Estimating the course of the COVID-19 pandemic in Germany via spline-based hierarchical modelling of death counts

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BIFI 2022

09.06.2022

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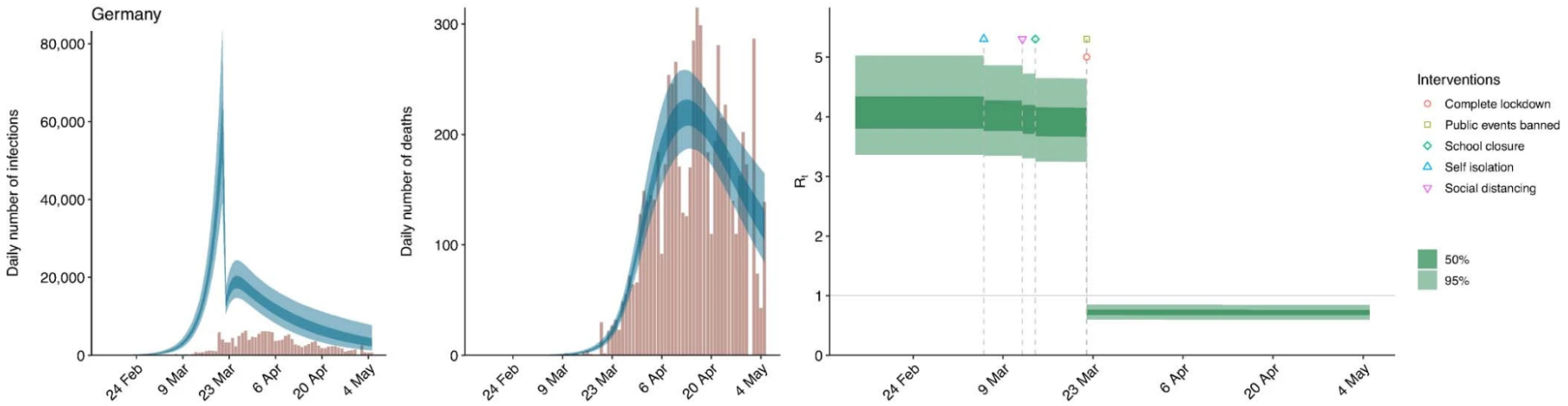

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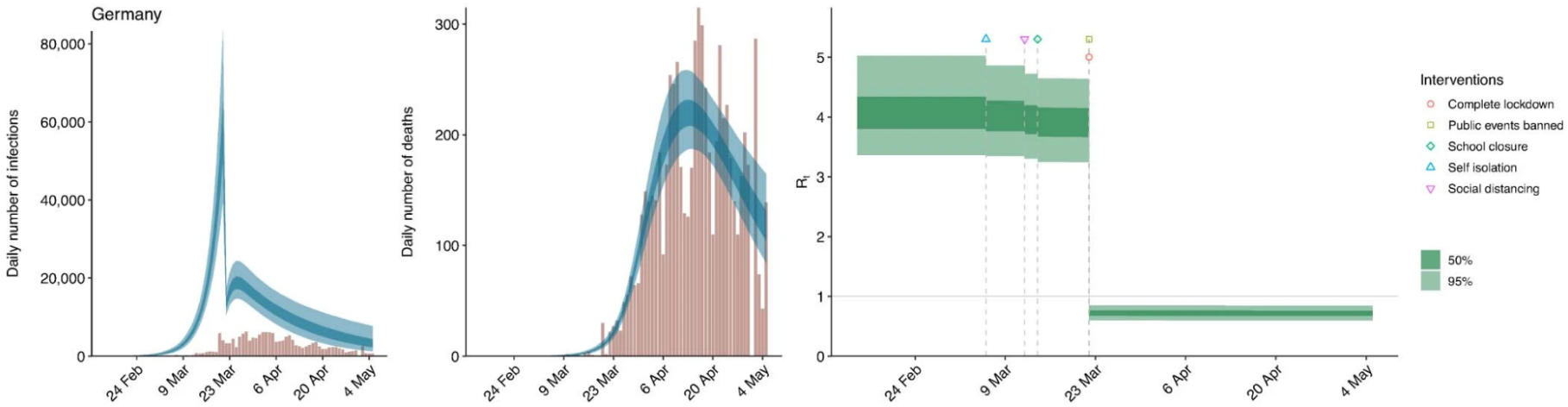

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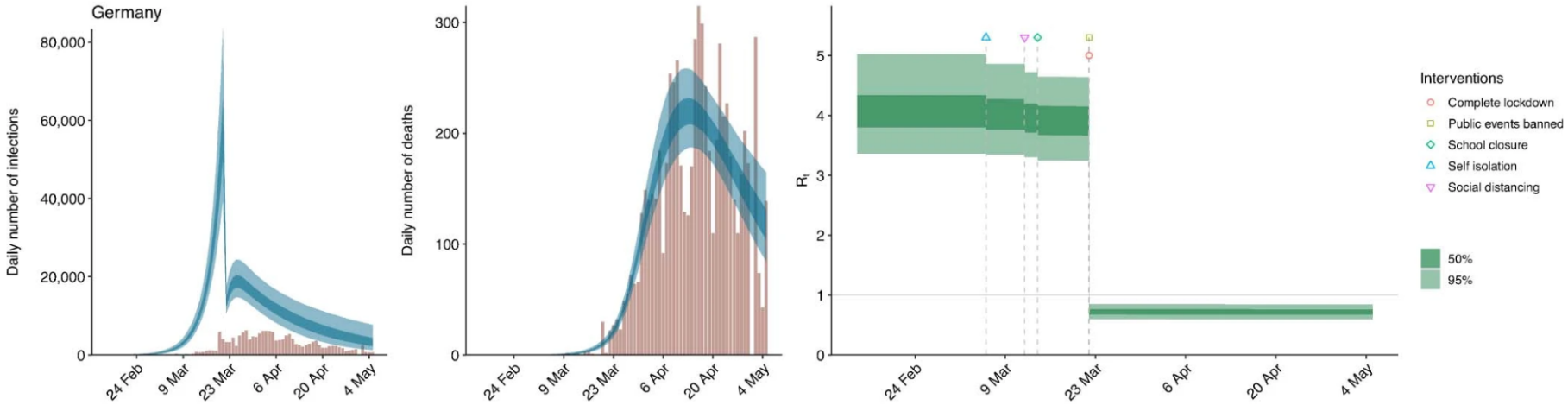
Aim

Application and adaptation of model of Flaxman et al. to estimate further course of pandemic in Germany

Modelling issues

Results of Flaxman et al. for first wave in Germany in 2020:



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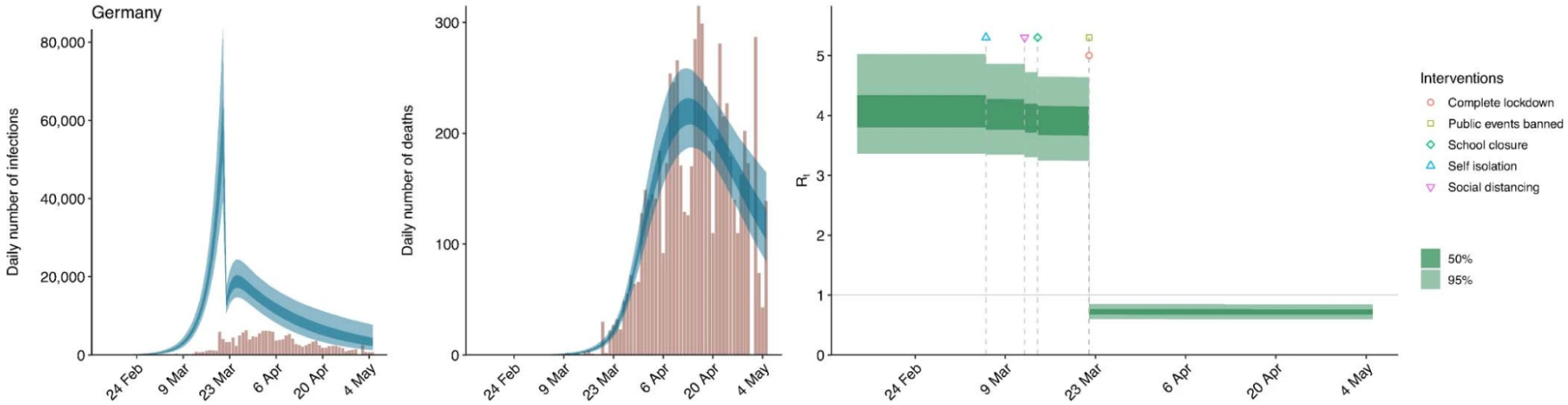

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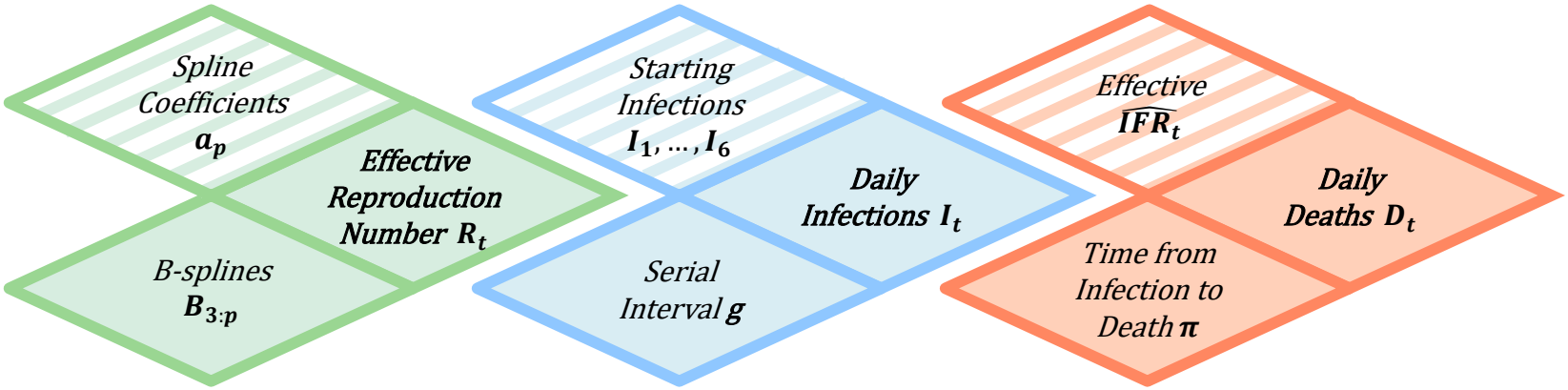
(2) Model did not fit well for the full first year of the pandemic (e.g. estimated infections $<$ confirmed cases)

Our adapted Bayesian hierarchical model



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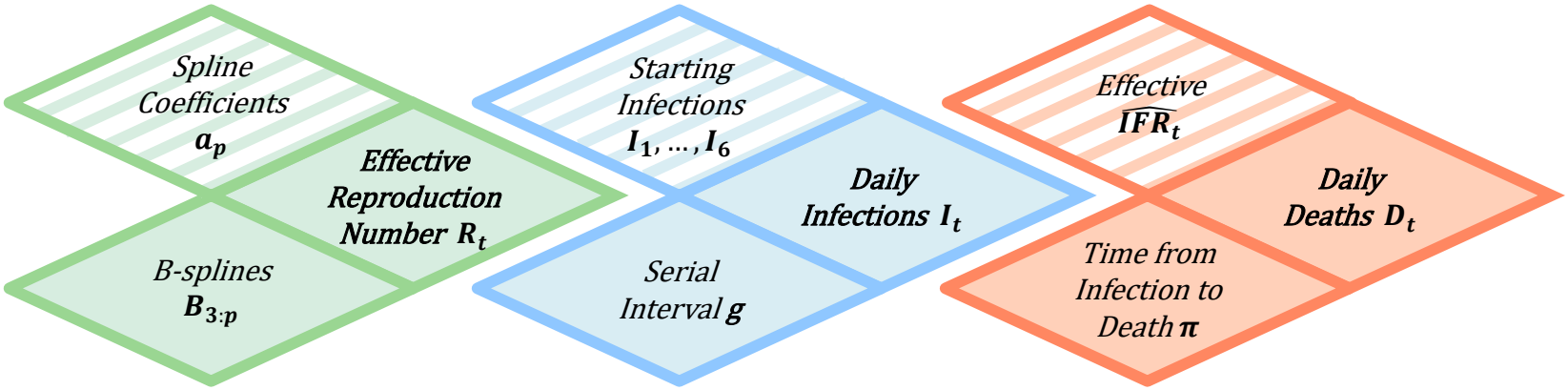

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$\rightarrow$ **Smooth data-driven estimation via splines**

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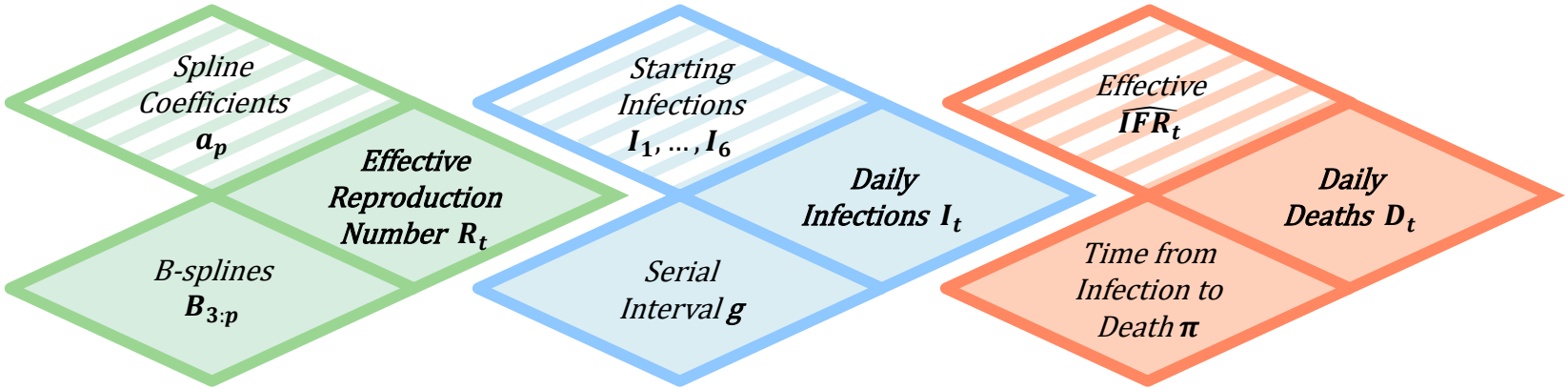

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Infection fatality rate (IFR)

Infection fatality rate/ratio (IFR): Deaths / Infections

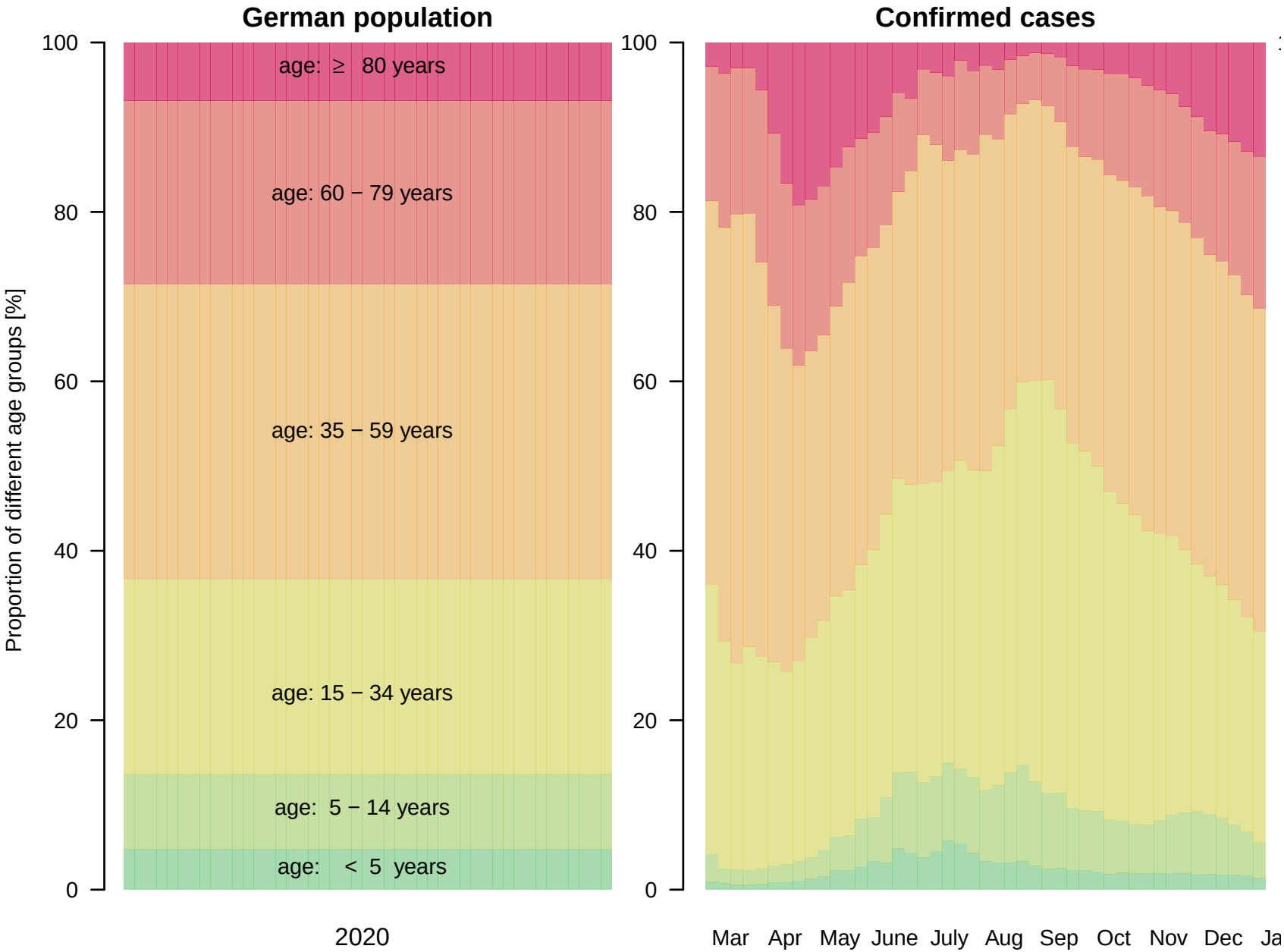
$\rightarrow$ Crucial link to infer infections from reported deaths

Age-specific IFR

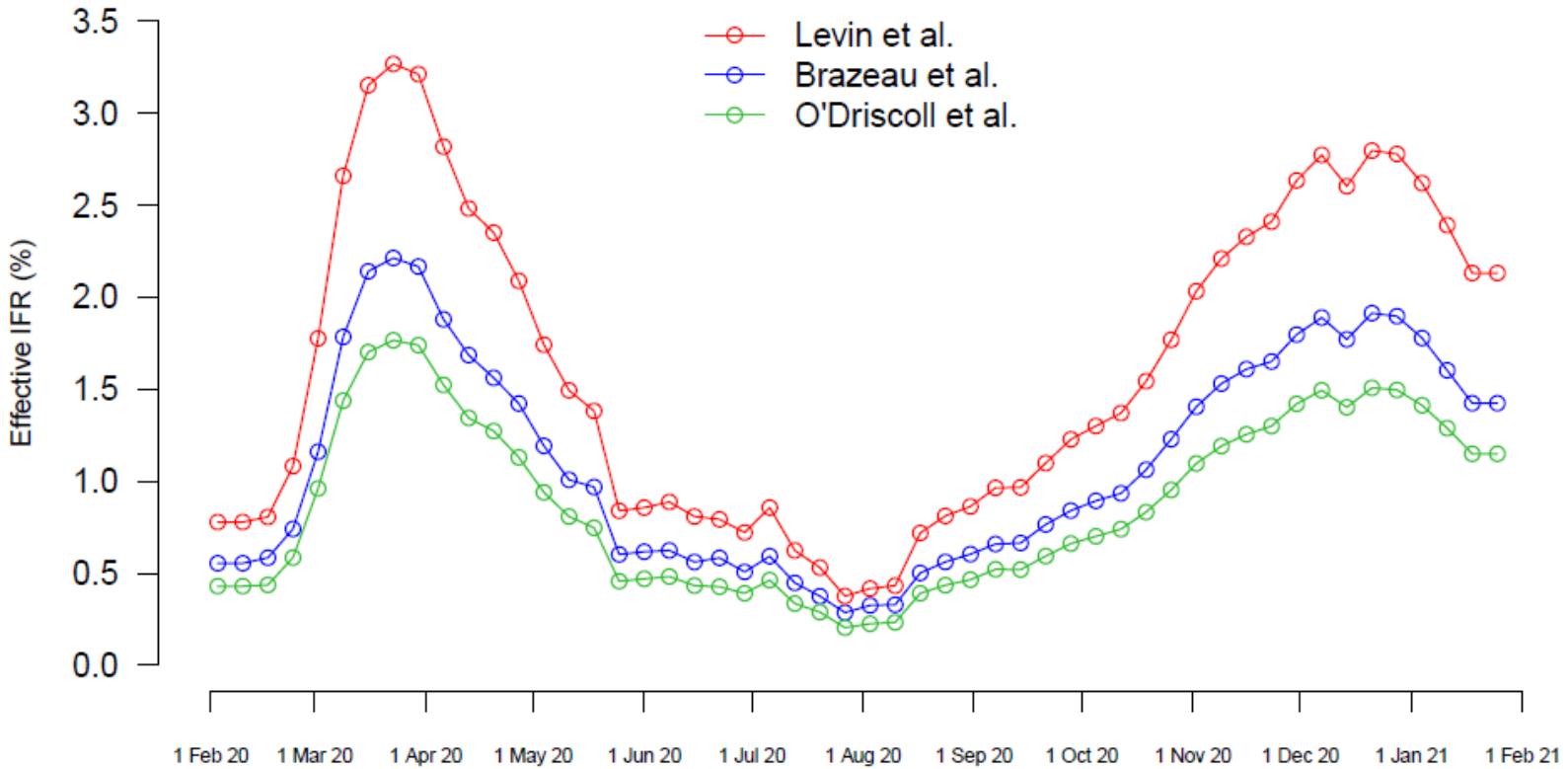
Age group	**O'Driscoll [5]**	**Verity [11]**
0-4	0.002 [0.001; 0.002]	0.002 [0.000; 0.025]
5-14	0.000 [0.000; 0.000]	0.004 [0.001; 0.037]
15-34	0.009 [0.007; 0.010]	0.041 [0.019; 0.110]
35-59	0.122 [0.115; 0.128]	0.349 [0.194; 0.743]
60-79	0.992 [0.942; 1.045]	2.913 [1.670; 5.793]
80+	7.274 [6.909; 7.656]	7.800 [3.800; 13.30]
$\overline{\text{IFR}}^{(i)}_{\text{DE}}$	0.756 [0.717; 0.796]	1.296 [0.694; 2.453]

IFR estimates are given in percentages (with 95% confidence intervals in brackets)

Age- and time-dependent risk of infection



Effective IFR for Germany



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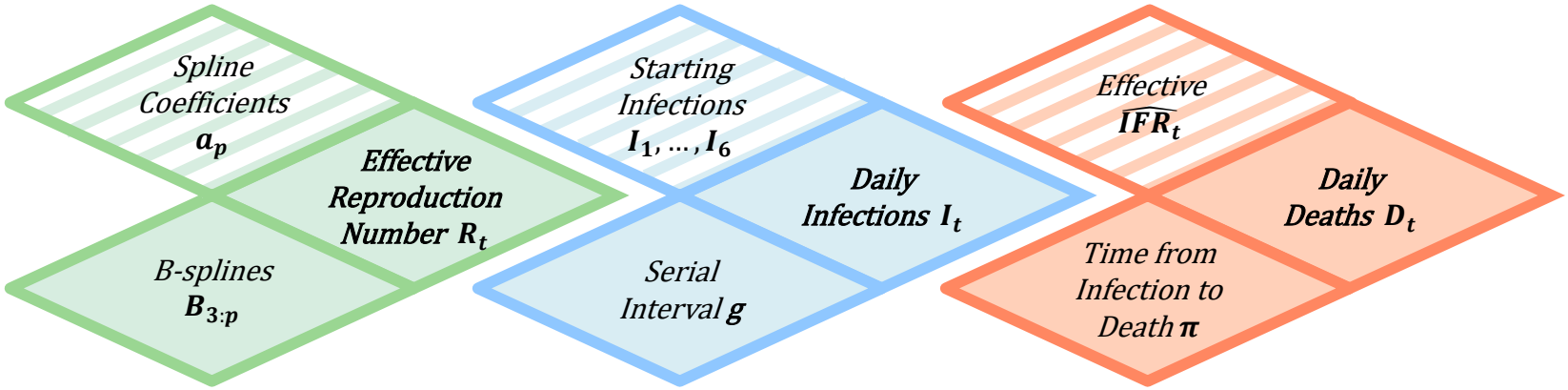

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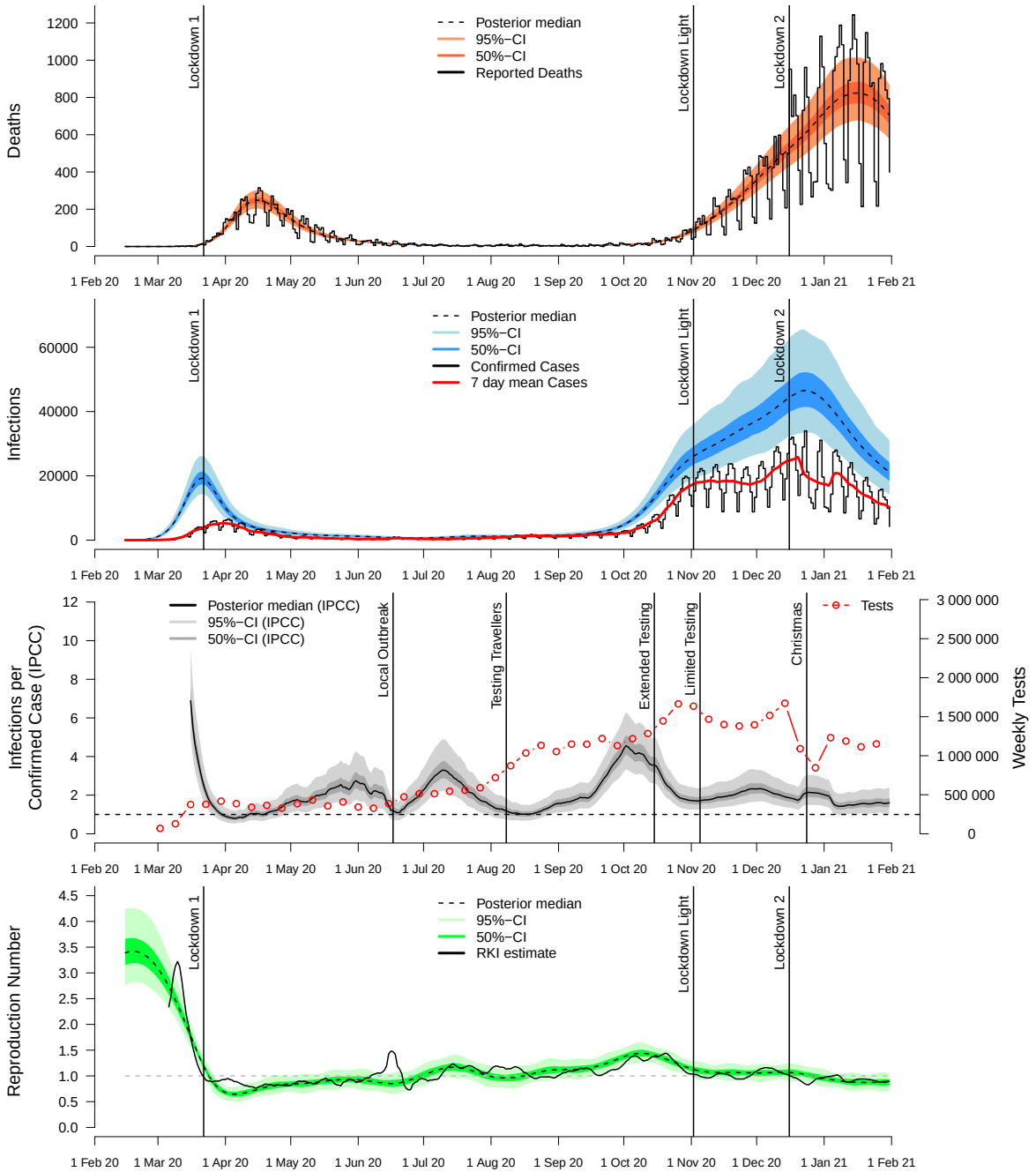
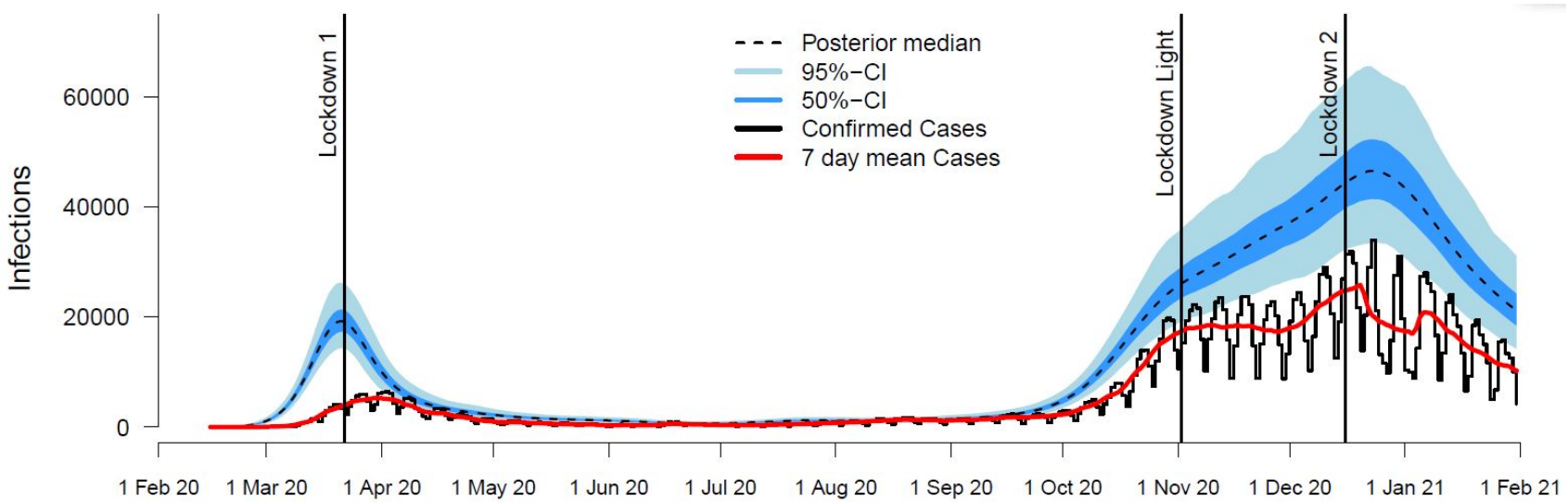
Results for Germany (first year)



Results for Germany: Estimated infections

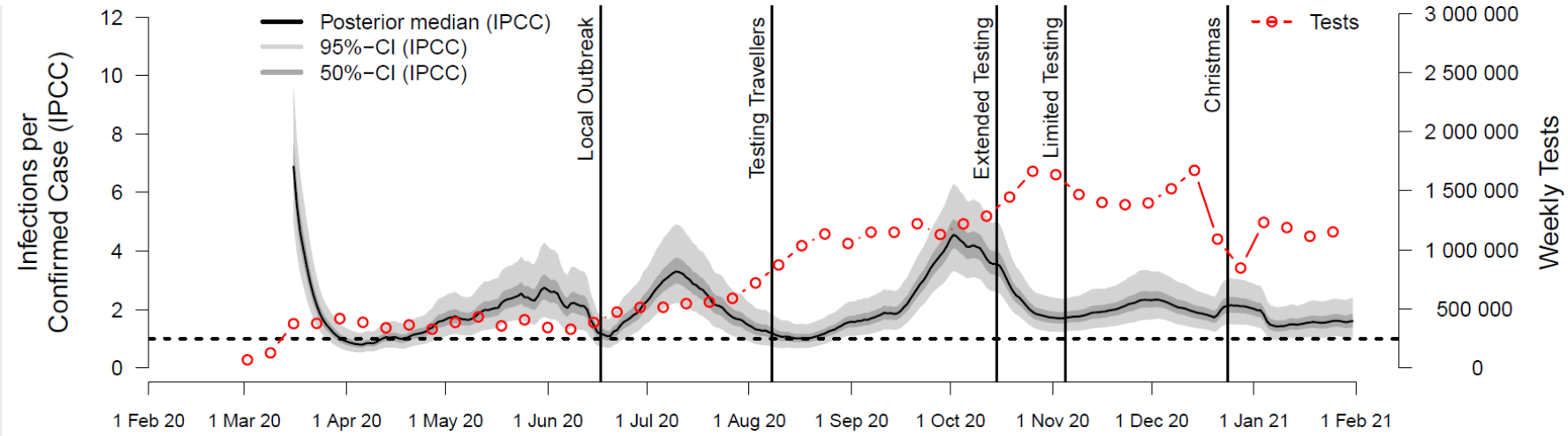


"Lockdown light": Restaurants and leisure facilities closed, while schools and shops remained open

$\rightarrow$ Flattening/decreasing trend in confirmed cases, but estimated infections continued to rise until one week after "second lockdown"

$\rightarrow$ Why?

Results for Germany: Dark figures

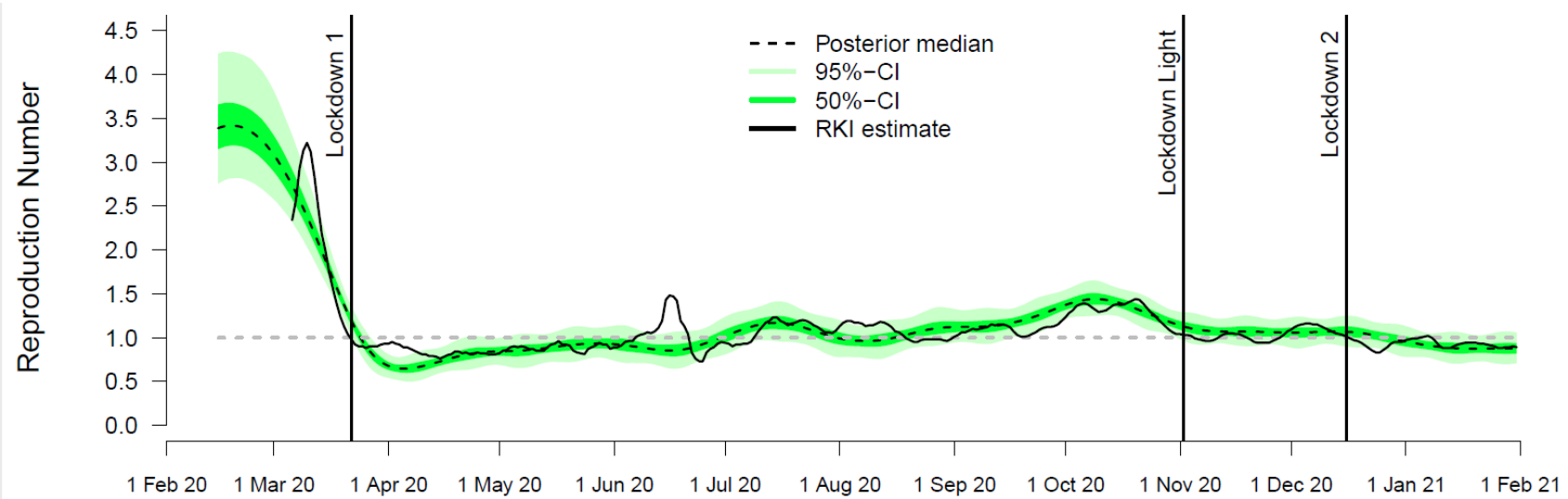


Infections per confirmed case (IPCC): Factor for dark figures of undetected infections

→ Limited (restricted) testing introduced almost concurrently with "lockdown light", leading to increase in estimated dark figures

→ Changes in IPCC often associated with changes in testing policies

Results for Germany: Effective reproduction number



Smooth estimation of effective reproduction number:

$\rightarrow$ Model estimates based on death counts often similar to RKI estimates based on confirmed cases

$\rightarrow$ However, model estimates based on death counts more robust to changes in testing

Limitations

Some limitations of our approach

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- Retrospective estimation approach
  $\rightarrow$ Not for now-casting and forecasting
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- Parametric assumptions, e.g. regarding time between infections and reported deaths
  $\rightarrow$ Specific assumptions may not work for other countries

Conclusions

Summary

Our spline-based hierarchical model based on death counts

- allows to disentangle effects of adapted testing from transmission dynamics
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Future research

- Incorporation of various pieces of information:
  Data on vaccinations, confirmed cases, hospitalizations, intensive care unit cases and death counts
- Account for altered intrinsic severity of different variants

Staerk, Wistuba & Mayr (2021). Estimating effective infection fatality rates during the course of the COVID-19 pandemic in Germany. BMC Public Health.

Wistuba, Mayr & Staerk (2022). Estimating the course of the COVID-19 pandemic in Germany via spline-based hierarchical modelling of death counts. Scientific Reports (accepted). Prep: https://arxiv.org/abs/2109.02599