Malaria and climate change: it’s complicated

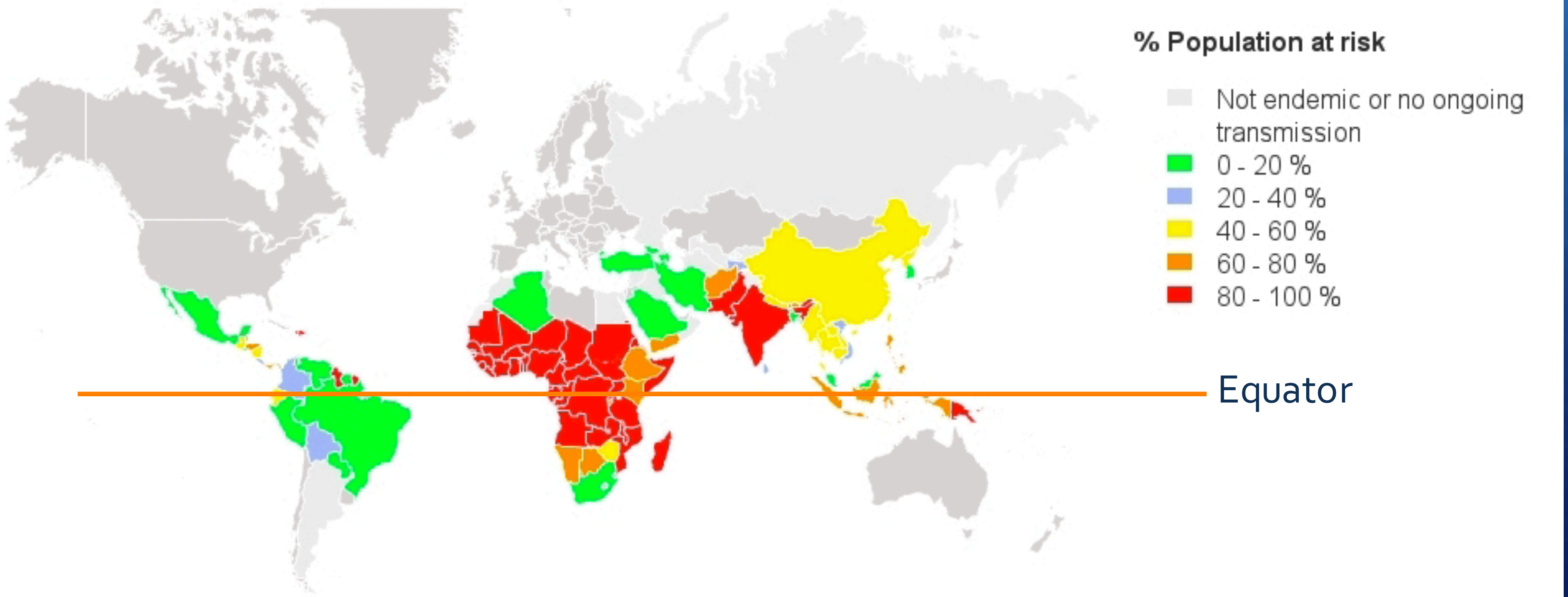
AGCI Workshop : Climate Change and Human Health
September 13, 2016

"Malaria is … a thousand different diseases and epidemiological puzzles.
Like chess, it is played with a few pieces, but is capable of an infinite variety of situations."

Hackett L: Malaria in Europe, an ecological study; 1937.

World-wide population at risk for malaria, 2013



Global Malaria Mapper, WHO, 2016

Malaria

- Five species of Plasmodium parasite cause malaria in humans: *P. falciparum; P. vivax; P. ovale; P. malariae. P. knowelsi*
- Most severe disease caused by *P. falciparum*
- *P. falciparum accounts for majority of malaria cases world-wide*

Table 1.2 Estimated number of cases of malaria and percentage due to *Plasmodium falciparum* in 2010

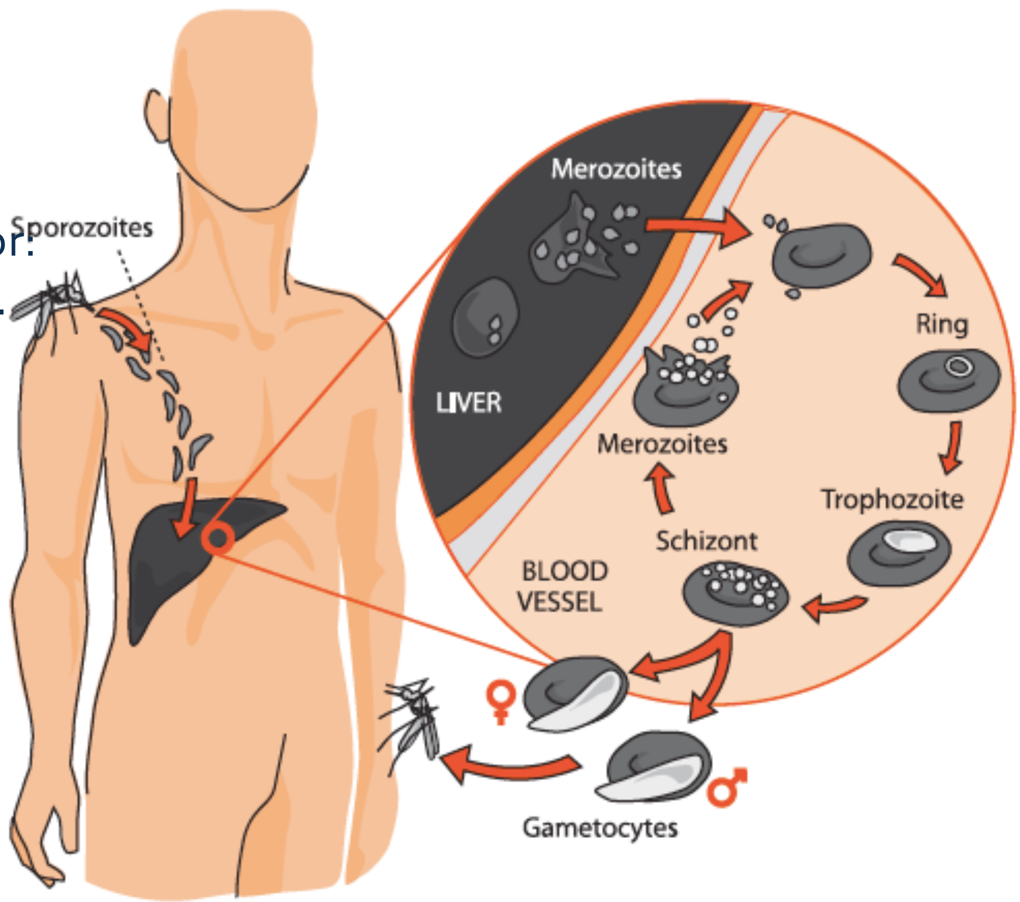
WHO Regional Office	Total no. of cases of malaria	Cases of malaria due to *P. falciparum* (%)	Total no. of malaria deaths due to *P. falciparum*
Africa	174 000 000	98	596 000
Americas	1 000 000	34	1000
Eastern Mediterranean	10 000 000	82	15 000
Europe	200	5	0
South-east Asia	28 000 000	54	38 000
Western Pacific	2 000 000	77	5 000
All	216 000 000	91	655 000

Data from WHO (2011)

Malaria life cycle in humans

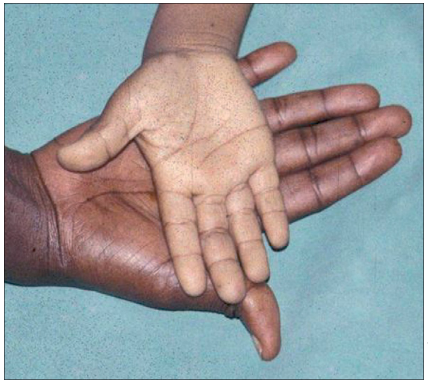
Mosquito vector:
Anopheles spp.

Fig. 1.1 Life-cycle of *Plasmodium* species in humans



Malaria-related Illness: Infants and Non-immunes

Repeated infections:
Anemia, intellectual and physical growth impairment

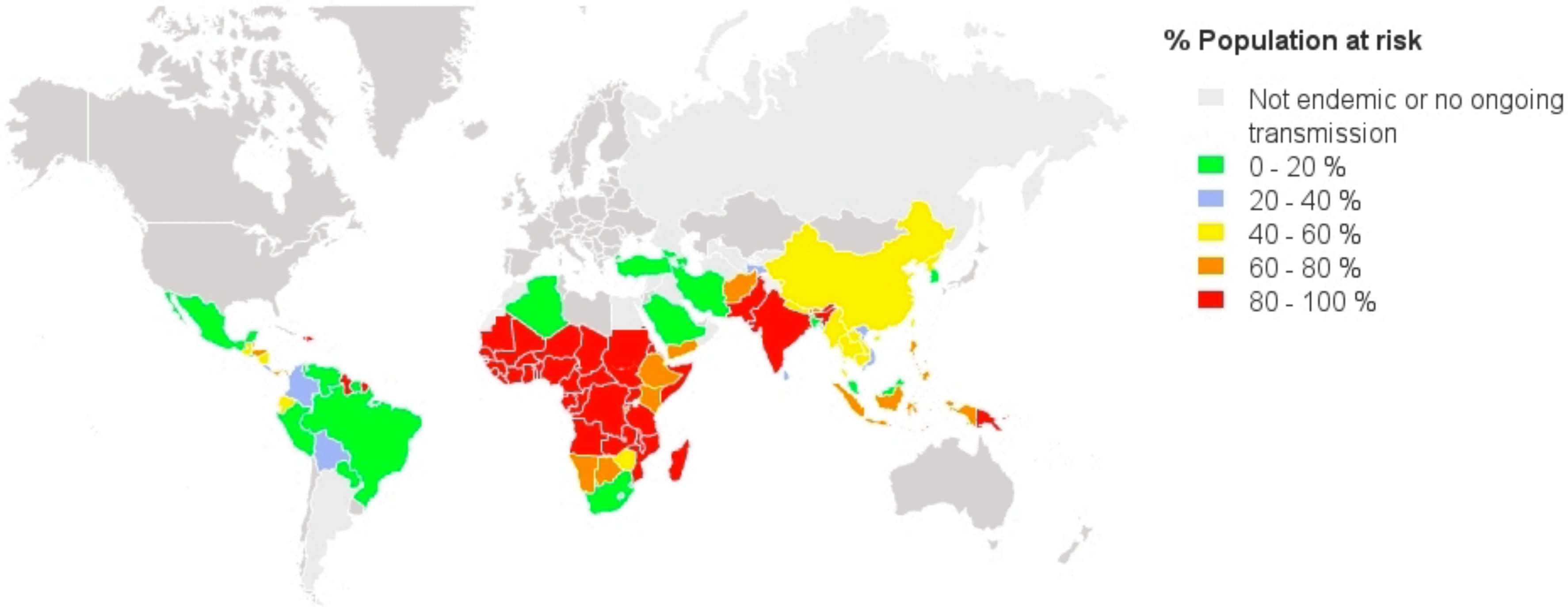


'Severe' malaria:
Profound anemia, CNS pathology with coma and seizures, long term Sequela, Acute respiratory distress

Death, primarily due to *P. falciparum*

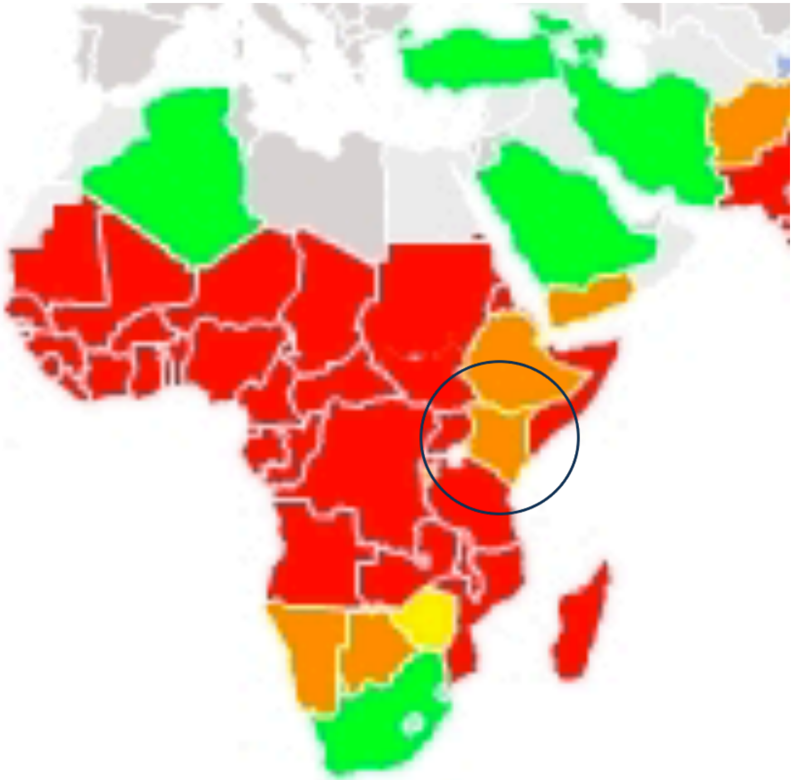
How does an epidemiologist think of scale in studying malaria?

World-wide population at risk for malaria, 2013



Global Malaria Mapper, WHO, 2016

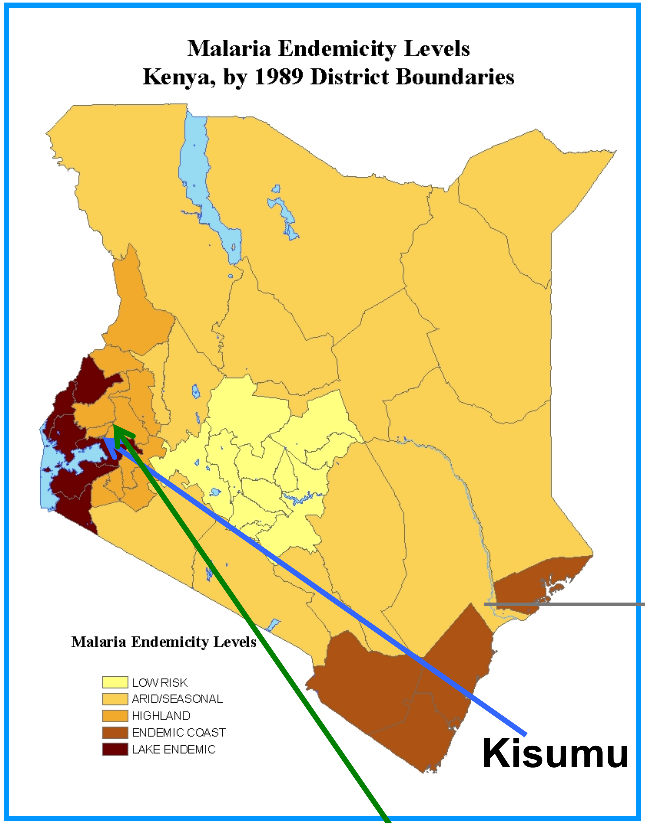
World-wide population at risk for malaria, 2013



Global Malaria Mapper, WHO, 2016

Centre for Global Health Research
Kenya Medical Research Institute

Variability of malaria transmission in Kenya

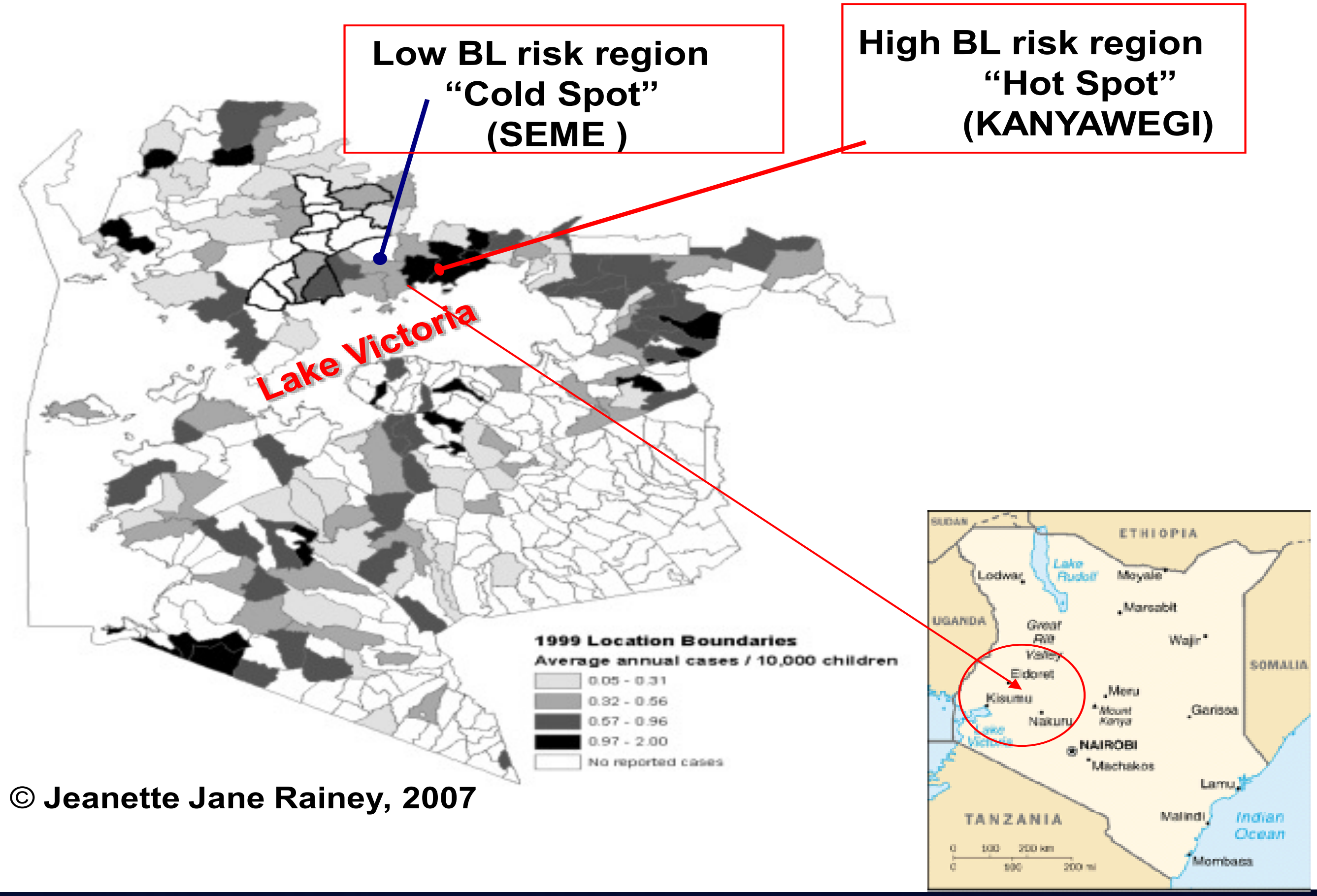


	Age Group (years)			
	1-4	5-9	10-14	All ages
	n (%)	n (%)	n (%)	n (%)
Kisumu				
No. of subjects	34 (32)	37 (35)	35 (33)	106 (100)
EBV seropositive	32 (94)	37 (100)	35 (100)	104 (98)
Mean hemoglobin (g/dl)	9.72	12.25	12.51	11.53
Subjects with P.f. positive smear	26 (77)	27 (73)	29 (83)	82 (77)
Mean body temperature (^{o}C)	36.80	36.76	36.89	36.82
Nandi				
No. of subjects	39 (30)	50 (38)	41 (32)	130 (100)
EBV seropositive	36 (92)	50 (100)	41 (100)	127 (98)
Mean hemoglobin (g/dl)	12.18	12.82	13.29	12.77
Subjects with P.f. positive smear	3 (8)	7 (14)	11 (26)	21 (16)
Mean body temperature (^{o}C)	37.21	37.18	37.09	37.16

Rainey, 2007, Moorman, 2005

Microgeographic variability of malaria

Study Area: Nyanza Province



Significant geographical variability in malaria prevalence even within small geographic region

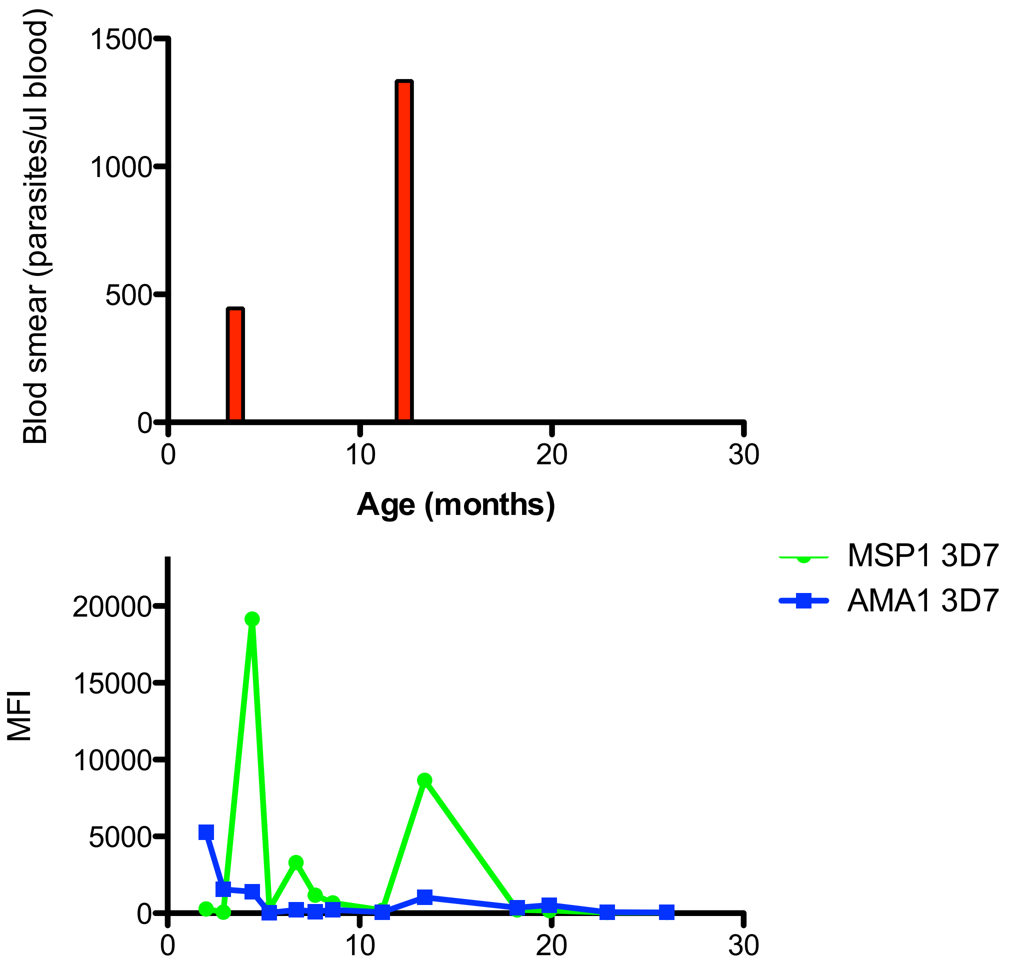
	eBL Low Incidence n=107		eBL High Incidence n=151		*p* value
Age (SD), years	5.08	(2.57)	4.96	(2.38)	0.70
Gender: n male (%)	51	(48)	68	(45)	0.68
Prevalence + for *parasites: n (%)	23	(22)	90	(62)	<0.001
Mean *parasite density (SEM): µL Geometric mean	2262 1155	(616)	7027 1085	(2111)	0.55
Mean EBV log viral load** (SD)	2.57	(0.81)	3.33	(1.56)	0.001
Mean hemoglobin (SEM): g/dL	12.05	(0.14)	11.50	(0.19)	0.016
Anemia† prevalence, n (%)	27	(25)	71	(47)	<0.001

Sumba et al., British J. Cancer 2010

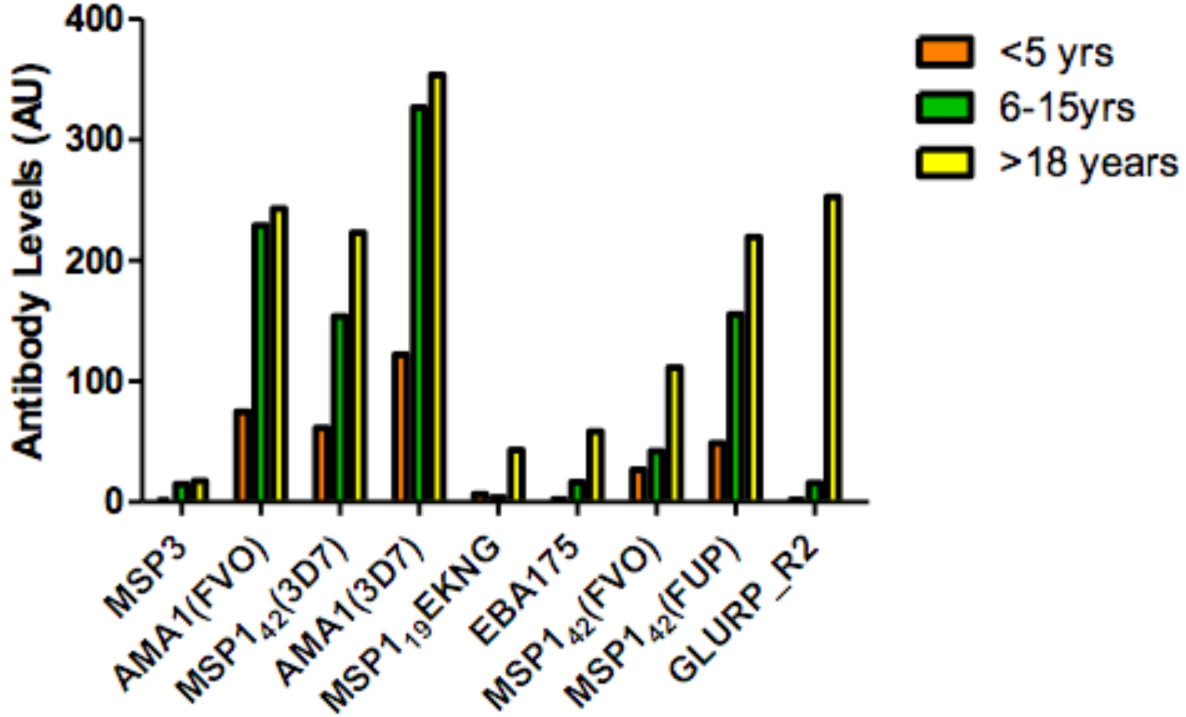
Summary

- Geographic variability of malaria prevalence even within small region.
- The percent of children (the not-yet immunes) that have parasites in their blood is an indicator of how much malaria exists within a region.

Antibodies to malaria have a short half-life



Immunity to malaria slow to develop



Summary

- Geographic variability of malaria prevalence even within small region.
- The percent of children (the not-yet immunes) that have parasites in their blood is an indicator of how much malaria exists within a region.
- Immunity to malaria is slow to develop, only protects against disease and not to re-infection.
- Malaria can be considered a **chronic infection** of children in holoendemic regions

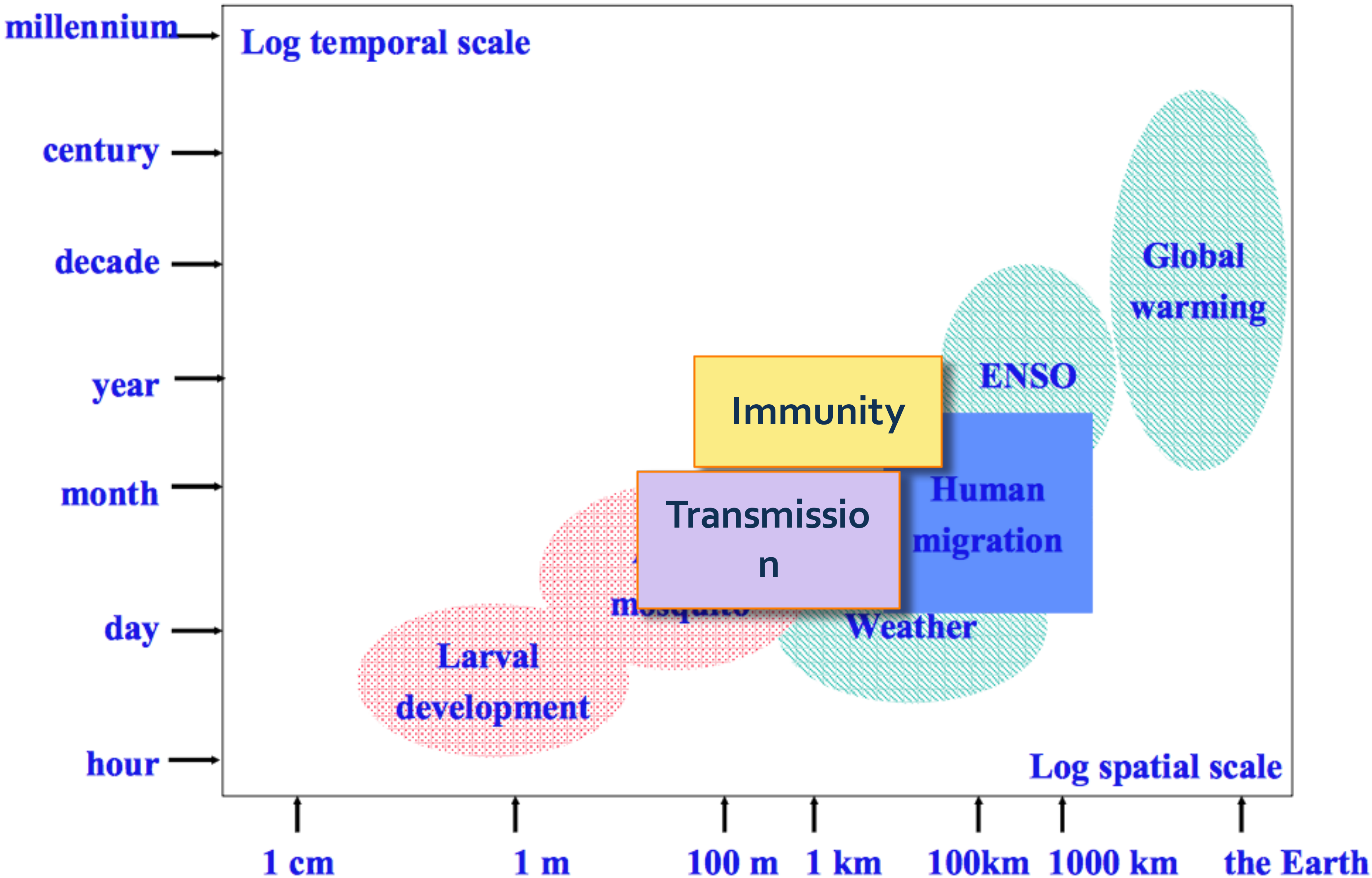
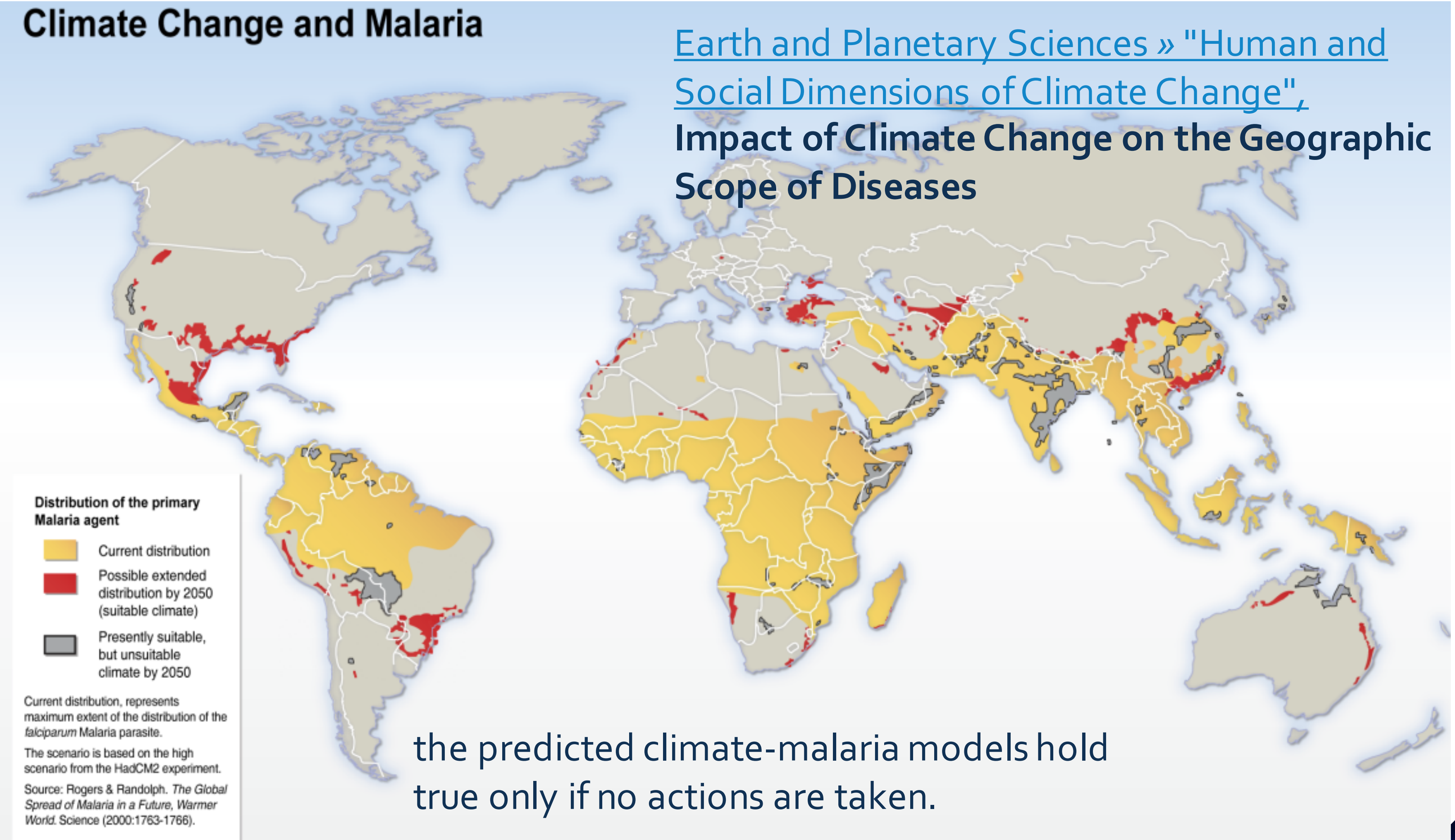


Figure 1. Some processes on different temporal and spatial scales that affect malaria epidemiology

Adapted from Martens and Thomas

How does climate affect malaria prevalence and distribution?



Earth and Planetary Sciences » "Human and Social Dimensions of Climate Change",

Impact of Climate Change on the Geographic Scope of Diseases

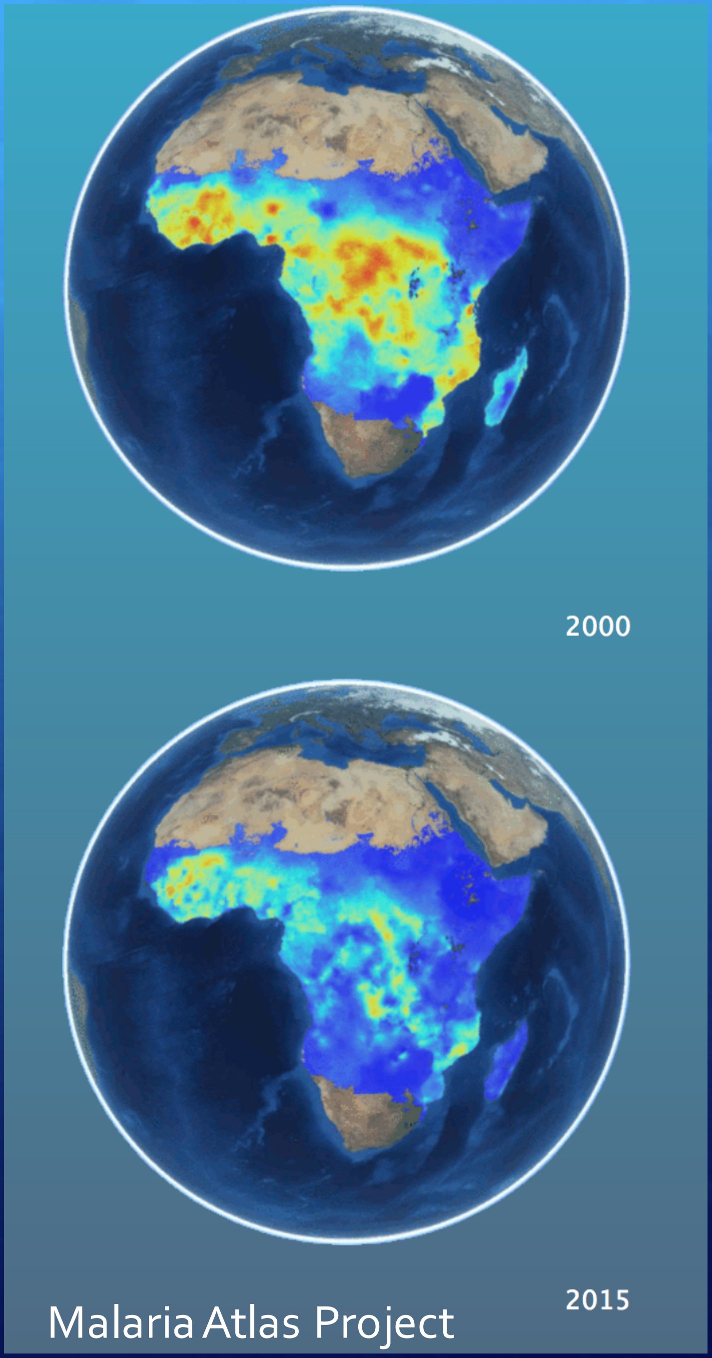
the predicted climate-malaria models hold true only if no actions are taken.

Malaria interventions have reduced parasite prevalence in last decade

Insecticide treated bed nets

Indoor residual spraying

New anti-malaria drugs



Does climate change result in malaria transmission in new regions of Africa?

Yes

Climate variability and malaria epidemics in the highlands of East Africa

Guofa Zhou[1], Noboru Minakawa[2], Andrew K. Githeko[3] and Guiyun Yan[1]

[1]Department of Biological Sciences, State University of New York at Buffalo, Buffalo, NY 14260, USA
[2]Faculty of Medicine, Saga University, 5-1-1 Nabeshima, Saga 849-8501, Japan
[3]Climate and Human Health Research Unit, Center for Vector Biology and Control Research, Kenya Medical Research
P.O. Box 1578-40100, Kisumu, Kenya

The causes of the recent re-emergence of malaria in the East African highlands probably involve a complex interplay among multiple factors, including climate, land use, topography, inadequate use of antimalarial drugs and drug resistance, socioeconomic status, health policy and public health control measures. It is important to determine the relative contribution of these factors. In our study, we statistically attributed the effects of autocorrelation, seasonality and climate variability to the temporal variation in the number of malaria patients in several highland sites in East Africa. We found that in three out of seven sites, climate variability contributed more variance to malaria patient numbers than did autocorrelation and seasonality. In all seven study sites, we found highly significant nonlinear, synergistic effects of the interaction between rainfall and temperature on malaria patient time series.

and clinics as human population size increas
countries during the study period.

Table 1 presents the change in human pop
and the number of health facilities in Rift
Nyanza provinces, in Kenya from 1981 to 1
Uganda from 1987 to 2001 (health facility data
are not available). We have chosen these two p
Kenya because the three study sites (Kericho,
Eldoret) are in Rift Valley province, and one si
Nyanza province. The rates of increase
population size and the total number of heal
are remarkably similar (Table 1). For examp
12-year period, the human population size ir
54.6% and 39.9% in Rift Valley and Nyanza provinces
respectively, and the total number of health facilitie
increased by 50.8% and 64.9%, respectively. Although th
number of health facilities at specific sites cannot b
inferred from the provincial-level data, there is no reaso

No

Climate variability and malaria epidemics in the highlands of East Africa

Simon I. Hay[1], G. Dennis Shanks[1], David I. Stern[2], Robert W. Snow[3], Sarah E. Randolph[1] and David J. Rogers[1]

[1]Department of Zoology, University of Oxford, South Parks Road, Oxford, UK, OX1 3PS
[2]Department of Economics, Rensselaer Polytechnic Institute, Troy, NY 12180, USA
[3]KEMRI/Wellcome Trust Collaborative Programme, PO Box 43640, 00100 Nairobi GPO, Kenya

Malaria epidemics in the highlands of East Africa garner significant research attention, due, in part, to their proposed sensitivity to climate change. In a recent article, Zhou *et al.* claim that increases in climate variance, rather than simple increases in climate mean values, have had an important role in the resurgence of malaria epidemics in the East African highlands since the early 1980s. If proven, this would be an interesting result but we believe that the methods used do not test the hypothesis suggested.

number of hospitals generally increases in p
the human population size increase, and thu
population size that each hospital has ser
similar during the study period', is not supp
article cited [3] which actually says the o
situation at specific sites cannot be inferre
national data, but they do provide evidenc
decline in per capita health service provisic
with many of the malaria resurgences'. N
numbers recorded at individual facilities cann
investigate epidemic trends without accour

TRENDS in Parasitology Vol.21 No.2 February 2005

Malaria and climate change: unanswered questions

- How do we bring the scales of climatology and malaria epidemiology together to increase our predictive/analytic power?
- How do interventions affect our modeling of disease?
- Does malaria contribute to other chronic diseases?

Indian J Nephrol. 2015 May-Jun; 25(3): 146–151. PMCID: PMC4446918
doi: 10.4103/0971-4065.140712

Dehydration and malaria augment the risk of developing chronic kidney disease in Sri Lanka

E. A. R. I. E. Siriwardhana, P. A. J. Perera, R. Sivakanesan,[1] T. Abeysekara,[2] D. B. Nugegoda,[3] and J. A. A. S. Jayaweera[4]

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Abstract

Go to:

Chronic kidney disease (CKD) of unknown etiology (CKDu) is a serious health issue in Sri Lanka. One-to-one age and sex-matched two sample comparative study was carried out in the Medawachchiya divisional secretariat area of the North Central Province (NCP) of Sri Lanka, by randomly selecting 100 CKDu patients and 100 age and sex-matched subjects from non-CKDu affected families from the same area. An interviewer-administered questionnaire was used for the collection of data pertaining to occupation, medical history and lifestyle. Data were analyzed using a conditional linear logistic model. Working for >6 h in the field per day, exposure to sun, drinking water only from well, consumption of <3 L of water per day, and having a history of malaria were found to be having significant ($P < 0.05$) likelihood toward the development of CKDu. Treatment of water prior to consumption had a significant protective effect against CKDu. Dehydration, history of malaria and drinking untreated well water from are likely contribute to the development of CKD of unknown etiology among the inhabitants of NCP, Sri Lanka.