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Understanding and forecasting SARS-CoV2 spread and transmission

Pierre Nouvellet,
Sangeeta Bhatia, Anne Cori, Neil Ferguson, Christl Donnelly
and Imperial COVID-19 Team

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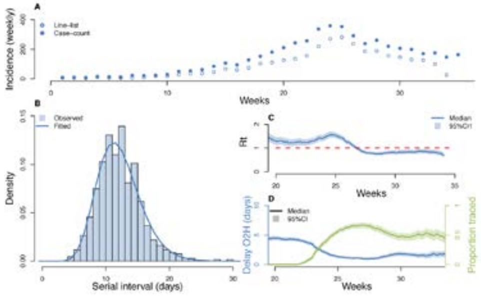
About myself

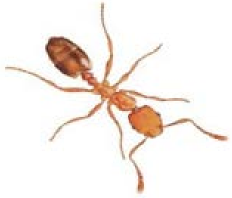
- PhD in quantitative biology (Sussex/Oxford): ant's behaviour, badger population dynamics

- Epidemiology of infectious diseases (Imperial/Sussex):
  - Statistical epidemiology
  - Dynamics of transmission

$$F \approx \frac{\sum_{i=\alpha}^{\omega} e_i F_i}{\sum_{i=\alpha}^{\omega} e_i}, \quad P_j \approx \frac{\sum_{i=1}^{\alpha} e_i P_i}{\sum_{i=1}^{\alpha} e_i}, \quad P_a \approx \frac{\sum_{i=\alpha+1}^{\omega-1} e_i P_i}{\sum_{i=\alpha+1}^{\omega-1} e_i}.$$

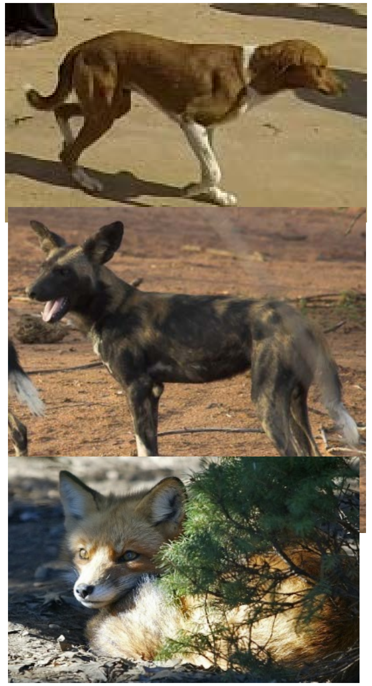


Ecology

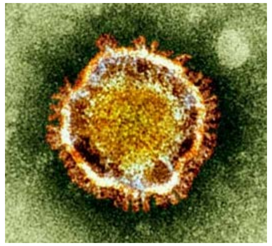


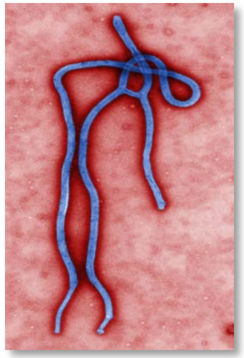
Vector-borne disease and NTDs

Wildlife epidemiology (e.g. rabies)



Emerging diseases and rapid response





Overview

- Short-term forecasts of SARS-CoV-2
  - Global forecast of deaths
- Mobility and transmission
  - Correlations between Rt and digital mobility measures
- Variant of concern
  - Estimating transmission advantage of new variant(s) of concern

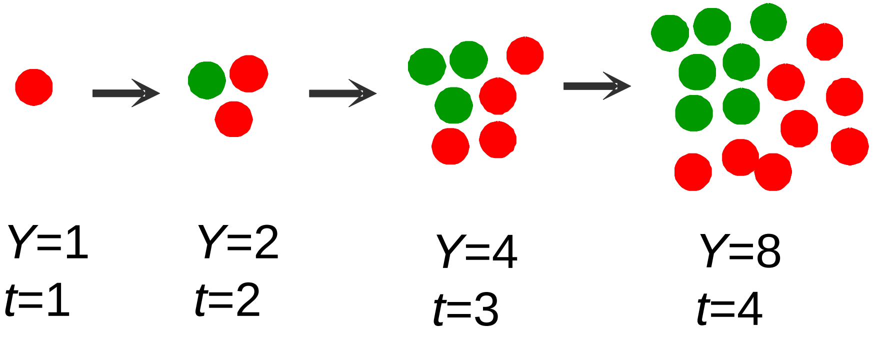
Overview

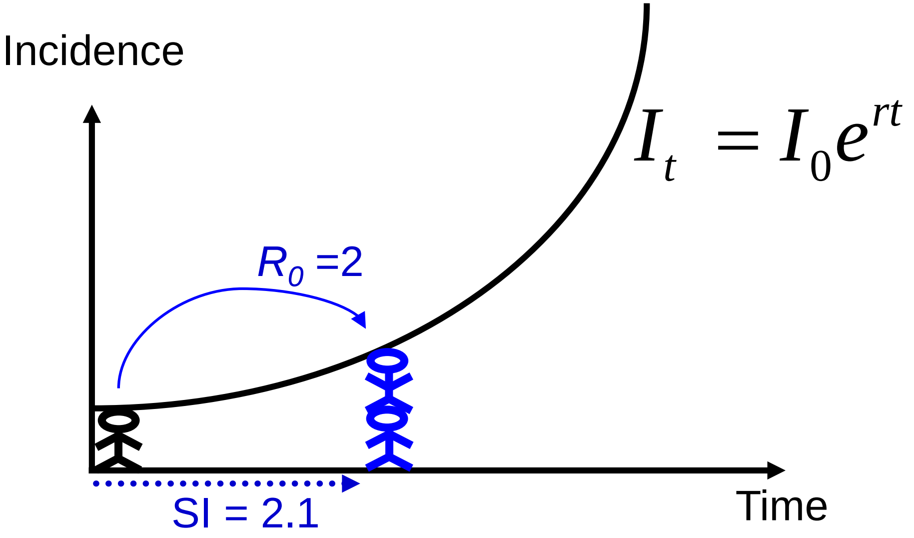
Quantitative Epidemiology: intersection between maths, statistics and ID epidemiology

Characterising the potential transmissibility of a pathogen:

- Basic reproduction number R0 : average number of secondary cases generated by an index case in a large entirely susceptible population.

Contagion



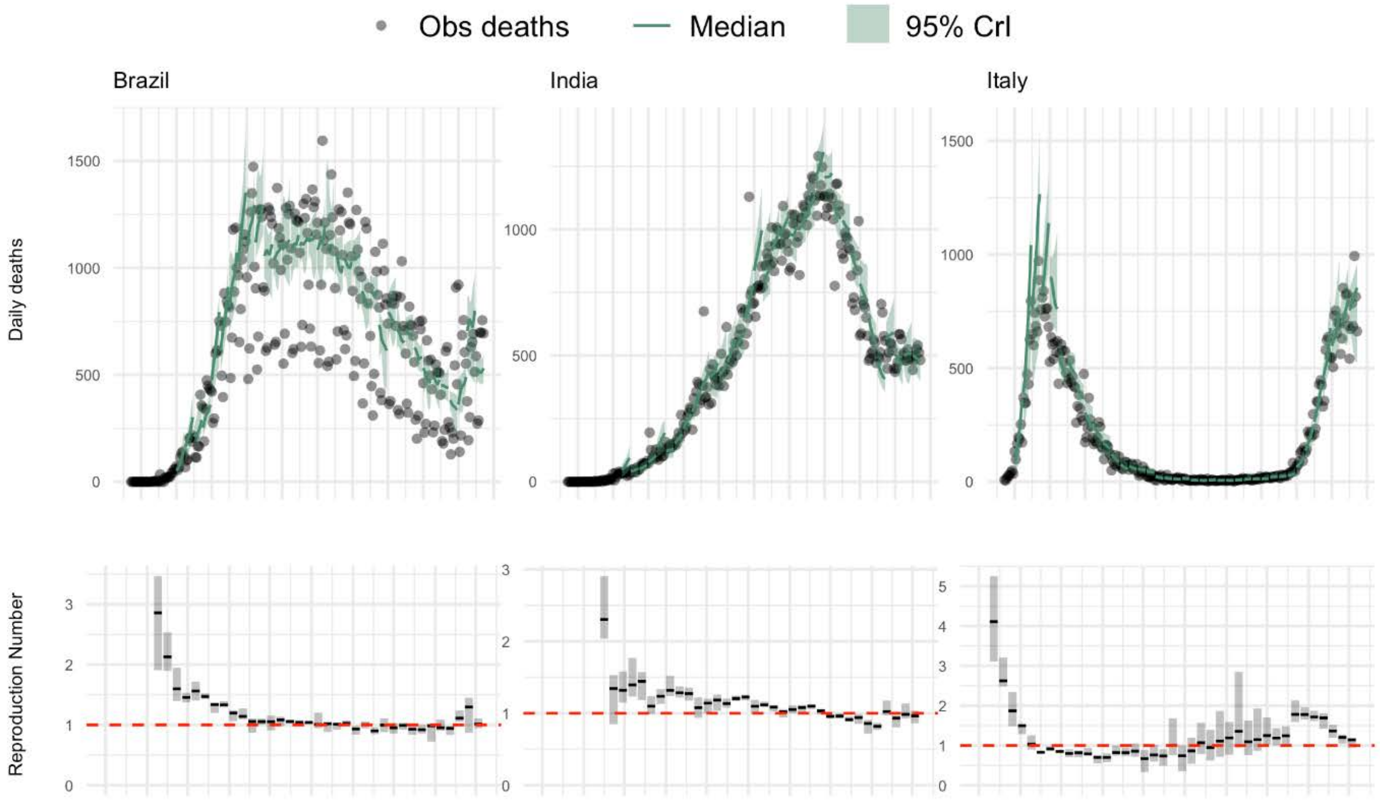


Formally, renewal equation (branching process):

$$I_t = \mathcal{P}\left(R_t \sum_{s=0}^{t} [I_{t-s}\, w_s] \right)$$

Short-term forecast of SARS-CoV-2

- Weekly report on trends across various countries with sustained transmission;
  - Up to 80 countries included,
  - Releasing since 8th March 2020, contribute to other forecasting effort (Reich Lab, European COVID-19 Forecasting Hub, etc.)



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Short-term forecast of SARS-CoV-2

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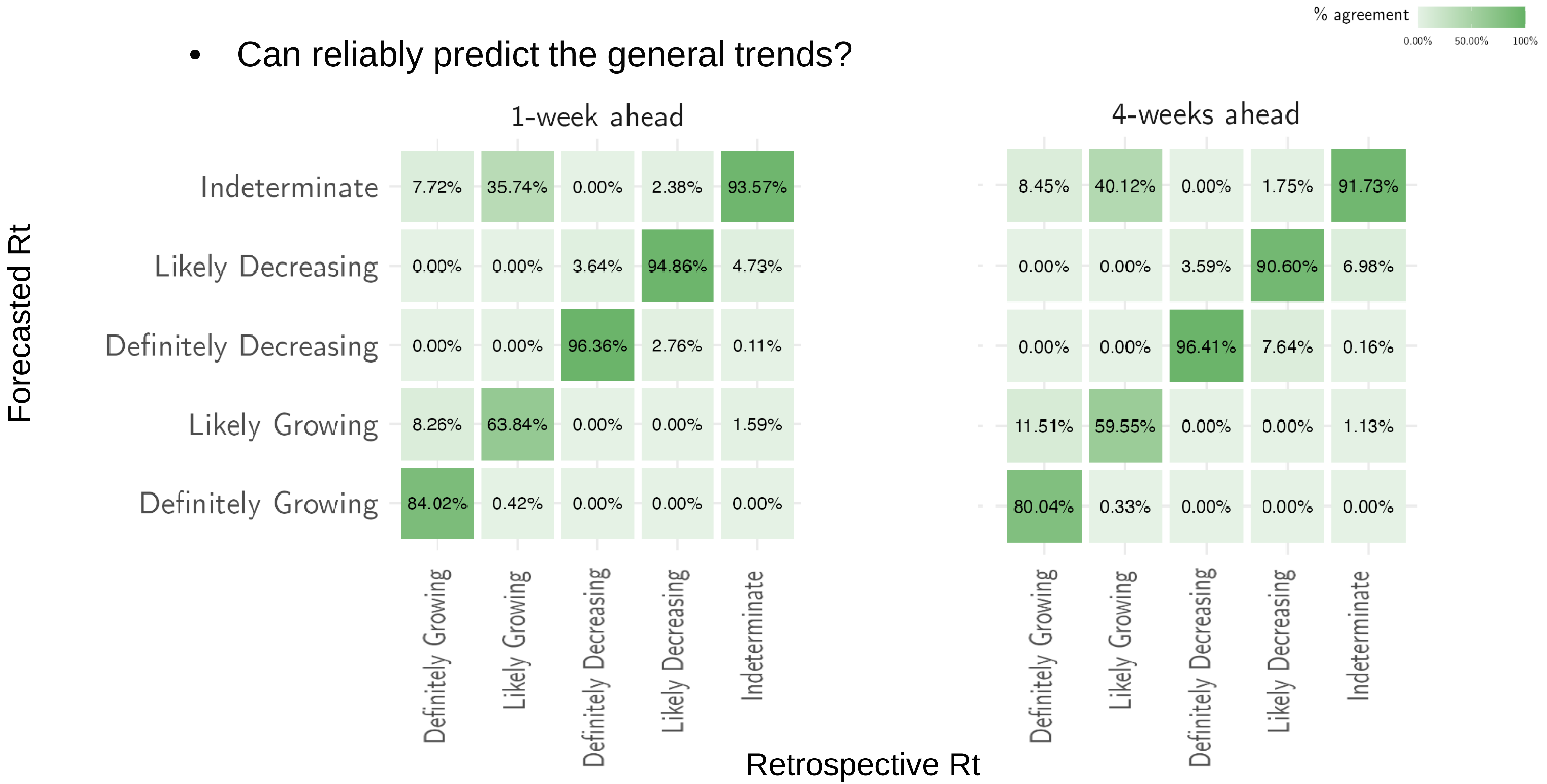
- Can reliably predict the general trends?

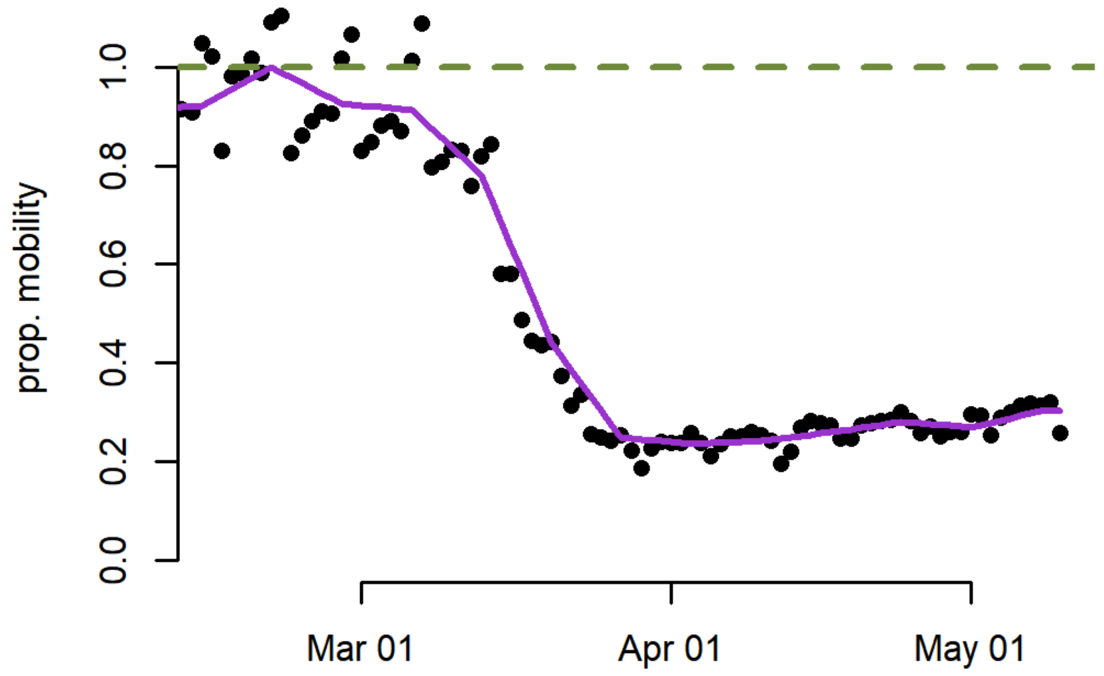


Short-term forecast of SARS-CoV-2

General conclusions

- Simple approach to predictions: allows global analysis
- Applicable to other infectious diseases
- Relatively accurate predictions

Mobility analysis



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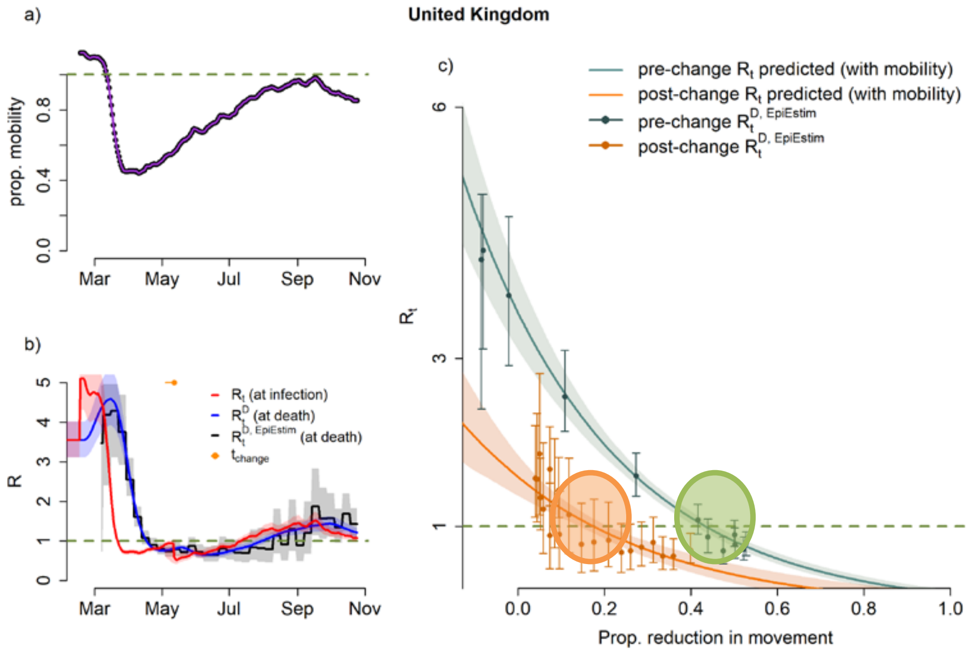
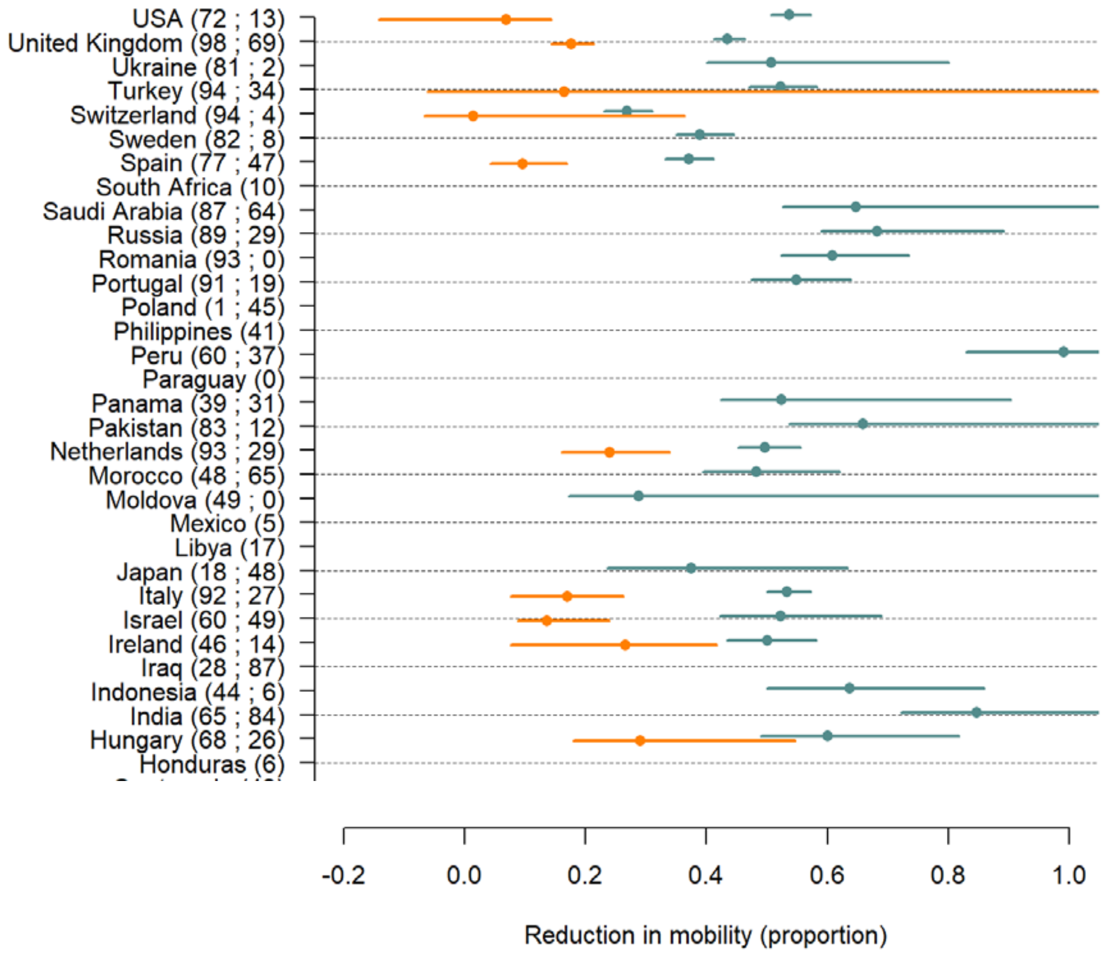
Mobility analysis

- Mobility analysis
  - ➢ Correlations Rt and digital mobility measures

Mobility threshold(s)





Mobility analysis

General conclusions

- Strong correlation between transmission and mobility
  - Initially, mobility explained ~75% of variation in Rt
  - Then, observed decoupling/dampening of the correlation
  - ~ the second wave, mobility explained ~30% of variation in Rt
- Allows some predictions of level of mobility restrictions required to achieve control
- Decoupling – dampening of the relationship may reflect:
  - Implementation of alternative control
  - Compliance with social distancing behaviour while increasing mobility

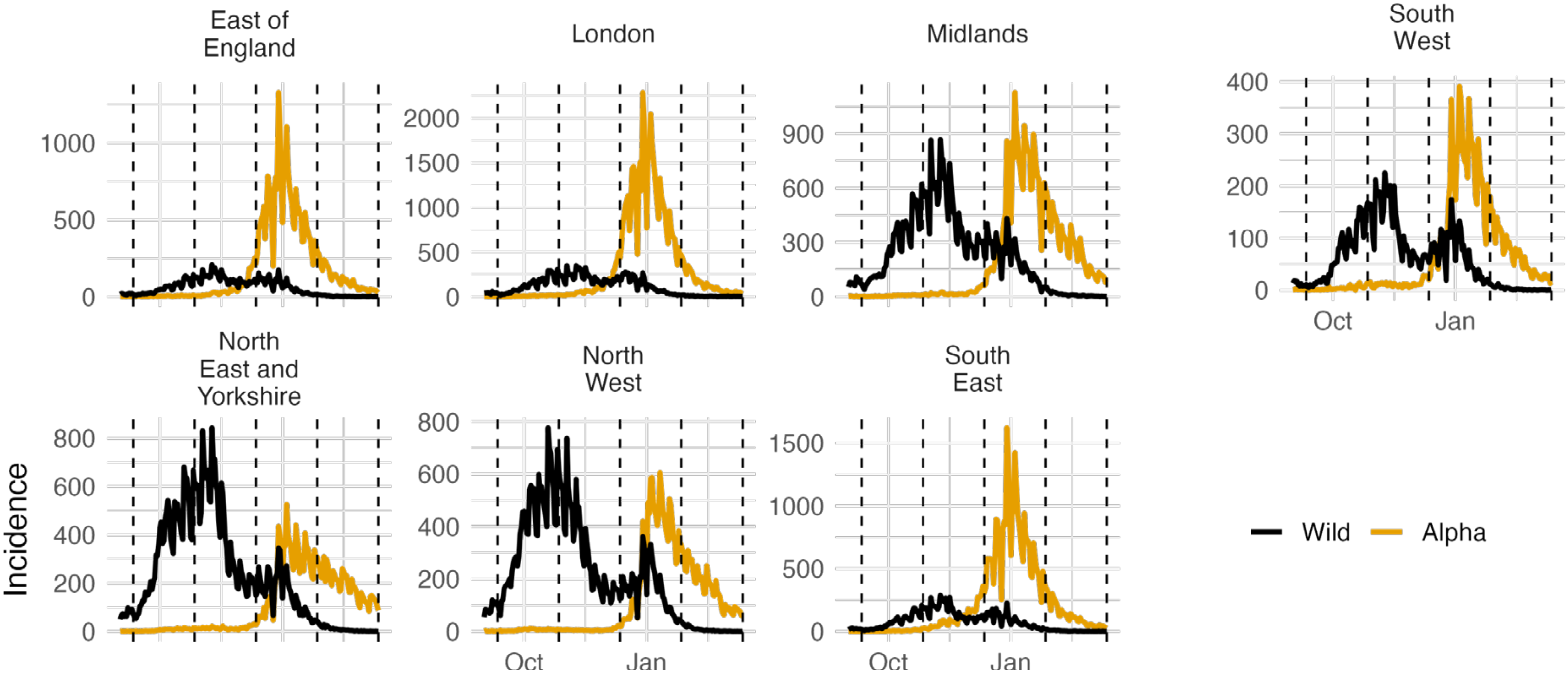
  - Difficulties in using for forecasting purposes as relationship is dynamic

Transmission advantage of variant(s)

- New variants of concern:
  - Alpha, beta, gamma and delta; all appear to have increased transmissibility
- Tool for real-time estimation of transmissibility
  - New extended exisiting framework to estimate Rt in multiple locations as well as transmission advantage of variant(s)

Transmission advantage of variant(s)

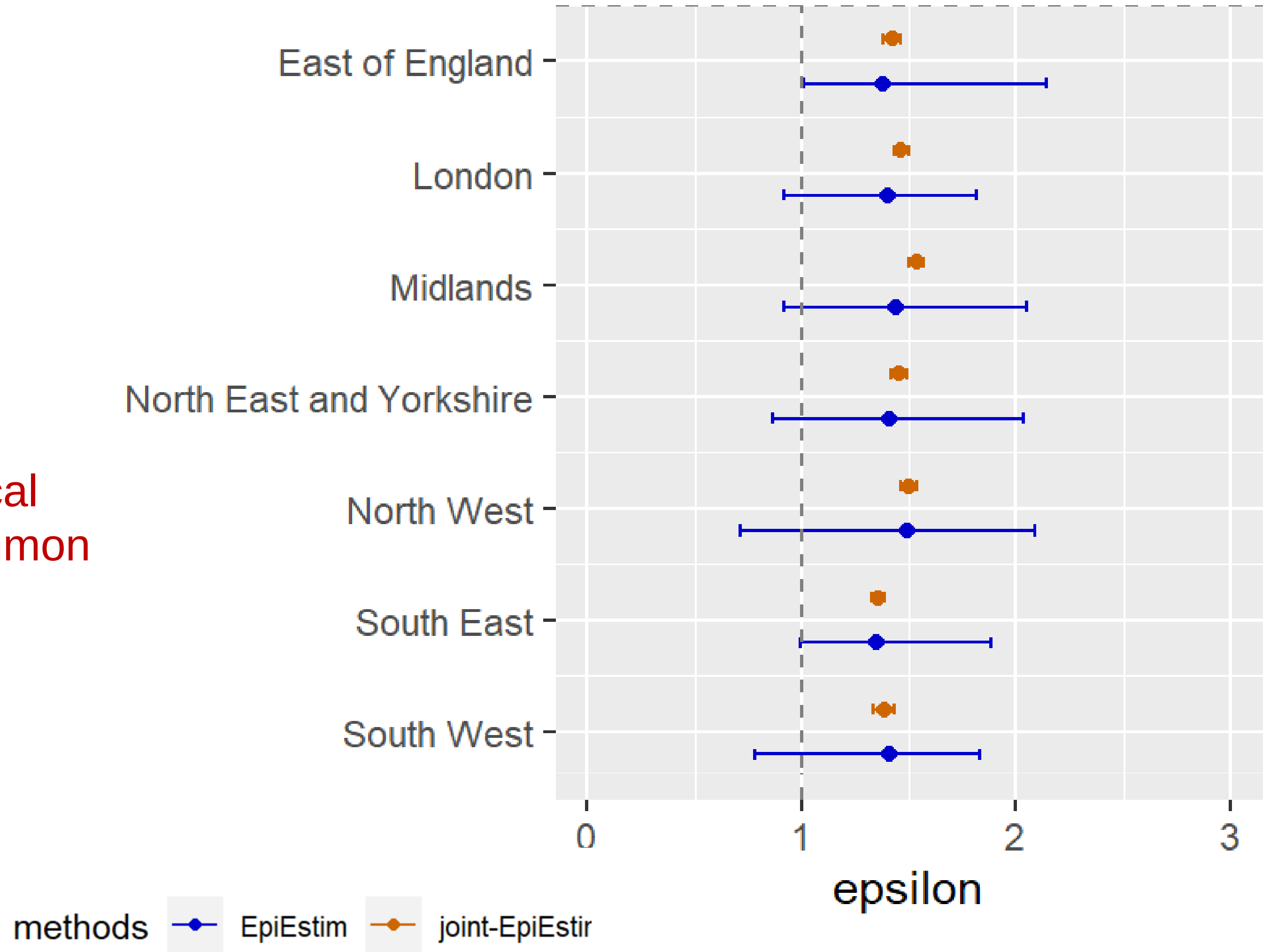
- Example of England; wild type and invasion of alpha variant



Transmission advantage of variant(s)

- Example of England; wild type and invasion of alpha variant

- MV-Epiestim
  - ➢ Bring real-time estimation within a single framework
  - ➢ Pool information by assuming common a local trend in transmissibility within locations, common transmission advantage across locations



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Transmission advantage of variant(s)

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- Example of England wild type and invasion of alpha variant

- Tool for real-time estimation of transmissibility

    - Takes advantage of pooling information
    - Applicable to multiple variants co-circulating (wild + >1 variants)
    - Applicable in real-time
    - Applicable to other infections with recurrent variants' emergence

- E.g. was applied to estimate delta variant transmission in England, as well as wild, alpha and beta/gamma variants in France.

Thanks