

# **The Impact of Insecticides and Nets Taxation on the Public Health and Economic Burden of Malaria**

Conceptual Framework and Literature Review

For the Development of an Advocacy Model

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## Acronyms and Abbreviations

CM	Cerebral Malaria
DHS	Demographic Health Survey
GDP	Gross Development Product
IQR	Inter Quartile Range
ITN	Insecticide-treated nets
LBW	Low Birth Weight
MICS	Multiple Indicators Cluster Survey
RBM	Roll Back Malaria
SMA	Severe Malaria Anemia
WHO	World Health Organization

## Executive summary

The 2001 Abuja Declaration on Roll Back Malaria in Africa includes a statement committing participating Governments to reducing taxation on nets, netting and related insecticides. Such measures are expected to increase the utilization of insecticide-treated and untreated nets and reduce the public health and the economic impact of malaria. This report presents a conceptual framework and the related literature review as a contribution to the development of a computer-based advocacy model, hereafter called the Model, which specifies these relationships.

Using data on the tax structure and price elasticity, Simon (2001) proposes a methodology to estimate the potential reduction in the retail price of treated and untreated nets and the corresponding increase in their purchase. No study examined the impact of the reduction in taxation of bed nets on their accessibility. Many behavioral and other factors also determine the purchase and use of bed nets and need to be taken into account when assessing the impact of reducing their taxation.

The public health impact of bed nets depends on their effectiveness on various clinical outcomes and on the proportion of the population using them properly. Lengeler (2004) provides summary measures of effectiveness of insecticide-treated and untreated nets in stable and unstable malaria endemic areas among non-pregnant populations. Ter Kuyle (2004) provides measures of effectiveness of ITNs among pregnant women in stable malaria areas. The most commonly available sources of data on coverage of children under five with treated and untreated nets are the large national demographic and health surveys but smaller local surveys including such data become more and more common.

In a review of the public health impact of malaria in Africa, Snow (2003) provides estimates of key malaria epidemiological parameters by “malaria risk strata” that are most relevant to the Model. The main clinical outcomes in this review are uncomplicated episodes, severe malaria, anemia, malaria in pregnancy (including anemia, low birth weight and infant and maternal mortality), child growth and development and death. Chima (2003) provides the most complete and recent review of the economic impact of malaria, with a focus on microeconomic studies of their direct (preventive, curative and others) and indirect (time lost to illness, death and care) costs.

### *Recommendations:*

- AED/NetMark should maintain an explicit conceptual framework and literature review when further developing and testing the Model with its intended clients, users and audience.
- The developers of the Model should clearly document the values chosen for each parameter and provide a range of options to the users. The Model should include sensitivity analyses as part of the analyses available to the users.
- AED/NetMark should consider developing the Model for wider advocacy applications in the context of Roll Back Malaria.

# 1 Introduction

This literature review has been conducted to contribute to the design and development of a computer-based advocacy model (hereafter called the Model) to illustrate the potential impact of reducing taxes and tariffs on bed nets, netting and related insecticides on the public health and economic impact of malaria.

The premise of the review was that the Model would build on two other advocacy models developed and used by the Academy for Educational Development, REDUCE-ALIVE and PROFILES, which include data and methods on:

- Productivity loss calculations using the human capital approach;
- Relationship between anemia and working capacity;
- Relationship between maternal anemia and low birth weight;
- Relationship between Low Birth Weight (LBW) and infant mortality.

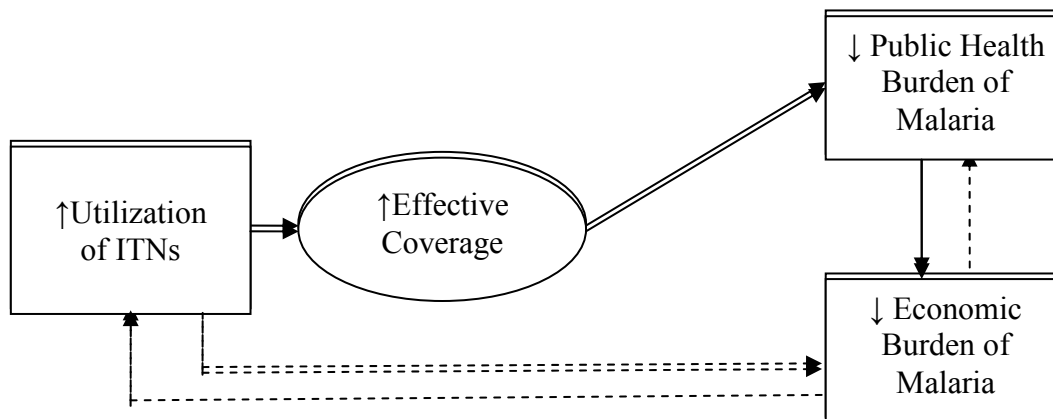
Given the specialized and rapidly evolving nature of the topic, I first explored the World Wide Web at large to identify the most recent relevant research and projects. I started from known websites such as the Roll Back Malaria and other related sites. I then used various search engines and followed the relevant links. The specific sites explored are listed in Appendix 1 with brief comments on the findings. I then conducted Pubmed searches using the term malaria in combination with economics, productivity, cost of illness, cost, pregnancy, anemia and nets. I first restricted the searches on reviews published in the last 10 years, then identified references in these reviews that contained the most influential and relevant studies. All references selected in the process are listed in Appendix 2 by alphabetical order of authors. Only a fraction of those are specifically referred to in this document.

## 2 Conceptual framework

The Abuja Declaration on Roll Back Malaria (RBM) in Africa includes a statement on the commitment of the Governments of the 44 participating countries to remove or reduce taxation on bed nets, netting and related insecticides (WHO 2003). Such measures are expected to increase the utilization of ITNs and reduce the public health and the economic burden of malaria. A critical factor in the quantification of these causal relationships in a given setting is the effective coverage of ITNs.

Figure 1 represents the basic structure of the Model, which is also used to organize the literature review. Each box represents a complex set of relationships that the Model will simplify and specify. The thick arrows represent the primary causal pathway between an increase in utilization of bed nets and a decrease in the public health and economic burden of malaria. The dotted arrows represent secondary relationships that are ignored in this review.<sup>1</sup>

**Figure 1 Basic structure of the Model**



*Note:* Thick arrows represent the primary and the dotted arrows represent the secondary causal pathways.

<sup>1</sup> Examples of secondary causal relationships are a decrease in expenditures on other personal protective measures resulting from an increase utilization of bednets, and the effect of reduced economic burden of malaria on health and utilization of bednets (reverse causation).

The Model must specify the main components and relationships above for the various target populations commonly defined for malaria control on the basis of their specific clinical manifestations and epidemiology:

1. Pregnant women
2. Children 0-4 years
3. School age children 5-14 years
4. Adults 15 years and older

Finally, the Model must specify these components and relationships on the basis of the malaria endemicity at the local level as determined by the type of parasite, vector population and other environmental and social determinants (Bremner 2001). As a first step in the development of the Model, only three types of malaria endemicity for *Plasmodium Falciparum*, the parasite responsible for more than 90% of the malaria burden in Africa, are considered for each population of interest:

1. No malaria transmission
2. Unstable malaria (highly seasonal or epidemic-prone areas)
3. Stable malaria (endemic areas)

The population distribution across these malaria risk strata in Africa is available by country and by age (0-4, 5-14, and 15+ years) in the MARA database.<sup>2</sup> Typically, populations living in areas with unstable malaria do not develop strong immunity and are at risk of severe malaria when infected at any age. By contrast, populations living in areas of stable malaria<sup>3</sup> are continuously exposed to malaria infection and develop specific immunity that protects them from severe malaria or even parasitemia. In such context, the burden of malaria is on very young infants (as a result from premature birth or low birth weight, growth faltering, severe anemia, and death) and pregnant women (increased morbidity and anemia due to pregnancy-related decrease of previous immunity, particularly among low parity women). This simplification of the complex nature of the malaria transmission and epidemiology is commonly used for policy and programming purposes (WHO/UNICEF 2003, Snow 2003) and is further discussed in section 5.

Table 1 characterizes the three tiers of the Model introduced above: (1) the basic structure of the Model; (2) the target populations, and (3) the type of endemicity. For each type of malaria endemicity and target population, the Model must specify the various outcomes of malaria infection and its economic burden and how these are affected by utilization of bed nets and its determinants including taxes and tariffs.

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<sup>2</sup> See MARA website (<http://www.mara.org.za>) or MaraLite CD.

<sup>3</sup> Unstable malaria areas are characterized by a parasite rate  $\leq 25\%$  or an entomological inoculation rate below 1.

**Table 1 The three tiers of the Model**

(1) Endemicity	(2) Target population	(3) Basic structure
No malaria	Pregnant women	<i>Utilization</i>
Unstable malaria	Child (0-4 years)	Determinants, including taxes and tariffs
Stable malaria	School age (5-14 years)	<i>Effective coverage</i>
	Adults (all others)	Coverage Effectiveness <i>Public health burden</i> Uncomplicated episodes Severe malaria Anemia Malaria in pregnancy Child growth and development Death <i>Economic burden</i> Direct costs Indirect costs Coping strategies and other social adaptations

Many other important factors are not specifically included in the Model at this first stage of its development:

- The presence of other parasites than *Plasmodium Falciparum* (*Vivax*, *Ovale* or *Malariae*)
- Intensity of transmission within stable malaria endemic areas (Snow 1999). If necessary, this can be specified by the age-specific prevalence of malaria infection.
- The seasonality of malaria transmission and its impact on the epidemiology and the economic consequences of malaria.
- The interactions between malaria and nutritional status (Caulfield 2003), and between malaria and other infectious diseases such as HIV infection (Corbett 2002; Steketee 2001; Molineaux 1997).
- The presence of other interventions implemented at the same time as ITNs (effective treatment; chemoprophylaxis or intermittent preventive treatment, focused in-door residual spraying), which can change the impact of the use of ITNs.
- Cost of treatment of side-effects such as adverse effects of antimalarials, HIV risks through blood transfusions (see Figure 3)
- Socioeconomic factors such as poverty, income, urban/rural residence, housing, occupation and education, which can have an impact on malaria morbidity and mortality, access to and use of preventive and curative services, and on the economic and social consequences of malaria (Barat 2003; Worrall 2002).

These factors are not further discussed in this review but may be taken into account in the Model at a later stage.

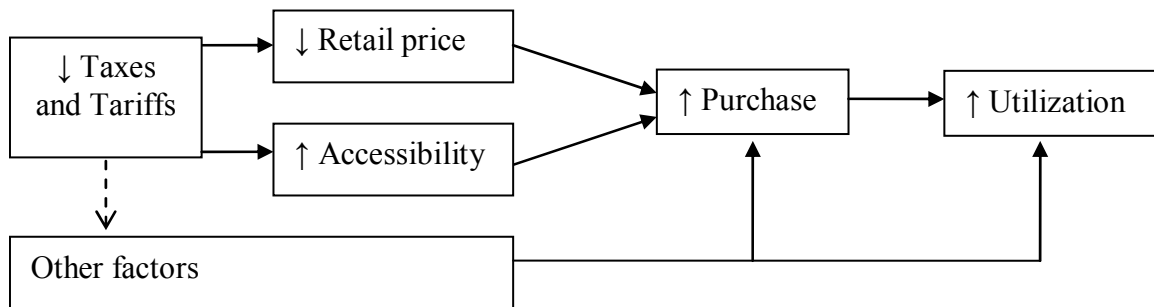


### 3 Utilization

Although ITNs and even untreated bed nets are demonstrated to reduce morbidity and mortality due to malaria among children under five and pregnant women, their utilization remains very low in many malaria endemic areas (WHO/UNICEF 2003).

The various determinants of utilization of ITNs and the potential impact of their taxation are represented in Figure 2 and discussed in this section. The removal or reduction of taxes and tariffs on ITNs, netting materials and insecticides is expected to increase utilization of ITNs through the reduction of their retail price and the increase of their accessibility, both mechanisms increasing their purchase. Purchase and utilization of ITNs are also determined by other factors.

**Figure 2 Determinants of utilization of ITNs including taxes and tariffs**



#### 3.1 Taxes and Tariffs

In 2001, RBM created a database on tariffs and taxes on bed nets and insecticides and on the status of the related policy reforms in 35 sub Saharan African countries (Simon 2001). This information is difficult to obtain on a regular and systematic basis because of the lack of standardization of the various products codes across Ministries of Commerce and because of the somewhat sensitive nature of this information typically not easily available to the public. An update of the “policy changes” since the Abuja Declaration is available for 18 countries for 2003 (WHO 2003) but no update of the country- and product-specific tariff and taxes is available. The review of the old and new tariffs and taxes in the seven countries where policy changes were effected by 2002 show that the structures of these taxes and the changes adopted vary by country (Simon 2002).

The process that leads to these policy changes and to their implementation and outcomes has been studied in three countries that effected such a change (Tanzania, Nigeria and Mali) and in two countries that did not (Ghana and Senegal) (Malaria Consortium 2002). Overall, the main lessons learned from this early experience are that:

- Local contexts and political systems are major determinants of policy change and implementation but regional policies also play a role.

- The pace of change in policies<sup>4</sup> is determined by broad-based support and by national policy champions;
- The achievement of the outcomes expected from policy changes require clearly formulated implementation strategies and continuous support, monitoring and evaluation;
- Reduction in taxation may stimulate importation at the expense of local production and longer term sustainability.
- Partial reduction in taxation limits the overall impact on health and disadvantages small businesses.

### **3.2 Retail price and accessibility**

Given the paucity of data on the market for ITNs and related materials in sub Saharan Africa, RBM developed a methodology to easily collect such data and conduct market analysis at the national level. RBM also developed and made available a web-based database to facilitate the exchange of such data collected in various countries, the application of standardized analyses, and the comparison of results across countries and over time (Larson 2002a).<sup>5</sup> The data collected so far through the proposed system is not available yet, except for that collected and used to analyze the retail market for bed nets in Kenya (Larson 2002b).<sup>6</sup>

This type of market analysis provides some of the data needed to estimate the potential impact of a reduction in taxes and tariffs on retail prices of ITNs. Simon and colleagues (2002; 2001) propose a methodology to calculate the potential reduction in retail prices of ITNs using two hypothetical situations, one in which ready-to-use ITNs are imported or one in which bed nets and insecticides are imported and local manufacturers produce the ITNs. Clearly, each country may have various combinations of these two and other scenarios at the same time and country-specific analyses are needed to disentangle and quantify the structure of their market for bed nets. The proposed formula and input data needed are otherwise appropriate for use in the Model.

No study of the impact of reduction of taxation of nets and insecticides on their accessibility has been found.

### **3.3 Purchase**

There is not much market data on the responsiveness of the demand for bed nets to their retail prices, but other types of data suggest that the demand for bed nets is price inelastic, that is, a percent decrease in price results in a smaller percent increase in purchase (Simon 2002).<sup>7</sup> One contingent valuation study<sup>8</sup> in Ethiopia found a point elasticity estimate for untreated nets of about -0.5 (Cropper 1999). Other studies of the re-

<sup>4</sup> The time needed to achieve a change in policy varied from one year in Mali to 5 years in Tanzania.

<sup>5</sup> See <http://dcc2.bumc.bu.edu/cih/>.

<sup>6</sup> After an analysis of the supply of bednets (very little import; local manufacturers producing 20 different brands, only two treated with insecticides; one additional brand produced and imported from Tanzania by PSI), the authors detail the availability and prices of bednets and insecticide treatments in this country.

<sup>7</sup> In absolute value, elasticity  $E = (Q2-Q1/Q1)/(P2-P1/P1) < 1$ .

<sup>8</sup> Survey-based approach for eliciting consumer's monetary valuation for hypothetical services or benefits, primarily their willingness-to-pay.

treatment rates suggested an elasticity of -0.75 in the Gambia after the introduction of a fee for insecticides (Cham 1997) and an elasticity of -0.16 when comparing the treatment rates in two villages in Senegal where treatment was offered at different prices (Zimicki 1996). Simon and colleagues (2002) use values of elasticity to price for bed nets between -0.5 and -1.5 in their various scenarios. Overall these findings of relatively low price elasticity of bed nets suggests that at least in the short-run, programs promoting their use should certainly not overlook the non-price factors of their utilization.

A more recent study in Nigeria, also based on willingness-to-pay, found similar mean values of price elasticity for ITNs (<1) as those discussed above, but higher values at actual selling prices, with values ranging from 2.1 in the highest to 3.15 in the lowest income quintiles (Onwujeke 2004). These finding must be confirmed with market data but suggest a quite high elasticity for ITNs and therefore the importance of price factors in determining their utilization, particularly among the poor.

Lower wholesale prices from lower tariffs and higher potential for profit from lower taxes may encourage a larger number of retailers to enter the market, thereby increasing accessibility and decreasing non-price costs of ITNs such as travel to points of sales. A larger number of retailers may also increase competition and ultimately decrease retail prices and increase purchases. No study or data was found on this otherwise important pathway to the increase in purchase and utilization of ITNs, which thus may have to be modeled using marketing data and approaches developed for other products.

### **3.4 Other factors**

The impact of removing or reducing taxation on ITNs also depends on other determinants of their purchase and utilization. These determinants include knowledge of the benefits of ITNs, preferences for bed nets as opposed to other malaria control measures and other goods, the availability of free or subsidized nets, etc. All these factors can be influenced by malaria control programs that promote utilization of ITNs, which typically combine targeted public subsidies<sup>9</sup> with stimulation of the commercial sector through large scale promotion (Hanson 2004).

### **3.5 Utilization**

Once purchased, bed nets may or may not be used by the most vulnerable members of the households (pregnant women and children under five), maintained and retreated properly, and used systematically when transmission of malaria occurs, which typically depends on seasons and the time of the day. Clearly, behavioral factors among ITNs owners influence the effectiveness of their use and must be taken into account when commonly available coverage data are used to infer impact on malaria morbidity and mortality based on estimates of effectiveness from control trials or intensively supported programs. This is further discussed in the next section.

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<sup>9</sup> Delivery of subsidized (free or lower price) nets to high-risk or vulnerable groups (pregnant women and children under five) through direct distribution in health centers, provision of vouchers, or other mechanisms (WHO 2003--workshop report).

## 4 Effective coverage

The effectiveness of an intervention like bed nets is the proportionate reduction in specific clinical outcomes among defined populations (children under five, pregnant women, others) using that interventions under programmatic, field, or routine conditions. In the case of an outcome measured by its “risk” (incidence, prevalence, or mortality) for instance, the effectiveness is defined as:

$$Effectiveness = \frac{R_0 - R_1}{R_0} = 1 - \frac{R_1}{R_0} = 1 - r$$

Where:

- $R_0$  = Risk in population without intervention
- $R_1$  = Risk in population with intervention
- $r$  = Relative risk (rate ratio)

The effectiveness of an intervention in a public health program may be higher or lower than its efficacy, that is, the same measure obtained in conditions avoiding all or most biases and confounding factors and minimizing random errors. These conditions are typically created in randomized controlled trials. The difference between effectiveness and efficacy can be due to various biological reasons such as synergistic or antagonistic effects of other factors (intensity of transmission; nutritional deficiencies), the presence of other effective interventions (smaller effect if adequate treatment is available), or a curvilinear dose-relationship (such as that resulting from the community effects obtained when bed nets coverage reach 60%) (Victora 2004). These differences can also be due to the quality of the implementation of the intervention like in the examples above (see section 3.5).

The effectiveness of an intervention implemented in a population, or impact,<sup>10</sup> is usually considered as proportionate to the coverage of the population using the intervention:

$$Impact = Effectiveness * Coverage$$

The product of the coverage and of the efficacy of an intervention is called here the “effective coverage” to highlight the fact that the application of the formula above to calculate the impact of a program in a specific context requires data on coverage that correspond to the values of effectiveness or efficacy available from intervention trials or other studies.

Both the effectiveness and the coverage can be adjusted as necessary to ensure that the two measures correspond to each other. Examples of such adjustment factor are the proportion of anemia due to malaria, as discussed in section 5.3, the proportion of

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<sup>10</sup> Lengeler and Snow (1996) use the terms individual effectiveness and community effectiveness, respectively, instead of effectiveness and impact as used here in a paper discussing issues of efficacy and effectiveness measurements with respect to insecticide-treated bed nets.

pregnant women with pregnancy 1 to 4, or some factors taking into account the proper use of ITN or compliance.

Combining the two formulas above and including an adjustment factor, the resulting risk in the population can therefore be expressed as follows:

$$\text{Impact} = \text{Effectiveness} * \text{Coverage} * \text{Adjustment} = \frac{R_0 - R_1}{R_0},$$

and the risk in the population with the intervention:

$$\begin{aligned} R_1 &= R_0 * (1 - \text{Effectiveness} * \text{Coverage} * \text{Adjustment}) \\ &= R_0 * (1 - \text{Coverage}) + R_0 * \text{Coverage} * (1 - \text{Effectiveness} * \text{Adjustment}) \end{aligned}$$

where *Adjustment* is the product of the adjustment factors for effectiveness and coverage.

This last formula is used in the Model to specify the risk of each clinical outcome of interest for each target population, epidemiological settings and scenario of coverage of bed nets. The difference between the risks under a scenario of higher and that under a scenario of lower coverage of bed nets is considered as the potential “gain.” This formula can be expanded to take into account the coverage of the population with nets of varying effectiveness such as nets or curtains, untreated or treated with various insecticides. Assuming that each person is only protected by one type of net (additive model), the risk in the population can then be calculated as:

$$R_1 = R_0 * \sum_i \text{Coverage}_i * (1 - \text{Effectiveness}_i * \text{Adjustment}_i)$$

where *i* is the type of net.

In addition to the values of effectiveness and coverage discussed below, the estimate of  $R_1$  clearly depends on the values chosen for  $R_0$ , the risk in the population without intervention. The available values of  $R_0$  for various outcomes of malaria are discussed in section 5. Using the formula above makes various assumptions concerning the values of  $R_0$  such as that it represents the risk in populations without intervention and that it is independent from the coverage of the intervention in the population of interest, which is rarely the case in public health programs. Although there are relatively simple ways to account for deviations from these assumptions, these are not further discussed here.

#### **4.1 Effectiveness**

Most of the research on the efficacy of bed nets has been done on the populations most vulnerable to malaria, that is, children under five and pregnant women. Various clinical outcomes have been measured for which effectiveness or efficacy values are available. There probably is no definite non-arguable value that can be used in any context and good judgment using all evidence available is needed to choose the best value for a given application of the Model.

The most recent and authoritative review of the efficacy of bed nets to prevent malaria among non-pregnant-only<sup>11</sup> populations is provided by Lengeler (2004) as part of the Cochrane Collaboration project. The review builds on the series of previous versions (Lengeler 2000, 1998) and adds most recent studies, primarily the Western Kenya insecticide-treated bed net trial (Nahlen 2003). Only 22 out of 113 studies of the effectiveness of nets are included in these estimates, one of the key criteria being to have a cluster or individual randomization design. Table 2 presents the measures of efficacy reported in this review for the outcomes of interest for the Model by epidemiological strata. Values of efficacy for insecticide-treated nets versus no nets and versus untreated nets (control) are provided when available. The number of studies included in the calculation of the estimates is also provided.

**Table 2 Efficacy of insecticide-treated bed nets on various malaria outcomes in stable and unstable malaria areas**

Malaria Outcome	Endemicity	Control	Efficacy	# of studies (comment)
All-cause child mortality	STABLE	No nets/curtains	17%	4
	STABLE	Untreated nets	23%	1
Malaria child mortality	STABLE	Untreated nets	14%	1
	STABLE	No nets	22%	1
Severe child malaria	STABLE	No nets	45%	1 (hospital-based)
Uncomplicated episodes	STABLE	No nets	50%	4
	STABLE	Untreated nets	39%	3
	UNST	No nets	62%	1
	UNST	Untreated nets	39%	4
Parasite prevalence (any)	STABLE	No nets	13%	7
	STABLE	Untreated nets	10%	3
	UNST	No nets	42%	1
	UNST	Untreated nets	-8%	1
High parasitemia	STABLE	No nets	27%	2
	STABLE	Untreated nets	33%	3
Anemia in children	STABLE	No nets	1.7%	6 (weighted mean difference PCV)
	STABLE	Untreated nets	0.4%	3
Anthropometry in children	STABLE	Untreated nets	+	1 (+: stat. sign.)
	STABLE	No nets	+	2 (+: stat. sign.)

*Source:* Adapted from Lengeler (2004)

The efficacy values above probably are the best to use in the Model at this point, keeping in mind that adjustments may be needed to be done given the context of interest as discussed in section above. Values from other studies may be valuable when applying the Model in a particular context even if their finding cannot be generalized for use elsewhere.

Over more than a decade during which the effectiveness of insecticide-treated nets was well-established and large ITN promotion programs were launched, one concern has been that a delayed mortality effect might result from a lower acquired immunity among

<sup>11</sup> All studies including only pregnant women are excluded of this review.

children protected from malaria infection during their first years of life. Several well-designed and well-conducted studies have recently shown no evidence for such effect (Diallo 2004; Phillips-Howard 2003; Binka 2002), which can therefore be ignored in the Model.

The estimates of efficacy on uncomplicated malaria episodes in Table 2 are based on studies of population with various age groups including 0-4 years, 0-9 years and adults, (pregnant women studies were excluded from the review). These values may actually vary with age.

The values of efficacy for anemia in children in Table 2 are expressed in as differences in the mean weighted percent Packed Cell Volume. Snow (2003) reports that most interventions trials of malaria prevention including the use of ITNs show a reduction of about 50% of the prevalence of anemia among children benefiting from these interventions.

Beside the efficacy measures above a series of evaluation studies of the impact of programs promoting ITN provides valuable values of their effectiveness. One of these studies is the evaluation of a large-scale social marketing program in two districts in Tanzania (Schellenberg 1999), which showed an effectiveness of ITNs of 27% on all-cause mortality (19% for untreated nets; Schellenberg 2001) and of 63% on anemia (defined as hemoglobin < 8/dl; 37% effectiveness for untreated nets; Abdullah 2001) among children under five.

Table 3 presents the efficacy measures for selected outcomes of malaria in pregnant women of interest for the Model in the study most commonly referred to with this respect (ter Kuyle 2003). This study was conducted in a high perennial malaria transmission area and the efficacy values are for no-nets as control among gravidae 1 to 4.

**Table 3 Efficacy of insecticide-treated bed nets on malaria in pregnancy in a stable malaria area**

Malaria Outcome	Efficacy
Parasitemia	38%
Placenta infection	35%
Anemia	47%
Low birth weight prevalence	28%

Source: ter Kuyle 2003; study population is gravidae 1-4.

Other commonly cited studies of the effectiveness of nets on malaria in pregnancy are reported by Shulman (1998), d'Alessandro (1996), and Doran (1993). Shulman reports no effect of insecticide-treated nets on morbidity from malaria (uncomplicated episodes and anemia) among primigravidae in a community randomized controlled trial in Kenya. D'Alessandro reports a lower prevalence of malaria infection, proportion of premature births and proportion of low birth weight among primigravidae from villages where ITNs were used as compared to control villages in the ITN national program in Gambia. Doran

reports significant effects of treated and untreated nets on maternal anemia and on the proportion of low birth weight among all pregnant women in a prospective comparison study on the Thai-Burmese border.

#### **4.2 Coverage**

Data on coverage of children under five by insecticide-treated or untreated nets are relatively easy to collect and are becoming widely available through demographic and health surveys at the national and regional level (DHS, MICS, and others) and sometimes at the local level (small surveys in local project areas). Typical indicators are the percent of children under a given age (2, 3, or 5) who are reported as having slept under an insecticide-treated or untreated nets during the night before the survey. In demographic and health surveys (DHS and MICCS) conducted in 28 countries between 1998 and 2001, about 15% of children under five slept under nets and less than 2% under ITNs (see summary Figure 2.3 in WHO/UNICEF 2003). Data on coverage of pregnant women are less often available and less reliable. Indicators can be the percent of pregnant women who slept under an ITN during the last night before the survey, but more often the percent of women who report having slept under an ITN during most of the nights during the pregnancy of their last born child.

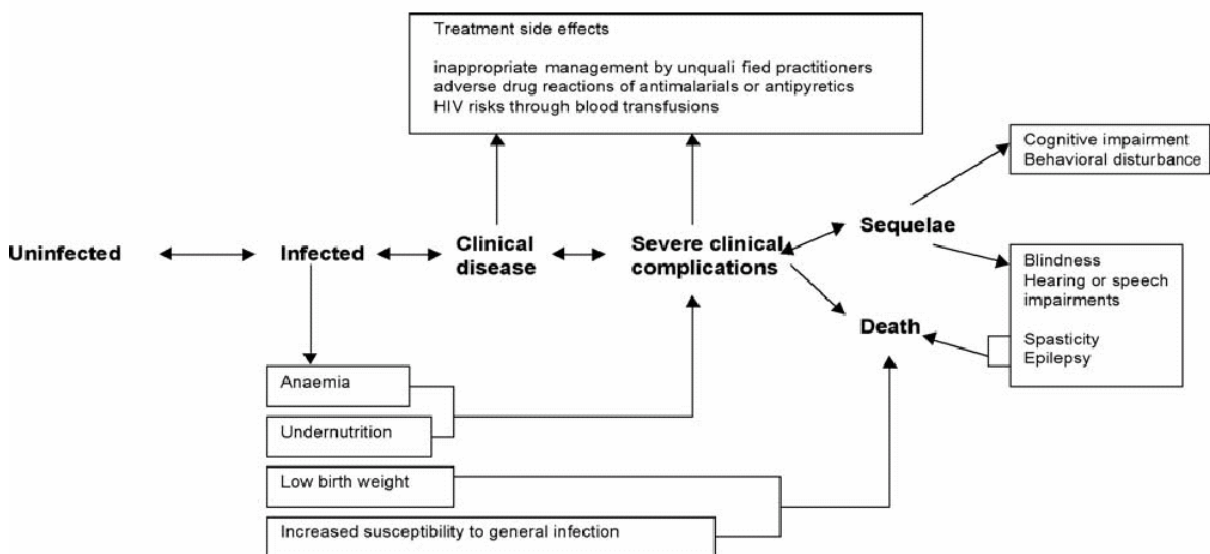


## 5 Public Health Burden

At this stage of the development of the Model, probably the most relevant and direct source of data on the public health burden of malaria is the review recently prepared by Snow and others (2003) for the Disease Control Priorities Project II hosted at the Fogarty International Center. This review presents summary estimates of the key malaria epidemiology parameters by “malaria risk strata” that correspond to the types of endemicity proposed in section 2 for the Model.

Figure 3 represents the various stages of malaria infection and clinical outcomes. This diagram is purposely borrowed “as is” from an authoritative malaria textbook (Snow 2002; also cited and used in Snow 2003) in an attempt to use the same concepts and terminology in the present document and in the Model.

**Figure 3 Stages of malaria infection and clinical outcomes**



*Source:* Snow (2002)

The summary epidemiologic estimates of the DCPPII review are presented below together with additional estimates and comments as appropriate.

### 5.1 Uncomplicated episodes

All estimates of the mild clinical manifestations of malaria, also referred to as malaria febrile attacks or uncomplicated episodes, depend heavily on the case definition (reported by patients versus by care takers, diagnosed on the basis of clinical versus laboratory criteria) and the source of data (survey, passive or more or less active surveillance, etc). The definition of the diagnostic criteria themselves is complicated by the facts that fever

is frequent and a sign of many other diseases and that malaria infection is common in endemic area without necessarily being associated with clinical diseases.<sup>12</sup>

The estimates of incidence and duration of malaria episodes proposed by the DCPPII review based on the best data on clinical malaria are appropriate for the Model. These are presented in the table below.

**Table 4 Incidence and duration of uncomplicated malaria episodes**

Age group	Incidence (Episodes per person per year)		Duration (Days)	
	Median	IQR <sup>1</sup>	Median	IQR
<b>Stable malaria areas</b>				
0-4	1.424	0.838, 2.167	5.1	4.3, 6.0
5-14	0.587	0.383, 0.977	5.1	4.3, 6.0
15+	0.107	0.074, 0.138	2.0	
<b>Unstable malaria areas</b>				
0-4	0.182	0.125, 0.216	5.1	4.3, 6.0
5-14	0.182	0.125, 0.216	5.1	4.3, 6.0
15+	0.091	0.063, 0.108	5.1	

Source: Snow (2003)

<sup>1</sup> IQR: Inter Quantile Range

## **5.2 Severe malaria**

The term severe malaria refers to various clinical complications of acute malaria attacks, typically among non-immune persons, young children over six months of age or travelers from non-endemic to endemic countries. The two main forms of severe malaria are cerebral malaria (CM) and severe malaria anemia (SMA), although other manifestations such as respiratory distress and hypoglycemia are frequently associated with CM and SMA or present alone and can cause important sequella and deaths. Studies of severe malaria often use site-specific definitions but cerebral malaria usually includes coma or prostration or multiple seizures and severe malaria hemoglobin of less than 5g/dl, both in association with malaria parasites.

It has been estimated that severe malaria represents about 3% of all attacks of malaria among children under five (Najera 1996) and that severe malaria anemia represents 60% of cases of severe malaria (Menendez 1997). Case fatality for severe malaria is very high even in hospitals, and range between 15 and 30 percent of cases of cerebral malaria and 5 to 15 of the cases of severe anemia (Taylor 2002).

Based on a series of hospital-based studies over the last 10 years in Africa, the CDPP-II review estimates the incidence of cerebral malaria in stable areas as 1.12 per 1,000 children 0-9 years per year, although these rates vary considerably, with lower rates in

<sup>12</sup> Up to 80% of children are parasitemic by age one in hyperendemic areas; this prevalence then decreases with age.

areas of most intense transmission. A case-fatality rate of 20% is commonly assumed in hospitals and is most likely much higher for the large proportion of cases who did not reach hospitals with good treatment and care. Cerebral malaria is also responsible for indirect and long-term consequences or sequella such as epilepsy, spasticity, cognitive and behavioral disturbances among survivors. The frequency of these sequella varies with the treatment and care received, and it has been estimated that 2% to 4% of survivors of CM suffer from persistent learning impairment including epilepsy and spasticity (Murphy 2001).

Severe malaria is more frequent and has a higher case fatality among pregnant women than among other adults. All pregnant women have higher risk of severe malaria in unstable areas but in stable areas mainly primigravidae and low parity women are affected. Severe malaria anemia increases both maternal and perinatal morbidity and mortality. Case fatality of cerebral malaria has been reported as 50% among pregnant women and 20% among non-pregnant women (Looareesuwan 1985).

### 5.3 Anemia

The proportion of anemia due to malaria, or Population Attributable Risk (PAR) of anemia for malaria, can be defined as:

$$PAR = (R - R_0)/R = p * (r - 1)/(1 + p * (r - 1)),$$

where  $R$  is the prevalence of anemia in the total population,  $R_0$  is the prevalence in the population without malaria),  $r$  is the relative risk ratio (prevalence of anemia without malaria versus prevalence with malaria), and  $p$  is the proportion of the population with malaria. Since  $R$  and  $R_0$  are rarely available, the last expression of PAR is commonly used when  $r$  is available from epidemiologic studies and  $p$  is available from other sources. However, these measures are difficult to interpret because there is no clear-cut definition of malaria infection and of anemia and because both malaria infection and anemia are very common and not necessarily related (one can be infected with malaria without disease).

In terms of anemia attributable to malaria among pregnant women, the threshold commonly used for these two conditions are a concentration of hemoglobin < 11g/dl for anemia and a parasitemia of > 10,000/dl for malaria. Using these criteria, the DCPPII review found that the PAR of moderate or severe anemia to due *Plasmodium Falciparum* in malaria endemic areas was between 2-15% (Snow 2003, summarized from Steketee 2001; see also Table 5 in section 5.4).

Among children, malaria can cause anemia through an increased rate of destruction of red blood cells resulting from hemolysis or increased spleen activity, typically during an acute malaria episode, or through a decreased production of red blood cells, typically during chronic infections. Such mechanisms may have different effects depending on the existence of nutritional (micronutrient and protein-caloric) deficiencies and on the genetic constitution. A recent analysis of the relationship between malaria infection and mild anemia (<11g/dl) among children showed a 6% increase in anemia for a 10% prevalence

of malaria infection and that 71% of anemia was associated with malaria (Korenromp and Snow, work in progress cited in Snow 2003, p32). This figure far exceeds what was found in the GBD study where only 18% of anemia was estimated to be attributable to malaria. Another approach to estimating the proportion of anemia due to malaria among young children is provided by the various interventions trials of malaria prevention such as the use of ITNs, chemoprophylaxis or intermittent preventive treatment which all showed a reduction of about 50% of the level of anemia among children benefiting from these interventions (Snow 2003).

No study was found to estimate the proportion of anemia due to malaria among non-pregnant adult population. This could therefore be ignored in the Model for now and one can consider that any estimate of the loss in productivity due to malaria would represent at least part of the indirect consequences of malaria anemia.

#### **5.4 Malaria in pregnancy**

The malaria PAR (see definition in section 5.3) for various pregnancy related conditions including infant mortality has been calculated using all the studies of malaria in pregnancy available between 1985 and 2000 (Steketee 2001). The table below summarizes these findings (Snow 2003).

**Table 5 Population attributable risk of malaria in pregnancy**

<b>Adverse event</b>	<b>Prevalence / incidence</b>	<b>Risk estimate</b>	<b>PAR (%)</b>
Moderate or severe anemia	1-20%	1.5-2.5	2-15
Low birth weight	12-20%	1.4-1.8	8-14
Pre-term LBW	3-8%	2.2-3.5	8-36
IUGR LBW	8-15%	1.7-5.5	13-70
Infant mortality	105 %	NA	3-8

Source: Snow 2003

Severe malaria among pregnant women is discussed in section 5.2. Data on maternal deaths due to malaria during pregnancy are presented in section 5.6 below.

#### **5.5 Child growth and development**

Beside the data presented above on malaria anemia in children and on low birth weight, there is no clear and consistent data on the impact of malaria on physical growth (Snow 2003, citing studies such as D'Alessandro 1995, Snow 1997, and Ter Kuyle 2003). Lengeler (2004) report three studies that show statistical association between the use of

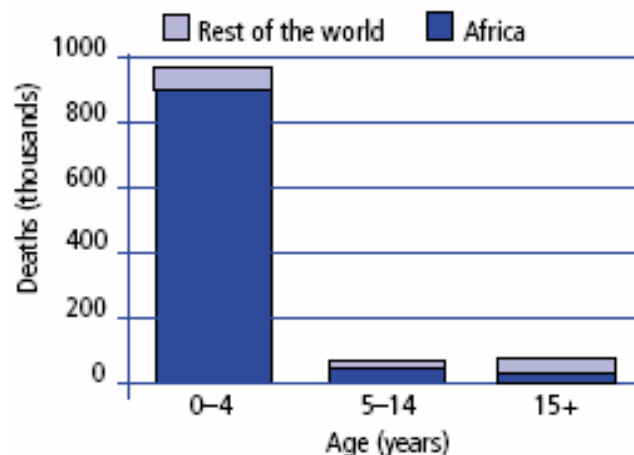
bed nets and one or several anthropometric indicators, but the effect is rather small (see Table 2). This suggests that this consequence of malaria in children can be ignored in the Model for now.

The data on the impact of malaria on school attendance and learning and cognitive performance are not conclusive. One study showed that malaria was responsible for a loss of 2% of the total school days per child and per year, 3-8% of all causes of absence, and 13-15% of all medical reasons (Brooker 2000, cited in Snow 2003). On-going studies on the impact of intermittent preventive treatment of malaria among infants may soon provide data with this respect.

### 5.6 Death

As a reminder, the total number of malaria deaths in 2000 was estimated by the WHO Global Burden of Diseases project as 1,080,000, with 966,000 (90%) in Africa (WHO 2001). The graph below shows the age distribution of these deaths, with nearly 90% occurring among children under five.

**Figure 4 Age distribution of malaria deaths in Africa and the Rest of the World**



Source: WHO/UNICEF 2003, based on estimates for 2000 from the WHO Global Burden of Diseases project

WHO (1997) also states that in 1994 “[A]n estimated 1.5 to 2.7 million people die of malaria each year.” This estimate based on “the most recent compiled data available at present on malaria throughout the world” may include direct and indirect malaria deaths.

The table below summarizes the estimates of malaria mortality rates among children under five in stable and unstable malaria endemic areas.

**Table 6 Malaria mortality rate among children under five**

Age group	Mortality rate (deaths per thousand per year)	
	Median	IQR
Stable malaria areas		
0-4	9.33	7.38-14.57
5-14	1.58	0.66-2.77
15+	0.60	0.37-0.94
Unstable malaria areas		
0-4	2.62	
5-14	0.94	
15+	0.71	

Source: Snow (2003)

<sup>1</sup> IQR: Inter Quantile Range

In stable malaria areas, the malaria PAR of anemia-associated maternal deaths has been estimated as 9%, and the maternal deaths associated with anemia represent about 41% of all maternal deaths (Brabin 2001). Therefore in these areas the malaria-anemia PAR of maternal deaths is 3.7%.<sup>13</sup>

In malaria unstable areas, a few studies show evidence of the high risk of maternal death and abortion among non-immune pregnant women. In Mozambique, for instance, malaria was found directly responsible for 15.5% of maternal deaths in a hospital (Granza 1998, cited in Snow 2003). In Ethiopia, the relative risk of abortion was 8 for women who had malaria during their pregnancy (Newman, cited in Snow 2003). The findings of these studies are not easy to generalize for the entire populations living in epidemic prone areas, and can be ignored in the Model for now.

Adult malaria mortality remains poorly defined but may become a more important consequence of malaria as the HIV epidemic continues to grow (Snow 2003).

Beside the direct malaria mortality estimates discussed above, there is evidence that malaria causes substantial mortality through its interaction effects with other infectious diseases and through other mechanisms such as adverse reactions to drugs or HIV infection from blood transfusion. This indirect mortality is shown in several clinical trials where the reduction in all-cause mortality is greater than what can be explained by the reduction in malaria-specific mortality. Overall, it is commonly accepted that this indirect mortality represents an additional 10% of what can be directly attributable to malaria.

<sup>13</sup>  $100 \times 0.09 \times 0.41 = 3.7\%$ .

## 6 Economic Burden

The most complete and recent review of the economic impact of malaria is provided by Chima, Goodman and Mills (2003). The presentation below is based on this review. Another key reference is the review of studies of the cost of illness and coping strategies for households by Russell (2003) and that covers HIV/AIDS, tuberculosis and malaria.

Although macroeconomic analyses of the relationship between malaria and economic development have been conducted at least as early as in the 30s (League of Nations 1933), the important implications of these relationships have recently regained interest (Sachs 2002, Gallup and Sachs 2001, McCarthy 2000). The latest of these two studies found that malaria accounted for a growth deficit in Gross Development Product (GDP) of 1.3% per year over the period 1965 to 1990 (Gallup 2001), a finding similar although substantially higher than the estimate of 0.6% found in the earlier study (McCarthy 2000). Macroeconomic data provide powerful arguments for supporting malaria control programs but provide little explanation about the mechanisms through which malaria impedes development. These data are therefore not directly useful for the development of the Model and these studies are not further reviewed in the present document.

Microeconomic studies of the impact of malaria have severe limitations (Chima 2003; Gallup 2001),<sup>14</sup> including the fact that they primarily use uncomplicated febrile episodes to estimate the burden of malaria and that they do not take into account the coping strategies that individuals and communities may use in reaction to malaria. Nevertheless, a series of studies conducted in the early 90s (Shepard 1991, Ettling 1994, Ettling 1991, Sauerborn 1991) and a few more recent studies (Jowett 2000; Cropper 1999; Meltzer 2003) provide widely cited data that can be used in the Model. The findings of these studies are presented below following primarily the review of this topic by Chima (2003).

Microeconomic studies of the economic impact of diseases typically distinguish direct and indirect costs, these two categories being further divided as follows:

- Direct costs:     Preventive costs
- Curative costs (treatment and care)
- Other financial costs
- Indirect costs:   Time lost to illness
- Time lost to death
- Time lost to caretakers

These costs can be met through various cost mobilization or coping strategies that are more difficult to quantify. Also, these costs are born by households, the government or the donors. All costs estimates cited by Chima (2003) and reported here are in 1999 US \$.

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<sup>14</sup> Gallup and Sachs (2001), after reviewing the methodological and measurement limitations of microeconomic studies of the impact of malaria, state that "In short, the impact of malaria on the productivity of individuals in areas of stable malaria cannot be assessed with the current state of research."

## 6.1 Direct costs

At the household level, prevention-related costs may include all personal protection measures, including bed nets. The range of expenditures found in the available studies is between \$0.05 to \$2.10 per capita per year, that is, between \$0.24 and \$15 per household per year. Variations depend on the local epidemiology, availability of personal protection devices and products, socioeconomic factors (urban/rural residence, income) and knowledge and beliefs about diseases and prevention measures. These expenditures are primarily made by the wealthiest individuals and households. While malaria prevention-related expenditures may be substantial, they are often motivated by overall nuisance like mosquitoes and other insects unrelated to malaria and therefore may persist even if malaria is eliminated.

Treatment-related costs to the households include the cost of drugs, health care workers or clinic fees, transportation and subsistence at a remote clinic. The range of expenditures found in the available studies is between \$0.41 to \$3.88 per capita and per year, that is, between \$1.28 and \$26 per household per year. One of these studies found that direct costs of malaria prevention and treatment represented 28% of the income of the very low-income household and 2% of the others (Ettling 1994). Typically based on household surveys with 2 to 4 week recall periods, these studies do not adequately reflect seasonality of mosquito biting, malaria manifestations, disposable income, access to prevention and treatment, and therefore of the direct malaria-related expenditures. Also, these studies are usually mainly based on acute febrile illnesses (of which may be only half is malaria), sometimes including mortality from malaria but rarely other clinical manifestations such as severe malaria or anemia.

At the Government level, malaria treatment and care in health services typically represents about 30% of outpatient visits and hospital admissions, and government expenditures on malaria are therefore often estimated as 30% of the total expenditures on health services (Chima 2003). When a specific government budget line for malaria-prevention measures exists, it typically represents a very small proportion of such estimates. The table below presents illustrative estimates of care and treatment in public health facilities found in a few studies using the above or similar method or sometimes more detailing accounting of costs.

**Table 7 Cost of outpatient and inpatient treatment and care of malaria**

Study location	Cost of treatment and care (\$)	
	Out patient	In patient
Tanzania	1.54-4.49	03.05-21.89
Kenya (pediatric cases)		36.00-68.00
Rwanda	1.56-3.12	08.73-37.60
Senegal (pediatric cerebral malaria)		154.00

*Source:* Chima 2003



## **6.2 Indirect costs**

The human capital approach considers the productive time lost to morbidity, care seeking, care giving or death as the indirect economic costs of poor health and diseases. These are usually estimated by the wage rate method whereby the number of days lost to illness is multiplied by the estimated value of a work day. These two factors vary considerably across studies depending on their actual values and the methods used to estimate them.

Most studies estimate the time lost by adults to malaria episodes (uncomplicated febrile illnesses) as being between 1 to 5 days (Chima 2003). However, it is quite frequent in such studies that a large proportion of adults do not report any work time lost, and therefore these estimates of duration would only relate to the more severe episodes which constitutes only a fraction of the malaria episodes. The time lost would also be expected to vary with the type of parasite, immunity, treatment received, type of economic activity, etc.

Defining the persons whose lost time is valued (adults versus children, housewives, unemployed, or elderly; sick person versus care taker) varies enormously across the contexts and the methodologies of the studies (Asenso-Okyere and Dzator; Cropper 1999; Leighton and Foster, cited in Chima 2003). Similarly, estimating the value of the time lost also varies across studies: estimates are derived from household data on annual cash and in-kind income, from estimates of the average wage (sometimes taking into account age, gender, economic activity or even seasonal variations), and various other methods. The average estimates of the indirect costs of a malaria episode in the studies above range between \$0.68 per children under five to \$23.0 per adults. Based on these estimates, the authors have calculated that the indirect costs of malaria represented 2.6% of annual household income in Malawi (Ettling 1993), and 2-6% and 1-5% of the annual GDP in Kenya and Nigeria, respectively (Leighton 1993).

Very few studies have included the productivity loss from premature deaths. One study in Rwanda and Burkina Faso provides a methodological example of discounting the value of years lost based on estimates of productive life expectancy at the age of death (Shepard 1991).

## **6.3 Total costs**

Most studies simply add the direct and indirect costs of malaria estimated as explained above. Examples of such estimates expressed as a percentage of the annual household income are presented in the table below.

**Table 8 Total cost of malaria at the household level**

Study location	Total cost of malaria (% annual household income)
Malawi:	
All households	7.2%
Very low income households	32.0%
Kenya:	9-18%
Nigeria:	7-13%

*Source:* Chima 1993

One study used such data on total costs obtained from four study sites in Africa to derive estimates of the total cost of malaria for the continent in 1987 as \$1,064 millions, that is, \$3.15 per capita and 0.6% of the GDP (1999 prices) (Shepard 1991). Another more recent study of malaria expenditures in Tanzania reports similar levels of per capita malaria expenditures (\$3.15) and percent GDP (1.1%) (Jowett 2000). The study of malaria expenditures in Tanzania also breaks down the total costs by household (71%), government (20%) and donors (9%).

## 7 Conclusions and recommendations

1. The preliminary conceptual framework and literature review presented here were developed at the same time as the first versions of the computer-based advocacy Model.

*Recommendations:*

- AED/NetMark should maintain an explicit and up-to-date conceptual framework and the related literature review when further developing and testing the Model with its intended clients, users and audience.
- Even if its goal is to present simple and focused messages to specific audiences, the Model should be completely documented and backed up with sound rationale, data and references to ensure credibility and effective advocacy in the long run.

2. Many parameters in the Model have a wide range of uncertainty.

*Recommendations:*

- The values of each parameter chosen by the developers of the Model should be clearly documented and a range of options provided to the users.
- Sensitivity analyses should be included in the Model as part of the analyses available to the users.

3. The Model has the potential to include other malaria control interventions than the use of ITNs and the related reduction of their taxation.

*Recommendations:*

- AED/NetMark should consider developing the Model for wider advocacy applications in the context of Roll Back Malaria.

# Appendix 1 List of websites

By alphabetic order:

## BASICS

<http://www.basics.org/>

## Boston University

<http://www.bumc.bu.edu/Departments/HomeMain.asp?DepartmentID=384>

A few papers on the impact of reduction on taxes and tariffs on the retail price of ITNs  
Database on market for ITNs and related materials (<http://dcc2.bumc.bu.edu/cih/>)

## CDC Center for Disease Control and Prevention, Division of Parasitic Diseases:

<http://www.cdc.gov/ncidod/dpd/parasites/malaria/default.htm>

## CID Center for International Development at Harvard University

<http://www.cid.harvard.edu/malaria/>

## EHP

<http://www.cdc.gov/ncidod/dpd/parasites/malaria/default.htm>

## Global Funds (GFATM)

<http://www.theglobalfund.org/en/about/fighting/malaria/>

Information on current projects but not on topics related to the Model.

## IDRC

<http://www.idrc.ca/>

Past research on bed nets ([http://web.idrc.ca/en/ev-31505-201-1-DO\\_TOPIC.html](http://web.idrc.ca/en/ev-31505-201-1-DO_TOPIC.html))

## LSHTM, health financing unit

Several papers on economics of malaria

## LSHTM, Malaria Consortium

[www.lshtm.ac.uk.itd/dcvbu/malcon/malcon/htm](http://www.lshtm.ac.uk.itd/dcvbu/malcon/malcon/htm)

## Malaria Foundation:

<http://www.malaria.org/>

## MARA

<http://www.mara.org.za/>.

<http://www.mara.org.za/lite/information.htm> (10 minutes demo tour on MARA LITe CD  
(\$100) with all MARA data and software to extract customized data sets).

## NetMark

<http://www.netmarkafrica.org/>

Several country-specific reports on malaria and ITNs.

## NIH, Fogarty International Center:

MIM: past and current research priorities

DCP-II: <http://www.fic.nih.gov/dcpp/wps.html> Work in progress on new Disease Control

Priorities project, including 6 working papers directly relevant to the Model.

## RBM

[www.rbm.who.int/](http://www.rbm.who.int/)

[www.mosquito.who.int/cgi-bin/rbm/login\\_rbm.jsp](http://www.mosquito.who.int/cgi-bin/rbm/login_rbm.jsp)

[www.who.int/inf-fs/en/InformationSheet10.pdf](http://www.who.int/inf-fs/en/InformationSheet10.pdf)

## UNICEF

<http://www.unicef.org/programme/health/malaria/malaria.htm>

## USAID/DEC

<http://www.dec.org>

Not much found there for the Model.

## Welcome Trust

[http://www.wellcome.ac.uk/en/malaria/MalariaAndPeople/malaria\\_and\\_people.html](http://www.wellcome.ac.uk/en/malaria/MalariaAndPeople/malaria_and_people.html)

## WHO

[www.who.int/health-topics/malaria.htm](http://www.who.int/health-topics/malaria.htm)

## World Bank

<http://www.worldbank.org/malaria>

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