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

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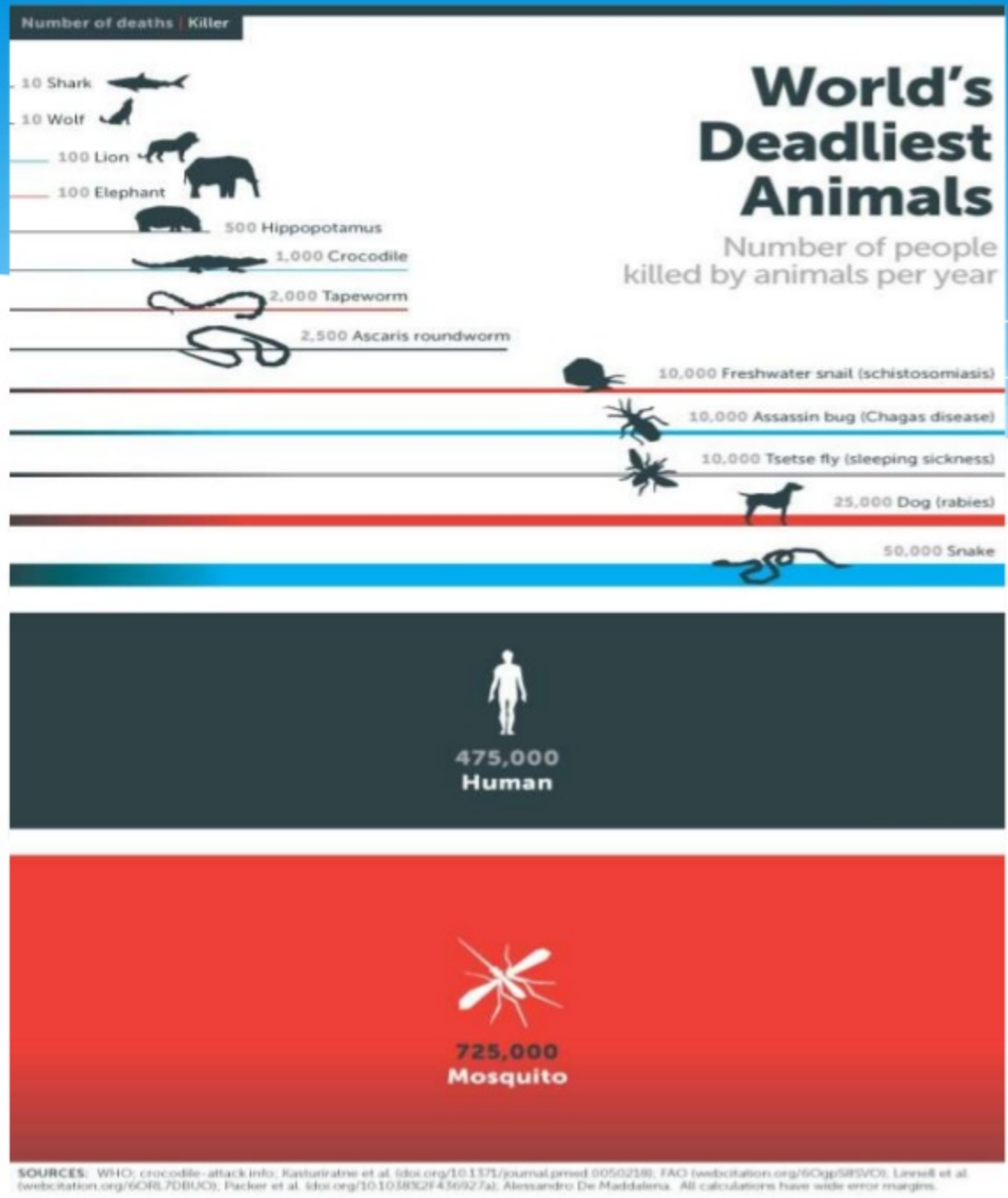


Source: http://www.gatesnotes.com/Health/Most-Lethal-Animal-Mosquito-Week 30/04/2014)

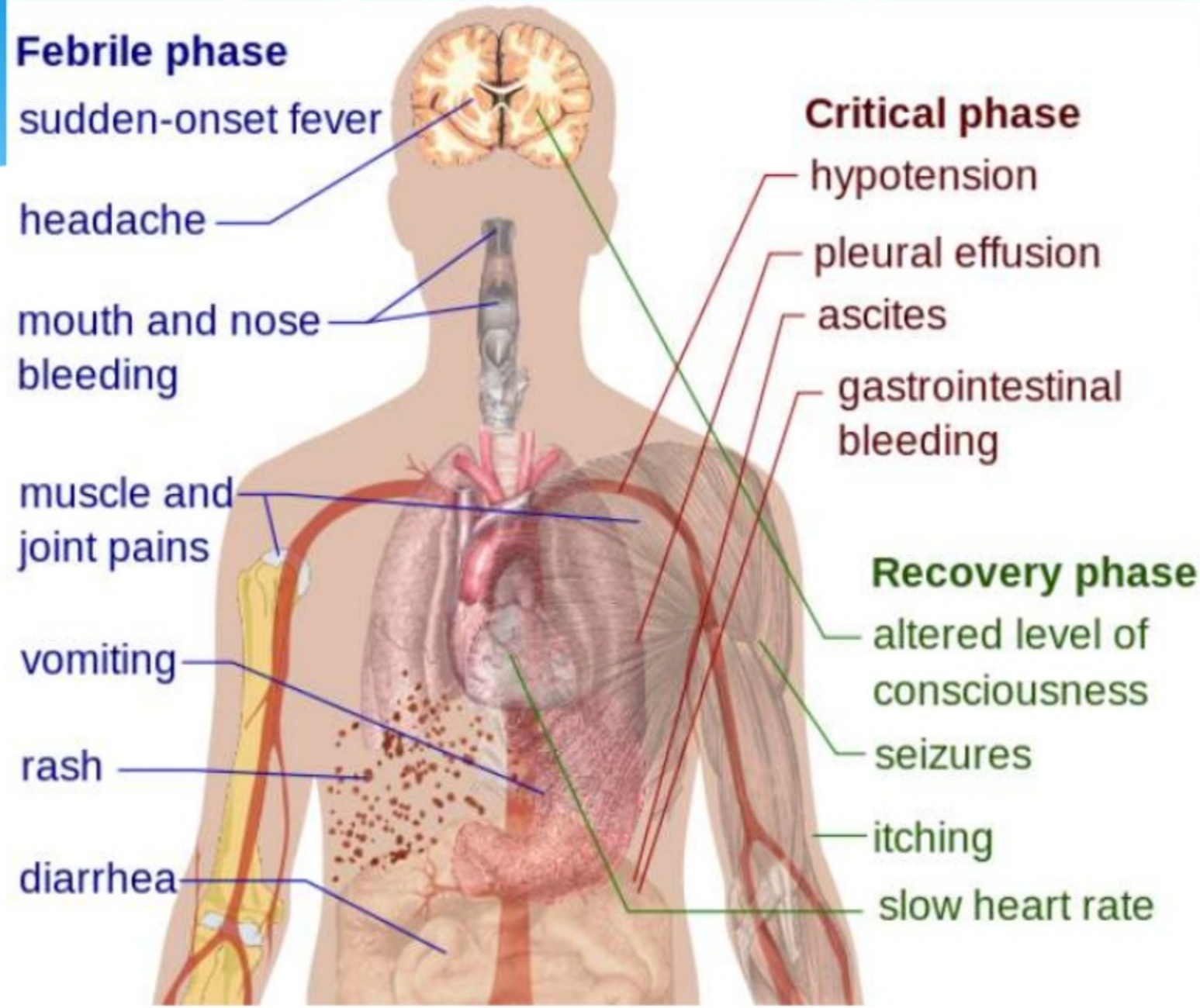
Introduction: what is dengue?

* 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)

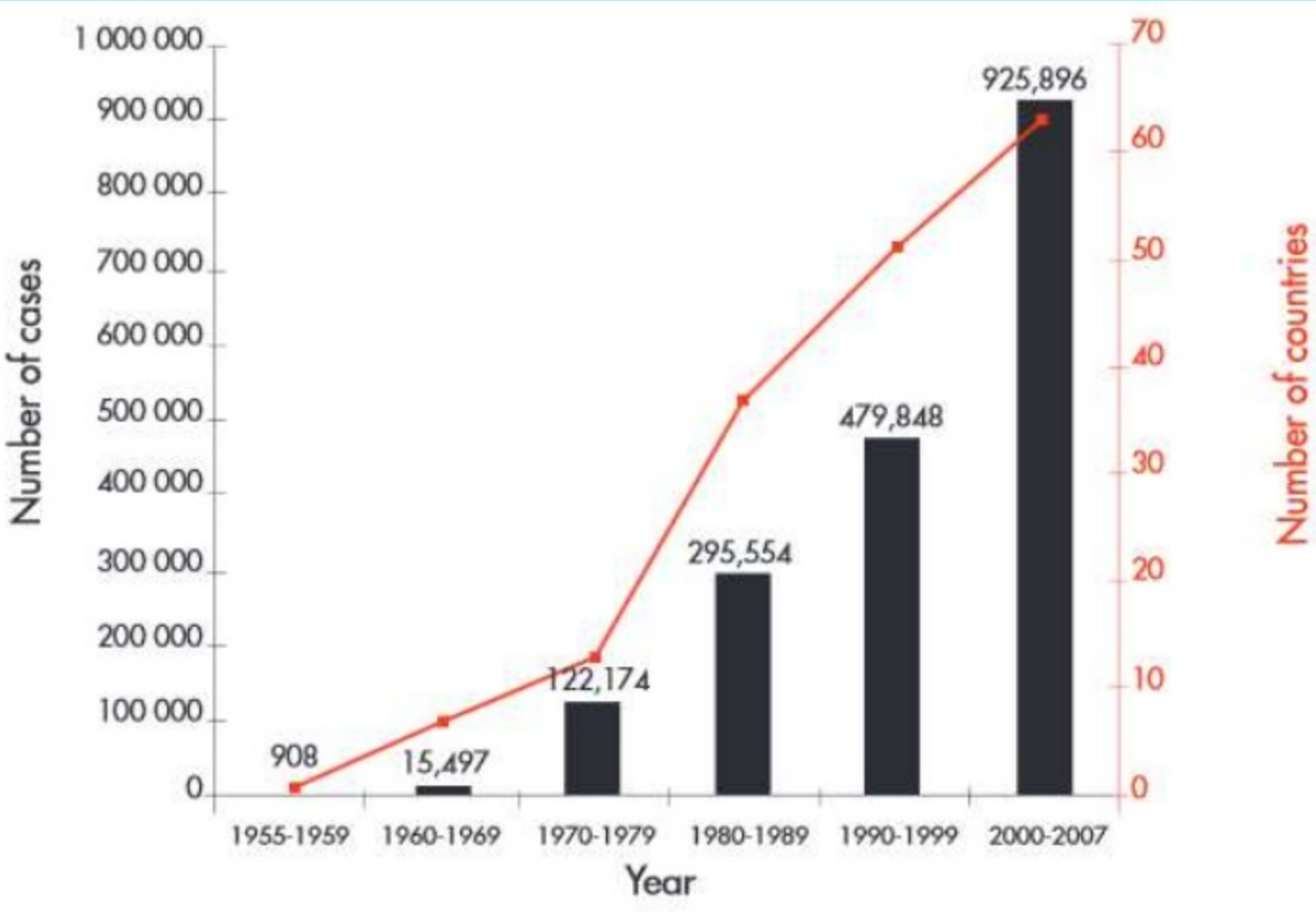
Dengue, countries or areas at risk, 2011

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)

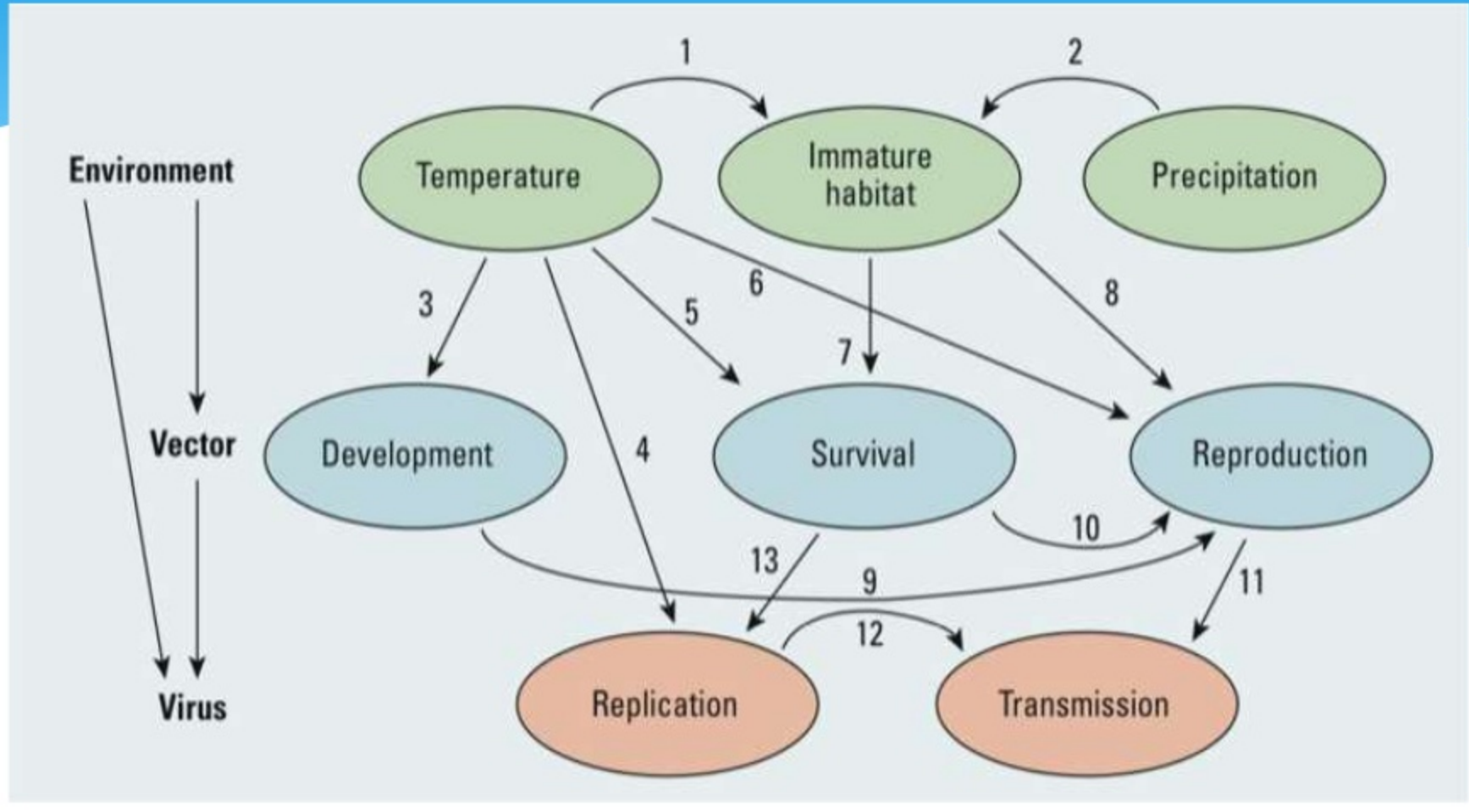
Dengue & weather/climate change (3)

* 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)