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Communicable diseases — evidence of an impact associated with global warming?

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Communicable diseases — associated with global warming?

- **Seasonality of infectious diseases**
- **Global warming: effect on ecosystems**
  - **Microbial proliferation**
  - **Impact on vectors**
  - **Human infrastructure: disasters → migration**
- **Specific infectious diseases, epidemics: examples**
- **WHO assessment**
- **Future — outlook**

Seasonality of infectious diseases

Hippocrates — 460 to 377 B.C.

Seasonal appearances of particular diseases formed the basis of the Hippocratic treatise on epidemics:

> **'Now let us consider the seasons and the way we can predict whether it is going to be a healthy or an unhealthy year'**
> **(Air, Water, Places, 10)**

> **'Every disease occurs at any season of the year but some of them … are of greater severity at certain times'**
> **(Aphorisms, III, 19)**

Mechanisms resulting in seasonality of person-to-person transmission are poorly understood.

Fisman DN. Annu Rev Public Health 2007;28:127-43
Naumova EN. J Public Health Policy 2006;27:1-12

A N

A C C O U N T

Of the Principal

Variations *of the* Weather,

And the Concomitant

Epidemical Diſeaſes,

From the Year 1726, to the End of the Year 1734.

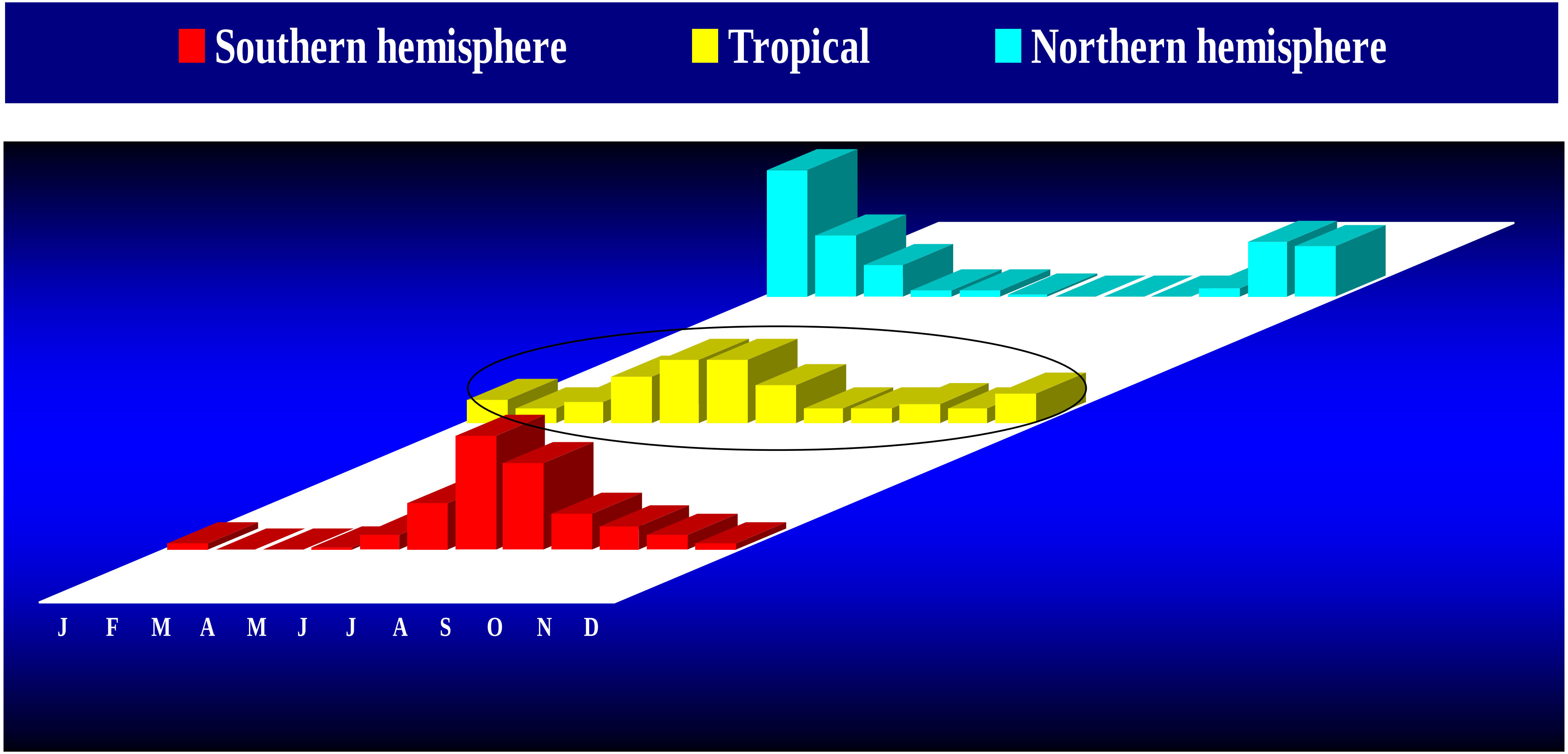
As they appeared at *RIPPON*, and the adjacent Parts of the County of *YORK*.

By *WILLIAM HILLARY*, M.D. at *BATH*.

Αἱ μεταβολαὶ τῶν ὡρέων μάλιστα τίκτουσι νοσήματα, καὶ ἐν τῇσιν ὥρῃσιν αἱ μεγάλαι μεταλλαγαὶ, ἢ ψύξιος, ἢ θάλψιος, καὶ τ' ἄλλα κατὰ λόγον οὕτως. ΙΠΠΟΚΡΑΤ. ΑΦΟΡΙΣΜ. τμῆμα τρίτον, Α.

Fisman D.H. Annu. Rev. Public. Health. 2007;28:127-143

Seasonal Occurrence of Influenza



Summary of influenza activity and occurrence in different climates

Reichelderfer PS et al. In Chan JC et al. Eds. Current topics in medical virology. World Scientific, Singapore 1989:412-44

Seasonality of infectious diseases

Enteric infections	Peak season
Campylobacter spp.	Summer
Salmonellosis	Summer
Giardia lamblia	Early fall
Rotavirus	Winter
Cryptosporidiosis	Snowmelt
Poliomyelitis	Humid summer

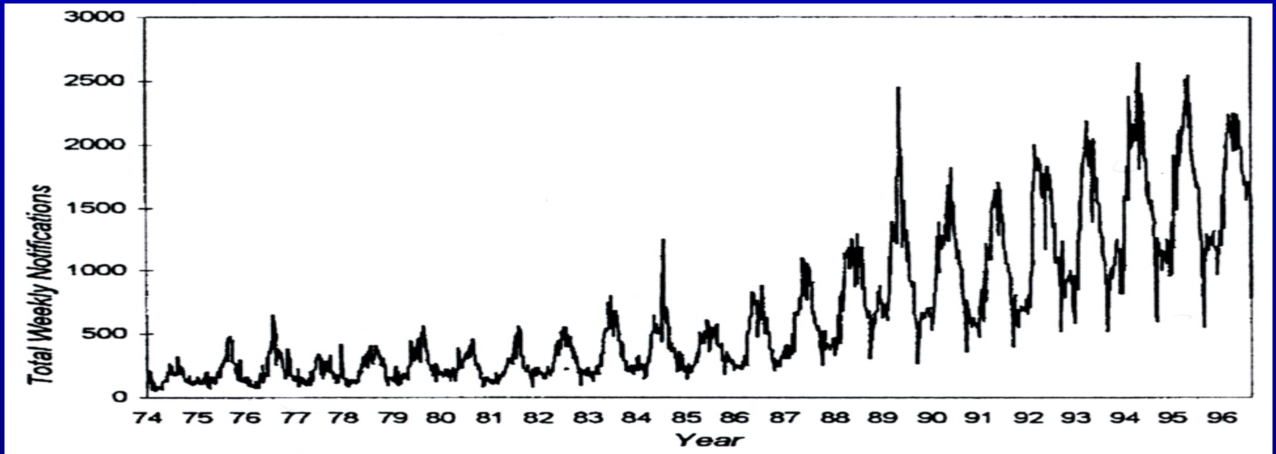
Other	
Meningococcal disease	Summer
Respiratory Syncytial Virus	Summer
SARS	Early fall

Naumova EN. J Public Health Policy 2006;27:1-12

Global warming — effects on ecosystems

Higher temperatures enhance microbial proliferation

- outbreaks of food-poisoning



Total weekly notifications of food poisoning in England and Wales 1974-1996

Bentham G & Langford IH. Int J Biometerol 2001;45:22-6

- epidemics of cholera
- salmonella spp

Europe: higher temperatures → 30% of cases

Kovats RS et al. Epidemiol Infect 2004;132:443-453

Notifications of food poisoning strongly associated with temperatures, BUT

- weak correlation in that specific week
- time lag 2 to 5 weeks!

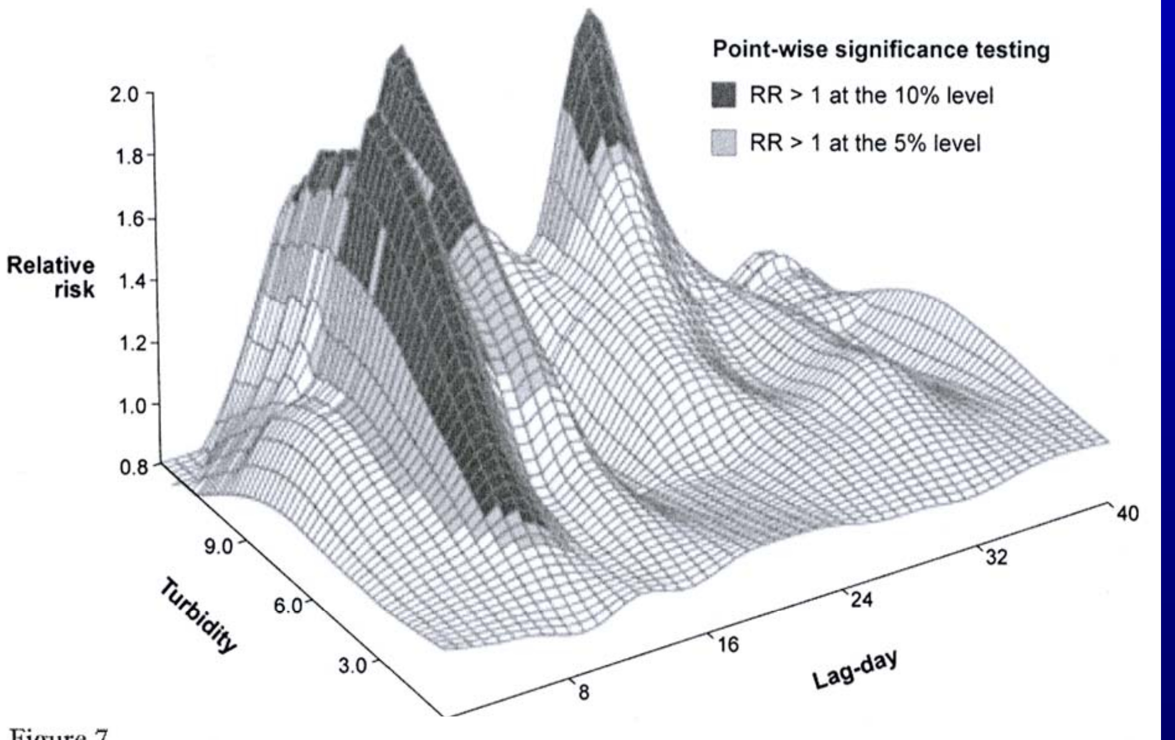


Figure 7

Impact of water turbidity on risk of diarrhea-related visits to children's hospitals in the Vancouver, Canada, area, 1996–1999, as presented in Reference 8. It can be seen that increased turbidity increases the risk at lags of ~10 days and 24 days; these different lags may represent diarrhea caused by pathogens with differing incubation periods. Source: Reference 8. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2006.

Consider

- increased incidence of infections in animals
- multiplication of pathogens in food

Fisman D. N. Annu Rev Public Health 2007;28:127-143

Food poisoning (FP) — multifactorial

Risks have increased due to (hypotheses)

- bulk purchase with longer storage at home
- more ready to eat food (take-away!)
- more risky food items: rare meat and seafood, exotica
- increased susceptibility in ageing population
- better notification

Seasonal variations influenced by differences in

- type of food consumed, e.g. ice cream *vs.* cheese fondue
- methods of (not) cooking

not only global warming — also behavioral changes!

Impact of climatic variations on

- infectious agents: viruses, bacteria, protozoa
- vectors: mosquitoes, ticks, sandflies, etc.

All devoid of thermostatic mechanisms

VECTORS

Temperature fluctuation affects rates of

- reproduction
- survival

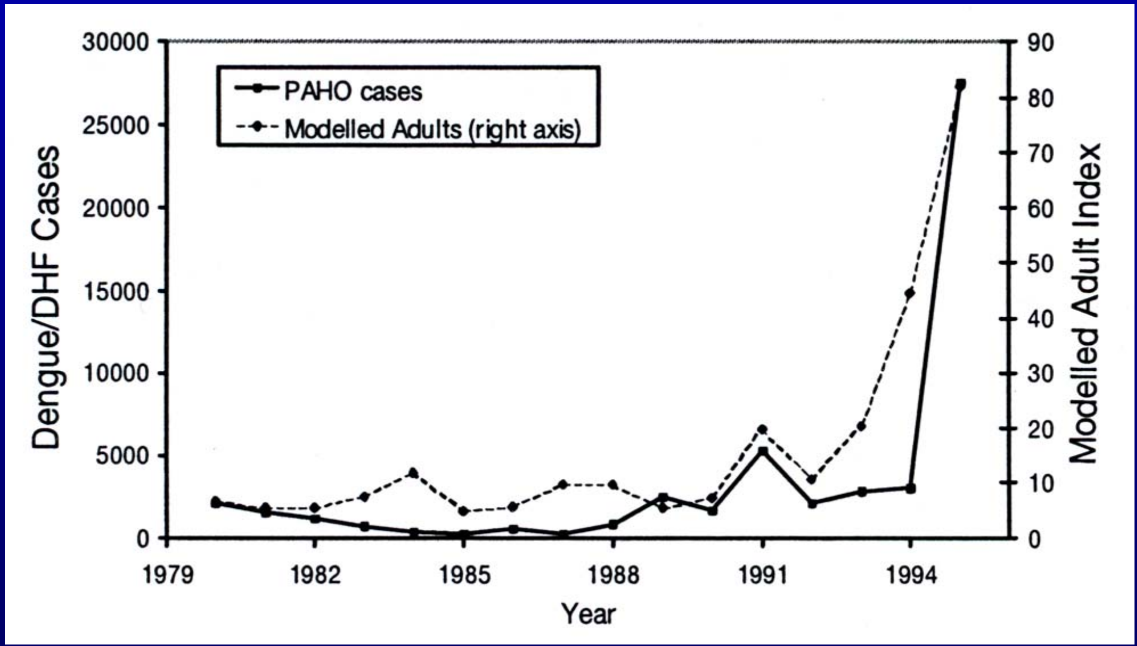
Temperature thresholds well defined

Kovats RS et al. Phil Trans R Soc Ser B 2001;356:1057-68
Gubler DJ et al. Environ Health Perspect 2001;109:223-33

Computer Modeling on Dengue Fever

- **Climate based: temperature, humidity, solar radiation, rainfall**
- **Mosquito *(Aedes aegypti)* physiology and development**

Simulated, climate-induced variations *vs.* reported cases

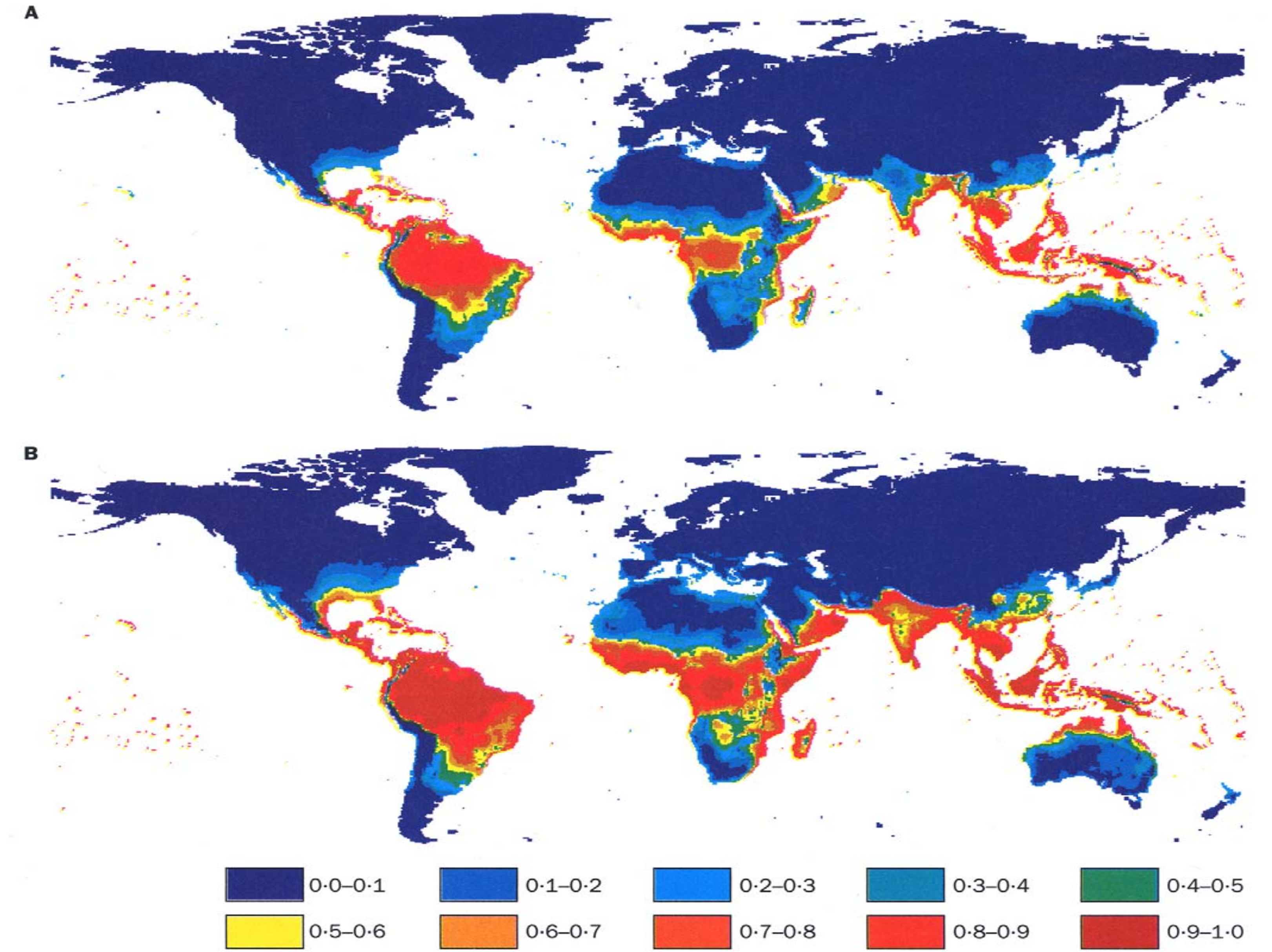


Honduras: Dengue/DHF cases (PAHO dataset) and modelled adult mosquito (*Aedes aegypti*) index. Correlation coefficient = 0.91* (0.88* detrended); *p < 0.05

→ Strong correlation with inter-annual variability (P<0.05)

Hopp MJ & Foley JA. Clim Res 2003;25:85-94

Population and climate changes effects on dengue



Hales S et al. Lancet 2002;360:830-4

World population at risk of dengue transmission

Year	Billion	Percent	Remarks
1990	1.5	30	Outbreaks 1975-96
2055	4.1	44	outbreaks contd.
2085	5.2	52	

Annual average vapor pressure most important predictor, forecast includes

- **population increase**
- **changes in humidity as per HADCM2**

Hales S et al. Lancet 2002;360:830-4

International Herald Tribune
Friday, February 20, 2004

Dengue hits Indonesia

175 die from mosquito-borne virus

Malaria transmission in East Africa

KENYA HIGHLANDS

- Infection rising to higher elevation with warming

ETHIOPIA HIGHLANDS (Debre Zeit Sector)

- Increasing malaria prevalence with warming

BUT — confounding factors:

- vector / disease control programs
- drug resistance
- migration
- immune status

→ **CONTROVERSIAL**

Malaria in Britain: Past, present, future

PAST

'The ague': high mortality in marshlands 15 to 19th centuries by *P. vivax* (!), similarly to the Netherlands

Decline from early 1800s → various hypotheses:

- **marsh drainage**
- **increasing livestock: diverted biting (likely theory!)**
- **improved housing, hygiene**

Gaardbo Kuhn K et al. PNAS 2003;100:9997-10001

Modeling of 'ague' deaths 1840 to 1910 — predictions for seven scenarios

Scenario	Deaths	Percentage difference*
Observed	8,209	—
No change in cattle density†	8,920	8.7 (7.6–9.9)
No change in wetland coverage†	9,092	10.8 (9.2–12.1)
No change in cattle density or wetland coverage†	9,806	19.5 (17.6–21.2)
1°C temperature increase	8,879	8.2 (7.3–9.2)
1°C temperature decrease	7,673	−6.5 (−8.4 to −4.2)
2.5°C temperature increase	9,397	14.5 (13.2–16.5)

*Compared with the observed number of deaths (with 95% confidence interval).

†Since 1840.

Gaardbo Kuhn K et al. PNAS 2003;100:9997-10001

Malaria in Britain: Present, future

PRESENT

Since 1953 >50,000 imported malaria: no secondary cases

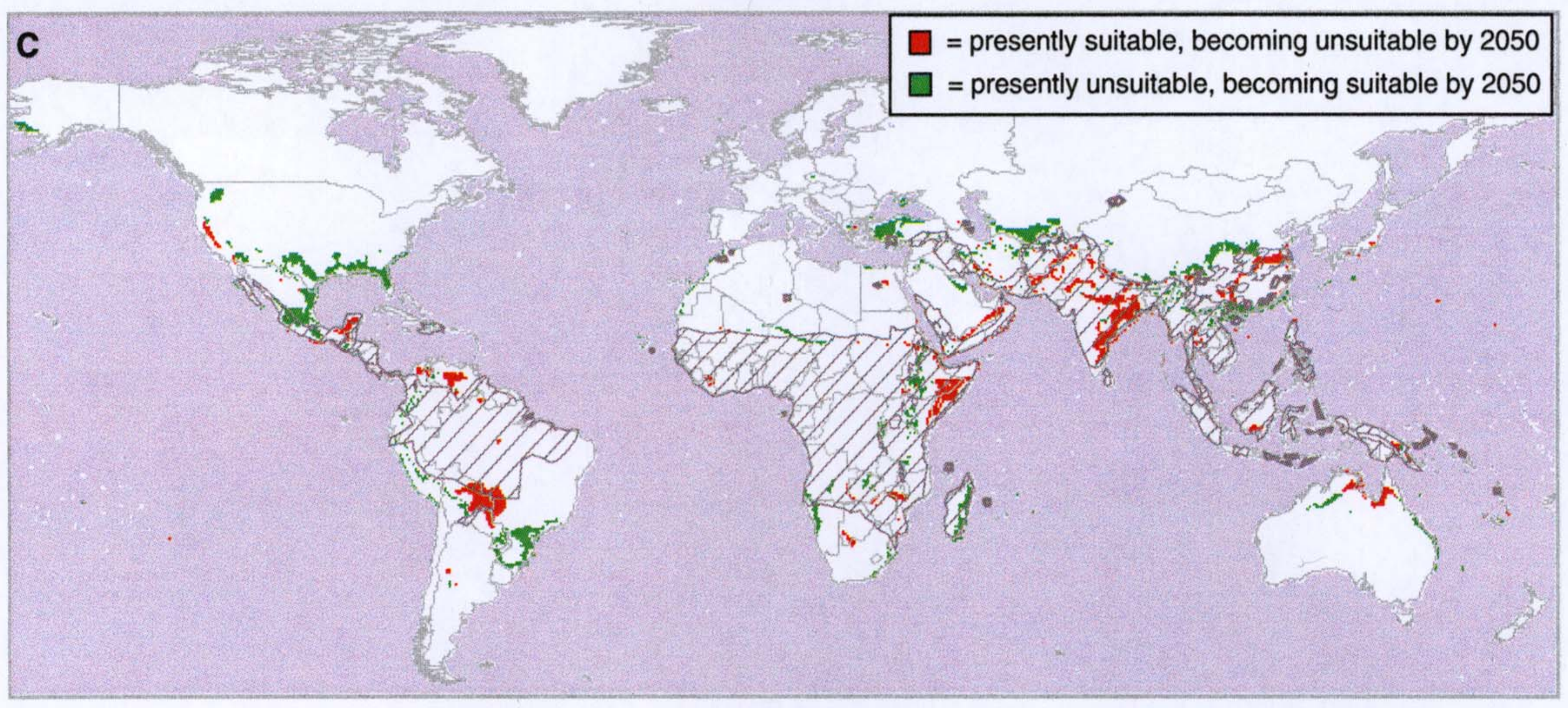
FUTURE

Mosquito abundance not related to multivariate climate

Projected increase in proportional risk insufficient for reestablishment of endemicity

Gaardbo Kuhn K et al. PNAS 2003;100:9997-10001
Rogers DJ. Randolph SE. Science 2000;289:1763-6

Worldwide malaria endemicity, 2050



The difference between the predicted distributions, showing areas where malaria is predicted to disappear (i.e., probability of occurrence decreases from >0.5 to <0.5) (in red) or invade (i.e., probability of occurrence increases from <0.5 to >0.5) (in green) by the 2050s in relation to the present situation. The gray hatching is the current global malaria map.

Rogers DJ, Randolph SE. Science 2000;289:1763-6

Malaria and El Nino/Southern Oscillation (ENSO)

ENSO is strong source of climate variability

Resulting malaria epidemics documented in:

- **Colombia**
- **Indian subcontinent: Lahore, Colombo**
- **Venezuela**
- **Uganda**

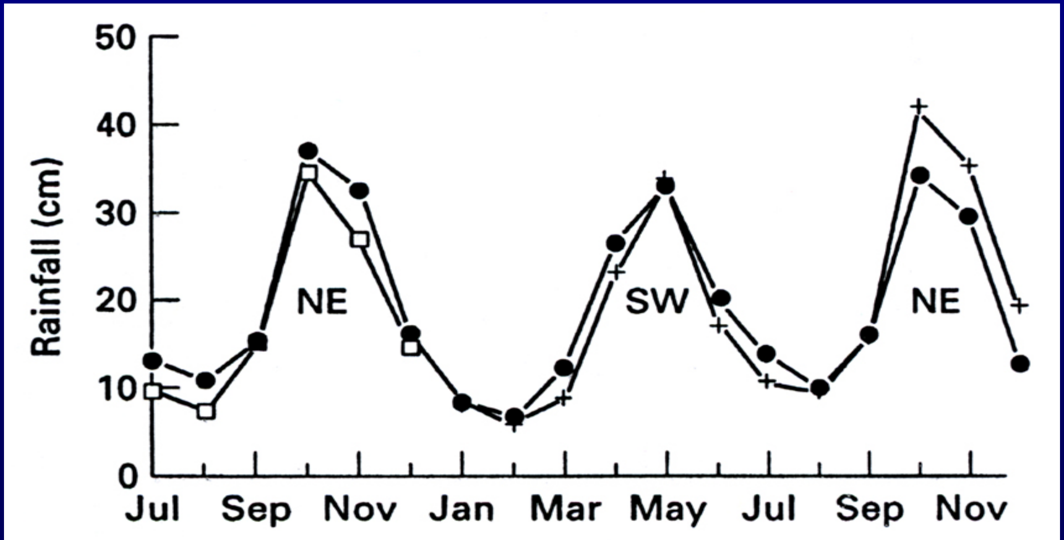


Figure 4 Average monthly rainfall in Colombo, SW Sri Lanka between 1870–1980, during □ pre-El Niño years and +, El Niño years, as compared to ●, other years (non-pre-El Niño and non-El Niño years respectively). North-east winter monsoon (NE), and south-west summer (SW) monsoon.

Bouma MJ, van der Kaay HJ. Trop Med Int Health 1996;1:86-96

How will ENSO dynamics change in a warmer world?

Unknown!

Regions most affected by ENSO:

- SE Asia
- S and E Africa
- SW U.S.A.
- parts of South America

Weather-related events and infectious diseases

Intensifying climatic conditions, together with a range of environmental, epidemiological and socioeconomic factors, are bringing about changes in the exposure of populations to infectious diseases, as illustrated by the following example of Rift Valley fever.

Above-normal rainfall associated with the occurrence of the warm phase of the El Niño Southern Oscillation phenomenon is increasing the breeding sites of mosquitoes, with a consequent rise in the number of outbreaks of Rift Valley fever.

From December 1997 to March 1998, the largest outbreak ever reported in East Africa occurred in Kenya, Somalia and the United Republic of Tanzania. The total number of human infections in the North Eastern Province of Kenya and southern Somalia alone was estimated at 89 000, with 478 "unexplained" deaths.

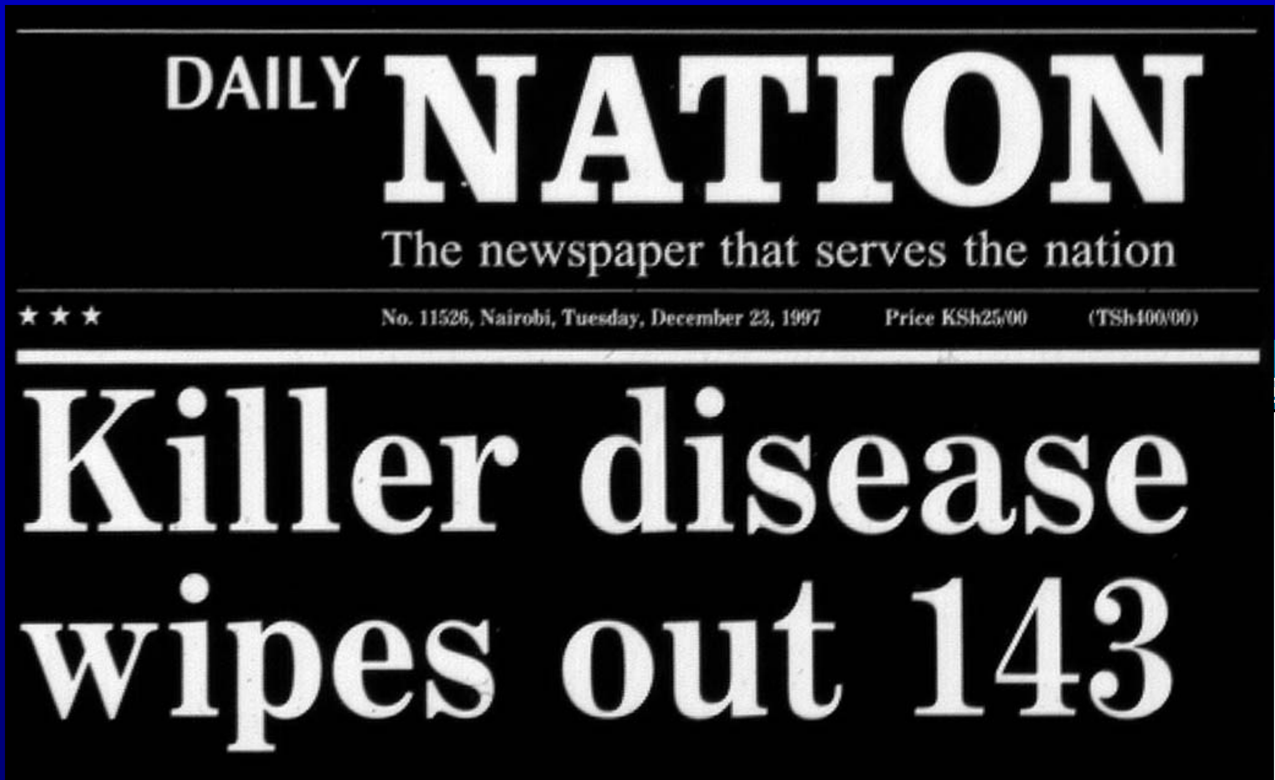
world health report 2007 — global public health security in the 21st century, p. 26

Other infectious diseases associated with climatic variations

Chikungunya	Traveler	N Italy
Cholera (zooplankton?)	ENSO	Bangladesh
Diarrheal disease, childhood	ENSO	Peru
Hantavirus syndrome, pulmon.	ENSO	SW U.S.A.
Leptospirosis		
Meningococcal disease		
Plague		SW U.S.A.
Rift Valley fever	ENSO	Kenya
Ross River virus		Australia
Tick-borne infections		
– Encephalitis (TBE)	DEBATED	Europe
– Lyme disease	DEBATED	

Patz JA et al. Nature 2005;438:310-7

Headlines

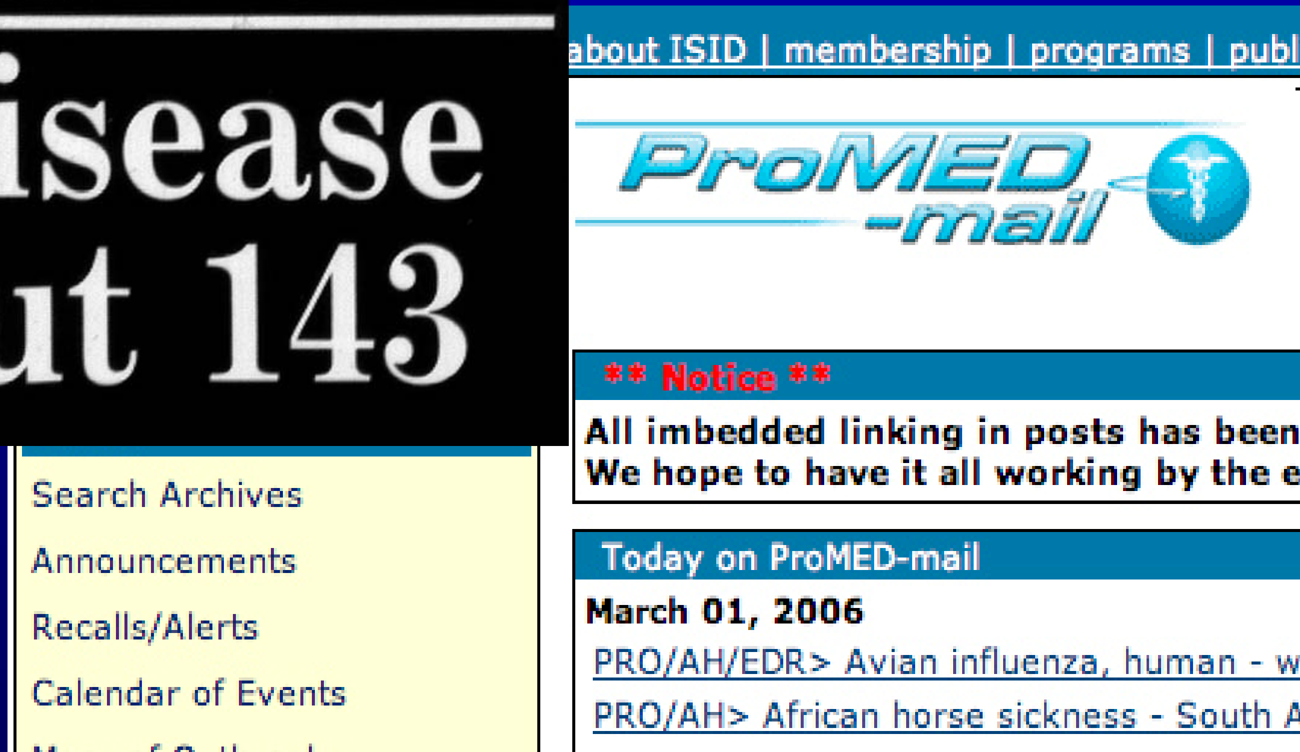


DAILY NATION

The newspaper that serves the nation

★ ★ ★ No. 11526, Nairobi, Tuesday, December 23, 1997 Price KSh25/00 (TSh400/00)

Killer disease wipes out 143



Destruction of infrastructure

Extreme weather events / disasters (e.g. hurricanes) followed by

- **Outbreaks**
  - **food-, waterborne**
  - **mosquito-borne: dengue, Rift Valley Fever**
  - **rabies (earthquakes, not climatic)**

Risk frequently exaggerated – less than in conflict-affected populations

Watson JT et al. Emerg Infect Dis 2007;13:1-5
De Ville de Goyet C. Lancet 2000;356:762-4

Destruction of infrastructure

Extreme weather events / disasters (e.g.hurricanes) followed by

- **Environmental refugees import infections: Norovirus in ‘Katrina’ evacuees in Texas**
  CDC: MMWR 2005;54:1016-8
- **Increase in rodents: e.g. emerging infections (plague — India 1994)**
  Diaz JH. J Travel Med 2006;13:361-72

Possible beneficial effects of global warming

- decreased influenza activity in temperate climate zone? **NO DATA!**
- fertilized females of *Culex pipiens* emerge in January → vulnerable to subsequent cold → less West Nile virus
- malaria: decrease in exposure in 25 million people (-0.92%) *vs.* increase in 23 million (+0.84%)

Rogers DJ. Randolph SE. Science 2000;289:1763-6

Summary and outlook

- Microbial proliferation	Increased risk
- Impact on vector	
– Usually	Increased risk
– Few areas	Decreased risk
- Human infrastructure	Damage > Risk

World Health Organization estimates

Climate change was estimated to be responsible in 2000 for

- **2.4% of worldwide diarrhoea**
- **6% of malaria in some middle income countries**
- **7% of dengue fever in some industrialized countries.**

In total, the attributable mortality was 154 000 (0.3%) deaths and the attributable burden was 5.5 million (0.4%) DALYs.

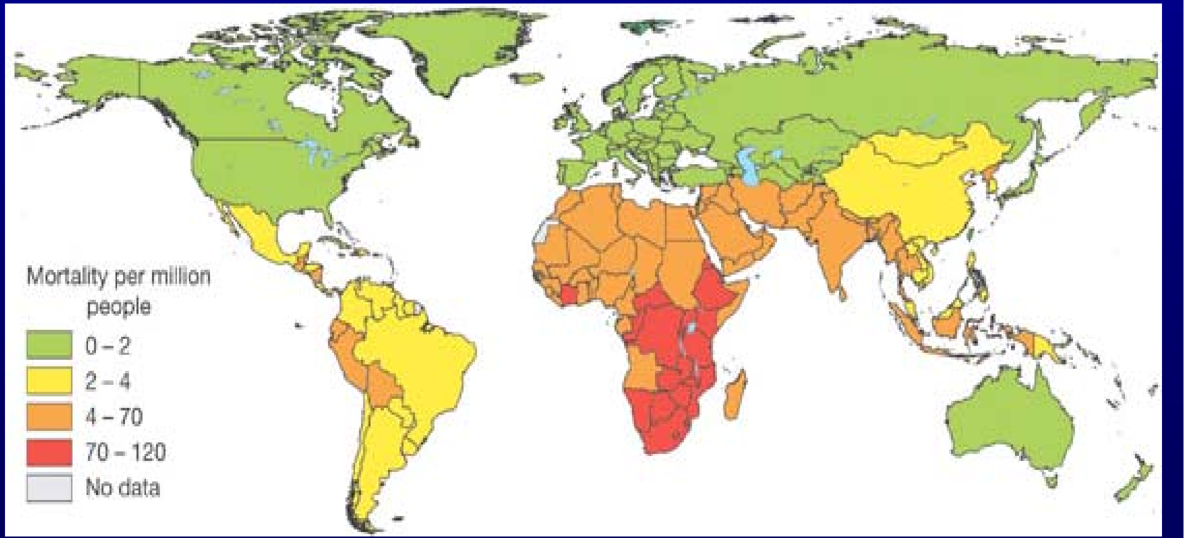
WHO. World Health Report 2002

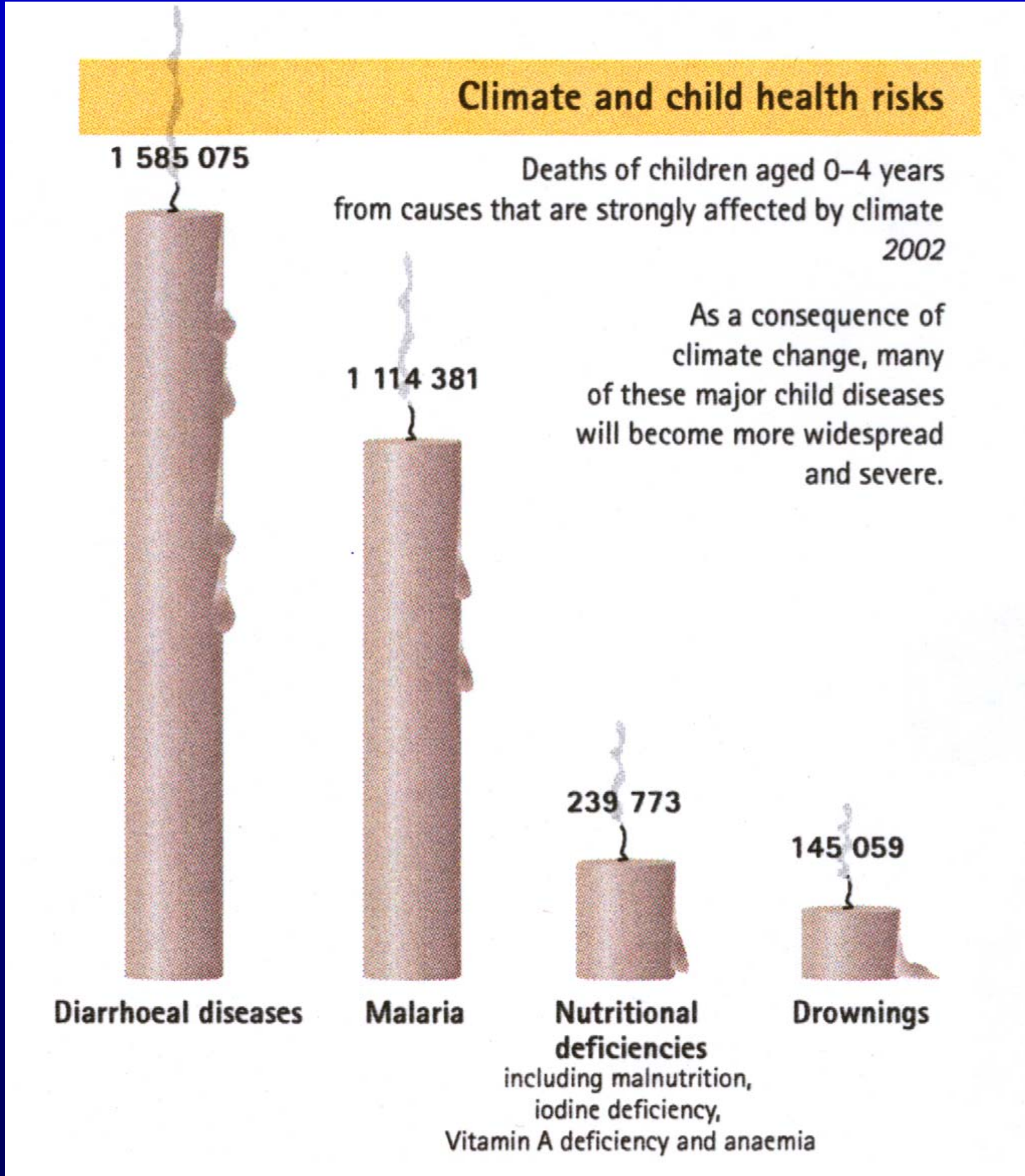
46% this burden occurred in SEAR-D

23% in AFR-E

14% in EMR-D

WHO. World Health Report 2002





http://www.who.int/ceh/publications/en/20globalwarming.pdf

WHO: Infectious diseases spread more rapidly

- Ease of international travel
- Population growth
- Resistance to drugs
- Under-resourced healthcare systems
- Intensive farming
- Degradation of the environment

Chan M in BMJ 2007;335:335-418 (1 September)

Predictions on consequences of global warming

Year	Effect	Consequence
NON-COMMUNICABLE DISEASES		
2080	Sea level + 40 cm	Flooding by coastal storm affects 200 M (now 75 M)
COMMUNICABLE DISEASE		
all predictions and models, excessive disease burden on regions with the lowest capacity of adaptation.		

Intergovernmental panel 2001 in Patz et al. Nature 2005;438:310-7

Speculations on future health effects

Must account for

- temperature levels
- future economical, technological and demographic evolution of societies
- public health response

<u>WHO projection to 2030:</u>

LARGE increase for relative risk of FLOODING

MODEST increase (16 – 28%) in

- malaria
- diarrhea

but great potential impact e.g. sub-Saharan Africa:

- malaria 1.600 deaths / million / year
- diarrhea 1.000 deaths / million / year