



**GLOBAL REPORT ON  
ANTIMALARIAL  
DRUG EFFICACY AND  
DRUG RESISTANCE:  
2000–2010**



**World Health  
Organization**

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# Abbreviations

<b>ACT</b>	artemisinin-based combination therapy
<b>ARC3</b>	artemisinin resistance project: pilot studies to confirm, characterize and plan for containment
<b>DNA</b>	deoxyribonucleic acid
<b>HIV</b>	human immunodeficiency virus
<b>IC<sub>50</sub>, IC<sub>90</sub>, IC<sub>99</sub></b>	50%, 90%, 99% inhibitory concentration
<b>PCR</b>	polymerase chain reaction
<b><i>PfATPase6</i></b>	gene encoding <i>P. falciparum</i> sarco-endoplasmic reticulum calcium ATPase 6
<b><i>Pfcrt</i></b>	gene encoding <i>P. falciparum</i> chloroquine resistance transporter
<b><i>Pfdhfr</i></b>	gene encoding <i>P. falciparum</i> dihydrofolate reductase
<b><i>Pfdhps</i></b>	gene encoding <i>P. falciparum</i> dihydropteroate synthase
<b><i>Pfmdr1</i></b>	gene encoding <i>P. falciparum</i> multidrug resistance 1 protein
<b><i>Pfnhe-1</i></b>	gene encoding <i>P. falciparum</i> Na <sup>+</sup> /H <sup>+</sup> exchanger
<b><i>Pfubp-1</i></b>	gene encoding <i>P. falciparum</i> deubiquitinating enzyme
<b><i>Pvdhfr</i></b>	gene encoding <i>P. vivax</i> dihydrofolate reductase
<b><i>Pvdhps</i></b>	gene encoding <i>P. vivax</i> dihydropteroate synthase
<b><i>Pvmdr1</i></b>	gene encoding <i>P. vivax</i> multidrug resistance 1 protein
<b>USA</b>	United States of America
<b>WHO</b>	World Health Organization

# Executive summary

## BACKGROUND

*Plasmodium* resistance to antimalarial medicines is one of the major obstacles in the fight against malaria. Comprehensive, up-to-date understanding of the scope of antimalarial resistance is essential for protecting the recent advances in malaria control. Without regular monitoring and reporting of antimalarial drug resistance, the disease burden and the economic costs of malaria will rise dramatically. In addition, ineffective treatment resulting from drug resistance might lead more patients to rely on the unregulated private sector, increasing the risk of reliance on monotherapy, substandard and counterfeit medicines and subsequently leading to the emergence or further spread of drug resistance.

Measurement of drug resistance in malaria is complex. The tools that are used to monitor drug efficacy and evaluate drug resistance are described in this report. Studies of clinical and parasitological outcomes are the main sources of information on which national malaria control programmes base treatment policy; however, other studies are needed to confirm drug resistance. The aim of in vitro studies is to measure the intrinsic sensitivity of parasites to antimalarial drugs; molecular markers are used to identify genetic mutations related to antimalarial drug resistance in the parasite genome; and pharmacokinetic studies characterize antimalarial drug absorption, distribution, metabolism and elimination in the body. While each method makes a contribution to a more complete understanding of antimalarial drug resistance, therapeutic efficacy studies remain the gold standard for guiding drug policy. This report is therefore based primarily on the results of therapeutic efficacy studies.

## WHO GLOBAL DATABASE ON ANTIMALARIAL DRUG EFFICACY

The results of therapeutic efficacy studies conducted within national malaria control programmes and in research institutes in which antimalarial treatment efficacy was diligently monitored, were systematically collected and analysed for the WHO global database on antimalarial drug efficacy. As of June 2010, the database contained the clinical and parasitological outcomes of 3932 studies conducted between 1996 and June 2010 on *P. falciparum* malaria; however, only those studies conducted during the past 10 years and which met the inclusion criteria were included in this report. The analysis was thus based on 1120 studies representing 81 848 patients. The results are presented for monotherapy and for combination therapy, by

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