Modelling the pandemic in Scotland (achievements and lessons)

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Introduction

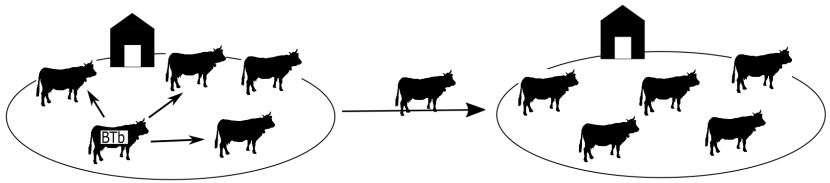
This talk will be on:

- SCoVMod—the Scottish Coronavirus Model;
- use in medium term projections and scenario modelling;
- results from modelling scenarios during the onset of Omicron VoC;
- what we learnt along the way.

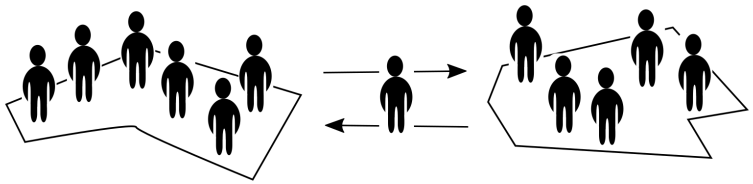
SCoVMod—the Scottish Coronavirus Model

Adapted from an existing agent-based, spatially heterogeneous transmission model:

TBMI:

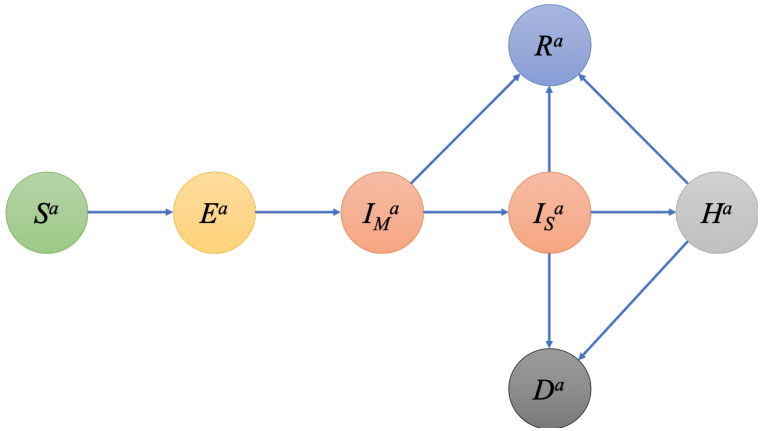


SCoVMod[1]:

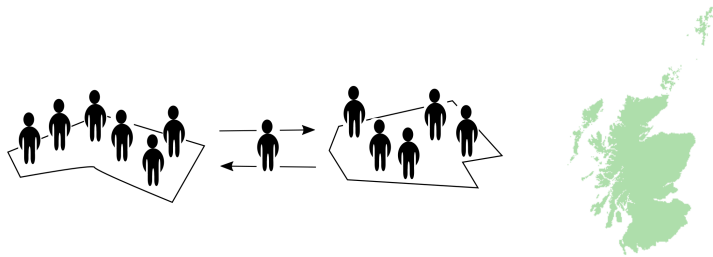


[1] Banks et al., *SCoVMod – a spatially explicit mobility and deprivation adjusted model of first wave COVID-19 transmission dynamics*, Wellcome Open Research (2022)

Model structure



- Local transmission:
  - age-structured compartmental model for each location (Census Output Area, 100 people)



- National transmission:
  - Network of locations
  - movements between weighted by census workplace movements
  - and local non-work movements (within IZ, neighbourhood)
  - time-variant weighting according to Google Mobility

Model structure

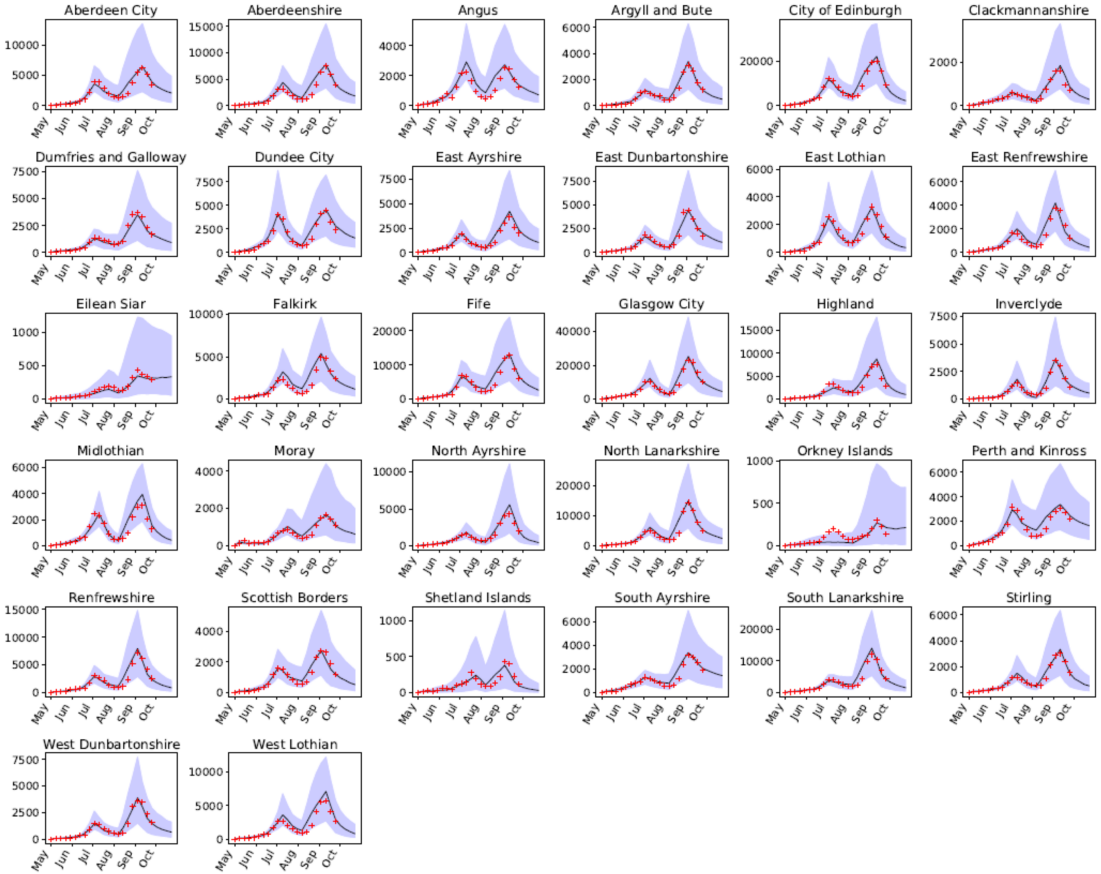
- Deprivation adjustment:
  - Significant correlation between SIMD Health Index
  - Transmission rates adjusted by HI score, per Council Area
- Vaccination:
  - Individuals in the model are flagged as vaccinated according to PHS vaccination data
  - Each vaccination dose has a time-variant efficacy
  - Efficacy data from UKHSA vaccine surveillance

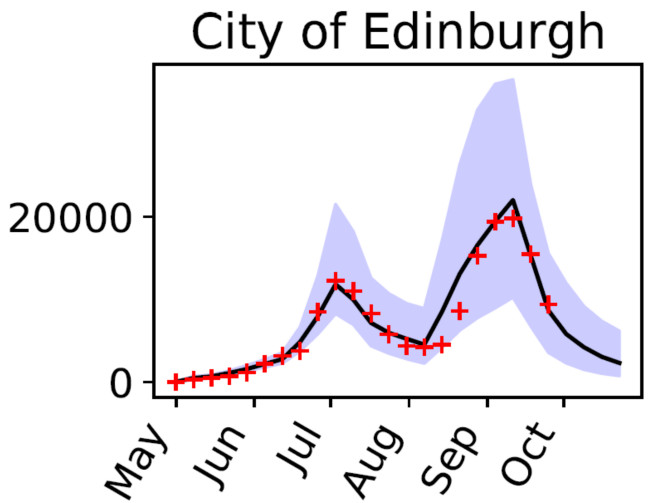
Model fitting

- Case ascertainment:
  - A separate model[2] estimates case ascertainment
  - and therefore infers the number of daily infections
  - from PHS case data and the ONS Infection Survey
  - Case ascertainment in Scotland has been roughly 25%
- Parameter estimation:
  - Fit against inferred infections (early versions used NRS deaths)
  - ABC-SMC, 9 parameters
  - Amazon EC2 (300 machines x 8 cores)
- Time-variant local transmission rates
  - Post-ABC, piece-wise, least-squares fit
  - inflection points (largely) correspond to NPI events
  - per Council Area

[2] Colman et al., *Estimating the proportion of SARS-CoV-2 infections ascertained through diagnostic testing*, medRxiv (2021)

Model fitting





Omicron VoC scenarios

Aim: take the existing model fit for Delta and project likely scenarios for the Omicron outbreak

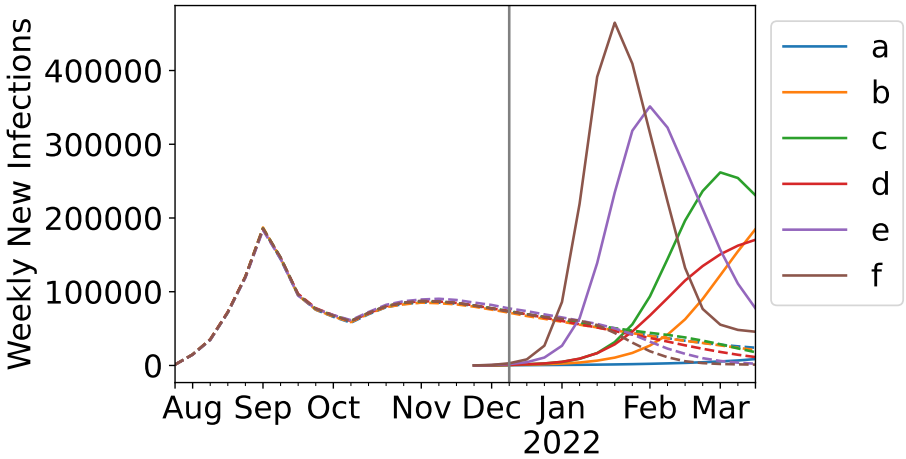
- Two-strain variant of the model constructed
- Complete cross-immunity between strains was assumed
- We vary transmission rate and vaccine efficacy for Omicron

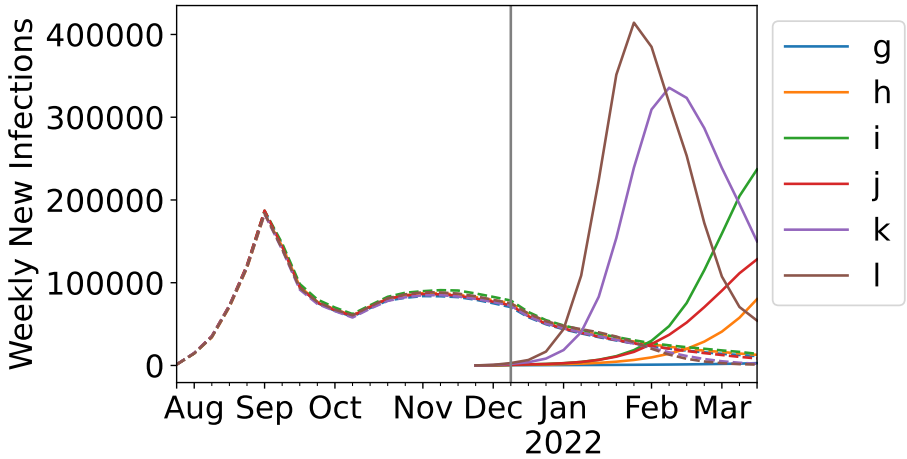
		Efficacy multiplier		
		2 dose	+15 weeks	Booster
Vaccine Escape Level	1	1	1	1
	2	1	0.45	0.8
	3	0.72	0.15	0.63

- UKHSA estimate of between 2.25× and 3.2× transmission advantage

Omicron VoC scenarios

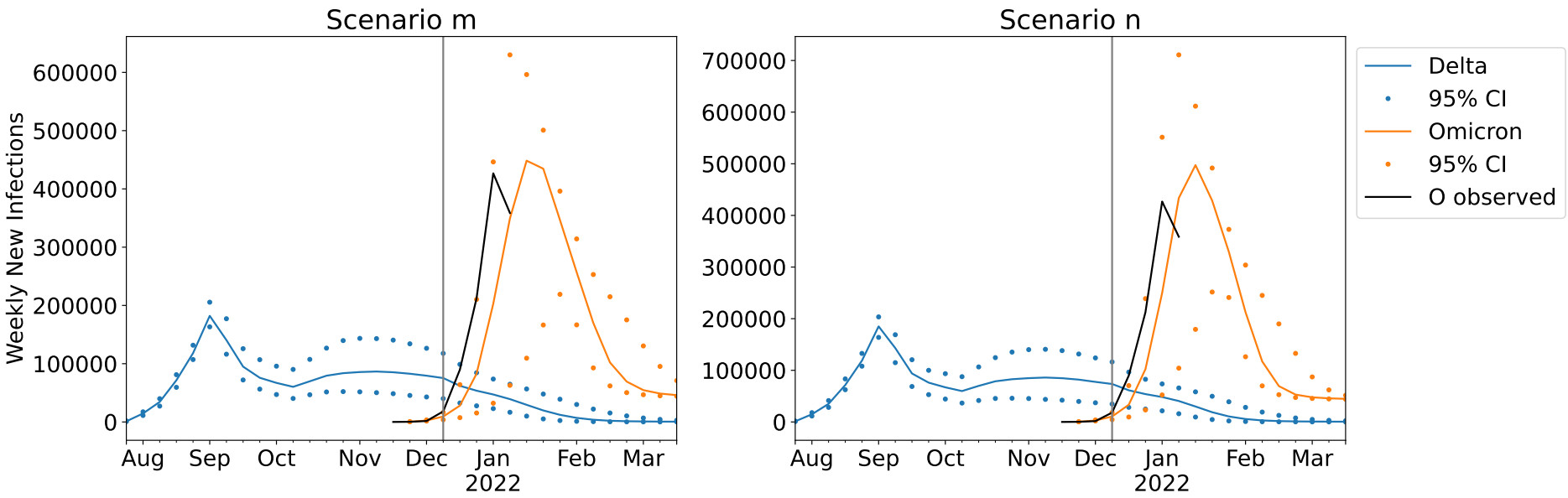
		Vaccine Escape Level		
		1	2	3
Transmission Level	1	a	b	c
	2	d	e	f
	1+NPI	g	h	i
	2+NPI	j	k	l





Omicron VoC adjusted scenario

- Best-fit scenario taken (high TR advantage)
- Growth rate adjusted to fit observed SGTF cases



- to give a TR advantage of between 3.6× and 4.0× (higher/lower vacc. esc. resp.)
- Timing a bit off, but magnitude predicted fairly well!

Achievements?

- Having a ready-to-go model useful for scenarios and informing policy
- Weekly modelling outputs to Scottish Government
- Ability to quick make use of privileged access to spatially detailed PHS data
- Capturing complex spatial heterogeneity (in disease and mobility)
- Making well-founded projections when it mattered (omicron outbreak)
- Doing it with a small team!

Lessons? (A really big slide with lots of stuff!)

- Being prepared: having a (almost) ready-to-go model was key
- Having the people to do it:
  - With the availability to work flexibly and funded appropriately
    - Research Software Engineer (Tom)
    - Core Scientist (me)
    - willing funders (Ewan, Wellcome Trust)
- RSE was key, with his knowledge of good software engineering:
  - Test Driven Development: unit tests so new code didn't break old code, large suite of tests built up
  - Ideally code review/paired programming, but we only had one RSE!
  - One RSE being a bottleneck we shifted some of the adaptation to data prep, to share the load:
    e.g. movements treated as in TBMI, but with an external movement generator based on data
- Hard to publish: useful and relevant work, but not ground-breaking
- Fitting a time-variant, spatially heterogeneous, event-driven transmission rate is hard and labour intensive.

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