

# RECON

Building the next generation of statistical tools for outbreak response using R

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28th November 2016

Imperial College London  
MRC Centre for Outbreak Analysis and Modelling

# Outline

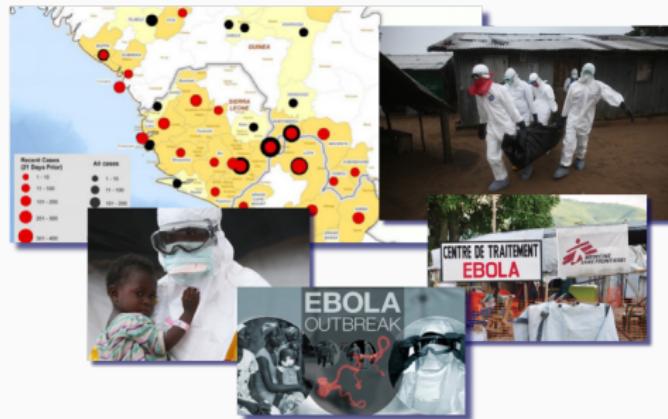
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1. Lessons learnt from the Ebola outbreak response
2. The R Epidemics Consortium
3. Up-and-coming RECON packages
4. Methodological dialogue during outbreak response

## Ebola response

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# Lessons learnt from the Ebola response



# Lessons learnt from the Ebola response



# Lessons learnt from the Ebola response

WHO Ebola response team

Help improving situation awareness

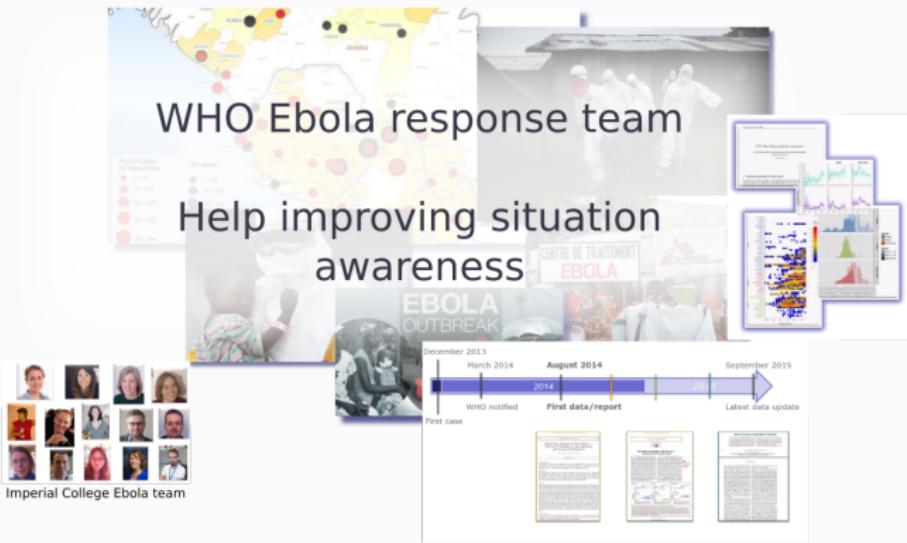
EBOLA OUTBREAK

December 2013      March 2014      August 2014      September 2015

First case      WHO notified      First data/report      Latest data update

Imperial College Ebola team

# Lessons learnt from the Ebola response



*Most statistical/modelling tools for situation awareness missing.*

# What tools do we need?

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Some examples:

- **data cleaning:** dictionaries, entry matching
- **graphics:** case incidence in space and time, contact tracing
- **parameter estimation:** key delays, transmissibility
- **estimate / test CFR:** gender, health care workers, treatments effects
- **predictions:** case incidence, mortality, evaluate interventions
- **report:** (semi-)automated situation reports

# Who do we need to develop these tools?



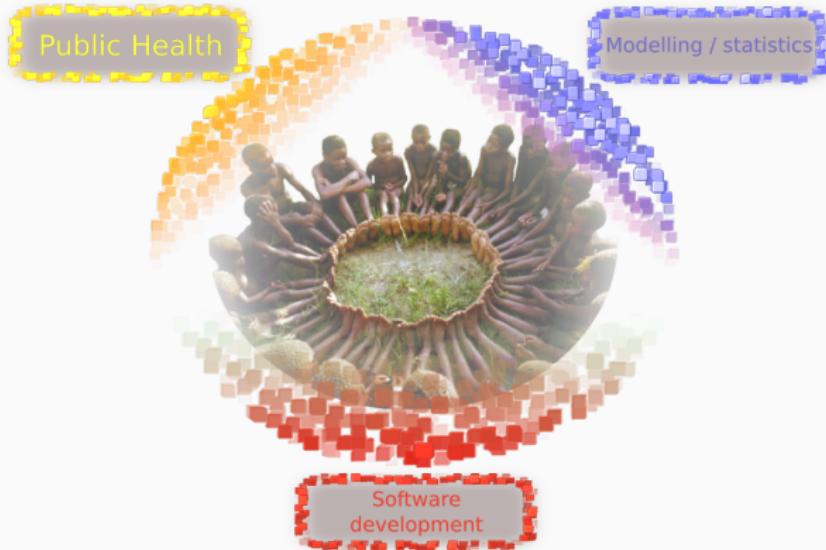
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# The R Epidemics Consortium

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# Hackout 3: a hackathon for emergency outbreak response

Last summer at the *rOpenSci* headquarters (Berkeley)



CDC  
CENTERS FOR DISEASE  
CONTROL AND PREVENTION

World Health Organization

MÉDECINS SANS FRONTIÈRES  
DOCTORS WITHOUT BORDERS

Public Health Agency of Canada

MRC  
Centre for Outbreak Analysis and Modelling

National Institute for Public Health and the Environment  
Ministry of Health, Welfare and Sport

Imperial College London

UNIVERSITY OF CAMBRIDGE

UNIVERSITY OF OXFORD

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

Public Health England

ecdc  
EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL

BERKELEY  
Institute for Data Science

wellcome trust  
sanger  
institute

JOHNS HOPKINS  
BLOOMBERG SCHOOL  
of PUBLIC HEALTH

# Hackout 3: from ideas to projects to...



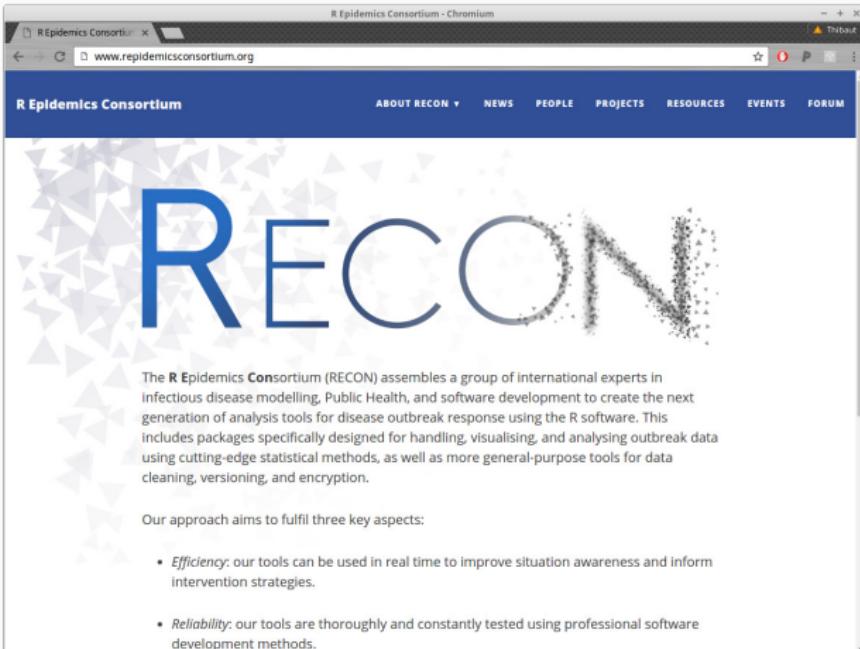
# Hackout 3: from ideas to projects to...



*How do we keep momentum once the event is over?*

# RECON: the R Epidemics Consortium

A taskforce to build a new generation of outbreak response tools in  .



The screenshot shows the homepage of the RECON website. The title bar reads "R Epidemics Consortium - Chromium" and the address bar shows "www.repidemicsconsortium.org". The header menu includes links for "ABOUT RECON", "NEWS", "PEOPLE", "PROJECTS", "RESOURCES", "EVENTS", and "FORUM". The main feature is a large, stylized word "RECON" where each letter is composed of numerous small, dark grey triangles, set against a background of a similar triangular pattern. Below the title, a paragraph describes the consortium's mission: "The R Epidemics Consortium (RECON) assembles a group of international experts in infectious disease modelling, Public Health, and software development to create the next generation of analysis tools for disease outbreak response using the R software. This includes packages specifically designed for handling, visualising, and analysing outbreak data using cutting-edge statistical methods, as well as more general-purpose tools for data cleaning, versioning, and encryption." A section titled "Our approach aims to fulfil three key aspects:" lists two bullet points: "*Efficiency*: our tools can be used in real time to improve situation awareness and inform intervention strategies." and "*Reliability*: our tools are thoroughly and constantly tested using professional software development methods."

[www.repidemicsconsortium.org](http://www.repidemicsconsortium.org)

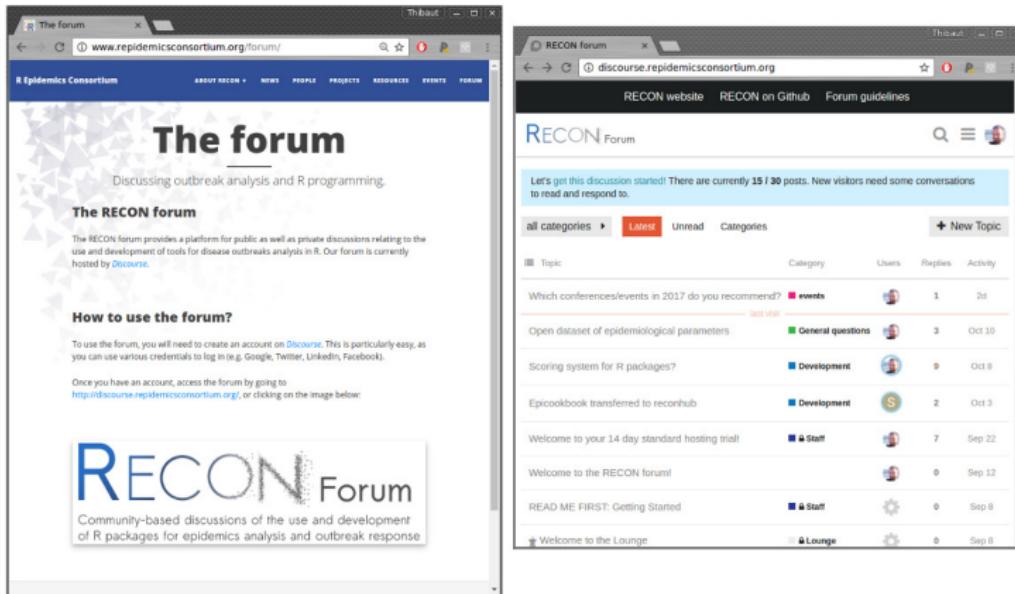
# RECON

*www.repidemicsconsortium.org*

- started 6th September 2016
- 46 people (41 members, 5 board)
- 10 countries, > 20 institutions
- ~ 10 new packages coming
- **public forum**, blog, online resources

# The RECON forum

A platform for discussing epidemics analysis in .

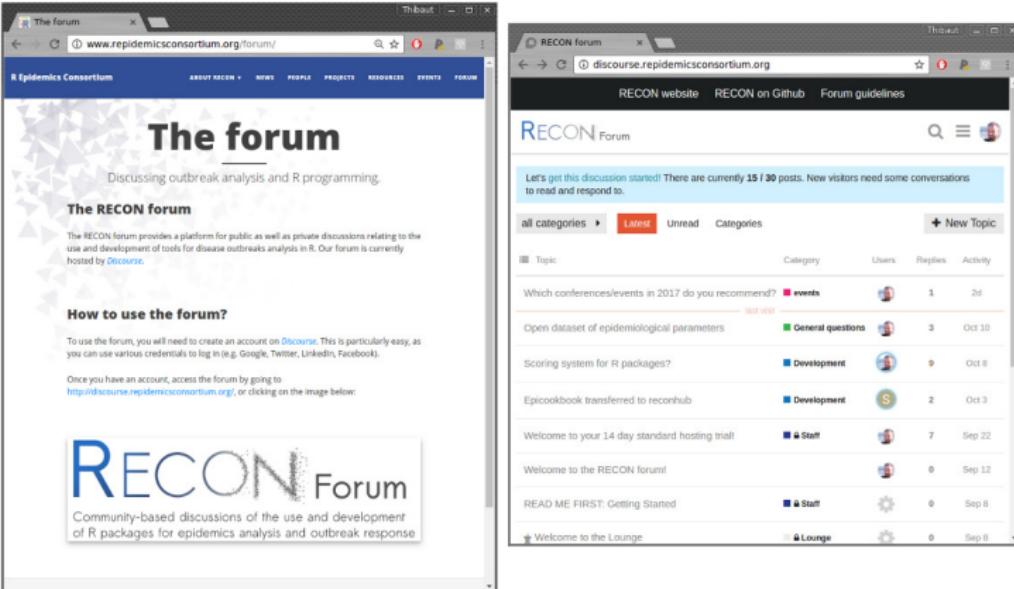


The image shows two side-by-side browser windows. The left window displays the official RECON forum at [www.repidemicsconsortium.org/forum/](http://www.repidemicsconsortium.org/forum/). It features a dark blue header with the 'Epidemics Consortium' logo and navigation links for About RECON, News, People, Projects, Resources, Events, and Forum. The main content area has a light gray background with a geometric pattern and contains the heading 'The forum' and a sub-section titled 'The RECON forum'. The right window shows a discourse instance at [discourse.repidemicsconsortium.org](http://discourse.repidemicsconsortium.org). The header includes links to the RECON website, GitHub, and Forum guidelines. The main area is titled 'RECON Forum' and shows a list of forum topics. A message at the top encourages users to start conversations. Below it, a table lists topics such as 'Which conferences/events in 2017 do you recommend?', 'Open dataset of epidemiological parameters', and 'Scoring system for R packages?'. Each topic includes a small profile picture, the category it belongs to (e.g., events, General questions, Development, Staff), the number of replies, and the date it was posted.

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Topic	Category	Users	Replies	Activity
Which conferences/events in 2017 do you recommend?	events	2	1	Oct 10
Open dataset of epidemiological parameters	General questions	3	0	Oct 10
Scoring system for R packages?	Development	9	0	Oct 9
Epicookbook transferred to reconhub	Development	2	0	Oct 3
Welcome to your 14 day standard hosting trial!	Staff	7	0	Sep 22
Welcome to the RECON forum!	Staff	0	0	Sep 12
READ ME FIRST: Getting Started	Staff	0	0	Sep 8
Welcome to the Lounge	Lounge	0	0	Sep 8

[www.repidemicsconsortium.org/forum](http://www.repidemicsconsortium.org/forum)

Join us!

# RECON package: what do we aim for?

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- **efficiency**: useful for improving situation awareness in real time; **cutting-edge, computer-efficient statistical methods**

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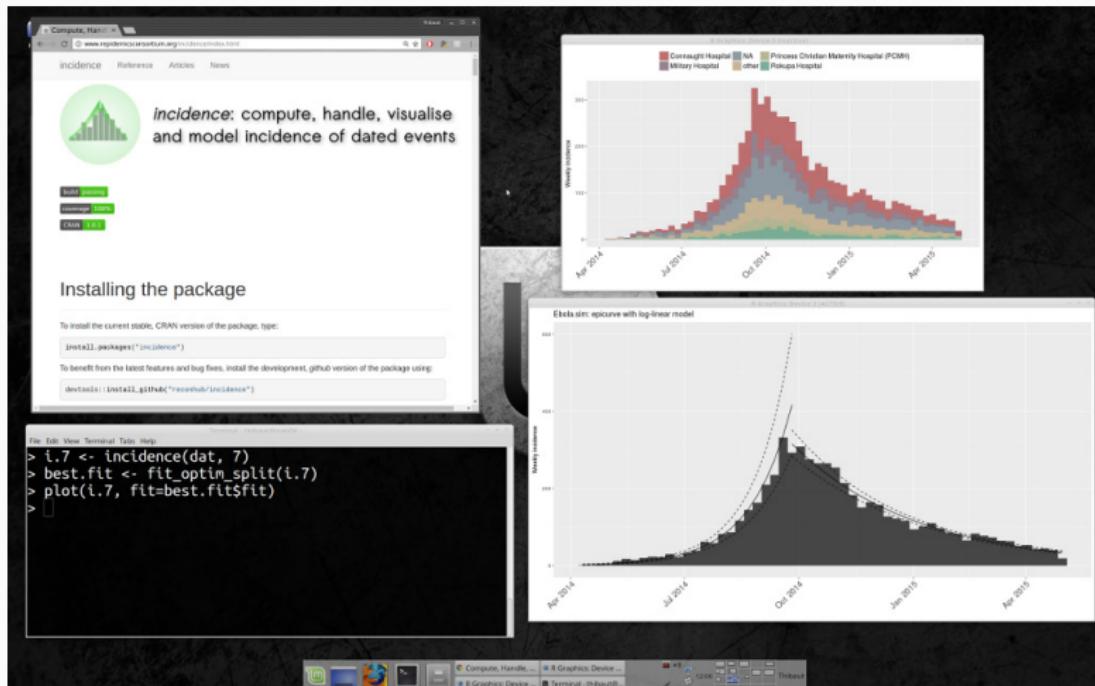
# RECON package: what do we aim for?

- **efficiency**: useful for improving situation awareness in real time; cutting-edge, computer-efficient statistical methods
- **reliability**: outputs can be trusted; continuous integration, extensive unit testing, code review, good practices
- **accessibility**: widely available, easy learning curve; extensive documentation, tutorials, websites, forum

## Up-and-coming RECON packages

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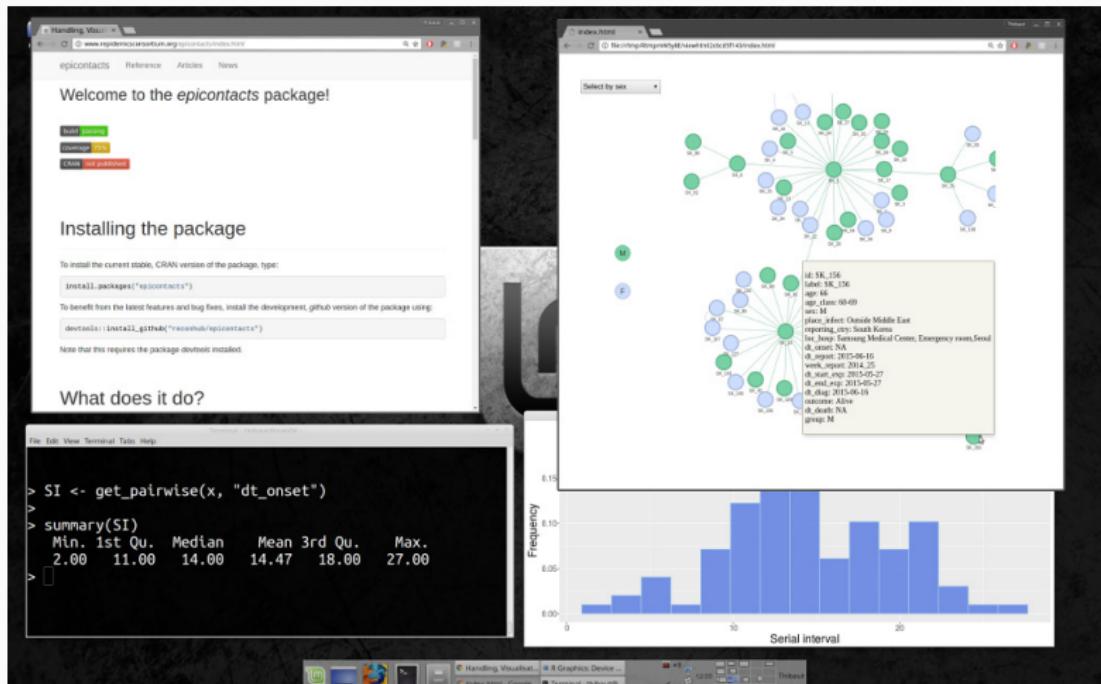
# *incidence*: computation, handling, visualisation and modelling of epicurves



[www.repidemicsconsortium.org/incidence](http://www.repidemicsconsortium.org/incidence)

[released]

# *epicontacts*: handling, visualisation and analysis of epidemiological contacts



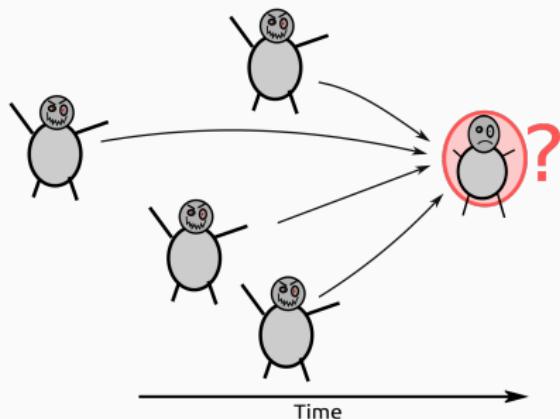
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[release December 2016]

## *outbreaker2*: inferring who infects whom in an outbreak

Original *outbreaker* model: timing of symptoms and pathogen genomes to infer infectors

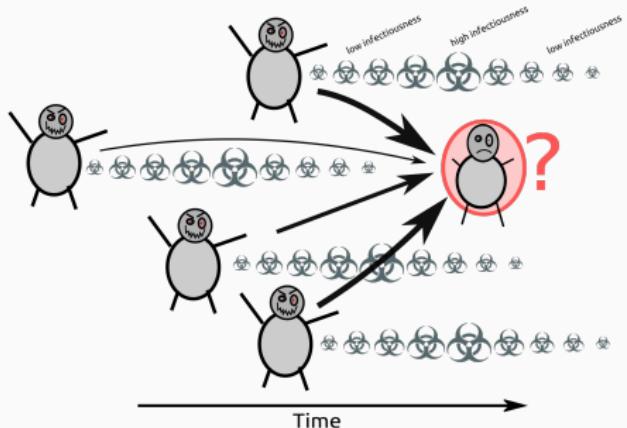
(Jombart et al, PLoS Comp Biol, 2014)



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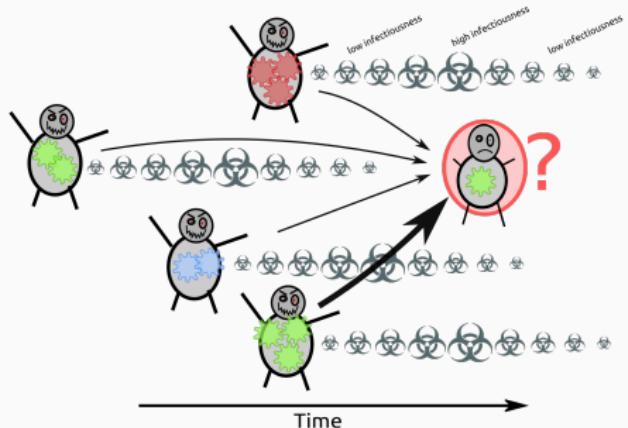


Since *outbreaker*: new models, data, and questions.

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Since *outbreaker*: new models, data, and questions.

**But:** methodological niche fragmented.

# Are different methods really... different?

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Different models can lead to very similar implementations.  
Can we find a **general formulation**?

## What do these model look like?

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- $a, b, c$ : different types of data
- $\theta$ : parameters / augmented data

Data are often assumed to be *conditionally independent*:

$$p(a, b, c|\theta) = p(a|\theta)p(b|\theta)p(c|\theta)$$

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Components can be treated as **plugins**.

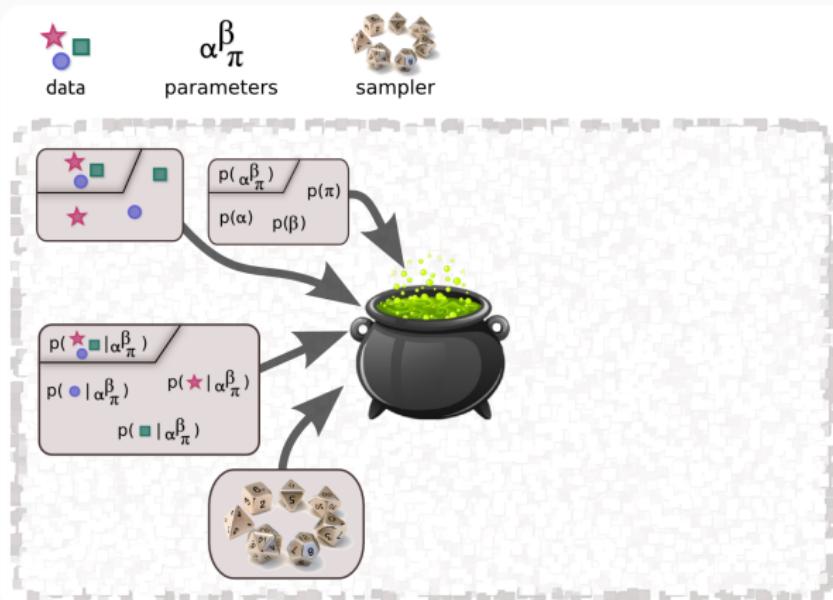
## *outbreaker2*: a general cauldron for cooking methods

Use-your-own: data type, likelihood, prior, MCMC.



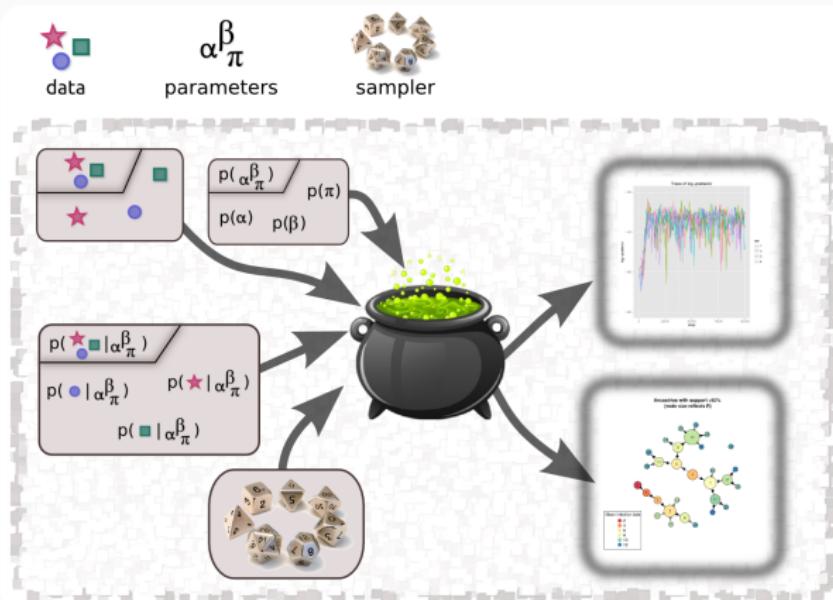
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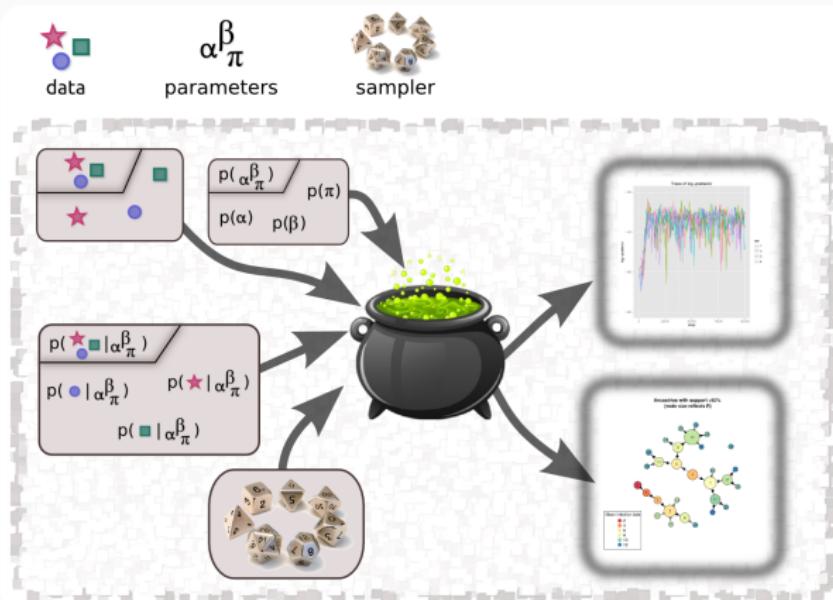
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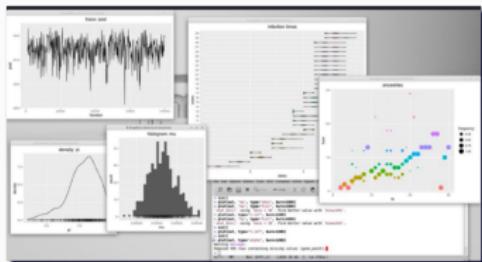
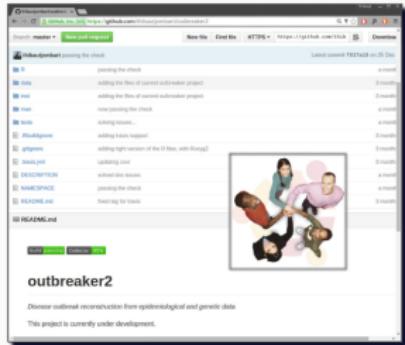
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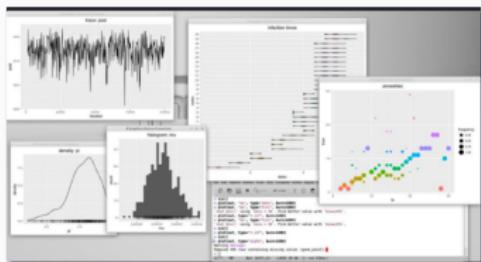
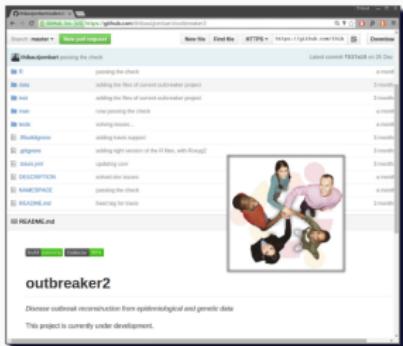
Modularity is key to generalising approaches

# *outbreaker2*: a general tool for outbreak reconstruction

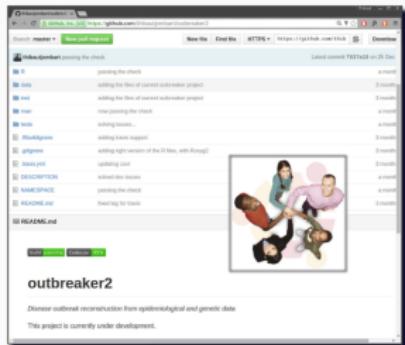


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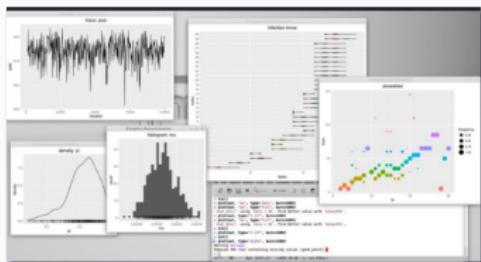
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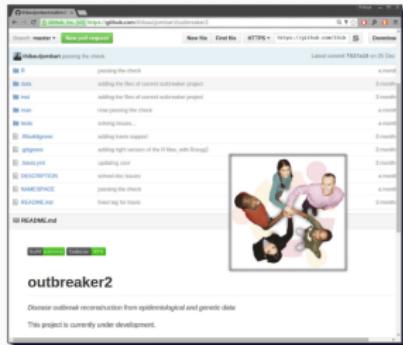
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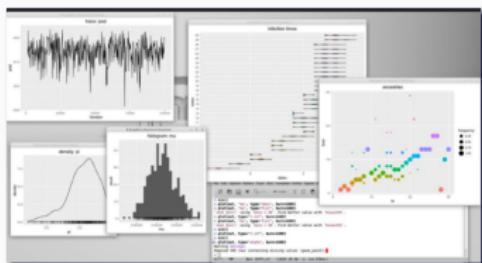
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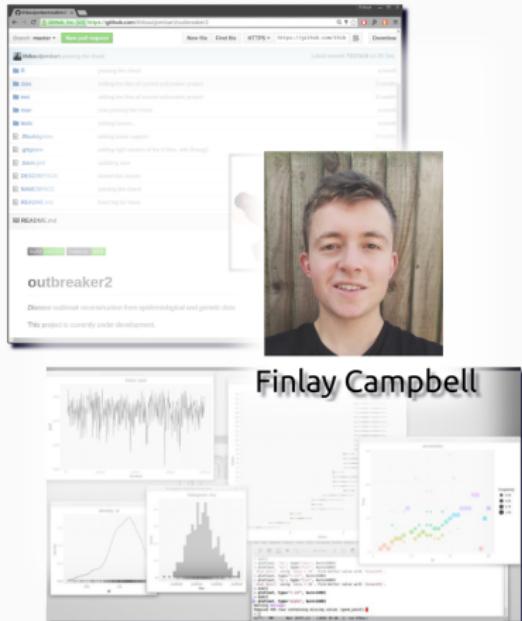


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- **new 'extensions'**: contact tracing, spatial structure, new MCMC
- **reliability**: continuous integration, extensive unit testing (aiming for 100% coverage)
- **prettier**: plot methods using *ggplot2*, interactive networks visualisation
- should **facilitate new contributions**

## Methodological dialogue

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# Methodological development relies on an interdisciplinary dialogue

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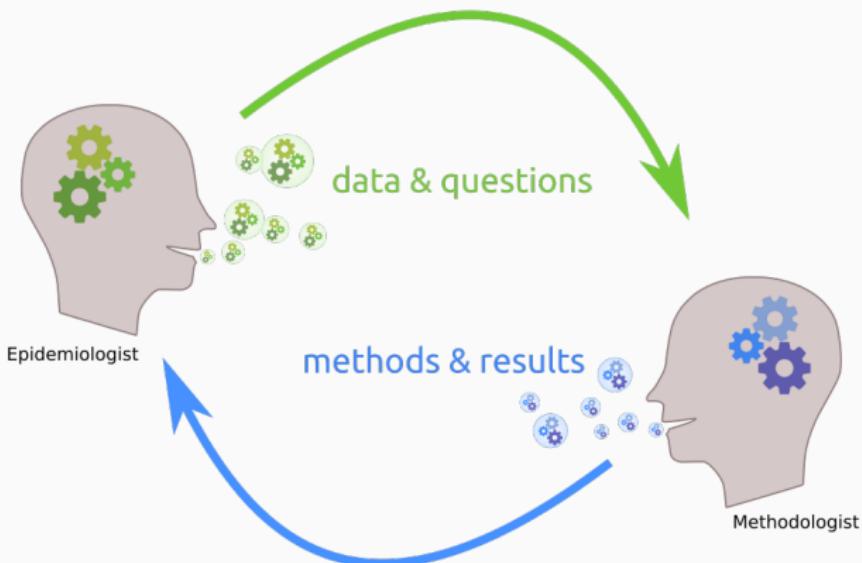


Epidemiologist

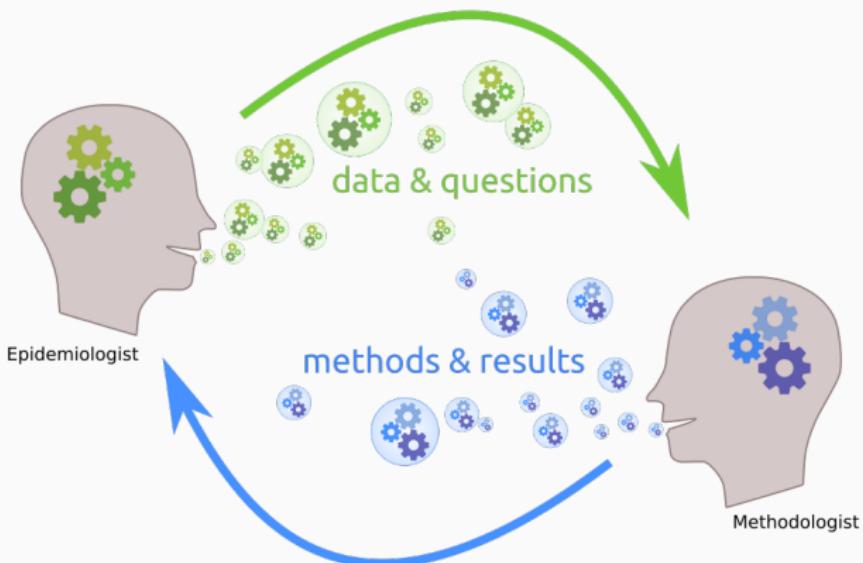


Methodologist

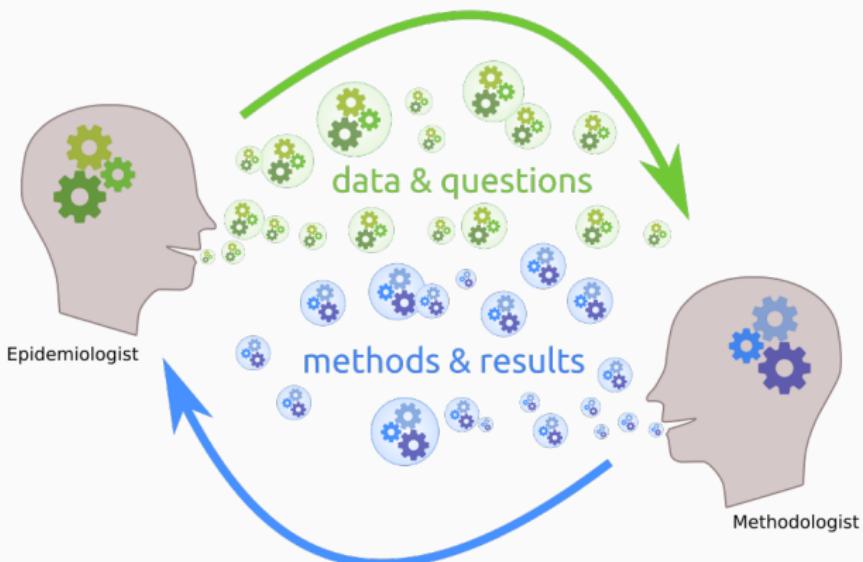
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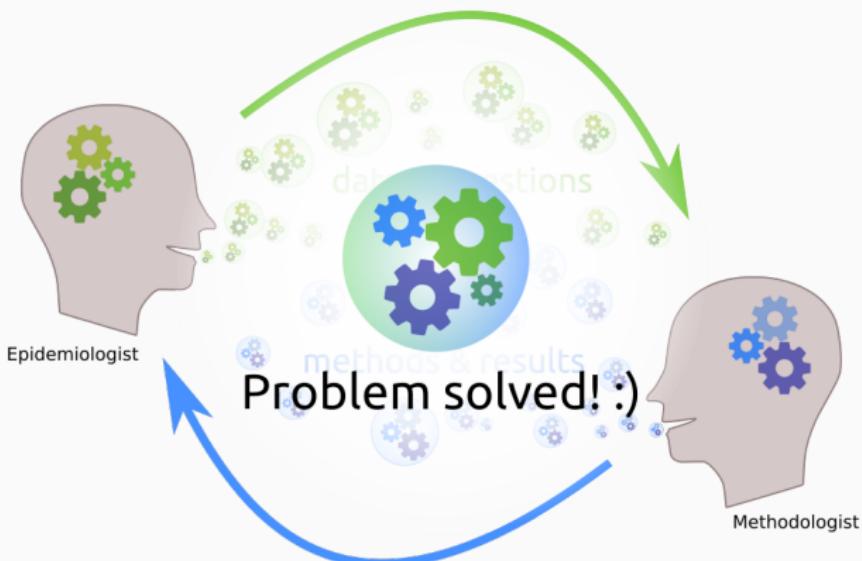
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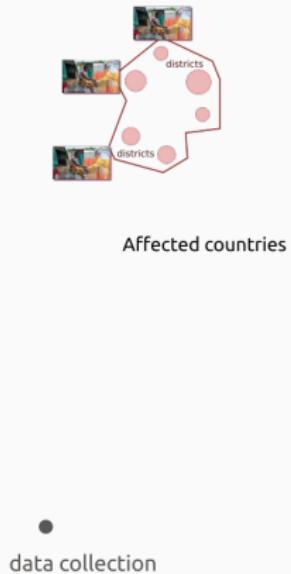
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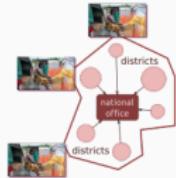
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# Outbreak response context creates distance and delays



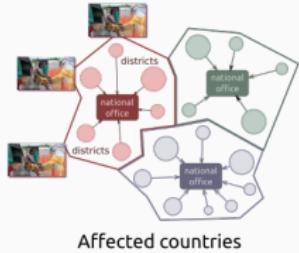
# Outbreak response context creates distance and delays



Affected countries

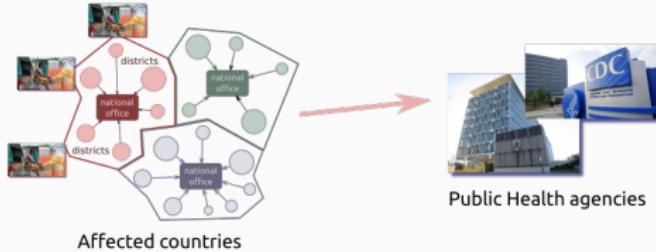
time (block = day)  
•   
data collection

# Outbreak response context creates distance and delays

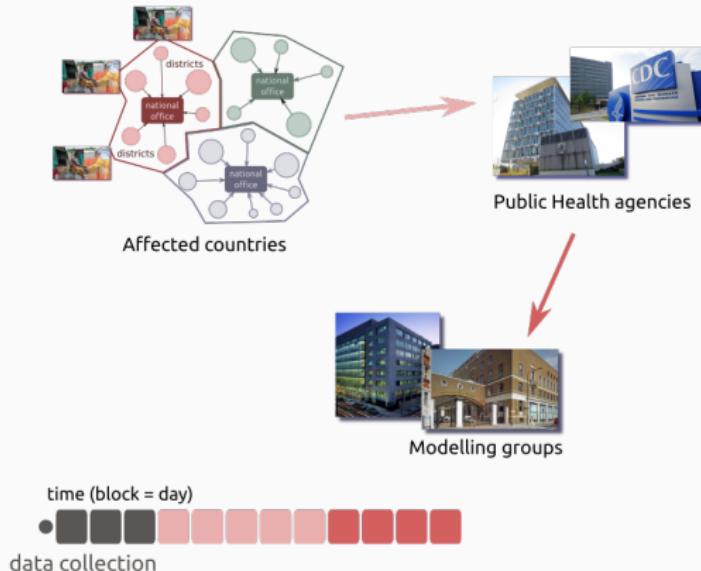


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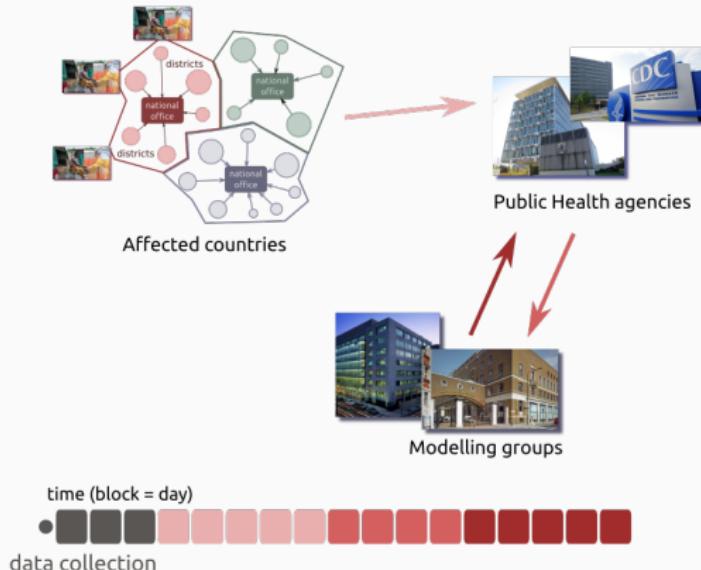
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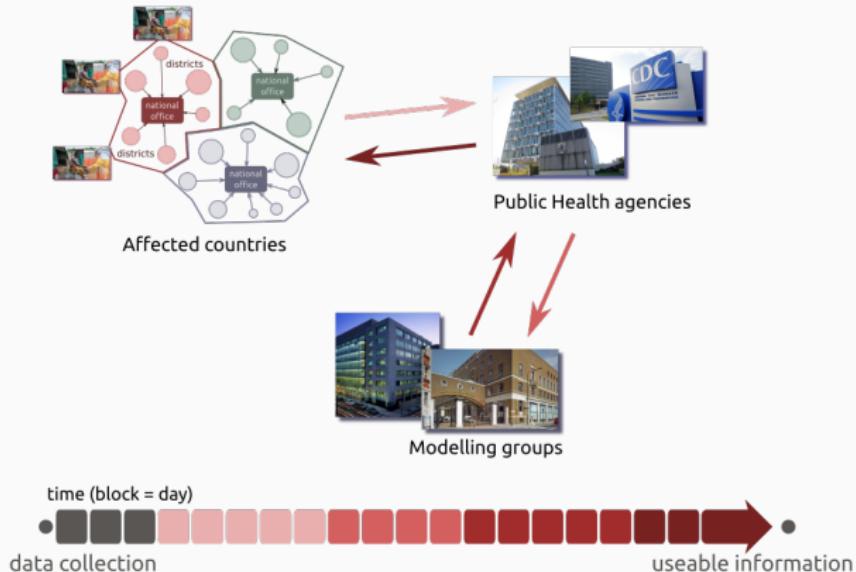
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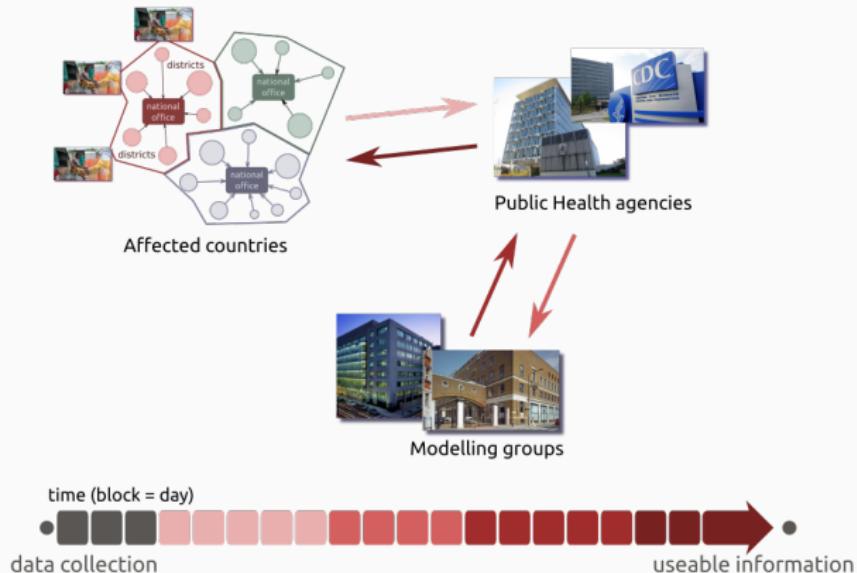
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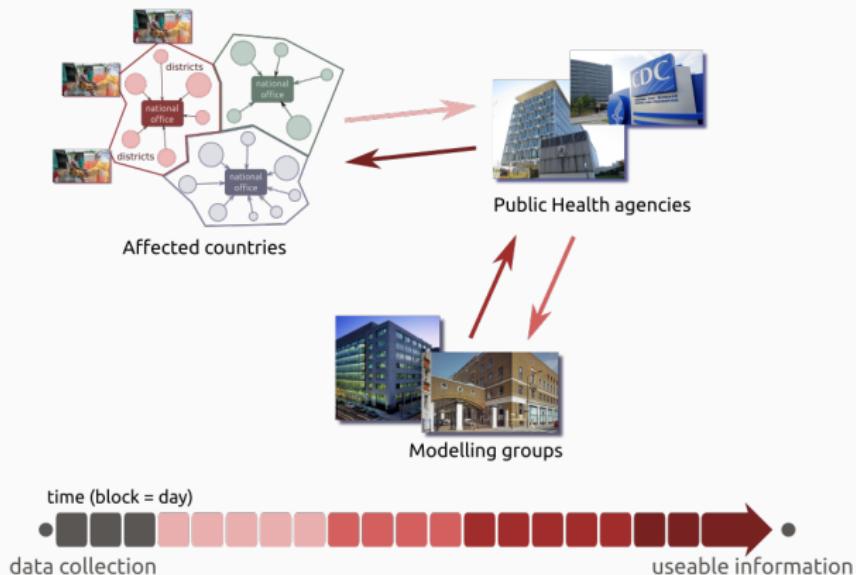


# Outbreak response context creates distance and delays



- efficient tools can shorten delays

# Outbreak response context creates distance and delays



- efficient tools can shorten delays
- potential of **embedding methodologists in outbreak response teams**

## Thanks to...

- **ESCAIDE** organisers
- **Imperial College**: Neil Ferguson, Rich Fitzjohn, Anne Cori, Finlay Campbell, Evgenia Markvardt, James Hayward
- **UC Berkeley**: Karthik Ram
- **Groups**: WHO Ebola Response Team, Hackout 1/2/3, RECON members
- **funding**: HPRU-NIHR, MRC

More on:

*[www.repidemicsconsortium.org](http://www.repidemicsconsortium.org)*

Questions?