Malaria Epidemiology and Economic/political perspective

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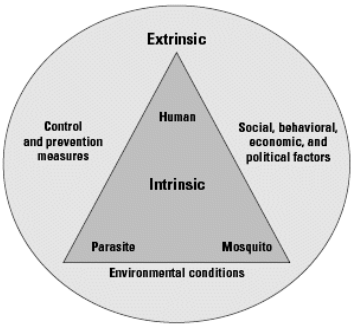
April 7, 2009

Goals for today

- Understand different types of epidemiological measurements for malaria and how they are used
- Consider the complexity of factors (determinants) that influence malaria transmission
- Understand the economic impact of malaria at the household and national level
- Understand the cost-benefit approaches used for malaria public health decision making

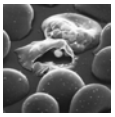
Determinants of malaria transmission



Source: Breman 2001.

Determinants of malaria transmission

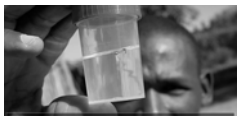
- **host determinants: age, immunity, genetics, behavior**



- **parasite determinants : species, virulence, genotype, drug resistance, reproductive rate**

Vector determinants:

Feeding preference
Feeding frequency
Longevity
Abundance



Environmental determinants:

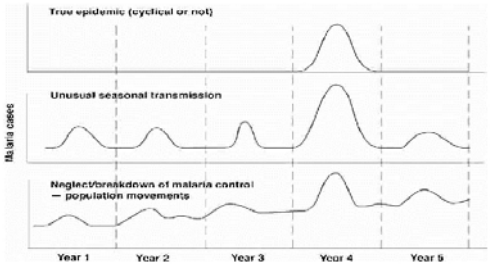
Temperature (18ºC)

Rainfall/humidity

Landscape ecology and altitude

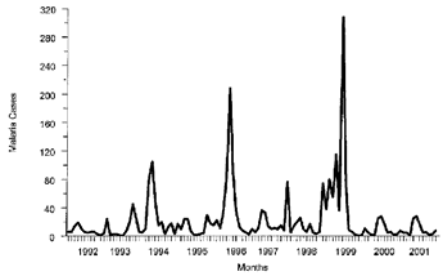
Climate change?

Cycles of disease



Classification of major malaria epidemic types. From: Worrall et al. The Burden of Malaria Epidemics and Cost-Effectiveness of Interventions in Epidemic Situations in Africa

Cycles of disease



Recurrent epidemic malaria in an epidemic-prone site in Ethiopia. Shown are *Plasmodium falciparum* cases diagnosed by examination of blood smears at the Hirna Sector Malaria Laboratory, Harer Region, West Harerge, Ethiopia between July 1991 and June 2001 (Ministry of Health, Ethiopia, unpublished data).

Source: Kiszewski and Awash Teklehaimanot 2004. A Review of the Clinical and Epidemiologic Burdens of Epidemic Malaria. Am. J. Trop Med. Hyg.

Malaria surveillance

Incidence rate = the number of *new cases* occurring within a set time interval (hard to measure, why?)

Prevalence rate = the number of cases of disease *present* in a population at a given time (approx. incidence x duration)

Incidence rate (per person-years):

$$IR = \frac{\#\text{ new cases per unit time}}{\#\text{ persons at risk during time}}$$

Ex: 9,230 new cases of malaria observed over 1 yrs, with 105,000 people in study that time

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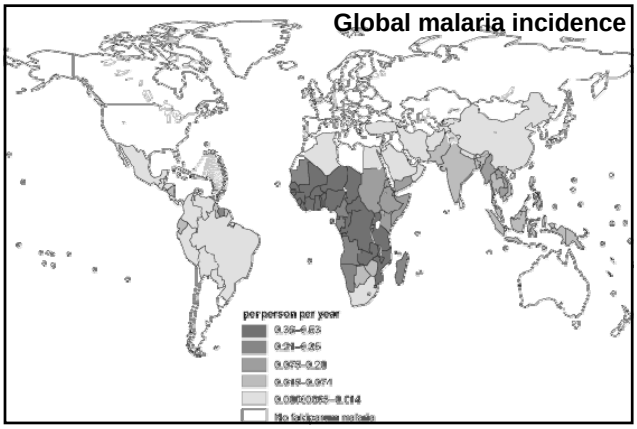
Ex: 9,230 new cases of malaria observed over 1 yrs, with 105,000 people in study that time

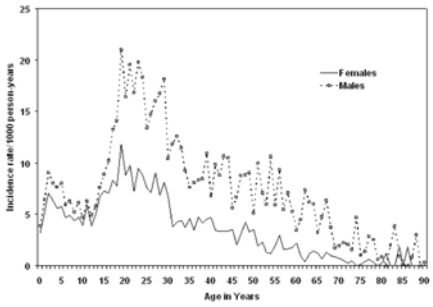
$$IR = \frac{9{,}230 \text{ new cases}}{105{,}000 \text{ persons at risk}}$$

= 0.0879 new malaria cases per person/year
(or 87.9 new cases per 1000 person/years)

Global malaria incidence



Age adjustment for incidence is critical for understanding risk:



Malaria incidence rate (per 1000 person-years) by age and gender in East Shoa, Ethiopia. Source: Yeshiwondim *et al. International Journal of Health Geographics* 2009 8:5

Entomological inoculation rate

EIR = mas

EIR = # of infective bites per unit time

m = vector density in relation to host

a = # of human blood meals per vector per day
(m*a can be estimated using human biting collections)

s= sporozoite rate (proportion of mosquitoes with malaria parasites in their salivary glands)

Epidemiological innoculation rate:

EIR = mas

15 *Anopheles* collected per person per night (=m), 78% are human-fed (= a) and 10% are infected with sporozoites (=s: sporozoite rate)

EIR = # mosquitoes x proportion human fed x proportion with sporozoites 15 x 0.78 x 0.1 = 1.17

each individual receives 1.17 infective bites per night

Basic reproductive rate = R_0

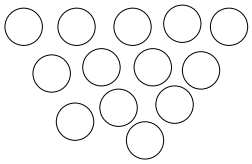
The average number of secondary cases that a single case may cause in a completely non-immune population

This determines transmission stability of an infection:

When $R_0 < 1$
the infection will die out

If $R_0 > 1$
there is a possibility of a major epidemic

Herd immunity: when immunity to infection of the majority of the population (or herd) provides protection to non-immune individuals



Herd immunity lowers $R_0 < 1$

Disability-adjusted life year (DALY)

- **a measure of overall disease burden**
- **combines mortality and morbidity in one common metric**

One DALY = one year of healthy life lost

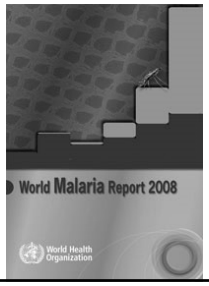
Table 21.1: Deaths and DALYs from Deaths Attributable to All Causes and to Malaria by WHO Region, 2000

		Deaths, 2000					DALYs from deaths, 2000				
		All causes		Malaria			All causes		Malaria		
Region	Population	Thousands	Percent	Thousands	Percent	Malaria deaths as a percent-age of all deaths	Thousands	Percent	Thousands	Percent	Malaria DALYs as a percentage of all DALYs
World	6,122,211	56,554	100.0	1,124	100.0	2.00	1,467,257	100.0	42,279	100.0	2.90
Africa	655,476	10,681	18.9	963	85.7	9.00	357,884	24.4	36,012	85.2	10.10
Americas	837,967	5,911	10.5	1	<0.1	0.02	145,217	9.9	108	0.2	0.07
Eastern Mediterranean	493,091	4,155	7.3	55	4.9	1.30	136,221	9.3	2,050	4.8	1.50
Europe	874,178	9,703	17.2	<1	<0.1	<0.010	151,223	10.3	20	0.04	0.01
Southeast Asia	1,559,810	14,467	25.6	95	8.5	0.70	418,544	28.5	3,680	8.7	0.90
Western Pacific	1,701,689	11,636	20.6	10	0.9	<0.09	257,868	17.6	409	1.0	0.20

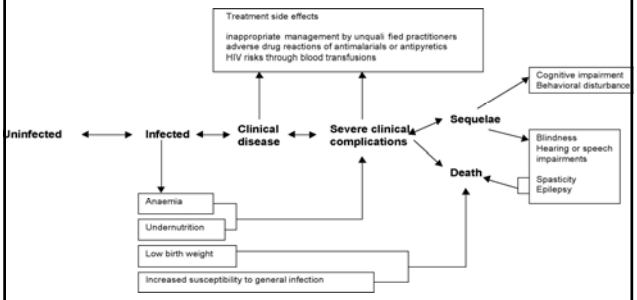
Source: Breman, Alilio, and Mills 2004; WHO 2002b.
Percentages may not add up to 100 percent because of rounding.

World Malaria Report

http://www.who.int/malaria/wmr2008/



The direct, indirect and consequential public health effects of *Plasmodium falciparum* malaria in Africa (Source: Snow & Gilles, 2002)



"As a general rule of thumb, where malaria prospers most, human societies have prospered least." – *Sachs and Malaney*

insight **review articles**

The economic and social burden of malaria

Jeffrey Sachs*† & Pia Malaney*

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†Commission on Macroeconomics and Health, World Health Organization, Avenue Appia 20, 1211 Geneva 27, Switzerland

Ways in which malaria imposes economic burden:

Household level:

changes behavior in response to disease

Ways in which malaria imposes economic burden:

"high fertility/high mortality" environment

- impacts allocation of resources to children (education, food, medicine)
- limits earning potential of women
- increases productive time lost on children who die
- reduces household savings

Ways in which malaria imposes economic burden:

National level - macroeconomic changes

- limits industry and foreign investment
- limits tourism

Am. J. Trop. Med. Hyg., 71(Suppl 2), 2004, pp. 165–171
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PUBLIC AND PRIVATE ROLES IN MALARIA CONTROL: THE CONTRIBUTIONS OF ECONOMIC ANALYSIS

KARA HANSON
Health Policy Unit, London School of Hygiene and Tropical Medicine, London, United Kingdom

"While there is widespread agreement that incentives for drug discovery are essential to provide appropriate incentives for pharmaceutical firms to invest in research and development, one consequence is that drugs for diseases that affect poor countries may be unaffordable."

Am. J. Trop. Med. Hyg., 71(Suppl 2), 2004, pp. 165–171
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Health Policy Unit, London School of Hygiene and Tropical Medicine, London, United Kingdom

Cost effectiveness analysis (CEA) of interventions:

- Informs decisions about how to allocate public sector health funds
- Cost effectiveness ratio (CER) can be calculated to compare interventions
- Expressed in terms of DALYs

Examples:

Insecticide treatment of existing nets:
$4-10 per DALY

Providing nets and retreatment:
$19-85 per DALY

Treating pregnant women:
$4-9 per DALY

Social marketing of bed nets:

Malaria control needs mass distribution of insecticidal bednets

Long-lasting insecticidal bednets (LLINs) are one of the major ways to control malaria, and they are widely accepted worldwide by communities in areas affected by malaria.[1,2] One LLIN costs about US$5 to manufacture and is effective for about 5 years. They have two kinds

The direct effect of LLINs is to protect the people sleeping under them, and it operates in three ways. First, the insecticide kills some of the *Anopheles* mosquitoes after a few minutes. Second, the LLIN repels a proportion of the mosquitoes after contact.[3] Third, the net acts as

The use of commercial marketing techniques in promotion and distribution of health services, not for profit, but to achieve social goals

Integrates response to consumer needs (example: net colors and shapes in Tanzania)

Often limits sales to high risk groups (pregnant women and children < 5

What are some criticisms?

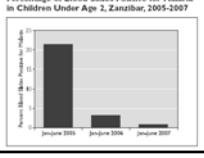
President's malaria initiative in 2005- present

About The President's Malaria Initiative

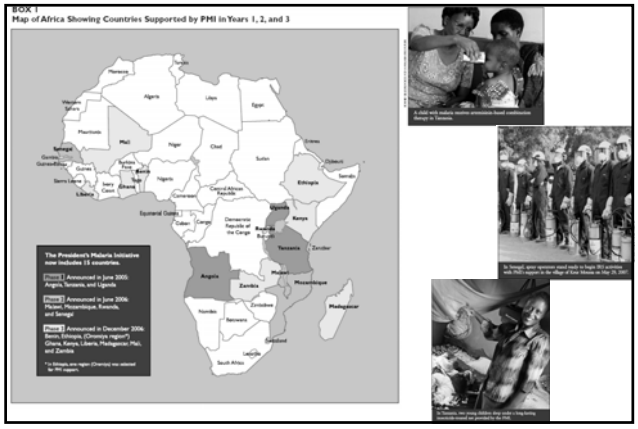
The President's Malaria Initiative (PMI) represents an historic five-year expansion of U.S. Government (USG) resources to fight malaria in the region most affected by the disease. The President committed an additional $1.2 billion in malaria funding to this initiative with the goal of reducing malaria-related deaths by 50 percent in 15 focus countries. This will be achieved by expanding coverage of highly effective malaria prevention and treatment measures to 85 percent of the most vulnerable populations – children under 5 years of age and pregnant women. This package of high-impact interventions includes insecticide-treated mosquito

Workers trained in IRS march on World Malaria Day in Agoro Sare, Kenya. Source: James Keivi/The Standard

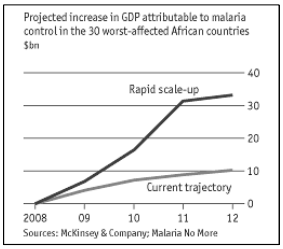
FIGURE 2
Percentage of Blood Slides Positive for Malaria in Children Under Age 2, Zanzibar, 2005-2007



Malaria Epidemiology, social and ecological perspective



How much is enough for malaria control?



WHO consultants estimate 2.2 billion/year would increase African GDP substantially

Is a focus on control in Africa appropriate?

30% of global mortality due to malaria is in Southeast Asia and the highest global concentration of drug resistance

April 10, 2008