

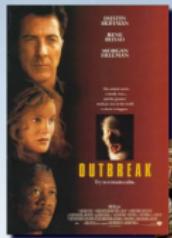
On the emergence of R as a platform for outbreak response

MRC Centre for Outbreak Analysis and Modelling
Imperial College London

Thibaut Jombart

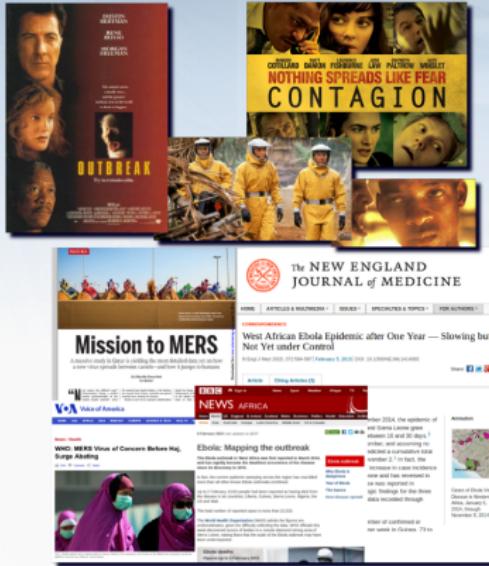
UseR! — 29th June 2016

Infectious disease outbreaks 101



The screenshot shows the homepage of The New England Journal of Medicine. At the top, there is a large image of a group of people in a clinical setting. Below it, a prominent headline reads "Mission to MERS" with a sub-headline "A team of experts in Spain is calling for the money needed to stop a new, more dangerous form of pneumonia from spreading". To the right, another section discusses the "West African Ebola Epidemic after One Year — Slowing but Not Yet under Control". The BBC News Africa page is also visible on the left side of the screen.

Infectious disease outbreaks 101



Outbreaks, in a nutshell

- infectious disease = caused by pathogen (e.g. virus, bacteria)
- new pathogen or introduction → new cases, unknown properties
- potential for rapid (exponential) spread
- mortality & morbidity

Infectious disease outbreaks 101



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Key questions

- How does it spread? How fast?
- How many people die? Who?
- How can we contain / mitigate it?

Infectious disease outbreaks 101



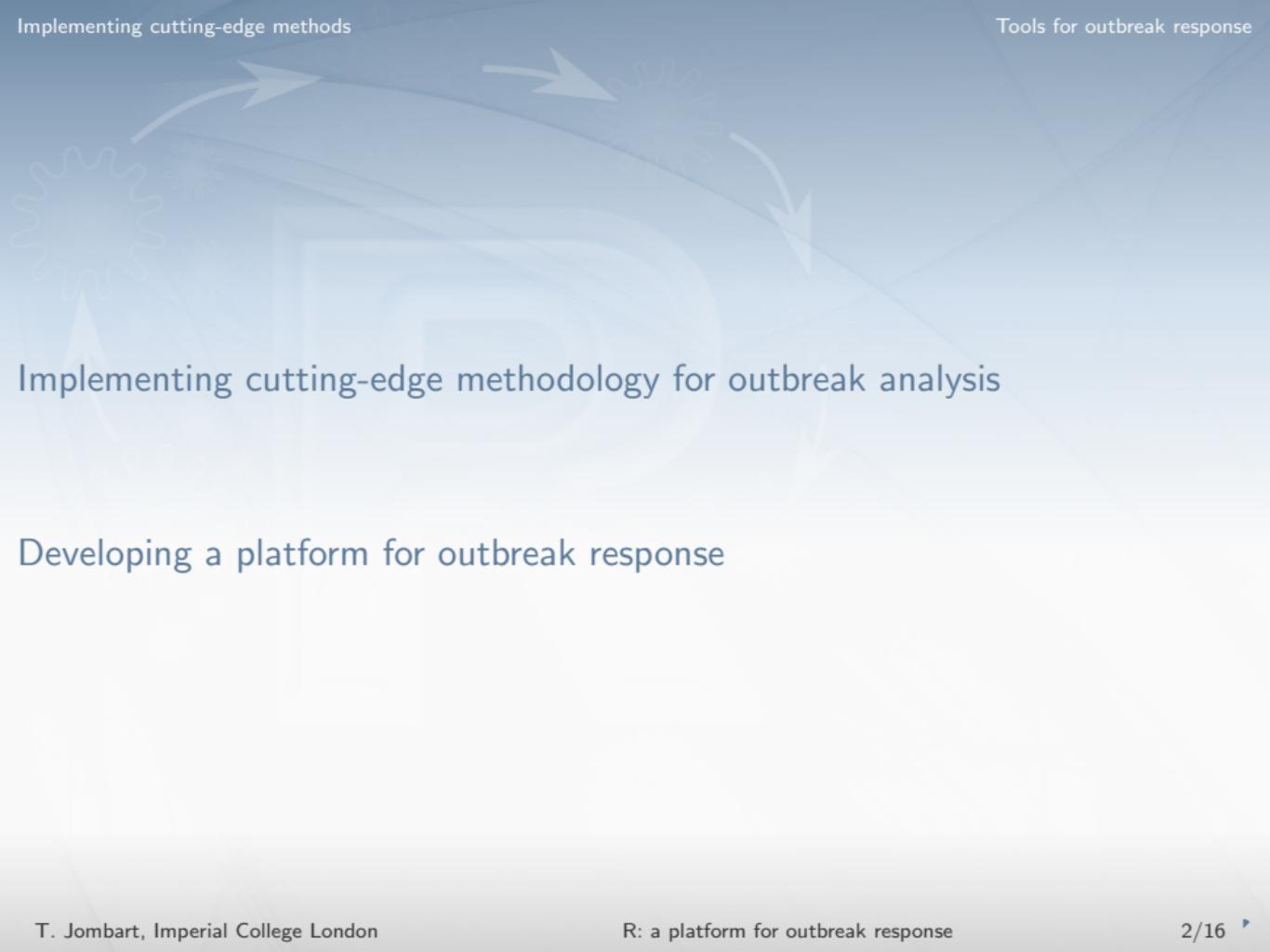
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Statistical analysis key to answer these questions.



Implementing cutting-edge methodology for outbreak analysis

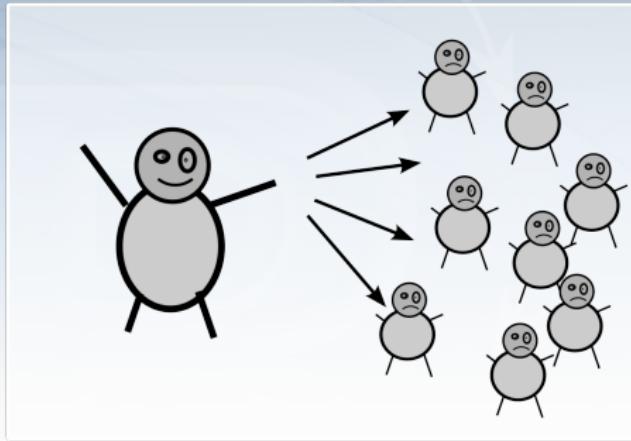
Developing a platform for outbreak response

Outline

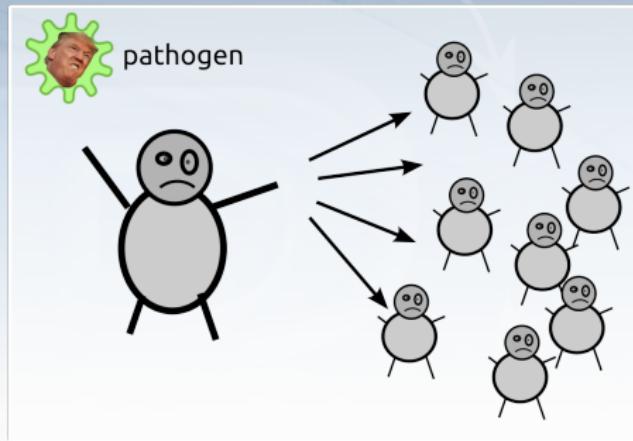
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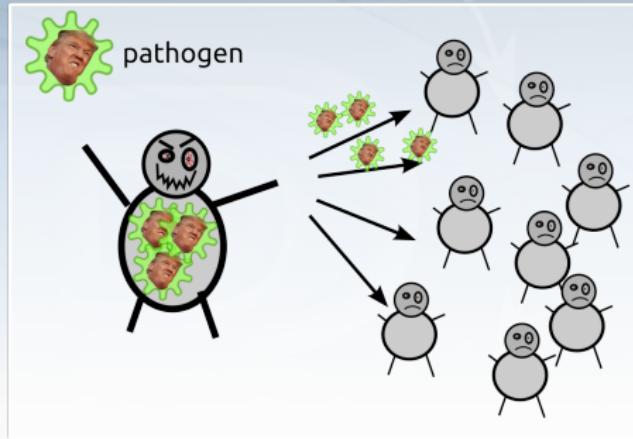
Estimating reproduction numbers (R)



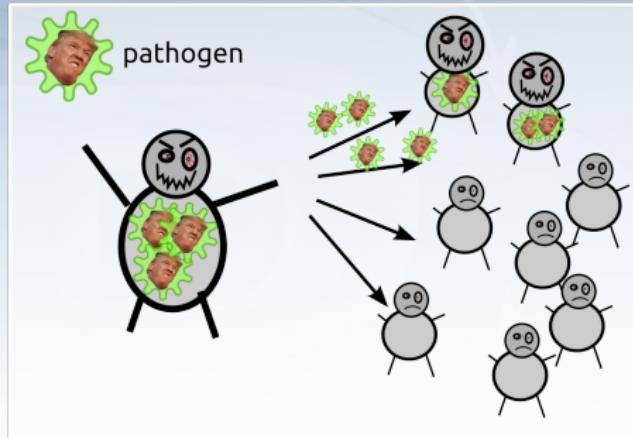
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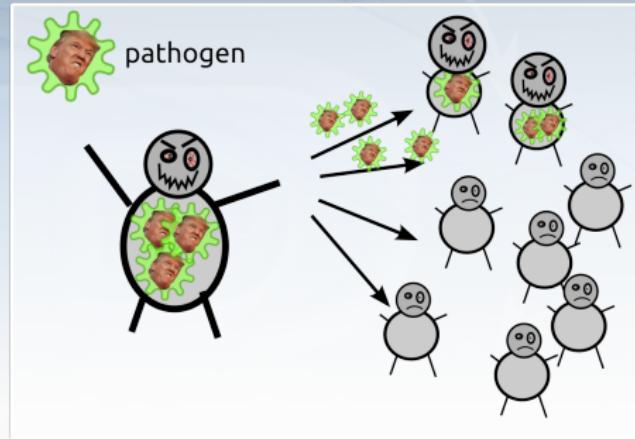
Estimating reproduction numbers (R)



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Estimating reproduction numbers (R)



Reproduction number (R)

- number of new infections caused by a new case
- impact outbreak growth, spread, and intervention strategies
- real-time estimation is essential

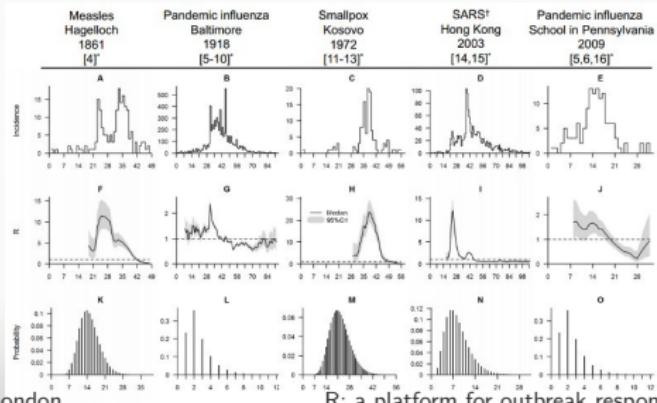
Predicting R in real time: the instantaneous reproduction number (R_t)



The R package EpiEstim

(Cori et al, Am J Epidemiol, 2013)

- real-time estimation of R_t , predicts new infections based on current data
- originally implemented as Excel spreadsheet (!)
- R package: better, faster, more reliable
- includes shiny server

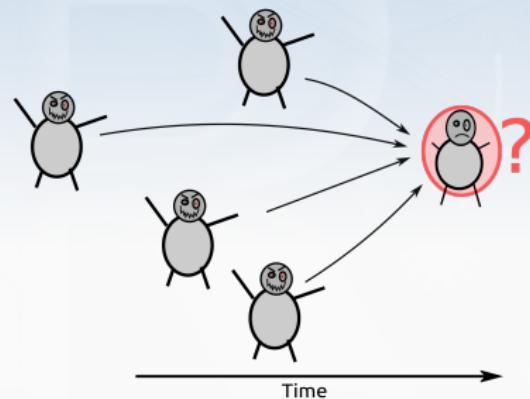


Who infects whom? An expanding methodological field

Original *outbreaker* model:

use timing of symptoms and pathogen genomes to infer likely infectors

(Jombart *et al*, PLoS Comp Biol, 2014)

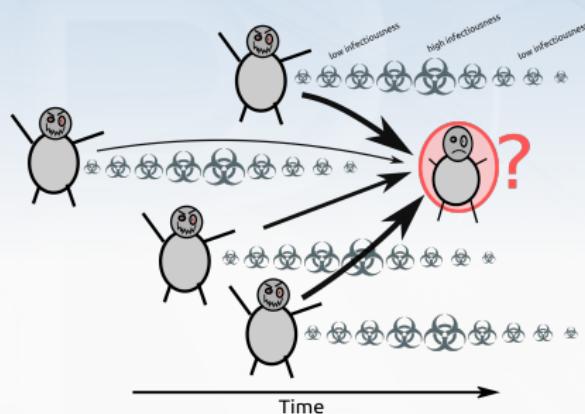


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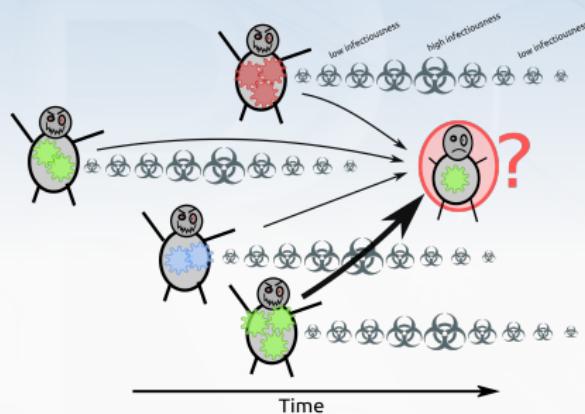
Since *outbreaker*: new models, data, and questions.

Who infects whom? An expanding methodological field

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Since *outbreaker*: new models, data, and questions.
But little code availability → limited reproducibility.

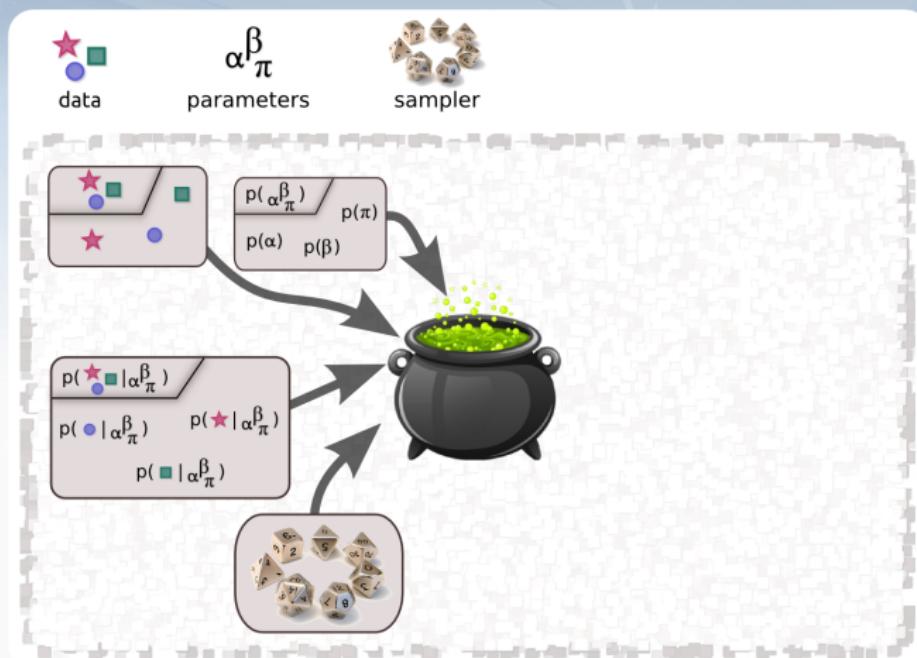
outbreaker2: a general cauldron for cooking methods

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



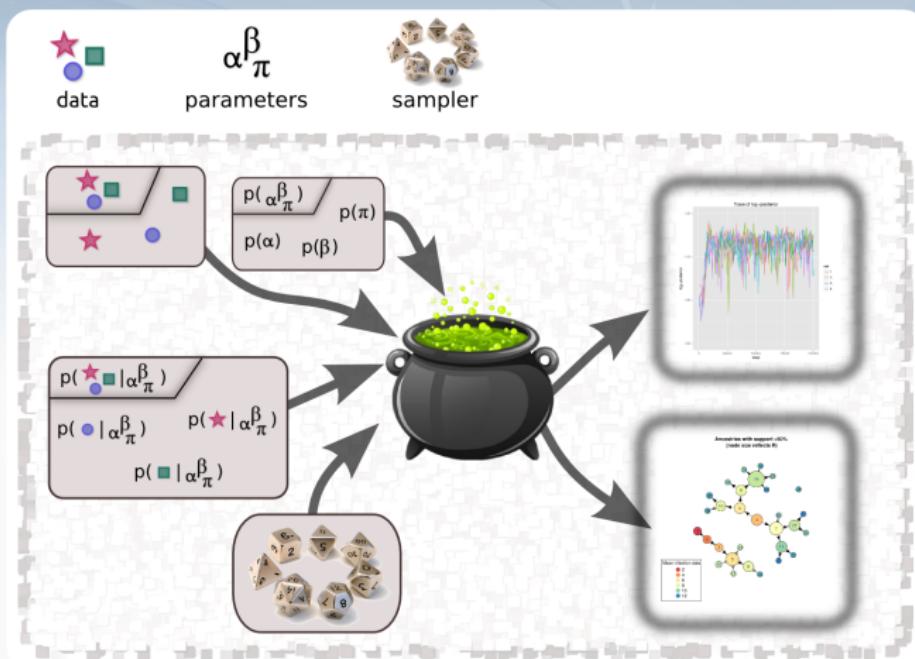
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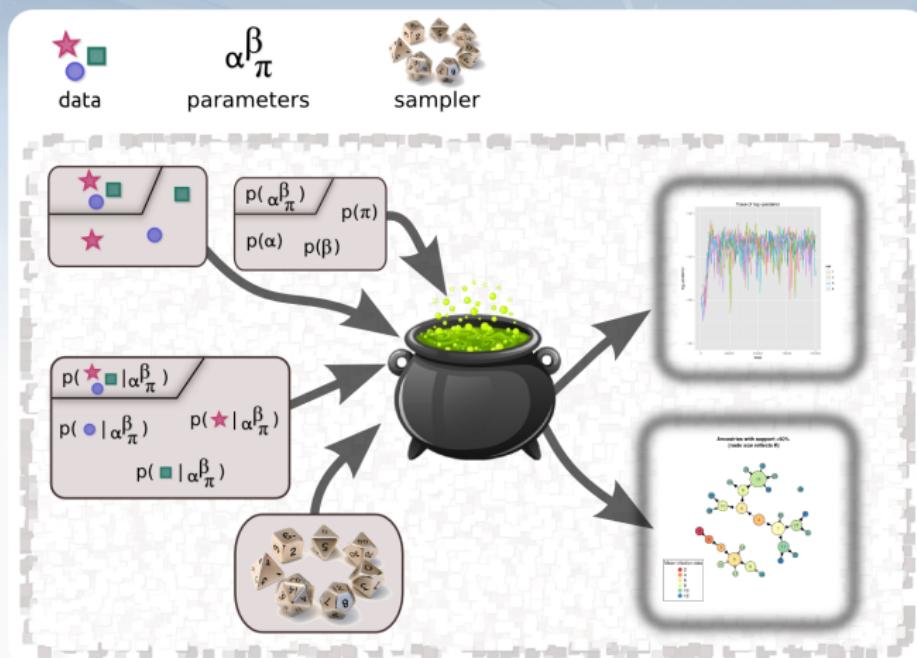
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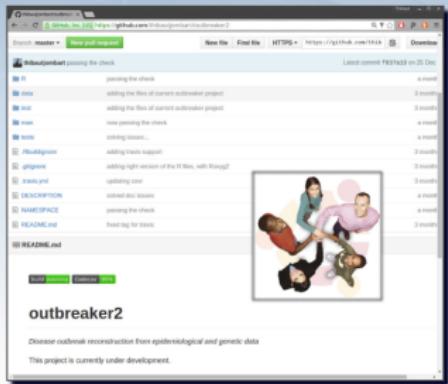
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Modularity is key to generalising approaches

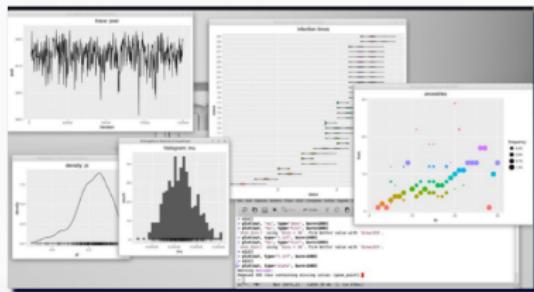
outbreaker2: a general tool for outbreak reconstruction



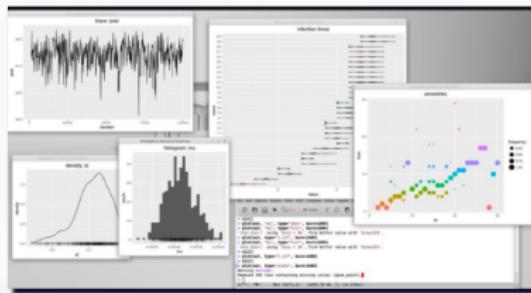
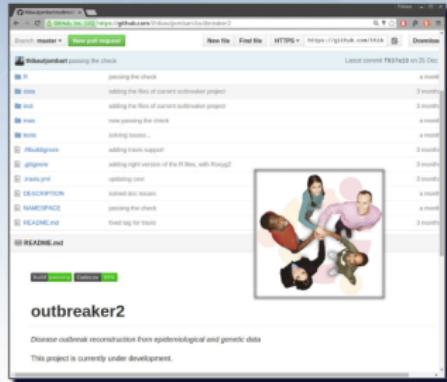
outbreaker2

Outbreak outbreak reconstruction from epidemiological and genetic data

This project is currently under development.



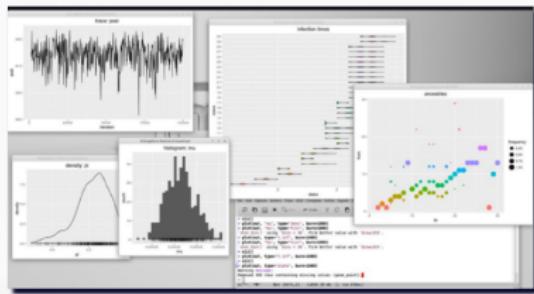
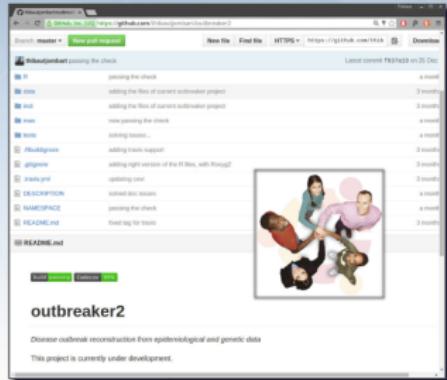
outbreaker2: a general tool for outbreak reconstruction



Objectives

- **modularity:** functional programming, closures (data attached to functions)

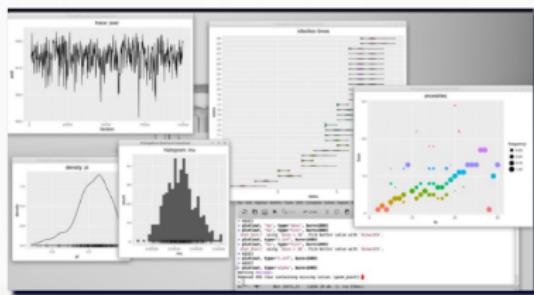
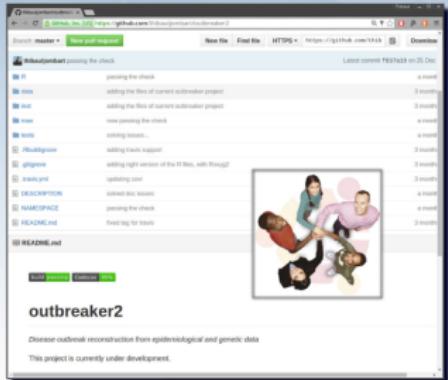
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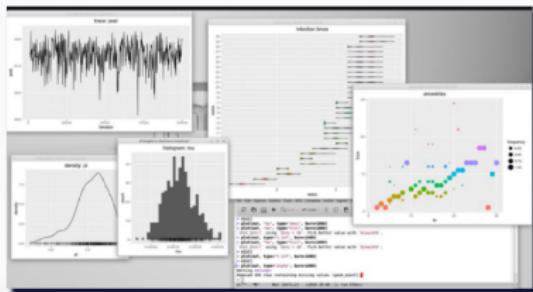
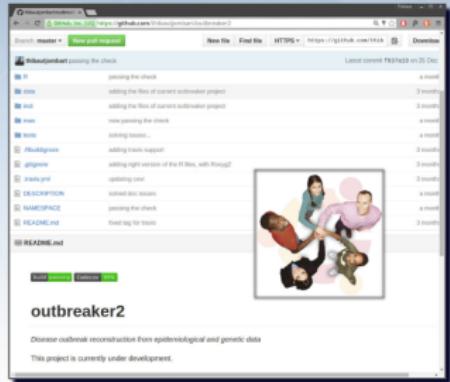
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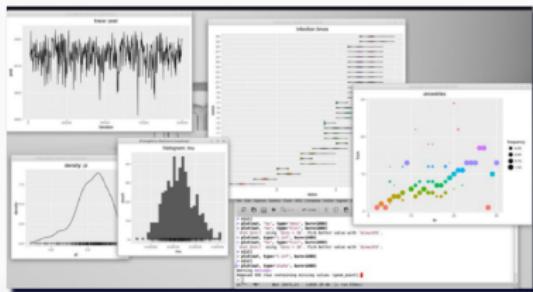
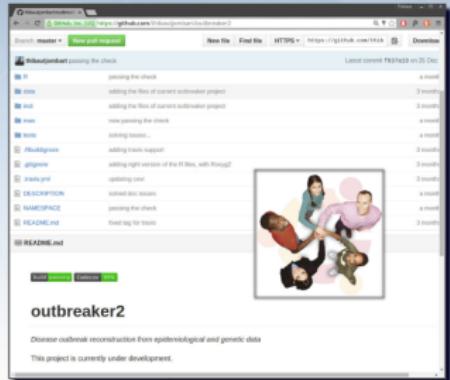
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outbreaker2: a general tool for outbreak reconstruction



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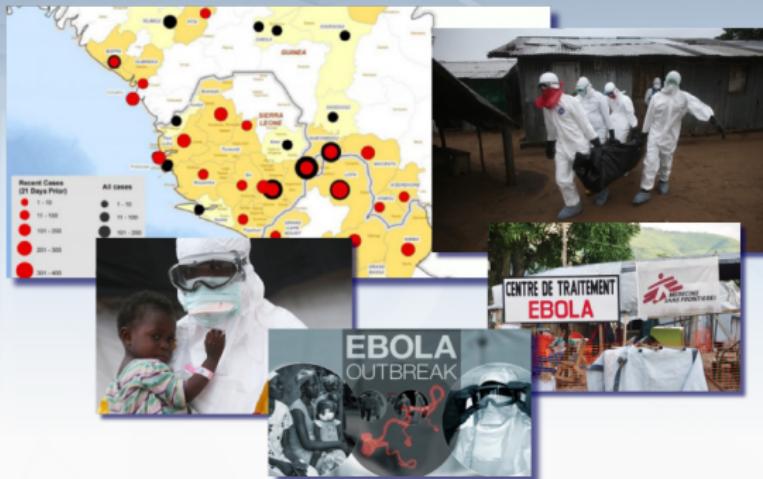
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- enable **contributions from the community**
- release planned in late 2016

Outline

Implementing cutting-edge methodology for outbreak analysis

Developing a platform for outbreak response

Ebola outbreak response



Ebola outbreak response



Ebola outbreak response

WHO Ebola response team

Help improving situation awareness

Imperial College Ebola team

Timeline:

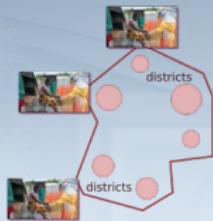
- December 2013: First case
- March 2014: WHO notified
- August 2014: First data/report
- September 2015: Latest data update

Ebola outbreak response



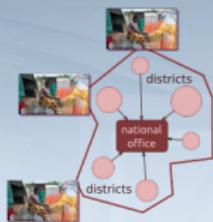
Most analysis tools for situation awareness missing.

No time to waste – challenges of a timely response



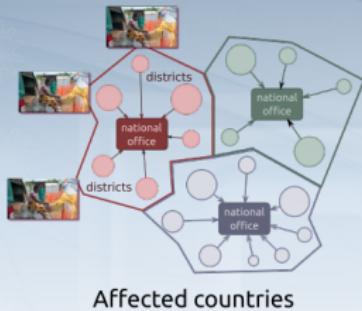
●
data collection

No time to waste – challenges of a timely response



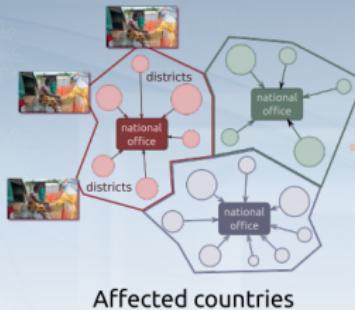
data collection

No time to waste – challenges of a timely response



●
data collection

No time to waste – challenges of a timely response



Public Health agencies

- time (block = day)

data collection

No time to waste – challenges of a timely response



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data collection

No time to waste – challenges of a timely response



data collection

No time to waste – challenges of a timely response



No time to waste – challenges of a timely response



Appropriate tools can shorten some of these delays.

Hackout 3: a hackathon for emergency outbreak response

Last week at the *rOpenSci* headquarters:



CDC CENTERS FOR DISEASE CONTROL AND PREVENTION

World Health Organization

MÉDECINS SANS FRONTIÈRES DOCTORS WITHOUT BORDERS

Public Health England

Public Health Agency of Canada

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

JOHNS HOPKINS BLOOMBERG SCHOOL of PUBLIC HEALTH

berkeley Institute for Data Science

wellcome trust sanger institute

Hackout 3: outcomes



epicontacts

exploration and analysis of contact data

X	ID	age	age class	sex	place	infect	reporting city	loc	loop	dt.	infect	dt.	report	week	report	dt.	xstart	exp	dt.
2	2_SK_1	43	40-69	F	Outside	Health Clinic	Pyeongtaek	35.10	18	2020-08-20	2020-08-20	2020-08-21	2020-08-21	2020-08-20	2020-08-20	2020-08-20	2020-08-20	2020-08-20	
3	2_SK_2	43	40-69	F	Outside	Health Clinic	Pyeongtaek	35.10	18	2020-08-20	2020-08-20	2020-08-21	2020-08-21	2020-08-20	2020-08-20	2020-08-20	2020-08-20	2020-08-20	
4	54_SK_34	43	40-69	F	Outside	Health Clinic	South Korea	35.10	18	2020-08-20	2020-08-20	2020-08-21	2020-08-21	2020-08-20	2020-08-20	2020-08-20	2020-08-20	2020-08-20	
5	75_SK_75	43	40-69	F	Outside	Health Clinic	South Korea	35.10	18	2020-08-20	2020-08-20	2020-08-21	2020-08-21	2020-08-20	2020-08-20	2020-08-20	2020-08-20	2020-08-20	

cleanr

aid for data cleaning based on
recursively growing dictionary

epimatch

case matching based on multiple fields

outbreaks

outbreak data repository

fancyestimstuff ??

key outbreak parameter estimation

Buidling a community for outbreak response



Buidling a R community for outbreak response



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Buidling a R community for outbreak response



What do we need?



- data versioning
- on-the-fly encryption: data, literate programming
- advanced unit testing: graphics, shiny apps
- web interfaces: dialogue between JS plugins and R/shiny
- autonomous (non-CRAN) package network (drat?)
- easy system deployment (docker?)
- ...

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We are recruiting!!

Thanks to

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1/2/3 teams, Neil Ferguson
- **students:** Finlay Campbell, Camilla Strang, Joel Hellewell
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- **Thanks for your attention!**