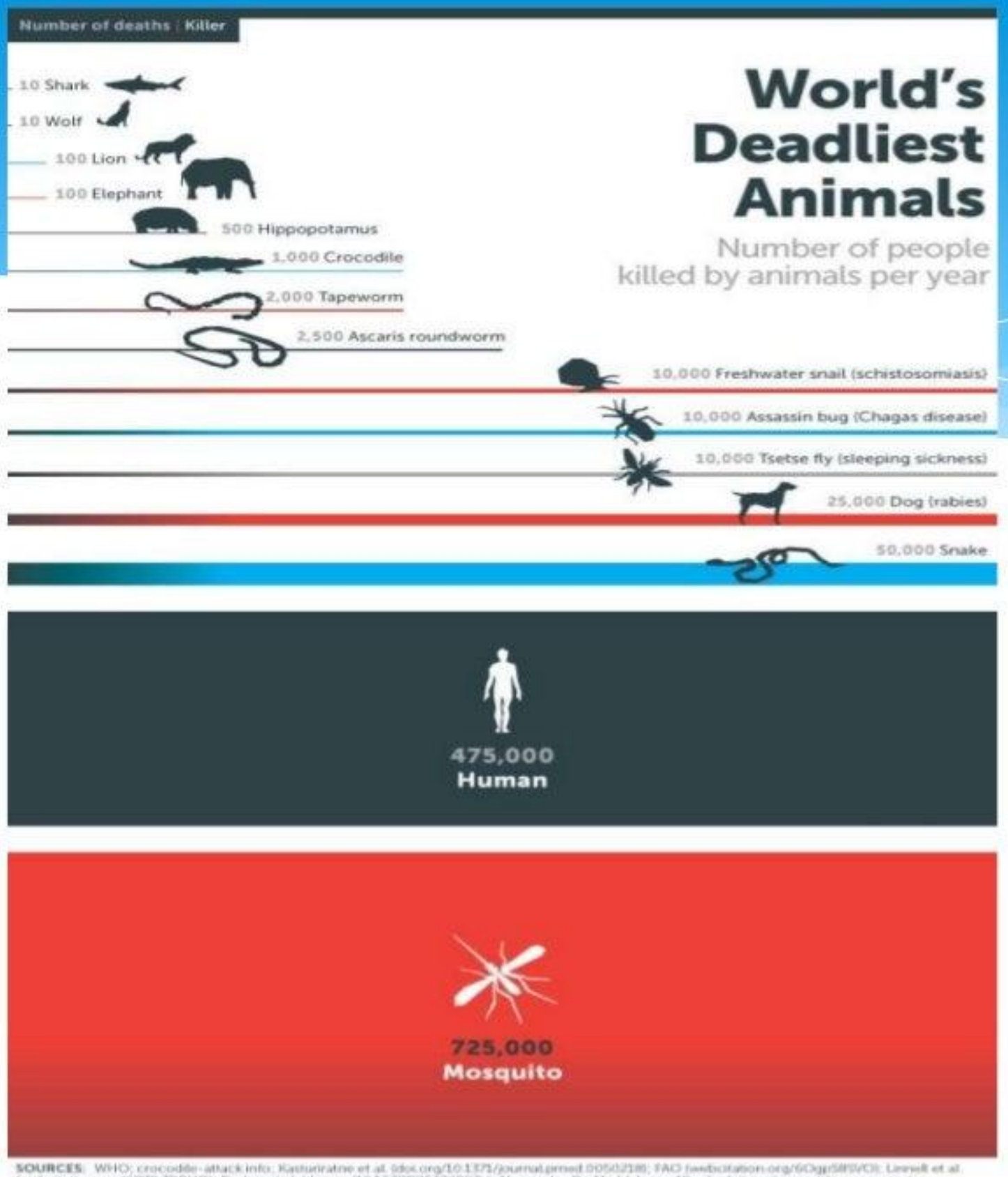
The Role of Weather and Climatic Changes in the Transmission of Dengue

Emmanuel O. Taiwo

(1st May 2014)

Contents

* Introduction: what is dengue?
* Spatial and temporal spread
* Climate/weather change: how does it drive dengue?
* Future scenarios
* Solutions: dengue prevention & control



World's Deadliest Animals

Number of people killed by animals per year

Source: http://www.gatesnotes.com/Health/Most-Lethal-Animal-Mosquito-Week 30/04/2014)

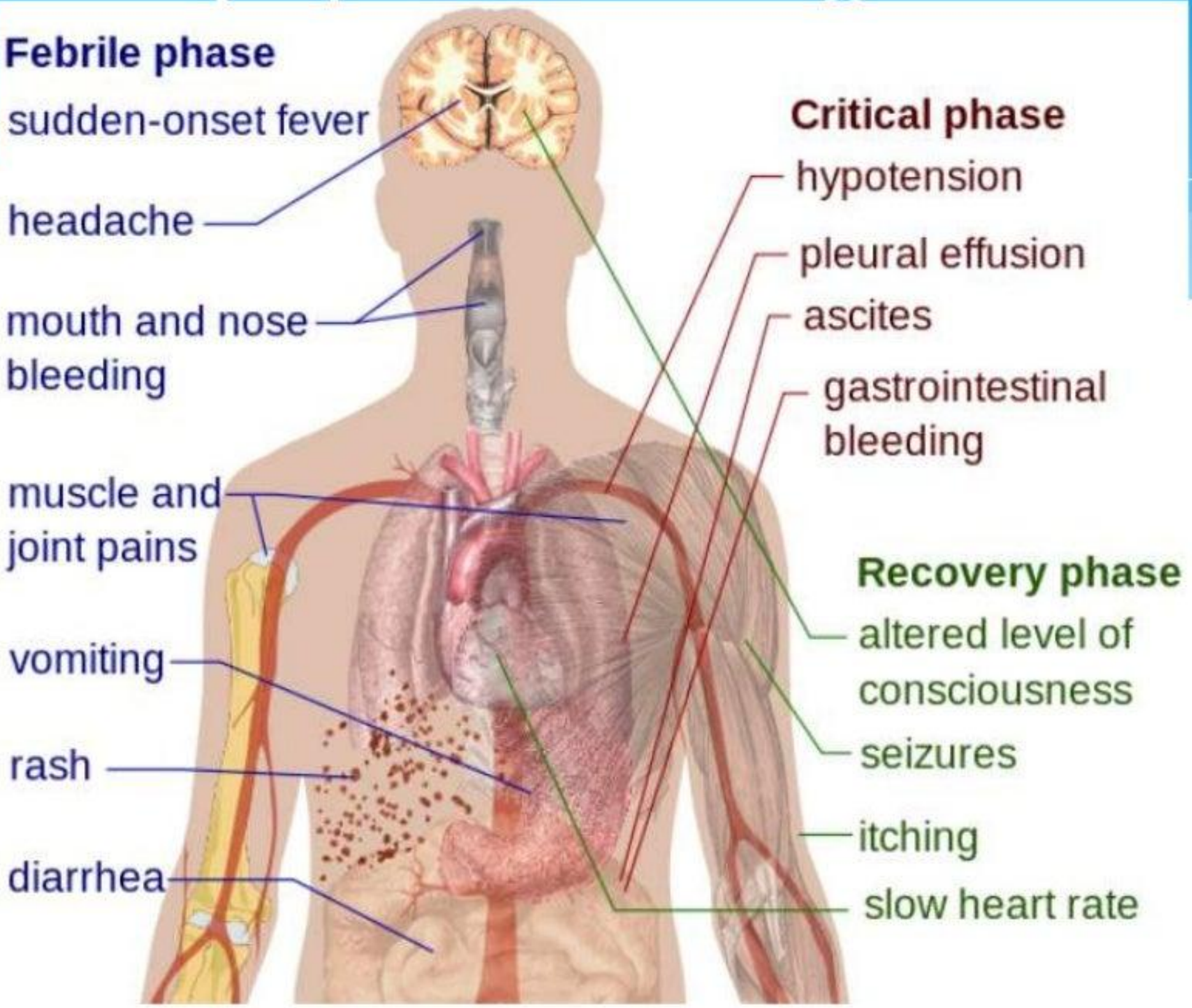
Introduction: what is dengue?

* An infectious disease transmitted by mosquitoes (mainly "*Aedes aegypti* ") carrying the virus
  * an RNA virus, genus: Flavivirus, family: Flavivirida
  * Other vectors: *Aedes albopictus, polynesiensis* & *scutellaris*

* World's most widely distributed mosquito-borne viral disease
* A feverish illness with symptoms appearing 3-14 days after an infective bite
* Complicated cases could lead to severe condition called 'dengue hemorrhagic fever'

(WHO, 2009)

Symptoms of dengue



(Source: http://en.wikipedia.org/wiki/File:Dengue_fever_symptoms.svg , 15/04/2014)

Introduction (2)

* Transmitted through "Infected-person-to-mosquito-to-another-person" pathway
* One bite can cause the disease
* Aedes mosquitoes flourish in rainy seasons
* However, they can breed in pools, water-filled vases, plastic bags, and cans all year-round

(Cunha and Stoppler, 2013)

* 22,000 deaths yearly, mostly among children
* There is currently NO CURE OR VACCINE for its treatment
* However, early detection and access to proper medical care lowers fatality rates below 1%

(WHO, 2014)

Spatial and temporal spread

* Prevalent in tropical and sub-tropical regions
* Predominantly in urban and semi-urban areas
* Leading cause of child mortality in many Asian and Latin American countries
* 50-100 million cases worldwide each year
* 22,000 deaths yearly, mostly among children
* Its global incidence has grown rapidly in recent decades
* 30-fold increase over the past 50 years
* About 50% of world's population now at risk
* Most rapidly spreading mosquito-borne viral disease

(WHO, 2014)

Dengue, countries or areas at risk, 2011

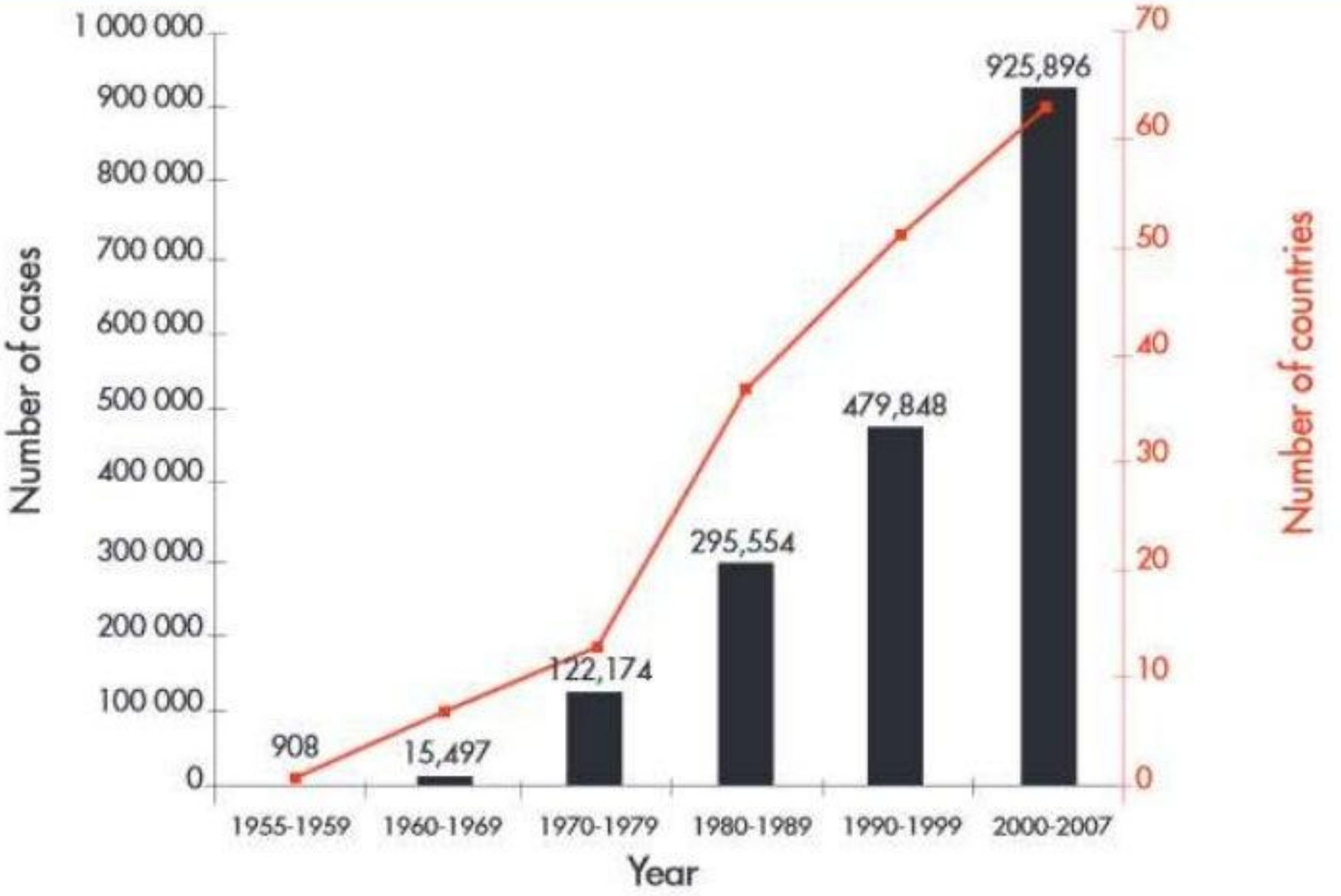
The contour lines of the January and July isotherms indicate areas at risk, defined by the geographical limits of the northern and southern hemispheres for year-round survival of Aedes aegypti, the principal mosquito vector of dengue viruses.

Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

World Health Organization

Source: WHO cited in Alvarado (2013)

1955 – 2007: The upward trend



Average annual number of dengue fever (DF) and dengue haemorrhagic fever (DHF) cases reported to WHO, and of countries reporting dengue, 1955–2007 (Source: WHO, 2009)

Dengue: Some recent outbreaks

* 2009: Key West, Florida, 28 to 55 cases (Cunha and Stoppler, 2013)
* 2011: Severe outbreak in Paraguay, hospitals became overcrowded (Cunha and Stoppler, 2013)
* 2011: Bolivia, Brazil, Columbia, Costa Rica, El Salvador, Honduras, Mexico, Peru, Puerto Rico, and Venezuela (thousands infected)
* 2012: first sustained transmission in Europe since 1920s reported in Madeira, Portugal (Sousa *et al.*, 2012)
* 2013: Outbreaks in the Caribbean: Puerto Rico, Virgin Islands and Cuba (Cunha and Stoppler, 2013)
* 2013: Thailand's worst outbreak in 20 years, 126 deaths, 135,344 people infected as of October (Cunha and Stoppler, 2013)
* Imported cases (*e.g.* tourism): Tahiti, Singapore, S.E. Asia, West Indies, India and Middle East (Cunha and Stoppler, 2013)

Weather and Climate Variability

* Weather and climate are variable, naturally
* Human influences accelerating the rate of climate change, thus causing chaotic global warming
* Ecosystems and living organisms depend on the *stability* of atmospheric services
* These atmospheric changes (whether short-term or long-term) have effects on living organisms (and their welfare)

- IPCC (2013, 2014)

Ongoing climate change: Features, impacts and threats

* Generally increasing temperatures
* Heat waves
* Floods
* More erratic changes in wind patterns
* Changing landscapes
* Rising sea levels
* Severe storms
* Increased severity of floods, droughts and fires
* Food insecurity
* Wildlife risks and possible extinction
* Economic risks
* Increased occurrence and spread of diseases
* Other health-related issues

IPCC (2013, 2014)

Climate change and diseases/health

* Strong links between climate and the **distribution**, **spread** and **severity** of pests, diseases and human health issues (IPCC, 2014)

* Regardless of the mode of disease spread: vector-, air-, water-, soil-, or food-borne

* Perhaps the strongest link of climate to human health has been drawn to vector-borne diseases (Morin *et al.*, 2013)

* Especially mosquito-borne ones: malaria, yellow fever and dengue (Morin *et al.*, 2013)

Dengue & weather/climate change

* IPCC AR5 WG II report (2014): As a vector borne disease **only dengue fever** was associated with climate variables at both the global and local levels (*high confidence*)

* "The disease is linked with climate on spatial, temporal and spatiotemporal scales"

* "The principal vectors for dengue, *Aedes aegypti* and *Aedes albopictus*, are **climate-sensitive**"

  * (IPCC, 2014)

Dengue & weather/climate change (2)

Climate affects the dengue virus and vector populations both directly and indirectly (Gubler *et al.* 2001)

* Climate influences dengue ecology by affecting:
  * vector dynamics
  * agent development (*e.g.* viral replication within mosquito)
  * mosquito/human interactions

- Morin *et al.* (2013)

* Temperature influences vector development rates, mortality, and behaviour (Tun-Lin *et al.*, 2000)

* Vector biology and viral replication are temperature- and moisture- dependent (Thai and Anders, 2011)

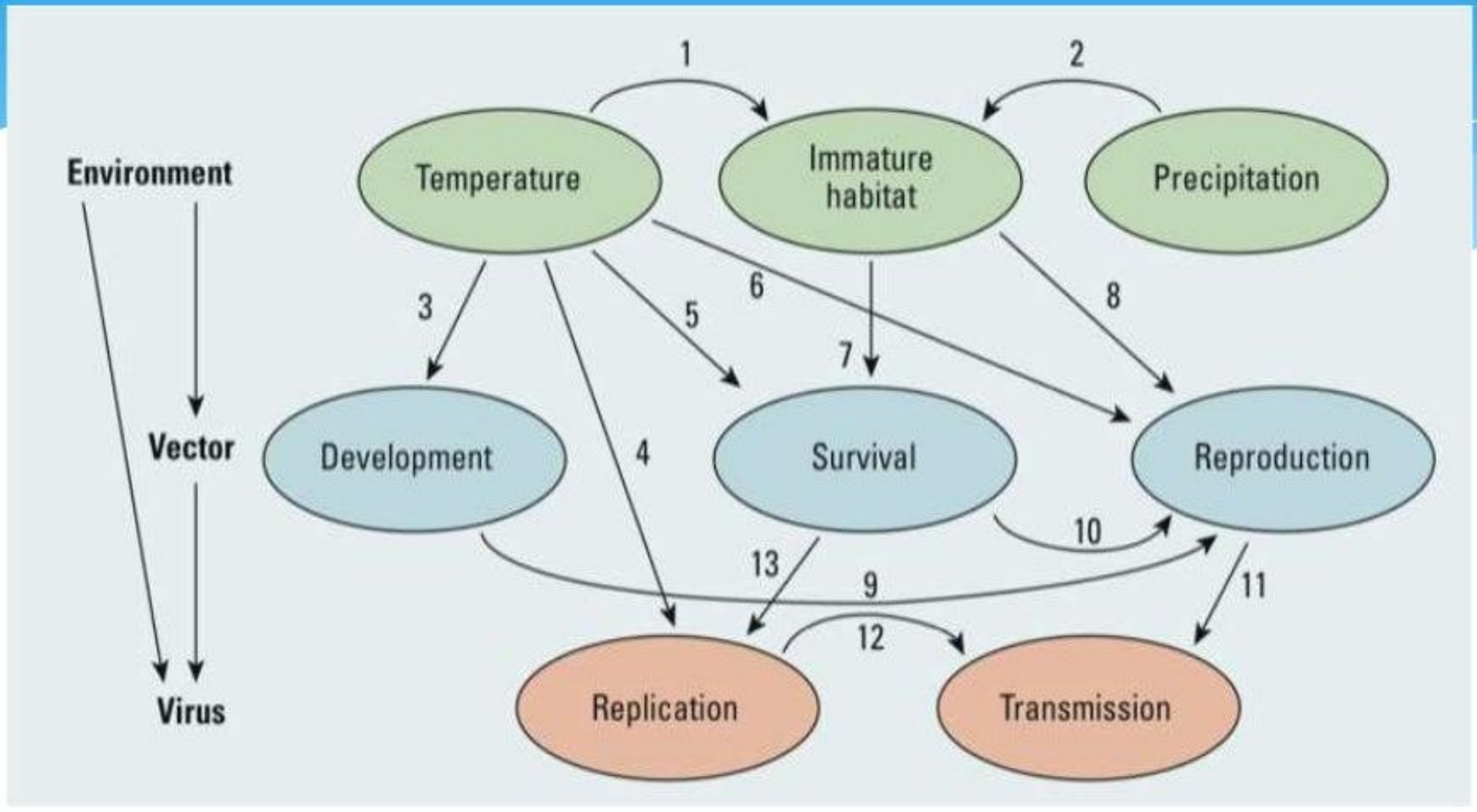
Dengue & weather/climate change (3)

* Temperature interacts with rainfall as the chief regulator of evaporation, thereby also affecting the availability of water habitats.

* **Indirect climatic influence** by changing LU/LC, which may in turn enhance or reduce vector populations
* For e.g. dengue incidence has been correlated with vegetation cover, grasses etc. (as breeding spaces for mosquitoes) (Troyo *et al*. 2009 in Morin *et al*., 2013)

* Climate also influences people's use of land, and this can affect mosquito populations, breeding etc. (Vanwambeke *et al*., 2007)

Dengue : ecological relationships



Interactions between climate, vector & virus

(Morin *et al.*, 2013)

Some empirical studies: South East Asia

* China: Distribution of *Ae. albopictus* in northwestern China highly correlated with annual temperature and precipitation
* Temperature, humidity and rainfall are positively associated with dengue incidence in Guangzhou, China
* Wind velocity is inversely associated with rates of the disease
    * (Li *et al.*, 2011; Lu and Lin, 2009; Wu *et al.*, 2011)
* Taiwan: Usually high incidence of dengue after typhoons
* The extreme rainfall, high humidity and water pooling = more/fresh breeding sites for mosquitoes (Lai, 2011)
* Bangladesh: observed records of high dengue incidence with precipitation extremes : a) high river levels b) drought (Padmanabha *et al.*, 2010)

More empirical studies: Mexico

* 23 years of dengue reports from 9 climatic regions of Mexico
* Findings: statistically significant (but **non-linear**) effects of weather on dengue
* Temperature: <5°C Tmin = almost no effect on dengue incidence
* >18°C Tmin = rapidly increasing effect on dengue
* Tmax >20°C = also increasing effect on dengue incidence,
* Dengue incidence peaked around 32°C, after which effect declined
* Rainfall: increasing effect up to 550 mm, beyond which such effect declines

- Colón-González *et al.* (2013)

Dengue & weather/climate change (4)

* Effects of higher temperatures:
  * Increased larva development rate
  * Reduced time for virus replication within vector
  * However, extremely high temperatures may reduce vector life span
* Effects of increased/varying precipitation:
  * variable effects on vector breeding sites
  * depends on where the breeding grounds are
* Humidity:
  * Higher humidity supports greater vector lifespan
  * Perhaps the most important climatic predictor of dengue globally

- Thai and Anders (2011)