Introduction to infectious disease data

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Clinic on the Meaningful Modeling of Epidemiological Data and BSc Honours Course in Biomathematics
African Institute for the Mathematical Sciences
Muizenberg, South Africa
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What is an infectious disease?

Disease

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

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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

Case definition

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

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Person:

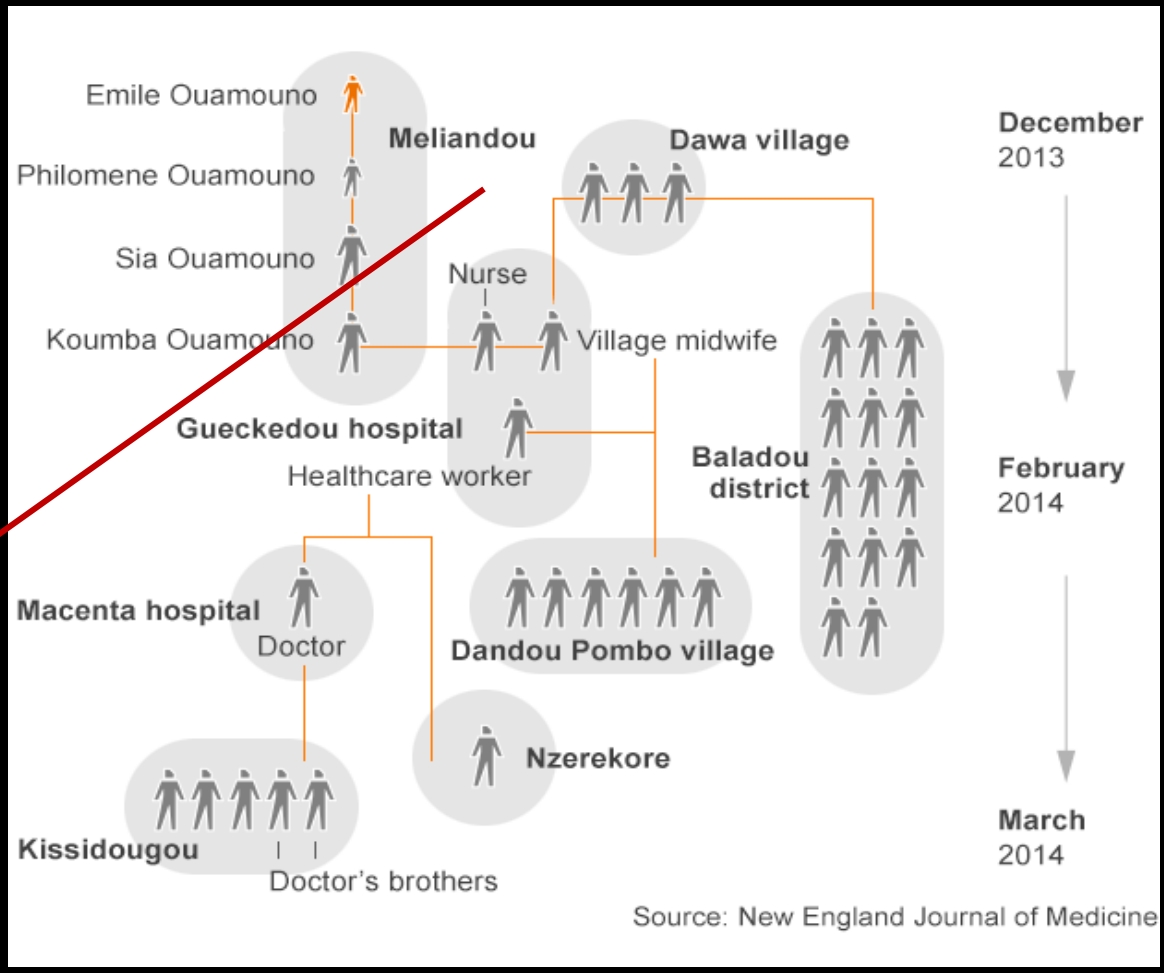
Place:

Time:

Clinical description:

A “case” study

West Africa



Case definition

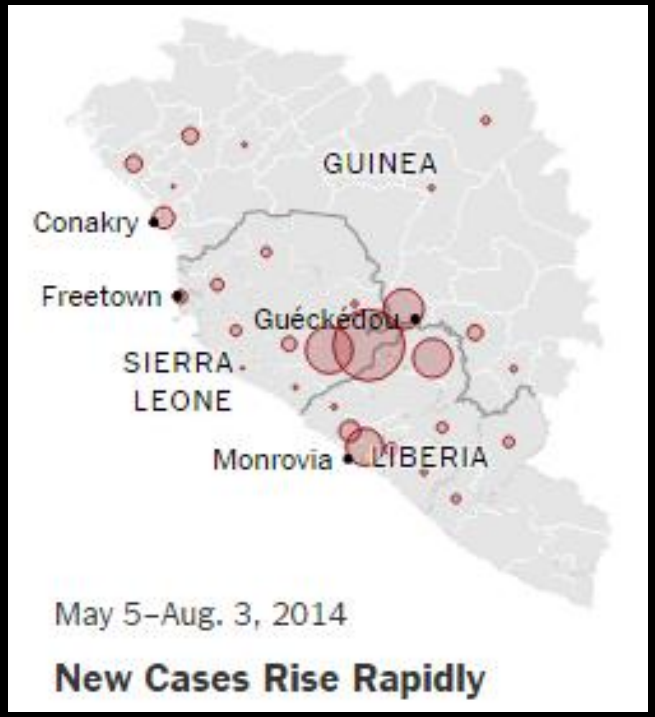
"a set of standard criteria for deciding whether a person has a particular disease [or infection]"

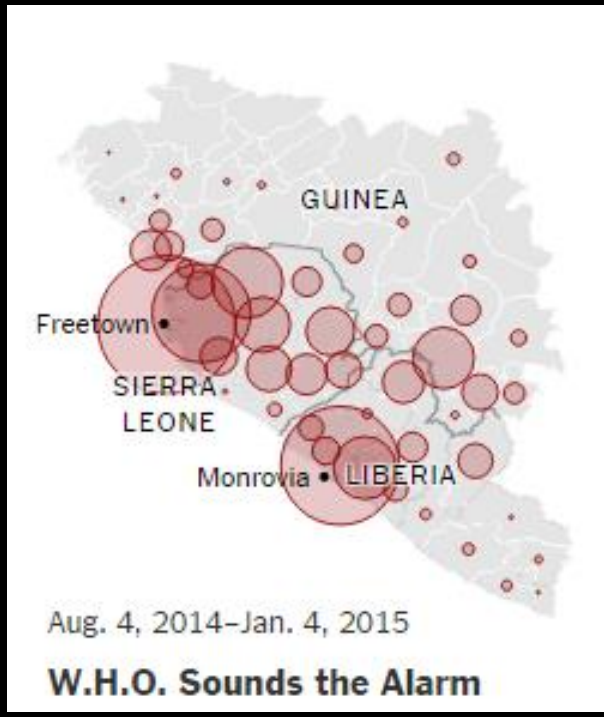
Person: Residents of Meliandou, recent visitors to Meliandou

Place: West Africa, Guinea

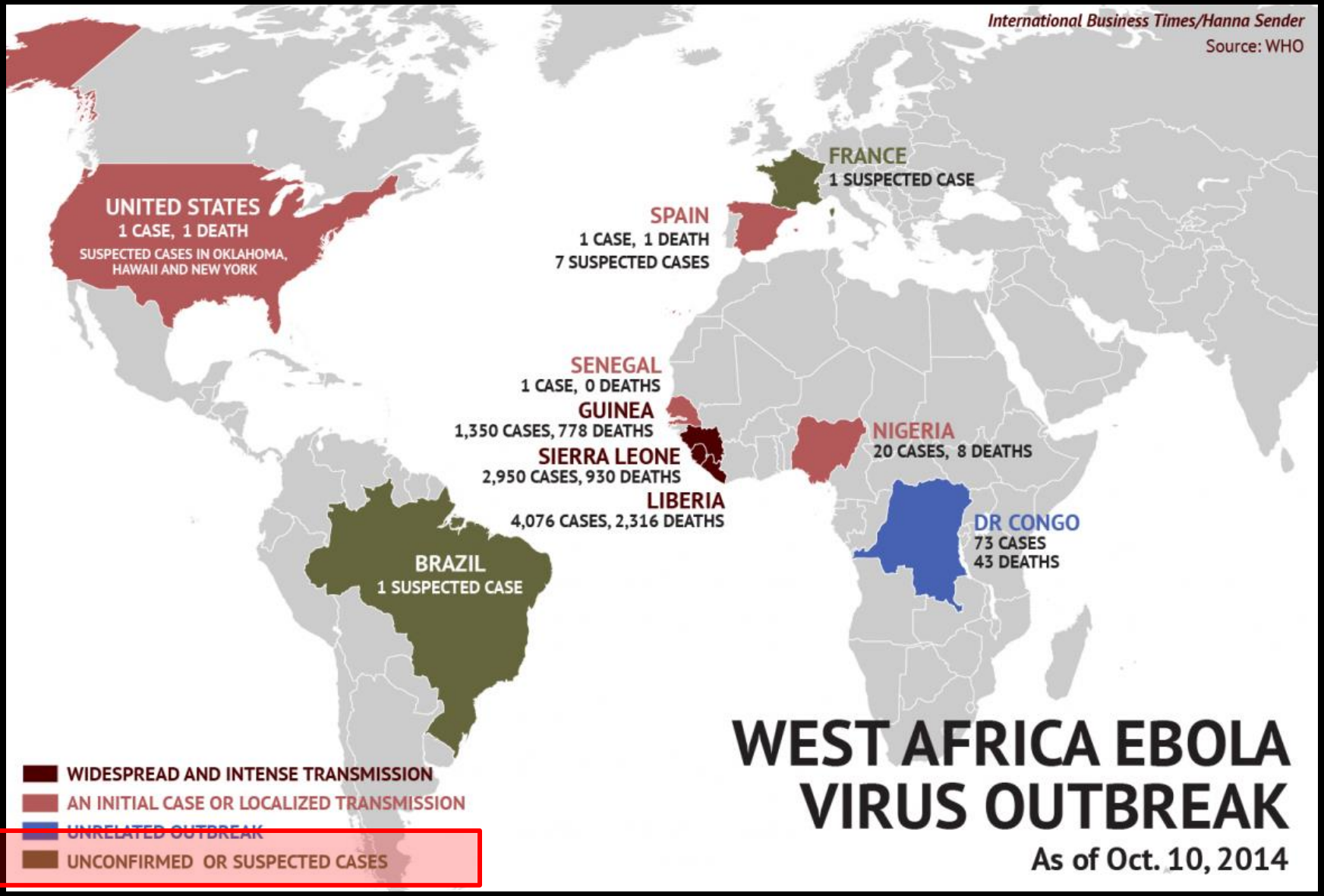
Time: On or after November 15, 2013

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





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
WEST AFRICA EBOLA VIRUS OUTBREAK
As of Oct. 10, 2014
WIDESPREAD AND INTENSE TRANSMISSION
AN INITIAL CASE OR LOCALIZED TRANSMISSION
UNRELATED OUTBREAK
UNCONFIRMED OR SUSPECTED CASES

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

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Case definition for Ebola

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

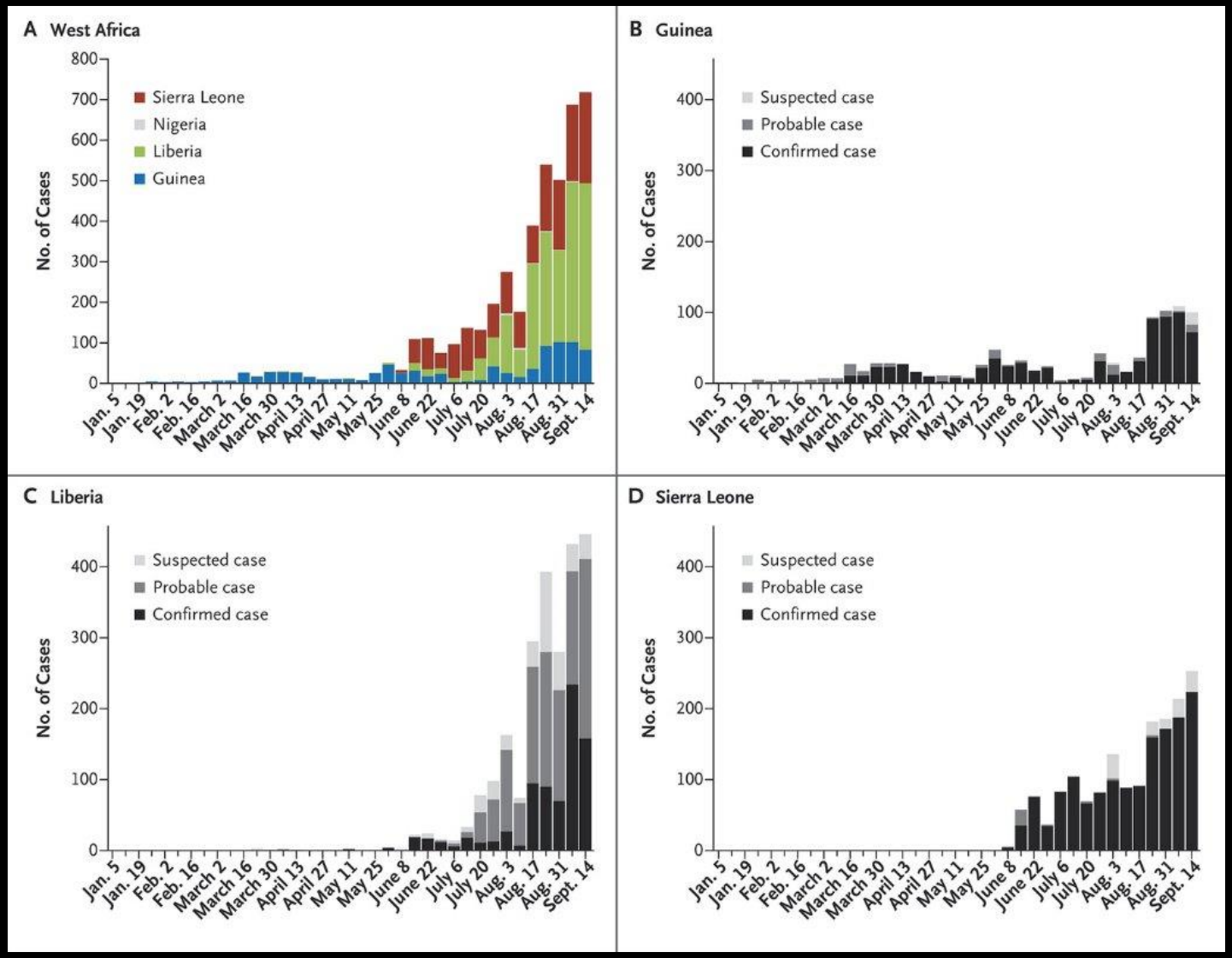
Place: Worldwide

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

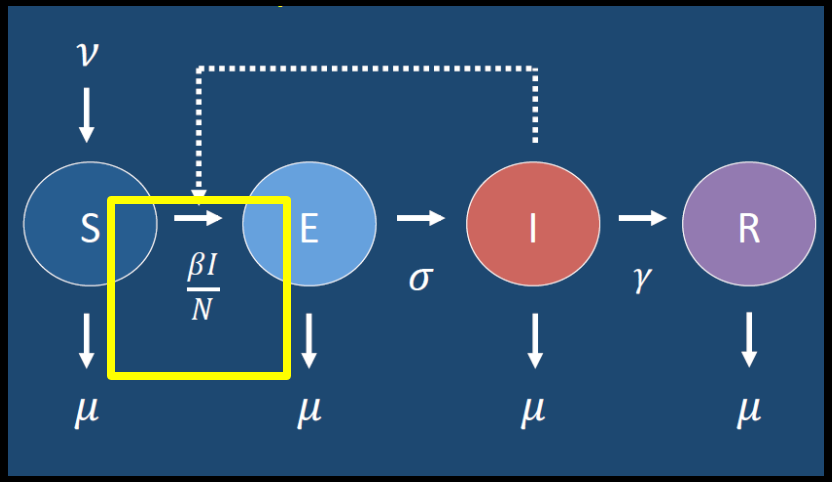
Weekly incidence of confirmed, probable and suspected Ebola cases in West Africa



Source: WHO Ebola Response Team N Engl J Med 2014; 371:1481-1495; DOI: 10.1056/NEJMoa1411100

Incidence of infection

Mathematical expression?



SEIR Model

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

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

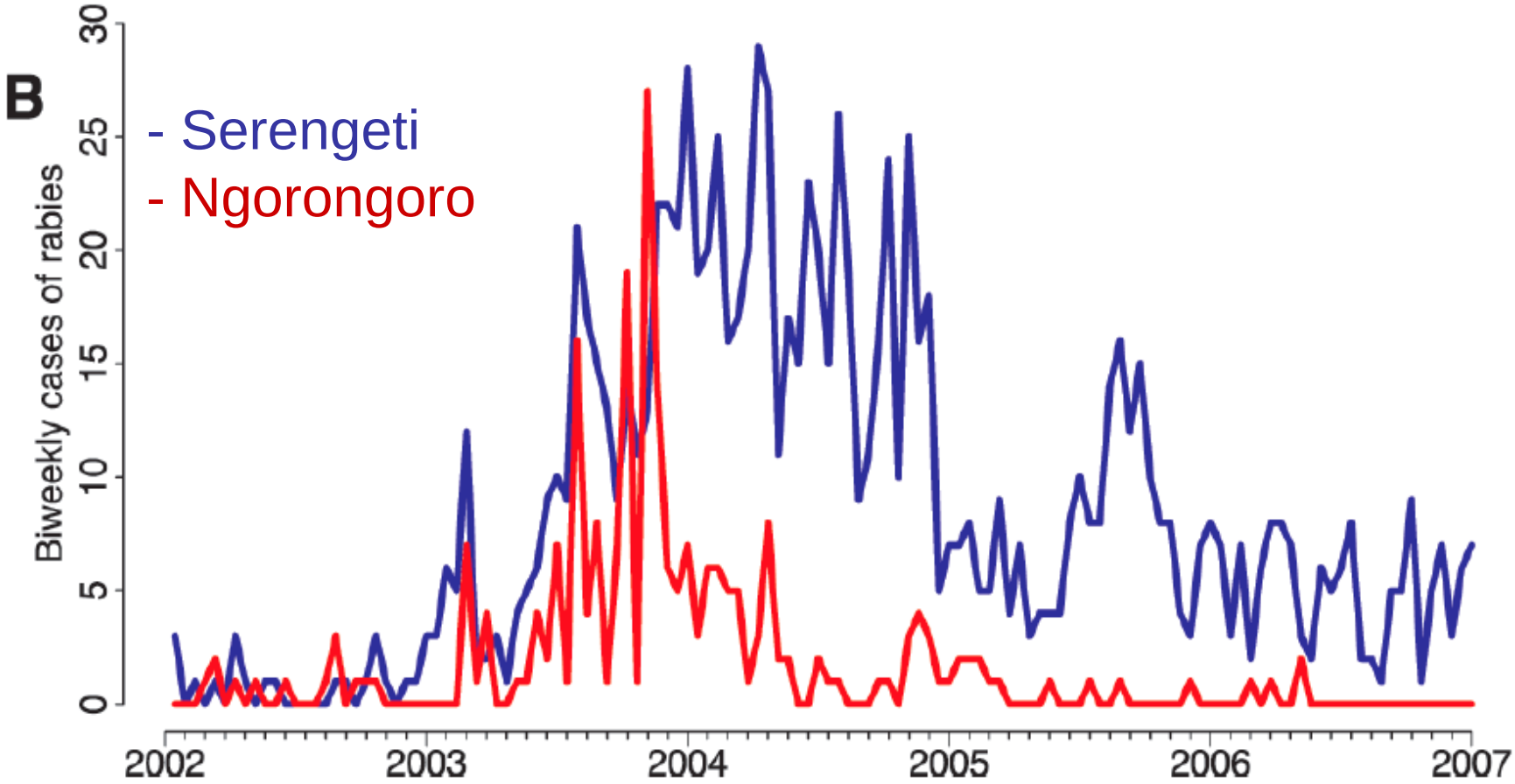
$$\frac{dI}{dt} = \sigma E - \gamma I - \mu I$$

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

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

Ways of collecting data on cases

Surveillance + Contact Tracing/Outbreak investigation



Hampson et al. 2009

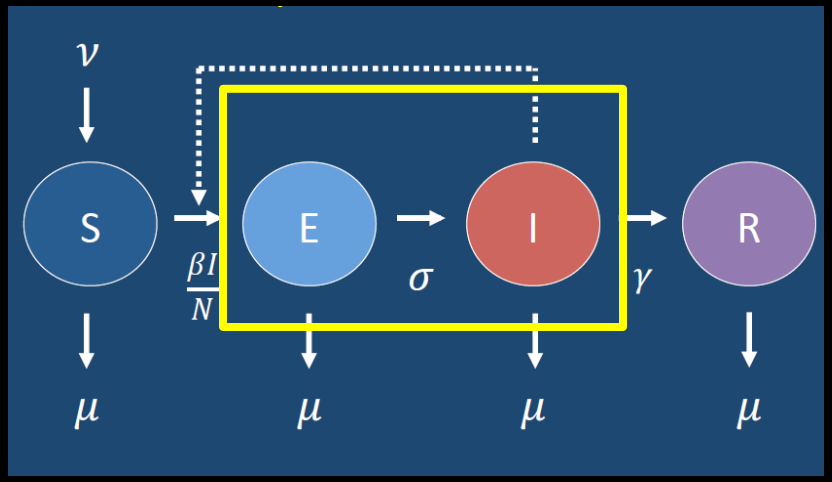
Ways of collecting data on cases

- Passive
- Active

Epidemiological studies

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

Prevalence



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

Mathematical expression?

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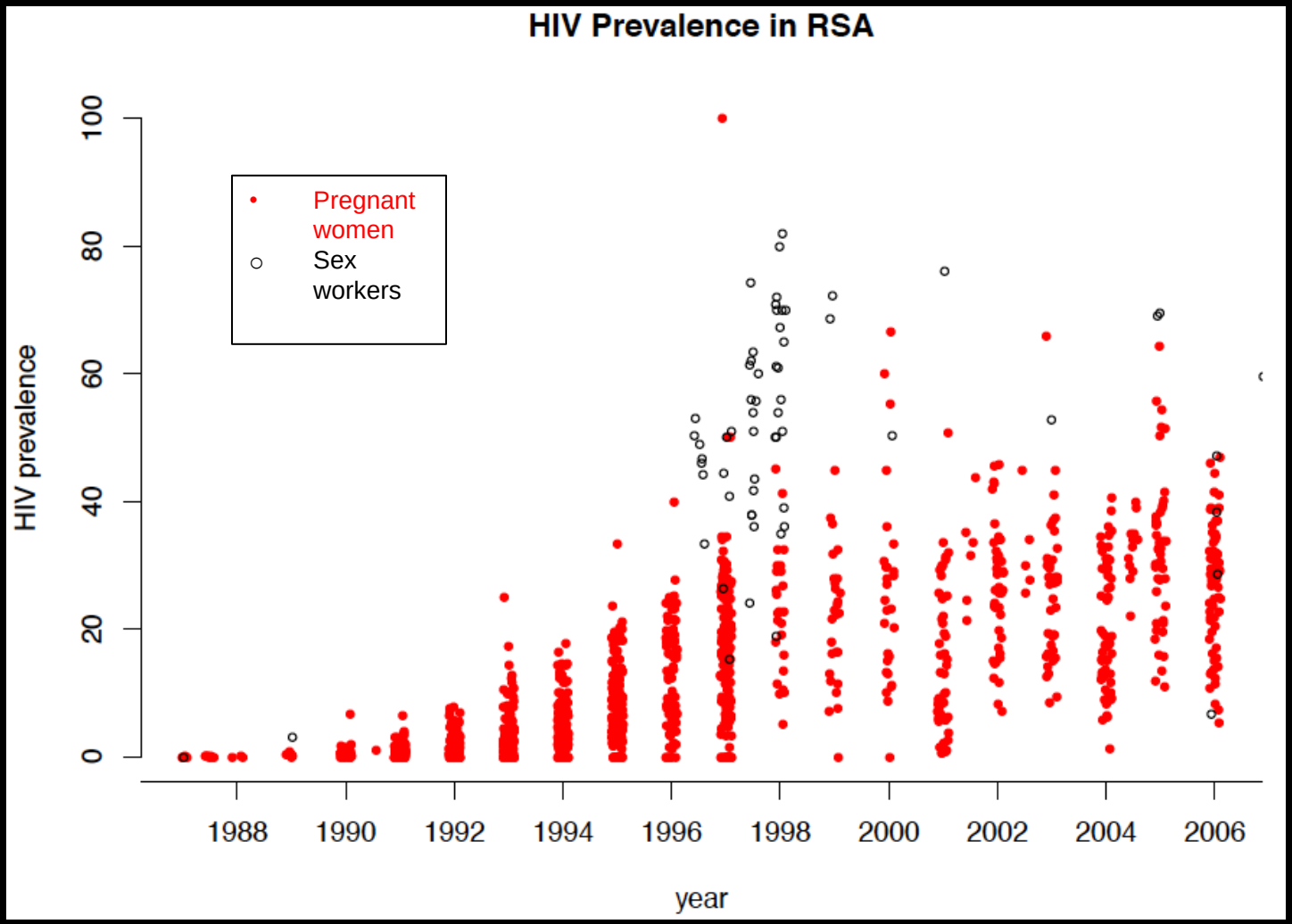
of infection

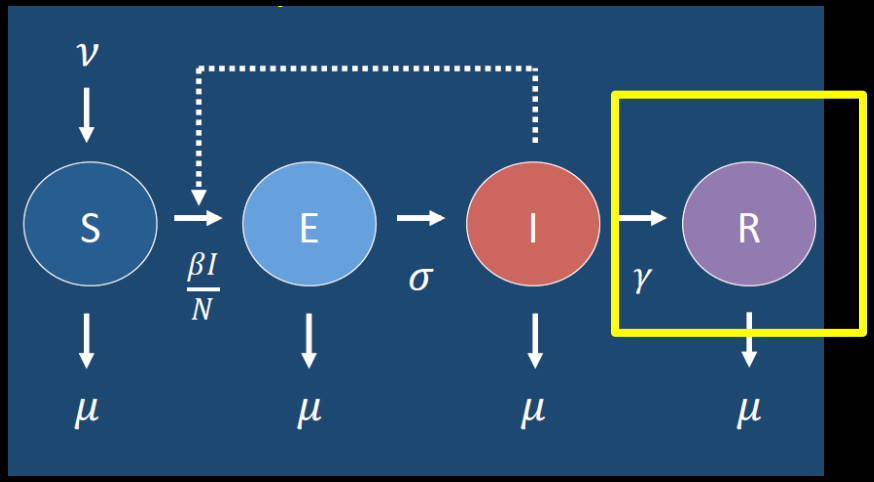
of antibodies (seroprevalence)

Prevalence



Source: UNAIDS HIV Surveillance Database

Prevalence



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

SEIR Model

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

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Mathematical expression?

of infection

of antibodies (seroprevalence)

Seroprevalence

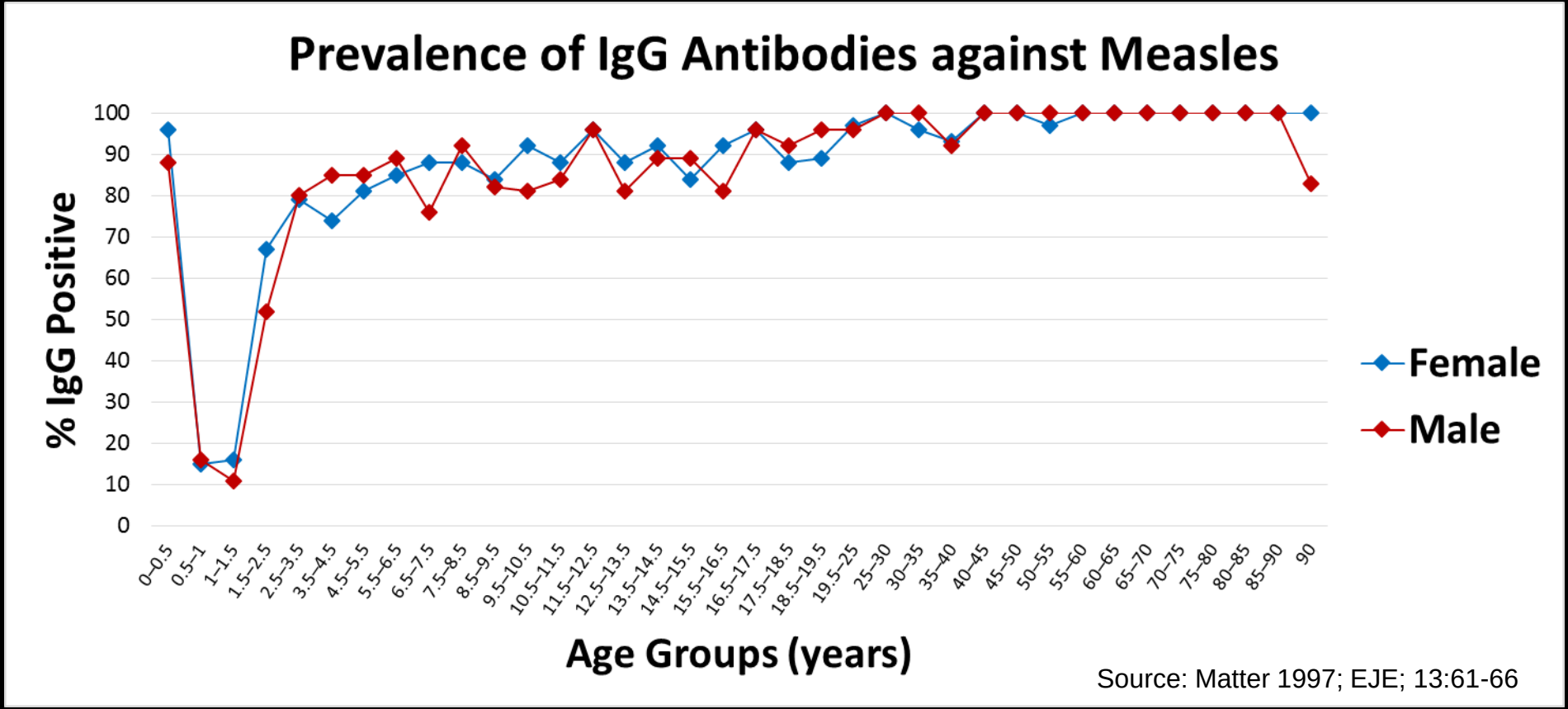
Can be related to:

* 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

Can be related to:

- Prevalence of infection
- Past exposure

May or may not be:

- Prevalence of resistance
- Specific to infection

Levels of data aggregation

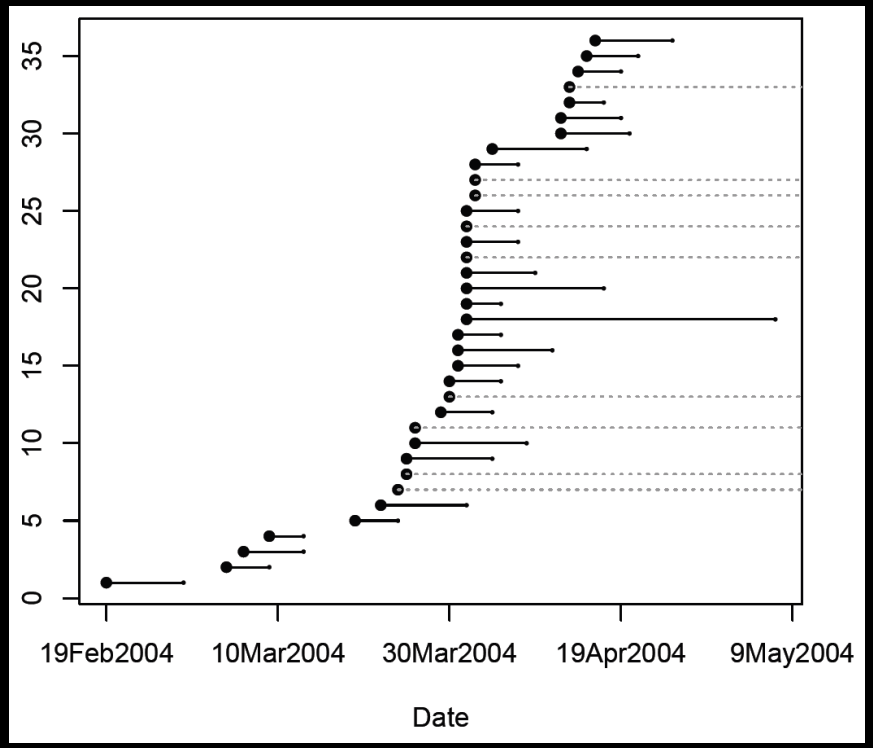
Aggregated data

De-identified data

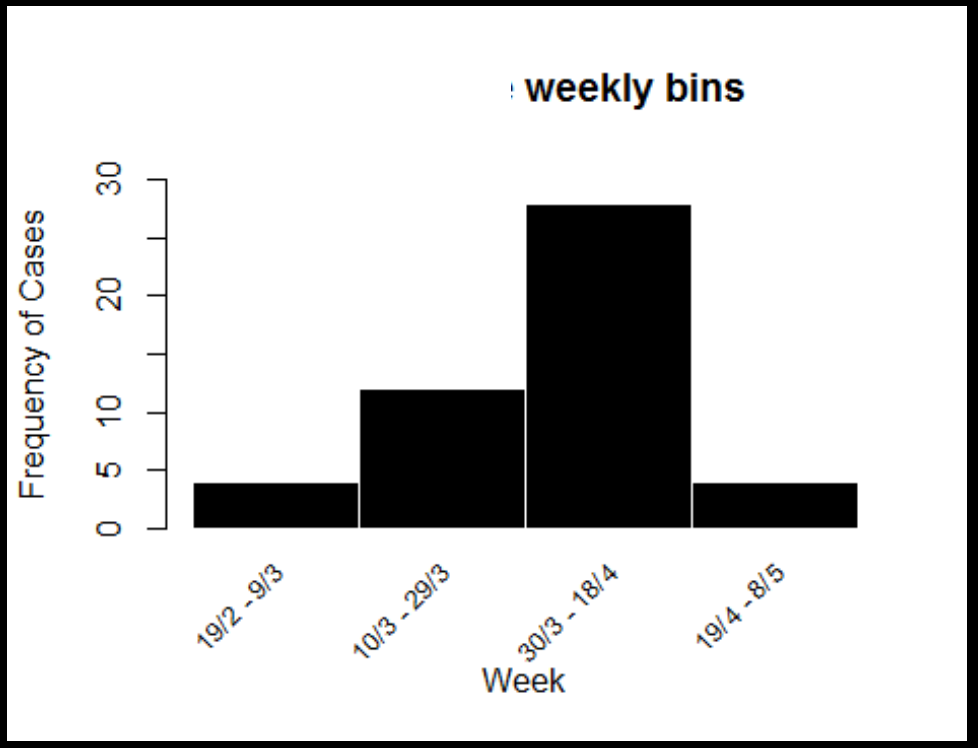
Personally identifying data

Levels of data aggregation

De-identified data

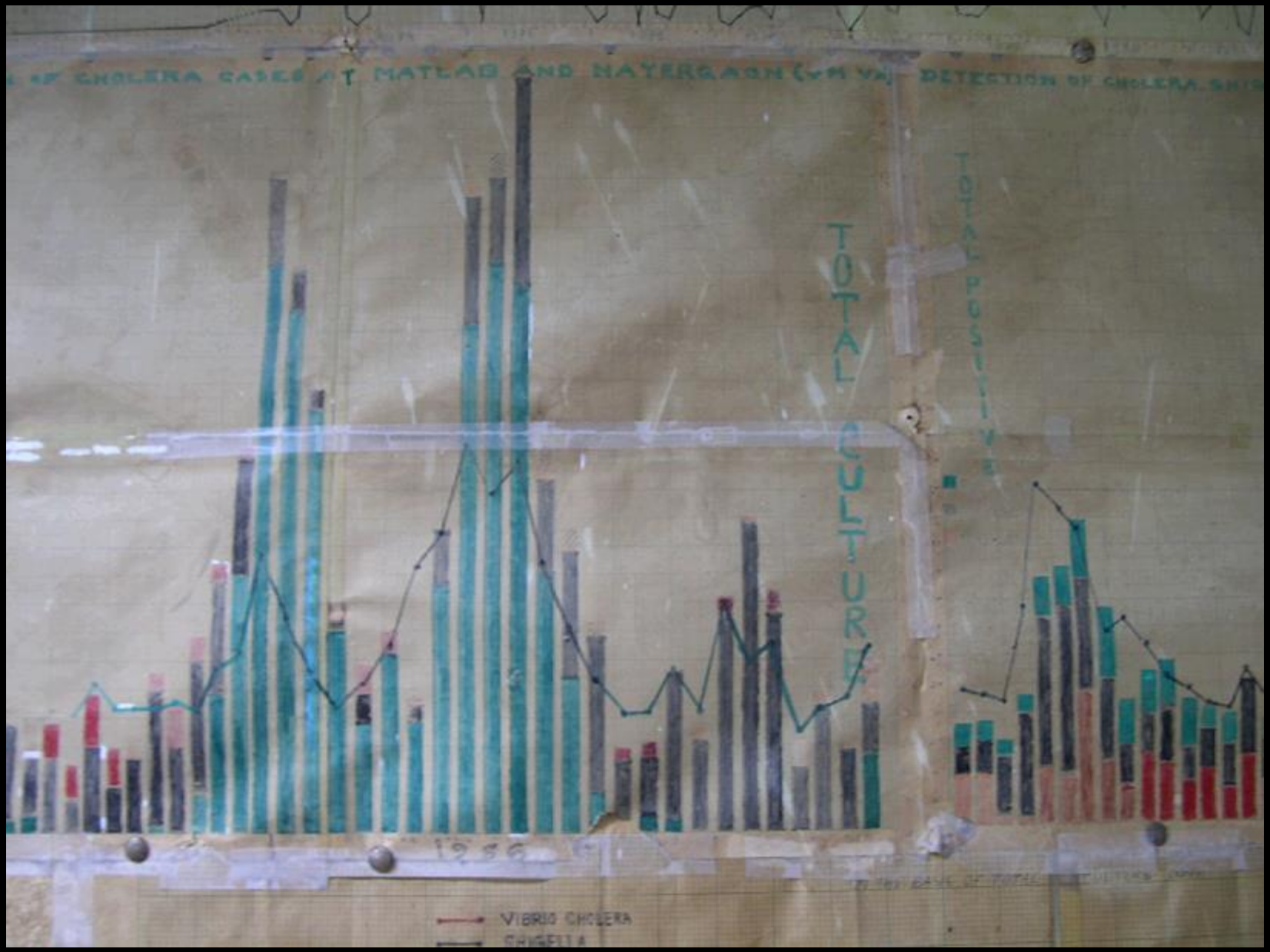


Aggregated data



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

Visualizing data before R…



End – Thank you!