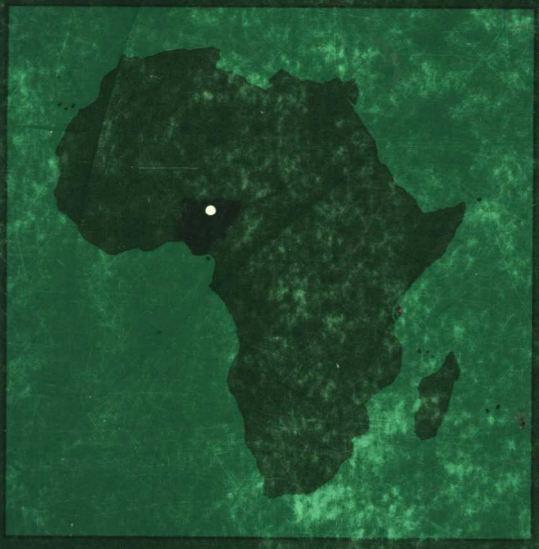
The Garki Project

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

L. Molineaux & G. Gramiccia



World Health Organization Geneva 1980

THE GARKI PROJECT

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

by

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WORLD HEALTH ORGANIZATION
GENEVA
1980

ISBN 92 4 156061 4

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PRINTED IN SWITZERLAND
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CONTENTS

Page

Foreword 11

CHAPTER 1. INTRODUCTION

Purpose of the publication 15
Previous epidemiological studies and control trials in tropical Africa 17
Rationale of the project 19
Objectives of the project 21

CHAPTER 2. THE STUDY DESIGN AND STUDY AREA

Study design, variables measured, and methods used 23
Malaria control strategies 23
Project phases and calendar 28
Villages selected for follow-up and villages treated by the various strategies 28
Variables measured, frequency of measurement, and methods used 30
Recording, storage and retrieval of data 33
Services and staffing 34
Area, climate, population 35
Orohydrography 35
Climate and vegetation 35
Meteorology 37
Population 39

CHAPTER 3. CONTROL OPERATIONS

Residual spraying 41
Sprayable surfaces 41
The spraying operations 42
Operational results: the coverage achieved and the dose applied 42
Administration of drugs 43
Mass distribution of sulfalene-pyrimethamine in 1972-1973 43
Post-intervention drug distributions in 1974-1975 48
Discussion 49
Summary 50

Page

CHAPTER 4. ENTOMOLOGY

Anopheline fauna and observations regarding minor species 53
Collections as indices of density 54
Baseline findings 56
Vector density 59
Sporozoite rates and inoculation rates 64
Vector behaviour 66
Age composition and longevity 71
Vectorial capacity 73
Effect of intervention, in particular residual spraying with propoxur 75
Results of the preliminary trial of propoxur 76
Effect of propoxur on vector density 77
Sporozoite rates and inoculation rates 84
Vector behaviour 85
Age composition and longevity 86
Vectorial capacity 86
After-effect of propoxur, after discontinuation of spraying 88
Vector density 88
Sporozoite rates and inoculation rates 90
Vector behaviour 90
Age composition and longevity 92
Bioassay and chemical tests 92
Compact versus scattered settlements 94
Anopheles gambiae and *A. arabiensis* 95
Discussion 99
The estimation of the vectorial capacity 99
Transmission in Garki and its natural variation 101
The effect of propoxur 101
A. gambiae, *A. arabiensis* and intraspecific cytogenetic variation 103
Evaluation of insecticidal impact 105
Summary and conclusions 106

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Page

CHAPTER 5. PARASITOLOGY

Methods 109
Method of blood examination 109
Collection and processing of blood films 111
Parasitology staff 111
Sensitivity and reproducibility of the blood examination method 111
The parasitological indices used 114
Parasitological findings in the absence of intervention 115
Prevalence and density of parasites 115
Incidence and recovery rates (conversion and clearance rates) 125
Relationship between parasitological and entomological findings 131
Mixed infections and the relationship between *P. falciparum* and *P. malariae* 134
The intervention phase: parasitological effect of the 3 control strategies 139
Prevalence and density of parasites 139
Incidence and recovery rates (conversion and clearance rates) 148
Relationship between parasitological and entomological findings 151
Mixed infections 151
The post-intervention phase: the resurgence of malaria 153
Prevalence and density of parasites 153
Incidence and recovery rates (conversion and clearance rates) 157
Relationship between parasitological and entomological findings 157
Discussion 159
The parasitological effects of immunity to *P. falciparum* 159
The effect of the 3 intervention strategies on the epidemiology of *P. falciparum* 162
The effect of mass drug administration on parasitological immunity to *P. falciparum* 165

Page

P. malariae, and its relationship to *P. falciparum* 167
P. ovale 170
Malaria in males and females 171
Summary 171

CHAPTER 6. IMMUNOLOGY

Material and methods 173
Serological results by age, survey and treatment 176
Immunoglobulin G 182
Immunoglobulin M 182
Precipitin (Ouchterlony) test—*P. falciparum* ... 183
Indirect fluorescent antibody (IFA) test—*P. falciparum* 183
Indirect fluorescent antibody (IFA) test—*P. malariae* or *P. brasilianum* 184
Passive (indirect) haemagglutination (IHA) test—*P. falciparum* 185
The longitudinal study of infants 185
Definition of 2 populations of infants 185
Immunoglobulin levels 186
Malaria antibody levels 186
Proportion positive by the serological tests 188
Serological results in the newborn in the post-intervention follow-up period 191
Variation by sex 191
Relationship between the results of the same serological test in the same person at the different surveys 191
Relationship between the results of different serological tests in the same person at the same survey 193
Relationship between parasitology and serology ... 194
Method of analysis of the baseline data 194
The precipitin test (*P. falciparum*) and *P. falciparum* parasitaemia 196
The IHA-*P. knowlesi* or IHA-*P. falciparum* test and *P. falciparum* parasitaemia 197
The IFA test and homologous parasitaemia 198
Immunoglobulin levels and parasitaemia 198

Page

Relationship between parasitological and serological findings during and after the intervention phase 199
Discussion 199
Age and the development of the active immune response in the unprotected population 199
Serological changes in the protected population 202
Serological changes in the post-intervention phase 204
The longitudinal study of infants 204
Comparison between males and females 205
The correlation between different surveys in the same person 206
The correlation between different serological tests in the same person 207
The relationship between serology and parasitology in the individual 207
Sensitivity and specificity of the serological tests 210
Summary 211

CHAPTER 7. ABNORMAL HAEMOGLOBINS AND ABO BLOOD GROUPS
Material and methods 213
Haemoglobin electrophoresis 215
Haemoglobins and genetic fitness 216
Sickle-cell trait and malaria 217
Sickle-cell trait, immunoglobulins and malaria antibodies 218
Immunoglobulins 218
Ouchterlony (precipitin) test with *P. falciparum* antigen 220
Indirect fluorescent antibody test 220
Indirect haemagglutination test with *P. falciparum* antigen 221
Immunology by sex, tribe and haemoglobin 222
Immunology, malaria parasitology and haemoglobin 222
Findings in the Hb SS persons 222
Findings in the Hb SC person 223

Page

Findings in the Hb AC persons 223
ABO blood groups and malaria 224
Discussion 224
Haemoglobin genotype frequencies, fitness, and parasitology 224
Serology of the Hb AA and Hb AS 226
The Hb SS 227
The Hb AC 227
The ABO blood groups and malaria 228
Summary 228

CHAPTER 8. DEMOGRAPHY
Methods 231
Demographic and parasitological (DP) surveys 232
Local registrars (pataucis) 232
Data-handling 232
Results 233
Distribution of the population by age and sex 233
Births 234
Deaths 236
Population movements 241
Demographic analysis of the MDA records 243
Discussion 244
Methods 244
Age and sex composition 244
Birth rate 245
Death rates, malaria and malaria control 245
Population movements 247
Summary 248

CHAPTER 9. CLINICAL SURVEYS
Nutritional anthropometry 251
Spleen surveys 253
Temperature surveys 253
Population, study design and methods 253
Results 255
Discussion 257
Nutritional anthropometric surveys 257

Page

Spleen rates 257
Temperature surveys 258
Summary 258

CHAPTER 10. THE MATHEMATICAL MODEL OF TRANSMISSION

The assumptions of the model 262
Epidemiological states and transitions 262
Superinfection 265
Dynamics of the human population 266
Vectorial capacity and inoculation rate 267
Equations of the model 268
Fitting of the model 270
Data selected for fitting 270
Estimation of model parameters 272
Testing of the model 273
Method of evaluation 273
Testing of the model against observations made in Garki before and during the application of propoxur 274
Testing of the model against observations made in Kisumu before and after the application of fenitrothion 277
Determination of the endemic level by the vectorial capacity 281
Variants of the model 283
Note on the computer programmes 283
Discussion 284
The model and reality 284
The present model and others 285
The model and the planning of malaria control 286
The model and the teaching of the epidemiology of malaria 287
Summary 287

CHAPTER 11. PRACTICAL CONCLUSIONS FOR THE FUTURE OF MALARIA CONTROL

The control of malaria in the Sudan savanna of Africa 290
Residual insecticides 290

Page

The combination of mass drug administration with residual insecticides 292
Selective chemotherapy and chemoprophylaxis 293
The use of the malaria transmission model for the planning of malaria control 294

References 297

Acknowledgements 307

Appendix 1. Staffing of the Project 308

Appendix 2. Cost of the Project 311

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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.

Dr T. Lepes
Director, Malaria Action Programme,
World Health Organization

Chapter One

INTRODUCTION

Purpose of the Publication

This publication is a comprehensive presentation of a study, carried out in an area of northern Nigeria from 1969 to 1976 by a WHO/Government of Nigeria research team, on the epidemiology and control of malaria in the African savanna. This research was planned and directed by a multidisciplinary group at WHO headquarters in liaison with the WHO Regional Office for Africa and in collaboration with the authorities and the staff of the Federal Republic of Nigeria and Kano State.

Although the work is completed with respect to the study of the epidemiology of malaria in the Sudan-type savanna, the planning and evaluation tools forged and tested there remain to be applied to the practical problems of malaria control under various ecological conditions, taking into account the various kinds of constraints. The work is continuing in particular in Bendel State, Nigeria, and its further results will eventually form the basis of a further publication.

This publication is addressed to all those interested in the problem of malaria in Africa and elsewhere. It is obviously not a complete textbook in this respect, because its contents are related to the objectives of the research project considered. Nevertheless, the scientific observations made in that project and the conclusions drawn from them should be useful to all those who either wish to know more about malaria epidemiology in its many aspects or are responsible for administrative and technical decisions for the planning, organization and evaluation of malaria control campaigns. For this second group of persons, the monograph should contain sufficient details and make, we hope, interesting and pleasant reading. For those, however, who are carrying out research on specific aspects of the epidemiology and control of malaria, this book may not contain sufficient details of the observations and results obtained. More detailed reports and analyses do, however, exist and it is from them that the summary tables, graphs and conclusions have been drawn. Some

additional information is available in separate publications, but much of it is to be found in various unpublished WHO documents that are not available in libraries or bookshops. These unpublished documents are included in the list of references, and copies may be requested by applying to the Director, Malaria Action Programme, World Health Organization, Geneva, Switzerland. In addition, most of the original data, including the longitudinal records collected during the work of the project, are stored on tape at WHO headquarters and access to these data for the purpose of further analysis can also be arranged. It is understood that any request for either documents or data will be considered on its merits and no commitment is made for the allotment of the resources that might be required.

The credit for the work described in this book goes to all those who have planned it, and even more to those who have executed it during 6 years of extremely hard field work. It would be difficult and invidious to assign the relative merit due to each one of them; however, the name and the function of all those who contributed to this work are listed at the end of the book, and a note at the beginning of each technical chapter indicates the names of those who were mainly responsible for the work described therein.

In addition to the scientific value of the observations and the practical guidelines to be derived from the conclusions, this book and the original data behind it have an important teaching value. This is especially relevant at a time when the passing of the malaria eradication period demands that the principles, methods and criteria for planning, conducting and evaluating malaria control programmes, adapted to the epidemiological, environmental and socioeconomic conditions of the areas concerned, will have to be learned again.

The book covers the 6 years' period of observations in the field. The technical chapters, dealing with each of the main disciplines applied in the study, cover for each subject the entire period—i.e., the baseline data collected before intervention, the results of the interventions and their analysis, and the observations carried out for two years after discontinuation of the control measures.

Each chapter concerned with a particular category of variables also relates them to what precedes; for instance, the chapter on parasitology cross-references the parasitological findings to the entomological findings previously described. Occasionally, the discussion of a chapter may anticipate some findings from subsequent chapters; for example, the discussion of parasitological results (Chapter 5) calls upon certain serological observations from Chapter 6. Summaries at the end of each technical chapter outline the main features therein of either scientific or practical value. In addition, the main conclusions are recapitulated in Chapter 11.

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