THE GARKI PROJECT

Research on the Epidemiology and Control of Malaria in the Sudan Savanna of West Africa

by

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FOREWORD

Malaria is undoubtedly one of the worst scourges of tropical Africa. The intensity of malaria transmission, although not uniform all over the continent, has been considered the main obstacle to any type of control of the disease for some years past. In 1934 James, a well-known British malariologist, suggested that in Africa young children should not be treated for their first attack of malaria so that they could develop some immunity. Similarly, famous malariologists like Swellengrebel maintained that, in areas with holoendemic (stable) malaria, man should not interfere with the established premunition of the human population since that would increase the severity of the clinical manifestations of malaria and the mortality caused by it in older children and adults. In fact, because of the presumed intensity of transmission, in addition to the lack of health infrastructure, Africa was not included in the global malaria eradication programme which was initiated by the World Health Organization in the mid 1950s.

The excellent results obtained elsewhere with DDT house-spraying in interrupting malaria transmission encouraged the initiation of more than 20 pilot projects in various African countries during the mid 1950s and early 1960s. In some countries, particularly in forested areas, the impression was that transmission could be interrupted if total coverage with insecticides and full surveillance were carried out. However, in none of these pilot projects were quantified epidemiological data collected in the course of operations that would have permitted a proper appreciation of the intensity of endemo-epidemicity and thus facilitated the planning of malaria control, particularly for the dry savanna areas.

In the light of the experience gained from pilot projects and in view of the insufficient knowledge and understanding of the quantitative dynamics of malaria transmission and of the impact of such control measures as residual house spraying and mass drug administration, WHO decided to initiate field research to provide information on all the factors that contribute to the maintenance of intensive transmission. The northern part of Nigeria was favoured for this research, Garki District was selected, and thus the project described in these pages was born.

When the research project was drawn up, it was decided to invest rather more resources than previously in the collection of baseline data and in the evaluation of the impact of house spraying with an effective residual

insecticide, alone or in combination with mass drug administration. The development of a mathematical model of transmission and its testing against hard data were part of this effort of understanding: if one could simulate realistically the transmission of malaria, one would presumably be closer to a balanced understanding of the interplay between the factors involved and better equipped for planning future control programmes. The Garki project also provided an unique opportunity to study a battery of seroimmunological tests before, during and after the application of control measures. The research project was designed to be limited in time, rather than as a pilot project to try out on a small scale a strategy that would later be applied on a large scale and over a prolonged period of time. It was essential to know what could or could not be achieved and, as far as possible, to find out why that was so; and it was therefore considered justified to apply control measures and methods of supervision that were more expensive than would be acceptable in a control programme. Great care was taken to protect the population involved from any untoward effect of the application of more or less intensive control measures over a short time; in the event, one of the results of the project was an increased awareness and a new understanding of malaria by the population and, with that, the adoption of self-medication, which is probably one of the most immediately applicable ways of reducing morbidity and mortality from malaria in a situation of the sort encountered in Garki.

The project largely reached its objectives, as this monograph shows. While several of the more striking results have been published elsewhere in a fragmentary way, in the present work the authors have aimed at a balanced account of all aspects of the study. The wealth of data collected did not make this easy. Some of the interpretations may be even challenged. The original data, collected with exceptional and meticulous care, are stored on tape and could be made accessible upon request to allow further or different methods of analysis.

This is not the place to summarize the project, but some of the findings may be highlighted here. First of all, a very high intensity of transmission was demonstrated: the vectorial capacity, which is an expression of the likelihood of transmission of the parasite, was about a thousand times the critical value required for the maintenance of endemic malaria; the entomological inoculation rate, or number of infections offered to man per unit of time, was about a hundred times the critical value. These very high levels of transmission put malaria in tropical Africa in a category of its own. The variations observed in the intensity of transmission from year to year and from village to village were well documented. Residual spraying with propoxur did not have the expected effect on the prevalence of malaria. The care with which both the control operations and the evaluation were conducted allow some firm conclusions: coverage was as

nearly complete as possible; the insecticide was very effective against the mosquito vectors (still producing a high mortality among them at the beginning of the third wet season after the last application!), although less so in reducing malaria; immigration of vectors or humans from unsprayed villages was not a significant factor. The decisive factors were the exophily of a fraction of the *Anopheles gambiae* sensu lato and a high man-biting rate—hence the high level of transmission. The same factors are also the main reason why the addition of mass drug administration, even at high frequency and coverage, while it reduced malaria to a very low level, failed to interrupt transmission. Variations in the degree of exophily between villages and between Garki and Kisumu, Kenya (where a quite distinct field trial of fenitrothion was conducted), explain the variations between villages in the effect of propoxur and most of the difference between the effect of the insecticides used in Garki and in Kisumu. Cytogenetic investigations pointed to a genetic basis for variation in resting behaviour within each of the two species of the *A. gambiae* complex occurring in Garki, and their results correlated well with the differences between villages in the effect of propoxur. If the resting behaviour of a mosquito species is genetically determined, exophily will be a stable characteristic of individual vectors, and the usual method of interpreting the impact of residual insecticides on longevity, which tacitly assumes uniform behaviour, is overoptimistic. Turning to the parasitological observations, the longitudinal nature of the study made it possible to show that everybody was infected early in life, not only by *Plasmodium falciparum*, but very probably also by *P. malariae*, and even by *P. ovale*, commonly described as a "rare" parasite. The effect of parasitism on immunity was well demonstrated, confirming much that was known but also producing some findings that either are new or were hitherto much less well documented. The seroimmunological study also yielded significant findings regarding the relationship between the various serological tests and parasitological findings, regarding the differences in immune response between males and females, between persons with and without the sickling trait, and between individuals, and regarding the effect of a drastic reduction in antigenic stimulation on the test results. The clinical studies, although limited in scope, demonstrated interesting relationships between body temperature and parasitaemia, and a significant effect of malaria control on the frequency of fever and on anthropometric indicators of the nutritional status of children. The demographic studies demonstrated that the infant mortality rate was very high before control, that its variation between years and between seasons was strikingly associated with the corresponding variations of the infant's risk of acquiring *P. falciparum*, and that it was significantly reduced by malaria control. Last but not least, the new mathematical model, painstakingly tested

against hard facts, allows much more realistic simulations of the epidemiology of malaria, both before and after the application of control measures, than was previously possible.

The future will tell whether the volume, quality and relevance of the information produced by the project have justified the relatively high investment. There are implications for the future as regards control, teaching and research. The control of malaria in the African savanna will benefit from careful consideration of the observations made in Garki, even the negative ones; it is better to know your enemy's (malaria's) strength and resilience. Control of malaria on a broader scale will benefit from the addition to our planning tools of a new, more realistic, simulation model. The data from Garki, their interpretation (even when it is controversial), and simulation exercises based on the model will add to the materials available for teaching the epidemiology of malaria. Future field research should benefit directly from the experience, good and bad, gained in the project, and some of the findings mentioned above may also give leads for basic research.

The project was made possible by the dedication and hard work of many, in Nigeria and outside, in WHO, and in numerous national scientific institutions; they are listed in an appendix. Whatever the merit of the work, it is shared by all involved, and in particular by the members of the team in Nigeria, working hard and productively, often in very difficult conditions, and by the population of the Garki District, without whose superb and lasting cooperation none of this would have been possible. It is hoped that they and their descendants, and similarly affected populations, will reap the real benefits.

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