

Perspective

Malaria Vector Management: Where Have We Come From and Where Are We Headed?

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Every year, an estimated 300–500 million new infections and 1–3 million deaths result from malaria. More than 90% of these cases occur in sub-Saharan Africa, mostly among the poorest without access to health facilities.¹ All segments of the society experience malaria, but the greatest mortality and morbidity occur in children younger than 5 years of age and pregnant women. Malaria impedes economic development not only by causing premature death but also through lost/diminished productivity, absenteeism, huge medical costs, and negative impact on fertility, population growth, and a country's savings and investments.² It is therefore not surprising that the gross domestic product of countries where malaria prospers is up to 5-fold lower than in countries without severe malaria.³

Since the discovery of the relationship between *Anopheles* mosquitoes and malaria transmission, vector control has been widely used as a malaria control strategy. Before World War II, source reduction and other antilarval measures were the main pillars of malaria control. Although these methods contributed significantly to earlier campaigns to eradicate malaria in countries such as Italy, Israel, and the United States,⁴ on a global scale, malaria continued to be a serious problem. When the insecticidal properties of dichlorodiphenyltrichloroethane (DDT) were discovered by Paul Muller in 1939, the focus shifted from antilarval measures to adult mosquito control. The effectiveness of DDT against indoor resting mosquitoes led to the view that malaria could be eradicated through a combination of indoor residual spraying (IRS) and disease surveillance to detect and treat any remaining infections. In line with this notion, the Eighth World Health Assembly adopted the concept of malaria eradication resulting in the birth of the Global Eradication Program of Malaria in 1955.⁵ The consequent eradication of malaria in the United States, the former Soviet Union, and Europe reinforced the belief that global eradication was possible. However, because of inadequate development of health facilities, socio-economic factors, operational difficulties, resistance by vectors, and non-compliance by humans,⁶ complete interruption of malaria was not achieved. Some authors also argue that even in areas where malaria was successfully eradicated, it is the changing socio-economic standards and not DDT or environmental modification/source reduction that mostly contributed to this success.⁷ Obviously, poverty and disease are interrelated, but there are reliable data showing the impact of DDT on malaria and the resurgence that followed after partial or complete withdraw of DDT.⁸

The malaria eradication policy was re-evaluated in 1969, and the 22nd World Health Assembly recommended that alternative approaches for malaria control be developed in areas where malaria eradication was considered unfeasible. Subsequently, the Alma Ata conference in 1978 recognized the need to devise malaria control strategies based on local epidemiologic and socio-economic conditions. Lack of funding, however, prevented many countries from adopting this strategy. Moreover, lack of political goodwill and the advent of chloroquine (a cheap and effective drug)-resistant *Plasmodium falciparum* in Africa ensured there were enough gametocyte carriers within the human populations to sustain malaria transmission.

The increasing burden of malaria by the early 1990s triggered formulation of the Global Malaria Control Strategy in 1992. In this meeting, the wide spatial variability of malaria problem was highlighted, and the need for local analysis of malaria problem as a means of assessing sustainability and cost-effectiveness was recognized. Currently, The World Health Organization's Roll Back Malaria (RBM) founded in 1998 aims at halving deaths from malaria by 2010 and by another half by 2015. This is to be achieved mainly through 1) improved case management, 2) intermittent preventative treatment of pregnant women, and 3) widespread use of insecticide-treated bednets (ITNs), mainly targeting children younger than 5 years of age and pregnant women.

The recent reports that ITNs can significantly reduce child mortality, severe pregnancy-associated anemia, and low birth weight infants^{9,10} have reinforced their importance in malaria control among children and pregnant women. Because young children and pregnant women experience the greatest morbidity and mortality from malaria, it seems logical to target the two groups in the widescale use of bednets. However, we are concerned whether this is the best strategy that will help the RBM to realize its goal by 2010. As mentioned earlier, worker absenteeism and lost/diminished productivity are among the many ways in which malaria drains the economy. Generally, women and young children depend on the other segment of the population for support. Therefore, targeting children and pregnant women and ignoring the other segment of the population may well reduce child mortality and morbidity but cause a shift of malaria to the unprotected group. If this happens, it means that these people will lose days from work and will not be able to care for young children and pregnant women. In the end, we are likely to witness a significant reduction in child mortality but an increase or no change in economic burden caused by disease. In other words, a strategy that limits interventions to young children and pregnant mothers has "moral value," but tangible socio-economic value to the family and the community can only be realized when older children and all adults are also included and do not suffer from malaria-induced morbidity. In fact,

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data from the 1999–2003 World Health Reports show that the annual mortality from malaria is higher today than before the RBM initiative came to work, an indication of a failing campaign.¹¹ Therefore, there is need for various stakeholders to re-evaluate the current policy and make the necessary amendments before it is too late.

Considering the global prevalence of malaria and the ease with which it has evaded the global control and eradication efforts, we can arguably say it is one of the successful human diseases. In our opinion, it seems the fight against the increasing burden of malaria will require adoption of multiple approaches that have proven effective now or in the past. The results of larval control earlier in the last century were spectacular but were not good enough to rid the world of malaria—so were the DDT during World War II and ITNs currently. In view of proven effectiveness of each of these vector control approaches, it would be interesting to see how they would impact malaria burden if they were applied in an integrated fashion relying on field-derived evidence-based information about the vector, parasite, and human host: the so-called integrated vector management (IVM) philosophy. This concept involves combining several vector control tactics, which if applied separately or not used at the right time or place would not achieve the desired results, but together with the correct information are mutually complementary. An IVM program involving source reduction, IRS (especially with DDT), and ITNs is now practical after the recent approval by the World Health Organization of DDT use in malaria control where the vectors are still susceptible to this chemical¹² and the renewed interest in larval control. It is worth noting that challenges such as civil unrest, tribal wars, and lack of political goodwill need to be addressed, because effective malaria control is only possible under a stable civil setting.

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