How can governments plan for the next pandemic? Real-time analysis case studies

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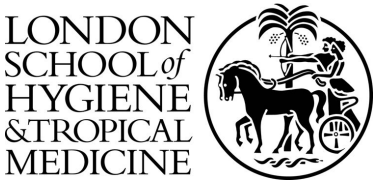
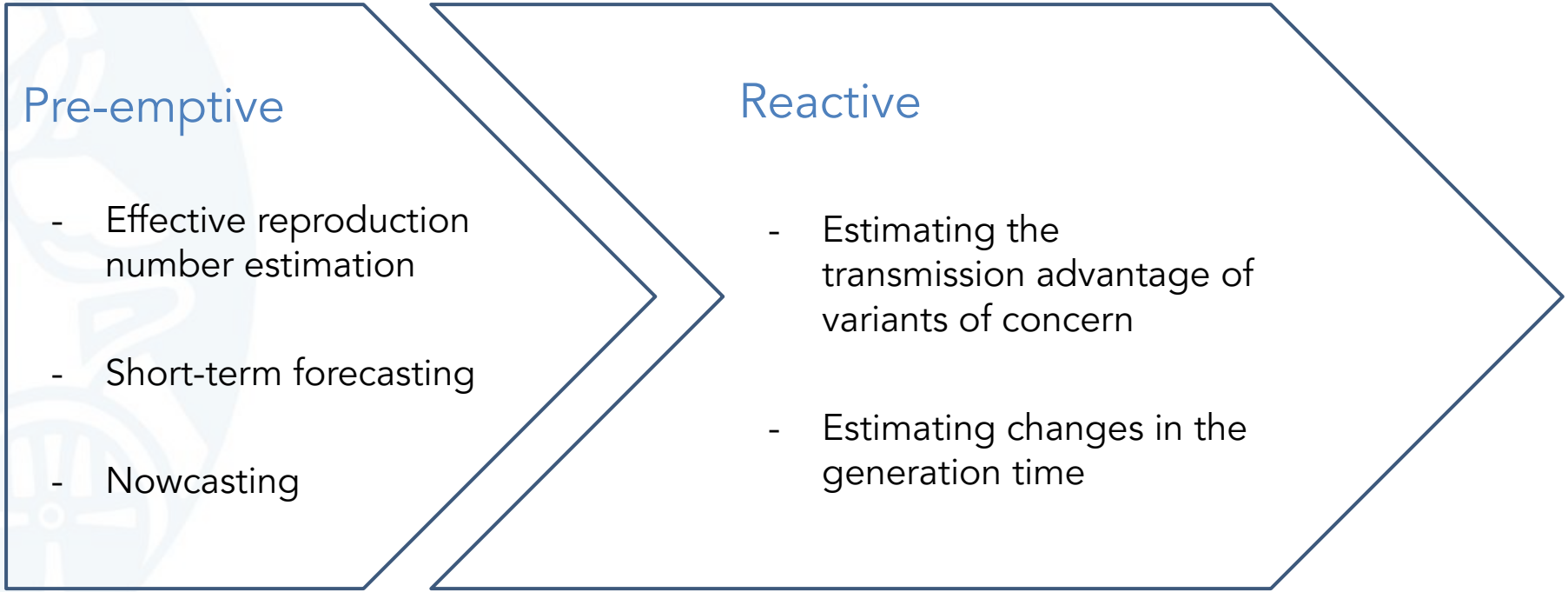


An 80% right paper before a policy decision is made is worth ten 95% right papers afterwards, provided the methodological limitations imposed by doing it fast are made clear.

Whitty et al. BMC Medicine, 2015, DOI: 10.1186/s12916-015-0544-8

Case studies



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Pre-emptive

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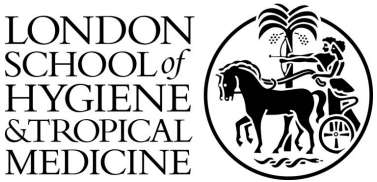
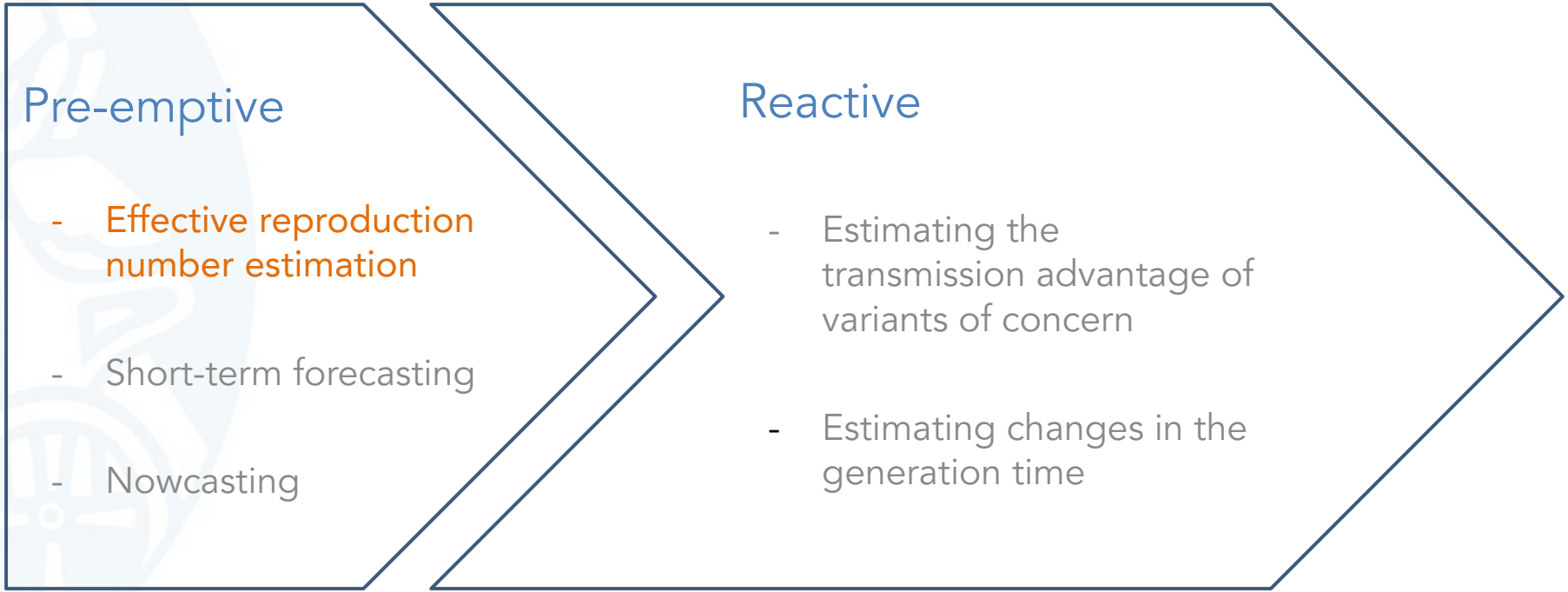


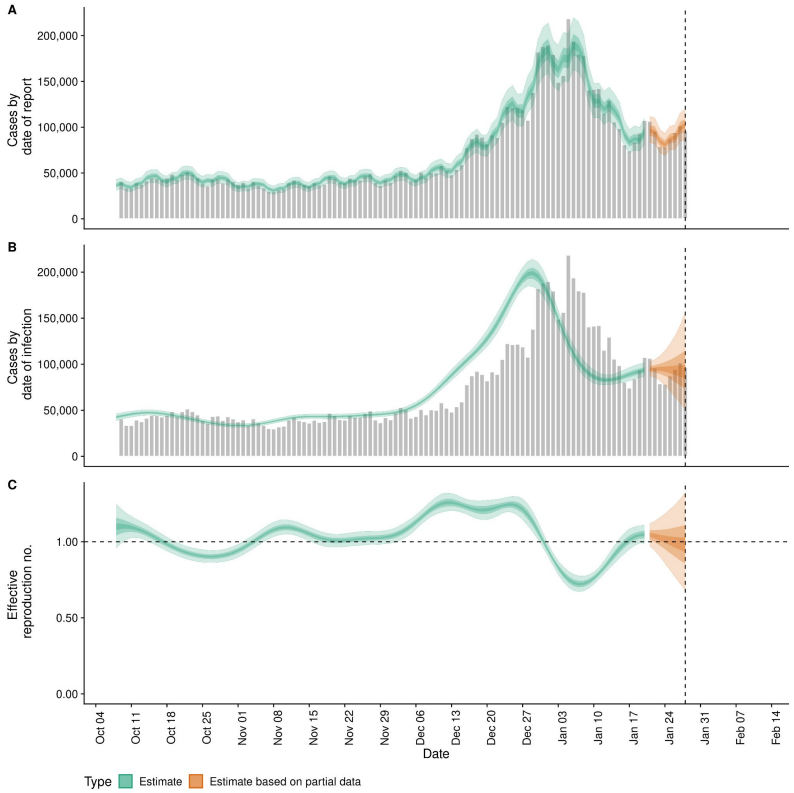
Case studies



Effective reproduction number estimation

The average number of secondary infections produced by a single infected person.

- A helpful metric to track transmission.
- Difficult to estimate as depends on unobserved infections and on the interval between primary and secondary infections.
- Estimating using various methodologies since February 2020.
- Estimates submitted as part of the SPI-M consensus estimate each week.
- Estimates also published each day for over 1000 locations since April 2020 on epiforecasts.io/covid.



Abbott et al. Wellcome Open Res, 2020, DOI: 10.12688/wellcomeopenres.16006.2

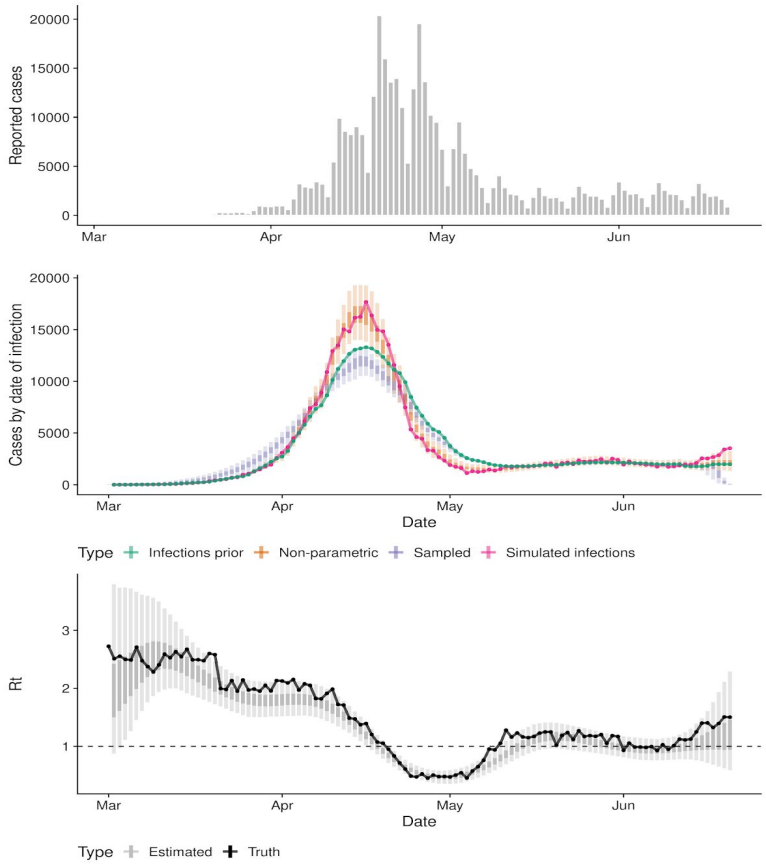
Effective reproduction number estimation

Key Challenges

- We care about linking policy changes with changes in transmission but only observe delayed proxies like reported cases and deaths.
- Surveillance data subject to a range of difficult to account for biases.
- Estimation at scale in real-time is computationally challenging.

Mitigations

- Generative model of latent infections.
- Worked with the Met Office to develop production ready code using computational resources donated by Microsoft Azure.
- Estimate independently on a range of data sources.



Sherratt et al. Phil Trans B, 2021, DOI: 10.1098/rstb.2020.0283

Effective reproduction number estimation

Abbott et al. Zenodo, 2020, DOI: 10.5281/zenodo.3957489

Lessons learnt

- Pre-emptive work can be a useful way to gain situational awareness.
- Real-time analysis often builds on analyses, tools, and data pipelines previously developed.
- Outputs are easiest to use when they are robust, modular, evaluated, and available.
- Combining estimates from a range of sources and methodologies are likely to improve decision making versus using a single analysis.
- Work that is good enough tends to be work that is available.

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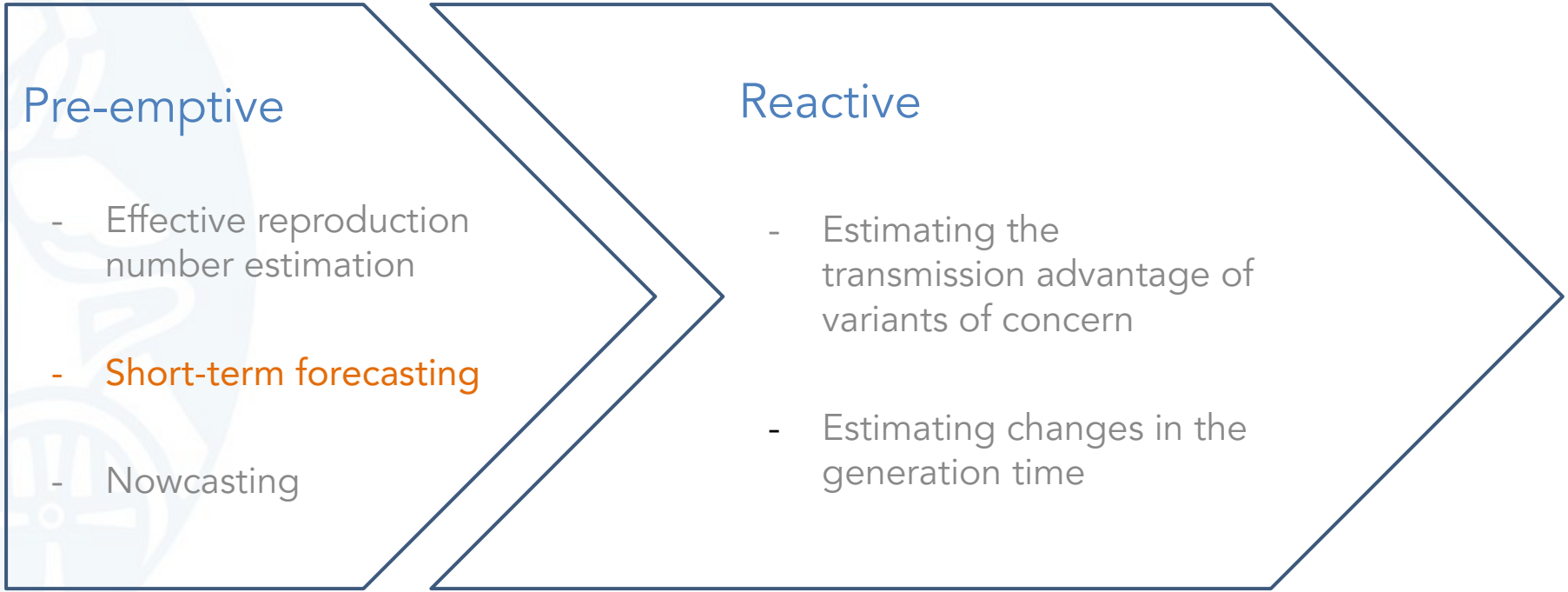
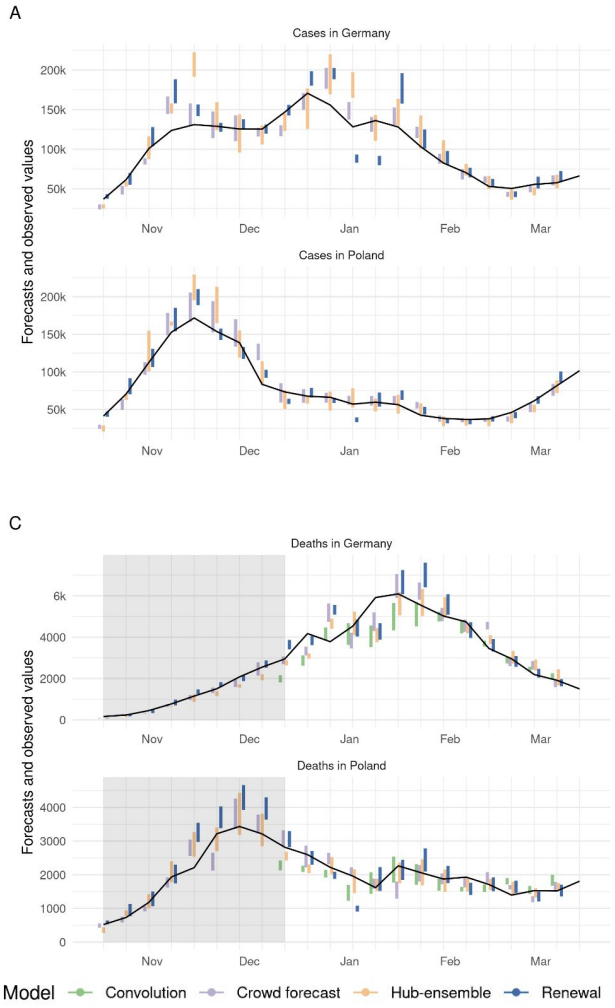


Short–term forecasts

What do we think will happen to reported metrics over the next 1-4 weeks

- Using the reproduction number model and similar discrete convolutions models.
- Submitting to the ECDC and CDC forecasting hubs weekly as well as to SPI-M 3 times a week until mid 2020.
- Performs well compared to other models but out performed by an all-model ensemble.
- Also outperformed by a human judgement model.
- All forecasts struggle to account for policy changes and behavioural changes.



Bosse et al. medRxiv, 2020, DOI: 10.1101/2021.12.01.21266598

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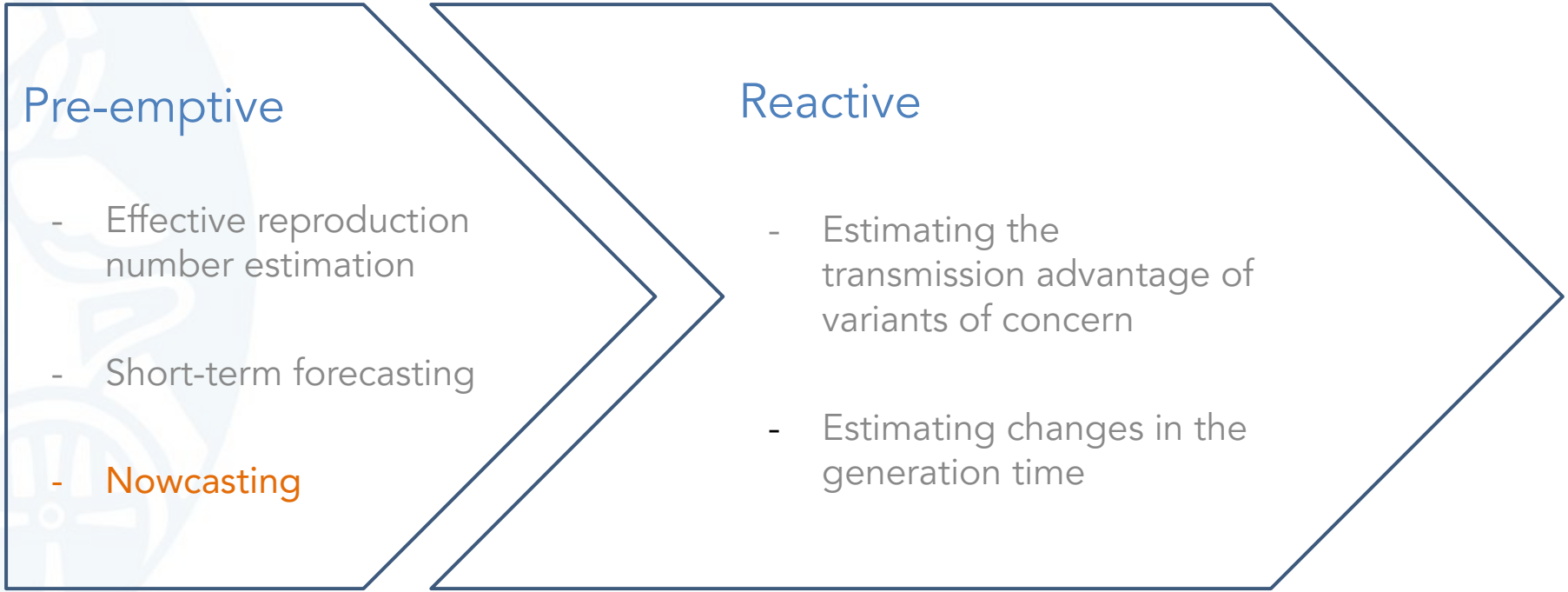
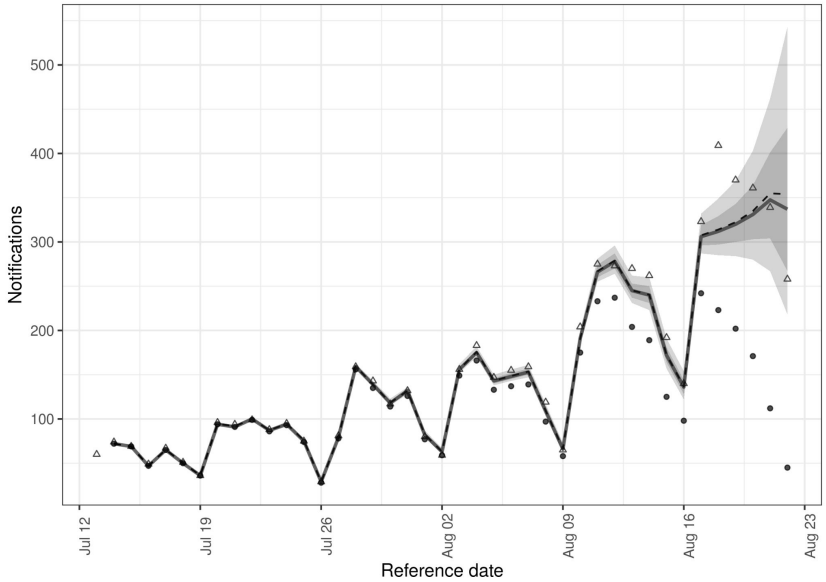


Nowcasts

What is happening now to metrics we partially observe

- International collaboration estimating 7-day hospital admissions by date of positive test in Germany (the key metric used by decision makers).
- Statistical approach is to decompose the model into forecast and reporting delay components.
- Multi-method ensemble outperforms any single model.
- Nowcasting is conceptually difficult to understand and so potentially under used.
- Open access tools, such as epinowcast, make access easier.



Bracher et al. covid19nowcasthub.de
Abbott et al. github.com/epiforecasts/eval-germany-sp-nowcasting
Abbott et al. github.com/epiforecasts/epinowcast

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Reactive

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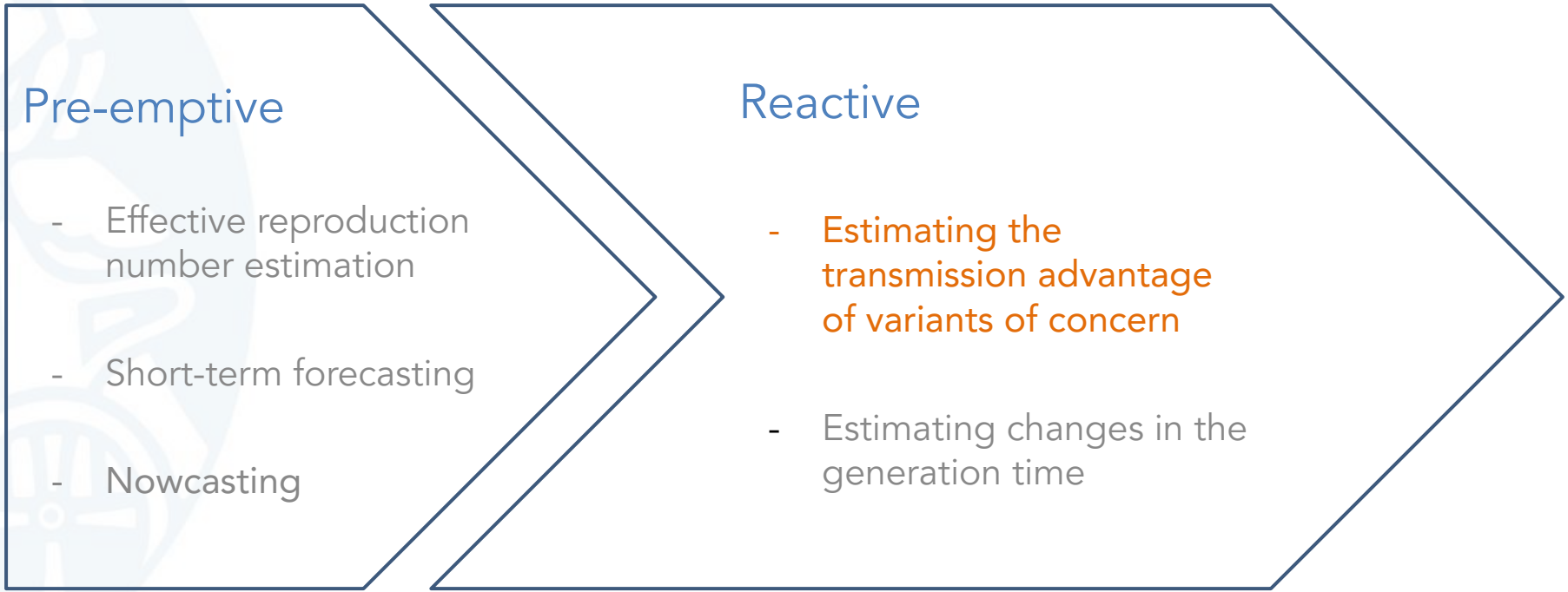
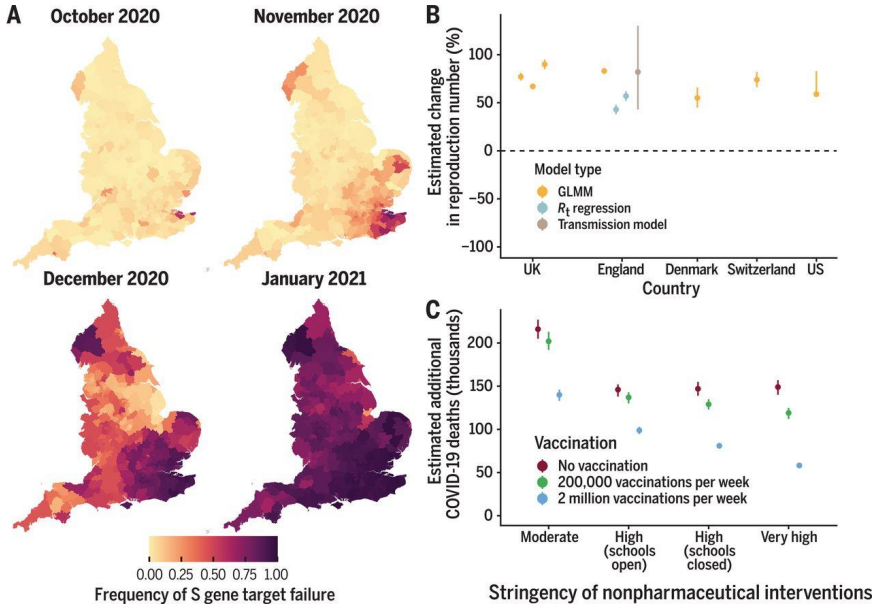
Case studies



Estimating the transmission advantage of Alpha

How much more transmissible is Alpha than wild-type?

- Part of a multi-method approach by Davies et al.
- Used reproduction number estimates by Lower-Tier local authority as "data" + S-gene target failure status (SGTF) as a proxy for variant status.
- Estimated the transmission advantage using an extended regression model adjusted for confounders
- Work done between December 20th 2020 and January 1st 2021.

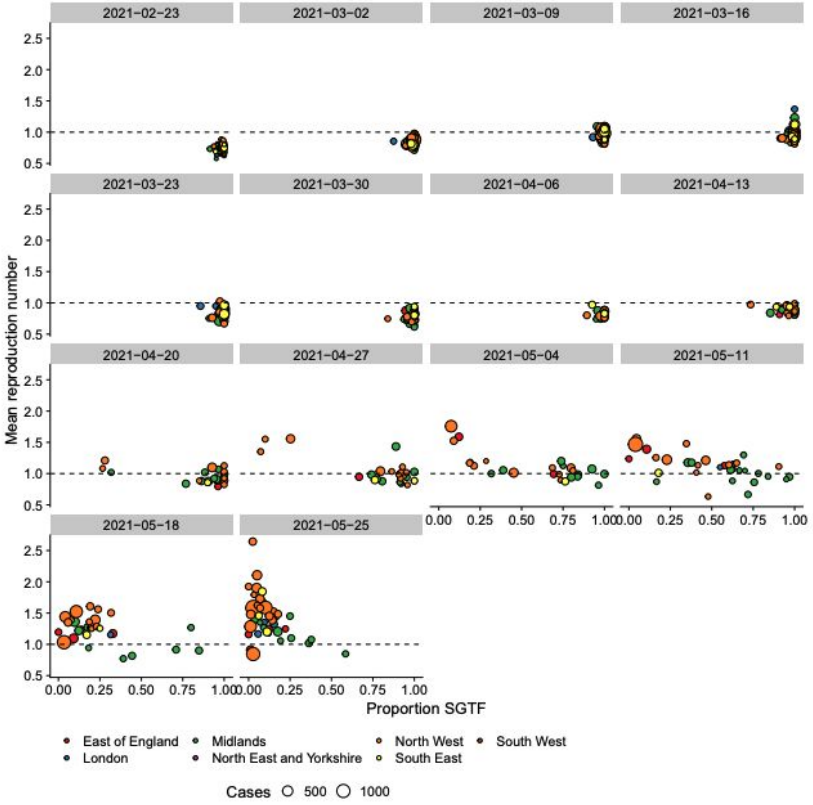


Davies et al. Science, 2021, DOI: 10.1126/science.abg3055

Estimating the transmission advantage of Delta

How much more transmissible is Delta than Alpha?

- Repurposed the approach used for Alpha using reproduction number estimates as data.
- Extended the methodology to include uncertainty for the reproduction number estimates and SGTF status.
- Estimates combined with others as apart of the SPI-M consensus statement.

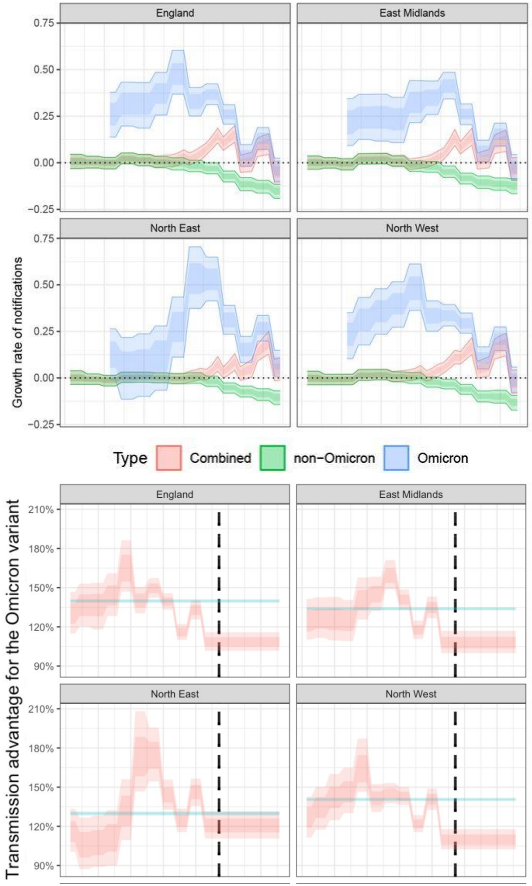


Abbott et al. medRxiv, 2021, DOI: 10.1101/2021.11.30.21267056v1

Estimating the transmission advantage of Omicron

How much more transmissible is Omicron than Delta and does it vary over time?

- Early evidence from South Africa suggested that Omicron may be more successful than Delta at escaping prior immunity.
- This would be identifiable as variation over time in the transmission advantage. Our previous analysis didn't support this.
- Repurposed methodology developed to evaluate the role of sequences for forecasting (forecast.vocs 📦).
- Identified a reduction in transmission advantage prior to Christmas (rather than the increase expected due to immune escape).
- A real-time report developed, submitted to SPI-M, and updated daily from the 18th of December 2021 to the 1st of January 2022.



Pearson et al. medRxiv, 2021, DOI: 10.1101/2021.12.19.21268038
Abbott et al. github.com/epiforecasts/omicron-sgtf-forecast/releases/tag/reportv1.3.0

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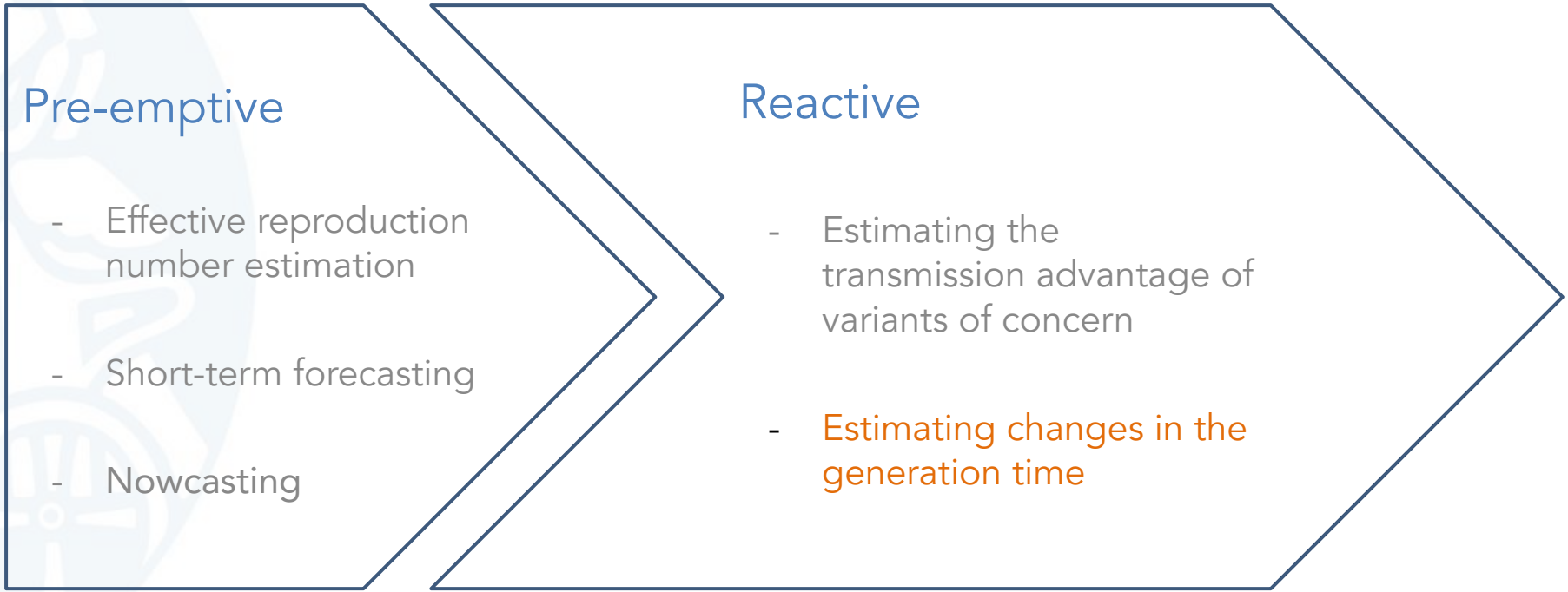
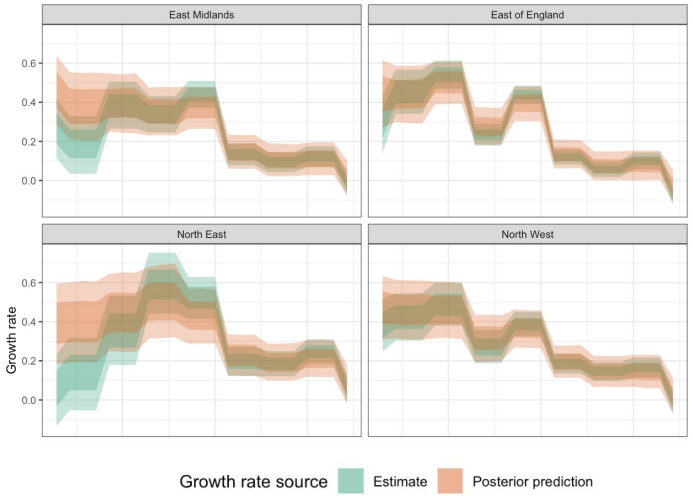


Estimating the generation time of Omicron

Is Omicron's generation time shorter than Delta's?

$$R = \left(1 + \bar{G}kr\right)^{\frac{1}{k}}$$

- Observed reduction in transmission advantage could indicate a shorter generation time.
- This is due to relationship between the daily growth rate and the reproduction number.
- Used growth rates for Omicron and Delta to explore this and found that a shorter generation time was plausible.
- Findings supported by a study from UKHSA using household contact data.
- Results available in early January and formed part of the SPI-M consensus statement.



Park et al. medRxiv, 2021, DOI: 10.1101/2021.05.03.21256545
Abbott et al. epiforecasts.io/omicron-sgtf-forecast/generation-time
Abbott et al. medRxiv, 2021, DOI: 10.1101/2022.01.08.22268920

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Summary

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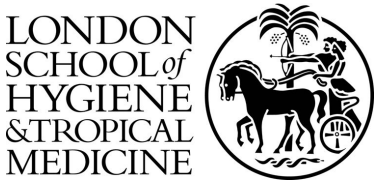

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Lessons learnt

- Higher standards can be achieved via teamwork, more pre-emptive work, and evaluation. These are currently all poorly incentivised.

- Real-time analysis is hard and those doing it need to be well trained in statistical methodology, software engineering, and public communication of limitations.

- This skillset is poorly rewarded by traditional academic incentives and difficult to acquire through currently available training.

Thanks to the epiforecast.io group for feedback on this talk and my collaborators for doing wonderful work. Please see individual slides for links containing more details of each case study.