Μεταπτυχιακό Πρόγραμμα Σπουδών

Διεθνής Ιατρική- Διαχείριση Κρίσεων Υγείας

Why is Malaria still killing so many people worldwide? Progresses and failures of the global Anti –Malaria campaign

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Περίληψη

Η ελονοσία αποτελεί ακόμη σήμερα ένα σημαντικό κοινωνικό, οικονομικό και αναπτυξιακό πρόβλημα το οποίο επηρεάζει άτομα, οικογένειες και χώρες. Μετά από μία περίοδο αμέλειας, η επιτακτική ανάγκη για έλεγχο της ελονοσίας έχει για μία ακόμη φορά αποσπάσει την προσοχή της διεθνούς κοινότητας υγείας. Η ανανεωμένη εστίαση στην εξάλειψη (παύση της μετάδοσης της ελονοσίας σε συγκεκριμένη γεωγραφική περιοχή) και την εκρίζωση (παγκόσμια καθολική εξαφάνιση του παράσιτου της ελονοσίας) έδωσε ώθηση σε νέες πρωτοβουλίες.

Σημαντική πρόοδος σημειώθηκε στην πρόληψη της ελονοσίας. Η κάλυψη με κουνουπιέρες επεξεργασμένες με εντομοκτόνο αυξάνεται με γρήγορους ρυθμούς σε πολλές χώρες (αύξηση κατά 42% στα μέσα του 2010). Αναπτύχθηκαν επιπρόσθετα μέτρα για έλεγχο του ξενιστή, όπως οι εσωτερικοί ψεκασμοί με εντομοκτόνο στις κατοικίες.

Επιπλέον πρόοδος επιτεύχθηκε και στην διάγνωση και την θεραπεία της ελονοσίας. Αυξήθηκε ο αριθμός των Rapid Diagnostic Tests (RDTs), των ανθελονοσιακών φαρμάκων, καθώς επίσης και το ποσοστό των ύποπτων περιστατικών που λαμβάνουν παρασιτολογικό διαγνωστικό τεστ από το 67% το 2005 στο 73% το 2009.

Συνολικά 11 χώρες παρουσίασαν μείωση μεγαλύτερη του 50% είτε σε επιβεβαιωμένα περιστατικά ελονοσίας είτε σε εισαγωγές και θανάτους από ελονοσία. Μία μείωση περίπου στο 50% στα επιβεβαιωμένα περιστατικά μεταξύ 2000 και 2009 παρατηρήθηκε σε 32 από τις 56 ενδημικές για ελονοσία χώρες εκτός Αφρικής. Το Μαρόκο και το Τουρκμενιστάν πιστοποιήθηκαν το 2010 από τον WHO ως χώρες που έχουν εξαλείψει την ελονοσία. Έχει εκτιμηθεί ότι τα περιστατικά ελονοσίας αυξήθηκαν από 233 εκατομμύρια το 2000 σε 244 εκατομμύρια το 2005 αλλά μειώθηκαν στα 225 εκατομμύρια το 2009. Ο αριθμός των θανάτων εκτιμάται ότι επίσης μειώθηκε από 985.000 το 2000 σε 781.000 το 2009.

Τα επενδυτικά κεφάλαια από διεθνείς πηγές αυξήθηκαν μεταξύ του 2000 και του 2009, ενώ παρέμειναν στα 1,8 δις US$ το 2010 –ποσό ουσιαστικά πολύ χαμηλότερο από το αναγκαίο χρηματικό ποσό για την επίτευξη των παγκόσμιων στόχων, που υπολογίστηκαν περίπου στα 6 δις US$ για το έτος 2010.

Και ενώ έχει παρατηρηθεί αξιοσημείωτη πρόοδος στην μείωση της ελονοσίας, υπήρξε αύξηση των περιστατικών ελονοσίας σε 3 χώρες το 2009 (Rwanda, Sao Tome and Principe, and Zambia). Η αύξηση αυτή τονίζει την εύθραυστη ισορροπία στον έλεγχο της ελονοσίας και την ανάγκη διατήρησης των προγραμμάτων ελέγχου ακόμη και όταν υπάρχει σημαντική μείωση των περιστατικών. Οι λόγοι που σχετίζονται με την «αναζωπύρωση» της ελονοσίας είναι διαφορετικοί και πολύπλευροι.

Καταρχάς η ελονοσία είναι μία πολύ-παραγοντική λοιμώδης ασθένεια. Προκαλείται από 5 είδη παρασιτικών πρωτοζώων του γένους Πλασμώδιο (*Plasmodium falciparum, vivax, ovale, malariae* και σε μικρότερη έκταση *knowlesi*) και μεταδίδεται στον άνθρωπο μόνο από το θηλυκό κουνούπι του είδους Ανωφελές (*Anopheles*).Υπάρχουν 30 διαφορετικά είδη κουνουπιών με διαφορετικές

αναπαραγωγικές και διατροφικές συνήθειες που καταλήγουν σε διαφορετικές ομάδες-στόχο στον πληθυσμό, με διαφορετικό φάσμα συμπτωμάτων και φυσικά με διαφορετική επιδημιολογική τοποθέτηση. Τα τωρινά προγράμματα ελέγχου και εξάλειψης της ελονοσίας αντιμετωπίζουν μία αξιοσημείωτη ανομοιογένεια στις δυναμικές μετάδοσης της ελονοσίας στις ενδημικές περιοχές που περιλαμβάνει διαφορές στα παράσιτα, στον ξενιστή, στον ανθρώπινο οργανισμό καθώς επίσης κοινωνικούς και περιβαλλοντολογικούς παράγοντες.

Οι περιορισμοί στις λειτουργικές επιχειρήσεις περιλαμβάνουν ελλιπείς υγειονομικές δομές, έλλειψη πολιτικής βούλησης, ανεπαρκείς οικονομικούς πόρους, έλλειψη ανθρώπινων πόρων και κατάλληλης εκπαίδευσης, υψηλό κόστος φαρμάκων και ακατάλληλα εργαλεία για την διακοπή της μετάδοσης της ασθένειας.

Σύμφωνα με μία σφαιρικά διαδεδομένη άποψη, η κατάλληλη χρήση των τωρινών σύγχρονων μέσων για την πρόληψη και αντιμετώπιση της ελονοσίας μπορεί να φέρει εξαιρετικά αποτελέσματα ειδικά όσον αφορά στην εξάλειψη της ασθένειας.

Summary

Malaria is an important social, economic and developmental problem affecting individuals, families, communities and countries. After a period of neglect, the urgent need to control malaria has once again engaged the attention of the international health community. A renewed focus on elimination (cessation of local transmission of malaria within a defined geographical region) and eradication (global disappearance of one or more species of malaria parasite) has spurred several new initiatives.

There has been an important progress in preventing malaria. Coverage with insecticide treated nets (ITNs) is increasing rapidly in some countries of Africa. Household ITN ownership having risen to 42% by mid-2010. Additional vector-control measures, including indoor residual spraying (IRS) and larval control have been deployed.

Furthermore progress has been achieved in the diagnosis and treatment of malaria. The number of Rapid Diagnostic Tests (RDTs) and ACTs procured is increasing, and the percentage of reported suspected cases receiving a parasitological test has increased from 67% globally in 2005 to 73% in 2009. Many cases still are treated without a parasitological diagnosis.

A total of 11 countries and one area in the WHO African Region showed a reduction of more than 50% in either confirmed malaria cases or malaria admissions and deaths in recent years. A decrease of more than 50% in the number of confirmed cases of malaria between 2000 and 2009 was found in 32 of the 56 malaria-endemic countries outside Africa, while downward trends of 25%–50% were seen in 8 other countries. Morocco and Turkmenistan were certified by the Director-General of WHO in 2010 as having eliminated malaria.

In 2009, the European Region reported no locally acquired cases of *P. falciparum* malaria for the first time.

It is estimated that the number of cases of malaria rose from 233 million in 2000 to 244 million in 2005 but decreased to 225 million in 2009. The number of deaths due to malaria is estimated to have decreased from 985 000 in 2000 to 781 000 in 2009.

The funds committed to malaria control from international sources have increased consistently between 2004 and 2009; funds remained at US$ 1.8 billion in 2010, substantially lower than the resources required to achieve global targets, estimated at more than US$ 6 billion for the year 2010.

While progress in reducing the malaria burden has been remarkable, there was evidence of an increase in malaria cases in 3 countries in 2009 (Rwanda, Sao Tome and Principe, and Zambia). The increases in malaria cases highlight the fragility of malaria control and the need to maintain control programmes even if numbers of cases have been reduced substantially. The reasons responsible for the resurgences of malaria can be different.

Malaria is not a single disease. The five Plasmodium species (*falciparum*, *vivax*, *ovale*, *malariae* and in less cases *knowlesi*) that cause human malaria are transmitted by more than 30 Anopheline mosquito species with diverse breeding and feeding habits, and result in different disease spectra, in different population target groups and epidemiological settings.

The current malaria control and elimination programs face remarkable heterogeneity of transmission dynamics of malaria in endemic areas, including differences in parasite, vector, human, social, and environmental factors.

Operational limitations include underperforming health services, lack of political will, insufficient financial, social and human resources, high cost of antimalarial drugs and for some areas, inadequate tools to interrupt transmission given an exceedingly high force of transmission. Each country presents different combinations of these problems and their determinants.

A widely held view suggests that with currently available tools, much greater gains could be achieved, including elimination from a number of countries. The best chance for successfully combating the disease requires a collaboration particularly of those responsible for control and research.

Introduction

Malaria is a tragic disease. It is preventable and curable at a comparatively low cost, and yet it continues to infect over 500 million people every year, killing over 1 million of them. It also levies a heavy economic toll; in some countries, the disease imposes a "growth penalty" of up to 1.3 percent of GDP per year (Roll Back Malaria, "Economic Costs of Malaria"). This is especially true in sub-Saharan Africa, where it disproportionately affects poor people who cannot afford treatment or who have limited access to health care. In these countries, fragile health systems expend a large portion of their resources on malaria—up to 40 percent of public health expenditures, 30–50 percent of inpatient admissions, and up to 60 percent of outpatient visits per year in some countries (Jeffrey Sachs and Pia Malaney, 2002: 680-85).

The unacceptable health burden of malaria and its economic and social impacts on development have made it a focal point of the international development agenda and the world has embraced an ambitious plan for scaling up malaria control that progresses towards country-by-country and regional elimination and the ultimate goal of global eradication (RBM Partnership, 2008). Over the past decade, resources and control efforts have intensified to a level not seen since the early days of the World Health Organization's Global Malaria Eradication Program (GMEP) in the late 1950s. Nonetheless, in 2009, with 3.28 billion people living in areas that have some risk of malaria transmission and about 1.2 billion people (one-fifth of the world's population) living in areas with a high risk of transmission (more than one reported case per 1,000 population per year), there were about 225 million cases of clinical malaria and 781,000 malaria-related deaths (Figure 1). Today, there is ongoing malaria transmission in 106 countries. Eighty-one of these countries are focusing on control, while 25 are in pre-elimination, elimination, and prevention of reintroduction phases; Morocco, the United Arab Emirates, and Turkmenistan have recently been certified as malaria free (World malaria report, 2010).

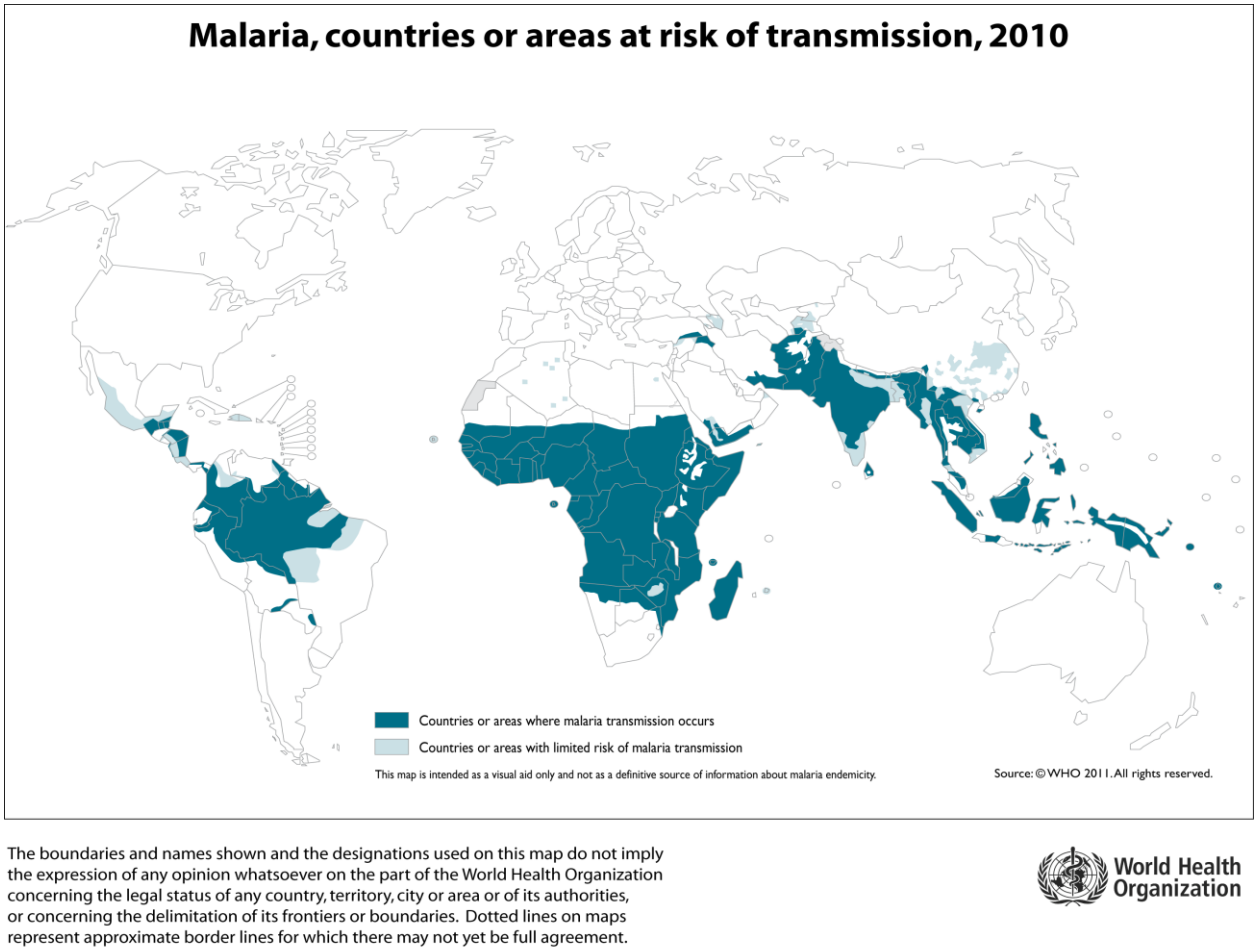

Figure 1: Countries at risk of malaria transmission in 2010 (by WHO)

Methods

We revised 40 articles 25 of which are from 2007 to 2011 and 11 from 2000 to 2005.

For the research we used the following key words: Malaria, Infectious diseases, World Malaria Day, Anti-Malaria Campaign, Global Health, Africa, mosquito, DDT, Malaria eradication programs, Malaria control strategies.

Historical background

The First Push for Eradication

During the first half of the 20th century, when 178 countries had endemic malaria, little progress was made, partly because efforts were disrupted by World Wars 1 and 2. However, from 1945 to 2010, 79 countries eliminated malaria (Wernsdorfer 1980: 1-93; Wernsdorfer et al, 2009: 95-107). Despite exponential population growth in malaria-endemic areas during the past 60 years, an estimated 50% of the world's population live in malaria-free areas, compared with only 30% in 1950 (Hay SI et al, 2004; 4:327-36, Guerra CA et al, 2008; 5: 38). Launched in the mid-1950s by World Health Organization (WHO), the first major international antimalarial campaigns focused on eradicating the disease in the Americas, Europe, Asia, and Oceania. In most of Africa, only pilot programs were introduced (Feachem et al, 2010; 376: 1566–78; Bate R, 2008; n.4).

At the outset, WHO's eradication campaigns enjoyed enormous success: by 1970, an estimated 1 billion people no longer lived in malaria-endemic areas, and malaria had been eradicated from rich countries (WHO, 1971). But just a few years later, the number of malaria infections was again increasing, driven by a resurgence of the disease in Africa and in countries previously declared free of the disease. "It had not been possible to pursue a vigorous campaign to eradicate malaria," WHO admitted in September 1971, because of "deficiencies in planning, management, administrative problems, and *particularly lack of government funds.*" (Lulu Muhe, Geneva: RBM, 2002).So WHO adopted "transitional" alternatives (WHO, Regional Office for South-East Asia, "Malaria: Historical Background").

Retrenchment and its consequences

In Southeast Asia, early eradication programs had significantly decreased malaria incidence. By WHO estimates, between 1950 and 1969, cases fell from a high of 110 million annually to nearly zero. But in the mid-1970s, coinciding with the abandonment of aggressive eradication campaigns, malaria incidence again spiked sharply. Alarmingly, the share of cases caused by the deadliest form of the malaria parasite increased from 19.6 percent of total cases in 1970 to 41.3 percent in 1991 (RBM, *Africa Malaria Report 2003*).

In Africa, pilot programs in the mid-1960s and 1970s had yielded spectacular successes. But with only a few exceptions, the disease remained unchecked in most of Africa, primarily because neither national governments nor international organizations were willing to invest the money or effort required.

Throughout the 1980s and 1990s, during which the international community did very little on malaria, the problem appeared to be worsening. Demographic surveillance systems in Africa indicated that the number of children dying from malaria rose substantially in eastern and southern Africa during the first half of the 1990s compared with the 1980s (there was little change in western Africa). In 1995, the United Nations (UN) General Assembly chastised the international community for

failing to act, noting that it was "deeply concerned by the development of more than three hundred million new cases of malaria annually and by the emergence of a new type of drug resistant malaria."(RBM vision, 2008).

Current situation: goals and targets for malaria control and elimination

From 2007, the United Nations -through the Millennium Development Goals (MDGs)- the World Health Assembly (WHA) and the RBM Partnership had consistent goals for intervention coverage and impact for 2010 and 2015 (Official list of MDG indicators, 2009). These goals have evolved in recent years, largely due to substantial progress in malaria control, with goals and targets becoming increasingly ambitious (Resolution WHA 58.2, 2005).

In April 2008 the United Nations Secretary-General (2008) put forward a vision of halting malaria deaths by ensuring universal coverage of malaria interventions by the end of 2010.

In September 2008 the RBM Partnership added three additional targets as part of the Global Malaria Action Plan as can be seen in Table 1.

United Nations, the World Health Assembly and the RBM Partnership targets to 2007	**RBM Partnership goals and targets from 2008**
Coverage of ≥ 80% by 2010 with four key interventions: • ITNs • IRS for targeted households • IPTp • Antimalarial medicines for patients with malaria.	Achieve universal coverage for all populations at risk of malaria using locally appropriate interventions for prevention and case management by 2010.
Reduce the number of malaria cases and deaths by ≥ 50% between 2000 and 2010 and by ≥ 75% between 2000 and 2015.	By 2010, halve the 2000 malaria burden and by 2015, reduce the number of cases by three quarters and the number of preventable deaths to near zero.
	Eliminate malaria in 8 to 10 countries by 2015 and afterwards in all countries that are currently in the pre-elimination phase. In the long-term, eradicate malaria worldwide by reducing the global incidence to zero through progressive elimination in countries.
MDG 4 target: By 2015 reduce by two-thirds the mortality rate among children under five.	
MDG 6 target: By 2015 have halted and begun to reverse the incidence of malaria and other major diseases.	

Table 1: GOALS AND TARGETS FOR MALARIA CONTROL AND THE MDGs (By WHO Malaria Report 2010)

In 2009, 23 countries in the WHO African Region and 42 in other WHO Regions had adopted the WHO recommendation to provide ITNs for all persons at risk for malaria, not just women and children; this represents an increase of 13 countries since 2008. A total of 83 countries, of which 39 are in the African Region, distribute ITNs free of charge (Global malaria control and elimination, 2008).
The Roll Back Malaria Global Malaria Action Plan (GMAP) and WHO have recently revised and updated the strategy and the steps for scaling up and sustaining malaria control (Figure 2).

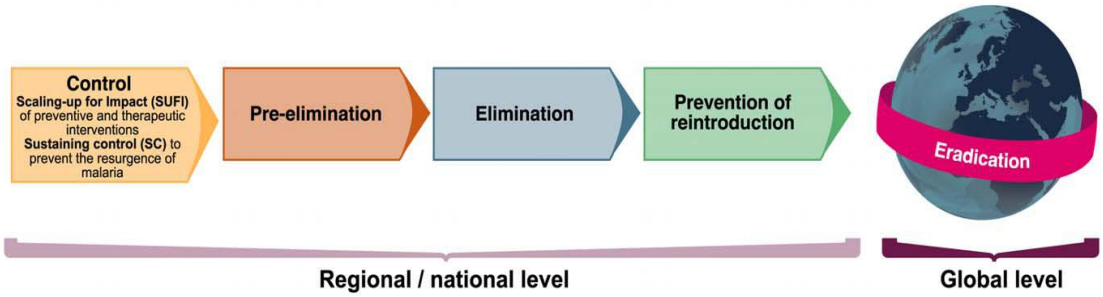

Figure 2: Epidemiological milestones. Image credit: Fusio´n Creativa.
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Malaria elimination

From a country perspective, interruption of local mosquito-borne malaria transmission, i.e. elimination of malaria, is the ultimate goal of malaria control. With rapid scale-up and sustained efforts, malaria transmission can be interrupted in low-transmission settings.
However, in areas of moderate to high transmission malaria transmission can be greatly reduced, but interruption of transmission is likely to require new tools. The WHO position on malaria elimination is set out in a recent meeting report (Moonen et al, 2010: 1592-1603) and is summarized below:
1. In areas of high, stable transmission, where a marked reduction in malaria transmission has been achieved (as may be indicated by slide positivity rates of less than 5%) a "consolidation period" should be introduced, in which: *(i)* control achievements are sustained, even in the face of limited disease; *(ii)* health services adapt to the new clinical and epidemiological situation with a lower case load and reduced levels of immunity; and *(iii)* surveillance systems are strengthened to allow rapid response to new cases. This transformation phase precedes a decision to re-orient programmes towards elimination.
2. Countries with low, unstable transmission (as may be indicated by less than 1 case per 1000 population per year) should be encouraged to proceed to malaria elimination, with *falciparum* elimination preceding *vivax* elimination where these species co-exist. Before making this decision, however, they should take account of the overall feasibility, including entomologic situation, programmatic capacity, fiscal

commitment, political commitment, and potential threats to success, including the malaria situation in neighbouring countries. Malaria elimination might require regional initiatives and support and will require strong political commitment.
3. Countries with an absence of locally acquired malaria cases for three consecutive years, and the systems in place to prove this, will be eligible to request WHO to initiate procedures to certify that they are malaria-free.

DEFINITIONS

Malaria control

Reducing the malaria disease burden to a level at which it is no longer a public health problem.

Malaria elimination

The interruption of local mosquito-borne malaria transmission; reduction to zero of the incidence of infection caused by human malaria parasites in a defined geographical area as a result of deliberate efforts; continued measures to prevent re-establishment of transmission are required.

Certification of malaria elimination

The official recognition of malaria-free status granted by WHO after it has been proven beyond reasonable doubt that the chain of local human malaria transmission by *Anopheles* mosquitoes has been fully interrupted in an entire country for at least 3 consecutive years.

Malaria eradication

Permanent reduction to zero of the worldwide incidence of infection caused by a particular malaria parasite species. Intervention measures are no longer needed once eradication has been achieved.

By World Malaria Report 2010

"The programmatic focus of a country seeking to control malaria as a public health problem involves the effective treatment of clinical malaria that is detected through passive surveillance integrated into the public health infrastructure and prevention of disease through high coverage with vector control measures. The main determinant of an elimination campaign is that, by contrast with a programme designed to maintain controlled low endemic malaria, it seeks to interrupt endemic transmission and prevent its re-establishment. The most important difference between acceptance of low-parasite prevalence and seeking to interrupt endemic transmission is the concentration of activities towards identification of residual transmission foci and intensification of efforts to eliminate the last few infections. Such an active campaign of case detection and response, coupled with directed vector control efforts, should root out not only clinical cases but also asymptomatic infections that potentially perpetuate transmission" (Petra Heyen, 2004: 30-34).

Nowadays, 109 countries are malaria free, 67 are controlling endemic malaria, and 32 are malaria-eliminating countries. There are, necessarily, discretionary judgments to be made with respect to marginal countries that could be categorised as either controlling or eliminating malaria.

Strategies for malaria control and elimination-Progresses and Failures

A. Vector control

A.1 Insect repellents

Most authorities recommend repellents containing N,N-diethylmetatoluamide (DEET) as the active ingredient. DEET repels mosquitoes, and other arthropods, and can be applied to the skin or clothing. Length of protection is also affected by temperature, perspiration, water exposure and abrasive removal. A significant health advantage of DEET is that only a few instances of toxic reactions have been confirmed, even though it has been much tested and widely used over a long period (Fischer and Bialek, 2002: 493-498).

A.2 Insecticide treated nets (ITNs)

In 2009, 39 of 43 malaria-endemic countries in the WHO African Region, and 44 of 63 endemic countries in other Regions reported having a policy of providing ITNs free of charge.
ITNs were being distributed to all age groups in 23 countries in the African Region, which represents approximately two-thirds of the countries responding to questions about ITN policy. The proportion of countries providing ITNs to all age groups is higher outside the African Region. In Africa almost all ITNs distributed are long-lasting ITNs (LLINs).
The number of nets delivered by manufacturers increased from 5.6 million in 2004 to 88.5 million in 2009 in sub-Saharan Africa (from 5.4 million to 78.5 million in countries in the WHO African Region (which does not include Djibouti, Somalia and Sudan). In the first three quarters of 2010 a further 106 million ITNs were delivered (figure 3).
Thus, in less than three years between 2008 and 2010 a cumulative total of 254 million ITNs were supplied and delivered to sub-Saharan Africa, enough to cover 66% of the 765 million persons at risk (assuming 2 people sleeping under each ITN).

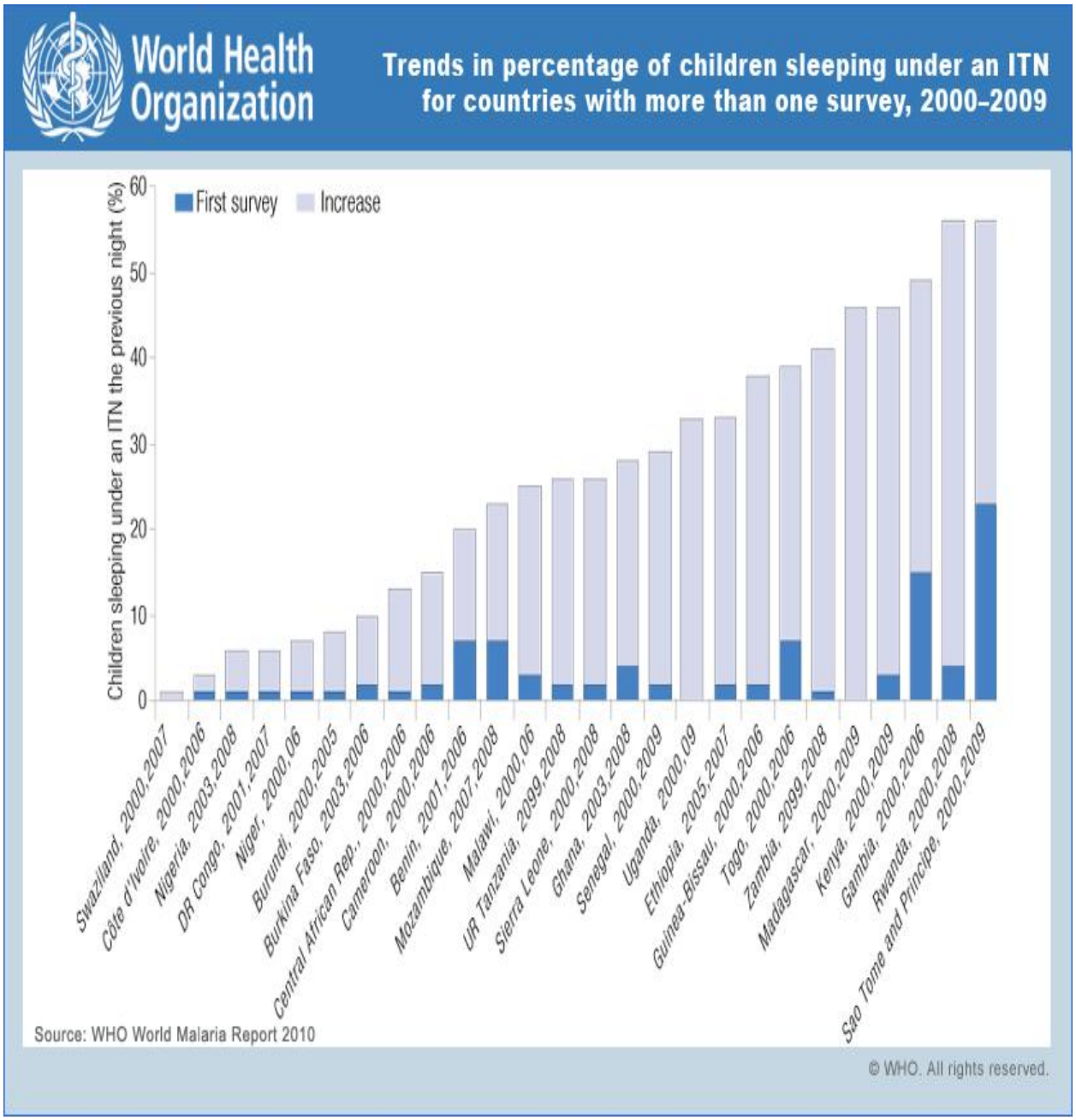

Figure 3: Situation and trends from 2008-2010. A cumulative total of 290 million insecticide-treated bed nets (ITNs) were delivered to Sub-Saharan Africa (By WHO).

There has been tremendous progress in increasing access to ITNs in the past 3 years, with more than 254 million ITNs delivered by manufacturers to countries in Africa between 2008 and the third quarter of 2010. Model-based estimates suggest that there has also been a substantial increase in the percentage of households owning at least one ITN from 27% in 2007 to 42% in 2010.

Overall 35% of young children slept under an ITN in 2010. Low rates of use reported in some surveys are primarily due to a lack of sufficient nets to cover all household members. Women are slightly more likely to sleep under an ITN than men (ratio women: men = 1.1) this is partly because pregnant women are more likely to sleep under an ITN than other women. There is no difference in usage rates between female and male children < 5 years of age (ratio girls: boys = 0.99). The percentage of children using ITNs is still below the World Health Assembly (WHA) target of 80% partly because up to the end of 2009, ITN ownership remained low in some of the largest African countries.

While the rapid scale up of ITN distribution in Africa is an enormous public health achievement, it also represents a formidable challenge for the future in ensuring that the high levels of coverage are maintained. Much of the progress to date has been achieved through mass campaigns and implementation through routine systems such as antenatal care and immunization programmes. Programmes need to be in place to ensure that those not benefiting from the campaigns also have access to nets.
Moreover, strategies need to be developed to replace the large number of ITNs that have recently been delivered. There is uncertainty over the extent to which ITN effectiveness decays over time, but the lifespan of an LLIN is currently estimated to be 3 years. Nets delivered in 2006 and 2007 are therefore due for replacement, and those delivered between 2008 and 2010 soon will be. Failure to replace these nets will increase the risk of a resurgence of malaria cases and deaths.

A.3 Progress in implementation of Indoor Residual Spraying (IRS)

IRS programmes have also expanded considerably in recent years, with the number of people protected in the African Region increasing from 10 million in 2005 to 73 million in 2009, a quantity which corresponds to protection for 10% of the population at risk. With the exception of India, the proportion of the population protected by IRS tends to be smaller than in the African countries which use IRS. The less extensive use of vector control may reflect the more focal nature of malaria outside Africa (Gogtay, 2004:5-6).

B. Diagnosis of malaria

In early 2010, WHO updated the recommendation on malaria diagnostic testing for suspected malaria to include children < 5 years of age. With this revision, all persons of all ages in all epidemiological settings with suspected malaria should receive a parasitological confirmation of diagnosis by either microscopy or Rapid diagnostic test (RDT). In 2009, 33 of 43 malaria-endemic countries in the WHO African Region and 45 of 63 endemic countries in other Regions reported having adopted a policy of providing parasitological diagnosis for all age groups. A total of 16 African countries are now deploying RDTs at the community level, as are 22 additional countries in other Regions.

As the incidence of malaria decreases through much of sub-Saharan Africa the need to differentiate malaria from non-malarial fevers becomes more pressing.

Countries that adopt universal testing will reduce their spending on Artemisinin-based combination therapy (ACT) but the savings will be offset by the cost of RDTs and alternative therapies and the increased time needed by health workers to examine patients. The total costs to the health system will depend on the cost of testing, the proportion of suspected malaria cases that are parasite positive, the sensitivity and specificity of tests, clinicians' adherence to test results, and the cost of treatment prescribed to parasite-positive and parasite-negative patients.

B.1 RDTs procured and distributed

The number of RDTs delivered by ministries of health has increased rapidly from less than 200 000 in 2005 to about 30 million in 2009, with most RDTs (44%) being used in the African Region followed by the South-East Asia Region (41%) and Eastern Mediterranean Region (11%). These totals, however, are likely to underestimate the quantity of RDTs distributed, as only 21 of the 43 endemic countries in the African Region reported these data in 2009. The number of patients receiving an RDT is generally lower than the number of RDTs delivered to health facilities, possibly because systems for reporting the number of patients tested with an RDT have not yet been well developed in many countries (Fukunda et al, 2011:S9).

B.2 Microscopic examination undertaken

The number of patients tested using microscopic examination fell from a peak of 165 million in 2005 to 151 million in 2009. The global total is dominated by India which accounted for 104 million slide examinations in 2005 and 94 million in 2009. Decreases in the number of patients examined by microscopy were reported in the Region of the Americas (50%), the European Region (20%) and the African Region (14%), while there was an increase in the Eastern Mediterranean Region (63%). Some of the decreases appear to be due to a reduction in case-loads, particularly in the American and European Regions, and to increased use of RDTs. However, these factors do not fully explain the decrease in patients examined by microscopy in some countries, where the data may reflect weakening of diagnostic systems or deterioration in reporting (figures 4 and 5).

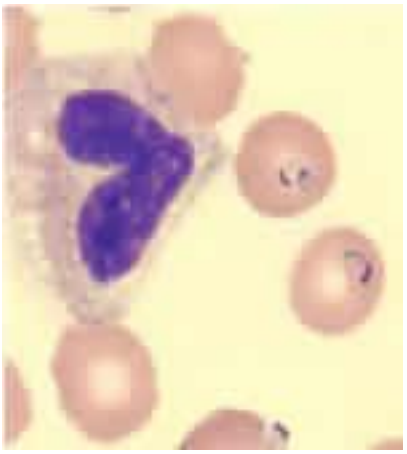

Figure 4: Blood smear stained with Giemsa, showing a white blood cell (on left side) and several red blood cells, two of which are infected with *Plasmodium falciparum* (on right side). (From CDC)

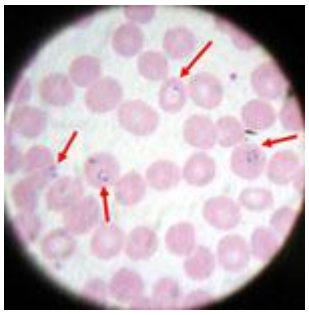

Figure 5: Blood smear from a patient with malaria; microscopic examination shows *Plasmodium falciparum* parasites (arrows) infecting some of the patient's red blood cells. (CDC photo)

The non-specific clinical presentation of most vector-borne diseases makes pathogen-level diagnosis difficult even in the hands of highly experienced clinicians. This emphasizes the need for highly trained laboratory scientists and technicians to use established diagnostic methods to enable informed individual and community prevention and treatment strategies (Gu et al, 2008:817-822).

Targeted characterization of infection rates and vector population densities maximizes the predictive power of field vector surveillance for human Vector Born Infections cases (Eisen et al, 2009: 1245-1255), helping decision makers prioritize vector control efforts and public awareness campaigns (Greenwood, 2010: S2).

C. Treatment of malaria and Chemo-prophylaxis

Chemoprophylaxis with an effective drug decreases deaths from malaria, prevents uncomplicated attacks of malaria, reduces the prevalence of anaemia and improves school attendance. Despite these impressive results, chemoprophylaxis in children has rarely been deployed on a large scale in malaria endemic populations (Thomas and Nchinda, 1998).

C.1 Artemisinin-based combination therapy (ACTs) adoption for malaria treatment

By the end of 2009, ACTs had been adopted as national policy for first-line treatment in 77 of 86 countries with *P. falciparum*; chloroquine is still used in some countries in the Region of the Americas. By mid-2010, 70 countries were deploying these medicines within their general health services, with varying levels of coverage.
The number of ACT treatment courses procured increased greatly from 11.2 million in 2005 to 76 million in 2006, and reached 158 million in 2009 (Figure 6).

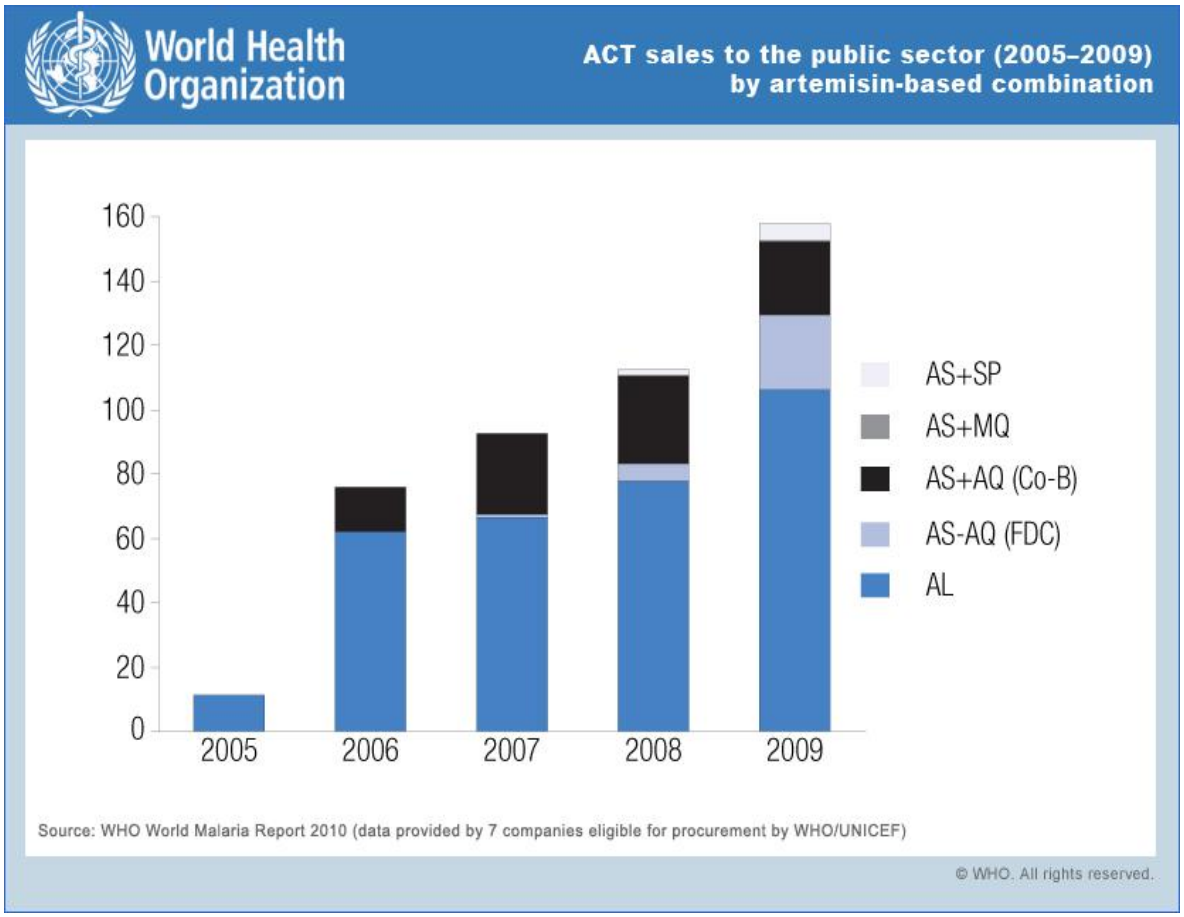

Figure 6: By the end of 2009, 11 Sub-Saharan African countries were able to provide enough ACT courses to treat 100% of their population.
AL= Artemether-lumefantrine AS= Artesunate, AQ= Amodiaquine MQ= Mefloquine SP= Sulfadoxine-pyrimethamine

C.2 Intermittent preventive treatment (IPT)

A total of 33 of 43 endemic countries in the African Region had adopted intermittent preventive treatment for pregnant women (IPTp) as national policy by the end of 2009, with two in the Eastern Mediterranean Region (Somalia and Sudan), and one in the Western Pacific Region (Papua New Guinea). No country has yet adopted a national policy of intermittent preventive treatment for infants (IPTi).

C.3 Antimalarial drug resistance

The use of oral artemisinin-based monotherapies threatens the therapeutic life of ACTs by fostering the spread of resistance to artemisinin. To contain this risk and to ensure high cure rates for *P. falciparum* malaria, WHO recommends the withdrawal of oral artemisinin- based monotherapies from the market and the use of ACTs instead, as endorsed by the World Health Assembly in 2007.

D. Vaccination

Vaccines can play a key role in multisectoral efforts to eliminate and eventually eradicate malaria. Current efforts to develop malaria vaccines are primarily focused on reducing infection rates, blocking replication of the parasite in the bloodstream, and the pathologic effects of the parasite in individuals, thereby reducing malaria morbidity and mortality in vaccinated individuals. Some of these vaccines, if highly effective, may also reduce transmission. These efforts need continued support and research (Breman et al, 2009:317-320).

E. Financing malaria control

Global resource requirements for malaria control were estimated in the Global Malaria Action Plan to exceed US$ 5 billion a year between 2010 and 2015 and US$ 4.75 billion between 2020 and 2025 (WHO report 2009).

- *External funding for malaria control***.** External funding has risen steeply in the past decade. However, commitments for malaria control appear to have stagnated in 2010 owing to smaller amounts requested in high quality proposals and thereby approved in Round 9 of the Global Fund malaria grants in 2009 (US$ 1.6 billion) compared to Round 8 in 2008 (US$ 2.9 billion).
- *Funding by national governments.* Spending on malaria control appears to have risen in all WHO regions in the countries that reported financial data. Large increases in donor financing therefore do not appear to have resulted in an overall reduction in the amount of domestic financing, although countries which had reduced their spending had received more external financing than those which increased their domestic spending.
- *Use of external and government funds.* External financing appears to be concentrated on programme activities, particularly the procurement of ITNs, antimalarial medicines and IRS. A larger proportion of national government financing is directed towards human resources but significant amounts are also spent on antimalarial medicines and IRS.
- *Funding per person by population size.* International disbursements for malaria increased between 2004 and 2008 to countries of all sizes. However those with smaller populations at risk continued to receive a greater amount of funding per person at risk than did the more populous countries. Outside the African Region the gap in funding between more populous countries and less populous countries has widened. In the WHO African Region the amount per capita provided to the least populous countries decreased in 2007.
- *Funding per person by phase of malaria control.* Countries in the pre-elimination and elimination phases (Mendis, 2009: 1-7) appear to spend more per person at risk of malaria than countries in the control phase. This finding is in line with other analysis which suggests that funding per person at risk will need to expand as countries progress towards elimination (Sabot et al, 2010:1604-1615). While the increased spending is partly due to larger amounts of external financing, government financing exceeds that of external financing in countries in the pre-elimination and elimination stages.

Discussion

Why is malaria still killing in the world?

Falciparum malaria is a complex disease with a patchy non-uniform distribution and clinical manifestations that vary from one area to another within an endemic-disease zone, often showing space-time clustering of severe malaria in the community (Snow et al, 1993:386-390) (Prudhomme et al, 2010: 545-555). The relationship between fevers, clinical disease, anaemia, and cerebral malaria remains the subject of current research. Persons with asymptomatic parasitemia constitute an important reservoir. The epidemiology of malaria (particularly the relationship between the clinical patterns of the disease in different locations, the pattern of severe disease, and causes of deaths due to malaria) needs future research (Kenrad et al, 2007: 6).

A number of factors appear to be contributing to the resurgence of malaria:

- Rapid spread of resistance of malaria parasites to chloroquine and the other quinolines.
- First-line treatments with ACTs were found to be 4–22 times more expensive (median price US$ 4.96) than the most commonly dispensed drug, which for all countries is a non-artemisinin treatment (median price US$ 0.37).
- Frequent armed conflicts and civil unrest in many countries, forcing large populations to settle under difficult conditions, sometimes in areas of high malaria transmission.
- Migration (for reasons of agriculture, commerce, and trade) of non-immune populations from non-malarious and usually low to other parts of the same country where transmission is high.
- Inadequate health infrastructures for managing treatment regimens and pursuing ongoing disease surveillance.
- Pressure from environmentalists against the use of DDT (which was then and remains today probably the most cost-effective insecticide).
- Changing rainfall patterns as well as water development projects such as dams and irrigation schemes, which create new mosquito breeding sites.
- Adverse socioeconomic conditions leading to a much reduced health budget and gross inadequacy of funds for drugs.
- High birth rates leading to a rapid increase in the susceptible population under 5 years of age.

- ❖ Changes in the behaviour of the vectors, particularly in biting habits, from indoor to outdoor biters.

- ❖ Climate changes: scientific evidence suggests that malaria varies seasonally in highly endemic areas. Malaria is probably the vector-borne disease most sensitive to long-term climate change (Feachem et al, 2009). Malaria thus provides several illustrative examples (based on historical studies) of the link between infectious disease and climate change, many of which have been described in the previous chapter.

- ❖ Local tradition and Health patterns: African populations have traditional perceptions about disease causation and management. Some diseases are considered suitable for management by western medicine, while others are considered the exclusive domain of local traditional health practitioners. Decisions to seek western medicine for any illness are often considered a last resort. Studies on health seeking behaviour, perceptions of malaria, treatments, and decision making for health care at the household level are crucial to malaria control.

- ❖ Education: Management of disease in the household devolves on mothers. Fever remains the most recognized symptom of malaria. Studies are ongoing to determine the proportion of fevers actually due to malaria. Mothers should be taught to recognize the symptoms of malaria, to provide home management, and to know when to refer cases to health centres. Four countries in Africa have developed and tested teaching guides to facilitate home management of malaria.

- ❖ Corruption in many countries and local communities.

- ❖ Lack of funds for research on neglected diseases.

Operational feasibility of malaria elimination assesses whether the interventions needed to achieve and sustain elimination can be implemented under local financial, demographic, political, and health-system constraints (Yekutiel, 1980).
The 108 countries that have eliminated malaria share important characteristics that can be measured as a proxy of operational feasibility, and which can be grouped into factors relating to:

- governance (political stability, government effectiveness, health expenditure)
- health systems (fully developed, functional general health services, high quality of training and personnel, immunisation coverage, coverage of antenatal care) and
- populations at risk (country totals and proportions at risk, accessing populations at risk) (Tatem et al, 2010: 1579-91).

Malaria as a Disease of the Poor

Tropical infectious diseases are the biggest killer of children and young adults globally, accounting for up to five million deaths each year (Review Report by WHO). The majority of these deaths occur in the poor less developed nations of Africa, Asia and South America. The disparity in health status probably results largely from differential access to drugs that are already available as well as to sanitation, safe water and housing, which influence the transmission of some diseases. The health disparity between rich and poor countries results in average life spans of 77 and 52 years respectively.

Malaria accounts for between <3% and 8% of all reasons for school absenteeism. Of preventable medical causes of absenteeism malaria accounts for a significant 13-50% of school days missed p.a (Brooker et al, 2000:183-186).

As a general rule of thumb, where malaria prospers most, human societies have prospered least. The global distribution of per-capita gross domestic product (GDP) in 1995, adjusted for purchasing power, shows a striking and unmistakable correlation between malaria and poverty.

Poverty is concentrated in the tropical and subtropical zones, the same geographical boundaries that most closely frame malaria transmission. The extent of the correlation suggests that malaria and poverty are intimately related. This correlation can, of course, be explained in several possible ways. Poverty may promote malaria transmission; malaria may cause poverty by impeding economic growth; or causality may run in both directions. It is also possible that the correlation is at least partly spurious, with the tropical climate causing poverty for reasons unrelated to malaria. It is certainly true that poverty itself can be held accountable for some of the intense malaria transmission recorded in the poorest countries. Personal expenditures on prevention methods such as bed nets or insecticides, increased funding for government control programs, and general development such as increased urbanization can reduce malaria transmission. Housing is also a major factor of prevention. The elimination of malaria from wealthier countries in the 1930s to 1950s was a result of both socioeconomic development and intensive anti-malarial interventions. The causation in the other direction, from malaria to poverty, also seems to be robust and powerful. Cross-country regression analysis estimating the long-term impacts of malaria on economic growth and development suggest the significance of the economic burden of the disease. This analysis finds that countries in which a high proportion of the population lived in regions of *P. falciparum* malaria transmission in 1965 had annual economic growth rates that were 1.3% lower than other countries over the period 1965–1990, even after controlling for the other standard growth determinants used in macroeconomic analyses. These other determinants include levels of human capital, life expectancy, initial income, and macroeconomic policy indicators of various kinds as well as geographical factors such as tropical location that could be simultaneously influencing malaria and economic growth. Because this shortfall refers to the annual growth rate, the long-term effect on the level of gross national product (GNP) per capita is the cumulative effect of an annual reduction in growth. GNP per capita in a malarious country is less than half of that in a non-malarious country (Gallup and Sachs, 2001: 85-96) (RBM 2001-2010) (Sachs and Malaney, 2002: 680-685).

Conclusions

Socioeconomic development and the fight against malaria have profoundly shaped the geographical distribution of the disease in the past century (Hay et al, 2009: 6) (Hay et al, 2004: 327-36) (Gething et al, 2010: 342-46). Major international agencies and many governments are now aiming for elimination of the disease (Feachem and Sabot, 2008: 1633-35). The decision to move to an elimination agenda within a country is complex and the consequences of an ill-informed decision are serious (Yekutiel, 1960: 669-83).Examination of lessons learned from past successes and failures can provide valuable insights into feasibility of elimination globally.

A strategy combating malaria should be both country-led and internationally supported. *Individual countries* are often best positioned to know which actions are most appropriate depending on the populations at risk, the level of transmission, the degree to which interventions are in place, and the capacity of countries' health systems to take these efforts further. The international community, on the other hand, plays a critical role by supporting countries and providing tools. Through cooperation, countries and international partners can achieve the near-term goals of mortality and morbidity reduction by 2010 and 2015 as well as the longer-term vision of worldwide eradication (WHA, 2008).

Acknowledgements

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