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.