Introduction to infectious disease data

Clinic on the Meaningful Modeling of Epidemiological Data, 2017
African Institute for Mathematical Sciences
Muizenberg, South Africa
May-June, 2017

Calistus Ngonghala, PhD
Assistant Professor in Mathematics
University of Florida

Faikah Bruce
Steve Bellan
Juliet Pulliam

Slide Set Citation: DOI:10.6084/m9.figshare.5044603
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Goals

- Overview the types of available data
- Relate available types of data with SEIR model output
- Highlight different approaches to data collection and presentation.

What is an infectious disease?

Disease

A deviation from the normal physiological status of an organism that negatively affects its survival or reproduction

Infectious Disease

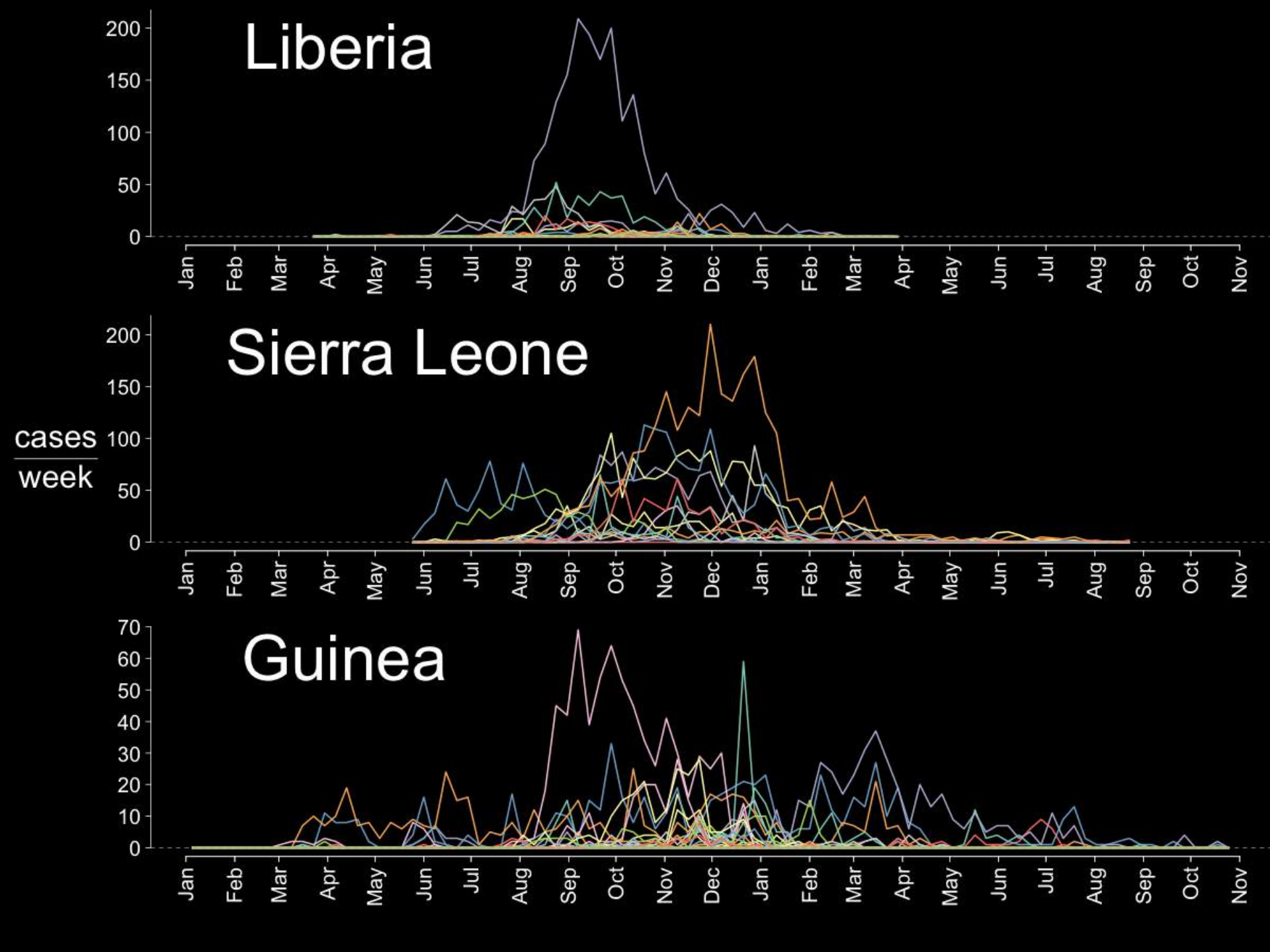
A disease in one organism (the host) that is caused by another organism (pathogen or parasite) which has entered the host's body

Ebola Virus

Tuberculosis Bacteria

HIV

Pathogen: Microorganism that causes disease (virus, bacteria, parasite)


Liberia
Sierra Leone
Guinea
cases
week
0
50
100
150
200
0
10
20
30
40
50
60
70
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov

Case definition

“a set of standard criteria for deciding whether a person has a particular disease [or infection]”

Case definition

"a set of standard criteria for deciding whether a person has a particular disease [or infection]"

Person:

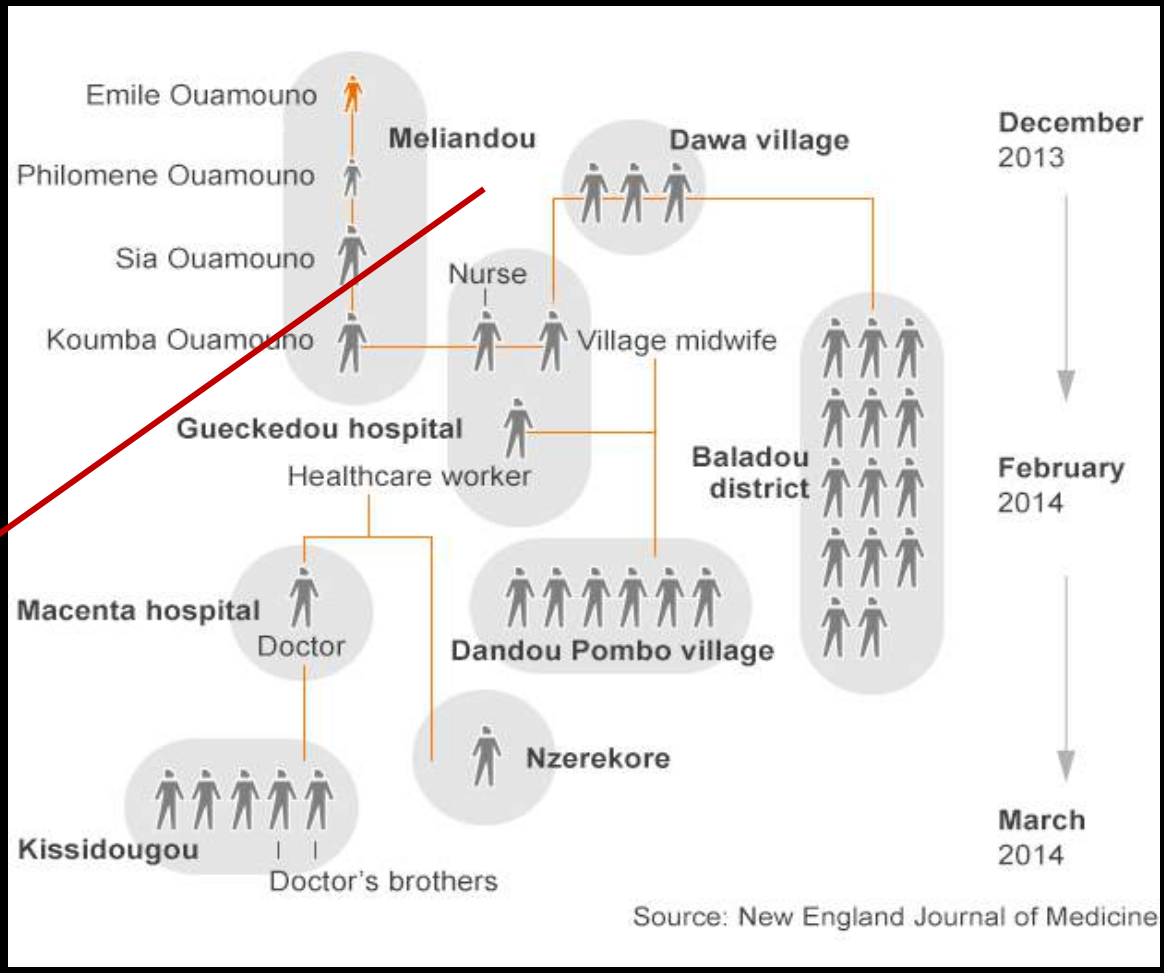
Place:

Time:

Clinical description:

A “case” study


Nouadhibou
MAURITANIA
Nouakchott
Dakar
SENEGAL
Banjul
Bissau
Bamako
MALI
GUINEA
Conakry
Freetown
SIERRA LEONE
Monrovia
CÔTE D'IVOIRE
Abidjan


Emile Ouamouno
Philomene Ouamouno
Sia Ouamouno
Koumba Ouamouno
Meliandou
Dawa village
December 2013
Nurse
Village midwife
Gueckedou hospital
Healthcare worker
Baladou district
February 2014
Macenta hospital
Doctor
Dandou Pombo village
Nzerekore
Kissidougou
Doctor's brothers
March 2014
Source: New England Journal of Medicine

Case definition

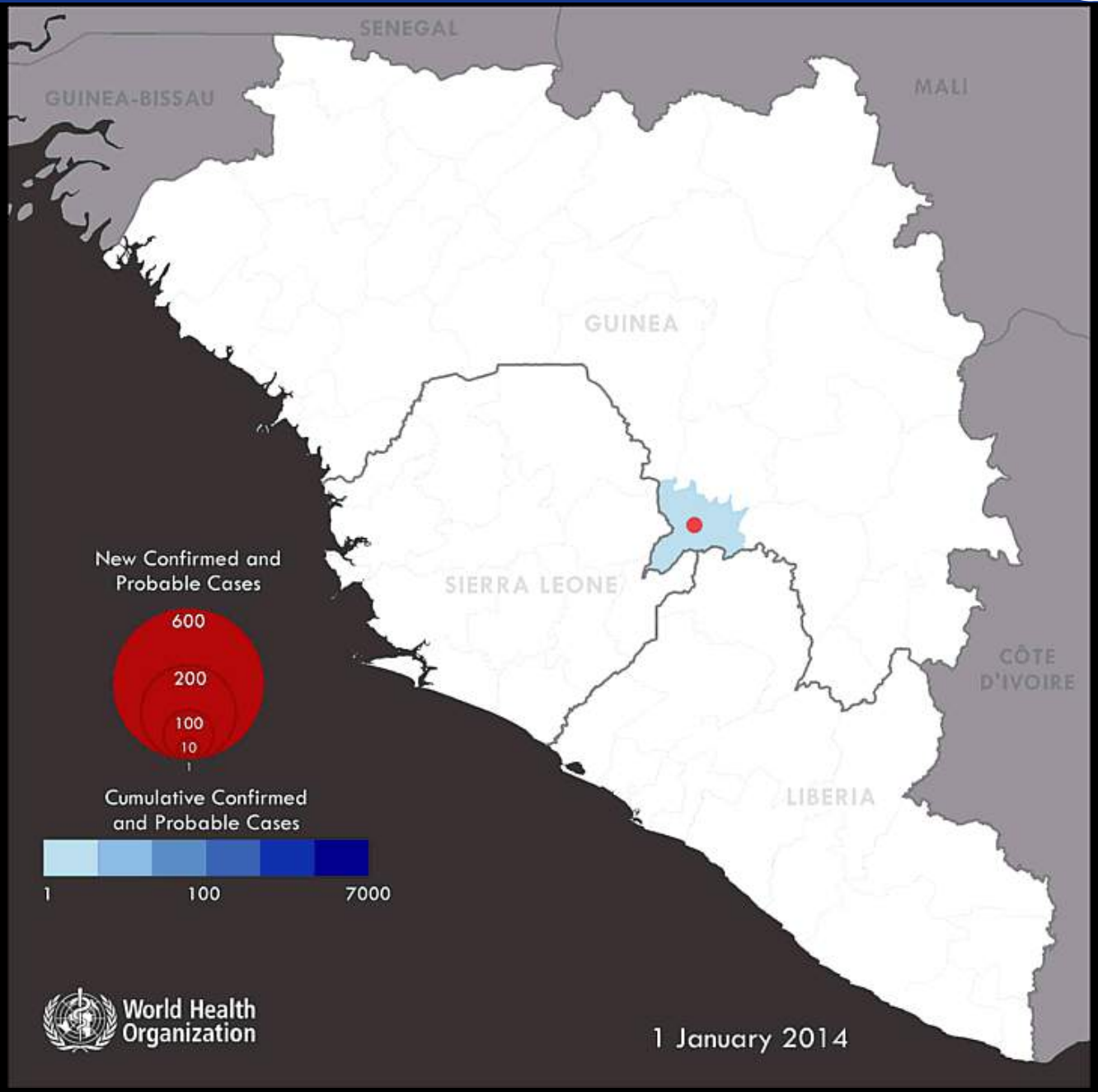
"a set of standard criteria for deciding whether a person has a particular disease [or infection]"

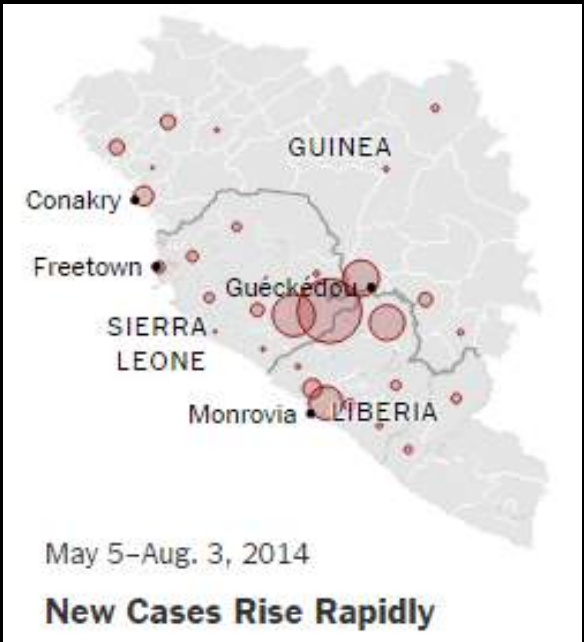
Person: Residents of Meliandou, recent visitors to Meliandou

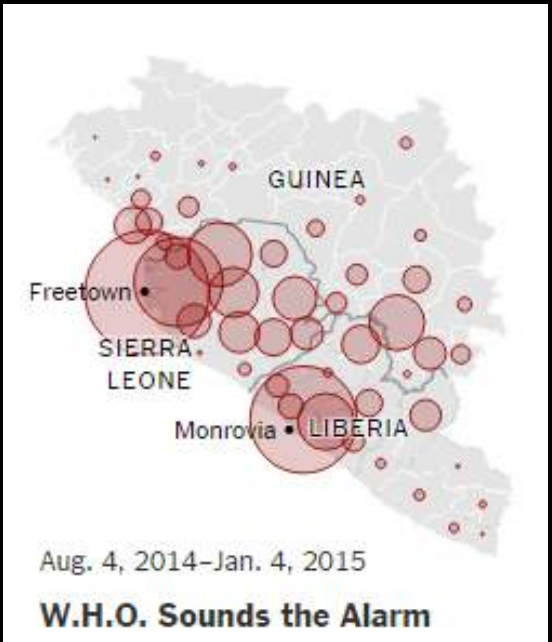
Place: West Africa, Guinea

Time: On or after November 15, 2013

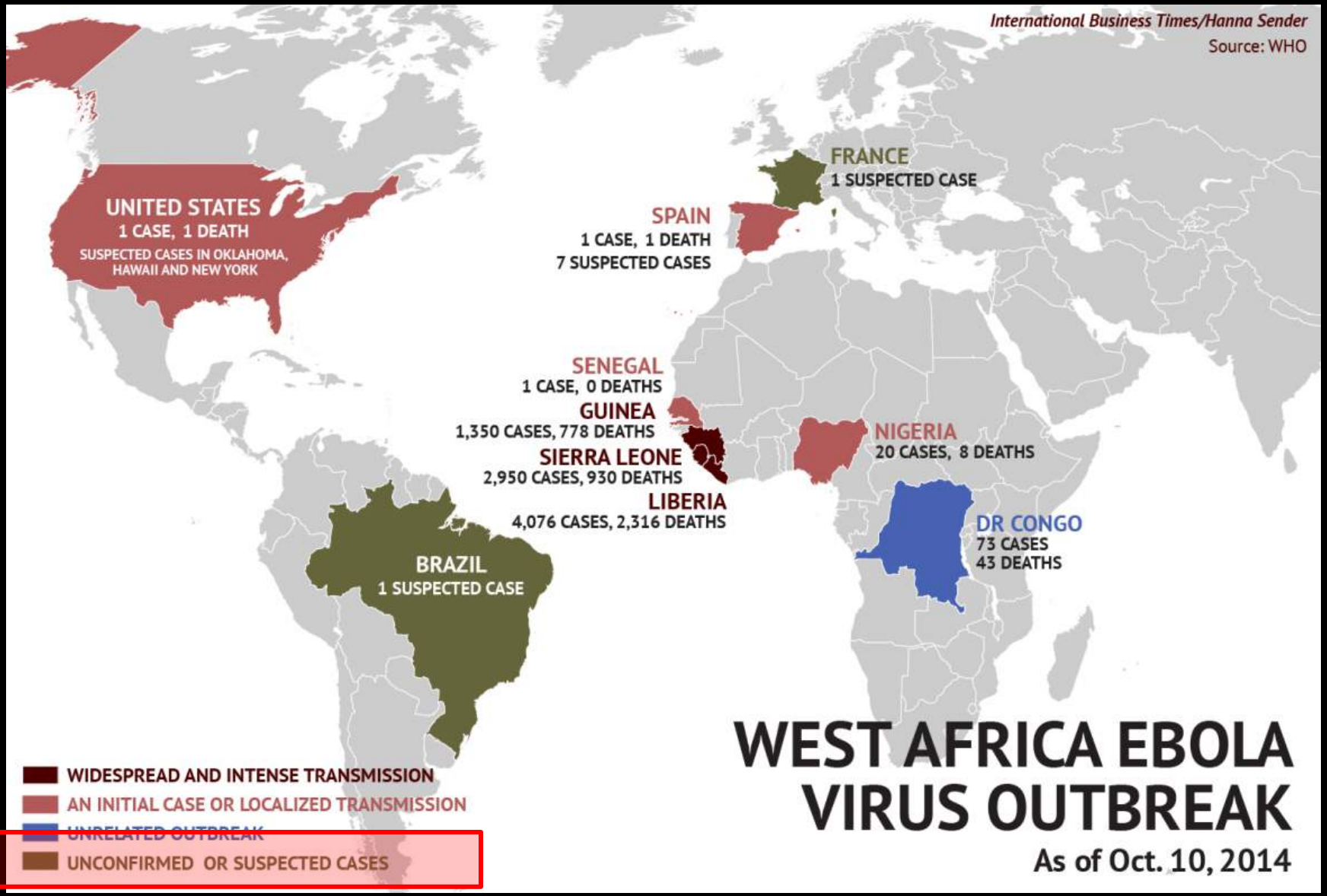
Clinical description: Elevated body temperature or subjective fever or symptoms, including severe headache, fatigue, muscle pain, vomiting, diarrhea, abdominal pain, or unexplained hemorrhage


SENEGAL
GUINEA-BISSAU
MALI
GUINEA
SIERRA LEONE
CÔTE D'IVOIRE
LIBERIA
New Confirmed and Probable Cases
600
200
100
10
1
Cumulative Confirmed and Probable Cases
1
100
7000
World Health Organization
1 January 2014





Source: World Health Organization


International Business Times/Hanna Sender
Source: WHO
UNITED STATES
1 CASE, 1 DEATH
SUSPECTED CASES IN OKLAHOMA, HAWAII AND NEW YORK
FRANCE
1 SUSPECTED CASE
SPAIN
1 CASE, 1 DEATH
7 SUSPECTED CASES
SENEGAL
1 CASE, 0 DEATHS
GUINEA
1,350 CASES, 778 DEATHS
SIERRA LEONE
2,950 CASES, 930 DEATHS
LIBERIA
4,076 CASES, 2,316 DEATHS
NIGERIA
20 CASES, 8 DEATHS
DR CONGO
73 CASES
43 DEATHS
BRAZIL
1 SUSPECTED CASE
WIDESPREAD AND INTENSE TRANSMISSION
AN INITIAL CASE OR LOCALIZED TRANSMISSION
UNRELATED OUTBREAK
UNCONFIRMED OR SUSPECTED CASES
WEST AFRICA EBOLA VIRUS OUTBREAK
As of Oct. 10, 2014

UNCONFIRMED OR SUSPECTED CASES

Confirmed case: signs and symptoms *plus* laboratory confirmation

Probable case: signs and symptoms in an individual meeting person, place, and time criteria *plus* contact with a known case *or* more specific clinical signs

Possible case: signs and symptoms in an individual meeting person, place, and time criteria *plus* a physician diagnosis

Suspect case: signs and symptoms in an individual meeting person, place, and time criteria

Not a case: failure to fulfill the criteria for a confirmed, probable, possible, or suspect case

Case definition

"a set of standard criteria for deciding whether a person has a particular disease [or infection]"

Person:

Place:

Time:

Clinical description:

Case definition

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Place: West Africa, Guinea

Time: On or after November 15, 2013

Clinical description: Elevated body temperature or subjective fever or symptoms, including severe headache, fatigue, muscle pain, vomiting, diarrhea, abdominal pain, or unexplained hemorrhage

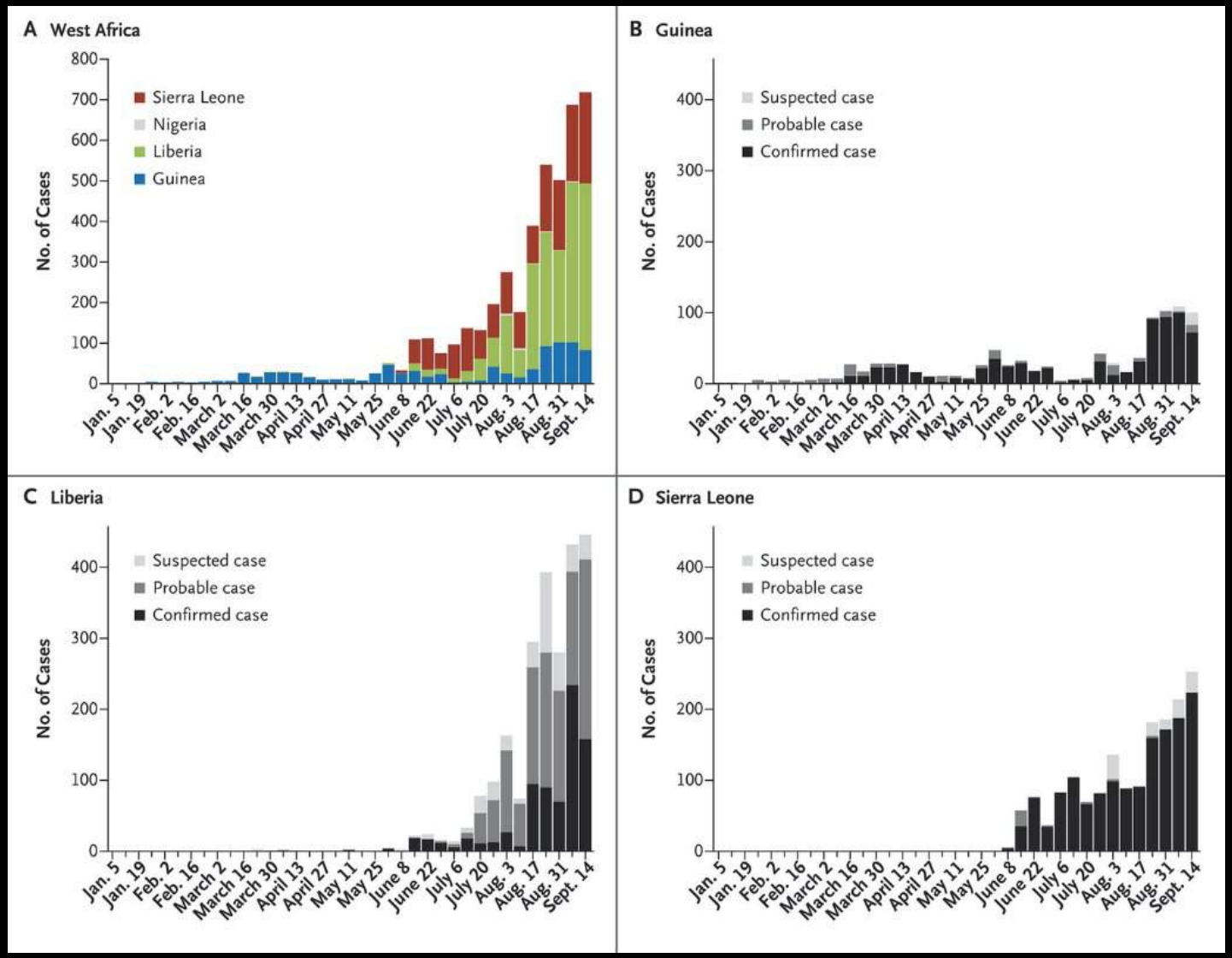
Case definition

"a set of standard criteria for deciding whether a person has a particular disease [or infection]"

Person: Residents of and recent visitors to West Africa, including Senegal, Guinea, Sierra Leone and Liberia, as well as their close contacts or others in their community
Place: Worldwide
Time: On or after November 15, 2013

Clinical description: Illness with onset of fever and no response to treatment for usual causes of fever in the area, and at least one of the following signs: bloody diarrhoea, bleeding from gums, bleeding into skin (purpura), bleeding into eyes and urine.

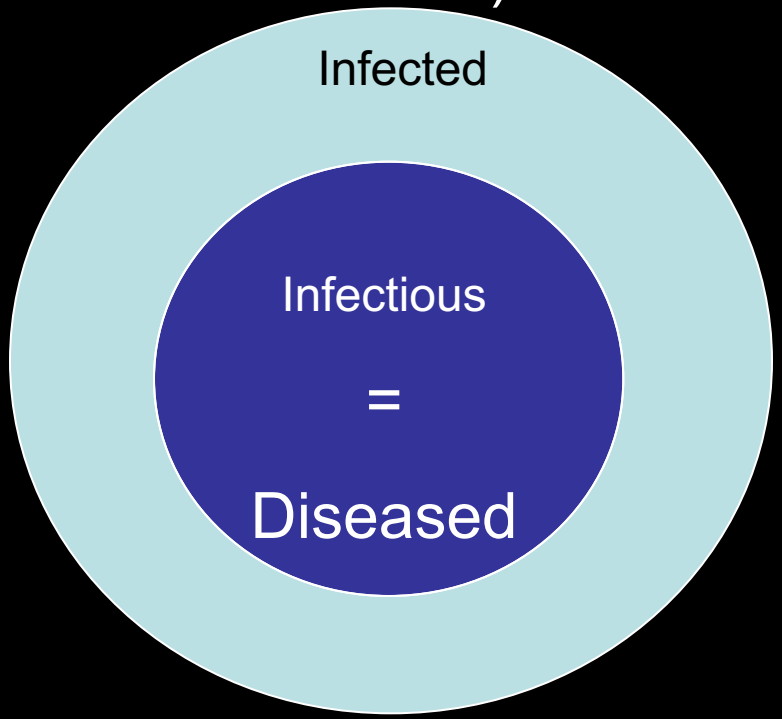
Incidence of disease

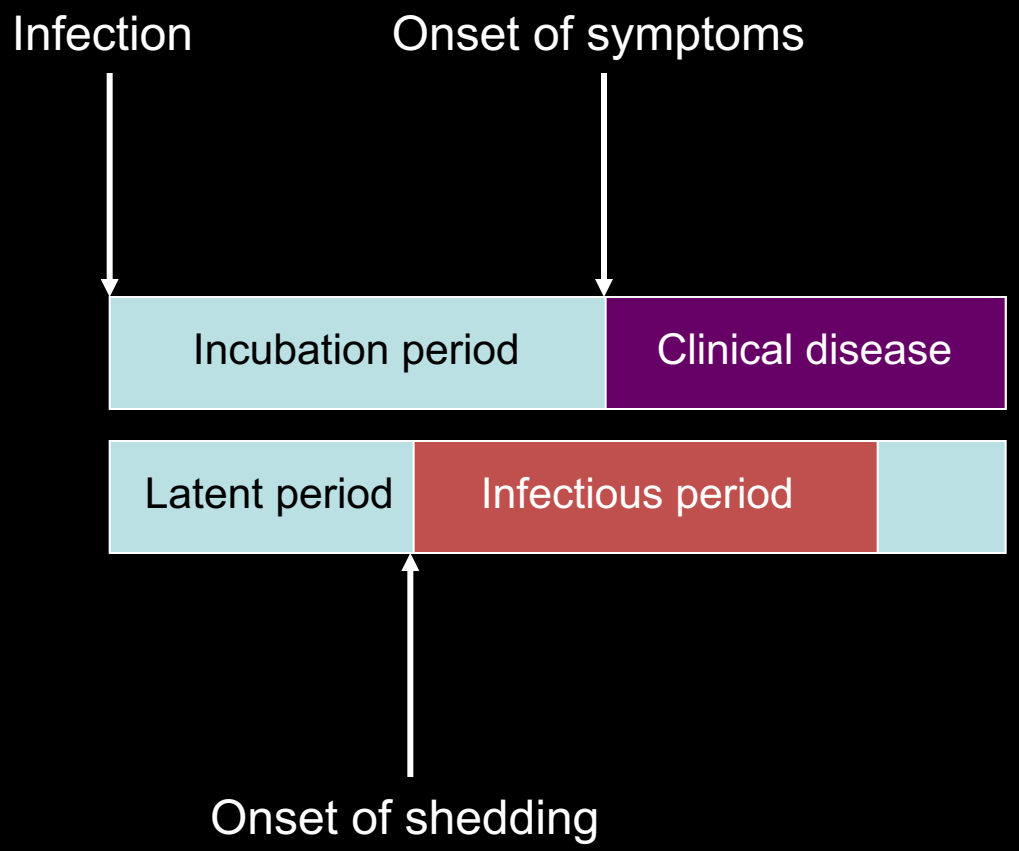


Incidence of Infection

Infectivity = 1

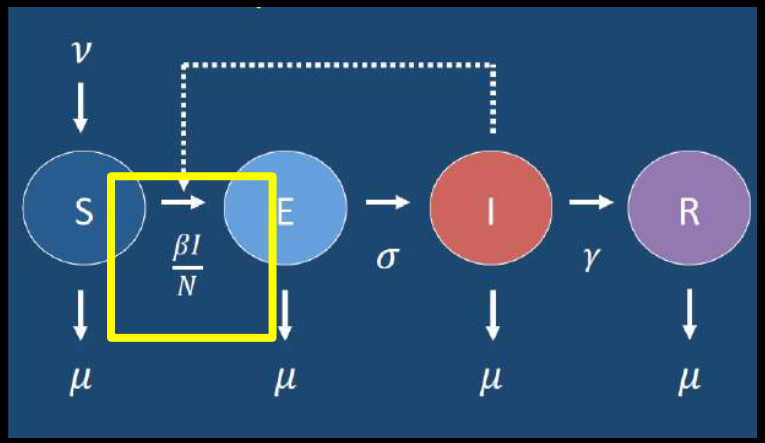
(everyone exposed becomes infected)





Incidence of infection

Mathematical expression?



SEIR Model

$$\frac{dS}{dt} = \nu - \frac{\beta SI}{N} - \mu S$$

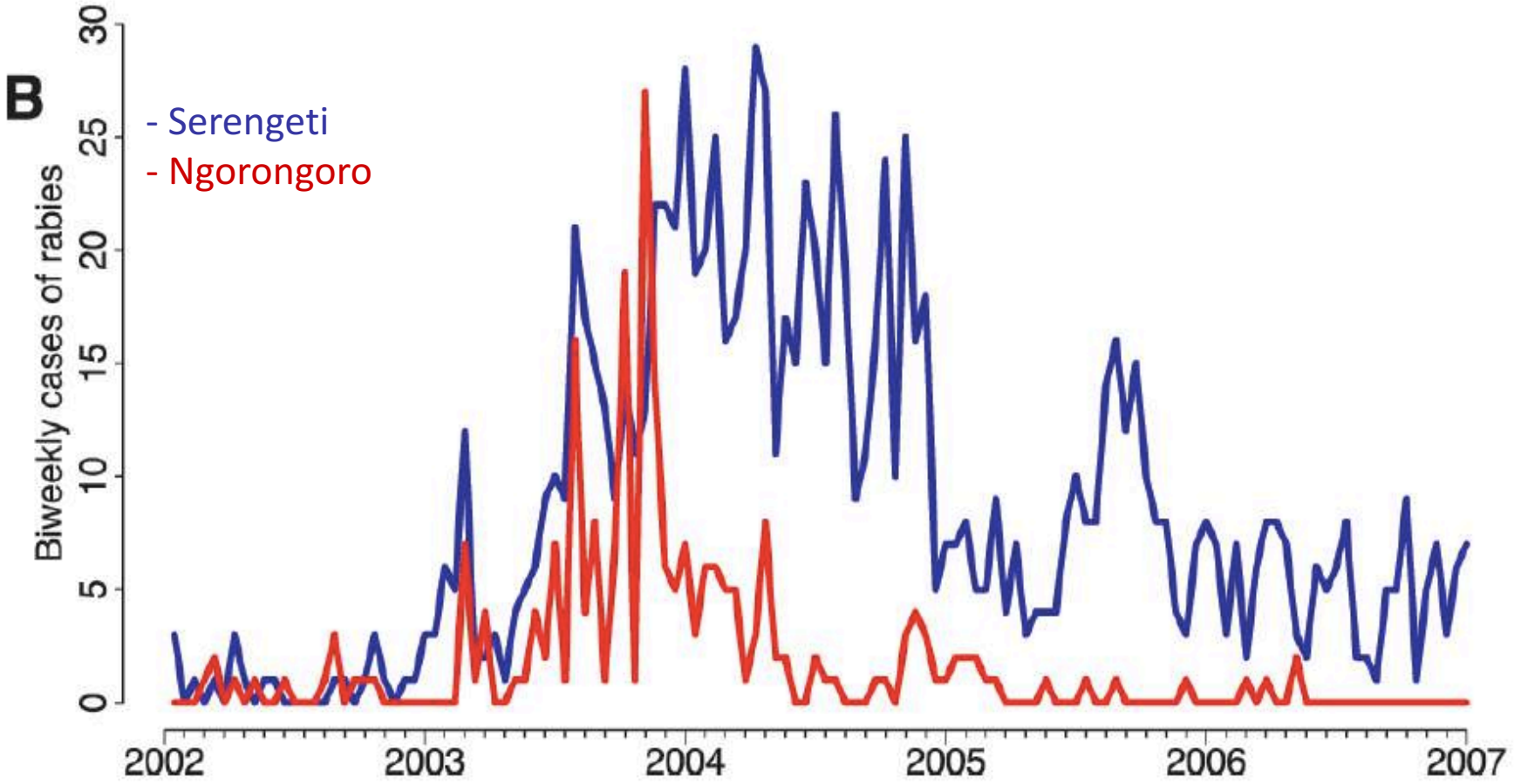
$$\frac{dE}{dt} = \frac{\beta SI}{N} - \sigma E - \mu E$$

$$\frac{dI}{dt} = \sigma E - \gamma I - \mu I$$

$$\frac{dR}{dt} = \gamma I - \mu R$$

ν	birth rate
μ	mortality rate
σ	1 / latent period
γ	1 / infectious period
β	transmission coefficient

Ways of collecting data on cases



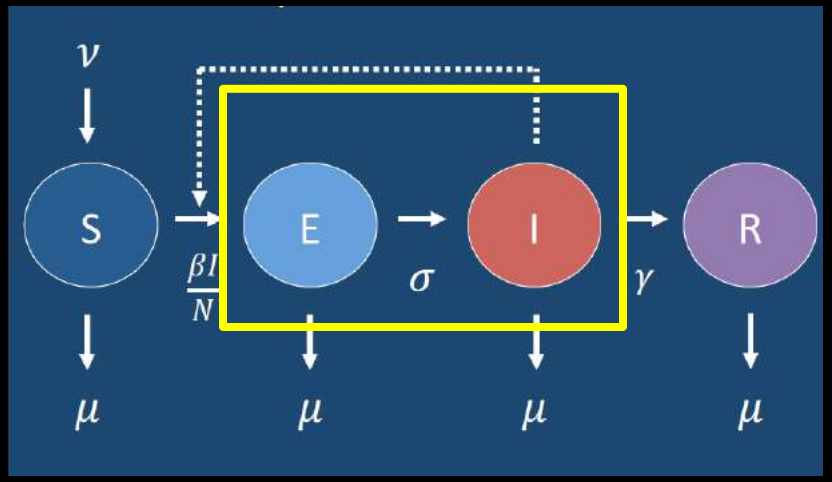
Ways of collecting data on cases

- Passive
- Active

Epidemiological studies

- Case-series
- Case-control
- Cohort
- Outbreak investigations

Prevalence



$$\frac{E+I}{N}$$

Mathematical expression?

SEIR Model

$$\frac{dS}{dt} = \nu - \frac{\beta SI}{N} - \mu S$$

$$\frac{dE}{dt} = \frac{\beta SI}{N} - \sigma E - \mu E$$

$$\frac{dI}{dt} = \sigma E - \gamma I - \mu I$$

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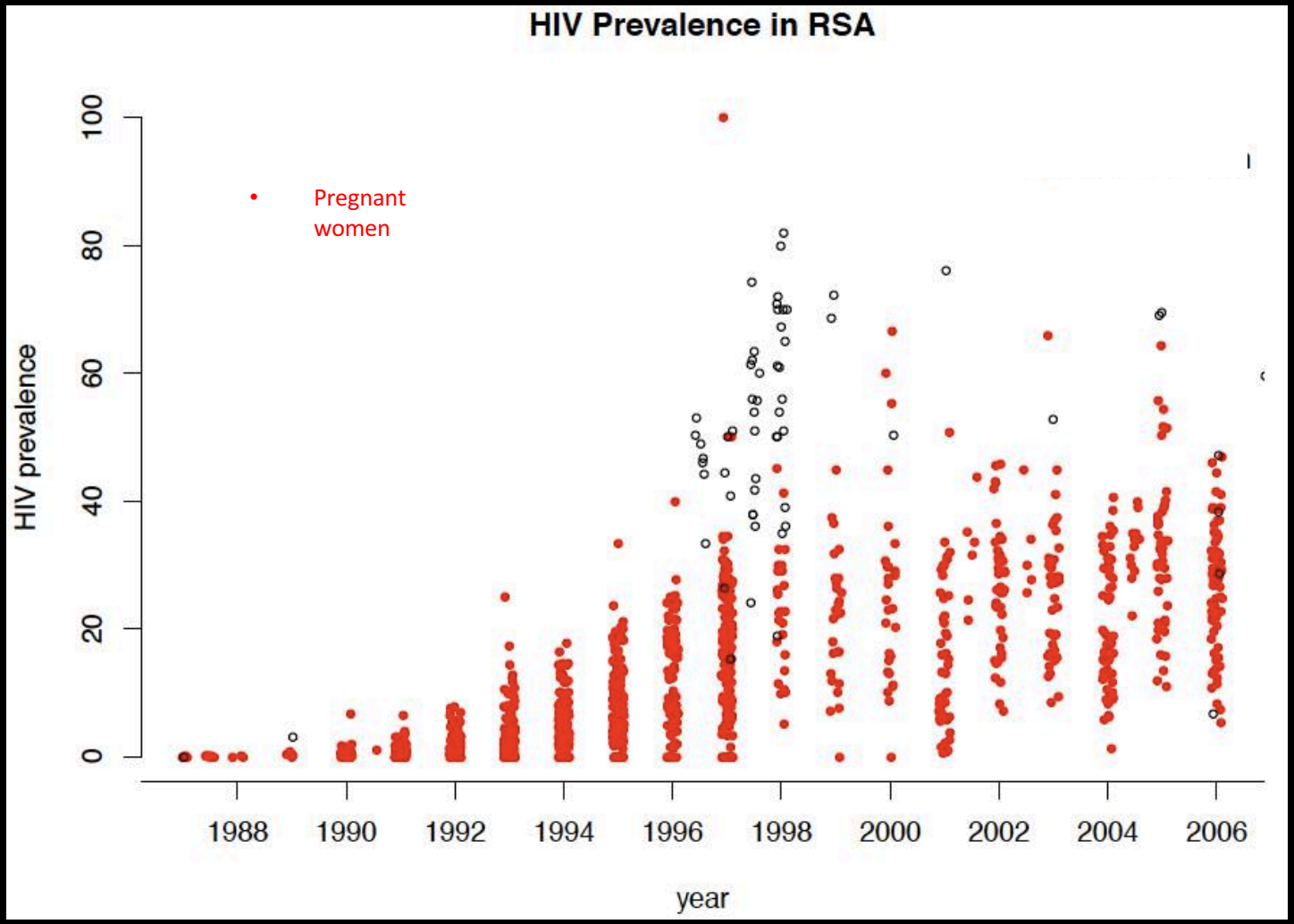
of infection

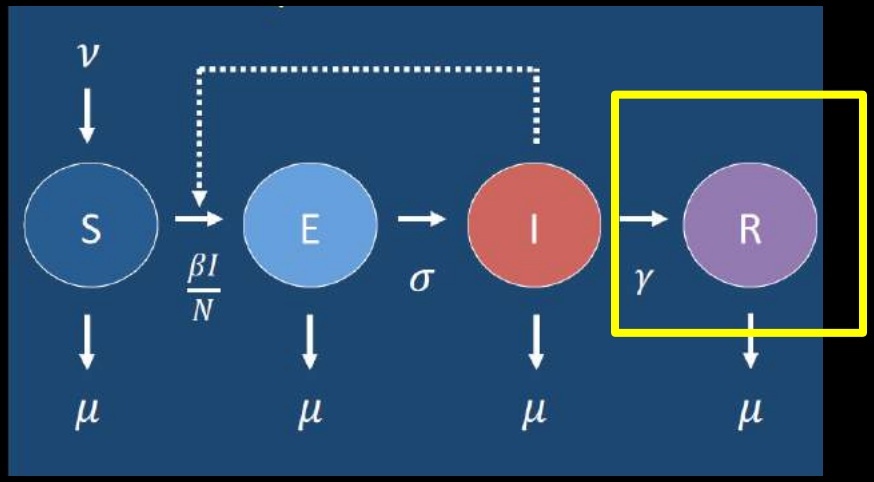
of antibodies (seroprevalence)

Prevalence



Source: UNAIDS HIV Surveillance Database

Prevalence



$$\frac{R}{N}$$

SEIR Model

$$\frac{dS}{dt} = \nu - \frac{\beta SI}{N} - \mu S$$

$$\frac{dE}{dt} = \frac{\beta SI}{N} - \sigma E - \mu E$$

$$\frac{dI}{dt} = \sigma E - \gamma I - \mu I$$

$$\frac{dR}{dt} = \gamma I - \mu R$$

ν	birth rate
μ	mortality rate
σ	1 / latent period
γ	1 / infectious period
β	transmission coefficient

Mathematical expression?

of infection

of antibodies (seroprevalence)

Seroprevalence

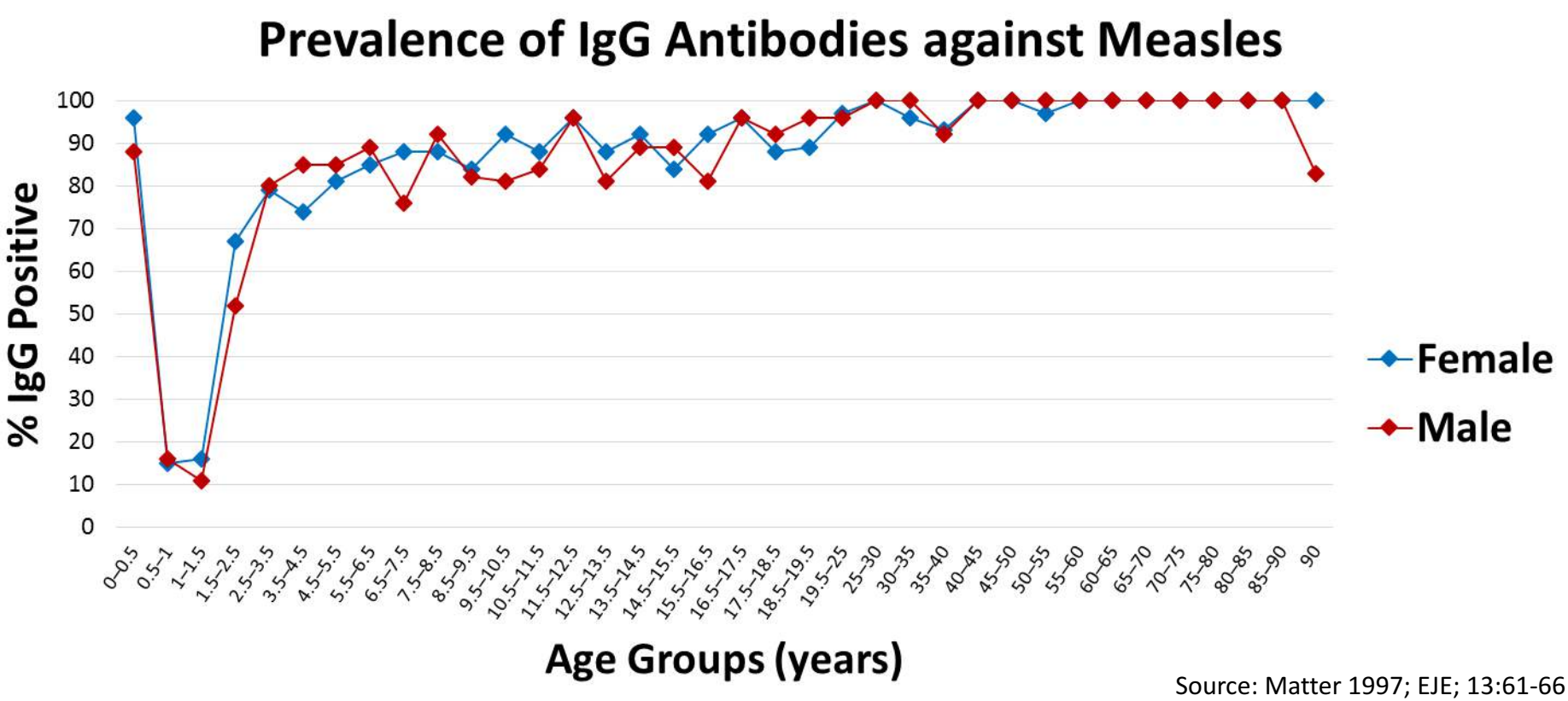
Can be related to:

- Prevalence of infection
- Past exposure

May or may not be:

- Prevalence of resistance
- Specific to infection of interest

Seroprevalence



Source: Matter 1997; EJE; 13:61-66

Levels of data aggregation

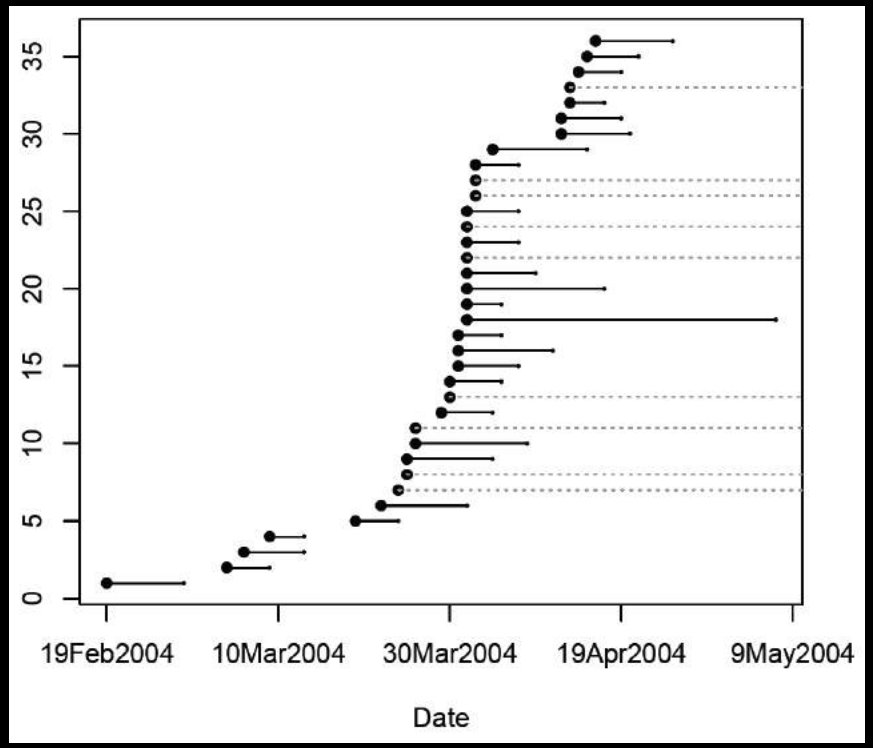
Aggregated data

De-identified data

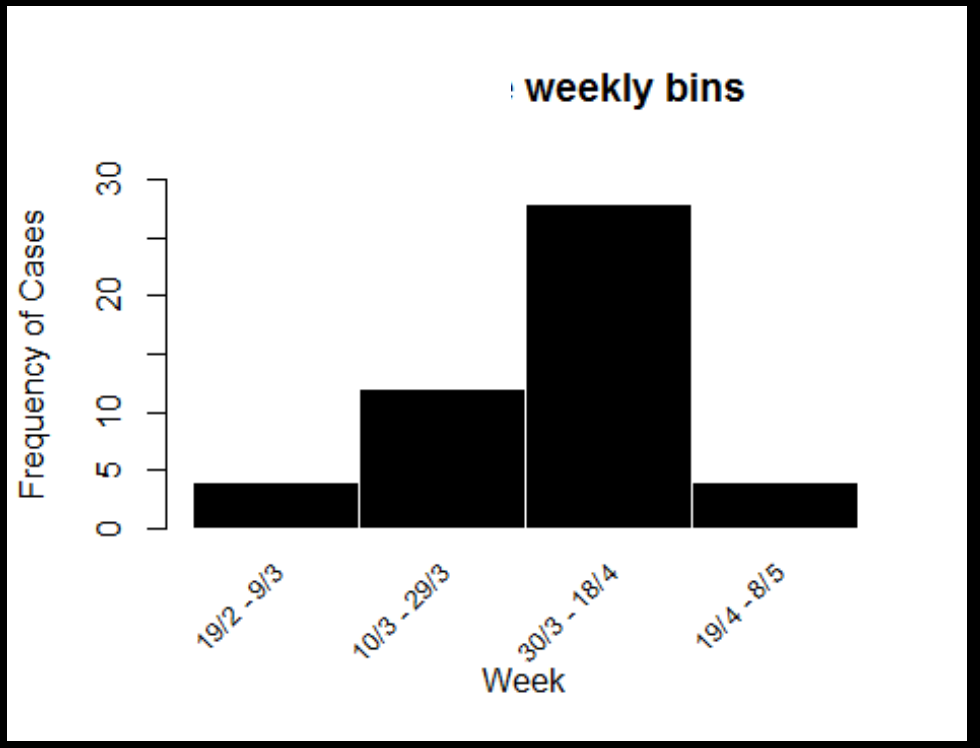
Personally identifying data

Levels of data aggregation

De-identified data

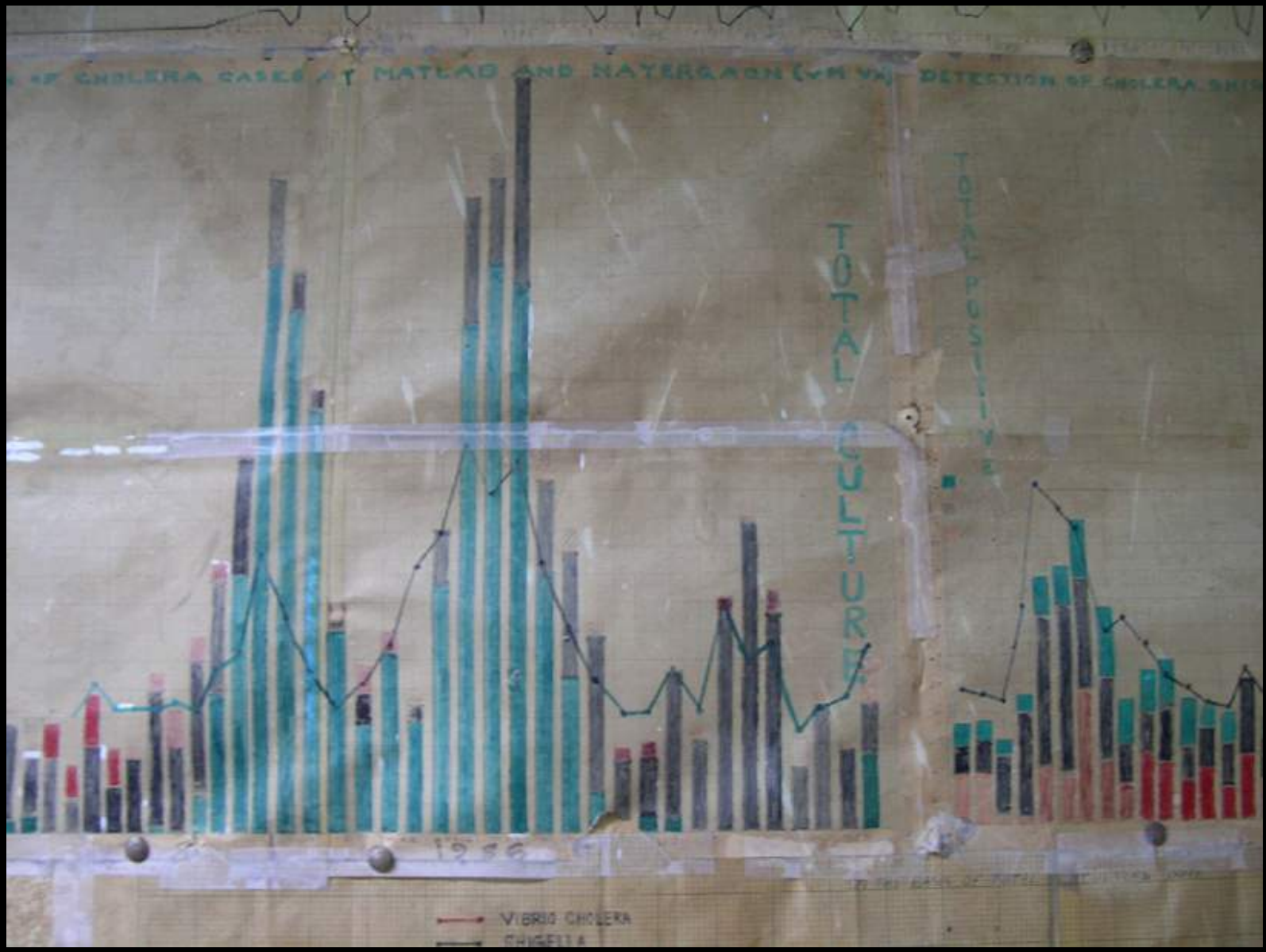


Aggregated data



Data from ICDDR,B and Gurley *et al*. 2007

Visualizing data before R…



Summary

- Linking model output with data is important
- Incidence and prevalence can be tabulated in SEIR model
- Case definition: uniform set of criteria for determining whether an individual has a disease
- Case definition can change across time/place
- Data collection methods affect data interpretation

Bruce F, Bellan SE, Pulliam JRCP. "Introduction to Infectious Disease Data" Clinic on the Meaningful Modeling of Epidemiological Data. DOI:10.6084/m9.figshare.5044603.

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