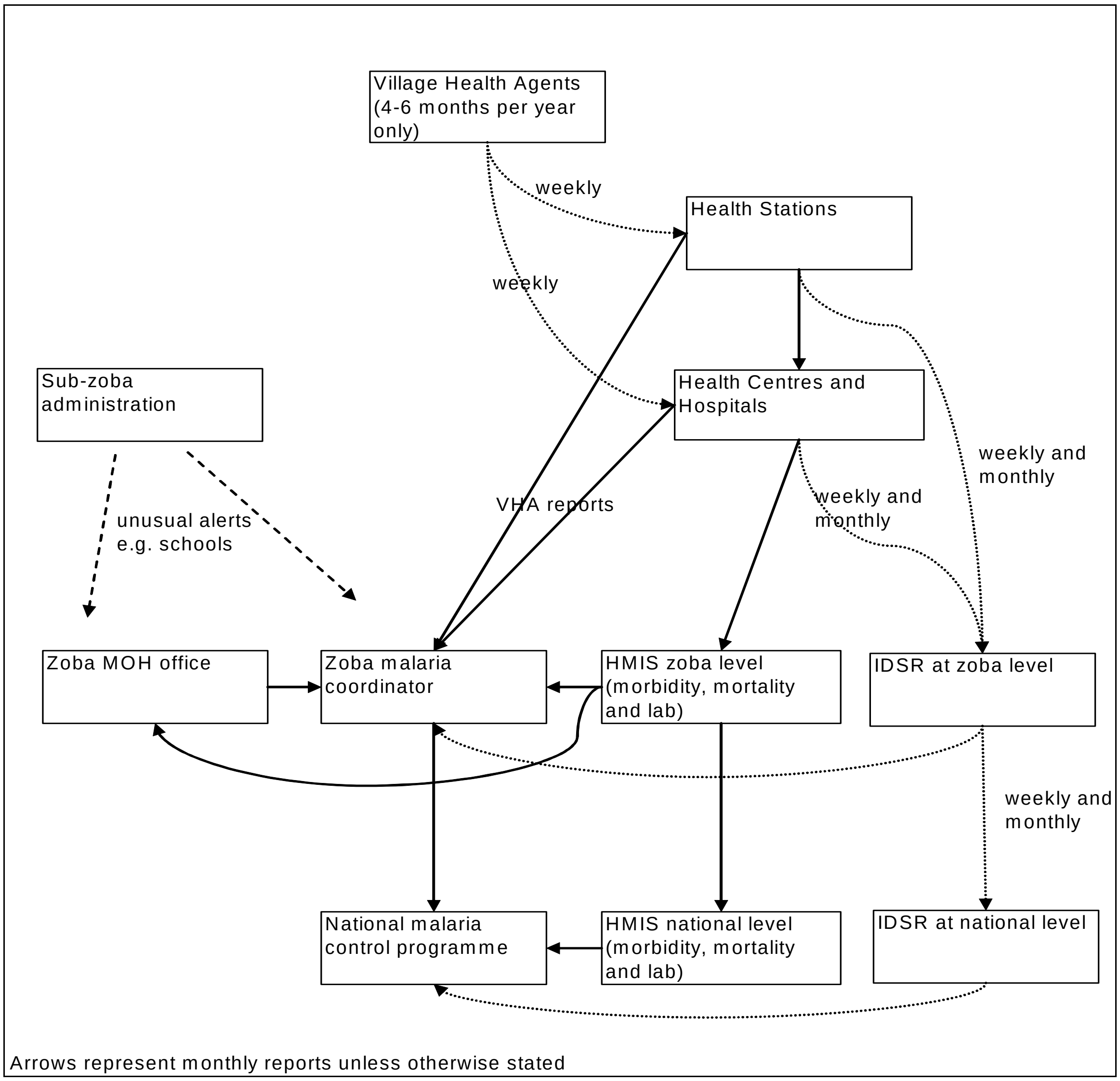
For health facility data, it is fortunate that the new NHMIS was implemented starting in 1998 in Eritrea with assistance from USAID/JSI. Most of the clinical data shown below from 1998 onwards come from the NHMIS, while prior data come from the NMCP records.

For the NHMIS, each health facility submits monthly reports of cases to the next higher-level facility and ultimately to the zoba health office, where the data is entered into an Access database. National data is combined in Asmara and is available to health programs for monthly and annual monitoring through a front-end graphing and mapping application known as the Decision Support System. The NHMIS requests reports from all types of health facilities including private doctors, worksite clinics, and internally displaced persons (IDPs) camps, (but not military facilities). Reporting rates are generally good for all zones (86% of monthly reports were received on time in 2003).

The NMCP maintains its own database of malaria cases and deaths by subzoba. One data source is the same health facility monthly report forms that the NHMIS uses. However, the malaria program also compiles weekly and monthly reports of cases treated by village health agents (not currently incorporated into NHMIS). In addition, the NMCP is the source of the 1996 to 1997 data, since these years were prior to NHMIS implementation.

Another potential information source is the Infectious Disease Surveillance and Response System, which requires weekly reports of cases of a set of 18 diseases from all health facilities. The diseases are either epidemic-prone or potentially eradicable diseases, which are being closely monitored. The system's data management tasks are formidable but are currently being upgraded with the installation of an EpiInfo-based computerized system at the zoba level. While it is difficult to integrate weekly and monthly reporting systems, attention is being paid to this problem. Case definitions in the IDSR differ from those in the NHMIS and thus yield additional information, including some data on malaria in pregnancy. Once fully computerized, this will be an invaluable source.

Figure 3. Information Flow on Malaria in the Ministry of Health, 2002



In the NHMIS, suspected malaria cases are reported by two age groups: under 5 years, and 5 years and above. Case definitions are clearly specified. Inpatient admissions for malaria as well as malaria deaths in health facilities by these two age groups are routinely reported. These data on number of cases and deaths are used to calculate monthly and annual proportional morbidity and mortality rates among patients seen at health facilities as well as to rank malaria as a cause of attendance, admission, or death by month and health facility.

The NHMIS reports both clinical malaria cases and confirmed cases by malaria species. However, confirmed cases are only reported from 2000 onwards, and a problem with the form design (since corrected) means that the past information is not very accurate. Also, only about half of the health facilities have diagnostic capability. Therefore, this work is restricted to clinically diagnosed (suspected) malaria only. Given the relatively low malaria prevalence in Eritrea and the fact that the highest prevalence is found in children over five years (i.e., when there are fewer other fever-causing diseases), this limitation is not such a drawback as it would be in more highly endemic areas

Records on malaria and on total cases seen as outpatients and inpatients from 1998–2002 were extracted from the NHMIS database and put into a Malaria Access database according to the procedure described in Appendix 2. Health facility data for 1996 and 1997 from NMCP records were added. The 2003 records were extracted separately after the end of 2003 and added to the 1996–2003 data.

The final CASES dataset organised by health facility and month is called "Malaria NHMIS 1996_2003.mdb." In addition to the analysis shown in this report, this dataset has been used in preparation of presentations that the NMCP and the MOH gave. Feedback and demonstration of the extraction process have influenced not only the way that data is synthesized in the NMCP, but also helped to improve the NHMIS. For example, reports of duplicate data values led to increased data checking and cleaning in NHMIS.

For longitudinal analysis of cases over time and for defining epidemics, missing data could cause severe bias. Therefore records from the 325 total health facilities in the CASES dataset were restricted to two smaller subsets for certain analyses:

- SUBSET 1: 252 government/church/NGO clinics, which represented all 58 subzobas, and excluded private and industry clinics, which tended to report sporadically. All subzobas are represented in this subset.
- SUBSET 2: 141 clinics, which reported more than 90% of months during 1997 to 2002. In this group, 6 subzobas did not have any clinics with sufficiently consistent reporting, leaving 52 subzobas for analysis.

The numbers of clinics and subzobas included in each subset by the above criteria are given by zoba in Table 1.

Table 1. Number of Health Facilities in Different Analysis Sets by Zoba (Excluding National Referral Hospitals)

CASES subset		**Anseba**	**Debub**	**Southern Red Sea**	**Gash Barka**	**Maekel**	**Northern Red Sea**	**Total**
ALL	Total health facilities	38	69	23	75	68	50	**325**
	Total subzobas	**11**	**12**	**4**	**14**	**7**	**10**	**58**
SUBSET 1	Health facilities excl. private/ industry clinics	32	64	16	61	35	37	**252**
	Subzobas represented	11	12	4	14	7	10	**58**
SUBSET 2	Health facilities reporting 90% in 1997–2002	27	34	9	22	22	27	**141**
	Subzobas represented	11	11	3	11	7	9	**52**

SUBSET 2 of the CASES dataset was used in most of the descriptive analysis of malaria trends and in the epidemic definition work. For the stratification process and assessment of control interventions, it was desirable to have all subzobas and time points represented. Therefore, SUBSET 1 was used but missing data points were imputed from the rest of the dataset. This is described in more detail under Section 2, below.

For comparing intensity of transmission between zobas and subzobas, it is necessary to adjust for population size and calculate an incidence rate per 1,000 population. For this purpose, the population estimates for 2000 in NHMIS were used (see Appendix 1), as they were complete by subzoba (although not by health facility).

While it is unlikely that the extreme variation in numbers of malaria cases by month is due to reporting bias, this was checked for by extracting the total number of patients seen by month as well the number of diagnoses of acute respiratory disease and diarrhoea seen by month for the last five years of the study period. These are described in Section 2, below.

1.2. Malaria Control Interventions

For the INTERVENTION dataset, the data categories required are:

1. Residual spraying
2. Impregnated nets issued and re-impregnated

3. Reduction of larval habitats (source reduction by filling, draining, and so forth)

4. Chemical treatment of larval habitats (temephos and Bti/Bs)

5. Treatments given by village health agents

While the first four categories are obviously malaria control efforts, the last category represents both a potential surveillance mechanism and a control measure. The village health agents provide a very large proportion of the presumptive malaria treatments given in the country, and the effect of this on transmission may be large. Treatments given at health facilities as a control measure could also be considered. However, this is not possible because then another way would be needed of measuring the outcome (number of malaria cases), since by definition, malaria treatment is always given to such cases.

Residual spraying is reported nationally on a seasonal basis, but in fact takes place during a limited number of months in the rainy season. Only two zobas (Gash Barka and Debub) were doing spraying routinely in 2003; Northern Red Sea ceased spraying in 2000. To assess the exact amount, timing, and location of spraying in the three zones, spraying records were sought from 1996 onwards. This required going to the zoba office and entering records from the paper forms. For Debub and Northern Red Sea, the exact dates of spraying by locality (village) were collected. In Gash Barka, such specific date information was not available, but the months of spraying and the order of sprayed subzobas are known. Therefore, at least the months of each locality's spraying could be estimated. The main variables collected by subzoba were the amount of insecticide used, number of houses sprayed, and population protected.

Bednet impregnation is currently reported monthly by subzoba to the national NMCP. Previously it was recorded also by health facility in Anseba. For Gash Barka and Anseba, records were available from 1998 by subzoba; in Debub it was not possible yet to get these until 2002 since unfortunately they are not forwarded above the subzoba level in Debub. This will be pursued. Similarly NRS and Maekel bednet data are only available so far for 2002–03. For this reason, the first analysis will concentrate on Gash Barka and Anseba. The main variables collected were number of impregnated nets issued, number of nets reimpregnated, and amount of permethrin used.

Source reduction, larviciding, and village health agent treatments are all reported monthly to NMCP head office on the "Community-based Activities" form. The data were available by subzoba and month from 1998 onwards for Gash Barka, Anseba, and Debub. The documentation for these activities is reasonably good from 2000 onwards, but very patchy prior to that. The format of the forms changed greatly over the years, but it was usually possible to extract the total number of malaria cases treated by village health agents, the total number of larval breeding sites dealt with (either by filling, leveling, draining, flushing or treating with larvicide), and the amount of oil or larvicide used in liters or milliliters (mls) respectively. Oil was used several years ago but has now been replaced by temephos (Abate).

Two problems with the INTERVENTION dataset are: (1) a lack of consistency (over space and time) in the variables collected to monitor this activity; and (2) that the monitoring variables are not population-based, making it hard to make comparisons between subzobas. In an attempt to solve these problems, the following adjustments were made: (a) restricting analysis to variables collected consistently; and (b) using subzoba populations to adjust for population, even if the activity was done in a small proportion of a subzoba.

1.3. Meteorology

The METEOROLOGY dataset comprises any available information on climate variables such as rainfall, NDVI (normalized digital vegetation index), and temperature variables.

There are two rainfall data sources for the country. The first is actual amounts of rain measured at ground rainfall stations, while the second is remotely sensed rain estimates, available since 1995 from the U.S. Geological Survey (USGS) through the Famine Early Warning System.

For the first source, Eritrea now has a large number (>50) of functioning rainfall stations managed by the Civil Aviation Department, the Ministry of Agriculture, the World Bank HAMSET project, the Ministry of Energy, or the Water Resources Department. Their locations have been mapped and were published in the July 2004 “Monthly Food Security Outlook” newsletter that the MOA and FEWS produced. At these stations, actual rainfall is measured daily and reported by phone or radio and/or in writing to the Civil Aviation Department and/or the Ministry of Agriculture. Certain key stations report daily by phone or radio to the Civil Aviation Department for weather forecasting purposes.

Current data from most of these rainfall stations are good and improving. The newly established sentinel site health facilities are also collecting rainfall data. However, for past data the analysis relied on the stations, which operated consistently in the last decade.

Rainfall at ground stations by month for 1992–2003 was obtained from the Meteorology Section at the Civil Aviation Department. A total of 23 stations had reported consistently since the early 1990s, and only these ones were used. Daily data is also recorded, but is only computerized since 2000.

A list of the 23 rainfall stations and the average rain in millimeters by calendar month and station is given in Appendix 3, together with the locations of the stations. The consistently reporting stations are not evenly distributed through out the country, but are concentrated in the highland and central region. However, there was at least one station in each zoba, and 22 of the 58 subzobas were represented by at least one station.

The second type of rainfall data will be referred to as “rainfall estimates” or RFE. IRI provided rainfall estimates from satellite data for the years 1995 to 2004 by month and subzoba boundary. Although the estimation method changed slightly in 2000, there was a 10-month period of overlap, which enabled us to derive corrected estimates for the first period. Only a few months had missing satellite rainfall estimates.

IRI also provided other climate information such as NDVI and temperature from remote sensing estimates in its data library. Currently this information is in the form of means, medians, minima, and maxima for the calendar months January to December, by subzoba, and over the years 1996 to 2003. Currently an attempt is being made to obtain estimates for each month separately, but this is a major undertaking, and they will not be available immediately. In the meantime, the monthly averages will be used.

1.4. GIS Data

GIS data does not constitute a separate dataset, but is essential for generation and interpretation of the three datasets already described. This section is provided because of the plethora of different departments in Eritrea using GIS, giving rise to a certain amount of confusion and discrepancy between datasets.

This project examined: (a) accurate zoba and subzoba boundaries; (b) locations of health facilities; (c) locations of rainfall stations; and (d) locations of villages classified as malarious/non-malarious. All of these were found from various sources and were made usable with the assistance of many people, especially staff at the National Statistics Office, the Water Resources Department, and IRI (special thanks to John del Corral). The following sections describe the different GIS data used by various government agencies, and point out which have been used in the current studies.

NHMIS (Ministry of Health)

The NHMIS includes a fairly basic mapping component, included in the Decision Support System front-end application to enable staff to visualize disease numbers by zoba or subzoba, or over time. However, incidence calculations by the areas are not yet fully implemented.

In the NHMIS system software, health facility coordinates as latitude-longitude are in the file "fac.dbf" although many are missing, and some are known to be inaccurate, (but which ones are not known). Zoba and subzoba shape files are also provided within the NHMIS system, and these have been used here in some figures for mapping incidence by subzoba over time.

National Statistics and Evaluation Office, Ministry of Trade and Commerce

In preparation for a UNFPA-funded census, the National Statistics and Evaluation Office (NSEO) has redone GPS locations for all villages, water-points, health facilities, roads, rivers, and other landmarks. They have provided village and health facility locations in UTM (Universal Transverse Mercator projection) format to the Ministry of Health for the Malaria Control Program. Any other use of this data is prohibited.

John del Corral of IRI transformed the UTM coordinates from the projection that NSEO used into latitude-longitude, so that more health facilities can be located or corrected in the NHMIS. The resulting coordinates are included together with the NHMIS coordinates in the file "HF Locations FINAL.xls" (see Appendix 4). The NSEO coordinates are regarded as "gold standard," if more than one set is available.

The NSEO also provided subzoba boundaries, which were slightly different from those in the NHMIS. The NSEO versions are used for mapping villages and health facilities and for the satellite rainfall estimates. There was some confusion in subzoba coding in the NSEO: subzoba code numbers were not only different from the MOH codes, but did not represent correct subzoba names according to location. These were manually corrected on June 9, 2004, and will be discussed with the NSEO at the earliest opportunity.

Water Resources Department, Ministry of Land, Water and Environment

For Debub zoba only, a file of village and health facility locations (plus rivers and roads) was obtained from the Water Resources Department. John del Corral again was able to transform these into latitude and longitude. The locations for Debub health facilities from this source are also given in "HFLocationsFINAL.xls" (see Appendix 4). The subzoba boundaries that the Water Resources Department uses are from the UN Office for the Coordination of Humanitarian Affairs (OCHA) in Asmara, and when correctly projected are the same as the NSEO boundaries, suggesting that they both originated from the same source.

Ministry of Agriculture

The Ministry of Agriculture was the site of an extensive land use mapping project called AFRICOVER that the Italian Cooperation funded. The project has since ended. The MOA Remote Sensing Department is continuing this work. So far, the Africover GIS data have not been obtained or used due to the fact that their department was in transition and because it is not clear how it relates to other GIS datasets in the country.

The MOA also runs many of the rainfall stations on its property with its personnel, who report rainfall amounts to the MOA and to the Civil Aviation Department. The FEWS project and the National Food Information System jointly publish (10-day) dekadal and monthly newsletters (since early 2004), which include rainfall data from stations as well as satellite-derived maps of recent rainfall and normalized vegetation data index (NVDI) obtained from the USGS. The exchange of information between MOA and the NMCP has improved recently, and the NMCP are included on the distribution list for these newsletters. A recent example of the "Monthly Food Security Bulletin" is in Appendix 5.

WHO Health Mapper

The Eritrea boundary files included in the WHO Health Mapper software have not been used at all because they show the old (pre-1996) zoba boundaries. There has not been any incentive for the MOH to use Health Mapper, because the NHMIS and other Ministries have already established GIS mapping using ArcView with more recent boundary files.

MARA (Mapping Malaria Risk in Africa)

Africa maps predicting the malaria endemicity level in various ways, based on climate models, are freely available on the web at http://www.mara.org.za/. These have been used to generate variables used in the stratification based on the prevalence survey data (Thomson et al.).

However, they are not a possible source of administrative boundaries since the maps show the old (pre-1996) zoba boundaries for the country.

Summary of health facility locations

The file “HFlocations Final.xls” (see Appendix 4) gives all the alternative coordinates for locations of health facilities. The three sources are Water Resources, NHMIS, or NSEO. The final latitude-longitude used for each facility is taken in this order of putative reliability:

1. NSEO if available; if not then
2. Water Resources Department, if available
3. If neither of the previous coordinates are available, NHMIS coordinates are used.

2. Data Analysis

2.1. Malaria Epidemiology

Variation by year, month, and zoba

Some example data extracted from the CASES dataset SUBSET 2, demonstrating the malaria situation in 1996 through 2003, will be shown in Figures 4 to 11. Some data types (e.g., inpatients) were only available from 1998 onwards, when the NHMIS started.

When comparing between zobas or subzobas, adjustments must be made for population size. Therefore, results are generally shown as incidence per 1,000, either annual or monthly. Annual incidence is the sum of the monthly cases divided by the population and is usually expressed per 1,000 population. Population estimates for 2000 by zoba or subzoba from the NHMIS were used (see Appendix 1). These are known to have inaccuracies but were the best available.

Figure 4 clearly shows the monthly variation in number of cases. The highest numbers of cases were observed in October in every year except two (2000 and 2002), when it was slightly higher in August than October. An extended peak in case numbers can be seen in late 1997-early 1998 and again in late 2000–early 2001. A general decline was seen in the height of the seasonal peak from 1998 (over 36,339 cases) to 2003 (about 7,200 cases). However, 2003 had a higher peak than 2002. This is cause for some concern.

Figure 4. Eritrea: Malaria Cases By Month, 1996–2003

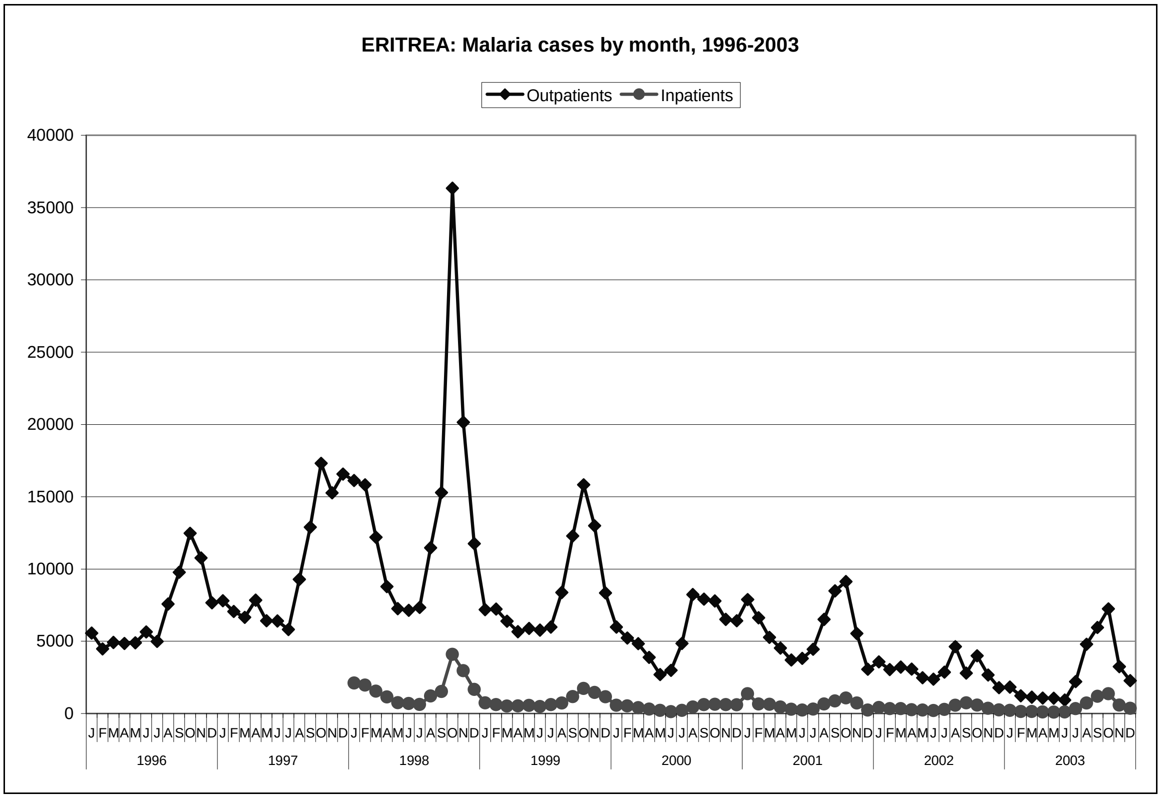
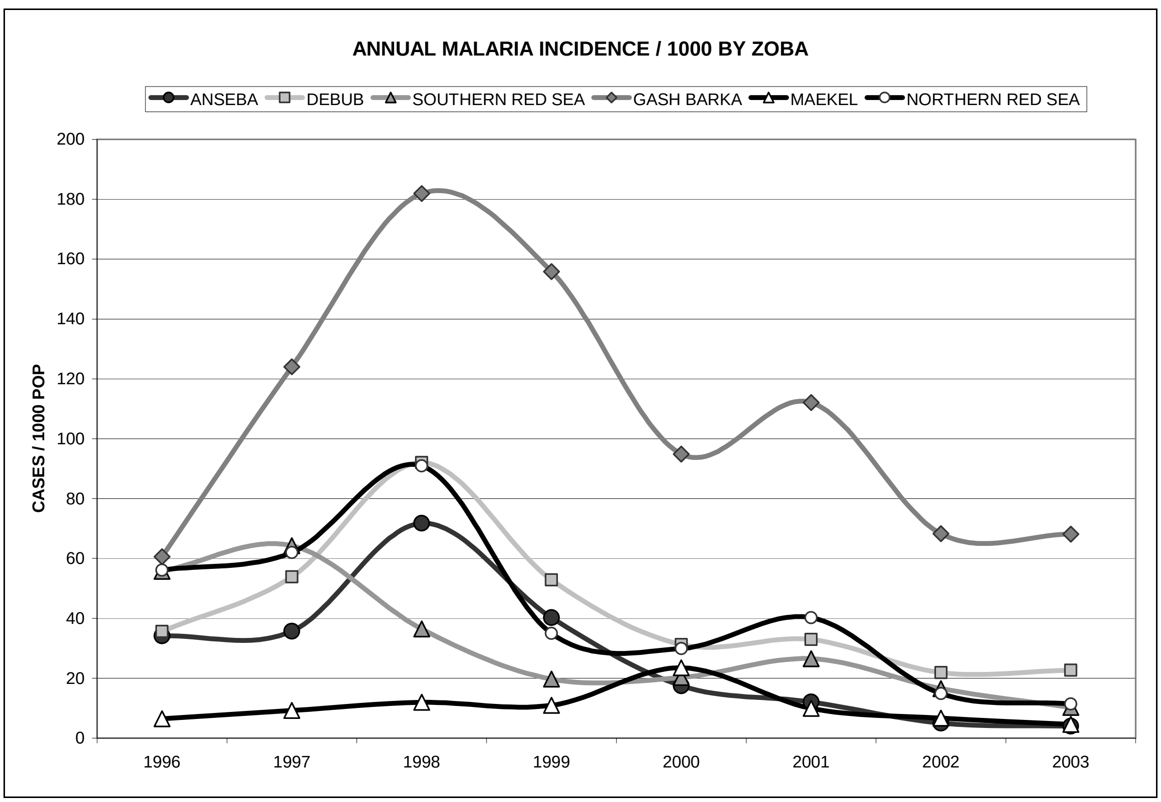


Figure 5. Annual Malaria Incidence per 1,000 in Eritrea by Zoba, 1996–2003



Gash Barka is clearly the zoba with the highest incidence of malaria per 1,000 persons (see Figure 5) followed by Debub and Northern Red Sea. Anseba has shown the greatest decline in malaria incidence in the last eight years and in 2003, had lower incidence than all but Maekel zoba. Southern Red Sea zoba had surprisingly high incidence once adjustment was made for population size.

The seasonal variation in number of cases shows two patterns. In the first pattern (see Figure 6), zobas Anseba, Gash Barka and Debub all usually have a peak of cases in August to October, although the actual number of cases shows large variation. The second pattern is shown by the other three zobas (see Figure 7), where there is a much more erratic picture. In Northern Red Sea (NRS), there were two notable years with high incidence peaking in January 1998 and January 2001, while Southern Red Sea and Maekel zobas show no obvious seasonal pattern. Note the different scales in Figures 6 and 7.

The distinctive peaks in NRS in 1998 and 2001 explain why the combined country data appear to show extended peaks of cases from October through January/February in 1997–1998 and 2000–2001(see Figure 4). This is a result of the combination of cases from Northern Red Sea (peaking in December-February) with the rest of the country’s cases (peaking in October).

Figure 6. Malaria Incidence/1,000 by month in Gash Barka, Debub, and Anseba Zobas (1996–2003)

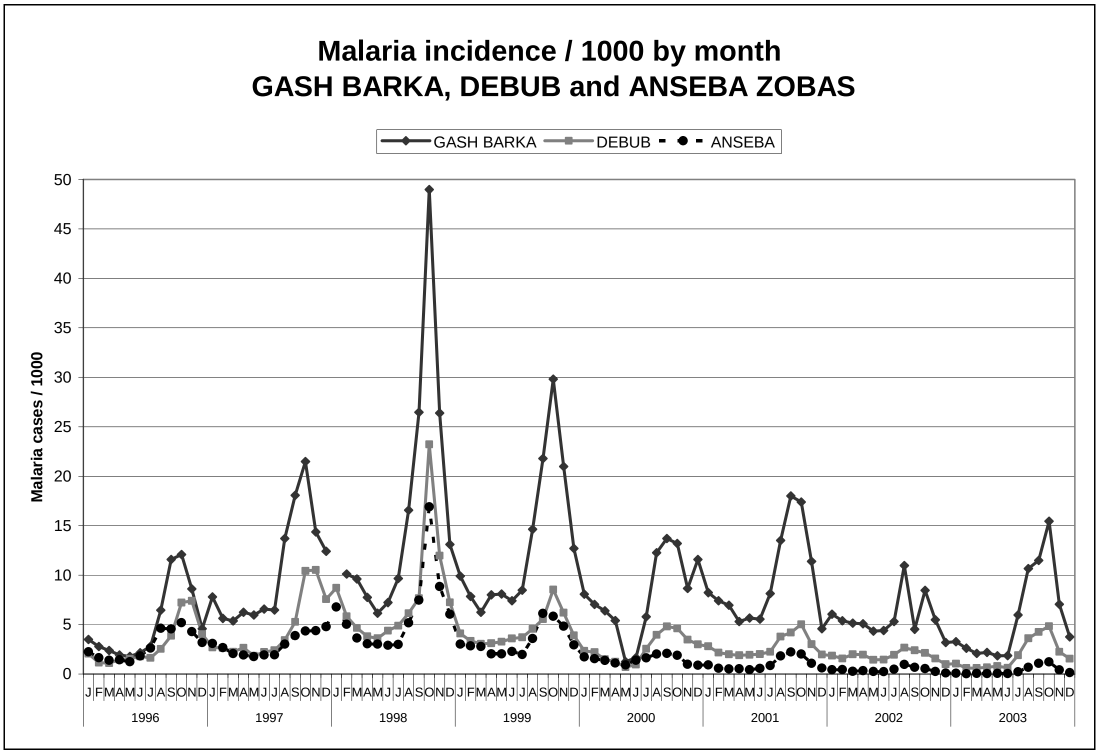
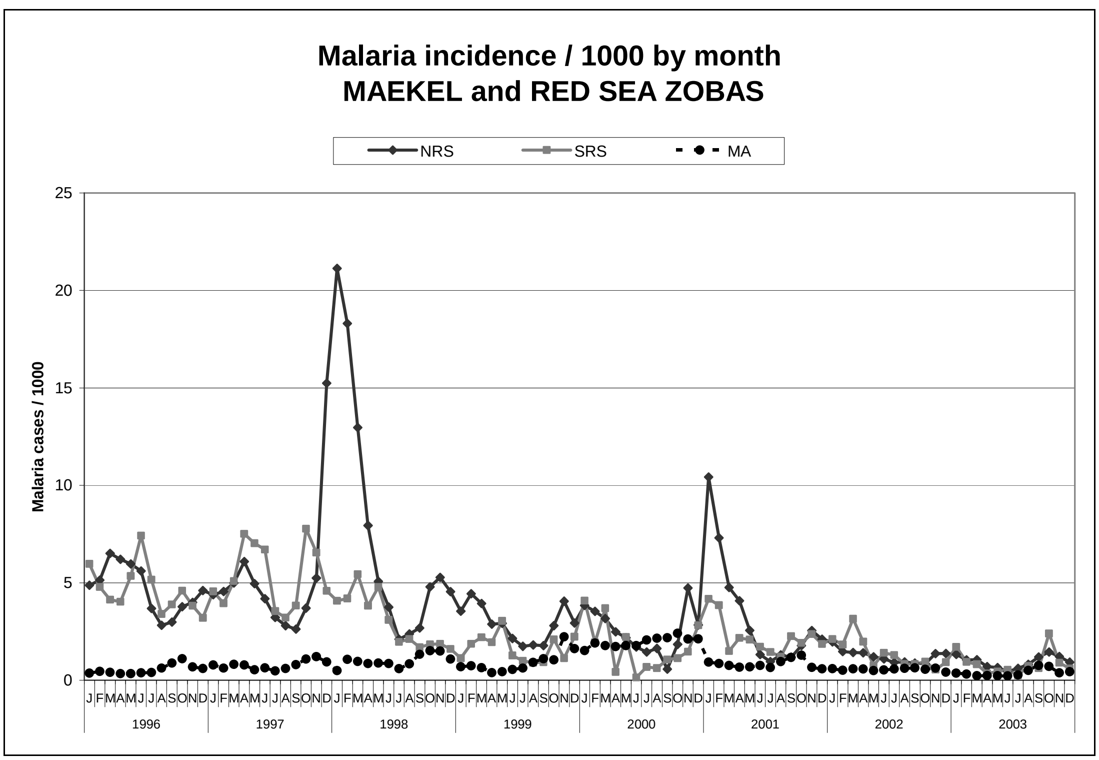


Figure 7. Malaria Incidence/1,000 by month in Maekel and Red Sea Zobas (1996–2003)



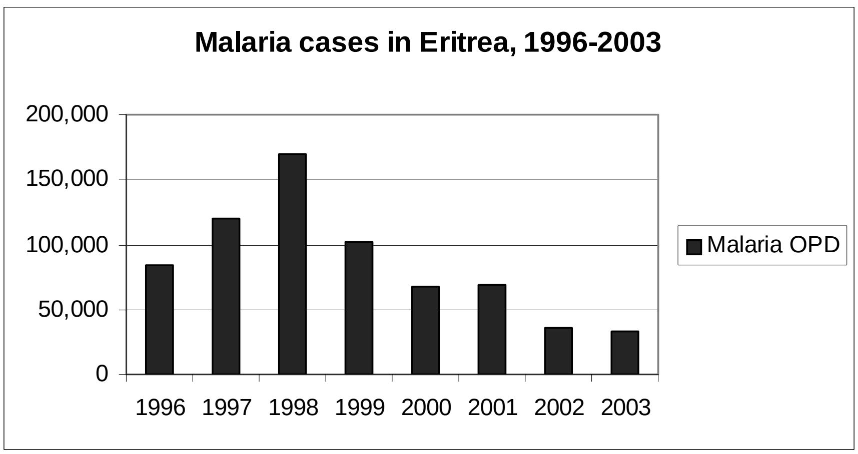
Figures 6 and 7 show that the countrywide trends in malaria cases are mostly determined by the Gash Barka cases, since this zoba has had the highest number of cases, especially in recent years. Up to 1999, Anseba zoba had a fairly significant annual peak, but the monthly variation has flattened since then (Figure 6).

While it is useful to give a general overview of the annual malaria situation for the country, the data analysis shows that combining data from diverse areas can give misleading patterns and should be done with caution. For setting priorities, allocating resources and timing control measures, examination of monthly or seasonal data by zoba and subzoba is necessary.

Annual trends

The steepest decline in the overall number of cases reported was seen between 1998 and 2000. A further decrease was observed from 2001 to 2002 (Figure 8). The situation is holding stable in 2003, with no major decrease from 2002.

Figure 8. Malaria Cases in Eritrea, 1996–2003



A matter of concern is the slight increase in both the number of cases in under five-year olds (see Figure 9) and in the number of malaria inpatients reported (see Figure 10) from 2002 to 2003. It is possible that as immunity wanes, a greater number of severe cases would be seen. However, it is not expected that there would be increased numbers of cases in younger age groups, in fact the opposite would be expected. Further investigation of inpatient and severe cases in under-five year olds is warranted.

Figure 9. Malaria Cases by Age Group, 1996–2003

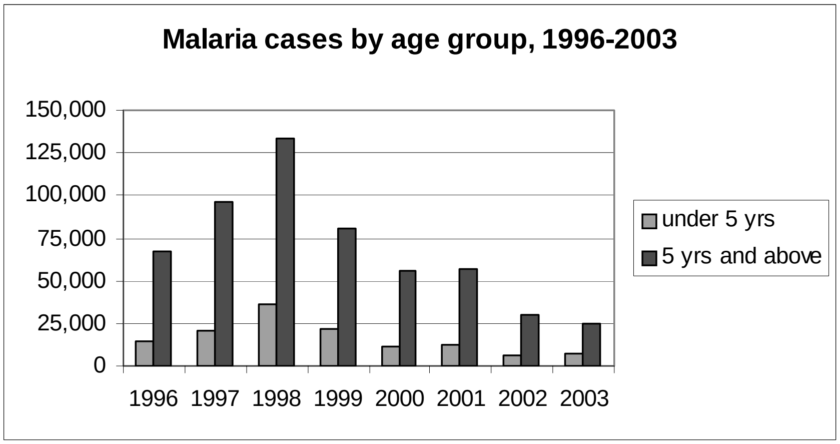
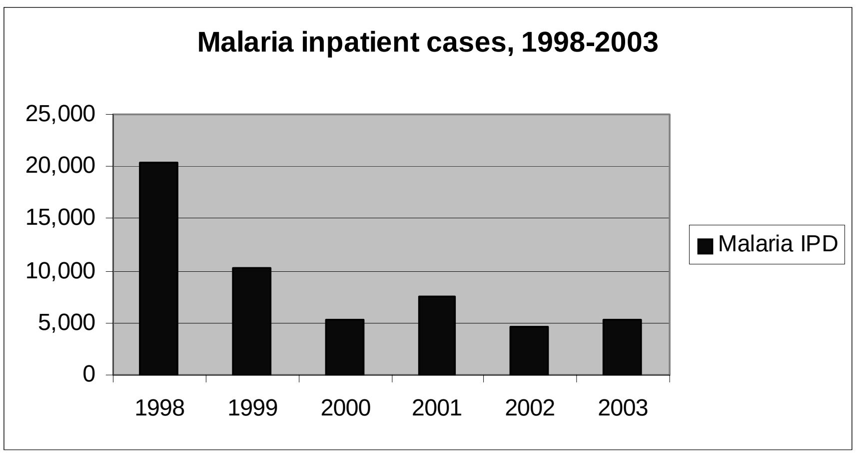


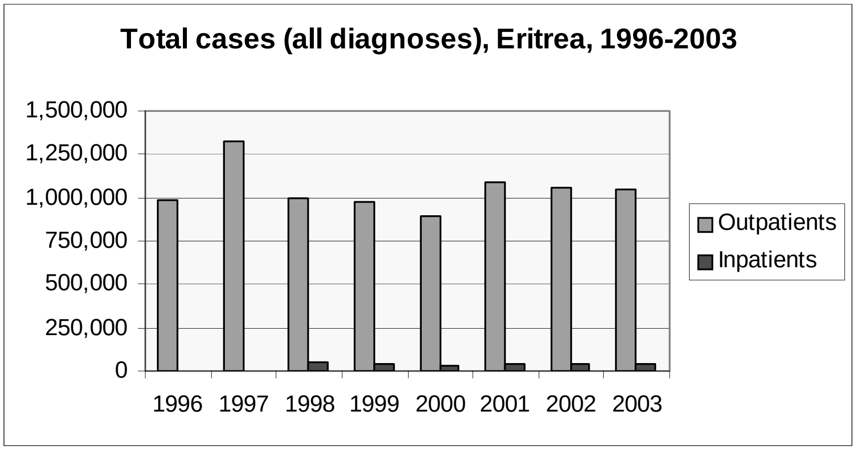
Figure 10. Malaria Inpatient Cases, 1998–2003



To investigate whether the decline in malaria cases is due to change in reporting rates, it is useful to examine trends in other diseases. This was done in two ways. First, trends in the total number of patients (any diagnosis) are examined, which were reported from 1996 to 2003 in the CASES dataset (see Figure 11). The total number of patients is always reported (total morbidity) to be able to calculate percent morbidity due to malaria. This is one of the indicators that WHO-Regional Office for Africa (AFRO) requests.

Figure 11 shows the reported cases of all diagnoses to be fairly stable from 1996 to 2003, although the higher number in 1997 is puzzling. Since the population has been increasing over these years and the data are not adjusted for population growth, a slow rise would have been expected in the number of cases of all diseases. This may not be observed because malaria used to make up a significant proportion of cases but has been declining.

Figure 11. Total Cases (All diagnoses), Eritrea, 1996–2003



As a second approach to examining overall reporting rates, the time trend was examined for other diseases. Figures 12 and 13 illustrate monthly trends obtained from the NHMIS for two other disease classifications (acute respiratory infection and diarrhea) in all age groups during the years of study.

Figure 12. Number of Acute Respiratory Tract Infections, Eritrea, 1998–2002

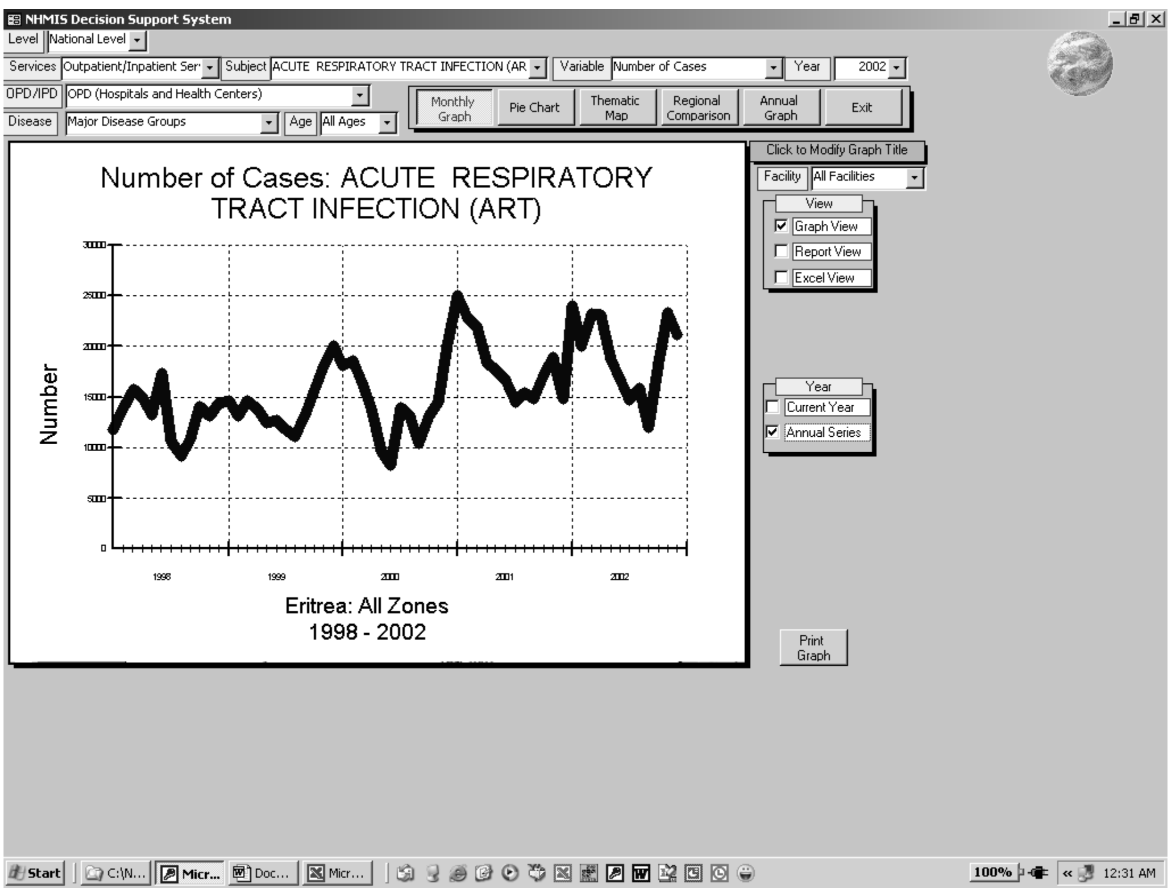
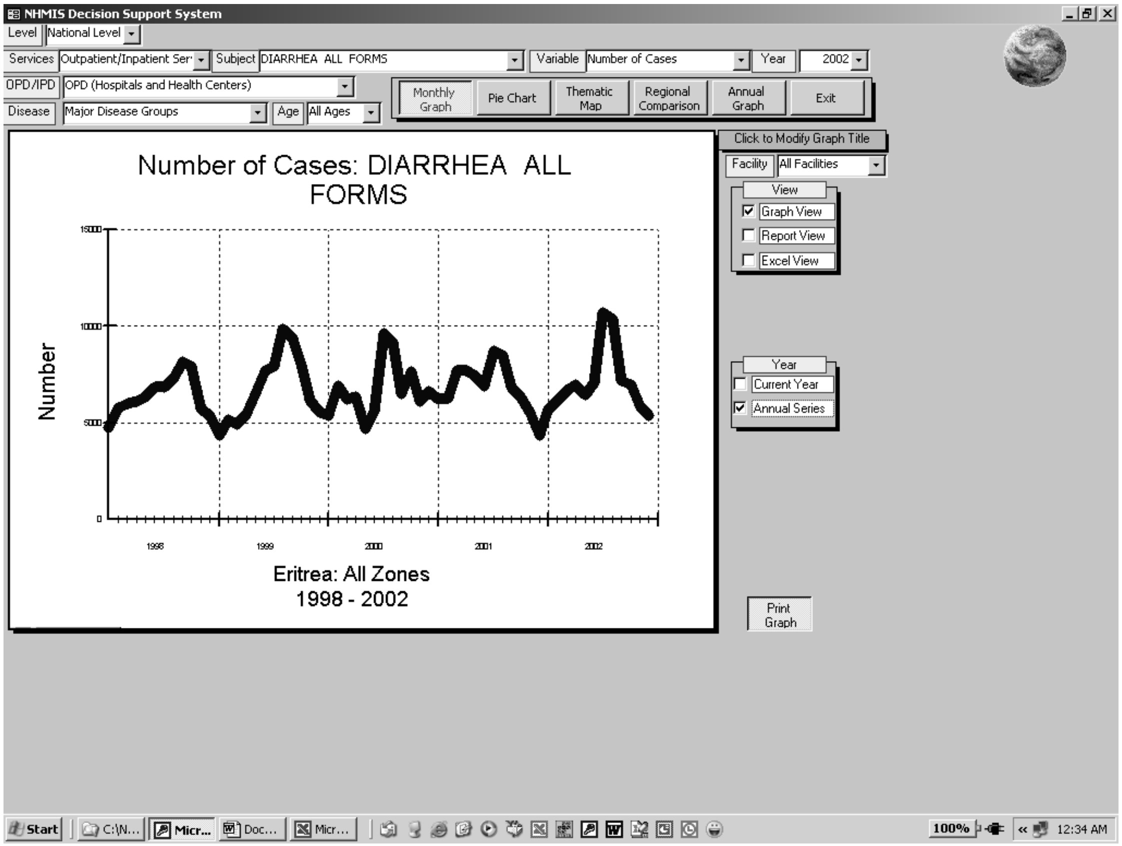


Figure 13. Number of Diarrhea Cases, Eritrea, 1998–2002



The graphs in Figures 12 and 13 illustrate the type of output available from the NHMIS. It is possible to extract a five-year span of monthly case numbers, but not longer spans of years. Therefore, 1998 to 2002 were chosen. It is also possible to print the graphs above directly from the NHMIS, but it is not straightforward to extract the data and print the graph only in another program such as Excel. A similar graph can be printed for malaria, but can be done either for health centres and hospitals or for health stations only. Both show the same downward trend illustrated in Figure 4, above.

Figures 12 and 13 show that the general trend of ARI infections is upwards, while for diarrhoea the number of cases is fairly stable. This suggests that the decline in malaria cases during 1998 to 2003 is not due simply to change (decrease) in reporting rate for the NHMIS over the years since its inception.

Progress towards malaria control targets

To assess progress in controlling malaria in Eritrea, achievements could be compared with the Abuja targets set by African Heads of State in 2000. These call for a 50% reduction in malaria mortality in under five-year olds by 2005. Eritrea also set its own national malaria control targets in a five-year plan for 2000–04; these targets were ratified at a meeting in Mendefera in 1999. In brief, a goal of 20% reduction per year in malaria morbidity and mortality was set at this meeting.

The choice of baseline year against which progress is measured will significantly affect the evaluation results. The transmission decline could be estimated since the recent peak year of 1998. However, 1999 is a better year to use as a baseline than 1998, for two reasons: (1) it gives five full years for the comparison; and (2) using an unusually high incidence year (1998) may produce an optimistically-biased estimate of the decline. Therefore, 2003 is compared to the 1999 baseline.

Malaria mortality in Eritrea has dropped by half since 1999 in both young children and the population as a whole. Total reported malaria deaths from all clinic monthly reports (reporting rate 79-86%) are shown in Table 2. The decline is not due to fall off in reporting because, if the data are restricted to the clinics with >90% reporting (SUBSET 2 of the CASES data), the decline in mortality from malaria is estimated at 63%.

Table 2. Deaths Attributed to Malaria, by Age Group, Eritrea, 1999 and 2003

	< 5 yrs	>=5 years	All ages
1999	62	137	199
2003	29	49	78
% reduction	53%	64%	61%

According to NHMIS extracted data, the number of malaria cases has dropped by half since 1999 in both young children and the population as a whole. Table 3 shows a summary of the decline in the reported malaria cases. Over the same time period, the total number of outpatient cases (all causes) increased by 8%. No adjustment has been made to these figures for changes in population size over the time period, so the decline is likely to be greater than estimated.

Table 3. Malaria Cases by Age Group, Eritrea, 1999 and 2003

	< 5 yrs	>=5 years	All ages
1999	37,452	136,971	174,423
2003	17,382	54,641	72,023
% reduction	54%	60%	59%

According to malaria program data, there were 179,501 cases in all age groups in 1999, and 65,518 in 2003. Although these differ somewhat from the Table 3 figures, the magnitude of the reduction (63%) was similar.

2.2. Control Measures: Impregnated Bednets

Status of Net Program Implementation

The impregnated net program is an area where Eritrea has shown remarkable and speedy implementation progress. Starting on a small scale in 1998, the bednet distribution and reimpregnation program has grown into a massive exercise. The distribution and implementation methods have evolved over this time period as experience has been gained. Initially, nets were not free, but have become so in “malarious” areas since 2002, (with pregnant women receiving free nets since 2001).

Malarious areas are defined at the village level in a non-specific way: in general, they are villages, which have experienced cases in the recent past or which are regarded as being at high risk due to location in lowlands or near rivers. The status of a village as malarious/non-malarious appears to be well known to the NMCP staff and the population in general, even if based on somewhat nebulous criteria. Because a village is the defining unit for the purpose of net distribution, many subzobas consist of a mixture of malarious and non-malarious villages. If nets are seen as a desirable item, there is scope for over-classification of villages as malarious because of the resulting availability (since 2002) of free nets.

As an entitlement program based on strict criteria (malarious or non-malarious classification of village), net distribution is kept under tight control, with the number of nets received by individual families being recorded at the kebabi administrative offices. Initially, one net per household was allowed in malarious areas, but this has recently been raised to two per family, with additional nets granted to very large families. Although this level of detail is not transmitted to NMCP, monthly reports on the net program do contain an enormous amount of information, including numbers and populations of villages in the subzoba, numbers and populations of villages covered by the program, numbers of different sizes of nets issued, retreated and remaining in stock, amount of permethrin used and in stock, and so on. One of the difficulties in quantifying this intervention’s effectiveness is deciding which indicators to use, since both the net and its treatment have effects on malaria transmission. Then these important indicators have to be distilled out of the large amount of information recorded and adjusted for the proportion of the population covered in each subzoba.

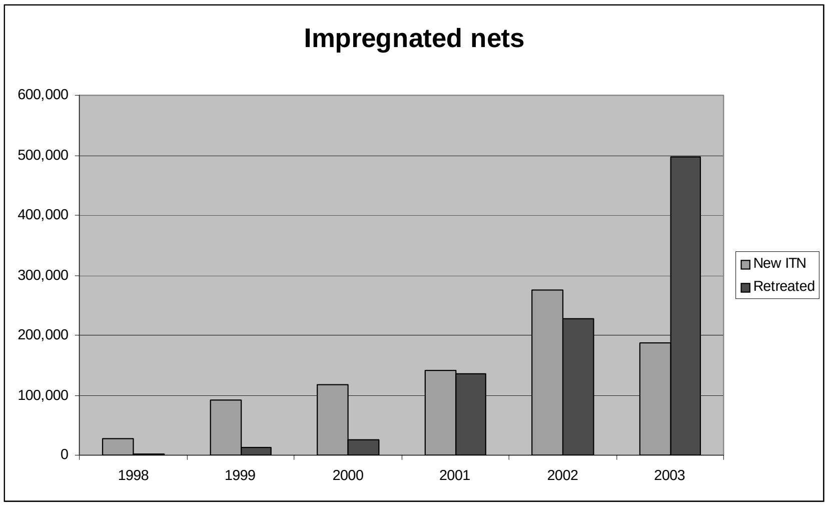
At present our focus is on three indicators by subzoba and month:

1. The number of new nets issued
2. The number of nets retreated with permethrin
3. The amount of permethrin used

For further analysis in investigating effectiveness, all of these three indicators cannot be used, since they are obviously correlated. Figure 14 shows the annual trend in Variables 1 and 2 in the above list. It shows that effort is now being concentrated on reimpregnation of current nets, with continuation of issuance of new nets at a lower level than the peak year of 2002. To capture both the effect of both new and reimpregnated nets in an efficient way, the total number of both new and reimpregnated nets is used as a variable in the regression analysis described below. Since both are treated with permethrin at the time of issuance or retreatment, this variable tends to emphasize the effect of the chemical over the physical effect of new nets.

As mentioned in Section 1, above, quality of reporting of the net program varies dramatically by zoba. In Debub, for example, records of numbers of nets issued are not forwarded above the subzoba level to the zone office or the NMCP head office. The reporting form also varied over time. The most complete information on issue of impregnated nets and retreatment rates by subzoba and month is available for Gash Barka and Anseba zobas for 1998 to October 2003.

Figure 14. Impregnated Nets, 1996–2003



The timing of net distribution and retreatment in Anseba and Gash Barka relative to the malaria transmission seasons is shown in Figures 15 and 16. The net program really got under way in 2000 in both zobas. In Anseba the program starts earlier in the year than in Gash Barka, but according to the graphs, both zobas achieved very large numbers of nets distributed or retreated in 2002.

Figure 15. Impregnated Nets and Malaria Cases by Month in Anseba Zoba, 1998–2003

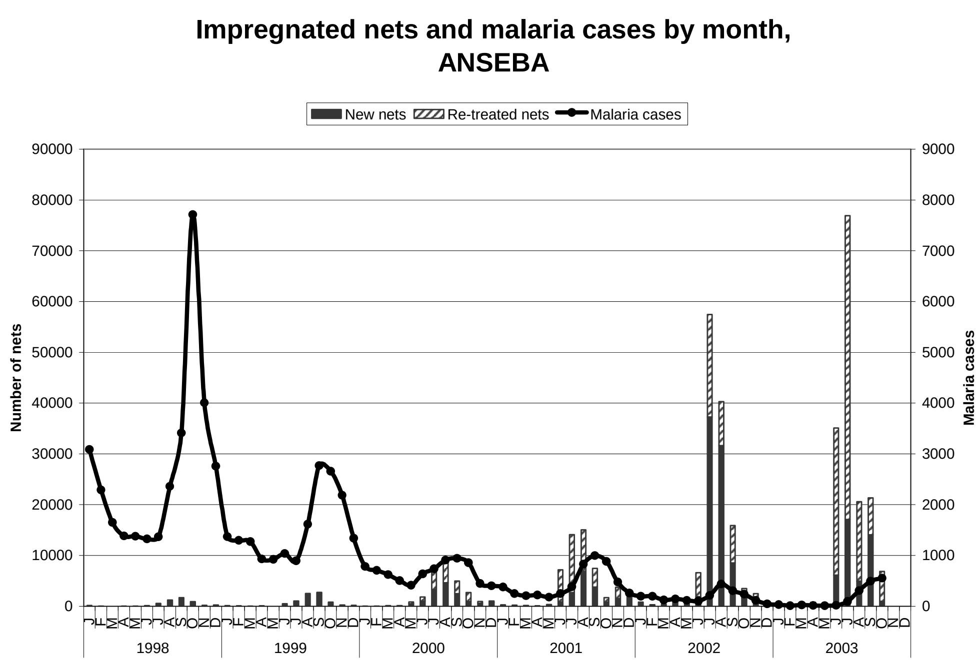
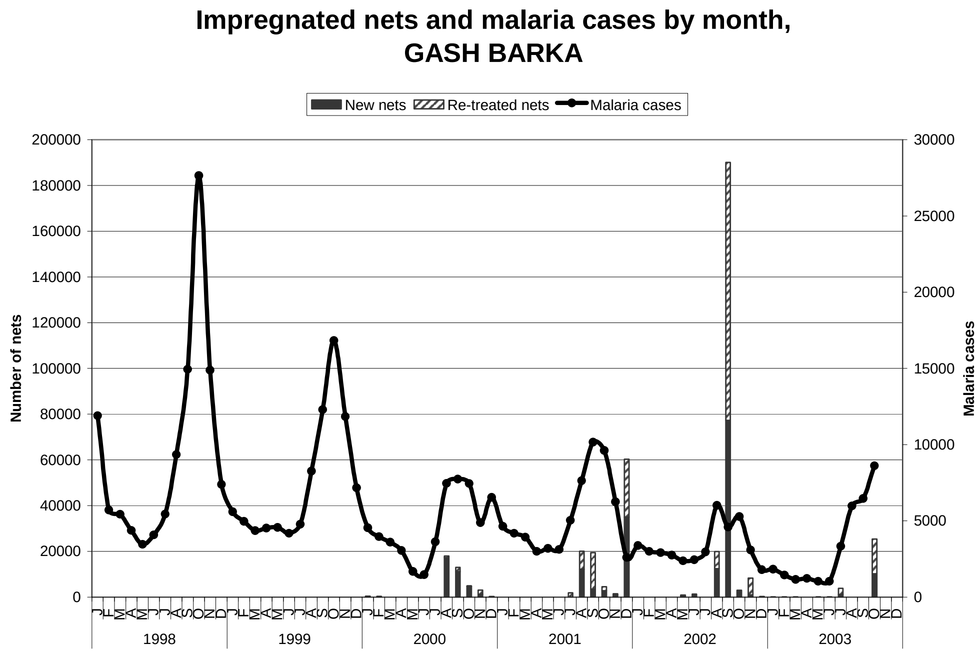


Figure 16. Impregnated Nets and Malaria Cases by Month in Gash Barka Zoba, 1998–2003



2.3. Control Measures: Larviciding and Source Reduction

Malaria control program staff and village health agents together with community members conduct activities intended to reduce the numbers of emerging mosquitoes. In some cases, particularly in towns, certain known breeding sites are monitored for larvae on a weekly basis and treated with larvicide only when larvae are detected.

Control activities are reported each month in terms of the number of breeding sites treated, filled, and/or drained, as well as the number of people involved in the work. Since “breeding site” can refer to anything from a wide river to a small pool, it is very difficult to quantify the effort involved in its elimination or treatment. If a site is a pool on the side of a river, it may come and go according to the rainfall, without human intervention. The amount of manpower involved in source reduction is one way of quantifying it (e.g., sites treated per person), but without knowing the size of the sites or the time spent by each person on the task, it is not very helpful.

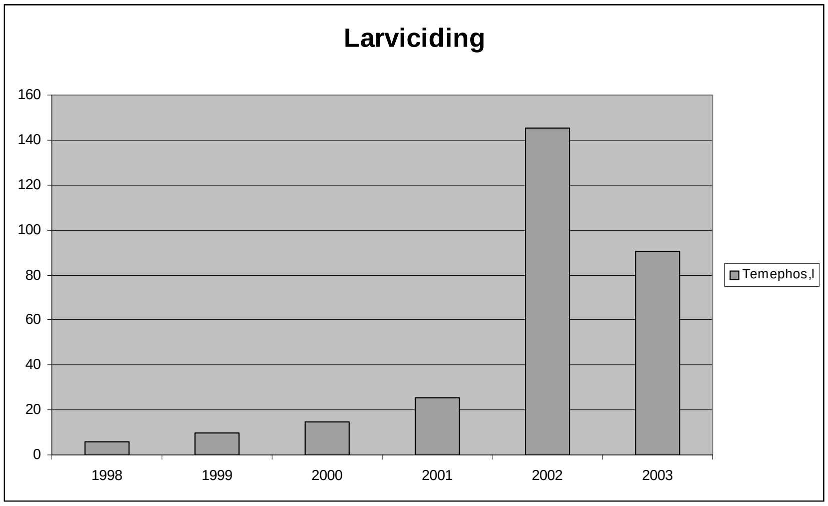
There is no information available on what *proportion* of the sites in a particular area are treated — for understandable reasons because the overall breeding area varies with the weather. In an attempt to quantify larval control efforts by subzoba and month, our analysis concentrates on two indicators:

1. The total number of sites eliminated, by whatever means

2. The amount of chemical used (temephos or, in earlier years, oil)

EHP has been conducting trials of biological larvicides (Bti and Bs) during the last two years to encourage and test this control method and to reduce the amount of potentially harmful chemicals used in the environment. However, the use of these agents is not yet widespread enough to have a large impact and is not considered here.

Figure 17. Liters of Temephos (Abate) Used in Larviciding, Eritrea 1998–2003



The increased focus on community-based activities seems to have led to a marked increase in the amount of larval control done throughout the country, using temephos (Figure 17). However, a falloff in 2003 compared to 2002 was observed. Reporting lag may be part of the reason for this.

In Anseba and Gash Barka, differences in the way larval control activities were reported mean that the best available indicator is a combined one: the total number of breeding sites controlled (i.e., either treated or eliminated). The monthly effort on this activity in these two zobas is illustrated in Figures 18 and 19.

Figure 18. Larval Control and Malaria Cases by Month, Anseba Zoba, 1998–2003

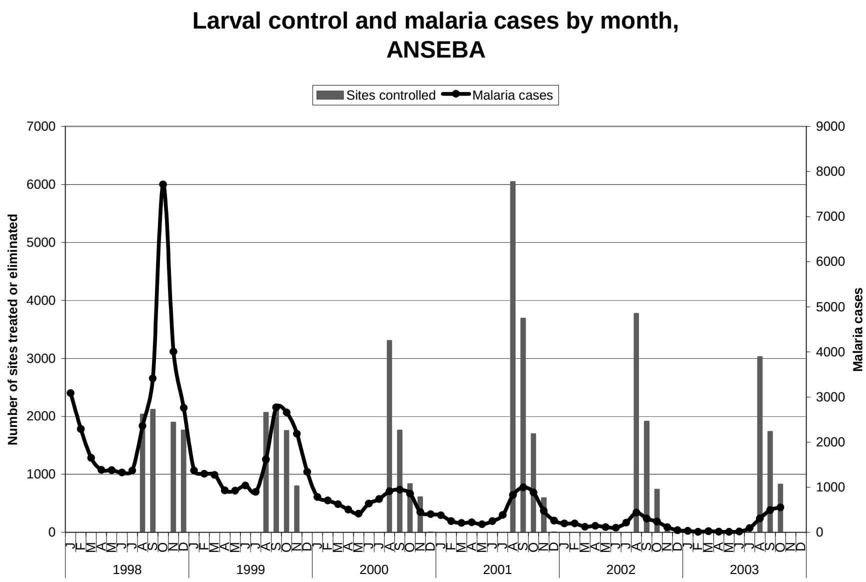
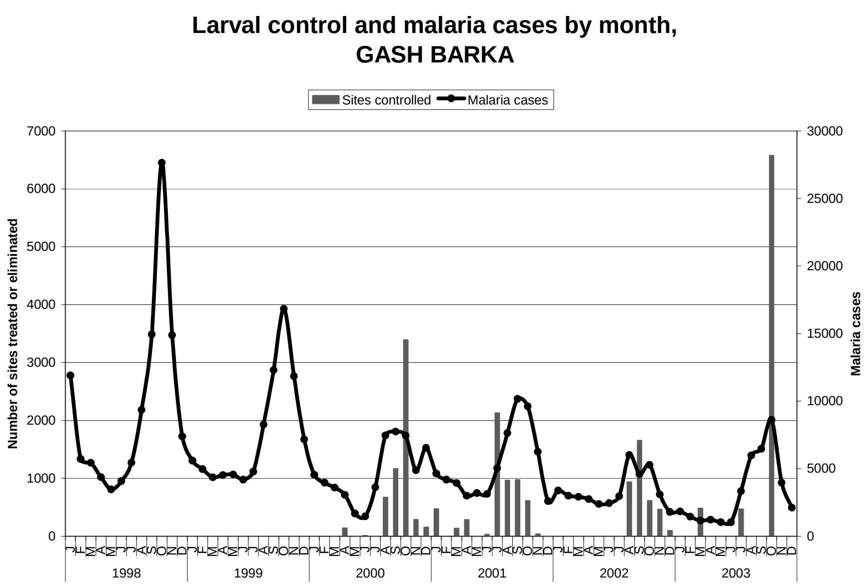


Figure 19. Larval Control and Malaria Cases by Month, Gash Barka Zoba, 1998–2003



2.4. Control Measures: Spraying

Recently, residual house spraying was done in three zobas (Gash Barka, Debub, and NRS), and covered between 7% and 13% of the zoba population on average in each year it was done. The spraying forms report the number of villages covered, numbers of structures sprayed and unsprayed, population covered, and amount of insecticide used. Because of the proliferation of possible indicators, there is a need to prioritize; the most useful indicator is the insecticide amount. This should be strongly correlated with both the number of structures sprayed and the population covered and may be more accurate than either of the latter.

Table 4 gives a summary of insecticide used in each of the three zobas by year, and Figures 20 to 22 show the totals by year. Graphs showing the number of villages and houses sprayed and proportion of the population protected in each year are also available, but show similar patterns to the insecticide amounts. Table 4 shows the details.

Figure 20. Insecticide Amount Used, Debub Zoba, 1999–2003

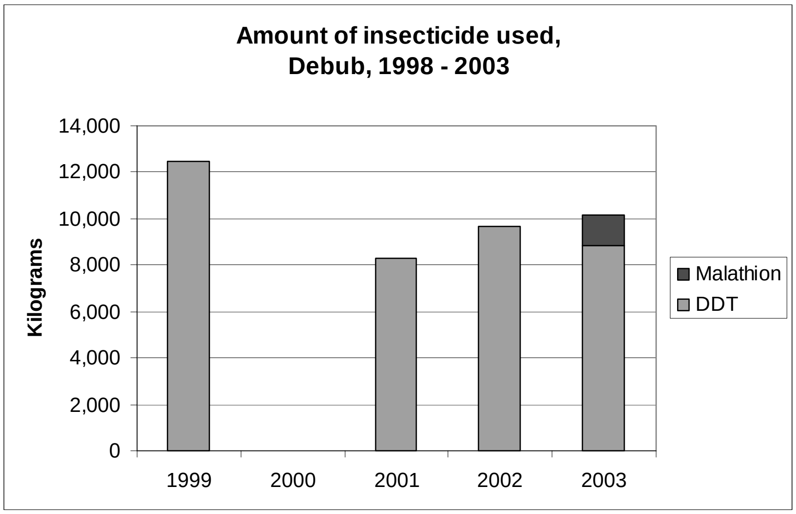


Figure 21. Insecticide Amount Used, Gash Barka Zoba, 1998–2003

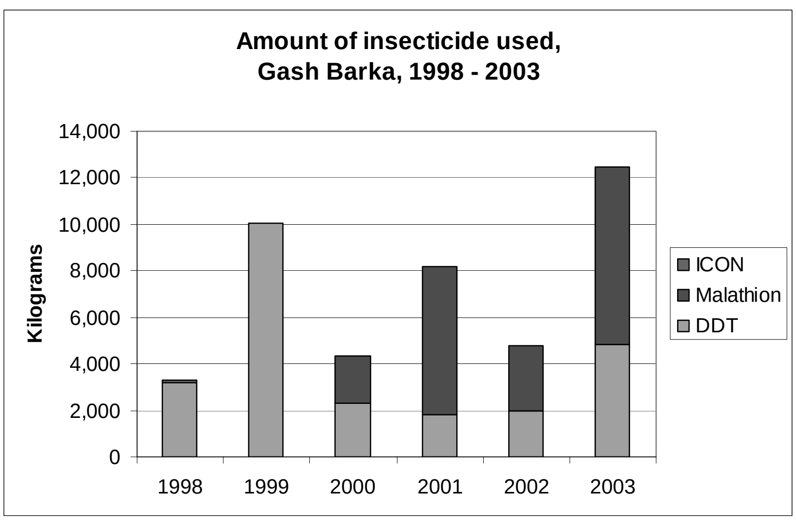
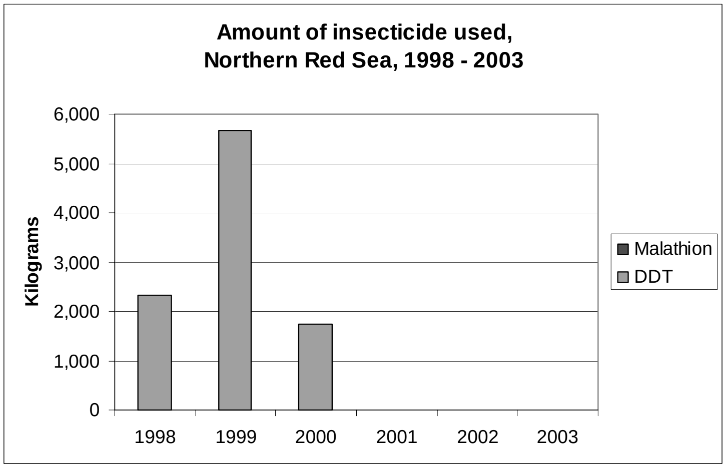


Figure 22. Insecticide Amount Used, NRS Zoba, 1998–2003



A large amount of DDT spraying was done in all three zobas in 1999, presumably in reaction to the high incidence in 1998. By 2003, the DDT amount used in Debub (see Figure 20) and Gash Barka (see Figure 21) was lower than in 1999. However, over the time period studied, DDT was partially replaced by malathion in Debub (see Figure 20) and to a greater extent in Gash Barka (see Figure 21). NRS spraying represents a small percentage of the overall total and was discontinued in 2000 (Figure 22).

A suggestion of malathion resistance in Tesseney, Gash Barka (~90% mortality in WHO tests) led to the exclusive use of DDT in this town for the last few years. This accounts for the DDT increase in 2003 in Gash Barka, since it was used in Barentu and Agordat as well as Tesseney. In the rural areas of Gash Barka and in Debub, malathion is generally accepted, except in bee-keeping areas of Debub. Debub zone used a mixture of DDT and malathion in 2003. There are two concerns that NMCP staff expressed about malathion:

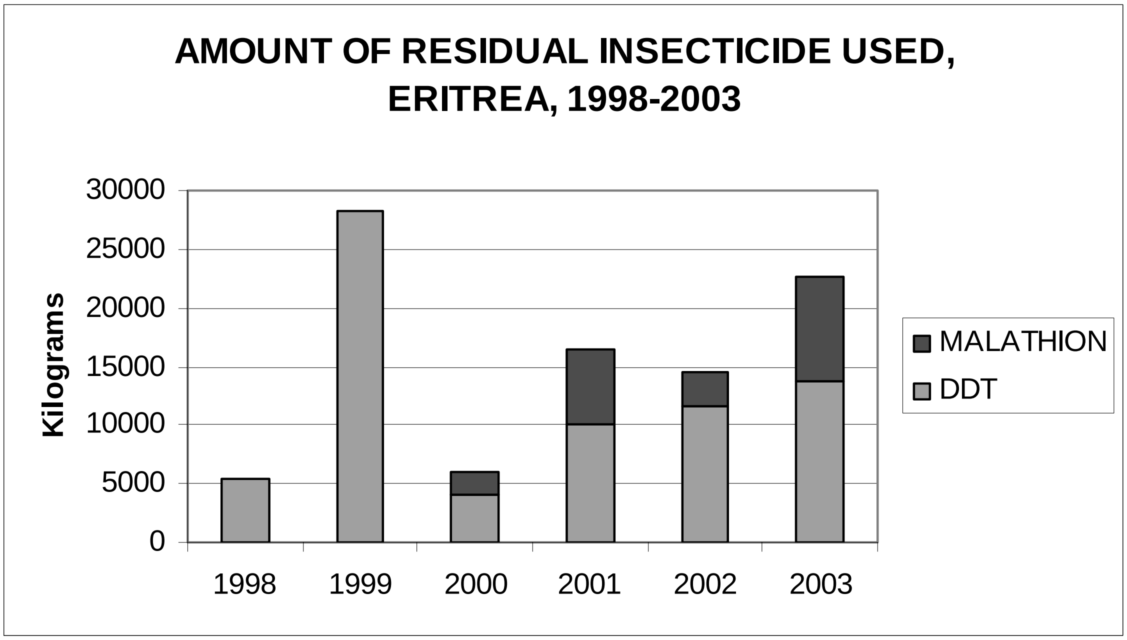
1. Its short half-life, which is said to reduce its effectiveness to 2–3 months
2. Its unpleasant smell

Because of Point 1, the perception is that malathion spraying should be delayed until late in the transmission season. The spray teams (two, one starting east, and one starting west of Mendefera) start out in July spraying DDT and switch to malathion in August. This perception may not be justified given the short transmission season.

Table 4. Summary of Indoor Residual Spraying, 1998–2003

		1998	1999	2000	2001	2002	2003
NUMBER LOCALITIES SPRAYED	DEBUB		202	0	88	172	124
	GASH BARKA	56	103	36	57	12	73
	NORTH RED SEA	43	35	34	0	0	0
	TOTAL	**99**	**340**	**70**	**145**	**184**	**197**
DDT (kg) USED	DEBUB		12459	0	8298.92	9674.94	8843.55
	GASH BARKA	3165.2	10070.5	2305.2	1789	1964.5	4808
	NORTH RED SEA	2331.9	5672.8	1731.2	0	0	0
	TOTAL	**5497.1**	**28202.3**	**4036.4**	**10087.92**	**11639.44**	**13651.55**
MALATHION (kg) USED	DEBUB		0	0	0	0	1324
	GASH BARKA	0	0	2007.7	6368.9	2810.8	7669.6
	NORTH RED SEA	7024.8	0	6927.2	0	0	0
	TOTAL	**7024.8**	**0**	**8934.9**	**6368.9**	**2810.8**	**8993.6**
HOUSES SPRAYED WITH DDT	DEBUB		42929	0	29930	33984	29894
	GASH BARKA	15321	15321	8094	6511	7191	12787
	NORTH RED SEA	7829	21541	5799	0	0	0
	TOTAL	**23150**	**79791**	**13893**	**36441**	**41175**	**42681**
HOUSES SPRAYED WITH MALATHION	DEBUB		0	0	0	0	4826
	GASH BARKA	0		19095	40320	15635	38251
	NORTH RED SEA	40167	0	16871	0	0	0
	TOTAL	**40167**	**0**	**35966**	**40320**	**15635**	**43077**
TOTAL HOUSES SPRAYED	DEBUB	0	42929	0	29930	33984	34720
	GASH BARKA	15321	15321	27189	46831	22826	51038
	NORTH RED SEA	47996	21541	22670	0	0	0
	TOTAL	**63317**	**79791**	**49859**	**76761**	**56810**	**85758**
POP PROTECTED WITH DDT	DEBUB		103156	0	77481	88617	74177
	GASH BARKA	49171	49171	28442	20746	31094	42269
	NORTH RED SEA	29301	58518	12509	0	0	0
	TOTAL	**78472**	**210845**	**40951**	**98227**	**119711**	**116446**
POP PROTECTED WITH MALATHION	DEBUB		0	0	0	0	11600
	GASH BARKA	0	0	47882	104395	45719	97644
	NORTH RED SEA	46950	0	46084	0	0	0
	TOTAL	**46950**	**0**	**93966**	**104395**	**45719**	**109244**
TOTAL POP PROTECTED	DEBUB	0	103156	0	77481	88617	85777
	GASH BARKA	49171	49171	76324	125141	76813	139913
	NORTH RED SEA	76251	58518	58593	0	0	0
	TOTAL	**125422**	**210845**	**134917**	**202622**	**165430**	**225690**
ESTIMATED POPULATION (2000)	DEBUB			755379			
	GASH BARKA			564574			
	NORTH RED SEA			459056			
	TOTAL (3 ZONES)			**1779009**			
	ANSEBA			457078			
	MAEKEL			538749			
	SOUTH RED SEA			66335			
	TOTAL (3 ZONES)			1062162			
	TOTAL (COUNTRY)			**2841171**			
% POP COVERED BY SPRAYING USING 2000 POP	DEBUB	0.0	13.7	0.0	10.3	11.7	11.4
	GASH BARKA	8.7	8.7	13.5	22.2	13.6	24.8
	NORTH RED SEA	16.6	12.7	12.8	0.0	0.0	0.0
	TOTAL (3 ZONES)	**7.1**	**11.9**	**7.6**	**11.4**	**9.3**	**12.7**

Figure 23. Amount of Residual Insecticide Used in Eritrea, 1998–2003



Looking at Figure 23, which shows the total insecticide used in the country, it cannot be said that there is a huge effort to replace DDT with other chemicals that would possibly be safer. In fact, the opposite seems to be true. The latest insecticide order to arrive from overseas (March 2004) was for 30,000 kilograms (kg) of DDT, and little malathion remains in stock.

The year 1999 was the peak year for insecticide use in the recent past. After a drop-off in the subsequent year, spraying in the country has shown a generally increasing trend.

To examine spraying distribution more closely, details by subzoba were examined. Gash Barka has excellent data on the amount of spraying done by subzoba each year from 1998–2003. From this data, the mean, minimum, and maximum percentage of the population covered by spraying each year was estimated (see Table 5). Table 5 also shows the number of years that each subzoba was included in the spraying rounds. This varied markedly: Barentu and Guluj subzobas were always included with a minimum of about 30% and maximum of about 70% of the population covered. On the other hand, Logo Anseba subzoba was never sprayed in these years, and the other subzobas were sprayed 1–5 times in the six-year period.

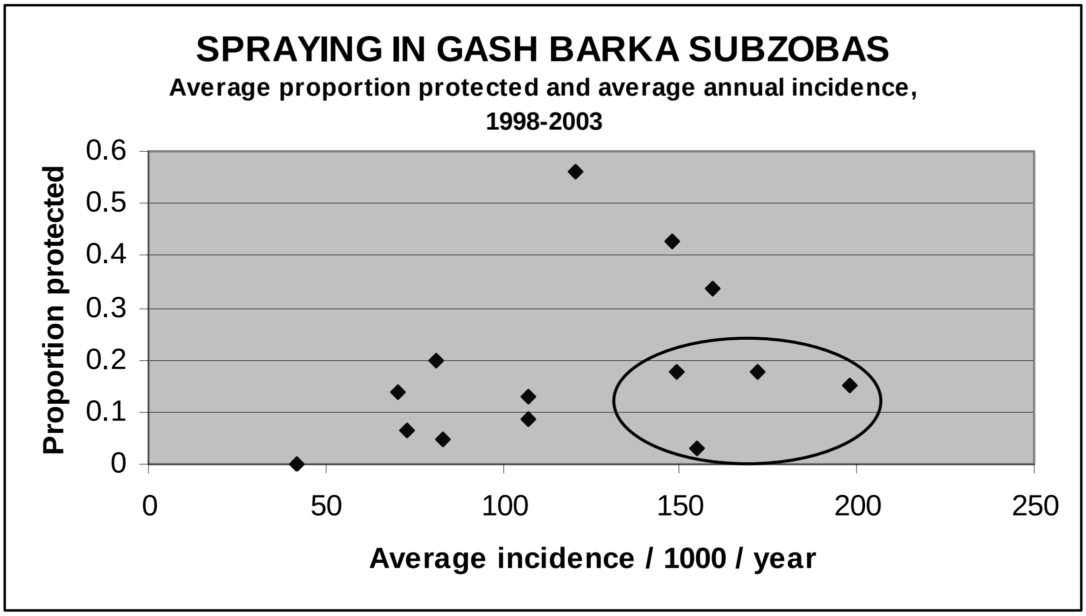
In addition to logistical concerns, the percentage of the population covered in each subzoba depends to some extent on what proportion of the population is perceived to be at risk of malaria. It is not explicitly based on the malaria incidence, but local expert knowledge is taken into account in planning each year's spraying rounds.

Table 5. Malaria Incidence and Spraying in Gash Barka Subzobas, 1998–2003

Subzoba	Average no. cases / year	Average annual incidence / 1000	Average % protected by spraying	Minimum % protected	Maximum % protected	No. years sprayed (out of 6)
AGORDAT	2526	81.2	20.0%	0.0%	47.7%	4
BARENTU	2514	120.6	55.9%	34.2%	72.6%	6
DIGHE	6121	149.0	17.6%	0.0%	29.8%	5
FORTO	4606	107.3	8.7%	0.0%	23.4%	3
GOGNE	3092	72.7	6.5%	0.0%	16.6%	4
GULUJ	8137	147.8	42.5%	26.0%	66.6%	6
HAYCOTA	3173	70.3	13.8%	0.0%	31.4%	4
LAELAY GASH	5905	107.3	13.0%	0.0%	24.5%	5
LOGO ANSEBA	1606	42.2	0.0%	0.0%	0.0%	0
MENSURA	8926	155.1	3.0%	0.0%	18.1%	1
MOGOLO	3881	171.8	17.8%	0.0%	47.2%	4
MULKI	2962	83.3	4.8%	0.0%	12.8%	3
SHAMBUKO	6765	197.7	15.3%	0.0%	34.8%	3
TESSENEY	6810	159.0	33.7%	0.0%	72.6%	5

Some subzobas with high incidence were not covered as well as those with lower incidence, which can be seen by plotting average proportion of the population covered against the average annual incidence (see Figure 24). The four subzobas marked with an oval in Figure 24 particularly stand out as subzobas with high average incidence, but low spraying coverage. These are Dighe, Mensura, Mogolo, and Shambuko subzobas, which all had average incidence of >140/1,000 persons/year (Table 5), but spray coverage averaging under 20% of the population.

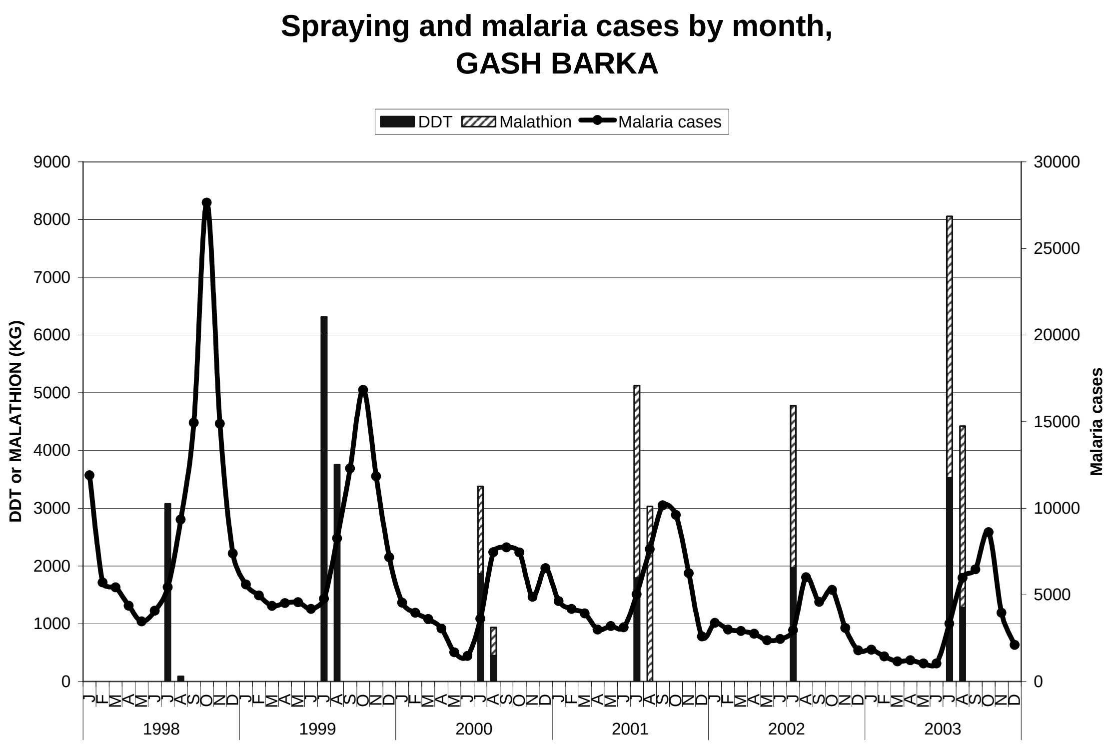
Figure 24. Spraying in Gash Barka Subzobas, 1998–2003



Planning for spraying could benefit from targeting subzobas with the highest incidence in the previous year, as well as making efforts to reach remoter areas with high incidence.

The timing of spraying by month in Gash Barka is shown in Figure 25. Spraying is quantified by the number of kilograms of DDT and malathion. The first month of each year's spraying round is usually one month prior to a steep rise in case numbers. Given that these people were infected two or more weeks before they became symptomatic, Figure 25 suggests that starting spraying a month or two earlier in the year might be advisable.

Figure 25. Spraying and Malaria Cases by Month, Gash Barka, 1998–2003



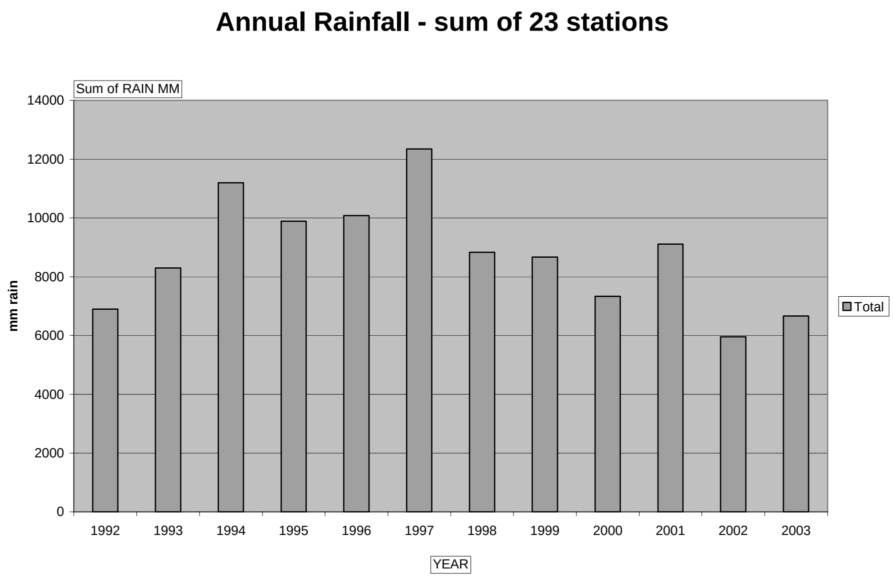
2.5. Meteorology

The meteorological information important to malaria transmission includes rainfall, temperature (minimum and maximum), and humidity estimates. Preliminary average monthly temperature data is available and other proxies for climate data such as the NVDI, but rainfall is the only data that is currently in a suitable time-series format.

Rainfall gauge estimates

Data was obtained from all available rainfall stations in the country from 1992 onwards. Of these, 23 had consistent records over a 10-year period. The average amount of rain per year by station over the 1992–2003 period varied from a low of 50 mm in Assab (Southern Red Sea) to a high of 680 mm in Adi-quala (Debub). However, all stations except Assab averaged over 200 mm per year. Summing the amounts from the 23 stations gives a crude estimate of the rainfall in the country. While it is obviously an underestimate, the true total should indicate the trends over time. The annual rainfall (sum of these 23 stations) for 1992–2003 is in Figure 26.

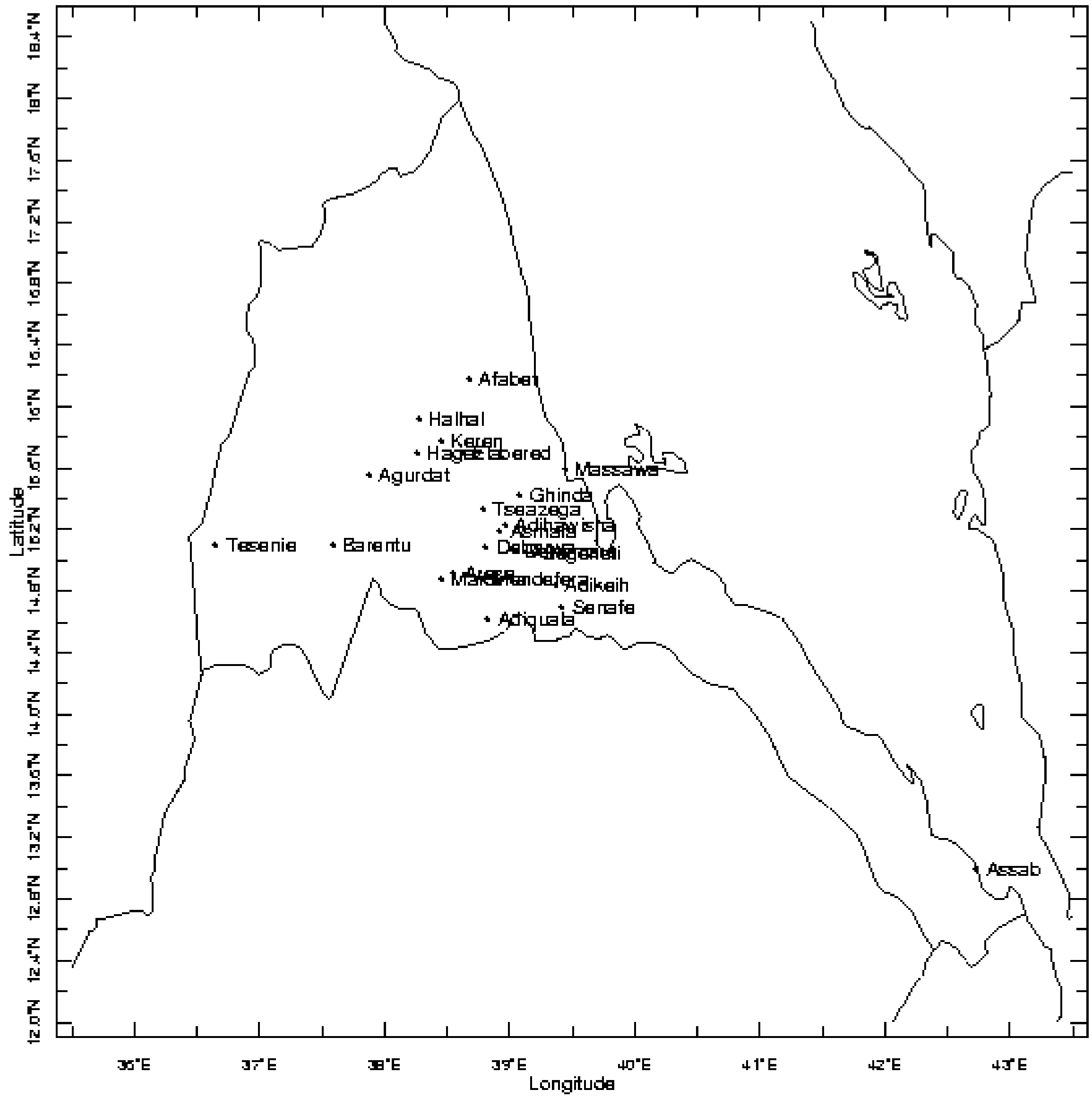
Figure 26. Annual Rainfall — Sum of 23 Stations, 1992–2003



Over the years of particular interest (1996–2003), it would appear from Figure 26 that there has been a trend of declining rainfall. Although some missing data have been recorded as zero, it is unlikely that this decline is completely accounted for by change in reporting rate, since these stations reported consistently, and in general, reporting improved over time. As can be seen in Figure 26, 1997 apparently had higher rain than 1998 (the year of highest malaria incidence). This is consistent with anecdotal reports and contemporary observations that stated that abnormally large amounts of rain fell during the last half of 1997 and continued into early 1998. It also seems from Figure 26 that total rainfall in the years 1998 to 2001 was fairly stable at around 7,000-9,000 mm per year (for these 23 stations), but the two subsequent years had lower rain with about 6000 mm per year (i.e., about a 25% reduction from the mean of 1998–2001).

However, it can be seen from the map of the 23 rainfall station locations (see Figure 27) that they are not evenly distributed, but concentrated in the central highland regions. Debub has nine stations, Anseba four, and Gash Barka, Maekel, and Northern Red Sea each have three; Southern Red Sea has only one. In addition, each represents only a point within each subzoba. In subzobas that have stations, there is only one per subzoba with the exception of Areza subzoba in Debub, which has two stations. Therefore rainfall gauge data is available for 22 out of the 58 total subzobas.

Figure 27. Locations of 23 Consistently Reporting Rainfall Stations



Satellite rainfall estimates

Satellite-derived RFE by subzoba boundary and month were obtained from the IRI data library (John del Corral and Benno Blumenthal). Michael Bell of IRI compared the gauge station rainfall amounts with the satellite rainfall estimates for the same time periods. The comparison was between the ground stations and remote sensed estimates for the nearest RFE grid. Overall, there was a good correlation between the two data sources, although this varied by station. This gives confidence in the RFE data.

Given the patchy distribution of the ground stations and the fact that they only represent point estimates, the analysis of control program effectiveness (see below) was done using the satellite rainfall estimates. Because of their greater consistency of coverage, the RFE estimates also enabled a thorough picture to be built up of the rainfall pattern by subzoba over the years of study.

The annual estimated rainfall from 1996 to 2003 is summarized in Figure 28 together with the number of malaria cases in the same years.

Figure 28. Satellite Rainfall Estimates and Malaria Cases, Eritrea, 1996–2003

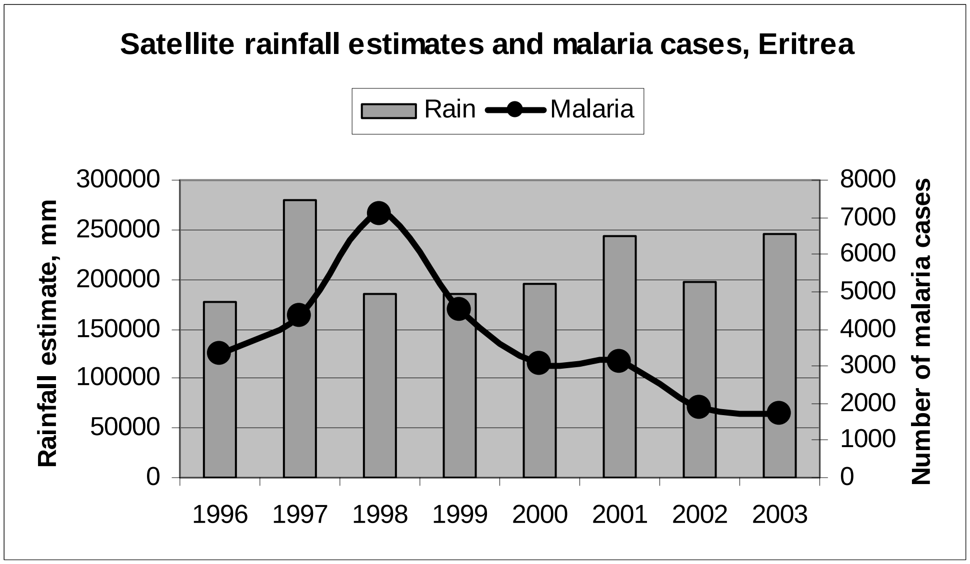
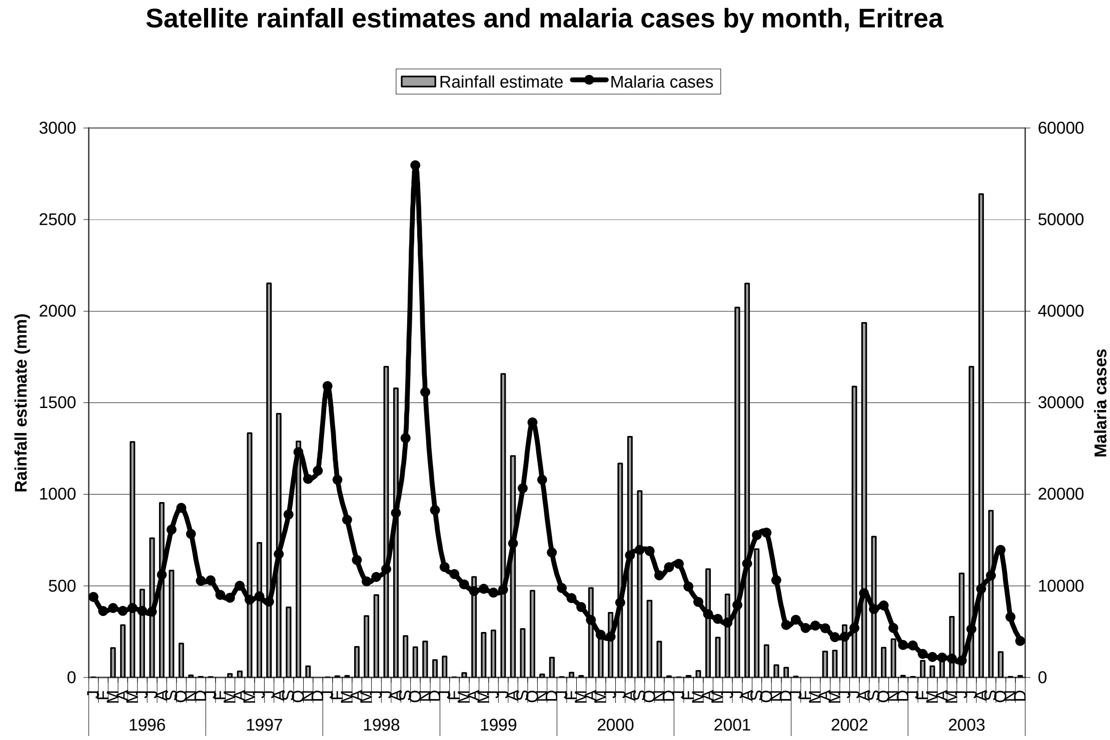


Figure 28 shows that, in contrast to the gauge estimates, satellite-derived rainfall estimates do not suggest a decrease in rain in the last few years; in fact, according to the satellite estimates, 2003 had the highest rainfall since 1997. The discrepancy between the two rainfall data sources may be explained by the fact that rain in the west of the country increased, while the central and coastal areas experienced a decreasing rainfall trend. This can be demonstrated by zoba-specific graphs of RFE (not shown). Since the majority of the ground rainfall stations are in the central upland regions, the western areas were underrepresented in the gauge data.

Plotting the data by year, as in Figure 28, obscures significant monthly variation in both rain and malaria. If the same data are examined by month (see Figure 29), the two- to three-month lag between rainfall and malaria cases is clearly seen. This is also apparent in the zoba graphs for Gash Barka, Anseba, and Debub (not shown), but is not so clear in Maekel and the Red Sea zobas.

Figure 29. Satellite Rainfall Estimates and Malaria Cases by Month, Eritrea, 1996–2003



Even in the western zobas, however, the size of the seasonal malaria peak is not obviously related to the size of the rainfall peak in the preceding few months. Other factors including the duration of rainy period are involved as well as the amount of malaria control activities done. For this reason, the data were analyzed in a combined fashion as described in the next section.

2.6. Combined Analysis of Datasets

Methods

The aim of this analysis is to combine data on rainfall, malaria control activities, and any other information available about the subzobas and analyze them using time-series regression by subzoba and month, to determine which variables if any are significantly associated with malaria incidence. In this way, the effects of each independent variable can (in theory) be separated out and its effect on the dependent variable (malaria cases) quantified.

A problem arises with analyzing malaria control activities when they tend to be concentrated in areas known to be at high risk for malaria. This may result in an apparent positive association between the intervention and malaria cases — a phenomenon known as endogeneity. One way around this problem is to use “instrumental variables.” These are variables unrelated to the outcome, but related to the variable in question. The instrumental variable “calendar month” was used to assess the effect of DDT spraying in Solomon Islands (Over et al. 2004). Once rainfall and other seasonal effects have been accounted for, there is no logical reason why calendar month should affect the number of malaria cases. However, spraying is strongly related to calendar month because of work schedules and budget cycles.

In Eritrea, spraying is the only control activity specifically targeted to high-risk malaria areas. Spraying is also planned for certain months of the year (July and August), although logistical problems may cause delay. Provision of impregnated bednets and larval control is much more generalized both in space and time. Nets are available in malarious areas, but this is a broad criterion essentially describing anyplace that has had malaria in the recent past. Unlike spraying, there is no distinction made between different levels of malaria transmission intensity when deciding where to issue nets or do larviciding. In addition, while effort on larviciding, net distribution and retreatment does not occur equally all year, it is done over a broader span of months than spraying (see Figures 15, 16, 18, 19, and 25, above).

Each of the datasets (CASES, INTERVENTION and METEOROLOGY) was structured as a monthly time-series by subzoba and the three sets were merged together. Because of the time lag caused by the developmental cycle of *Anopheles* mosquitoes and by the parasite's incubation period, rainfall variables were lagged by up to five months. To account for the persistence of malaria control activities beyond the actual month of application, depreciated amounts of the intervention variables were calculated based on an estimated 20% depreciation per month (resulting in decay to half the original value by six months). Sensitivity analysis using higher depreciation rates was also performed.

Variables used to capture the effects of malaria control activities were as follows:

- DDT used in kg
- Malathion used in kg
- Number of people covered by spraying (as an alternative to the above two)
- Number of new nets distributed and old nets reimpregnated (a proxy for the amount of permethrin used)
- Number of larval breeding sites treated or eliminated (used as a combined variable because they were sometimes not distinguished in the records)

Cumulated values of DDT, malathion, nets, and larval control were calculated as the sum of last month's distribution plus the depreciated values of all previous months.

The procedures used were ordinary least-squares and time-series regression, with or without instrumental variables, using the following STATA version four commands: *reg, ivreg, xtreg,* and *xtivreg.* The analysis was done first using data from the whole country (for the rainfall variables) and second only for Anseba/Gash Barka zobas (for the rainfall and intervention variables). This is because bednet data for the other zobas (by subzoba/month) is still incomplete. Note that spraying was not done in Anseba.

Variables included in all models are the subzoba population (to weigh the number of cases and the interventions according to population size) and the "cluster." Cluster represents one of five strata into which subzobas are classified by principal components analysis and non-hierarchical clustering techniques (see the report by M. Thomson). The strata represent levels of seasonality and transmission intensity. A variable for time trend (mseq = sequential month since January 1996) is included in some models.

In the following Tables 6–8, the results are presented as regression coefficients for various models. The z-values are given in brackets, followed by the significance levels. If the significance level is <0.05, then there is a significant association between the variable and the outcome (malaria cases).

If a coefficient is positive, then this means that increased amount of the variable in question leads to an increase in cases. For example, more rain in a particular month is associated with more malaria cases three months later. The exception to this interpretation is when there is endogeneity, i.e., there appears to be association between a variable (e.g., DDT) and malaria, but it is an artificial effect of the fact that DDT is targeted to where cases are highest.

If the coefficient is negative, then increased amounts of the variable are associated with less malaria. Thus more nets might lead to less malaria. It is expected that malaria control activities would have negative coefficients if they are effective in reducing cases. If the interventions are not effective, the coefficients could be either positive or negative, but not significant as measured by the z-value and p-value. The magnitude of the coefficient represents the strength of the relationship. Thus a high value for a variable's coefficient (e.g., 4.0) means that each unit of the intervention is associated with a bigger difference in the outcome than a unit of a variable with smaller coefficient (e.g., 2.0).

Effects of rain and cluster

Satellite rainfall estimates are used in the following analyses. The results shown in Table 6 suggest the following:

1. Malaria cases decreased by the current rainfall, but increased by rain two, three, and four months previously. The amount of rain falling one month or five months previously does not appear to be important according to this model. The relationship is non-linear as shown by the significant squared terms for current rain and for rain three and four months earlier. The size of the coefficient is related to the strength of the effect and is measured by units in which variables are measured. Thus each mm of rain falling is associated on average with 5.9 more cases of malaria/subzoba three months later (given all the other variables).

2. There is a highly significant sequential monthly trend of decreasing number of cases, independent of rainfall and cluster. On average, there has been a decrease of two cases of malaria per subzoba every month.

Table 6. Regression Results for Model 1 (Entire Country)

(No intervention variables)

	Coefficient	z-value	p-value
Subzoba population	**0.0023**	3.98	**<0.001**
Current rain	**-1.901**	3.01	**0.003**
$(\text{Current rain})^2$	**0.031**	2.82	**0.005**
Rain lagged 1 month	0.493	0.78	0.436
$(\text{Rain lagged 1 month})^2$	0.009	0.83	0.405
Rain lagged 2 months	**2.927**	4.74	**<0.001**
$(\text{Rain lagged 2 months})^2$	0.007	0.64	0.523
Rain lagged 3 months	**5.859**	9.50	**<0.001**
$(\text{Rain lagged 3 months})^2$	**-0.458**	4.32	**<0.001**
Rain lagged 4 months	**2.884**	4.62	**<0.001**
$(\text{Rain lagged 4 months})^2$	**-0.584**	5.49	**<0.001**
Rain lagged 5 months	1.050	1.60	0.109
$(\text{Rain lagged 5 months})^2$	-0.125	1.02	0.308
Sequential month	**-2.115**	17.82	**<0.001**
Cluster 1	**141.1**	3.67	**<0.001**
Cluster 2	**411.2**	8.63	**<0.001**
Cluster 4	**-93.92**	2.67	**0.008**
Cluster 5	**229.4**	4.09	**<0.001**
Constant	46.89	1.26	0.208
No. of observations	5162		
No. of subzobas	58		

The second point is an extremely important result because if accepted, it shows that the decline in malaria in Eritrea since 1998 cannot be attributed to declining rainfall. The question is whether this sequential trend is due to malaria control activities. This was investigated in Gash Barka and Anseba where there is reasonably good data on interventions. Results of attempts to answer this question are in Tables 7 and 8.

Effects of Interventions

Adding the malaria control activities into the model, initially assuming 20% depreciation rate for each of them, the analysis is restricted to Anseba and Gash Barka. The results in Table 7 are stated as two models: 2 and 3. Model 2 adds the intervention variables and uses *xtreg* as before. Model 3 uses calendar month as an instrumental variable.

Table 7. Regression Results for Models 2 and 3: Gash Barka/Anseba

	Model 2: Gash Barka and Anseba			**Model 3 Gash Barka and Anseba Instrumented**		
	Coefficient	**z-value**	**p-value**	**Coefficient**	**z-value**	**p-value**
DDT (kg)	**0.168**	4.55	**<0.001**	0.234	0.81	0.420
Malathion (kg)	-0.054	1.10	0.272	0.018	0.12	0.901
Nets (new + reimpregnated)	**-0.022**	11.96	**<0.001**	**-0.022**	9.49	**<0.001**
Breeding sites controlled	**-0.054**	2.07	**0.038**	**-0.051**	1.95	(**0.052)**
Subzoba population	**0.007**	6.14	**<0.001**	**0.007**	2.19	**0.029**
Current rain	**-2.729**	2.22	**0.026**	**-2.51**	1.81	**(0.070)**
$(\text{Current rain})^2$	0.012	0.71	0.481	0.007	0.31	0.759
Rain lagged 1 month	**4.059**	2.98	**0.003**	**4.080**	2.91	**0.004**
$(\text{Rain lagged 1 month})^2$	**-0.046**	2.66	**0.008**	**-0.049**	2.61	**0.009**
Rain lagged 2 months	**7.132**	5.24	**<0.001**	**7.099**	5.01	**<0.001**
$(\text{Rain lagged 2 months})^2$	**-0.066**	3.87	**<0.001**	**-0.067**	3.98	**<0.001**
Rain lagged 3 months	**9.878**	7.54	**<0.001**	**9.913**	7.38	**<0.001**
$(\text{Rain lagged 3 months})^2$	**-0.101**	6.13	**<0.001**	**-0.104**	6.27	**<0.001**
Rain lagged 4 months	**2.224**	1.93	**0.054**	2.214	1.85	**(0.064)**
$(\text{Rain lagged 4 months})^2$	**-0.071**	4.41	**<0.001**	**-0.073**	4.55	**<0.001**
Cluster 1	**196.78**	4.79	**<0.001**	194.57	1.67	**(0.094)**
Cluster 2	**439.67**	10.29	**<0.001**	**430.68**	3.38	**0.001**
Cluster 4	**-82.15**	1.55	**0.120**	-81.67	0.55	0.585
Constant	**242.21**	4.06	**<0.001**	**-243.43**	1.46	0.144
Number of observations	1650			1650		
Number of subzobas	25			25		

In Model 2 (Table 7), nets and larval control both have the expected negative coefficients (i.e., more of the intervention is associated with decreased malaria cases), which are significant ($p<0.05$). For nets, the regression coefficient of -0.02 suggests that each net issued or impregnated reduces malaria by 0.02 cases per month per subzoba on average. Put another way, each increase of 100 impregnated nets per subzoba (roughly equivalent to one liter of permethrin) is associated with a reduction of two cases of malaria per month on average, given all other variables in the model. Similarly, for every 100 breeding sites treated or eliminated, on average, the number of cases is reduced by five.

Malathion spraying also has a negative coefficient, but it is not significant. On the other hand, DDT is highly significant with a positive coefficient, suggesting that it is an endogenous variable.

To correct for endogeneity, the DDT variable was "instrumented" on calendar month and a two-stage regression using *xtivreg* was conducted. As shown in Model 3 (Table 7), this removes the perverse effect of DDT without affecting the other coefficients very much. The coefficients for nets and larval control remained of similar magnitude, although larval control becomes of marginal significance at p=0.052. However, in Model 3, the sign of the DDT spraying variable is still positive — in other words, DDT is not associated with reduction in the number of malaria cases.

As stated above, there was no spraying done in Anseba. Therefore, the two zobas were analyzed separately to see whether the interventions were acting differently in each zoba, although this stratification has the disadvantage of cutting the sample size by about half. Results are shown in Table 8. Note that there are no subzobas in Cluster 2 in Anseba and none in Cluster 4 in Gash Barka.

Table 8. Regression Results for Models 4 and 5: Anseba and Gash Barka

	Model 4: Anseba Instrumented			**Model 5 Gash Barka Instrumented**		
	Coefficient	**z-value**	**p-value**	**Coefficient**	**z-value**	**p-value**
DDT (kg)				0.025	0.10	0.922
Malathion (kg)				-0.125	1.05	0.292
Nets (new + reimpregnated)	**-0.016**	8.12	**<0.001**	**-0.020**	6.87	**<0.001**
Breeding sites controlled	**-0.029**	1.73	**(0.084)**	-0.038	1.02	0.308
Subzoba population	**0.004**	9.54	**<0.001**	**0.010**	9.18	**<0.001**
Current rain	**-3.701**	2.11	**0.035**	**-4.326**	2.17	**0.030**
$(\text{Current rain})^2$	**0.072**	1.79	**(0.074)**	0.027	0.99	0.321
Rain lagged 1 month	-1.160	0.62	0.532	5.890	2.57	0.922
$(\text{Rain lagged 1 month})^2$	0.037	0.91	0.362	-0.061	2.54	0.292
Rain lagged 2 months	**5.698**	3.13	**0.002**	**9.834**	4.42	**<0.001**
$(\text{Rain lagged 2 months})^2$	**-0.086**	2.13	**0.033**	**-0.099**	4.13	**<0.001**
Rain lagged 3 months	**6.055**	3.42	**0.001**	**14.577**	6.94	**<0.001**
$(\text{Rain lagged 3 months})^2$	**-0.117**	2.94	**0.003**	**-0.153**	6.44	**<0.001**
Rain lagged 4 months	2.705	1.59	0.112	1.473	0.80	0.424
$(\text{Rain lagged 4 months})^2$	**-0.082**	2.06	**0.040**	-0.070	3.13	0.922
Cluster 1	**90.60**	3.29	**0.001**	195.09	4.17	0.292
Cluster 2				**434.21**	7.25	**<0.001**
Cluster 4	**-91.32**	6.21	**<0.001**			0.308
Constant	**-71.48**	3.00	**0.003**	**394.34**	6.71	**<0.001**
Number of observations	726			924		
Number of subzobas	11			14		

In both zobas individually, the number of nets remains a highly significant variable in the models, with $p<0.001$ in both cases. The larval control coefficient has a significance level of $p=0.084$ in Anseba (i.e., of marginal significance), while it shows no evidence of effect at all in Gash Barka. Given the very localized effect of larval control activities, it is surprising that any effect at all can be detected. It makes logical sense that if any effect exists, it would show up in zobas with lower incidence overall (e.g., Anseba) rather than in the most highly-endemic zoba of Gash Barka.

3. Improvements in Malaria Control Operations

This section contains suggestions for improvements in malaria control operations based on the findings described in Sections 1 and 2, above. A brief background is presented initially on the malaria control program's present organization.

3.1. Current Control Operations

Each zoba is managed by a malaria coordinator who plans the annual program of activities, which includes spraying (if done), net distribution and retreatment, and larval control operations. The coordinator is responsible for planning the timing and location of activities, getting information out to villages and health facilities, arranging who will do the work and when, obtaining transport from the zoba vehicle pool, and expediting the funds for paying workers. The coordinator also has to monitor the activities performed, keep records up to date manually and on the computer, and prepare monthly, quarterly, and annual reports of the malaria situation and expenditure.

Interpersonal skills and supervisory competence are crucial for the malaria coordinators. Zobas have one or more malaria and/or entomology technicians based at subzoba level who need supervision in conducting larval control, the net program, data reporting, and any operational research that is being done. Some zobas also have malaria data entry clerks. The newly qualified public health technicians are also now being deployed to health centers and stations in the subzobas; although they report to the health facility supervisors, they will need technical assistance from the malaria staff. Training and supervision of village health agents is a major responsibility of the malaria coordinators, although for clinical guidance, the village health agents work with the health staff.

In addition to direct supervision, the coordinator's work involves liaison with villagers, health facility supervisors, health workers who help with the net impregnation, zoba health information managers, water and environmental sanitation workers, and local administrative staff who handle net distribution.

Three of the most challenging aspects of a coordinator's work are:

1. The highly variable seasonal nature of the work, meaning times of frantic workload interspersed with slow periods

2. Accessing transport to supervise staff and visit villages which are widely dispersed, often in remote areas

3. Having to supervise staff who may have conflicting work responsibilities imposed by other supervisors, or whose work depends on factors they cannot control (such as breeding sites that exist because of poor sanitation or water supply problems).

Despite all of these difficulties, in general the zoba coordinators and their staff do a fantastic job of juggling their responsibilities. Although like most public health workers they are not noticed or appreciated until something goes wrong, the effects of their work speak for themselves through the decline in cases.

Funding

A large proportion of malaria control activities are funded from donor grants. Some of this money is given for specific activities and therefore imposes constraints on the program. For example, WHO allocates funds specifically for indoor residual spraying, while HAMSET funds can be used to purchase bednets and permethrin or used to fund community development activities, particular those involving cooperation with other health programs or social sectors such as the Ministry of Education. The definition of community development activity is quite broad, however, and has covered activities such as urban larval control campaigns. Other constraints on activities are imposed by levels at which funds are awarded. Most grants come through the national level and are allocated to zoba by the NMP, but some (e.g., HAMSET) are awarded at least in part at the zoba level. These have to be individually applied for and are awarded in a competitive process by zoba-level HAMSET committees. The different funding streams can result in time-consuming administrative work for zoba managers.

Most grant funds have clearly-specified objectives and budgetary allocations, which are written well in advance, as well funding agency-specific reporting requirements. Much of this administrative work is invisible to the zoba managers because it is done at the national level, but it is certainly advantageous to them to be aware of what targeted funds are available in any given year when making annual plans (see below). As in all project-based funding, the ability to mold the description of one’s routine or desired activities to fit the funding agency’s objectives is a beneficial skill.

There do not seem to be any specific “quotas” of funds to different zobas based on their number of malaria cases, for instance, in the previous year. One exception to this is that residual insecticides are allocated only to Gash Barka and Debub, because Anseba and Northern Red Sea do not wish to use spraying and the other two zobas are believed not to have high enough incidence to warrant it. Nets, permethrin, and other supplies seem to be allocated to zobas based on the amount requested, usually estimated from the relative number of households living in malarious areas. From that point it is up to the zoba manager to spread the available resources between subzobas as he/she sees fit.

Planning process

At the national level, an action plan is produced each year for the following calendar year. It restates the goals outlined in the five-year plan and specifies in detail what will be done during the next 12-month period.

Requirements for insecticide, bednets, and larvicidal chemicals are discussed in the zobas and subzobas in January and February each year, and requests are then submitted to Asmara for consideration at the time of the annual meeting in February or March. Thus if new additional materials are needed above what is in stock at the zoba, requests have to be made well before the main rainfall for that year occurs (starting in July/August), and therefore actual rainfall cannot be figured into the calculation. Even seasonal climate predictions would not be available at that early stage in the year.

For spraying in Debub and Gash Barka, insecticide requests are based on the number of villages planned to be sprayed, average houses per village and average wall area of a house, (using a dose of 2g/m2 DDT and 4 g/m2 malathion). The latter dose was doubled in 2003 from 2 g/m2, based on tests indicating a low level of resistance to malathion. The amount of spraying to be done is decided based on a long-standing priority list of localities, together with a "gut feeling" about how bad a year it will be for malaria.

Zoba requests presented at the annual malaria meeting are not automatically fulfilled. If certain insecticides are requested from the NMP office, other available ones may be substituted. For example, in 2003 Gash Barka requested only DDT, but received mostly malathion. However, the actual amounts (rather than type of insecticide) requested and supplied appear to be generally comparable.

Requests for bednets, permethrin, and larvicides are submitted at the same time as the residual insecticide requests. Needed bednets are estimated based on subzoba populations and numbers of households, the proportion of each subzoba population living in malarious areas, the previously issued number of nets, and the coverage goal for bednets (currently two per household). At present there is no provision for a "net lifetime" (i.e., replacement of worn-out nets), since the program is relatively new. This will become an issue soon.

The major decision in spray planning is how many teams to employ. There are usually two teams in Debub, but has varied from one to three teams in Gash Barka in the last few years. Each team needs two full-time pickup trucks to transport the spraying squad leader, spraymen, and the insecticide. Once the number of teams has been decided, villages are allocated to them in such a way that the spraying round can be completed in about two months, starting ideally at the beginning of July.

The timing of the main annual meeting is set to fit the malaria season in the western zobas, but is inconvenient for the Red Sea zobas since they are still in the malaria transmission season and may not have had sufficient time to prepare requests for the next year. Although discussions are also held at subsequent quarterly meetings of the zoba malaria officers throughout the year, there definitely seems to be the possibility that the Red Sea zobas could get short-changed in the resource allocation process.

3.2. Potential Improvements

Four categories of potential improvements come to mind: mix of activities; targeting; timing; and monitoring. These are considered in order.

Mix of Activities

All the evidence to date suggests that the impregnated net program in Eritrea has been a huge success. Because of this, there is no reason to change this aspect, except to streamline the process still further and incorporate a system for replacement of worn-out nets after a certain time period. There is some doubt about the program's sustainability at its current intense activity level. Making nets available for private (perhaps subsidized) purchase through alternative sources, especially in towns, would be a good addition to the current free availability only in malarious areas. Improving distribution to pregnant women, older children who sleep apart from their mothers or away from home (e.g., at school), and other distinct populations such as the military would be a way to further improve the program.

There was a strong suggestion in the regression analysis that larval control was associated with a reduction in malaria cases, at least in Anseba. While doubts linger both about the analysis and about the quantification of this activity, it should remain a strong focus and even be expanded, as long as the monitoring of it is improved concurrently, so that it can be better assessed (see monitoring, below).

Treating larval sites in towns regularly with temephos seems to be a manageable strategy in Eritrea. However, it will never be able to deal with the large rivers and streams that play a significant role in providing larval breeding sites in Eritrea, particularly as the rivers start to dry up and pool. Given the importance and difficulty of these sites, some new methods are needed for their treatment. Intermittent flushing strategies or channelling are not possible with current infrastructure, but aerial spraying of larvicide or up and down river beds, either on a regular schedule or a certain number of days after rain falls, should definitely be tried.

More micro-dams are being proposed in Eritrea to solve water shortage problems, and the best method of larval control in these has to be decided. In irrigated areas, cycles of flooding and drying may be possible, but are unlikely to be acceptable because of the consequent waste of water. Increased larviciding with Bti/Bs, biological control, or again aerial spraying are possible options that could be evaluated.

Although there is no evidence yet from the present studies that indoor residual spraying with DDT or malathion is effective at reducing transmission of malaria, this is a preliminary result based on only one zoba (Gash Barka) and the results from Debub need to be analyzed. Also, there needs to be a suitable way found to combine the DDT and malathion variable into one so that more power is achieved in the spraying variable.

If after further analysis the results are similar, then either:

1. Improve the effectiveness of the spraying by changing when or how it is done, or even increase the amount of spraying until it reaches an effective threshold amount, OR

2. Cease spraying and devote the effort to other activities such as larval control and environmental management.

In the meantime, evidence shows that the spraying is not necessarily reaching some of the subzobas in Gash Barka with the highest incidence, so some program reorganization is called for. Changes could also be made in the timing (see below).

Targeting

Targeting means prioritizing activities at certain sites rather than at others. In general, it should be done based on transmission intensity, so that control is most concentrated where the burden of disease is greatest. The NMCP is already doing this to a certain extent, because it only distributes nets in areas known to be malarious. Now with better information, it is easier to prioritize within the malarious areas, at least to the subzoba level. For example, based on the information in Table 5, some subzobas are known to have three times the incidence of malaria than others and should therefore probably receive greater attention. Good measures on which to prioritize are the average incidence by subzoba, the previous year's incidence by subzoba, or even the ranking of subzobas by incidence.

There are exceptions to the rule that most activities should be done in areas with highest incidence. It should also be done in areas that:

1. Have a relatively low incidence but a concentration of cases due to large dense population (e.g., Massawa, towns in Gash Barka)

2. Have a generally low incidence, but a high risk of devastating outbreaks, (e.g., IDP camps with people displaced from non-malarious into malarious areas)

3. Are prone to localized epidemics that could act as the starting points to spread more widespread epidemics. (It is not known exactly where these are yet, but further study of the data from the last eight years may help to pinpoint these "incubators" of epidemics. Certain volatile places on the western and eastern escarpments spring to mind, such as Hagaz, Ghinda, and Shieb.)

For targeting larval control, a lot is now known about the relative importance of different types of breeding sites for the *Anopheles arabiensis* vectors (Shililu et al. 2003). This work must be carefully studied to improve larval control. To build on this, it may also be useful to study which are the most "productive" breeding sites by doing pupal (rather than larval) surveys.

Targeting can also refer to special high-risk populations. Pregnant women and children under-five are vulnerable groups for malaria, and special campaigns (perhaps a different one each year) can be devoted to reaching them.

Timing

Figure 25 indicates that spraying in Gash Barka was done in July and August each year, which is before the cases have reached their peak numbers and after the cases have started to rise. Notably, the peak of cases sometimes occurred in August and September, rather than October, in Gash Barka. It is recommended that spraying begin two months earlier, in May and June, to try and prevent the rise before it occurs. Concern has been expressed that the half-life of the insecticide is too short for this approach to work, so data on this matter from the insecticide susceptibility tests should be closely examined first.

Earlier spraying would have the advantage of cutting the mosquito population down early in the season and reducing the number of infections that persist through the dry season. It will be essential to eliminate the latter in Gash Barka to better control the seasonal peak.

Figures 15 and 16 show that the provision of nets is more spread out over the second half of the year than spraying. This is good in terms of spreading the heavy workload, but again it would be desirable to start earlier, so that everyone has a treated net in his or her house ready to use before cases start to rise in July and August.

Monitoring

The bednet and spraying program are well monitored (almost excessively so) in terms of recordkeeping, with some data items collected that are not used. The most important tasks are to make sure that a few key indicators are reported by subzoba level to the NMP. The best key indicators are ones that can be used to quantify the effort put in — amounts of insecticides actually used, for example, rather than amounts sent from Asmara to the zoba. These amounts used must be checked against other variables such as numbers of nets or numbers of houses sprayed to ensure consistency.

There does not seem to be any evidence of supervisory visits made to check on spraying or net impregnation soon after it was done — this could have occurred, but was not recorded. It seems essential because shortcuts will always start to appear in any workplace, if attention is not being paid to how the job is done. The same issue applies to checking on the larval control done in towns that is very vaguely recorded.

For larval control, the monitoring indicators need to be revised. The number of person-hours and who did the work would be useful in addition to the number of sites and amount of chemical used. From present records it is not possible to quantify how much work community volunteers and malaria technicians did. In the towns, sometimes very large numbers of people are recorded as participating in a campaign, but it is not known if it was for five minutes or a whole day.

Better record keeping and tighter control on stocks would be easier if there were improved (secure and environmentally sound) storage locations in the zobas for nets and insecticides.

3.3. Sentinel Sites

With support from EHP and other sources, the NMCP is in the process of establishing a network of sentinel sites (based at certain health facilities covering up to 22 subzobas), where improved monitoring of malaria will take place. Sentinel sites were initially designed as locations where intense monitoring of epidemiological, entomological, and environmental variables would be done to predict and/or prevent epidemics. For various reasons, the entomological monitoring side of this process is very difficult to achieve. These reasons include the small numbers of mosquitoes typically caught in Eritrea and the consequent lack of precision in the population estimates, as well as the lack of knowledge of what would constitute an abnormal number of mosquitoes caught.

Over time, the concept of sentinel sites has evolved and they are now seen as places where improved data handling and analysis will take place. In addition, diagnostic services for malaria will be available at all sites (either microscopy or Optimal), leading to increased use of confirmed rather than suspected malaria as a case definition, as well as improved ability to track the different malaria species. This will be a huge improvement over using clinically-diagnosed cases as the main malaria indicator.

The sentinel sites will also be ideal places to improve the choice of indicator variables for monitoring control methods (larviciding, house spraying, or net impregnation rates) since activities can be more closely evaluated. A good first step is the comprehensive mapping of all potential breeding sites as a denominator for the amount of effort put into larval control. Schemes for usefully classifying larval sites would also be useful to develop, as well as ways to measure their productivity such as the evaluating the pupal surveys mentioned above.

4. Malaria Epidemics

4.1. Epidemic Definition

The usual definition of an epidemic is: "The occurrence in a community or region of cases of an illness, clearly in excess of normal expectancy."

It is clear from this definition that an estimate of "normal expectancy" in a particular place and time is needed to determine whether it has been exceeded. In addition, one needs to distinguish an abnormal rise in cases from a usual seasonal increase. Thus the past history of cases in a particular area is needed so that the number of cases expected is known. This has been provided by the cases dataset, which has generated the number of cases observed by health facility and subzoba for the eight years 1996–2003. The CASES dataset (SUBSET 1) has been used, together with the prevalence survey data (Sintasath et al. submitted), to prepare a malaria stratification map for Eritrea, which M. Thomson et al. reported separately.

One of the NMCP's targets is to reduce the number of malaria epidemics and the number of cases during epidemics. To give a figure for the number of epidemics, a cut-off value is needed that exceeds by some margin the normal number. The correct threshold to use in determining that an epidemic is occurring is still under investigation. There is no absolute standard. Six proposed methods are:

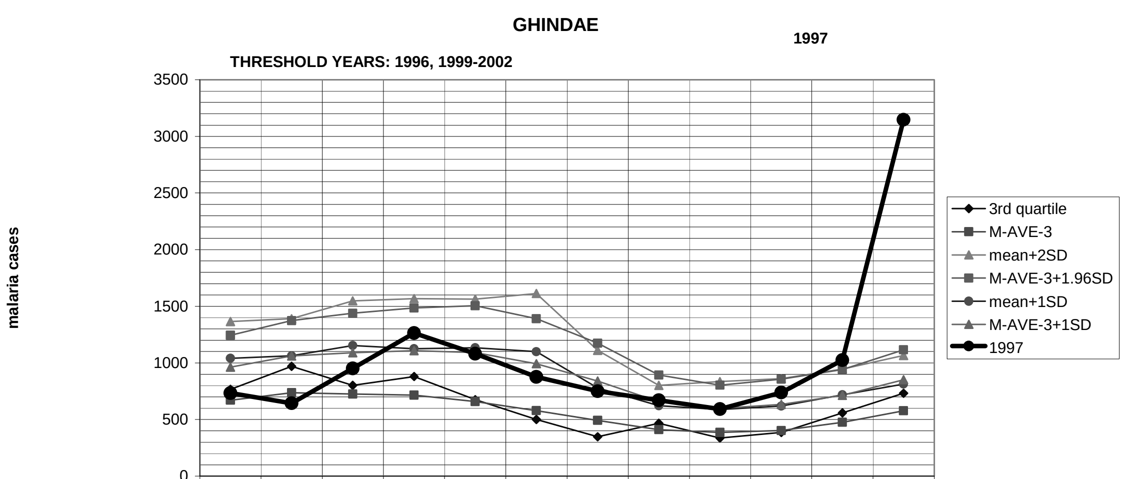
1. Third quartile of the observed monthly number of cases
2. Mean monthly cases plus one standard deviation
3. Mean monthly cases plus two standard deviations
4. Three-month moving average of number of observed cases plus one standard deviation
5. Three-month moving average of number of observed cases plus two standard deviations
6. C-SUM – the average cumulative sum of the number of cases per month in each year

Five of these potential threshold levels (a, b, c, d, and e, above) were calculated by subzoba/month from all eight years' data, are collected in Appendix 6, and are not shown here for space reasons. The sixth method (C-SUM) is still being investigated. The Excel spreadsheet used was developed as a combination of the one given in the "Epidemic Manual" together with a WHO/RBM version that Dr. Christa Hook wrote.

SUBSET 2 of the CASES dataset was used for this analysis to avoid problems of missing data, although the process could now be repeated with the more complete SUBSET 1 now that the missing data points have been imputed. All 52 subzobas in this subset (out of the 58 total subzobas) were analyzed. The graphs in Appendix 6 show the various thresholds as well as the typical seasonal pattern of cases in their locations. These thresholds calculated from all eight years' data would be useful from this point in time forward to determine whether epidemics have occurred.

Since it is not correct to assess epidemics for the same years as those from whence came the data used to generate the thresholds, the following approach has been taken. Instead of using the eight years — 1996–2003 — to evaluate the threshold, it was recalculated based on five years — 1996, 1999, 2000, 2001, and 2002. Then data from each subzoba for 1997, 1998, and 2003 were investigated one year at a time to classify each month in those years as "epidemic" (cases above the line) or not. These years were chosen so that the timing of the 1997-1998 epidemic could be closely investigated, so that any epidemics occurring in the most recent year (2003) could be identified and potentially stopped in their tracks. The number of epidemics occurring in 1997, 1998, and 2003 was quantified using various thresholds, potentially as an additional marker of the success of the control program. Two example subzobas out of the 58 total analyzed are shown in Figures 30 and 31.

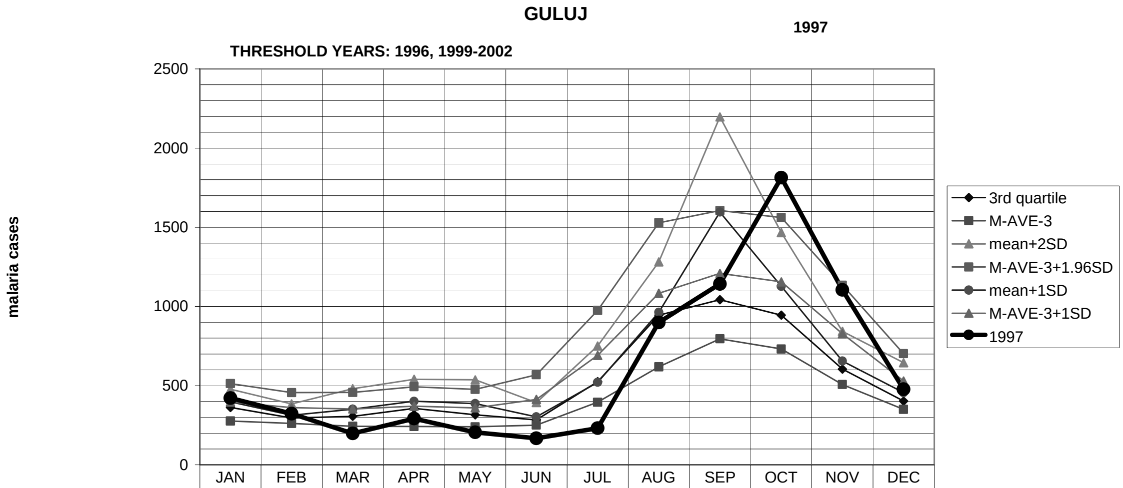
Figure 30. Epidemic Thresholds and 1997 Cases, Ghinda Subzoba, Northern Red Sea



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3rd quartile	766	970	801	879	675	500	348	468	336	385	558	731
M-AVE-3	670	736	725	715	658	578	491	410	387	403	476	577
mean+2SD	1365	1391	1549	1568	1563	1613	1111	801	834	862	946	1066
M-AVE-3+1.96SD	1243	1374	1438	1485	1505	1391	1173	892	804	856	941	1115
mean+1SD	1041	1062	1153	1126	1133	1100	778	622	588	618	719	814
M-AVE-3+1SD	963	1061	1089	1108	1090	993	839	656	599	634	713	852
1997	734	643	951	1263	1080	877	750	670	592	739	1025	3148

In Ghinda subzoba (Figure 30), there is a huge increase above all the thresholds at the end of 1997. Signs of what was coming were apparent by November. In this case it would not have made much difference which threshold was used. However, earlier in the year (April), the number of cases exceeded some of the thresholds and not others. If mean plus 1 standard deviation had been used as threshold, it might have prompted the authorities to take some extra action or at least to investigate the situation further.

Figure 31. Epidemic Thresholds and 1997 Data, Guluj Subzoba, Gash Barka



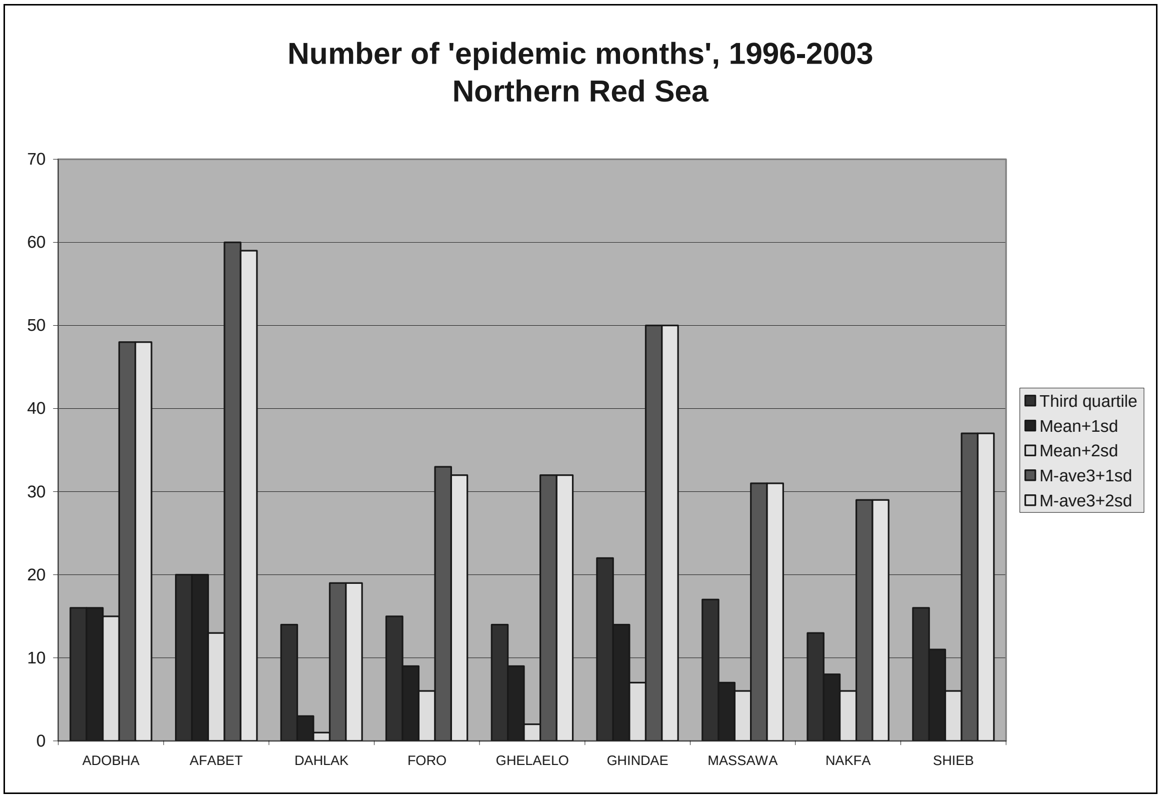
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3rd quartile	362	296	307	356	316	284	525	945	1043	945	604	403
M-AVE-3	276	262	243	242	240	251	395	619	796	732	507	351
mean+2SD	477	384	481	540	537	393	750	1281	2197	1467	844	645
M-AVE-3+1.96SD	513	456	457	493	476	569	975	1529	1606	1562	1134	701
mean+1SD	398	313	352	402	387	303	521	963	1596	1127	655	457
M-AVE-3+1SD	397	361	352	370	360	413	691	1083	1209	1155	827	530
1997	422	323	198	292	205	168	231	899	1142	1813	1105	477

In Guluj subzoba (Figure 31), there was also something strange going on at the end of 1997. In October the cases spiked above all the thresholds for that month. This demonstrates the importance of having month-specific thresholds, because the high number of cases probably seemed at the time to be just the normal seasonal peak (which actually occurs usually in September in this subzoba, rather than October). The only threshold in September that gave warning of what was about to happen in October was the third quartile, which was exceeded in September and was close to being exceeded in August. However, the October peak was resolved quickly, and cases were down to normal levels by December.

Which threshold should be used? There is no absolute standard. A comparison of the number of epidemics detected using different thresholds is shown in Figure 32. For simplicity, only subzobas in Northern Red Sea are shown.

Figure 32 shows that "moving average-based" thresholds are the most sensitive measures overall for detecting epidemics, but that there is little difference in sensitivity between the "moving average plus one standard deviation" or "moving average plus two standard deviations". If sensitivity was our only criterion, either of these two thresholds could be used.

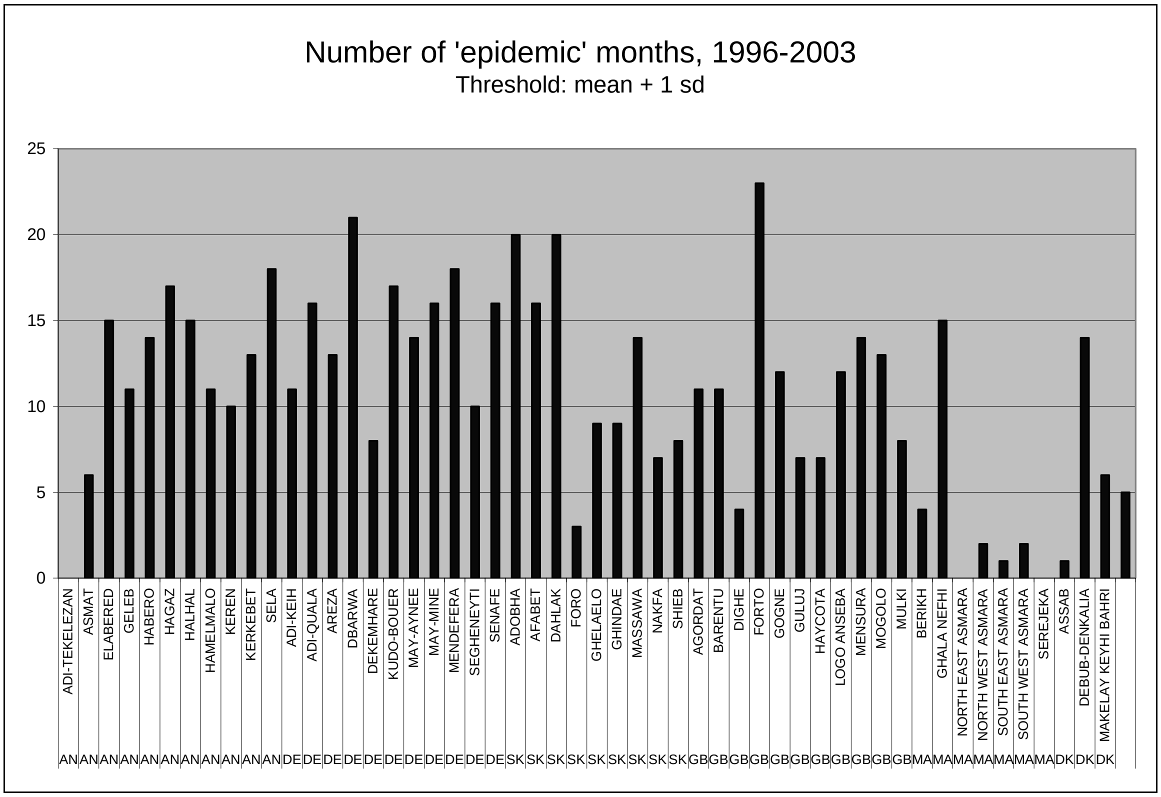
Figure 32. Number of "Epidemic Months," Northern Red Sea, 1996–2003



However, there is a severe drawback to using the moving average: it delays epidemic detection because tends it to flatten out the curves. This effect can be seen in Guluj subzoba, Figure 31, above. Both moving average curves (plus 1 or plus 2 sd) are flatter than their corresponding mean curves. (It is not so obvious in Ghinda subzoba in Figure 30 because of generally lower numbers of cases there.) This results in higher thresholds early in the malaria season, and lower peaks overall, for "moving average" thresholds. Therefore, abnormal early increases in case numbers are harder to detect, and the moving average is biased towards epidemic detection after the peak of cases has passed. Thus many of the "epidemics" shown in Figure 32 are detected on the "down side" of the seasonal peaks, when case numbers are waning rather than rising. Since early detection is a major aim of this process, moving average thresholds do not appear suitable for our purposes. Of the three remaining options, the third quartile is generally the most sensitive as a cutoff, while the mean + 2 sd is the least sensitive. To avoid false alarms or missed alerts, the mean plus 1 sd may be the best threshold to use.

Using the threshold of mean plus 1 sd, it was determined whether or not each month was an epidemic month for each subzoba in 1997, 1998, and 2003 (see Figure 33). Similar graphs were prepared for the other potential thresholds. By this means, the subzobas can be ranked according to epidemic tendency. For example, Forto subzoba in Gash Barka had the greatest number of epidemic months (23 out of 36 months over the period of study (1997, 1998, and 2003)), while NE Asmara and Serejeka subzobas in zoba Maekel had no epidemic months in this period. It can be seen from Figure 33 that there is great variation within a zoba in the frequency of epidemics. Northern Red Sea (SK in Figure 33) shows perhaps the greatest variation, while most subzobas of Debub have high numbers of epidemic months.

Figure 33. Number of “Epidemic Months,” 1996–2003



A related question is “Which months of the year are most prone to epidemics?” This can be addressed by means such as that shown in Table 9, which shows the number of epidemics occurring nationwide in each month of 1997, 1998, and 2003. Shaded blocks represent abnormal months, again according to the mean+1 sd threshold.

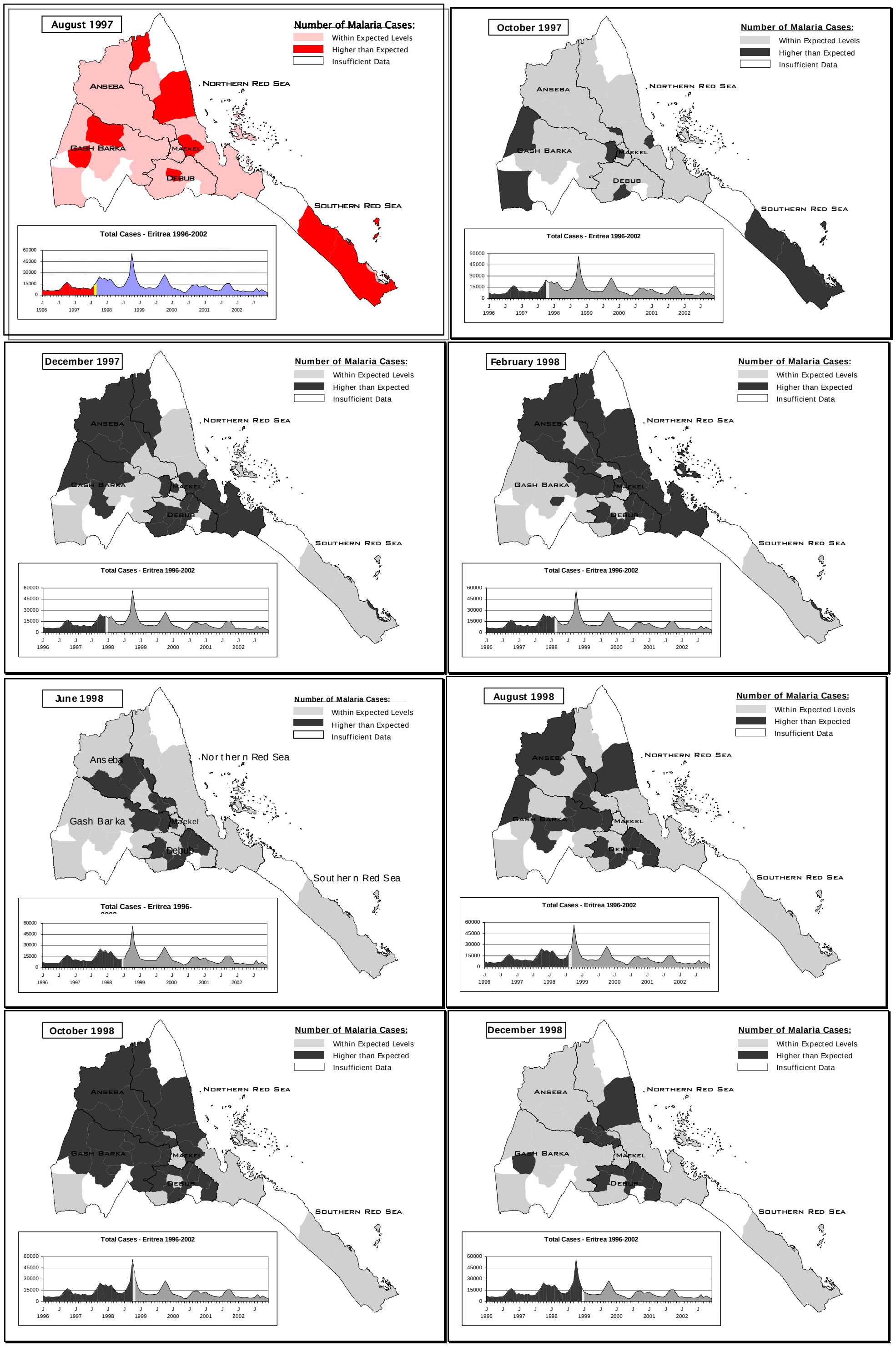
Table 9 shows that February 1998 was the month with the highest number of epidemics (37), followed closely by October 1998 with 36. In 2003, on the other hand, there have been only seven months with elevated numbers of cases by the mean+1 sd criterion. These occurred in two subzobas of NRS, two in Debub, and one in Gash Barka.

Finally perhaps the most meaningful way to look at these data is on a map. Figure 34 shows sequential maps by two-month intervals between mid-1997 and the end of 1998.

Table 9. Epidemic Months by Subzoba in 1997, 1998, and 2003

ZONE(	SUBZNAME	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D	
AN	ADI-TEKELEZAN	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	ASMAT	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	1	1	1	0	0	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
AN	ELABERED	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	GELEB	1	1	1	1	0	1	0	0	1	1	0	0	1	1	1	1	1	1	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
AN	HABERO	1	0	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	HAGAZ	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	HALHAL	0	0	0	0	1	0	0	1	0	0	0	1	1	1	0	0	0	0	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	HAMELMALO	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	0	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	KEREN	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	KERKEBET	0	0	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
AN	SELA	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	1	0	0	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
DE	ADI-KEIH	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
DE	ADI-QUALA	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0		0	0	0	0	0	0	0	0	0	0	0	0	
DE	AREZA	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
DE	DBARWA	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	1		0	0	0	0	0	0	0	0	1	0	0	0	
DE	DEKEMHARE	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
DE	KUDO-BOUER	0	0	0	0	1	0	0	0	0	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0		0	0	0	0	0	0	0	1	0	0	0	0	
DE	MAY-AYNEE	0	0	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
DE	MAY-MINE	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	
DE	MENDEFERA	1	1	1	0	1	0	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
DE	SEGHENEYTI	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
DE	SENAFE	1	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
SK	ADOBHA	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
SK	AFABET	0	0	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	1	0	0	0	
SK	DAHLAK	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
SK	FORO	0	0	1	1	1	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
SK	GHELAELO	0	0	0	0	1	1	1	1	1	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
SK	GHINDAE	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
SK	MASSAWA	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
SK	NAKFA	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
SK	SHIEB	0	1	0	0	0	0	0	1	0	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0	1	1	1	0	
GB	AGORDAT	0	0	0	0	1	1	0	0	0	0	0	1		1	1	1	1	0	0	1	0	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	BARENTU	0	0	0	0	0	0	0	0	0	0		0		1	1	0	0	0	0	0	0	1	1	0		0	0	0	0	0	0	0	0	0	0	0	0	
GB	DIGHE	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	FORTO	0	0	0	0	0	0	1	1	1	1	1	1		0	0	0	0	0	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	GOGNE	0	0	1	1	1	1	0	0	0	0	0	0		0	0	0	0	0	0	1	0	1	0	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	GULUJ	1	1	0	0	0	0	0	0	0	1	1	1		0	0	0	0	0	0	0	0	1	1	0		0	0	0	0	0	0	0	0	0	0	0	0	
GB	HAYCOTA	0	1	1	1	0	1	0	1	0	1	0	0		1	1	1	0	0	0	0	0	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	LOGO ANSEBA		0	1	0	0	0	0	0	1	1	1	1		1	1	0	0	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	MENSURA	0	0	0	0	1	0	0	0	0	0	0	1		1	1	1	1	1	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	
GB	MOGOLO	0	0	0	0	0	0	0	1	1	0	0	0		0	0	1	0	0	0	1	1	1	1	0		0	0	0	0	0	0	0	1	0	0	0	0	
GB	MULKI	0	0	1	1	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1	1	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	BERIKH	1	1	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	GHALA NEFHI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	NORTH EAST ASMARA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	NORTH WEST ASMARA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	SOUTH EAST ASMARA	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	SOUTH WEST ASMARA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
MA	SEREJEKA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
DK	ASSAB	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
DK	DEBUB-DENKALIA	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
DK	MAKELAY KEYHI BAHRI	0	0	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	
	SUM	12	15	18	23	18	12	14	15	17	23	25	34	31	37	33	27	25	22	19	23	24	36	32	26		0	0	0	0	0	0	0	2	3	1	1	0	

Figure 34. Subzobas with Epidemics,*August 1997 to December 1998

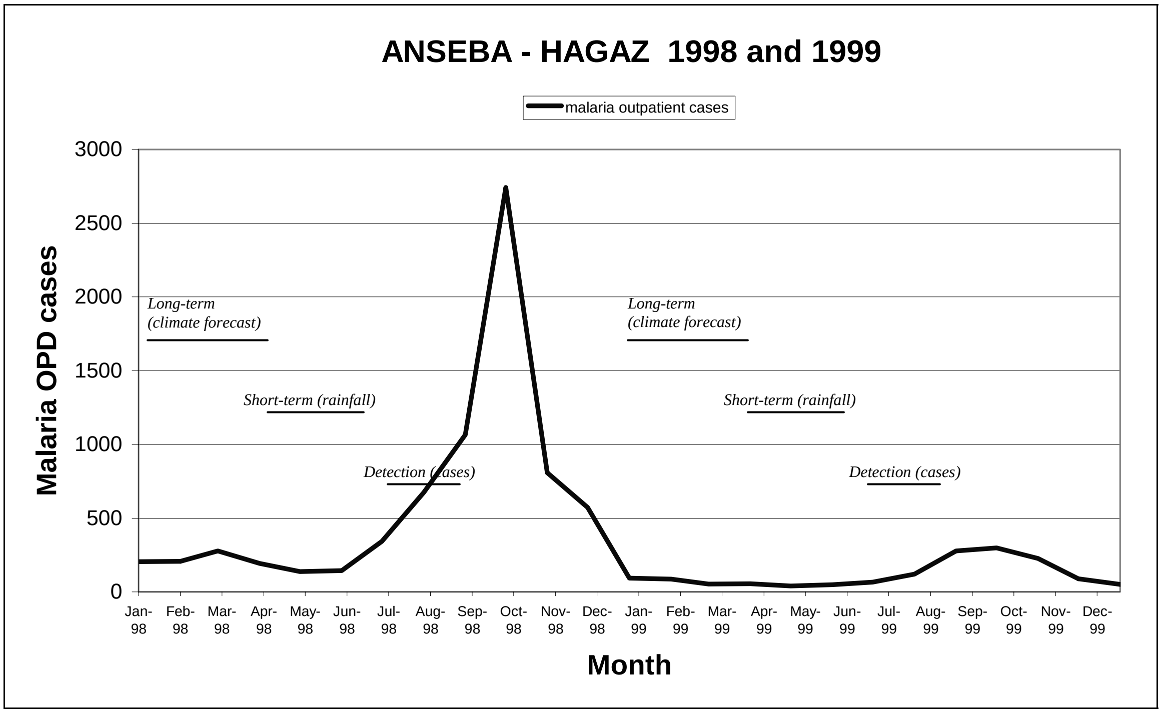


** An epidemic is defined as cases >mean+1 sd for that month, using CASES dataset, SUBSET 2. Graphs at two-month intervals are shown. Inset demonstrates the monthly cases for the country as a time series and indicates the current month in yellow.*

4.2. Epidemic Prediction

There are distinct stages defined in the process of epidemic warning and forecasting. They can be divided into “long-term forecasting” and “short-term warning.” The time scales involved are shown in Figure 35, with reference to actual data from Hagaz subzoba in zoba Anseba during 1998 and 1999. “Long term” means three or more months in advance of the anticipated peak malaria season. “Short term” means two to three months before the anticipated season.

Figure 35. Time Scales for Epidemic Prediction, Anseba - Hagaz Subzoba, 1998–99



Long-term Forecasting

Since malaria is highly dependent on rainfall, predicting malaria epidemics is essentially a matter of forecasting the climate, i.e., whether the coming season is likely to be wetter or drier than usual. Long-term forecasting several months in advance using meteorological data gives fairly general seasonal climate predictions. These are not very accurate and only give a probability of whether the rainfall will be higher or lower than usual or will be normal.

The Climate Outlook Forum in Nairobi produces a seasonal climate forecast for the Greater Horn of Africa several times a year. The forecasts are based mainly on sea surface temperatures in the tropical Atlantic and Indian oceans as well as El Niño conditions in the Pacific Ocean. The NFIS and the FEWS project for Eritrea publicize these forecasts, and they are sent out from the Ministry of Agriculture in the NFIS/FEWS newsletter. An example is shown in Figure 36.

Figure 36. June to September 2004 Climate Outlook

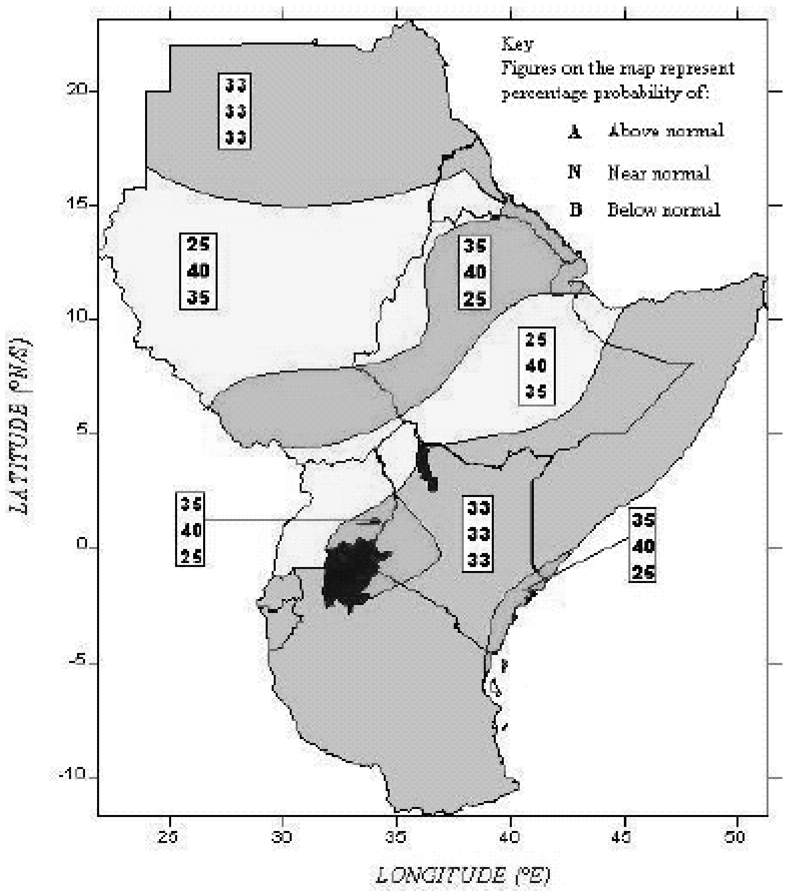


Figure 36 shows that Eritrea is divided into three regions, each with different forecasts (shaded differently). For each region there is a given probability of above normal, near normal, or below normal rain (top, middle, and lower numbers in each box respectively). For example, for the southwest of Eritrea (shaded yellow), there is a 25% probability of above normal rain, a slightly elevated (40%) probability of near normal rain, and a 35% probability of lower than normal rain.

These probabilities are not particularly helpful in deciding whether it will be a bad malaria season or not. However, seasonal rain prediction is a rapidly evolving science, and other climate models being tested may soon give better predictions. In the meantime, if there is a seasonal forecast giving an elevated probability (40% or higher) of above- normal rainfall, this should trigger stronger monitoring of local rainfall data (ground or satellite derived). Such a forecast can also provide information influencing the extent of the planned spraying rounds for that year as well as give added impetus to net distribution, re-impregnation, and health promotion activities.

Short-term Warning

Short-term warning, two to three months in advance, is based on actual rainfall amounts occurring. There is a two- to three-month lag in the relationship between rain and malaria cases because of the time for mosquito development and feeding, parasite development in the mosquito, and the disease incubation period.

These are the rainfall data sources for short-term warning:

1. Monthly and dekadal (10 day) rainfall amounts and numbers of rain days reported by rainfall stations at Ministry of Agriculture sites and other stations throughout Eritrea

2. Meteorological data (rainfall, temperature, and relative humidity) recorded on a daily basis at sentinel sites

3. Rainfall amounts estimated from satellite photographs, made available on the Internet by the Africa Data Dissemination Service, and published by the NFIS/FEWS office in the form of an email newsletter that began publication in 2004. An example is given as Appendix 5.

In the FEWS bulletins, maps are produced showing where rain is slightly above normal or greatly above normal. These will be extremely useful and should prompt increased vigilance, an increased amount of larviciding and source reduction, and health promotion activities urging net reimpregnation and daily use of nets. However, short-term warning is too late to change the planned spraying rounds in Gash Barka and Debub.

At the moment, entomological data (numbers of adult or larval mosquitoes caught in routine standardized catches at sentinel sites) are not useful for prediction or for triggering control activities because there is not enough background data (8–10 years) on mosquito numbers at sufficient numbers of sites, and thus the suitable threshold numbers of mosquitoes are not yet known. It seems better to measure rainfall, which precedes high mosquito numbers, than wait for the mosquitoes themselves.

5. Conclusions

The main conclusion from this study is that malaria has decreased markedly in Eritrea over the last six years, and that at least part of this decrease has been due to the NMP's work. Malaria mortality in Eritrea has dropped by half since 1999 in both young children and the population as a whole, and the number of malaria cases has dropped by half since 1999 in both young children and the population as a whole.

This report shows that combining data from diverse areas can give misleading patterns and should be done with caution. Due to extreme variation in transmission seasons by area of the country and by year, pooling data for the whole country obscures the situation in the smaller zobas. Using population-based indicators both for malaria cases and for control measures is essential for understanding the relationship between control inputs and outcomes and for identifying the areas with highest transmission rates. For setting priorities, allocating resources, and timing control measures, it is necessary to examine monthly or seasonal incidence by zoba and subzoba.

Routine data that the program and other departments in the Ministry of Health collected was of overall good quality. Three databases on malaria cases, control activities, and meteorology by month and subzoba for 1996–2003 were compiled and combined together for analysis to assess the success of the control program activities.

The control program has been very active and well supported. In the last five years about half a million nets have been distributed. Indoor residual spraying was done in two zobas, using DDT exclusively until 1999 when 28,000 kg of DDT were used, after which both DDT and malathion were used. The spraying amount dropped to a low level in 2000, but has increased steadily since then. Almost 14,000 kg of DDT and 9,000 kg of malathion were used in 2003. Larviciding with temephos has increased about five-fold from 1998 to 2003. The NMCP coordinates the work of a large network of village health agents providing presumptive treatment in the villages, and they are responsible for more than half of the malaria treatments now given in the country.

Cross-sectional time-series regression analysis clearly demonstrated the relationship between monthly rainfall and malaria, showing that rainfall two and three months earlier was a major determinant of the number of cases. In addition, rainfall in the current month was negatively associated with malaria cases, perhaps because heavy rainfall stops mosquitoes from feeding and washes out their resting and egg-laying sites.

This work has demonstrated many advantages to the use of satellite-derived rainfall estimates, because of their consistency and complete coverage of the country compared to isolated and unevenly distributed rain gauge measurements. Further meteorological predictors of malaria are still being investigated.

After rainfall had been taken into account, sequential month data remained a highly significant variable in the model, indicating a declining trend of malaria over time. Therefore decline in rainfall can be discounted as the main explanation for the decrease in malaria cases in Eritrea. Further analysis aimed to determine whether the malaria control activities were associated with the decline and if so, which ones.

The results indicated a highly significant negative association between the number of net impregnations done per subzoba by month and the number of malaria cases seen in that month. A strong suggestion of a similar negative association between the number of larval breeding sites controlled and the number of malaria cases was also observed in Anseba zoba, but not in Gash Barka.

Initial regression analysis showed a significant positive association between DDT and malaria cases, which is probably due to endogeneity, i.e., the tendency to spray in areas with high numbers of cases. Use of the calendar month as an instrumental variable corrected for the DDT endogeneity in the regression, but the analysis failed to then show any negative association between amount of DDT used and malaria cases. If this result is confirmed in Debub zoba, it makes a strong case for stopping indoor residual spraying and concentrating on other activities.

The case data was also used to investigate the pattern of epidemics in the country. Five-year data (1996, 1999–2003) was used to generate mean cases per month by subzoba as well as five different potential epidemic thresholds based on the following: mean plus 1 or 2 standard deviations, three-month moving average plus 1 or 2 sd, and the third quartile. Different thresholds summarized the number of epidemic months occurring in each subzoba during the years 1997, 1998, and 2003, to identify areas more or less prone to epidemics.

For identifying epidemics, little difference in the number detected was observed if either the three-month moving average +1sd or +2sd thresholds was used. Both these and the third quartile method were overly sensitive, which would result in false alarms of epidemics. In addition, because the three-month moving average smoothes out the epidemic curves, consequently it delays early detection of abnormal increases in cases. The mean+2 sd threshold, on the other hand, appeared too insensitive. Using mean +1 sd gave a balance between sensitivity and specificity.

A clear epidemic definition now enables us to identify subzobas and times at highest risk. Forto in Gash Barka had the highest number of epidemic months in recent years, but other Gash Barka subzobas were at relatively low risk of abnormal case numbers. All Debub subzobas were at relatively high risk of epidemics. Using this epidemic definition, more epidemics would have been observed early in 1998 than later in that year, which could have served as warning of impending serious trouble.

References

NSEO/OrcMacro. Demographic and Health Survey, Eritrea 2002. NSEO/OrcMacro, Asmara Eritrea and Calverton, Maryland, USA.

Over M, B. Bakote'e, P. Wililkai, R. Velayudhan, and P.M. Graves. 2004. Impregnated nets or DDT residual spraying? Field effectiveness of malaria prevention techniques in Solomon Islands, 1993-1999. *American Journal of Tropical Medicine and Hygiene* 71 (2): (Supplement) 214-223.

Shililu et al. Larval paper. Working paper.

Shililu et al. 2003. High seasonal variation in entomologic inoculation rates in Eritrea, a semi-arid region of unstable malaria in Africa. *American Journal of Tropical Medicine and Hygiene* 69: 607-613.

Sintasath et al. Malaria prevalence and associated risk factors in Eritrea. Working paper.

WHO/RBM (World Health Organization/Roll Back Malaria). 2004. Draft Field Guide for Malaria Epidemic Assessment and Reporting, WHO/HTM/MAL/2004.1097.

WHO/RBM Technical Support Network for the Prevention and Control of Malaria Epidemics. Malaria early warning systems: a framework for field research in Africa. Concepts, indicators and partners, WHO/RBM, 2001.

World Bank. 1998 (for population estimate).

World Bank. 1999 (for demographic rates).

Appendix 1. Subzoba codes and populations

ZONECODE	ZONENAME	SUBZNO	SUBZONE	NSEOCODE	NSEONAME	Pop2000
AN	ANSEBA	301	ADI-TEKELEZAN	401	Adi Techelezan	32777
AN	ANSEBA	302	ELABERED	402	Ilaber`ad	48905
AN	ANSEBA	303	GELEB	403	Gheleb	34760
AN	ANSEBA	304	KEREN	404	Keren City	76533
AN	ANSEBA	305	HAGAZ	405	Hagaz	64859
AN	ANSEBA	306	HALHAL	406	Halhal	51290
AN	ANSEBA	307	HABERO	407	Haboro	46901
AN	ANSEBA	308	ASMAT	408	Asmat	35272
AN	ANSEBA	309	KERKEBET	409	Kerkebet	28823
AN	ANSEBA	310	SELA	410	Sel`a	9866
AN	ANSEBA	311	HAMELMALO	411	Hamelmalo	27093
DE	DEBUB	501	DBARWA	601	Debarwa	89509
DE	DEBUB	502	AREZA	602	Areza	82300
DE	DEBUB	503	MENDEFERA	603	Mendefera	57464
DE	DEBUB	504	DEKEMHARE	604	Decemhare	61660
DE	DEBUB	505	SEGHENEYTI	605	Seghenayti	50479
DE	DEBUB	506	ADI-KEIH	606	Adi Qeih	49863
DE	DEBUB	507	SENAFE	607	Sena`fe	80488
DE	DEBUB	508	TSORENA	608	Tserona	37221
DE	DEBUB	509	ADI-QUALA	609	Adi Quala	83800
DE	DEBUB	510	KUDO-BOUER	610	Imni-Hali	58328
DE	DEBUB	511	MAY-MINE	611	May_Mne	65385
DE	DEBUB	512	MAY-AYNEE	612	May-`Aini	38880
DK	SOUTHERN RED SEA	101	ARETA	101	A`rayta	19696
DK	SOUTHERN RED SEA	102	MAKELAY KEYHI BAHRI	102	Maekelay Denkali	13750
DK	SOUTHERN RED SEA	103	DEBUB-DENKALIA	103	Debubawi Denkali	11637
DK	SOUTHERN RED SEA	104	ASSAB	104	Asseb City	21251
GB	GASH BARKA	401	AGORDAT	503	Aqurdat City	31105
GB	GASH BARKA	402	BARENTU	507	Barentu	20833
GB	GASH BARKA	403	DIGHE	504	Dighe	41094
GB	GASH BARKA	404	FORTO	509	Forto	42944
GB	GASH BARKA	405	GOGNE	508	Gogne	42551
GB	GASH BARKA	406	HAYCOTA	510	Haykota	45146
GB	GASH BARKA	407	LOGO ANSEBA	501	Logo-Anseba	38090
GB	GASH BARKA	408	MENSURA	502	Mensura	57537
GB	GASH BARKA	409	MOGOLO	505	Mogolo	22584
GB	GASH BARKA	410	GULUJ	512	Golij	55046
GB	GASH BARKA	411	SHAMBUKO	506	Shambuqo	34213
GB	GASH BARKA	412	MULKI	514	Molqi	35550
GB	GASH BARKA	413	TESSENEY	513	Tessenay	42835
GB	GASH BARKA	414	LAELAY GASH	511	La`lay Gash	55046
MA	MAEKEL	601	SEREJEKA	201	Serejeqa	55301
MA	MAEKEL	602	BERIKH	202	Berikh	44749
MA	MAEKEL	603	GHALA NEFHI	203	Gala`Nefhi	47769
MA	MAEKEL	604	SOUTH EAST ASMARA	205	Debubawi Mibraq	84154
MA	MAEKEL	605	NORTH EAST ASMARA	204	Semyenawi Mebraq	114794
MA	MAEKEL	606	NORTH WEST ASMARA	207	Semenawi Me`arab	112281
MA	MAEKEL	607	SOUTH WEST ASMARA	206	Debubawi Me`arab	79702
SK	NORTHERN RED SEA	201	GHELAELO	301	Gel`alo	24977
SK	NORTHERN RED SEA	202	FORO	302	Foro	47952
SK	NORTHERN RED SEA	203	DAHLAK	303	Dahlak	3054
SK	NORTHERN RED SEA	204	MASSAWA	304	Massawa	35615
SK	NORTHERN RED SEA	205	GHINDAE	305	Ghenda`a	64207
SK	NORTHERN RED SEA	206	SHIEB	306	She`ab	54936
SK	NORTHERN RED SEA	207	AFABET	307	Af`abet	104562
SK	NORTHERN RED SEA	208	NAKFA	308	Naqfa	55189
SK	NORTHERN RED SEA	209	KARORA	309	Karura	44408
SK	NORTHERN RED SEA	210	ADOBHA	310	Adobha	24155

Appendix 2. 1996-2002 Access NHMIS extraction procedure

METHODS USED TO CREATE THE DATASET OF MALARIA DATA FOR 1996-2002

(tblMalTotal1996_2002 in MalariaNHMIS.mdb)
Dataset prepared between Oct 2002 and June 2003
Patricia M Graves

This dataset was prepared for the following reasons:

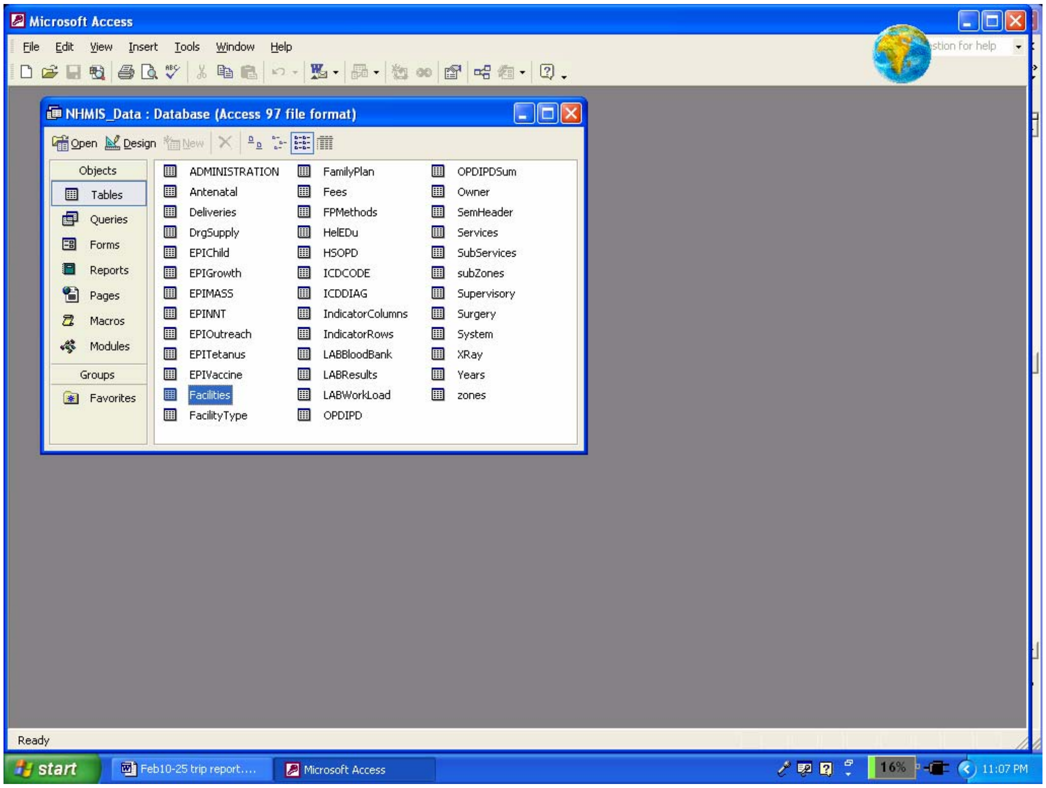
1) To clarify the pattern of malaria transmission in different parts of the country, and assist in geographic stratification of malaria;
2) To obtain long-term data for calculating epidemic thresholds for health facilities and subzones;
3) To investigate and learn from what was happening in various parts of the country in the lead up to the 1998 epidemic;
4) To prepare a longitudinal dataset for investigation of the effectiveness of different malaria control methods used in the country.

Apart from these reasons, the dataset can be used to evaluate the status of malaria in the country compared with past years, and to estimate the percent change in incidence over the time period covered. It could also help to improve the effectiveness of malaria control by identifying problem areas or improve the timing of interventions.

The dataset came from two sources: NMCP data for 1996 and 1997 and NHMIS (SEMISH) data for 1998 to 2002. The NMCP data was in Excel; apart from reorganizing the Excel files for import to Access, the only changes made were to the spellings of health facility and subzone names to the same as those used in the NHMIS. The major work was in extracting the NHMIS records for malaria in a form useful to the NMCP. How this was done is described below.

Description of the NHMIS data and important tables

The NHMIS data (also known as SEMISH data) are entered into a file in each zoba. Every month the zoba SEMISH clerk sends the data electronically or on disk to the national office. The files from each zoba are combined to make an updated version of NHMIS_data.mdb. Files ending in “mdb” are Microsoft Access databases. An Access database consists of a number of tables containing related information. When you open a database you will see a list of the tables as shown in the picture below, which shows the tables in the NHMIS database.



The file NHMIS_data.mdb contains the cumulative data from 1998 to the present. The file is very large and will continue to get larger. The data is organized by health facility and month. Each health facility has a unique ID code (called “FacID” in some tables and “Facility” in others). It is a text code consisting of a two letter zone code, a four-five letter code for the name of the facility, and a two letter code for the type of facility.

Another part of the NHMIS system is the Decision Support System (DSS). Files for the DSS are in the database NHMIS_graph.mdb. It is not necessary to have NHMIS_graph.mdb installed in order to look at and use the NHMIS_data.mdb.

The important tables for the malaria program are the following:

OPDIPD: Number of outpatients and inpatients, <5 and >=5 with particular diagnoses seen that month at Health Centres and Hospitals. Malaria is coded as ICD codes 043 and 043.1-6.
OPDIPDSUM: Summary of outpatients and inpatients seen at each facility that month.
HSOPD: Number of outpatients seen that month at health stations with particular diagnoses. Malaria is coded as “Malaria (Clinical diagnosis)”.
LABRESULTS: Numbers of lab tests and results.
FACILITIES: List of health facilities, codes, types, subzones and zones.

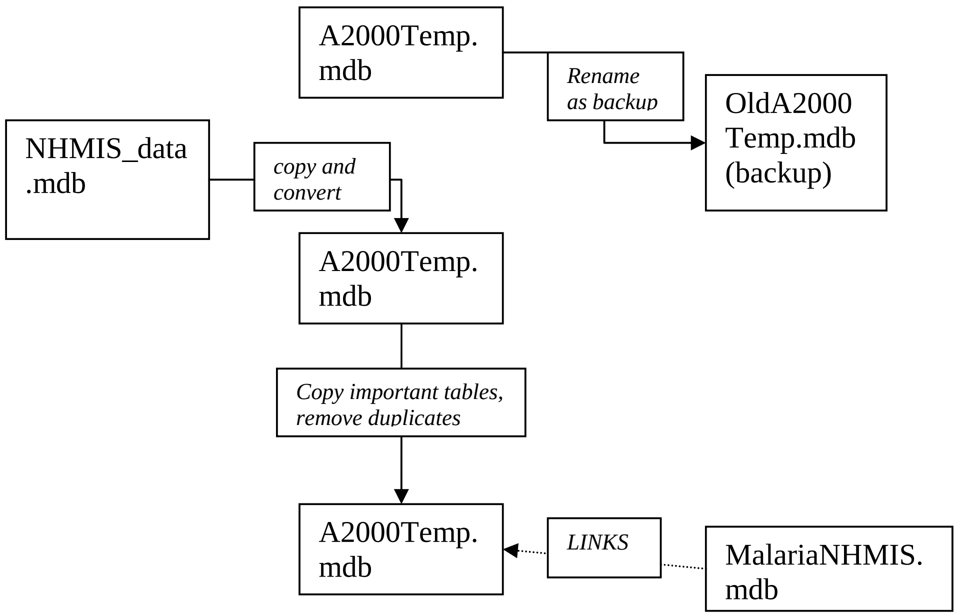
Description of the Malaria_NHMIS database

A second database linked to the NHMIS_data.mdb was created, called Malaria_NHMIS.mdb. It contains links to the important tables for malaria data, as well as a number of “Queries” which pick out malaria data.

Procedure for copying, converting, and cleaning database of duplicates

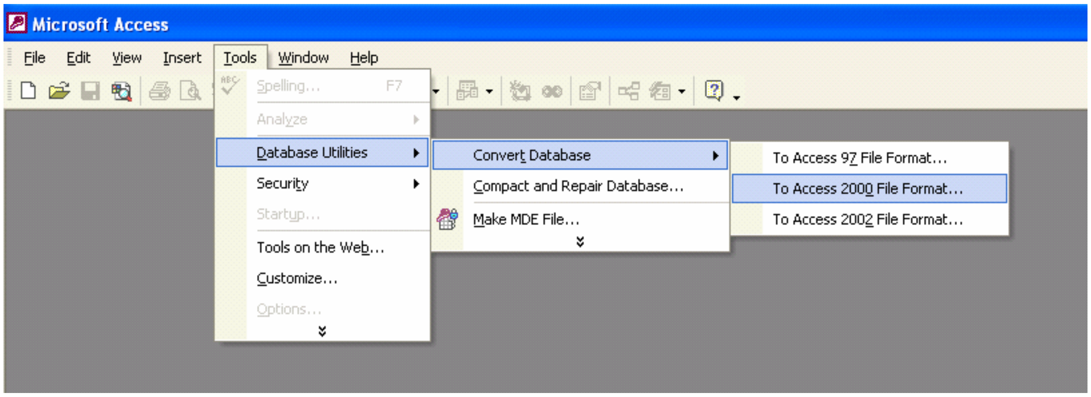
It was necessary to convert the NHMIS_data.mdb into Access 2000 form so that it could be cleaned of duplicate records. The database was copied and converted at the same time.

The system for handling the NHMIS data and extracting the malaria data is shown in the figure below:



We made a copy of NHMIS_data.mdb, converted it to Access 2000 format and called it A2000Temp.mdb. (In future if this procedure is repeated, previous versions of A2000Temp.mdb should be renamed to something else first like OldA2000Temp.mdb and kept as a backup).

To copy and convert a database, open the Access program and click on
Tools – Database Utilities – Convert Database – To Access 2000 File Format
As shown below:

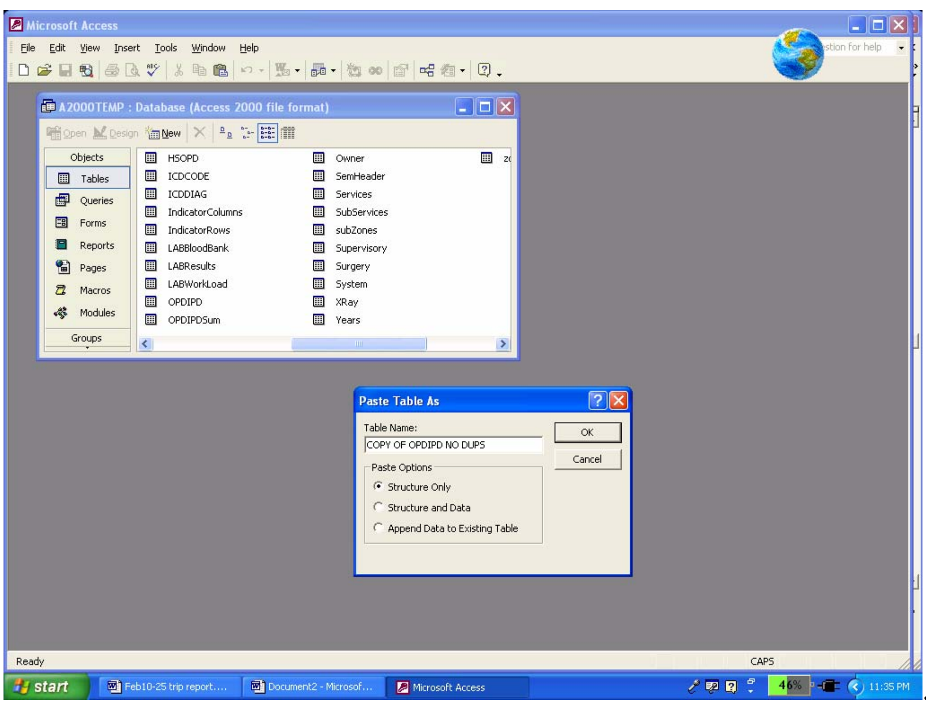


It will ask you which database you want to convert. Find the NHMIS_Data.mdb in C:\NHMIS (or wherever you put it), select it and click on OK.

It will ask you what to call the converted database – call it A2000TEMP.mdb and click OK. Now you have a copy of the data for safety, and you can also alter the table structure.

To get rid of duplicate records, you have to make a copy of an individual table as "Structure only", and change its structure so that all fields are primary key fields. Then you append the table which has the duplicates onto the copy. Because primary key variables have to be unique, duplicates will not be appended.

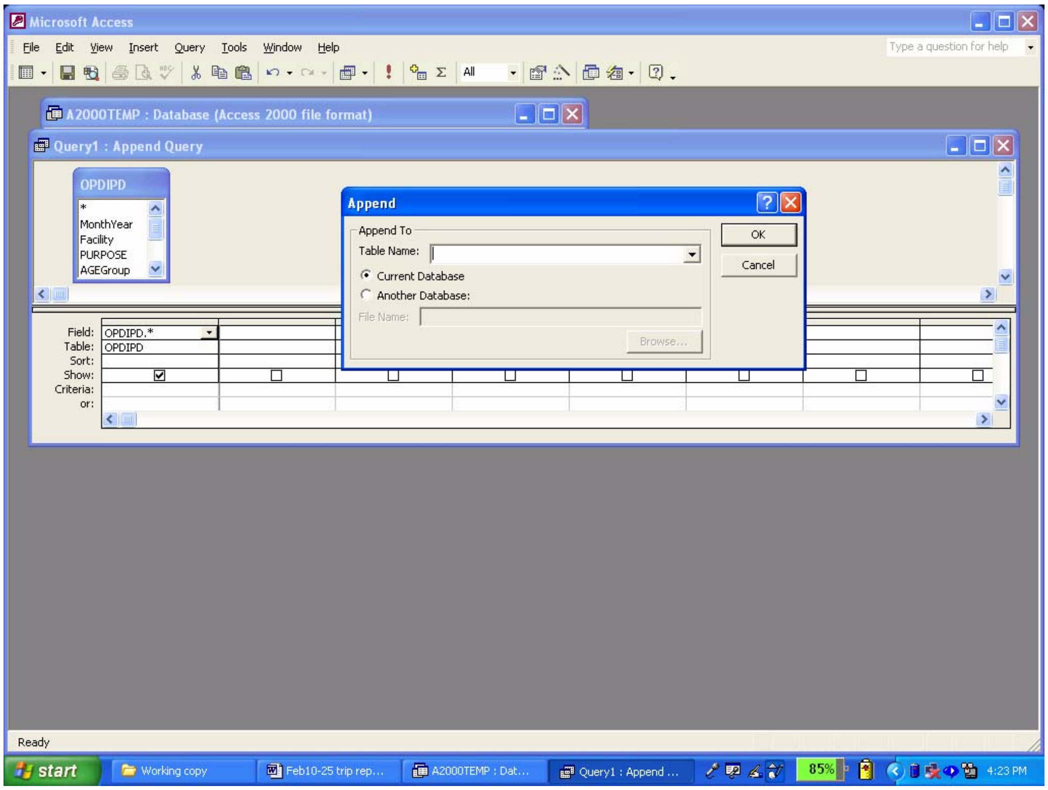
In A2000TEMP.mdb we made copies of the Tables needed (OPDIPD, HSOPD, and LABRESULTS).



In the ‘Paste Table As’ box we chose “Structure Only” under the Paste options and called the table COPY OF OPDIPD NO DUPS.

After opening the table just made (COPY OF IPDOPD NO DUPS) in Design view, every field was made a primary key by highlighting the rows at the left hand side, and clicking the key symbol. The table was saved and closed.

An Append query was created to add OPDIPD onto COPY OF OPDIPD NO DUPS as shown below:



The procedure was repeated for for the other tables needed (HSOPD, LABRESULTS). The Facilities table already has a unique field (FacID) so did not need to be cleaned it of duplicates.

Finally all the primary keys added to the Table structure were removed, by opening the “COPY OF” table in Design View, highlighting all the rows and clicking on the key symbol on the toolbar.

What data was extracted and where from?

Outpatients and Inpatients, malaria cases and malaria deaths in ‘under 5’ and ‘5 and above’ from COPY OF OPDIPD table using “Malaria – all types”;
Outpatient malaria cases from health stations, ‘under 5’ and ‘5 and above’ from COPY OF HSOPD table using “Malaria (Clinical Diagnosis);
Confirmed Pf and Pv cases from COPY OF LABRESULTS table.

Creation of the Facility-Month table for merging

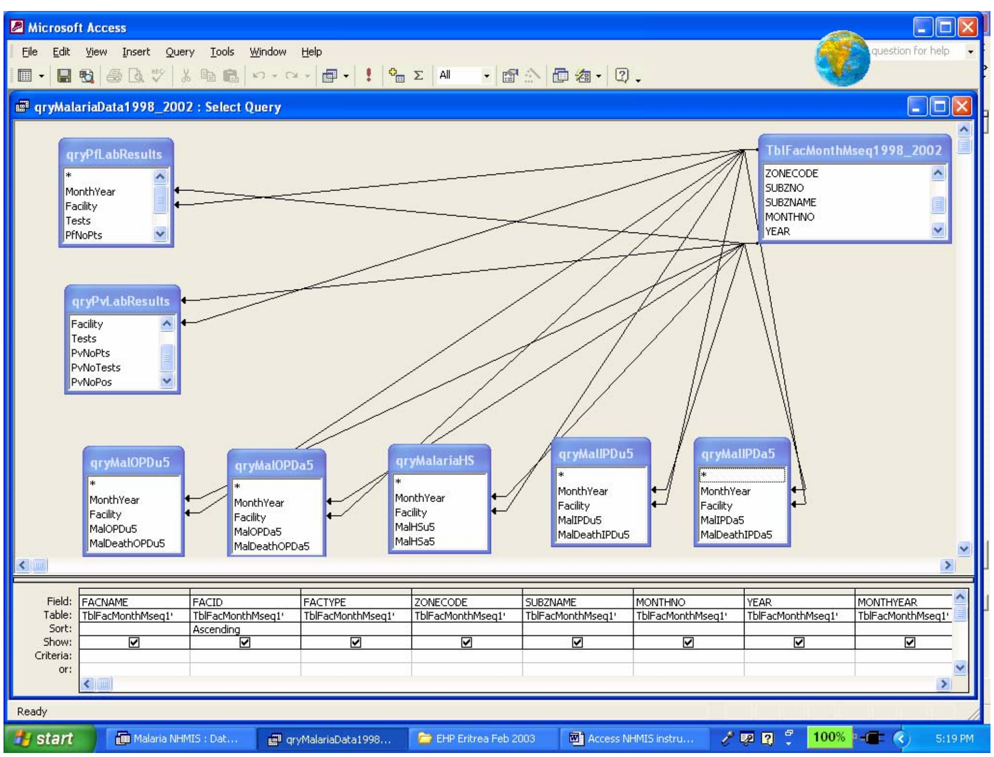
In order to bring all the data together from various NHMIS Data files, there must be a listing of all the facilities and all the months. These were created for each year in Malaria_NHMIS.mdb up to year 2003.

The table tblFacMonthMseq1998-2002 contains the date as "MONTHYEAR" as well as YEAR, MONTH and MSEQ. MSEQ is the sequential month since Jan 1996, added as a convenience for sorting and future analysis. MONTHYEAR, MONTH and YEAR are stored as text format, even though they are numbers. YEAR and MONTH can be converted back to numbers for merging with other data if necessary.

List of queries and explanation of what they select

qryMalOPDu5	Malaria cases and deaths, OPD less than 5, HC and HO
qryMalOPDa5	Malaria cases and deaths, OPD 5 and above, HC and HO
qryMalIPDu5	Malaria cases and deaths, IPD less than 5, HC and HO
qryMalIPDa5	Malaria cases and deaths, IPD 5 and above, HC and HO
qryMalariaHS	Malaria cases, HS, both age groups.
qryPfLabResults	Confirmed P.falciparum cases
qryPvLabResults	Confirmed P.vivax cases

qryMalariaData1998-2002 Combines all the data from the first seven queries above together with the tblFacMonthMSeq1998-2002 (a complete listing of facilities and months). This query is saved as a Select query so to make the new table (tblMalariaData1998-2002), this query was changed from a Select query to a Make-Table Query. The query design is shown below.



qryTotOPDu5	Total cases and deaths, OPD less than 5, HC and HO
qryTotOPDa5	Total cases and deaths, OPD 5 and above, HC and HO
qryTotIPDu5	Total cases and deaths, IPD less than 5, HC and HO
qryTotIPDa5	Total cases and deaths, IPD 5 and above, HC and HO
qryTotalHS	Total cases, HS, both age groups

qryTotalData1998-2002 Combines all the data from the five queries above together with tblFacMonthSeq1998-2002 into a new table called tblTotalData1998-2002. It is of very similar design to the malaria table.

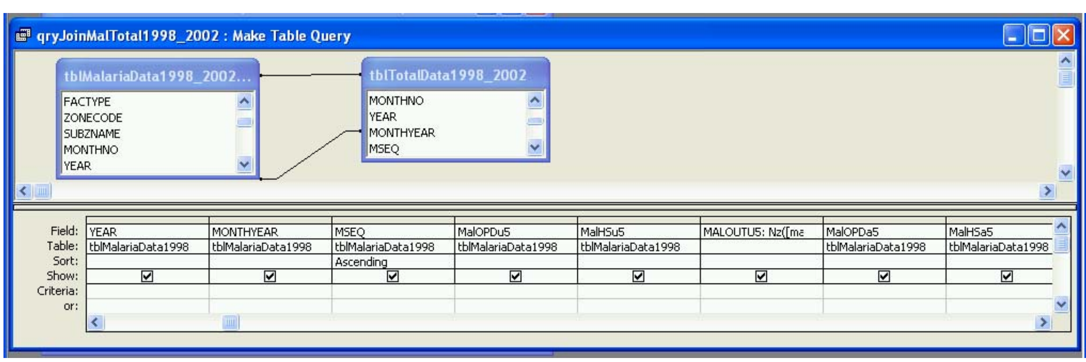
Note the lines which are used to link the queries and tables. Each query is linked to the tblFacMonthMseq1998-2002 by matching the MONTHYEAR and FACID fields. The join properties in each case are set to a “right outer join” (the arrows are pointing from tblFacMonthMSeq1998-2002 to the other queries). This means that during the merge, ALL records from tblFacMonthMseq1998-2002 will be kept, whilst only those records which match on the linked field will be kept from the other queries.

For information: to change the join properties, you click on the line connecting the tables, then right-click and select “Join Properties”.

Note that the total number of patients for each health facility was extracted from the COPY OF OPDIPD table by summing over all the diagnoses. This is not strictly correct because there may be more diagnoses than patients. I attempted to extract the total patients from the OPDIPDSum table, but the sums obtained were obviously not realistic. In any case, the sum of diagnoses is what is filled in by the malaria staff when they enter onto the malaria forms.

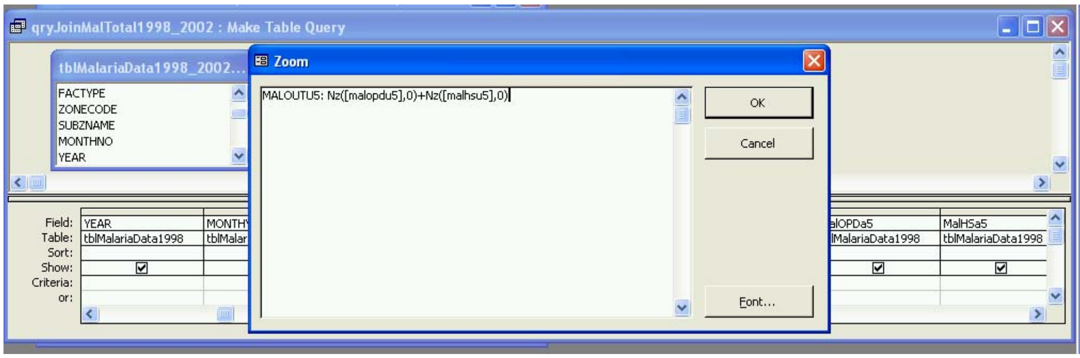
At this point we had two separate tables, one with the malaria data and one with the total data. These were checked again for duplicate records using the “Find Duplicates Query Wizard” under Query-New. (I found 23 duplicates in the MalariaData table. They were duplicate Facility-Months which had different data in each. For each duplicate or triplicate pair, I deleted the record(s) with the lowest numbers).

The two tables (Malaria and Total) were merged together using the query qryJoinMalTotal1998-2002. (see below)



In addition to joining the two tables, this query also performed calculations on certain fields. It added up the number of outpatients at HC and HS, and added up the number of under and over fives for out-and in-patients and deaths, for both malaria and total cases.

An example of the formulas used is shown below. To see the addition formulas in a given cell, you place the cursor in a cell and press Shift-F2.



Because Access will not add across cells if one of them is empty, you have to specify that the 'null' cells should be treated as zeros. The syntax for such a formula is as follows (also shown above): MALOUTU5: Nz([MalOpdU5],0)+Nz([MalHsU5],0). This formula places the under-five cases from HC and HS in one column called MALOUTU5. Other formulas are similar.

One problem with this approach is that it placed zeros in the sum column when both cells to be added are empty (i.e. missing). This was fixed later.

A similar procedure was followed for the 1996-1997 data, except that we only have total data (not by agegroups) for many HFs in these years. The 1996_1997 data was merged with tblFacMonthMseq1996_1997 (N=7800) to give tblRecreate1996_1997(30May2003)

The 1996_1997 data (N=7800) was then appended onto the 1998-2002 data (N=19500) using qryAdd96_97to98_02. Searching for duplicates enabled correction of some wrongly entered years. The final table was called **tblMalTotal1996_2002** (N=27300).

Non-matched health facilities and name changes

There were four health facilities in the 1996_1997 data for which a FacID could not be found in tblFacilities. They are as follows:
DE Subzone Segheneyti, St Michel HS
MA Subzone SW Asmara, Biet-Mika HS
MA Subzone SE Asmara, Mai-Welaku HC
MA Subzone SW Asmara, Malta-Clinic HA
Therefore these records were dropped out of the dataset during the merge with tblFacMonthMseq1996_1997.

In addition, the following health facility names were changed in the 1996_1997 data to match the names in the NHMIS data:
DE Subzone Dbarwa, Adi-Gulti HS changed to Adi-Gebray HS (there is already an Adi-Gulti HS in Areza subzone).
Quahito HS changed to Kohayto HS (Adi-Keih subzone in DE)
Edaga-Aiba changed to Edaga Clinic
Mai-Nefhi changed to Merhano (Ghalanefhi Subzone)
GB Mensura Subzone, Megarih changed to Migrah (there is another Megarih in AN, Keren subzone).

The list of Health facilities used in this work had 325 records. Currently (late 2002) the list has 330 health facilities.

Sorting out of missings and zeros

To clean up the data, the following steps were followed using a series of update queries:

1) If TOTOUT (total number of outpatients) was Zero or Null (missing), it was assumed to be a missing report. Therefore any Zeroes in the other variables should really be Missing (Null). If they were left as Zeroes, they would bias any summary results. The following variables were changed to Null (missing) in the following order:
MALOUTU5, MALOUTA5, MALOUT, TOTOUTU5, TOTOUTA5, TOTOUT

2) If TOTIN (total number of inpatients), for a health facility which has inpatients, was Zero or Null (missing), it was assumed to be a missing report. Therefore any Zeroes in the other inpatient variables should really be Missing (Null). If they were left as Zeroes, they would bias any summary results. The following variables were changed to Null (missing) in the following order:
MALINU5, MALINA5, MALIN, TOTINU5, TOTINA5, TOTIN

Notes

For some early data in some zones, we only have malaria data and not the total outpatients. Therefore to count the number of clinics reporting in any given month, use MALOUT rather than TOTOUT.

The data on deaths and on confirmed cases has not been cleaned as above for outpatient and inpatient data. It may contain inappropriate Zeros instead of Missings.

Conversion of MonthYear to Month and Year

The NHMIS stores dates as a combined Month and Year text variable. If you need to separate it out into its components, use the following formulas:

YEAR: Right([MONTHYEAR],4)
In other words, take the right 4 digits of MONTHYEAR for the year.

MONTH: Val(IIf(Len([MONTHYEAR])=5, Left([MONTHYEAR],1),Left([MONTHYEAR]2)))
In other words, if the length of MONTHYEAR is 5, for example 12002, then take one leftmost digit as the month; otherwise take the left two digits, for example 122002.

If you ever need to go back the other way, ie. Create MONTHYEAR from its components, this is the formula for combining two text variables:
MONTHYEAR: [MONTHNO] & [YEAR]

Appendix 3. Rainfall Station Locations

RAINFALL STATIONS			LOCATIONS		Debub water resources dept, transformed *(WR_debub_hosp_lon_lat.xls)*		National Statistics and Evaluation Office, transformed *(pg_2004_Eritrea_hosp_lon_lat.xls)*		NHMIS clinic locations, Ministry of Health *(HFLocationsFinal.xls from NHMIS fac.dbf)*			Average Annual
ZONECODE	SUBZONE	STATION	LAT	LON	WR_Lat	WR_Lon	NSEO_Lat	NSEO_Lon	FACID	Nhmis_Lat	Nhmis_Lon	Rain (mm)
AN	ELABERED	Elabered	38.63158	15.70998			38.63158396	15.70998204				509.4
AN	HAGAZ	Hagaz	38.27	15.71					ANHAGAZHC	38.27	15.71	243.0
AN	HALHAL	Halhal	38.28042	15.93277			38.28042388	15.93277402	ANHALHAHC	38.81	15.08	427.5
AN	KEREN	Keren	38.46*	15.78*								434.0
DE	ADI-KEIH	Adikeih	39.37371	14.84873	39.3737146	14.84873253			DEADIKEHO	39.37	14.85	366.3
DE	ADI-QUALA	Adiquala	38.8361	14.6334	38.83610363	14.63340066			DEADIQUMH	38.83	14.62	670.2
DE	AREZA	Areza	38.5623	14.93102	38.56230092	14.93101565	38.56255831	14.92959337	DEAREZAHC	38.57	14.92	397.5
DE	AREZA	Maidima	38.46531	14.89122	38.46530649	14.89121686	38.46632807	14.90384839	DEMAYDIHS	38.46	14.90	354.7
DE	DBARWA	Debarwa	38.82189	15.09827	38.82188689	15.0982657			DEDBARWHC	38.84	15.09	516.1
DE	DEKEMHARE	Dekemare	39.05202	15.06486	39.0520207	15.06485753			DEDEKEMHO	38.82	15.58	474.4
DE	MENDEFERA	Mendefera	38.7986	14.88481	38.79859888	14.88480788						586.5
DE	SEGHENEYTI	Segeneti	39.19227	15.05919	39.19226931	15.05919427			DESEGHEHC	39.19	15.05	400.1
DE	SENAFE	Senafe	39.42664	14.70612	39.42663989	14.70611612			DESENAFMH	39.42	14.70	466.0
DK	ASSAB	Assab	42.74	13.00					DKASSABHO	42.74	13.00	43.8
GB	AGORDAT	Agurdat	37.89	15.56					GBAGORDHO	37.89	15.56	340.5
GB	BARENTU	Barentu	37.59	15.11					GBBARENHO	37.59	15.11	413.3
GB	TESSENEY	Tesenie	36.66	15.11					GBTESSEHO	36.66	15.11	280.1
MA	ASMARA	Asmara	38.93*	15.20*								459.2
MA	BERIKH	Tseazega	38.79976	15.34567			38.79976337	15.34566863	MATSEAZHS	37.86	14.86	302.8
MA	GHALA NEFHI	Adihawisha	38.96735	15.23886			38.96735179	15.23885539	MAADIHAHS	38.97	15.24	344.1
SK	AFABET	Afabet	38.69	16.19					SKAFABEHO	38.69	16.19	191.1
SK	GHINDAE	Ghinda	39.09	15.44					SKGHINDHO	39.09	15.44	496.4
SK	MASSAWA	Massawa	39.45	15.61					SKMASSAHO	39.45	15.61	117.1

* from the internet

Appendix 4. HF Locations

ZONECODE	SUBZNO	SUBZNAME	FACNAME	FACID	FACTYPE	OWNER	POP2000	WR_subzone	WR_Village	WR_factype	WR_owner	WR_LAT
AN	301	ADI-TEKELEZAN	ADI-TEKELEZAN	ANADITHC	HC	MOH	32000					
AN	308	ASMAT	ASMAT	ANASMATHC	HC	MOH	17536					
AN	308	ASMAT	EROTA	ANEROTAHS	HS	MOH	11648					
AN	302	ELABERED	ELABERED	ANELABECL	CL	MOA						
AN	302	ELABERED	ELABERED	ANELABEHC	HC	MOH	9835					
AN	302	ELABERED	HADISH ADI	ANHADISHS	HS	MOH	7687					
AN	302	ELABERED	HALIBMENTEL	ANHALIBHS	HS	CCM	10837					
AN	302	ELABERED	SHEB	ANSHEBHS	HS	MOH						
AN	303	GELEB	GELEB	ANGELEBHS	HS	MOH	24095					
AN	303	GELEB	MEHLAB	ANMEHLAHS	HS	MOH	7538					
AN	307	HABERO	FILFILE	ANFILFIHS	HS	MOH	9237					
AN	307	HABERO	HABERO	ANHABERHC	HC	MOH	23622					
AN	305	HAGAZ	ASHERA	ANASHERHS	HS	CCM	3708					
AN	305	HAGAZ	BEGU	ANBEGUHS	HS	CCM	3586					
AN	305	HAGAZ	DAROTAI	ANDAROTHS	HS	MOH	2782					
AN	305	HAGAZ	GLASS	ANGLASSHS	HS	CCM	5421					
AN	305	HAGAZ	HAGAZ	ANHAGAZHC	HC	MOH	15624					
AN	305	HAGAZ	HASHISHAY	ANHASHIHS	HS	MOH	6344					
AN	305	HAGAZ	KERMED	ANKERMEHS	HS	MOH	6041					
AN	306	HALHAL	GEBEY ALEBU	ANGEBEYHS	HS	MOH	2253					
AN	306	HALHAL	HALHAL	ANHALHAHC	HC	CCM	10853					
AN	306	HALHAL	MELEBSO	ANMELEBHS	HS	MOH	14064					
AN	311	HAMELMALO	BEJUK	ANBEJUKHS	HS	MOH	12396					
AN	311	HAMELMALO	FREDAREB	ANFREDAHC	HC	CCM	6181					
AN	311	HAMELMALO	JENGEREN	ANJENGEHS	HS	MOH	3947					
AN	304	KEREN	DR.ABALLA OMER	ANABDACL	CL	PRV						
AN	304	KEREN	BLOCO KEREN	ANBLOCOHS	HS	MOH	14000					
AN	304	KEREN	DR.DANI	ANDANICL	CL	PRV						
AN	304	KEREN	ANSEBA DENTAL	ANDENTACL	CL	PRV						
AN	304	KEREN	DIHNET CL	ANDIHNCL	CL	PRV						
AN	304	KEREN	GEZA-MANDA	ANGEZAHS	HS	CCM	11000					
AN	304	KEREN	KEREN	ANKERENHO	HO	MOH	375391					
AN	304	KEREN	JOKO MCH	ANKJOKOMC	MC	MOH	14000					
AN	304	KEREN	DR.LEUL	ANLEULCL	CL	PRV						
AN	304	KEREN	MEGARIH	ANMEGARHS	HS	MOH	14000					
AN	304	KEREN	SHIFSHIFIT	ANSHIFSHS	HS	MOH	12000					
AN	309	KERKEBET	KERKEBET	ANKERKEHC	HC	MOH	25536					
AN	310	SELA	SHERIT	ANSHERIHS	HS	MOH						
DE	506	ADI-KEIH	ADI-KEIH	DEADIKEHO	HO	MOH	42337	Adi Keih	Adi Keih	HO	MOH	39.37371
DE	506	ADI-KEIH	ADI-KEIH	DEADIKEHS	HS	MOH		Adi Keih	Adi Keih	HS	MOH	39.3794
DE	506	ADI-KEIH	DR.TESFALEM	DEDRTESCL	CL	PRV		Adi Keih	Dr Tesfalem(Adi ke	HC	PRV	39.37446
DE	506	ADI-KEIH	HAWATSU	DEHAWATHS	HS	CCM		Adi Keih	Hawatsu	HS	CCM	39.35031
DE	506	ADI-KEIH	KARIBOSSA	DEKARIBHS	HS	MOH		Adi Keih	Karibossa	HS	MOH	39.42334
DE	506	ADI-KEIH	KOHAYTO	DEKOHAYHS	HS	MOH		Senafe	Kohayto	HS	MOH	39.40122
DE	506	ADI-KEIH	TEKONDAE	DETEKONHS	HS	CCM	2376	Adi Keih	Tekondae	HS	CCM	39.39388
DE	509	ADI-QUALA	ADI-JENU	DEADIJEHS	HS	CCM	8735	Adi Quala	Adi Jenu	HS	CCM	38.8862
DE	509	ADI-QUALA	ADI-QUALA	DEADIQUMH	MH	MOH	73387	Adi Quala	Adi Quala	MH	MOH	38.8361
DE	509	ADI-QUALA	AGRA IDP	DEAGRAHS	HS	MOH						
DE	509	ADI-QUALA	ENDAGHERGIS	DEENDACHS	HS	CCM	27295	Adi Quala	Enda Ghergis	HS	CCM	38.7558
DE	509	ADI-QUALA	ENDAGHERGIS	DEENDAGHS	HS	MOH	27295	Adi Quala	Enda Ghergis	HS	MOH	38.75362
DE	509	ADI-QUALA	SHEKA-IYAMO	DESHEKAHS	HS	MOH	10613	Adi Quala	Sheka Iyamo	HS	MOH	38.8419
DE	502	AREZA	ADI-GULTI	DEADIGLHS	HS	MOH	7500	Areza	Adi Gulti	HS	MOH	38.58781
DE	502	AREZA	ADI-GUROTO	DEADIGUHS	HS	MOH	10000	Areza	Adi Guroto	HS	MOH	38.66971
DE	502	AREZA	AREZA	DEAREZAHC	HC	MOH	79052	Areza	Areza	HC	MOH	38.5623

DE	502	AREZA	MAY-DIMA OPHTHALMIC	DEMAYDIHC	HC	NGO		Areza	Mai Dima Opthalmic	HC	NGO	38.46533
DE	502	AREZA	MAY-DIMA	DEMAYDIHS	HS	MOH	18636	Areza	Mai Dima	HS	MOH	38.46531
DE	502	AREZA	UBEL	DEUBELHS	HS	MOH	6500	Areza	Ubel	HS	MOH	38.45891
DE	502	AREZA	ZEBANDEBRI	DEZEBANHS	HS	MOH	8769	Areza	Zebandebri	HS	MOH	38.53131
DE	501	DBARWA	ADI-BEZAHANIS	DEADIBEHS	HS	EVM	12139	Dbarwa	Adi Bezahans	HS	EVM	38.75718
DE	501	DBARWA	ADI-FELESTI	DEADIFEHS	HS	MOH	8945	Dbarwa	Adi Felesti	HS	MOH	38.69961
DE	501	DBARWA	ADI-GEBRAY	DEADIGEHS	HS	MOH	4220	Dbarwa	Adi Ghebray	HS	MOH	38.7404
DE	501	DBARWA	DBARWA	DEDBARWHC	HC	MOH	73600	Dbarwa	Dbarwa	HC	MOH	38.82189
DE	501	DBARWA	GERTETE	DEGERTEHS	HS	MOH	8935	Dbarwa	Gertete	HS	MOH	38.7333
DE	501	DBARWA	SHIKETI	DESHIKEHS	HS	MOH	8124	Dbarwa	Shiketi	HS	MOH	38.8636
DE	501	DBARWA	TERA EMNI	DETERAEHS	HS	MOH	7827	Dbarwa	Tera Emni	HS	MOH	38.8229
DE	504	DEKEMHARE	ALLA	DEALLAHS	HS	MOH	3435					
DE	504	DEKEMHARE	DEKEMHARE HS1	DEDAKEMHS	HS	MOH						
DE	504	DEKEMHARE	DEKEMHARE HS1	DEDAKMHS	HS	MOH						
DE	504	DEKEMHARE	DEKEMHARE	DEDEKEMHO	HO	MOH	57804	Dekemhare	Dekemhare	HO	MOH	39.05202
DE	504	DEKEMHARE	DEKEMHARE	DEDEKEMHS	HS	CCM		Dekemhare	Dekemhare	HS	CCM	39.05109
DE	504	DEKEMHARE	DR MULUGETA	DEDRMULCL	CL	PRV		Dekemhare	Dr Mulgeta	HC	PRV	39.05295
DE	504	DEKEMHARE	FEKEIH	DEFEKEIHS	HS	MOH	2710	Dekemhare	Fekeih	HS	MOH	38.9127
DE	504	DEKEMHARE	MAY-EDAGA	DEMAYEDHS	HS	MOH	8361	Dekemhare	Mai Edaga	HS	MOH	39.04563
DE	510	KUDO-BOUER	ANAGER	DEANAGEHS	HS	MOH	3450	Dekemhare	Anager	HS	MOH	38.74172
DE	510	KUDO-BOUER	KUDO-BOUER	DEKUDOBHC	HC	MOH	44537	Emni haili	Kudo Bouer	HC	MOH	38.74336
DE	510	KUDO-BOUER	MAYSAGLA IDP	DEMAYSAHS	HS	MOH		Emni haili	Mai Sagla IDP	HS	MOH	38.91854
DE	512	MAY-AYNEE	GENSEBA	DEGENSEHS	HS	MOH	10000	Mai Aynee	Genseba	HS	MOH	39.08244
DE	512	MAY-AYNEE	KINAFNA	DEKINAFHS	HS	MOH	6427	Mai Aynee	Kinafna	HS	MOH	39.01405
DE	512	MAY-AYNEE	OBALE IDP	DEOBALEHS	HS	MOH		Mai Aynee	Obale IDP?	HS	MOH	39.13122
DE	512	MAY-AYNEE	QUATIT	DEQUATIHC	HC	MOH	33239	Mai Aynee	Quatit	HC	MOH	39.22026
DE	512	MAY-AYNEE	UNAWATOT IDP	DEUNAWAHS	HS	MOH		Mai Aynee	Unawatot IDP	HS	MOH	39.06058
DE	511	MAY-MINE	DABRE	DEDABREHS	HS	MOH	6653	Mai Mine	Dabre	HS	MOH	38.55999
DE	511	MAY-MINE	MAY-MINE	DEMAYMIHC	HC	MOH	41761	Mai Mine	Mai Mine	HC	MOH	38.4975
DE	511	MAY-MINE	MAY-MINE	DEMAYMIMC	MC	CCM		Mai Mine	Mai Mine	MC	CCM	38.4875
DE	503	MENDEFERA	ADI-UGRI	DEAIDUGHO	HO	MOH	49000	Mendefera	Adi Ugri	HO	MOH	38.7986
DE	503	MENDEFERA	BERHAN	DEBERHACL	CL	PRV		Mendefera	Berhan	HC	PRV	38.8142
DE	503	MENDEFERA	KUDO-FELASI	DEKUDOFHS	HS	MOH	6850	Mendefera	Kudo Felasi	HS	MOH	38.84617
DE	503	MENDEFERA	MENDEFERA	DEMENDEHS	HS	CCM	25000	Mendefera	Mendefera	HS	CCM	38.8183
DE	505	SEGHENEYTI	AKRUR	DEAKRURHS	HS	MOH	3229	Segeneyti	Akrur	HS	MOH	39.23674
DE	505	SEGHENEYTI	DEREA	DEDEREAHS	HS	MOH	4856	Segeneyti	Derea	HS	MOH	39.33426
DE	505	SEGHENEYTI	DIGSA	DEDIGSAHC	HC	CCM	8000	Segeneyti	Digsa	HC	CCM	39.221
DE	505	SEGHENEYTI	HADIDA	DEHADIDHS	HS	MOH	5183	Segeneyti	Hadida	HS	MOH	39.14733
DE	505	SEGHENEYTI	HEBO	DEHEBOHS	HS	CCM	3927	Segeneyti	Hebo	HS	CCM	39.26039
DE	505	SEGHENEYTI	INGELA	DEINGELHC	HC	CCM	20000	Segeneyti	Ingela	HC	CCM	39.13101
DE	505	SEGHENEYTI	SEGHENEYTI	DESEGHEHC	HC	MOH	40202	Segeneyti	Segheneyti	HC	MOH	39.19227
DE	507	SENAFE	FORTO	DEFORTOHS	HS	MOH	15775	Senafe	Forto	HS	MOH	39.39512
DE	507	SENAFE	HARENA IDP	DEHARENHS	HS	MOH						
DE	507	SENAFE	MESEREHA	DEMESERHS	HS	CCM	8031	Senafe	Mesereha	HS	CCM	39.47307
DE	507	SENAFE	MONOKSOYTO	DEMONOKHS	HS	CCM	8743	Senafe	Monoksoyto	HS	CCM	39.48709
DE	507	SENAFE	SENAFE	DESENAFHS	HS	CCM		Senafe	Senafe Hs	HS	CCM	39.42573
DE	507	SENAFE	SENAFE	DESENAFMH	MH	MOH	80000	Senafe	Senafe	MH	MOH	39.42664
DE	507	SENAFE	SERHA	DESERHAHS	HS	MOH						
DE	508	TSORENA	DEKILEFAY	DEDEKILHS	HS	NGO		Tserona	Dekilefay	HS	NGO	39.3034
DE	508	TSORENA	ENDABA-STIFANOS	DEENDABHS	HS	MOH		Mai Aynee	Endaba Estifanos	HS	MOH	39.09406
DE	508	TSORENA	GHENZEBO	DEGHENZHS	HS	MOH		Tserona	Ghenzebo	HS	MOH	39.26591
DE	508	TSORENA	ONA-ANDOM	DEONAANHS	HS	MOH	37307					
DE	508	TSORENA	TSORENA	DETSOREHC	HC	MOH	31771	Tserona	Tserona	HC	MOH	39.2016
DK	101	ARETA	AYTUS	DKAYTUSHS	HS	MOH						
DK	101	ARETA	AYUMEN	DKAYUMEHS	HS	MOH	3450					

DK	101 ARETA	EGROLI	DKEGROLHS	HS	MOH	3429
DK	101 ARETA	TIO	DKTIOMH	MH	MOH	8562
DK	104 ASSAB	ASSAB PORT	DKASSABHC	HC	IND	
DK	104 ASSAB	ASSAB	DKASSABHO	HO	MOH	
DK	104 ASSAB	ASSAB-KEBIR	DKASSABHS	HS	MOH	
DK	104 ASSAB	BAHTI-MESKEREM	DKBAHTIHS	HS	MOH	5498
DK	104 ASSAB	DR.GHIRMAI	DKDRGHCL	CL	PRV	
DK	104 ASSAB	DR.TEKLE T/	DKDRTCL	CL	PRV	
DK	104 ASSAB	HARSILE	DKHARHS	HS	NGO	
DK	104 ASSAB	PRISON	DKPRIHS	HS	PRV	
DK	104 ASSAB	REFINERY	DKREFINHC	HC	IND	
DK	104 ASSAB	SALINA	DKYALINCL	CL	IND	
DK	103 DEBUB-DENKALIA	ABO	DKABOHS	HS	CCM	2101
DK	103 DEBUB-DENKALIA	BERASOLE	DKBERASHS	HS	MOH	
DK	103 DEBUB-DENKALIA	BEYLUL	DKBEYLUHS	HS	MOH	1826
DK	103 DEBUB-DENKALIA	HARENA	DKHAREHS	HS	IND	
DK	103 DEBUB-DENKALIA	RAHAITA	DKRAHAIHS	HS	MOH	1826
DK	103 DEBUB-DENKALIA	WADE	DKWADEHS	HS	MOH	7245
DK	102 MAKELAY KEYHI BAHRI	AFAMBO	DKAFAMBHS	HS	MOH	4945
DK	102 MAKELAY KEYHI BAHRI	BEL-EBUY	DKBELEBHS	HS	MOH	3230
DK	102 MAKELAY KEYHI BAHRI	EDI	DKEDIHS	HS	MOH	
GB	401 AGORDAT	AGORDAT	GBAGORDHO	HO	MOH	33113
GB	401 AGORDAT	AGORDAT	GBAGORDMC	MC	MOH	33113
GB	401 AGORDAT	ENGERNE	GBENGERHS	HS	CCM	4236
GB	401 AGORDAT	HAMED	GBHAMEDCL	CL	PRV	
GB	401 AGORDAT	TESFAY	GBTESFACL	CL	PRV	
GB	402 BARENTU	BARENTU	GBBARENHO	HO	MOH	27117
GB	402 BARENTU	FITSUM	GBFITSUCL	CL	PRV	
GB	403 DIGHE	ADI-IBRAHIM	GBADIIBHS	HS	MOH	3081
GB	403 DIGHE	DIGHE	GBDIGHEHS	HS	MOH	8288
GB	403 DIGHE	KATRENAY	GBKATREHS	HS	MOH	4681
GB	403 DIGHE	KERU	GBKERUHS	HS	MOH	6727
GB	403 DIGHE	SHATERA	GBSHATEHC	HC	MOH	29994
GB	403 DIGHE	TEKRERET	GBTEKREHS	HS	MOH	3160
GB	404 FORTO	FORTO	GBFORTOHC	HC	MOH	10373
GB	404 FORTO	GHIRMAYKA	GBGHIRMHS	HC	MOH	8050
GB	404 FORTO	MOLOVER	GBMOLOVHS	HS	MOH	4213
GB	404 FORTO	SAWA	GBSAWAHS	HS	MOH	5170
GB	405 GOGNE	DASSIE	GBDASSIHS	HS	MOH	6946
GB	405 GOGNE	GOGNE	GBGOGNEHS	HS	MOH	17821
GB	405 GOGNE	KULUKU	GBKULUKHS	HS	CCM	1982
GB	405 GOGNE	TAKAWDA	GBTAKAWHS	HS	MOH	
GB	410 GULUJ	ADI-SHEGALA	GBADISHHS	HS	MOH	
GB	410 GULUJ	GERGEF	GBGERGFHS	HS	MOH	5669
GB	410 GULUJ	GERSET	GBGERSHS	HS	MOH	
GB	410 GULUJ	GULUJ	GBGULUJHC	HC	MOH	16379
GB	410 GULUJ	OMHAJER	GBOMHAJHS	HS	MOH	6230
GB	410 GULUJ	SABUNAIT	GBSABUNHS	HS	MOH	
GB	410 GULUJ	SANDASHINA	GBSANDAHS	HS	MOH	4036
GB	410 GULUJ	TEBELDIA	GBTEBELHS	HS	MOH	6561
GB	406 HAYCOTA	ALEBU	GBALEBUHS	HS	MOH	14500
GB	406 HAYCOTA	HAYCOTA	GBHAYCOHC	HC	MOH	23376
GB	414 LAELAY GASH	ADI-KESHI	GBADI-KHS	HS	MOH	
GB	414 LAELAY GASH	ANTORE	GBANTORHS	HS	MOH	7250
GB	414 LAELAY GASH	AUGARO	GBAUGARHS	HS	MOH	13246

GB	414 LAELAY GASH	BUKO	GBBUKOCL	CL	NGO	
GB	414 LAELAY GASH	DERSENEY	GBDERSECL	CL	MOB	
GB	414 LAELAY GASH	HADISH-ADI	GBHADISCL	CL	MOB	
GB	414 LAELAY GASH	MAI-SHIGLY	GBMAI-SHS	HS	MOH	
GB	414 LAELAY GASH	MEFLECH	GBMEFLECL	CL	NGO	
GB	414 LAELAY GASH	SHILALO	GBSHILAHS	HS	MOH	
GB	414 LAELAY GASH	TOKOMBIA	GBTOKOMHC	HC	MOH	
GB	407 LOGO ANSEBA	ADI-NIAMIN	GBADINIHS	HS	MOH	
GB	407 LOGO ANSEBA	KERENAKUDO	GBKERENHS	HS	MOH	7000
GB	407 LOGO ANSEBA	MEKERKA	GBMEKERHC	HC	MOH	11060
GB	407 LOGO ANSEBA	MELEZANAY	GBMELEZHS	HS	MOH	3000
GB	408 MENSURA	ADERDE	GBADERCHS	HS	EVM	4230
GB	408 MENSURA	DULUK	GBDULUKHS	HS	MOH	4533
GB	408 MENSURA	GERGER	GBGERGRHS	HS	MOH	5887
GB	408 MENSURA	HIRKUK	GBHIRKUHS	HS	MOH	5082
GB	408 MENSURA	MENSURA	GBMENSUHC	HC	MOH	13831
GB	408 MENSURA	MIGRAH	GBMIGRAHS	HS	MOH	4774
GB	408 MENSURA	SHELAB	GBSHELBHS	HS	MOH	
GB	409 MOGOLO	AREDA	GBAREDAHS	HS	MOH	5101
GB	409 MOGOLO	DERET	GBDERETHS	HS	MOH	4028
GB	409 MOGOLO	MOGOLO	GBMOGOLHC	HC	CCM	8031
GB	409 MOGOLO	TOMBITA	GBTOMBIHS	HS	MOH	1819
GB	412 MULKI	DERABUSH	GBDERABHS	HS	MOH	7069
GB	412 MULKI	ENDA-GABR	GBENDAGHS	HS	MOH	
GB	412 MULKI	MULKI	GBMULKIHC	HC	MOH	14205
GB	411 SHAMBUKO	AKLELET	GBAKLELCL	CL	MOB	
GB	411 SHAMBUKO	BINBINA	GBBINBIHS	HS	CCM	3578
GB	411 SHAMBUKO	BUKA	GBBUKACL	CL	MOB	
GB	411 SHAMBUKO	BUSHUKA	GBBUSHUCL	CL	MOB	
GB	411 SHAMBUKO	DEDA	GBDEDAHS	HS	MOH	
GB	411 SHAMBUKO	KERCASHA	GBKERCAHS	HS	MOH	3124
GB	411 SHAMBUKO	KOROKON	GBKOROKCL	CL	MOB	
GB	411 SHAMBUKO	KOROKON	GBKOROKHS	HS	MOH	
GB	411 SHAMBUKO	KOTOBIA	GBKOTOBHS	HS	MOH	2230
GB	411 SHAMBUKO	SHAMBUKO	GBSHAMBHC	HC	MOH	5568
GB	411 SHAMBUKO	UGUMA	GBUGUMACL	CL	MOB	
GB	413 TESSENEY	ALIGHIDIR	GBALIGHHC	CL	MOA	3356
GB	413 TESSENEY	FANKO	GBFANKOHS	HS	MOH	11000
GB	413 TESSENEY	TALATA ASHER	GBTALATHS	HS	MOH	5479
GB	413 TESSENEY	TESSENEY	GBTESSEHO	HO	MOH	43409
GB	413 TESSENEY	TESSENEY	GBTESSEMC	MC	MOH	43409
MA	602 BERIKH	HAZEGA	MAHAZEGHS	HS	CCM	
MA	602 BERIKH	TSADA CHRISTEAN	MATSADAHC	HC	MOH	
MA	602 BERIKH	TSEAZEGA	MATSEAZHS	HS	MOH	
MA	603 GHALA NEFHI	ADI-HAUSHA	MAADIHAHS	HS	MOH	
MA	603 GHALA NEFHI	GULIE	MAGULIHS	HS	MOH	
MA	603 GHALA NEFHI	HIMBERTI	MAHIMBEHS	HS	MOH	
MA	603 GHALA NEFHI	KETEMWWULIE	MAKETEMHS	HS	MOH	
MA	603 GHALA NEFHI	MERHANO	MAMERHHC	HC	MOH	
MA	605 NORTH EAST ASMARA	ACRIA	MAACRIAHC	HC	MOH	
MA	605 NORTH EAST ASMARA	ARBATE-ASMARA	MAARBATHS	HS	MOH	
MA	605 NORTH EAST ASMARA	DR. ABDU M/TAHA	MADRABDCL	CL	PRV	
MA	605 NORTH EAST ASMARA	DR. EFREM ZEWELDI	MADREFRCL	CL	PRV	
MA	605 NORTH EAST ASMARA	DR.SURUR ALIABDU	MADRSURCL	CL	PRV	
MA	605 NORTH EAST ASMARA	DR. TESFAI W/GERGISH	MADRTESCL	CL	PRV	

MA	605	NORTH EAST ASMARA	DR.YIFEDEAMALK T/MARIAM	MADRYIFCL	CL	PRV
MA	605	NORTH EAST ASMARA	EDAGA CLINIC	MAEDAGACL	CL	MOH
MA	605	NORTH EAST ASMARA	EDAGA HAMUS	MAEDAGAMH	MH	MOH
MA	605	NORTH EAST ASMARA	ERITREA ELECTRIC AUTH.	MAERELECL	CL	IND
MA	605	NORTH EAST ASMARA	SABA	MASABAHS	HS	MOH
MA	605	NORTH EAST ASMARA	WAKA	MAWAKACL	CL	PRV
MA	605	NORTH EAST ASMARA	ZEMENAWI CLINIC	MAZEMENCL	CL	PRV
MA	606	NORTH WEST ASMARA	AFRICA MATCH FACTORY	MAAFRICL	CL	IND
MA	606	NORTH WEST ASMARA	ASMARA PICKLING TANNERY	MAASPICCL	CL	IND
MA	606	NORTH WEST ASMARA	COCA-COLA SOFT DRINK	MACOCACCL	CL	IND
MA	606	NORTH WEST ASMARA	ERITREAN KOREAN GARMENT	MAERKOGCL	CL	IND
MA	606	NORTH WEST ASMARA	HAZHAZ HOSP	MAHAZHAHO	HO	MOH
MA	606	NORTH WEST ASMARA	HAZHAZ	MAHAZHAHS	HS	MOH
MA	606	NORTH WEST ASMARA	MAI-TEMENAI	MAMAITEHS	HS	MOH
MA	606	NORTH WEST ASMARA	RED SEA LEATHER TANNERY	MAREDSLCL	CL	IND
MA	606	NORTH WEST ASMARA	REHABILITATION CENTER	MAREHABCL	CL	IND
MA	606	NORTH WEST ASMARA	SEMENAWI ASMARA	MASEMENHC	HC	MOH
MA	601	SEREJEKA	ADI-SHEKA	MAADISHHS	HS	MOH
MA	601	SEREJEKA	AZIEN	MAAZIENHS	HS	MOH
MA	601	SEREJEKA	BELEZA	MABELEZHS	HS	MOH
MA	601	SEREJEKA	EMBADERHO	MAEMBADHS	HS	MOH
MA	601	SEREJEKA	GESHNASHIM	MAGESHNHS	HS	MOH
MA	601	SEREJEKA	SEREJEKA	MASEREJHC	HC	MOH
MA	601	SEREJEKA	WEKI	MAWEKIHS	HS	MOH
MA	601	SEREJEKA	ZAGIR	MAZAGDEHS	HS	CCM
MA	604	SOUTH EAST ASMARA	ADDIS-ALEM	MAADDISHC	HC	MOH
MA	604	SOUTH EAST ASMARA	ASMARA BEER FACTORY	MAASBEFCL	CL	IND
MA	604	SOUTH EAST ASMARA	ASMARA TEXTILE FACTORY	MAASTEFCL	CL	IND
MA	604	SOUTH EAST ASMARA	BRITISH AMERICAN TOBACCO	MABRAMTCL	CL	IND
MA	604	SOUTH EAST ASMARA	ASMARA CERAMICS FACTORY	MACERACL	CL	IND
MA	604	SOUTH EAST ASMARA	DR. MUSSIE G/MICAEL	MADRMUSCL	CL	PRV
MA	604	SOUTH EAST ASMARA	DR. T/HAIMANOT TSEGAI	MADRTHACL	CL	PRV
MA	606	SOUTH EAST ASMARA	DURFO	MADURFHS	HS	MOH
MA	604	SOUTH EAST ASMARA	FAMILY REPRODUCTIVE	MAFAMICL	CL	PRV
MA	604	SOUTH EAST ASMARA	FAMILY REPRODUCTIVE	MAFAMILCL	CL	PRV
MA	604	SOUTH EAST ASMARA	LALAMBA SACK FACTORY	MALALAMCL	CL	IND
MA	604	SOUTH EAST ASMARA	LASALE	MALASAHS	HS	MOH
MA	604	SOUTH EAST ASMARA	METAL WORKS FACTORY	MAMETALCL	CL	IND
MA	604	SOUTH EAST ASMARA	RED SEA FOOD PRODUCTION	MAREDSFCL	CL	IND
MA	604	SOUTH EAST ASMARA	SELAM CLINIC	MASELAMCL	CL	PRV
MA	604	SOUTH EAST ASMARA	ST. ANTONIO	MASTANTHS	HS	CCM
MA	604	SOUTH EAST ASMARA	TELE-CLINIC	MATELECCL	CL	IND
MA	203	SOUTH WEST ASMARA	DAHLAK SHARE COMPNAY	MADAHLACL	CL	IND
MA	607	SOUTH WEST ASMARA	DENDEN	MADENDEHS	HS	MOH
MA	607	SOUTH WEST ASMARA	FELEGE HIWET	MAFELEGHS	HS	MOH
MA	607	SOUTH WEST ASMARA	FRE-SELAM	MAFRESEHS	HS	MOH
MA	607	SOUTH WEST ASMARA	GERITERIC CLINIC	MAGERITCL	CL	PRV
MA	607	SOUTH WEST ASMARA	GODAAIF	MAGODAHC	HC	MOH
MA	607	SOUTH WEST ASMARA	GODAIF	MAGODAIHS	HS	MOH
MA	607	SOUTH WEST ASMARA	SABUR P. SERVICE	MASABURCL	CL	IND
MA	607	SOUTH WEST ASMARA	SEMBEL	MASEMBECL	CL	PRV
MA	607	SOUTH WEST ASMARA	SEMBEL	MASEMBEHS	HS	MOH
MA	607	SOUTH WEST ASMARA	SOAPRAL FACTORY	MASOAPRCL	CL	IND
MA	607	SOUTH WEST ASMARA	VILLAJO	MAVILLAHS	HS	MOH
NR	701	NATIONAL REFERRAL	BERHAN AYNE OPHTHALMIC	NRBERHAHO	HO	MOH

NR	701	NATIONAL REFERRAL	HALIBET	NRHALIBHO	HO	MOH	
NR	701	NATIONAL REFERRAL	HANSSENIAN	NRHANSSHO	HO	NGO	
NR	701	NATIONAL REFERRAL	HAZHAZ	NRHAZHAHO	HO	MOH	
NR	701	NATIONAL REFERRAL	MEKANE HIWET OBS_GYN	NRMEHIOHO	HO	MOH	
NR	701	NATIONAL REFERRAL	MEKANE HIWET PEDIATRIC	NRMEKANHO	HO	MOH	
NR	701	NATIONAL REFERRAL	ST. MARY	NRSTMARHO	HO	MOH	
SK	210	ADOBHA	HIMBOL	SKHIMBOHC	HC	MOH	15610
SK	207	AFABET	AFABET	SKAFABEHO	HO	MOH	72640
SK	207	AFABET	AFABET	SKAFABEMC	MC	MOH	
SK	207	AFABET	FELKET	SKFELKEHS	HS	MOH	20436
SK	207	AFABET	KAMCHEWA	SKKAMCHHC	HC	MOH	19985
SK	203	DAHLAK	DAHLAK	SKDAHLAHC	HC	MOH	
SK	203	DAHLAK	DEHILE	SKDEHILHS	HS	MOH	
SK	203	DAHLAK	DERBUSHET	SKDERBUHS	HS	MOH	
SK	202	FORO	FORO	SKFOROHC	HC	MOH	11800
SK	202	FORO	IRAFAYLE	SKIRAFAHC	HC	MOH	5700
SK	202	FORO	ROBROBIA	SKROBROHS	HS	MOH	
SK	202	FORO	SILIKE	SKSILIKHS	HS	MOH	
SK	201	GHELAELO	BADA	SKBADAHC	HC	MOH	6000
SK	201	GHELAELO	BUYA	SKBUYAHS	HS	MOH	
SK	201	GHELAELO	GHELAELO	SKGHELAHC	HC	MOH	
SK	201	GHELAELO	INGEL	SKINGELHS	HS	MOH	3754
SK	201	GHELAELO	MENKALELE	SKMENKAHS	HS	MOH	
SK	206	GHINDAE	DANKUR	SKDANKUHS	HS	MOH	
SK	205	GHINDAE	DEMAS	SKDEMASHS	HS	MOH	
SK	205	GHINDAE	EMBATKALA	SKEMBATHS	HS	MOH	800
SK	205	GHINDAE	GAHTELAY	SKGAHTEHS	HS	MOH	3071
SK	205	GHINDAE	GHINDAE	SKGHINDHC	HC	IND	
SK	205	GHINDAE	GHINDAE	SKGHINDHO	HO	MOH	18815
SK	205	GHINDAE	GHINDAE	SKGHINDHS	HS	CCM	2000
SK	205	GHINDAE	MAYHABAR	SKMAYHAHS	HS	MOH	2500
SK	205	GHINDAE	NEFASIT	SKNEFASHC	HC	MOH	8000
SK	205	GHINDAE	SHEBAH	SKSHEBAHS	HS	MOH	5286
SK	205	GHINDAE	TESFA CLINIC	SKTESFACL	CL	PRV	
SK	209	KARORA	KARORA	SKKARORHS	HS	MOH	
SK	209	KARORA	MAHMIMET	SKMAHMIHC	HC	MOH	26000
SK	204	MASSAWA	AMATERE MCH	SKAMATEMC	MC	MOH	72640
SK	204	MASSAWA	CEMENT FACTORY	SKCEMENHS	HS	IND	
SK	204	MASSAWA	DR.IBRAHIM	SKDRIBRCL	CL	PRV	
SK	204	MASSAWA	DR.JEMAL	SKDRJEMCL	CL	PRV	
SK	204	MASSAWA	DR.MAHMUD	SKDRMAHCL	CL	PRV	
SK	204	MASSAWA	DR.SOLOMON	SKDRSOLCL	CL	PRV	
SK	204	MASSAWA	Dr. YOHANNESS TEKESTE	SKDRYOHCL	CL	PRV	
SK	204	MASSAWA	ENKULU	SKENKULCL	CL	NGO	
SK	204	MASSAWA	HIRGIGO	SKHIRGIHS	HS	MOH	2000
SK	204	MASSAWA	KUTMIA	SKKUTMIHS	HS	MOH	
SK	204	MASSAWA	MASSAWA	SKMASSAHO	HO	MOH	24940
SK	204	MASSAWA	MASSAWA PORT	SKMASSAHS	HS	IND	
SK	204	MASSAWA	SALINA	SKSALINCL	CL	IND	
SK	204	MASSAWA	TIWALET	SKTIWALHS	HS	MOH	3068
SK	206	MASSAWA	WEKIRO	SKWEKIRHS	HS	MOH	5427
SK	209	NAKFA	AGRAIE	SKAGRAIHS	HS	MOH	
SK	208	NAKFA	BACKLA	SKBACKLA	HS	MOH	0
SK	208	NAKFA	BACKLA	SKBACKLHS	HS	MOH	
SK	208	NAKFA	NAKFA	SKNAKFAHO	HO	MOH	43941

FacSZNO	FacVILLNAME	NhmisLat	NhmisLon	NseoSZNM	kebabi	adi	NSEOlat	NSEOlong	LAT_FIN	LON_FIN
301	Adi Tekelezan	38.78	15.6	ADI-TEKELEZAN	Adi Tekeliezan	Adi Tekeliezan	38.78735719	15.57047489	38.78735719	15.57047489
308	Asmat	38.59	15.68	ASMAT	Asneda	Asneda	38.05104748	16.24151846	38.05104748	16.24151846
308	Erota	37.98	16.15	ASMAT	Erota	Erota	37.95838658	16.16885311	37.95838658	16.16885311
302	Elabered	0	0							
302	Elabered	0	0	ELABERED	Eden	Eden	38.63158396	15.70998204	38.63158396	15.70998204
302	Hadish Adi	39.63	15.21	ELABERED	Hadsh Adi	Hadsh Adi	38.62302586	15.64881743	38.62302586	15.64881743
302	Halibmentel	39.08	14.97	ELABERED	Halib Mentel	Halib Mentel	38.54525124	15.74479667	38.54525124	15.74479667
302	Sheb	38.67	15.74	ELABERED	Shieb Seleba	Shieb Seleba	38.67007007	15.74680227	38.67007007	15.74680227
303	Geleb	38.78	15.83	GELEB	Geleb	Geleb	38.76176445	15.8355731	38.76176445	15.8355731
303	Mihilab	38.75	15.75	GELEB	Mhlab	Mhlab	38.75483956	15.74638974	38.75483956	15.74638974
307	Filfle	38.4	16.03	HABERO	Flfle	Flfle	38.39234165	16.02274991	38.39234165	16.02274991
307	Haboro	0	0	HABERO	Aretay	Aretay	38.31473749	16.1767438	38.31473749	16.1767438
305	Ashera	0	0							
305	Begu	0	0	HAGAZ	Beghu	Gh'ab	38.44580515	15.7298038	38.44580515	15.7298038
305	Darotai	0	0							
305	Glass	0	0	HAGAZ	Ghlass	Ghlass	38.31655872	15.72254871	38.31655872	15.72254871
305	Hagaz	38.27	15.71						38.27	15.71
305	Hashishay	0	0	HAGAZ	Hashishay	Hashishay	38.15022867	15.78459205	38.15022867	15.78459205
305	Kermed	38.49	15.59						38.49	15.59
306	Gebey Alebu	0	0	HALHAL	Gebey Alebu	Gebey A lebu	38.21658996	15.94354396	38.21658996	15.94354396
306	Halhal	38.81	15.08	HALHAL	Halhal	Halhal	38.28042388	15.93277402	38.28042388	15.93277402
306	Melebso	0	0	HALHAL	Melebso	Twareba/Melebso	38.21557028	16.01342622	38.21557028	16.01342622
311	Beguk	38.2	16.01						38.2	16.01
311	Fredarb	38.53	15.83	HAMELMALO	Fredareb	Fredareb	38.5375046	15.82668584	38.5375046	15.82668584
311	Jengerien	0	0							
304	DR.ABALLA OMER	0	0							
304	Bloco Keren	0	0							
304	DR.DANI	0	0							
304	ANSEBA DENTAL	0	0							
304	DIHNET CL	0	0							
304	Geza Manda	0	0							
304	Keren	0	0							
304	Joko MCH	0	0							
304	DR.LEUL	0	0							
304	Megarh	38.45	15.32						38.45	15.32
304	Shifshifit	0	0							
309	Kerkebet	0	0							
310	Sherit	0	0							
506	Adi-Keih	39.37	14.85						39.3737146	14.84873253
506	Adi-Keih	39.33	14.9						39.37939822	14.83529631
506	Dr.Tesfalem	0	0						39.37445744	14.84829732
506	Hawazu	39.35	14.9	ADI-KEIH	Mendefera	Hawatsu	39.35180222	14.90053823	39.35180222	14.90053823
									39.42333775	14.91912588
506	Kohayto	0	0						39.40122331	14.89179674
506	Tekondae	39.38	14.82						39.3938804	14.81051581
509	Adi Jenu	38.88	14.67	ADI-KEIH	Adi-Bahro	Adi-Johni	38.88585362	14.67381411	38.88585362	14.67381411
509	Adi-Quala	38.83	14.62						38.83610363	14.63340066
509	Enda Gergis	38.75	14.56						38.75580477	14.56119335
				ADI-KEIH	Enda Gherghs	Endaghherghs	38.75678699	14.55985578	38.75678699	14.55985578
509	Sheka-iyamo	0	0						38.84190063	14.72030699
502	Adi Gulti	38.59	15	AREZA	Adi Gulti	Adi Gulti	38.58416943	14.99631143	38.58416943	14.99631143
502	Adi Goroto	38.68	14.92	AREZA	Adigrato	Adigrato	38.68198663	14.91141895	38.68198663	14.91141895
502	Areza	38.57	14.92	AREZA	Areza	Areza	38.56255831	14.92959337	38.56255831	14.92959337

502	Maidima Ophthal	0	0						38.46532504	14.88369438
502	Mai Dima	38.46	14.9	AREZA	May Duma	May Duma	38.46632807	14.90384839	38.46632807	14.90384839
502	Ubel	0	0	AREZA	Geza Dungur(Obel)	Obel(Aleda)	38.45538656	14.67230879	38.45538656	14.67230879
502	Zibandebri	38.65	15.41	AREZA	Zbandebri	Zbandebri	38.53138568	14.75472218	38.53138568	14.75472218
501	Adi Bezhans	38.77	15.06	DBARWA	Adi Bezahans	Adi Bezahans	38.7593187	15.05895671	38.7593187	15.05895671
501	Adi Felesti	38.7	15.13	DBARWA	Adi Felesti	Adi Felesti	38.69453647	15.13533883	38.69453647	15.13533883
501	Adi Gebray	38.74	15.21	DBARWA	Adi Gebray	Adi Gebray	38.74039426	15.21162998	38.74039426	15.21162998
501	Dbwarwa	38.84	15.09						38.82188689	15.0982657
501	Geretete	38.91	15.02	DBARWA	Gert eti	Gert eti	38.73325895	15.01308912	38.73325895	15.01308912
501	Shiketi	38.86	15.15	DBARWA	Shketi	Shketi	38.8633688	15.14415636	38.8633688	15.14415636
501	Teramni	38.83	15.01	DBARWA	Tera Imni	Tera Imni	38.82325555	15.01556369	38.82325555	15.01556369
504	Alla	0	0	DEKEMHARE	Ghaden	Ala	39.09734063	15.16055918	39.09734063	15.16055918
504	Dekemhare HS1	0	0							
504	Dekemhare	38.82	15.58						39.0520207	15.06485753
504	Dekemhare	38.82	15.58						39.05109027	15.06487582
504	Dr. Mulugeta	0	0						39.05295092	15.06397123
504	Fekeih	39.07	14.85	DEKEMHARE	Harien	Einfoqeyh	38.91279707	15.02222474	38.91279707	15.02222474
504	May Edaga	38.97	14.98	DEKEMHARE	Maiedaga	Maiedaga	39.04406961	14.99147896	39.04406961	14.99147896
510	Anagr	0	0						38.74171955	14.85619699
510	Kudo Abur	38.74	14.72	KUDO-BOUER	Kudo Abu ur	Adi Chalqui	38.73712447	14.72472299	38.73712447	14.72472299
									38.91853536	14.70668421
512	GENSEBA	0	0	MAY-AYNEE	Geneseba	MaEkheno	39.08022207	14.83631154	39.08022207	14.83631154
512	Kinafna	38.02	14.79	MAY-AYNEE	Qinafna	Qinafna	39.0186872	14.78578347	39.0186872	14.78578347
									39.13122281	14.85643129
512	QUATIT	0	0	MAY-AYNEE	QaAtit	QaAtit	39.22041971	14.80641976	39.22041971	14.80641976
									39.06058415	14.67734035
511	Dabre	38.56	14.59						38.5599887	14.59218275
511	Mai Mine	38.5	14.56	MAY-MINE	Maimne	Maimne	38.49826749	14.55307922	38.49826749	14.55307922
511	Mai Mine	38.5	14.56						38.48750075	14.54359818
									38.79859888	14.88480788
503	Berhan	0	0						38.81419764	14.89665675
503	Kudo Felasi	38.85	14.87	MENDEFERA	Kudo Felasi	Kudo Felasi	38.84102177	14.86552829	38.84102177	14.86552829
503	Mendefera	38.78	14.96						38.81829826	14.89591861
505	Akrur	0	0	SEGHENEYTI	Akhrur	Akhrur	39.23295869	15.07592589	39.23295869	15.07592589
505	Derea	0	0	SEGHENEYTI	DerA	DerA	39.33259012	14.77018341	39.33259012	14.77018341
505	Digsa	39.23	14.99						39.2210011	14.99671738
505	Hadida	39.13	14.95	SEGHENEYTI	Hadida	Hadida	39.14774211	14.95109338	39.14774211	14.95109338
505	Hiebo	39.26	15.05	SEGHENEYTI	Hiebo	Hiebo	39.26273578	15.05433033	39.26273578	15.05433033
505	Engela	39.14	14.93	SEGHENEYTI	Hadida/Engela	Engela	39.13817772	14.92957214	39.13817772	14.92957214
505	Segeneiti	39.19	15.05						39.19226931	15.05919427
507	Forto	38.36	15.87						39.39512142	14.58594275
507	Misariaha	39.45	14.62	SENAFE	Zigfet	Misarha	39.45413936	14.61537152	39.45413936	14.61537152
507	Monekseyto	39.48	14.53	SENAFE	Menekhuseyto	Menekhuseyto	39.47963964	14.53120036	39.47963964	14.53120036
507	Senafe	0	0						39.42573125	14.70697675
507	Senafe	39.42	14.7						39.42663989	14.70611612
508	Dekilefay	0	0	TSORENA	Deqi Liefay	Deqi Liefay	39.28560198	14.76310366	39.28560198	14.76310366
508	Endaba-Stifanos	0	0	TSORENA	Endaba Estfanos	Endaba Estfanos	39.09358411	14.67564967	39.09358411	14.67564967
508	Genzeb	39.28	14.71	TSORENA	Gnzebo	Gnzebo	39.27170952	14.70170252	39.27170952	14.70170252
508	Ona-Andom	0	0	TSORENA	Una Andom	Una Andom	39.21504895	14.76000658	39.21504895	14.76000658
508	Tzerona	39.2	14.63	TSORENA	Tsorona	Tsorona	39.19525367	14.61867953	39.19525367	14.61867953
101	Aytus	0	0	ARETA	Tio	Tio	40.96065457	14.68454739	40.96065457	14.68454739
101	Ayumen	0	0	ARETA	Alati	Aytus	40.98347157	14.50418713	40.98347157	14.50418713

101	Egroli	0	0	ARETA	Ayumen	Ayumen	41.074975	14.0367757	41.074975	14.0367757	
101	Tio	0	0	ARETA	Egdoli	Egdoli	41.17337675	14.20297161	41.17337675	14.20297161	
104	Assab Port	0	0								
104	Assab	42.74	13						42.74	13	
104	Bahti Meskerem	0	0								
104	Dr. GhirmayY	0	0								
104	Dr. TecleT	0	0								
104	Prison	0	0								
104	Salina	0	0								
103	Abo	42.74	12.82	DEBUB-DENKALIA	Abo	Abo	42.75228721	12.84218459	42.75228721	12.84218459	
103	Beilul	42.34	13.25	DEBUB-DENKALIA	Beylul	Beylul	42.3215718	13.25851132	42.3215718	13.25851132	
103	Rahayta	43.07	13.18	DEBUB-DENKALIA	Rahaita	Rahaita	43.08679196	12.72873355	43.08679196	12.72873355	
103	Wade	41.9	13.19	DEBUB-DENKALIA	Wade	Wade	41.89933826	13.17693151	41.89933826	13.17693151	
102	Afambo	41.52	13.57	MAKELAY KEYHI BAHRI	Afambo	Afambo	41.51343261	13.56630696	41.51343261	13.56630696	
102	Belubuy	41.4	13.81	MAKELAY KEYHI BAHRI	Balubuy	Balubuy	41.39859415	13.81272341	41.39859415	13.81272341	
102	Edi	37.14	15.93	MAKELAY KEYHI BAHRI	E ddi	E ddi	41.68932023	13.92957174	41.68932023	13.92957174	
401	Agordat	37.89	15.56						37.89	15.56	
401	Agordat	0	0								
401	Engerne	38.01	15.33	AGORDAT	Engerne	Engerne	38.02411352	15.54301376	38.02411352	15.54301376	
401	Tesfay	0	0								
402	Barentu	37.59	15.11						37.59	15.11	
403	Adi Ebrahim	37.34	14.79						37.34	14.79	
403	Dghe	38.47	17.42								????
403	Katrenay	37.22	15.54	DIGHE	Aefhimbol	Adi Qtrienay	37.35295832	15.90084552	37.35295832	15.90084552	
403	Keru	37.21	15.62	DIGHE	Kieru	Kieru	37.2030924	15.62353171	37.2030924	15.62353171	
403	Shatera	0	0								
403	Tekreriet	37.72	15.53	DIGHE	Tekreriet	Adi Mlich	37.72030667	15.51293351	37.72030667	15.51293351	
404	Forto	36.97	15.61	FORTO	Forto	Forto	36.97447274	15.59923121	36.97447274	15.59923121	
404	Ghrmayka	36.67	15.63	FORTO	Grmaika	Grmaika	36.67908328	15.61171357	36.67908328	15.61171357	
404	Molover	37.01	15.9	FORTO	Molober	Molober	37.09814039	15.98603329	37.09814039	15.98603329	
405	Dase	37.5	14.92	GOGNE	Dasse	Dasse	37.48588834	14.92295746	37.48588834	14.92295746	
405	Gognie	37.34	15.12	GOGNE	Gogne	Gogne	37.34108229	15.13059326	37.34108229	15.13059326	
405	Kuluku	37.63	14.96	GOGNE	Kuluku	Kuluku	37.6332905	14.955477	37.6332905	14.955477	
405	Takawda	0	0	GOGNE	Tekawda	Tekawda	37.40037579	15.3450403	37.40037579	15.3450403	
410	Adi-Shegala	36.73	14.75	GULUJ	Ameilo	Adi-Shekgala	36.90152862	14.7263272	36.90152862	14.7263272	
410	Gergef	36.67	14.61	GULUJ	Gherghef	Gherghef	36.66215806	14.61405187	36.66215806	14.61405187	
410	Gerset	0	0	GULUJ	Gherset	Gherset	36.77073264	14.90160181	36.77073264	14.90160181	
410	Guluj	36.73	14.75	GULUJ	Golij	Golij	36.72531499	14.74088993	36.72531499	14.74088993	
410	Omhager	36.66	14.33	GULUJ	Omhajer	Omhajer	36.65207199	14.32305202	36.65207199	14.32305202	
410	Sabunait	0	0	GULUJ	Sabunayt	Sabunayt	36.81551669	14.67803082	36.81551669	14.67803082	
410	Sandashina	36.72	14.65						36.72	14.65	
410	Tebeldia	0	0	GULUJ	Tebeldya	Tebeldya	36.7148758	14.65111304	36.7148758	14.65111304	
406	Alebu	36.87	15.22	HAYCOTA	Alebu	Alebu	36.8703723	15.22077992	36.8703723	15.22077992	
406	Haykota	37.09	15.19	HAYCOTA	Haykota	Haykota	37.08117622	15.19316563	37.08117622	15.19316563	
414	Antore	37.21	14.55	LAELAY GASH	Antore	Tahtay Antore	37.19694357	14.51873795	37.19694357	14.51873795	
414	Augaro	37.3	14.78	LAELAY GASH	Awgaro	Awgaro	37.30597938	14.78479002	37.30597938	14.78479002	

				LAELAY GASH	Buko	Adi Amir	37.2419566	14.78882983	37.2419566	14.78882983
				LAELAY GASH	Mai shigli	Dnsit	37.13307664	14.67101427	37.13307664	14.67101427
				LAELAY GASH	Shelalo	Shelalo	37.57334018	14.66169769	37.57334018	14.66169769
414	Tokombia	37.47	14.78						37.47	14.78
407	Adi Niamin	38.56	14.92	LOGO ANSEBA	Adi Neamn	Adi Neamn	38.69092741	15.49549474	38.69092741	15.49549474
407	Kernakudo	38.67	15.29	LOGO ANSEBA	Kerena Kudo	Kerena Kudo	38.66927673	15.28418026	38.66927673	15.28418026
407	Mekerka	38.71	15.39						38.71	15.39
407	Melezanay	36.93	14.57	LOGO ANSEBA	Mlezanay	Mlezanay	38.63885925	15.46163983	38.63885925	15.46163983
408	Aderde	38.14	15.66	MENSURA	Aderde	Aderde	38.13626798	15.65270114	38.13626798	15.65270114
408	Duluk	38.07	15.36	MENSURA	Dluk	Dluk	38.05955407	15.35531133	38.05955407	15.35531133
408	Gerger	38.68	15.78	MENSURA	Ghergher	Ghergher	38.50502873	15.4372701	38.50502873	15.4372701
408	Hirkuk	38.14	15.66	MENSURA	Hirkok	Hirkok	38.31433896	15.57365955	38.31433896	15.57365955
408	Mensura	38.26	15.47	MENSURA	Mensura	Mensura	38.27180801	15.47606988	38.27180801	15.47606988
408	Migrah	0	0							
408	Shelab	0	0	MENSURA	Shelab	Measker Shelab	38.11330526	15.72885964	38.11330526	15.72885964
409	Areda	37.6	15.26	MOGOLO	Areda	Areda	37.59859281	15.25461339	37.59859281	15.25461339
409	Deret	0	0	MOGOLO	Deret	Hufnoch	37.83075346	15.34076029	37.83075346	15.34076029
409	Mogolo	37.65	15.32						37.65	15.32
409	Tombita	37.71	15.29						37.71	15.29
412	Derabush	38.18	15.03						38.18	15.03
412	ENDA-GABR	0	0	MULKI	Adi Gultna (Enda Gabr)	Enda Gabr	38.31086526	14.80914727	38.31086526	14.80914727
412	Molki	38.23	14.92	MULKI	Molqi	Molqi	38.22736278	14.88943439	38.22736278	14.88943439
410	Aklelet	36.73	14.75						36.73	14.75
411	Bimbina	37.75	14.96	SHAMBUKO	Binbina	Binbina	37.75542183	14.96398545	37.75542183	14.96398545
411	Bushuka	0	0	SHAMBUKO	Bshuka	Bshuka	37.91376608	14.95084559	37.91376608	14.95084559
411	Deda	38.49	15.41						38.49	15.41
411	Kerkasha	37.73	15.05	SHAMBUKO	Kerkasha	Kerkasha	37.73156503	15.05187871	37.73156503	15.05187871
411	Korokon	0	0	SHAMBUKO	Anbori	Korokon	37.9684367	15.08507996	37.9684367	15.08507996
411	Kotobia	0	0	SHAMBUKO	Koitebia	Koitebia	37.88654557	15.09715801	37.88654557	15.09715801
411	Shambuko	37.83	15.92						37.83	15.92
413	Ali Gidir	36.59	15.13	TESSENEY	Ali ghidr	Ali ghidr	36.57746511	15.11448065	36.57746511	15.11448065
413	Fanko	0	0	TESSENEY	Fanko	Fanko	36.8726844	14.96437677	36.8726844	14.96437677
413	Telata Asher	36.52	15.17	TESSENEY	Talata Asher	Talata Asher	36.51338561	15.1637413	36.51338561	15.1637413
413	Teseney	36.66	15.11						36.66	15.11
413	Teseney	36.66	15.11						36.66	15.11
602	Hazega	38.83	15.4	BERIKH	Hazega	Hazega	38.83020701	15.39611496	38.83020701	15.39611496
602	Tzaida Kiristia	39.26	14.77	BERIKH	Tsaeda Christian	Tsaeda Christian	38.85078659	15.33925337	38.85078659	15.33925337
602	Tzeazega	37.86	14.86	BERIKH	Tseazega	Tseazega	38.79976337	15.34566863	38.79976337	15.34566863
603	Adi Hawsha	38.97	15.24	GHALA NEFHI	Adi Hawsha	Adi Hawsha	38.96735179	15.23885539	38.96735179	15.23885539
603	Gulie	0	0	GHALA NEFHI	Gulie	Adi Chelge	39.01486763	15.31727896	39.01486763	15.31727896
603	Himbrti	38.74	15.26	GHALA NEFHI	Hmbrti	Hmbrti	38.73668055	15.25550143	38.73668055	15.25550143
603	Kutmo Awlae	38.83	15.26	GHALA NEFHI	Ktmewlie	Ktmewlie	38.82557109	15.25531695	38.82557109	15.25531695
603	Merhano	38.77	15.23	GHALA NEFHI	Merhano	Merhano	38.91125736	15.25722062	38.91125736	15.25722062
605	Acria	0	0							
605	ArbateAsmara	0	0							
605	Dr.Abdu	0	0							
605	Dr.EfremZ	0	0							
605	Dr.SururA	0	0							
605	Dr.TesfaiW	0	0							

605	Dr.YfdeT	0	0							
605	EdagaCl	0	0							
605	Edagahamus	0	0							
605	EriElecAu	0	0							
605	Saba	0	0							
605	WAKA	0	0							
605	Zemenawi	0	0							
606	Africa Match Fa	0	0							
606	Asmara Pickling	0	0							
606	Coca-Cola Fac.	0	0							
606	EriKorean	0	0							
606	Hazhaz Hosp	0	0							
606	Hazhaz	0	0							
606	Maitemenai	0	0							
606	Red Sea Leather	0	0							
606	Rehabilitation	0	0							
606	SemienawAsmara	0	0							
601	Adi Sheka	38.89	15.49	SEREJEKA	Adi Sheka	Adi Sheka	38.89565491	15.48866137	38.89565491	15.48866137
601	Azien	0	0	SEREJEKA	Azien	Azien	38.90043412	15.49614937	38.90043412	15.49614937
601	Beleza	38.92	15.43	SEREJEKA	Beleza	Beleza	38.9262579	15.42376939	38.9262579	15.42376939
601	Embaderho	0	0	SEREJEKA	Embaderho	Embaderho	38.89308403	15.42961438	38.89308403	15.42961438
601	Geshenashem	38.82	15.52	SEREJEKA	Adekelom	Gashnashm	38.82495362	15.52629872	38.82495362	15.52629872
601	Serejeka	38.83	15.48	SEREJEKA	Serejeka	Serejeka	38.84823083	15.48471925	38.84823083	15.48471925
601	Weki	38.88	15.55	SEREJEKA	Weki	Weki	38.87824063	15.54986768	38.87824063	15.54986768
601	Zagir	38.9	15.54						38.9	15.54
604	Adis Alem	0	0							
604	Asmara Beer Fac	0	0							
604	Asmara Textile	0	0							
604	British America	0	0							
604	Asmara Ceramics	0	0							
604	Dr. MusieG/M	0	0							
604	Dr. T/haimanot	0	0							
604	Durfo	0	0	SOUTH EAST ASMARA	Durfo	Enda Siraj	38.97906681	15.42195438	38.97906681	15.42195438
604	Family Producti	0	0							
604	Lalmba Sack Fac	0	0							
604	Lasale	0	0							
604	Metal Works Fac	0	0							
604	Red Sea Food Pr	0	0							
604	Selam Clinic	0	0							
604	St. Antonio	0	0							
604	Tele-Clinic	0	0							
607	Dahlak Share Co	0	0							
607	Denden	0	0							
607	Felege Hiwet	0	0							
607	Fre Selam	0	0							
607	Geriatric Clini	0	0							
607	Godaif	0	0							
607	Godaif	0	0							
607	Sabur Printing	0	0							
607	Sembel	0	0							
607	Sembel	0	0							
607	Sopral Fac.	0	0							
607	Vilago	0	0							
701	BERHAN AYNE OPH	0	0							

701	Halibet	0	0							
701	Hanssenian	0	0							
701	MEKANE HIWET OB	0	0							
701	MEKANE HIWET PE	0	0							
701	ST. MARY	0	0							
210	Himbol	0	0	ADOBHA	Adobha	Adobha	38.23479009	17.10946862	38.23479009	17.10946862
207	Afabet	38.69	16.19						38.69	16.19
207	Afabet	38.69	16.19						38.69	16.19
207	Felket	38.62	16.1	AFABET	Felket	Felket	38.61808104	16.09502232	38.61808104	16.09502232
207	Kamchiwa	38.71	16.44	AFABET	Naro Ans	Qamchewa	38.69686874	16.43209048	38.69686874	16.43209048
203	Dahilak Keber	40	15.62	DAHLAK	Durbushet	Dahlak Kebir/Berkish	40.00690596	15.61901451	40.00690596	15.61901451
203	Dehile	0	0	DAHLAK	Dihl	Dahar	39.62894884	15.92027474	39.62894884	15.92027474
203	Derbushet	0	0	DAHLAK	Durbushet	Durbushet	40.11882188	15.67267195	40.11882188	15.67267195
202	Foro	39.62	15.26	FORO	Foro	Foro	39.62164055	15.26538106	39.62164055	15.26538106
202	Irafailie	39.74	15.08	FORO	Erafayle	Erafayle	39.75203001	15.07927334	39.75203001	15.07927334
202	Rubrubia	39.48	15.3	FORO	Robrobia	Robrobia	39.48293274	15.29721166	39.48293274	15.29721166
201	Bada	40.11	14.56	GHELAELO	Bada	Boleli	40.13592637	14.55954837	40.13592637	14.55954837
201	Buya	0	0							
201	Gelalo	40.08	15.11	GHELAELO	Ghelaelo	Ghelaelo	40.06607209	15.11309723	40.06607209	15.11309723
201	Engel	39.85	15.45	GHELAELO	Einghel	Debah Einghel	39.85652394	15.45063313	39.85652394	15.45063313
201	Menkalele	0	0	GHELAELO	Bardoli	Mekanil	39.80155459	15.29318723	39.80155459	15.29318723
205	Dankur	38.89	15.67						38.89	15.67
205	Demas	39.21	15.47	GHINDAE	Demas	Demas	39.21195873	15.47600871	39.21195873	15.47600871
205	Embatkala	39.08	15.4	GHINDAE	Embatkala	Embatkala	39.08226981	15.39919325	39.08226981	15.39919325
205	Gahtielay	39.15	15.52	GHINDAE	Gahtelay	Gahtelay	39.15285363	15.52681244	39.15285363	15.52681244
205	Ghindae	0	0							
205	Gindae	39.09	15.44						39.09	15.44
205	Ghinda	0	0							
205	Mai Habar	39.06	15.27	GHINDAE	Mai Habar	Mai Habar	39.05495027	15.27311651	39.05495027	15.27311651
205	Nefasit	39.06	15.33	GHINDAE	Nefasit	Nefasit	39.06569474	15.32189877	39.06569474	15.32189877
205	Shebah	39.05	15.7						39.05	15.7
205	TESFA CLINIC	0	0							
209	Karura	38.37	17.7	KARORA	Qarora	Dghe Qarora	38.36801594	17.68064326	38.36801594	17.68064326
209	Mahmimet	38.54	17.37	KARORA	Mahmimet	Mahmimet	38.5461936	17.37860487	38.5461936	17.37860487
204	Amatere	0	0							
204	Cement Factory	0	0							
204	Dr. Ibrahim	0	0							
204	Dr. Jemal	0	0							
204	Dr. Solomon	0	0							
204	Dr. YOHANNESS	0	0							
204	Enkulu	0	0							
204	Hirgigo	39.46	15.54	MASSAWA	Hirghigho(04)	Hirghigho(04)	39.44895491	15.54073814	39.44895491	15.54073814
204	Kutmia	0	0							
204	Massawa	39.45	15.61						39.45	15.61
204	Massawa Port	0	0							
204	Tiwalet	0	0							
204	Wekiro	39.31	15.82	MASSAWA	Wekiro	wekiro	39.30811044	15.81202514	39.30811044	15.81202514
208	Agraie	38.28	17.42						38.28	17.42
208	Backla	0	0	NAKFA	BaQla	BaQla	38.35485248	16.60793126	38.35485248	16.60793126
208	Nakfa	38.49	16.67	NAKFA	Nakfa	Nakfa	38.48538473	16.65910675	38.48538473	16.65910675

206	Shieb	0	0	SHIEB	Mensheb	Mensheb	39.05472815	15.84305604	39.05472815	15.84305604

Appendix 5. NFIS Agromet Update Dekad 01 July 2004

NATIONAL FOOD INFORMATION SYSTEM OF ERITREA (NFIS)

(Coordination for Food Insecurity, Nutrition and Vulnerability Information Activities)

Agro-met Update

Contact: nfis@moa.gov.er

Dekadal Issue | Number 12/2004 | Dekad 1, July, 2004

Agro-meteorological Assessment | Remote Sensing

Agro-meteorological Assessment

Climatology

Rain showers and cloudiness persisted all over the Kremti rain-receiving areas. Vegetative growth of the Azmera-surviving long cycle crops and emergency of early sowed short cycle crops were observed in some parts of Debub and Maekel regions. Most part of southeastern, eastern lowlands and northwestern parts of the country remained under dry and sunny condition, as it is normal during this part of the year. The observed rainfall improved the grazing areas and the recharge of ground-water levels over the Kremti areas, while

Ground Reports

The reports from ground stations for the first dekad of July 2004 is given in table 1. Most of the reporting stations are from zoba Debub. The spatial and temporal distribution of the rain fall activity was also good in the other zobas under the Kremti season influence. 1-4 rainy days reported from the reporting stations. The Mai Aini station in the Debub's Hazemo plains reported 14mm in two rainy days, which contributed to improve the moisture in the area after a dry spell in June. According to the rainfall estimations (agro-meteorological model based on remote sensing data) the area received between 16-40mm.

Table 1 Cumulative rainfall record in mm for stations that reported rainfall

ZOBA	STATIONS	Cumulative rainfall for first dekad of July 2004	Number of Rainy days
Maekel	Asmara	5.4	1
	Serejeqa	3	1
Debub	Adi Kuala	74.2	4
	Dbarwa	15.2	1
	Dekemhare	14	1
	Dgsa	7.3	3
	Drko	5	1
	Hal Hale	14.5	2
	Kurbaria	10	1
	Mai Aini	14	2
	Mai Mne	10.1	4
	Maiedaga	32	1
	Mendefera	18.4	2
	Segeneiti	5	2
	Senafe	19	2
Gash Barka	Barentu	11.7	1
	Golige	5.1	1
	Mensura	2	1
Anseba	Hamelmalo	34.6	2
	Keren	17.4	3

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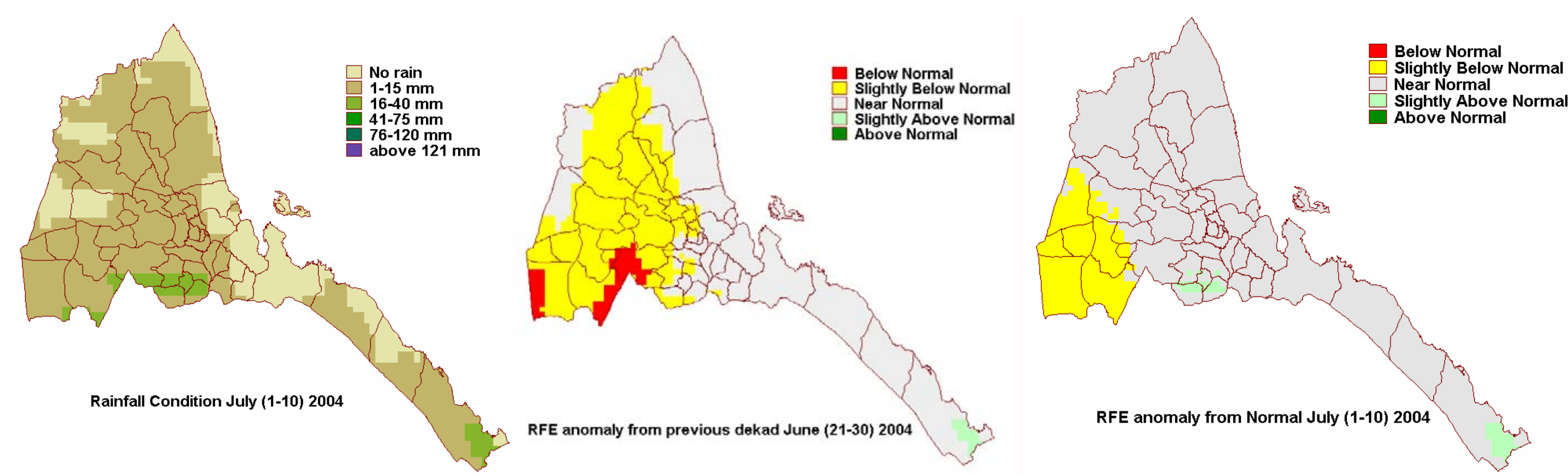
Remote Sensing

<u>Figure 1.</u> RFE (Rain Fall Estimate) images for the 1-10 of July 2004, anomaly from previous Dekad and long term average of the Dekad (*source*: *USGS)*



The rainfall estimate images of the first Dekad of July 2004 as well as anomaly (differences) images with respect to the previous Dekad and Long Term Average (LTA) are shown in the figure 1 above.

The RFE image for the dekad shows between 1-15 mm of rainfall for most of the country except parts of the southeastern and northeastern coastal areas as well as part of western lowlands. Rainfall estimates ranging from 16-40 mm are indicated over the southern part of sub zobas La'elay Gash and Molqi of zoba Gash Barka and sub zobas Emni Haili, Areza, Mendefera and Adi Kuala in zoba Debub. Parts of sub zoba Senafe and Tsorona in the same zoba are also marked with no rainfall

The anomaly images indicate below normal and slightly above normal conditions with respect previous dekad and long term average. The slightly above normal condition was marked in southern tip of zoba Southern Red Sea and parts of sub-zoba Mai Mne, Emni Haili and Adi Kuala of zoba Debub. Compared with the previous dekad, slight decrease was calculated for most of the Kremti rain-receiving areas especially parts of zoba Anseba, Debub, Gash Barka and Maekel. With respect to the long-term average, the decrease was restricted to parts of zoba Gash Barka. The remaining part of the country are estimated under near normal condition.

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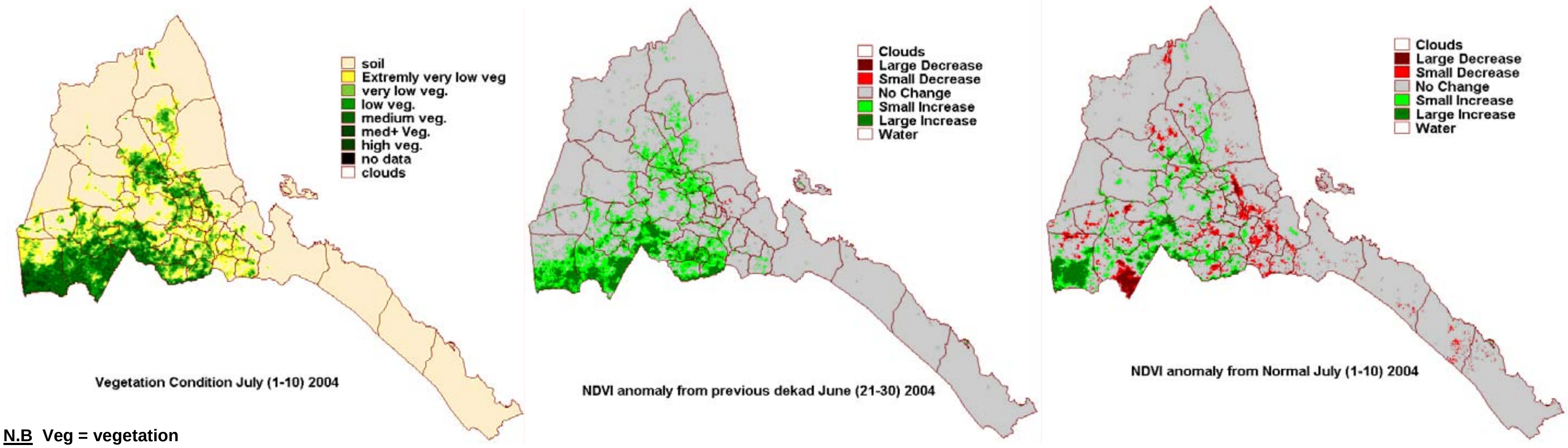
<u>Figure 2.</u> NDVI (SPOT Normalized Difference Vegetation Index) images of 1-10 of July 2004 and its anomalies from previous Dekad and Long Term Average of the Dekad *(Source: FAO)*



<u>N.B</u> Veg = vegetation

As a result of June's rainfall, the vegetation cover for the first Dekad of July 2004 has slightly improved in the central, southern and southwestern part of the country. Although it is restricted to some pocket areas in the highlands and western lowlands, there are indications of medium vegetation coverage. The southwestern parts of Gash Barka, central Anseba and southwestern part of zoba Debub show a vegetation cover slightly better than the other Kremti rain receiving areas.

This Dekadal anomaly image compared with the previous Dekad of June (21-30) shows that there is an improvement in vegetation cover in parts of Gash Barka, Debub, Anseba and Northern and Southern Red Sea zobas. However in the remaining parts of the country the vegetation cover is the same. The deterioration was limited to parts of sub zoba Ghindae in Northern Red Sea.

When the current dekad is compared to the long-term average for the same period, there is much more deterioration of vegetation conditions of Gash Barka, Debub, Makel, Anseba and Gash Barka. The deterioration was extensive in parts of sub zoba La'elay Gash and eastern escarpment. Deterioration of the vegetation condition in the eastern escarpments is usual during this time of the year. There are some pocket areas in zobas Gash Barka, Debub, Northern Red Sea and Anseba with some improvements on the vegetation cover. Furthermore some pocket areas of zobas Anseba, Maekel, Gash Barka, Northern and Southern Red Sea and Debub also indicated deterioration in vegetation cover. The grazing condition is expected to improve.

In general, it can be said that the vegetation condition as estimated by the SPOT satellite is gradually improving along the year (no deterioration is reported), but is inferior in some parts of the country when compared to the average 1998-2004. If rains continue, more improvements are expected as well as a closing gap with respect to the LTA. Much attention has to be paid to this situation as at least 2 drought years are considered in the averaged period.

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Appendix 6. 1996-2003 Epidemic Threshold Calculation Sheet

Data entry sheet - epidemic threshold calculation based on 5 years' monthly data

to be used together with *Field Guide for Malaria Epidemic Assessment and Reporting, WHO/HTM/MAL/2004.1097*

THRESHOLD YEARS: 1996, 1999-2002 **SUBZOBA**

This excel sheet is set up to do calculations automatically. Enter or copy raw data into rows 39 to 46 below. Do NOT change other cells.

	Dec copied	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Jan copied
1996	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12
1999	NA	12	7	4	4	2	3	15	30	34	61	41	11	3
2000	11	3	14	2	4	25	25	30	39	38	41	35	22	13
2001	22	13	9	11	13	16	22	37	24	22	30	11	10	12
2002	10	12	8	6	7	4	9	0	2	1	4	1	0	NA
2003	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Automatic calculations

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
sum	43	40	38	23	28	47	59	82	95	95	136	88	43	40
mean		10	10	6	7	12	15	21	24	24	34	22	11	
SD		5	3	4	4	11	10	16	16	17	24	19	9	
mean+SD		15	13	10	11	23	25	37	40	40	58	41	20	
mean+2SD		19	16	13	15	33	36	53	55	57	82	60	29	
M-AVE-3		10	8	7	8	11	16	20	23	27	27	22	14	
SD M-AVE-3		6	4	4	7	9	12	14	15	18	19	19	13	
M-AVE-3+1SD		16	12	11	15	20	28	33	37	45	46	42	27	
M-AVE-3+1.96SD		21	16	15	22	28	40	46	52	62	64	60	39	
3rd quartile		12	10	7	9	18	23	32	32	35	46	37	14	

Threshold overview: graph with thresholds appears in sheet "threshold graph"

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3rd quartile	12	10	7	9	18	23	32	32	35	46	37	14
M-AVE-3	10	8	7	8	11	16	20	23	27	27	22	14
mean+1SD	15	13	10	11	23	25	37	40	40	58	41	20
mean+2SD	19	16	13	15	33	36	53	55	57	82	60	29
M-AVE-3+1SD	16	12	11	15	20	28	33	37	45	46	42	27
M-AVE-3+1.96SI	21	16	15	22	28	40	46	52	62	64	60	39

RAW DATA

Mark missing data as "NA", do not leave cells blank, EXCEPT IN LIGHT BLUE ROWS: DELETE "NA" AND LEAVE BLANK.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1996	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	12	7	13	5	8	6	3	15	24	20	16	17