Epidemiology and surveillance: Changing the global picture of malaria—myth or reality?

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Abstract
The burden of malaria remains unacceptably high, and the greatest burden is borne by the African continent. There is now wide agreement on the control strategies and tools, and a considerable increase in global resources invested in malaria control efforts. However, challenges remain, especially with achieving the necessary population coverage with these interventions in order to change the epidemiology of the disease. Existing tools may not be optimal, and are liable to fail with time, just as previous ones did. Current global antimalarial efforts need to be underpinned by a strong research and development agenda. If all these factors are taken into consideration, reducing the burden of malaria would seem more like a reality than a myth in the foreseeable future.

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1. Introduction
Malaria currently receives global attention as both a health and development issue, to a greater extent than it has done in the past 50 years. This has resulted in greater financial investments in both malaria control and research. However, major challenges remain in translating these investments to a reduction in the disease burden.

2. The Global burden of malaria
Malaria remains one of the main global health problems of our time. As of 2004, 107 countries and territories report areas under the risk of malaria transmission, with about 3.2 billion people at risk.

Present estimates of clinical malaria episodes vary from 350 to 650 million annually (Snow et al., 2005, WHO, 2005). Over 60% and 90% of the clinical episodes and deaths from falciparum malaria occur in Africa south of the Sahara, where more than a million children mostly under the age of 5 years die from malaria each year (WHO, 2003).

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Malaria is also a major contributor to anemia in children and pregnant women leading to adverse birth outcomes (spontaneous abortions, stillbirth, premature delivery and low birth weight).

The economic burden of malaria is estimated at an average annual reduction in economic growth of 1.3% for those African countries with the highest burden with an estimated 12 billion USD lost to the African continent’s GDP annually (Sachs, 2001). Of the 4 species responsible for human malaria disease, *Plasmodium falciparum* causes most of the severe disease and deaths, and is most prevalent in Africa. Africa is by far the region with the greatest burden of malaria cases and deaths, most of it due to *P. falciparum* malaria. The malaria morbidity and mortality rates in Africa began an upward trend since the 1970s probably mainly due to an increasing parasite resistance to chloroquine and resistance of the vector mosquitoes to insecticides (Carter and Mendis, 2002; Korenromp et al., 2003; ter Kuile et al., 2004).

It is estimated that malaria in Asia contributes about 38% of the global burden of clinical malaria with an estimated 49% of it’s population at risk of malaria. About half of the malaria cases outside Africa is due to *P. vivax* malaria (Mendis et al., 2001).

3. Determinants of malaria burden

The prevalence of malaria is determined by multiple factors, accounting for a wide variation in the burden across the different regions of the world. One of the major factors being the intensity of malaria transmission. This is defined as the rate at which people get inoculated with malaria parasites from mosquitoes. It is usually expressed as the annual entomological inoculation rate (EIR) i.e., the average number of infectious bites by malaria-infected mosquitoes delivered to an individual human in the area in the period of one year. It is the EIR that largely determines the epidemiology of malaria and the pattern of clinical disease in that locality. At the upper end of the malaria transmission range is areas in tropical Africa, where EIRs of up to 500–1000 occur (Hay et al., 2000). At the lowest end of the range are EIRs of 0.01 or below as in the temperate climates of the Caucuses and Eastern Europe where malaria transmission is only barely sustained. Between these extremes are situations of unstable malaria such as in much of Asia and Latin America where EIRs fall below 10, often between 1–2, and situations of stable but seasonal malaria as in much of West Africa where the EIR range from 10 to 100. Other factors affecting the epidemiology includes the levels of socioeconomic development, and the capacity of the health care system to deliver anti-malarial interventions.

4. Strategies for controlling malaria

The last 50 years have seen some major global efforts led by WHO, to control malaria. Lessons learnt from the earlier campaigns of malaria eradication (Litsios, 1996) and more recently, the Africa Malaria Initiative informed a rethink of the control strategy and in 1998, led to the launch of roll back malaria (RBM) initiative. The overall goal of RBM is to halve the malaria mortality by 2010 and again by 2015 based on a strategy of:

a. early diagnosis and prompt and effective antimalarial treatment;

b. mosquito vector control (including the use of insecticide treated mosquito nets—ITN, indoor residual spraying-IRS);

c. intermittent preventive therapy in pregnancy (IPT);

d. prevention and controlling malaria epidemics;

RBM was underpinned by the following principles:

- Malaria will be addressed as human development issues as much as a health problem, and will be tackled through a high profile international health effort.
- Malaria control interventions will be delivered through existing health systems, strengthening them in the process, rather than through a ‘vertical’ disease control approach.
- Endemic countries would be in the lead of this effort that would be supported by a high level of political commitment.
- The effort will be a partnership between different sectors, e.g., the public and private, and the various stakeholders—Government, NGO’s, international, multilateral and bilateral agencies, and extending beyond the health sector.
5. Goals of roll back malaria

At a summit meeting of the African Heads of State, the first one to exclusively address a health issue (the Abuja Summit, 2002), the highest level of political support was pledged for this effort and the countries set for themselves, the following intervention coverage targets to achieve the RBM goal (WHO, 2000a):

- At least 60% of those suffering from malaria should be able to access and use correct and appropriate treatment within 24 h of the onset of symptoms.
- At least 60% of those at risk of malaria, particularly pregnant women and children under 5 years of age, should sleep under an ITN.
- At least 60% of all pregnant women who are at risk of malaria (especially those in their first pregnancies), should receive IPT.

6. Current state of antimalarial interventions

Recent surveys have found that approximately 50% of all fevers in African children are treated with antimalarial medicines. However, most of these treatments have been with antimalarial medicines to which there are high levels of parasite resistance (Deming et al., 1989; Ejezie et al., 1990; WHO, 2003a).

To achieve the target of reducing the morbidity and mortality of the disease, there is the need to take these proven interventions to scale for effective coverage. With the availability of new tools for the control of malaria such as the replacement of failing monotherapy with Artemisinin based Combination Therapies (ACTs) and long-lasting insecticide treated nets (LLIN), and a substantial increase in global financial investments for malaria control through mechanisms such as the GFATM, the principle challenge is to scaling up these interventions and ensure they reach the most vulnerable population groups, who are also the most difficult to access.

An overall view of the current levels of intervention shows that although between 2001 and the first quarter of 2005, 45 countries world wide (25 from Africa) have adopted ACTs as either first or second line treatment for malaria, only about 24 of these are actually deploying these medicines and most are still on a very limited scale.

7. What impedes progress?

Why does malaria persist as a major public health problem despite existence of interventions of proven efficacy? This is due largely to variability of malaria, with the problems and constraints of malaria control programmes varying between and within countries.

- Delivery of interventions and health care to the poor is a major challenge, and a particularly difficult one when working through weak health systems.
- Funds reaching countries are too little and too slow even with current mechanisms such as the Global Fund to fight HIV/AIDS, TB and Malaria.
- Malaria is a complex moving target with the parasite and the mosquito vector evolving to developing resistance to available medicines and insecticides respectively, and the resistance of human host to the behavior changes necessary for the effectiveness of available tools.
- Imperfect tools, insufficient knowledge to adapt available tools and to formulate new tools.

8. Changing the global malaria picture?

Reducing the burden and thus change the pattern of malaria particularly in Africa, requires the proper use and at the appropriate coverage and scale of use of control interventions which have proven efficacy and
effectiveness. However, major challenges exist which must be addressed.

8.1. Feasibility of going to scale

Financial constraints: though there have been a substantial increase in the monetary investment to malaria (both at country and international levels) it still falls below the estimated US$ 3.2 billion per year required for effective control in 82 countries with the highest burden of disease (WHO, 2003b). The end-users - these being mainly the very poor people, presently bear the main cost of antimalarial interventions (Ettling et al., 1994). Strategies to ensure that affordable prices are achieved through systematic cost reduction efforts and rigorous promotion of competition should be put in place, along with key strategies to improve affordability include making price information widely available; adopting generics based medicines policies; and reduction of duties, taxes, and mark-ups. The feasibility of making available targeted interventions at no cost to the most vulnerable groups should be explored.

Sustainable financing should be achieved by increased public funding; better use of out-of-pocket spending; expansion of health insurance schemes where possible, and targeted external funding (grants, loans, donations) where necessary.

8.2. Health System strengthening

The current coverage by the public sector health systems in most of the malaria endemic countries averages between 30–60% of the population at risk (Deming et al., 1989; Brinkmann and Brinkmann, 1991; Ruebush et al., 1995). There is the need to establish and strengthen infrastructure/systems to ensure that they have the capacity to deliver effective interventions, in particular to the vulnerable groups. This include the strategies for delivering treatment at the community or home level, and improving the patient referral systems to higher level of the health system when necessary.

8.3. Gap in knowledge and tools

Targeted basic and operational research is required to improve the understanding of the disease and thus allow for identifying new tools relevant to control, while at the same time improve the understanding of the deployment environment and adaptation of existing tools for their maximal impact. Some broad areas of research relevant to control of malaria are listed below:

8.3.1. Basic research

- Basic understanding of the disease and search for possible new tools to combat the disease.
- New knowledge in pathogenesis to facilitate better case management.
- Use of newly available genomic and proteomic data for identification of drug and insecticide target identification.
- Understanding the dynamics of the human and environmental factors that drive failure of available tools (drugs and insecticides).

8.3.2. Operational and implementation research

- Better understanding and refinement of tools to disease control situations in the field.
- Maximal impact of intervention strategy.
- Optimization of existing tools and their use.
- Understanding the deployment environment for improved deployment.
- Strategies for scaling-up intervention and improve early access.
- Enhancing adherence to tools.
- Tracking effectiveness of existing monitoring and evaluation tools.
- Optimizing or identification of indicators.
- Molecular markers for drug resistance (new antimalarial medicines).
- Identifying indicators with better sensitivity and specificity.
- Validation of indicators and adaptation to control situation.

Achieving the goals of reducing the burden of malaria will involve addressing all these issues. However, meeting these requirements will entail significant financial investments and a sustained effort.

9. Conclusion

The burden of malaria remains unacceptably high. There is now a wide agreement on the control strategies and tools, and a considerable increase in global resources invested in malaria control efforts. How-
ever challenges remain especially in achieving the necessary population coverage with the existing interventions in order to change the epidemiology of the disease. For relatively little cost of less than US$10, malaria can be both prevented and cured using existing tools, i.e., effective medications–artemisinin-based combination therapies (ACT), integrated vector control measures–including ITN (LLIN), and IPT in pregnant women. However, this is still well beyond the per capita health budget of most African countries. Existing tools may not be optimal, and are liable to fail with time, just as previous ones did. Current global antimalarial efforts need to be underpinned by a strong research and development agenda. If all these factors are taken into consideration, reducing the burden of malaria would seem more like a reality than a myth in the foreseeable future.

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