Modelling to support regions implementing an elimination strategy

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Modelling to support regions implementing elimination

1. Model fitting
2. Scenario modelling
3. Theory to support elimination
4. Data and analysis needs

Terminology

Elimination: Reduction to zero incidence in a given area

Eradication: Elimination on a global scale

Suppression: Low incidence

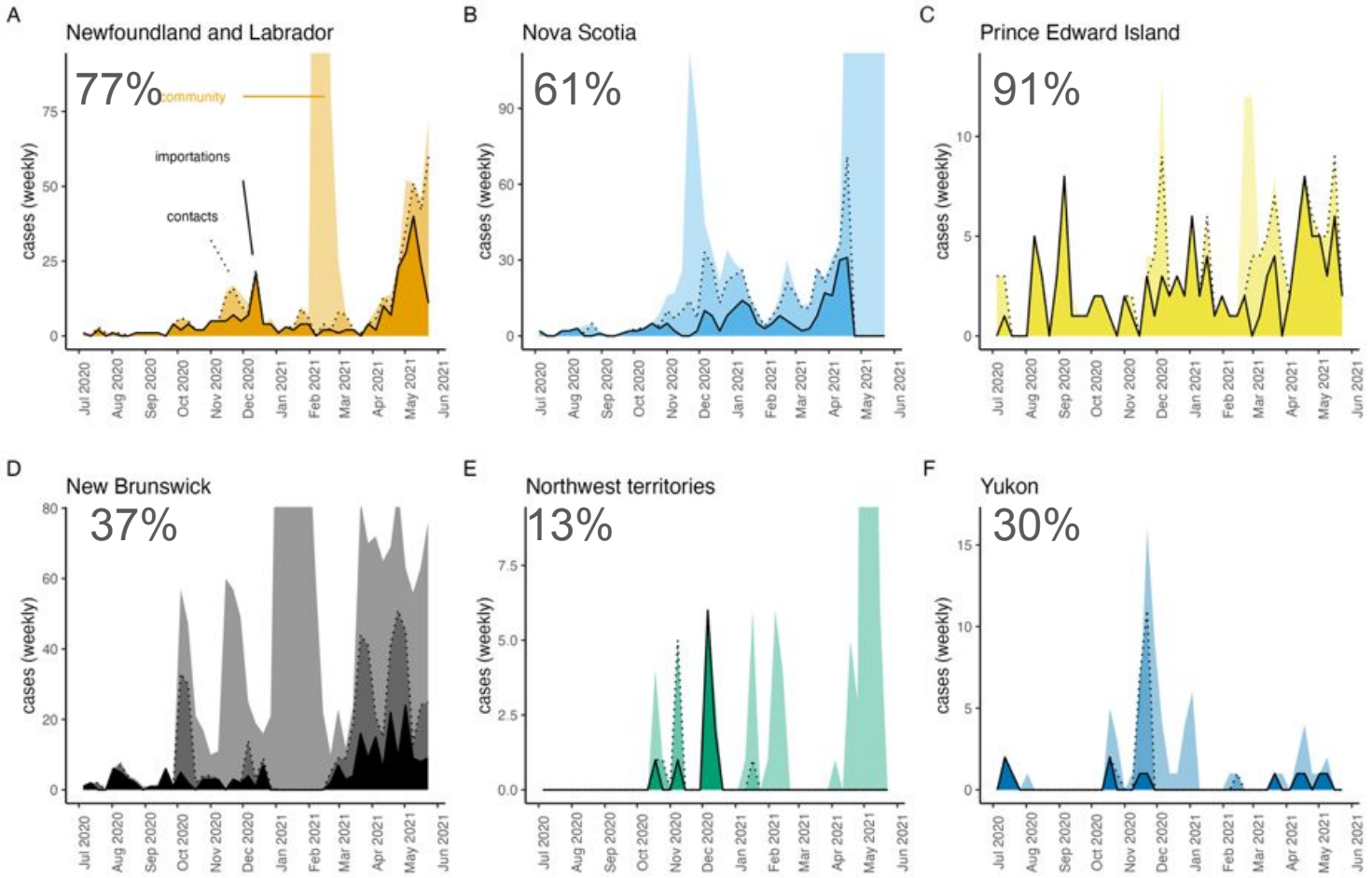
Mitigation: Controls an outbreak, i.e., hospitalizations below capacity

Importation: an infected person with a history of recent travel

Travel-related cases: a close contact of an importation

Data

Mean daily % of reported cases that are travel-related



Hurford et al. 2023. *Pandemic modelling for regions implementing an elimination strategy.* Journal of Theoretical Biology

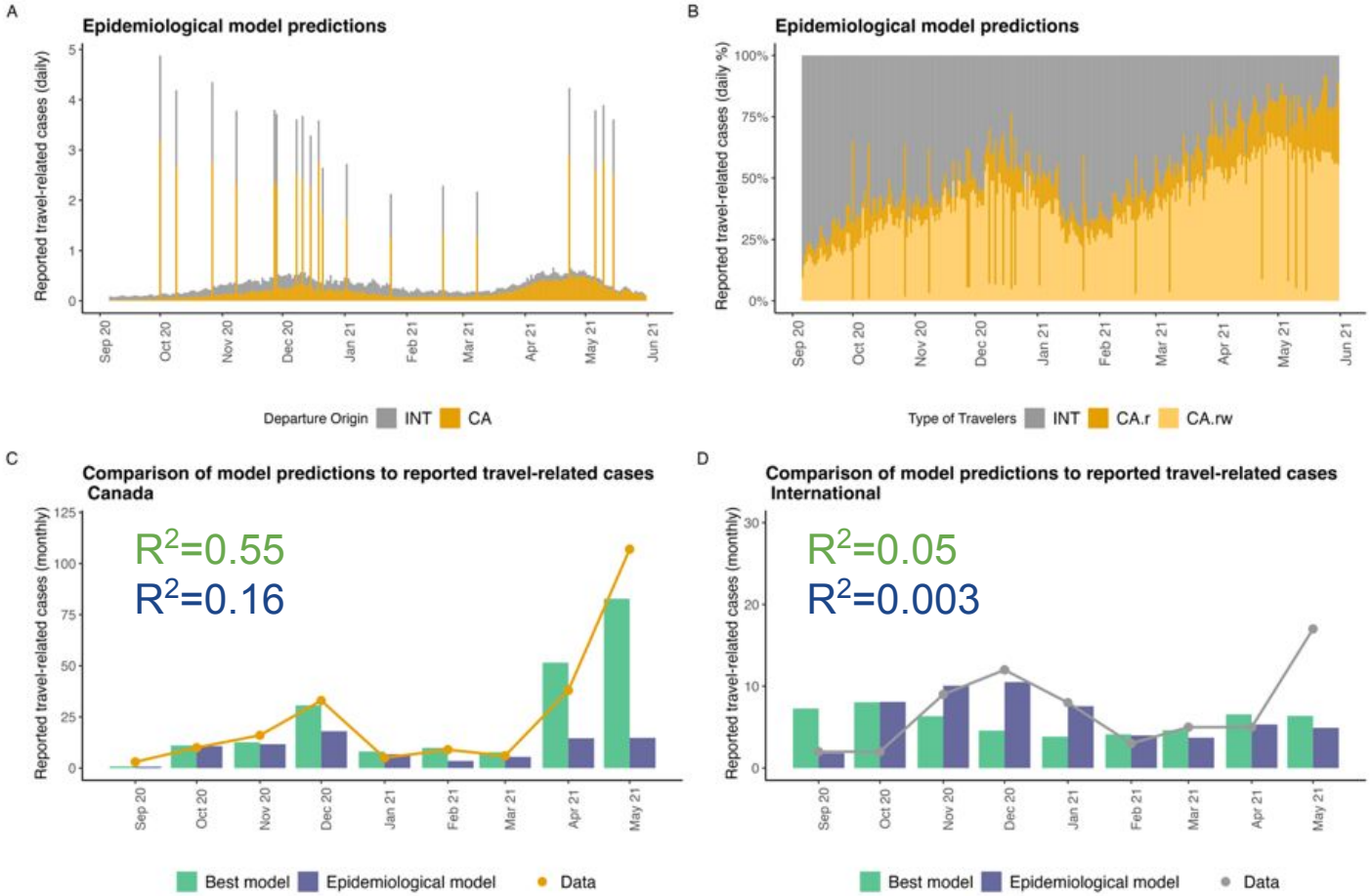
Models

i. Importation model
   - Reported cases in other regions
   - Inbound travel volumes
   - Testing criteria

ii. Community spread model
   - SEAIR (transmission rate, duration of infectiousness, symptoms)

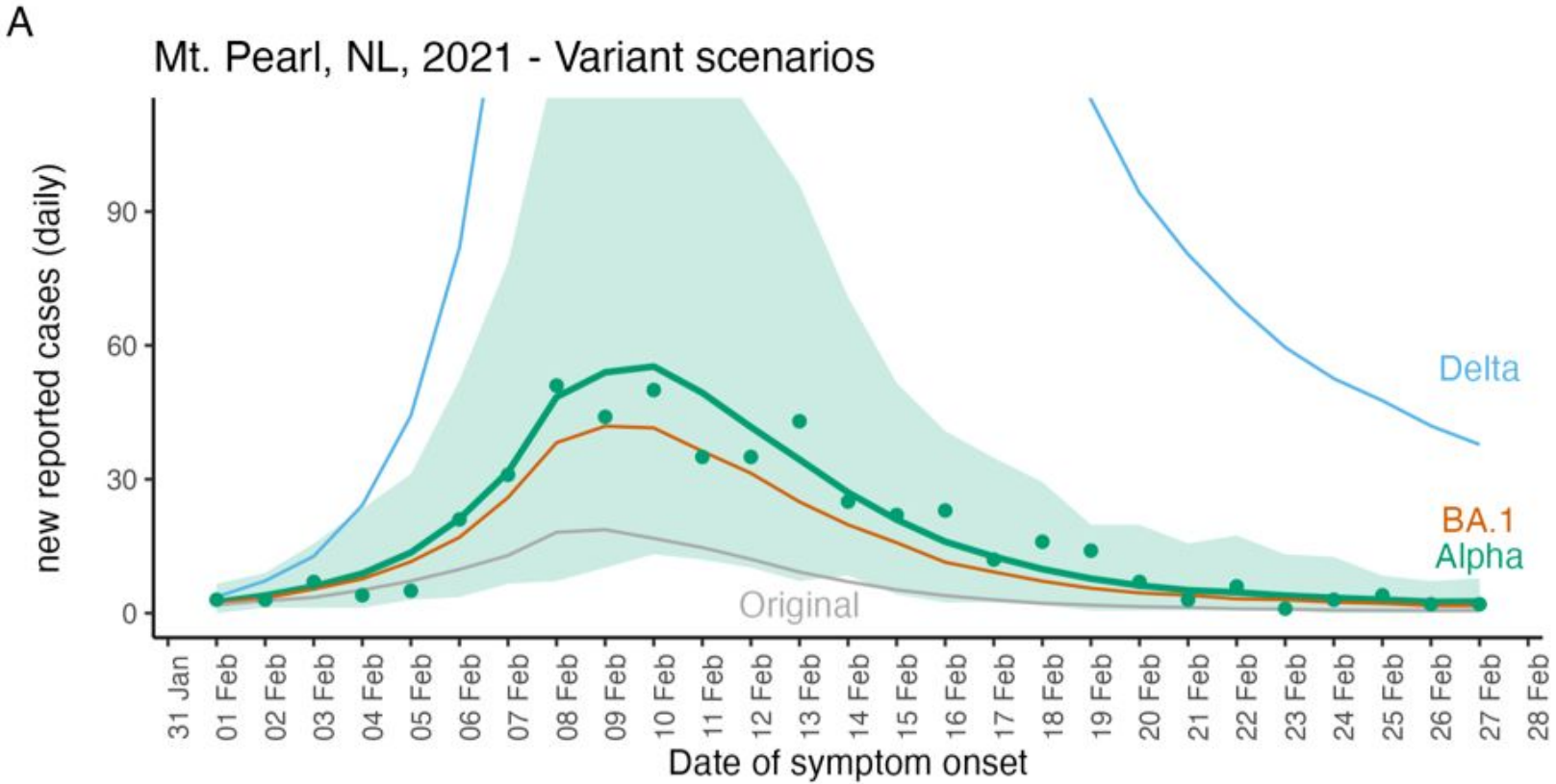
iii. Spillover model
   - Link between i. and ii.

i. Importation model



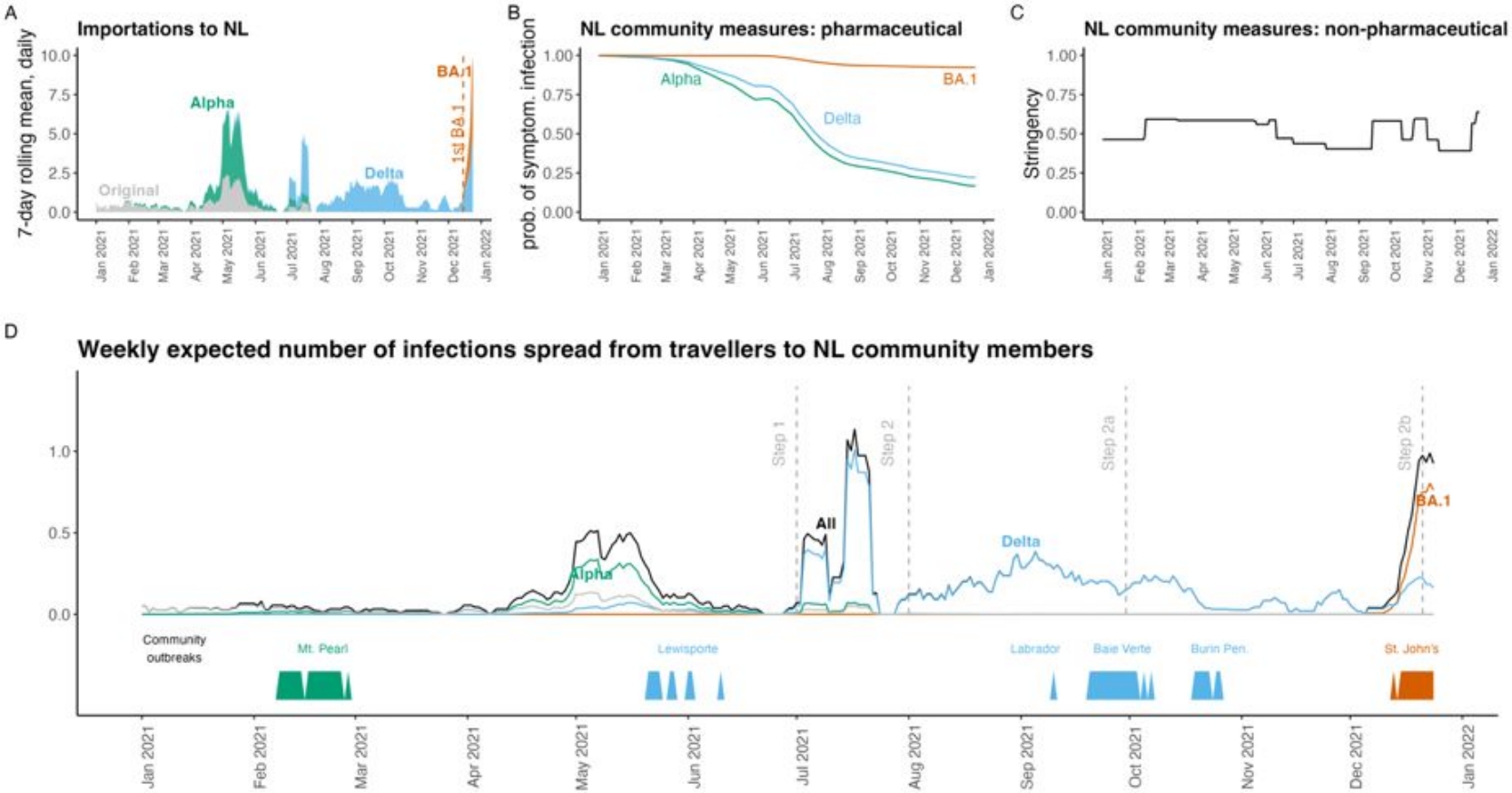
Mohammadi et al. 2023. *Importation models for travel-related SARS-CoV-2 cases reported in Newfoundland and Labrador during the COVID-19 pandemic.* MedRxiv

ii. Community spread model



Hurford et al. 2023. *Pandemic modelling for regions implementing an elimination strategy.* Journal of Theoretical Biology

iii. Spillover model



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1. Model fitting: importation-community spread switch model

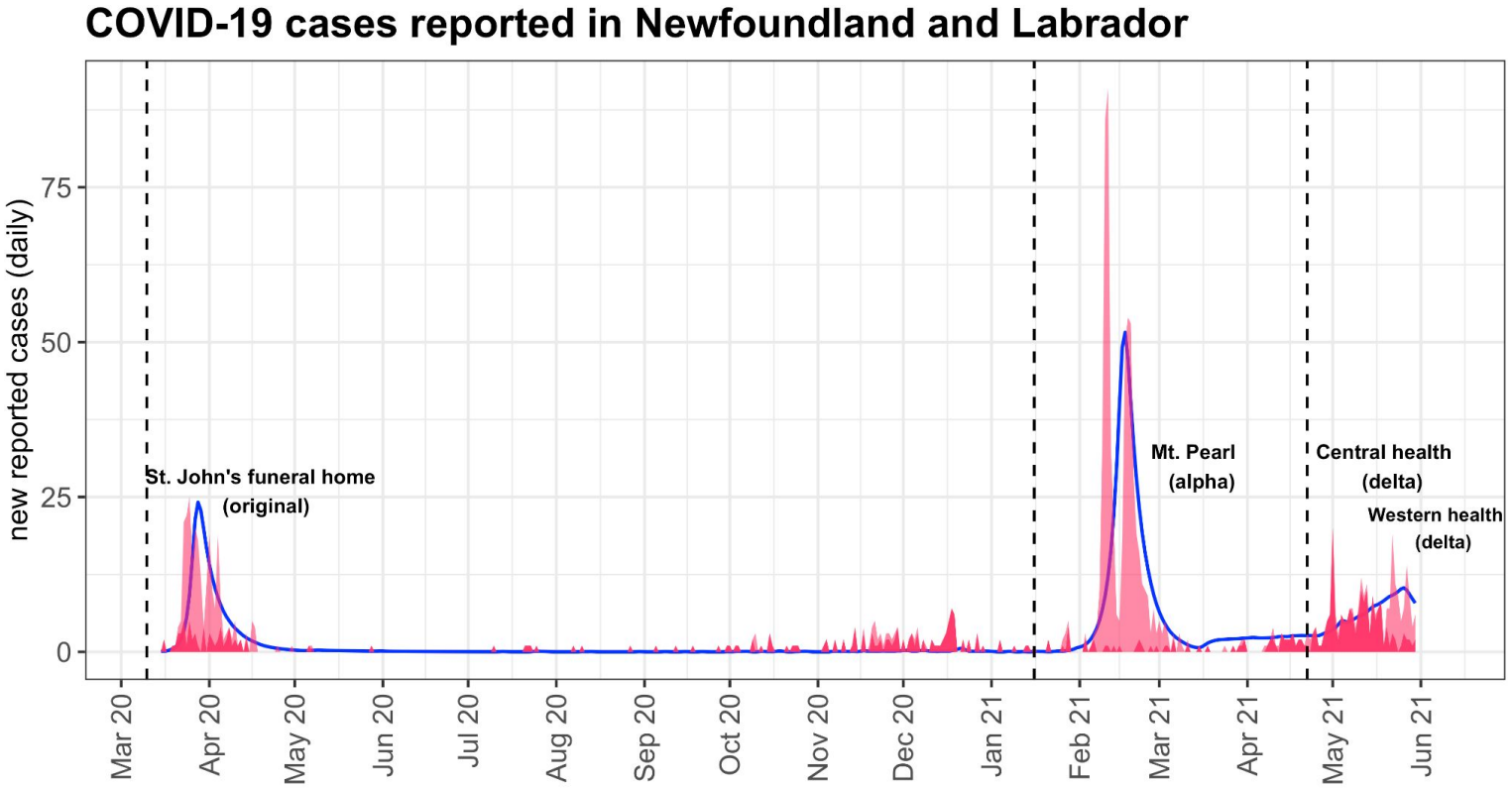
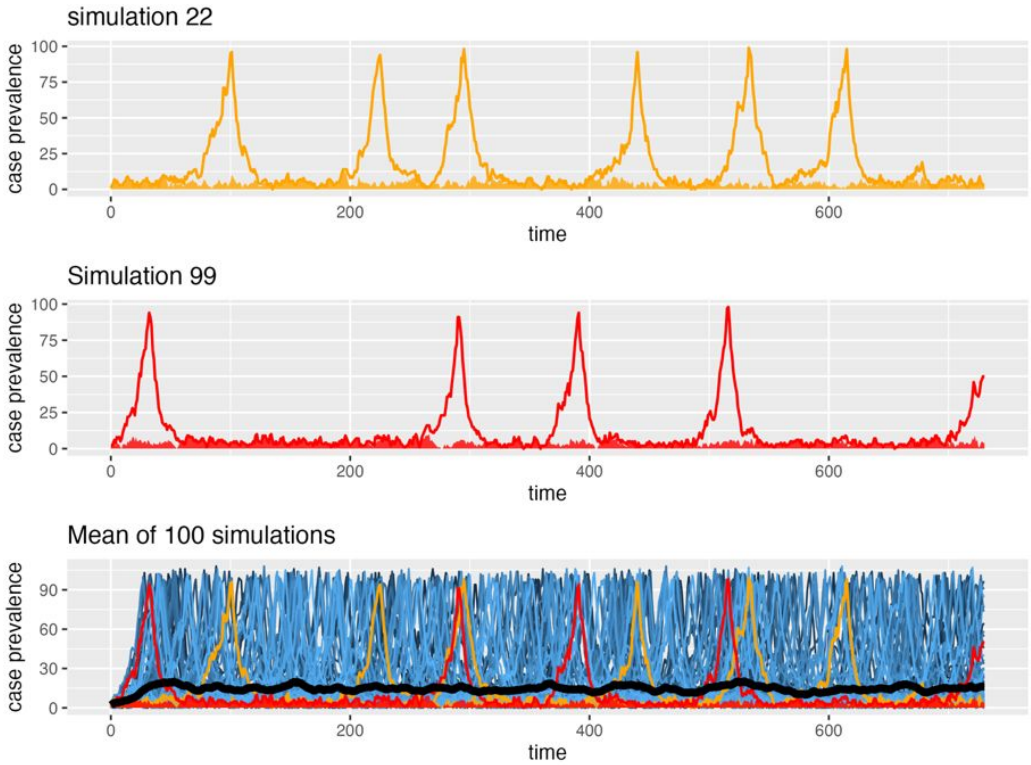


Figure by Zahra Mohammadi

1. Model fitting: importation-community spread switch model

- Data: incidence of travel-related cases (dark shading) and community cases (light shading)
- Include a variable that is travelers in isolation
- 10 days before a reported community outbreak, briefly allow the rate that an isolating traveler infects a susceptible community members to be positive (vertical dashed line)
    - All other times this rate is 0
- When infectious individuals is less than a small threshold, set to 0.

1. Model fitting: rationale for the switch model

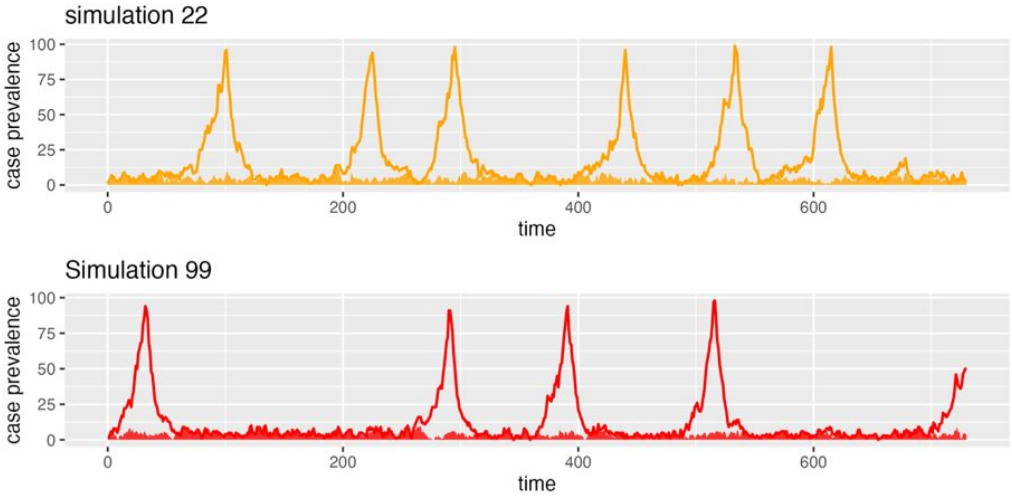


Undesirable dynamics when:

- start date of a community outbreak is treated as uncertain
- a fractional number of individuals with imported infections are exposed to a community with $R_t > 1$

Alternatively, fit separately to each community outbreak

2. Scenario modelling



- Community outbreak dates determined by travel-related cases
- R_t > 1 except from when community cases ≥ 100 until elimination

Multiple realizations

DO:

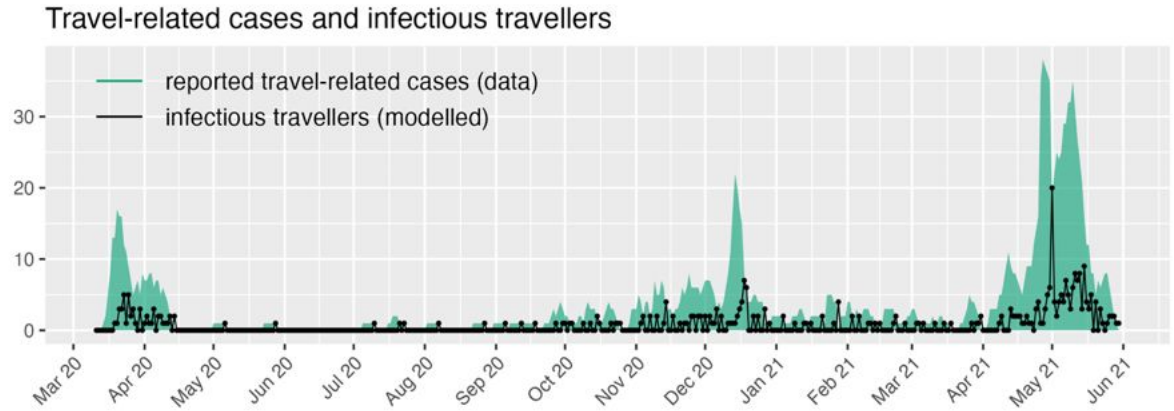
- Av. number of community outbreaks
- Av. size of community outbreak
- Av. days without community cases

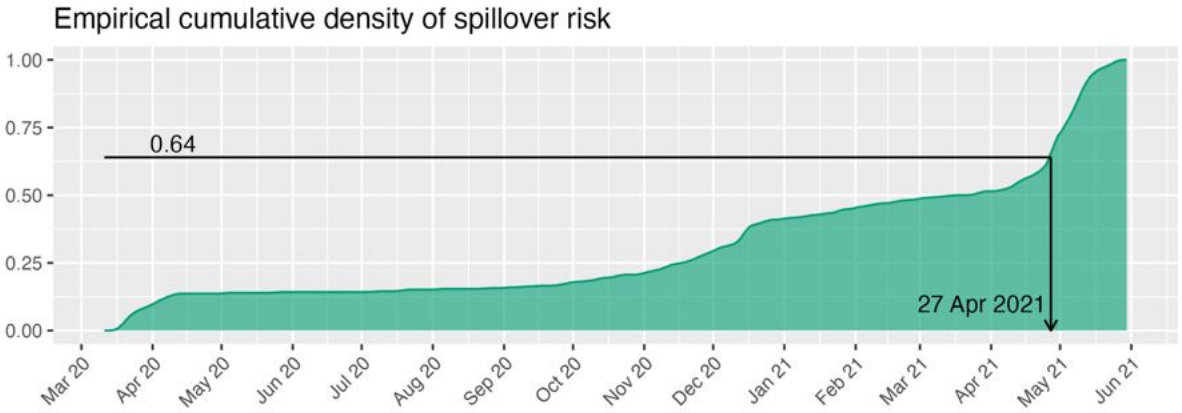
DO NOT:

- Av. prevalence at a given time
- Consider the date meaningful

2. Scenario modelling: spillover model

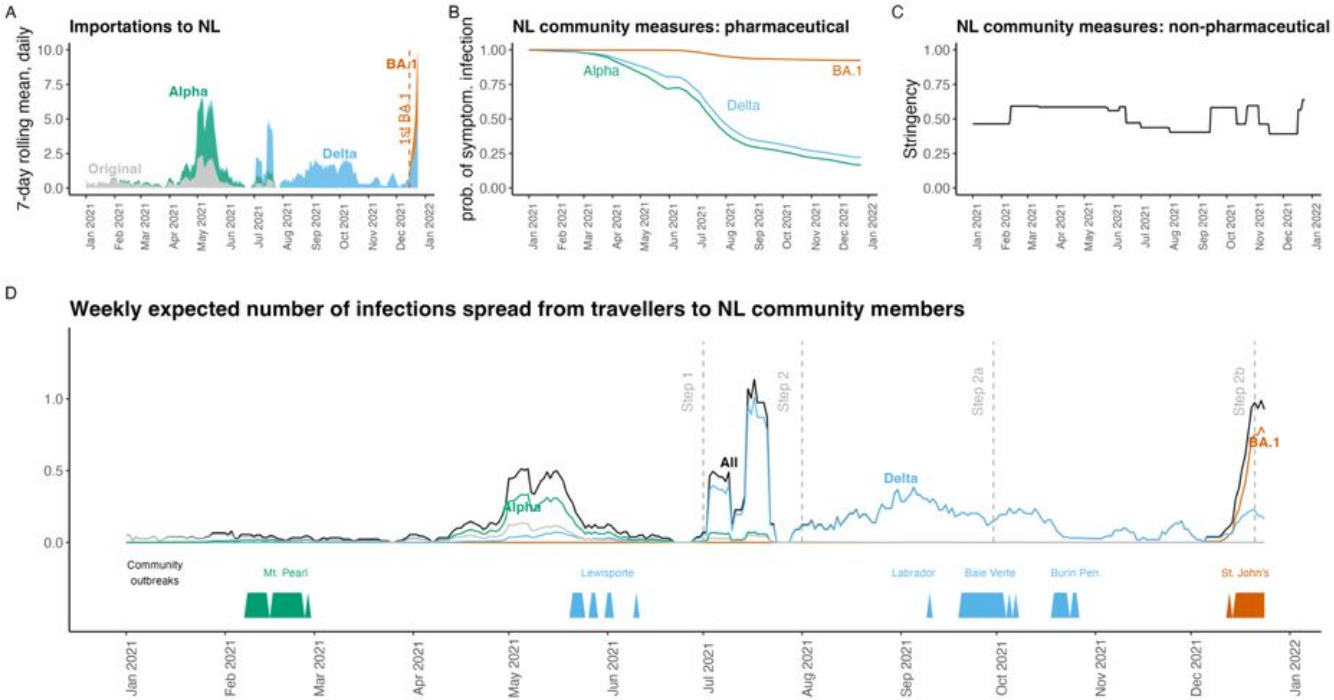
Use the inverse cumulative method to sample the start dates for community outbreaks



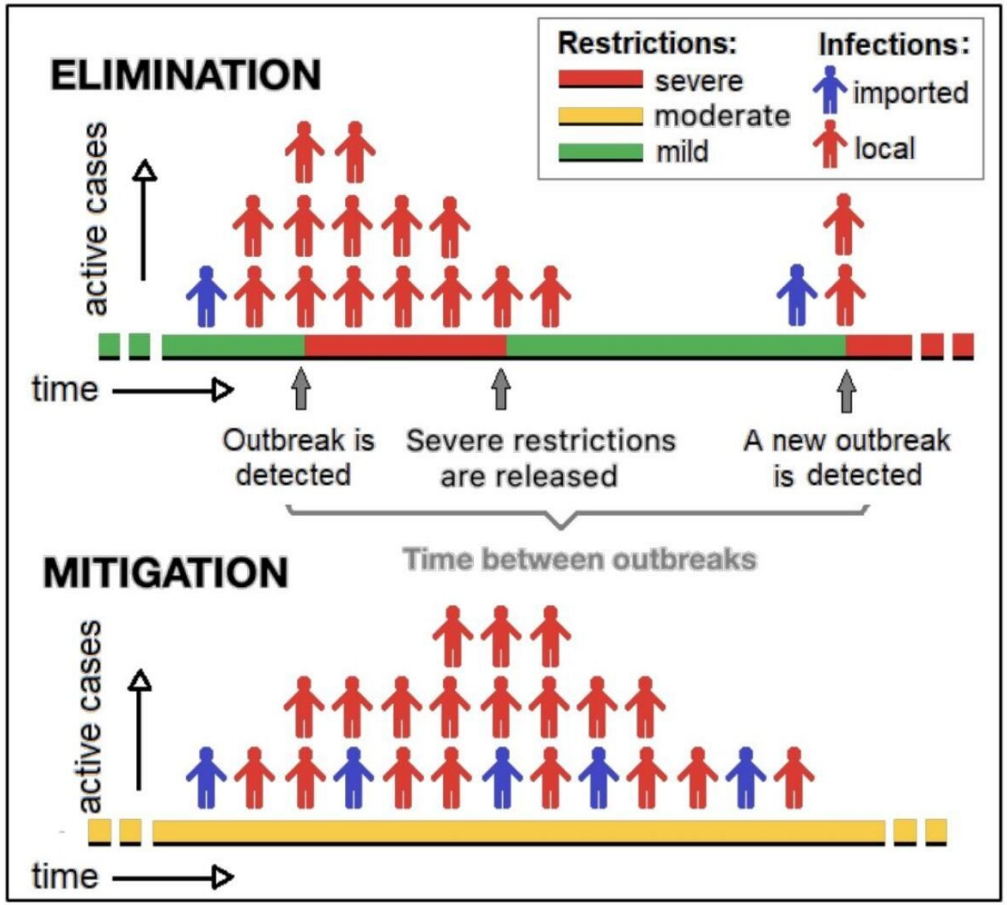


2. Scenario modelling: spillover model

Extend this idea by using the same method for a more detailed spillover model:

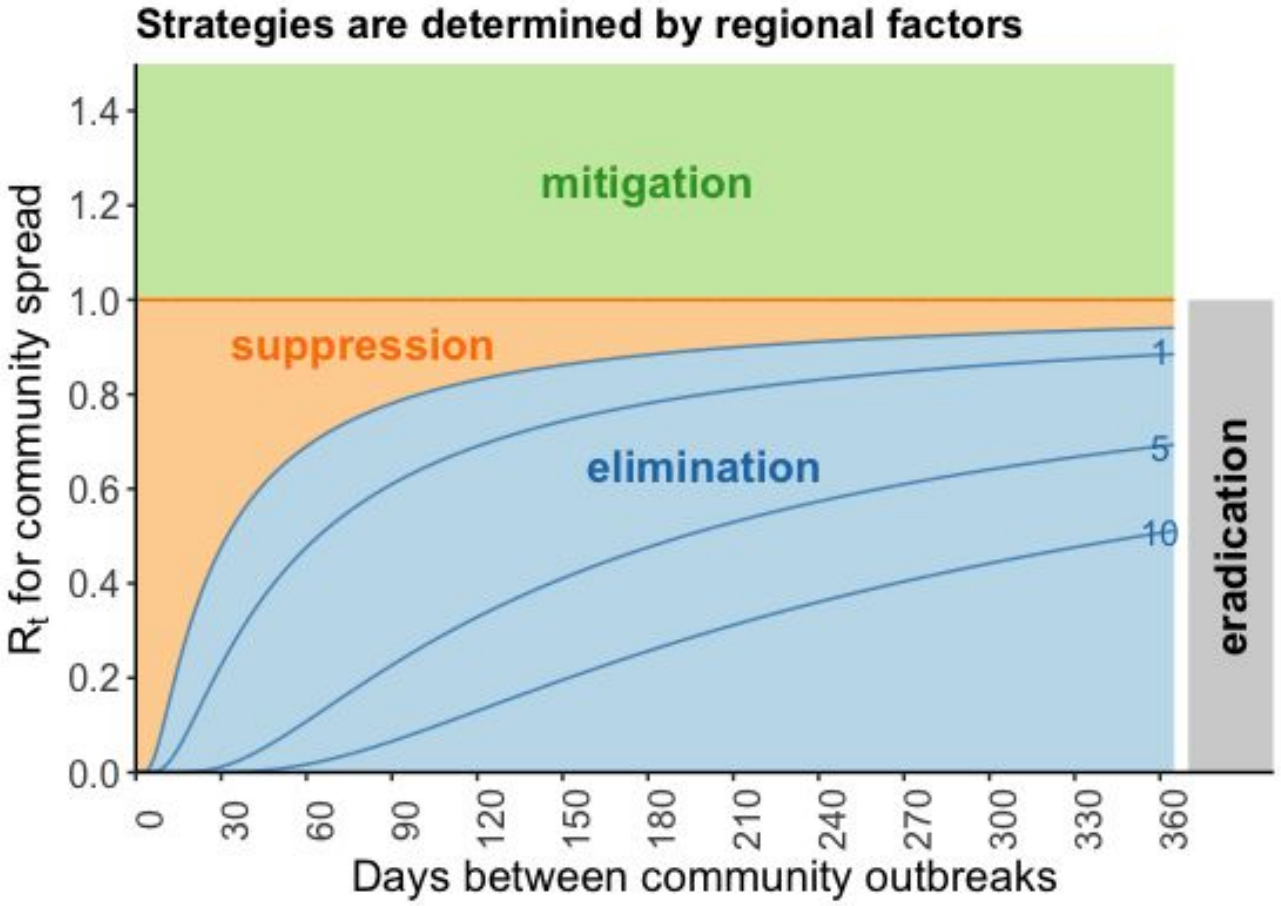


3. Theory to support elimination



Martignoni and Hurford. 2023. *Elimination is no longer feasible in Newfoundland and Labrador. Here's why.* CBC Newfoundland and Labrador

3. Theory to support elimination

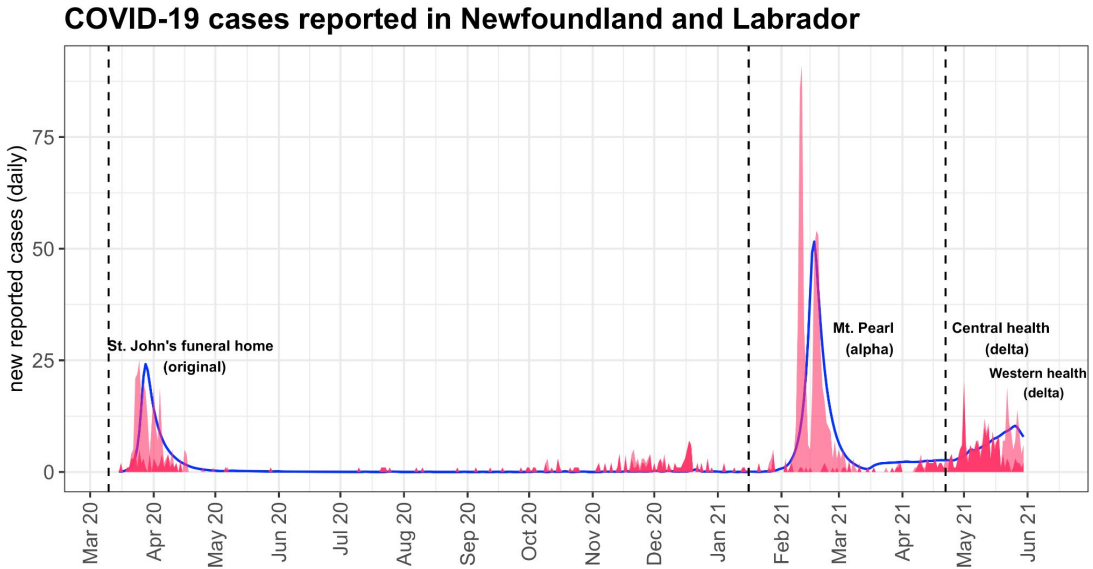


3. Theory to support elimination

When can strict NPIs be eased? (WHO defines a COVID-19 outbreak over 28 days after the last case)	Parag et al 2021
R_t estimation in low incidence regions	Parag et al 2021
Criteria to form travel bubbles	Slide 16. Yang et al. 2021
Rotational workers as a vaccination priority group	Importation and spillover model
Reopening	Hurford et al. 2023
Travel restriction justification in vulnerable populations	

Parag et al. 2021. *Deciphering early warning signals of SARS-CoV-2 elimination and resurgence from limited data at multiple scales.* J. Roy. Soc. Interface.
Yang et al. 2021. *The differential importation risks of COVID-19 from inbound travellers and the feasibility of targeted travel controls: A case study in Hong Kong.* Lancet Regional Health Western Pacific.

4. Data and analysis needs



Need data that distinguishes between importations, close contacts, and community cases

Not provided in public PHAC data sources for Atlantic Canada and the territories during the pandemic

4. Data and analysis needs: importation models are informative

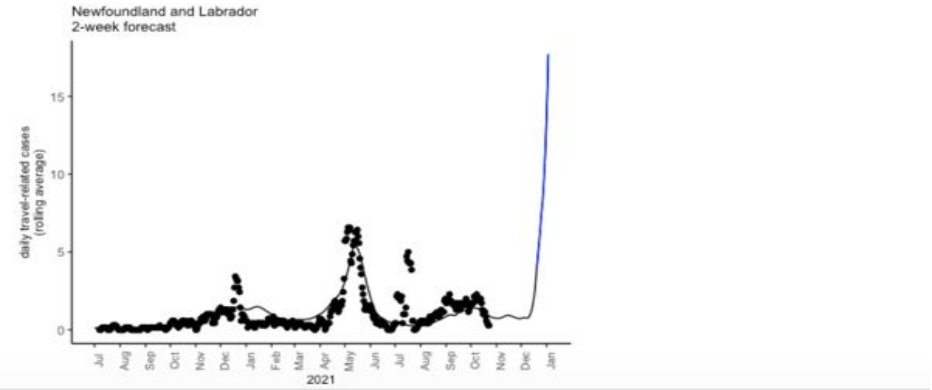
-------- Forwarded Message --------
Subject: Risk of importation
Date: Tue, 21 Dec 2021 07:40:43 -0330
From: Amy Hurford <ahurford@mun.ca>
To:

Hi

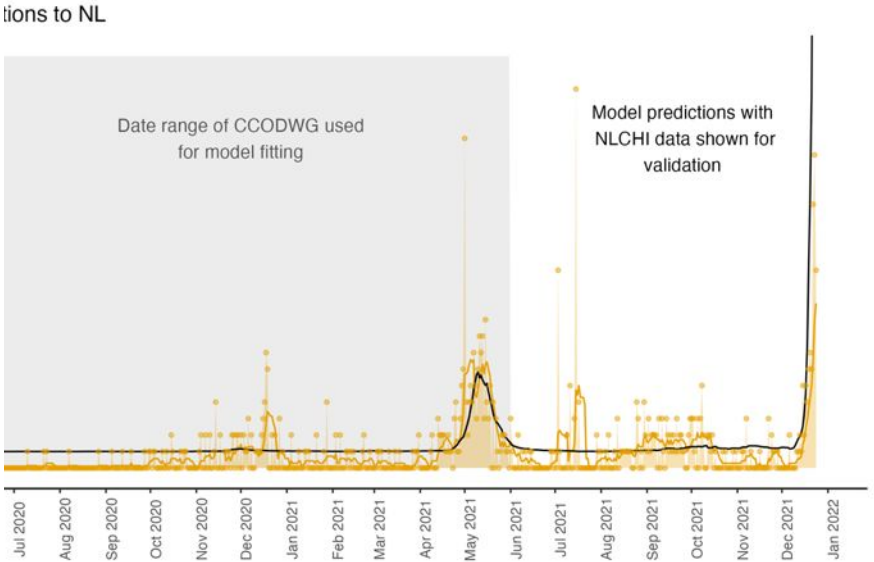
I opened up my graph this morning – it runs automatically, and it looks awful.

Hope you are keeping OK.

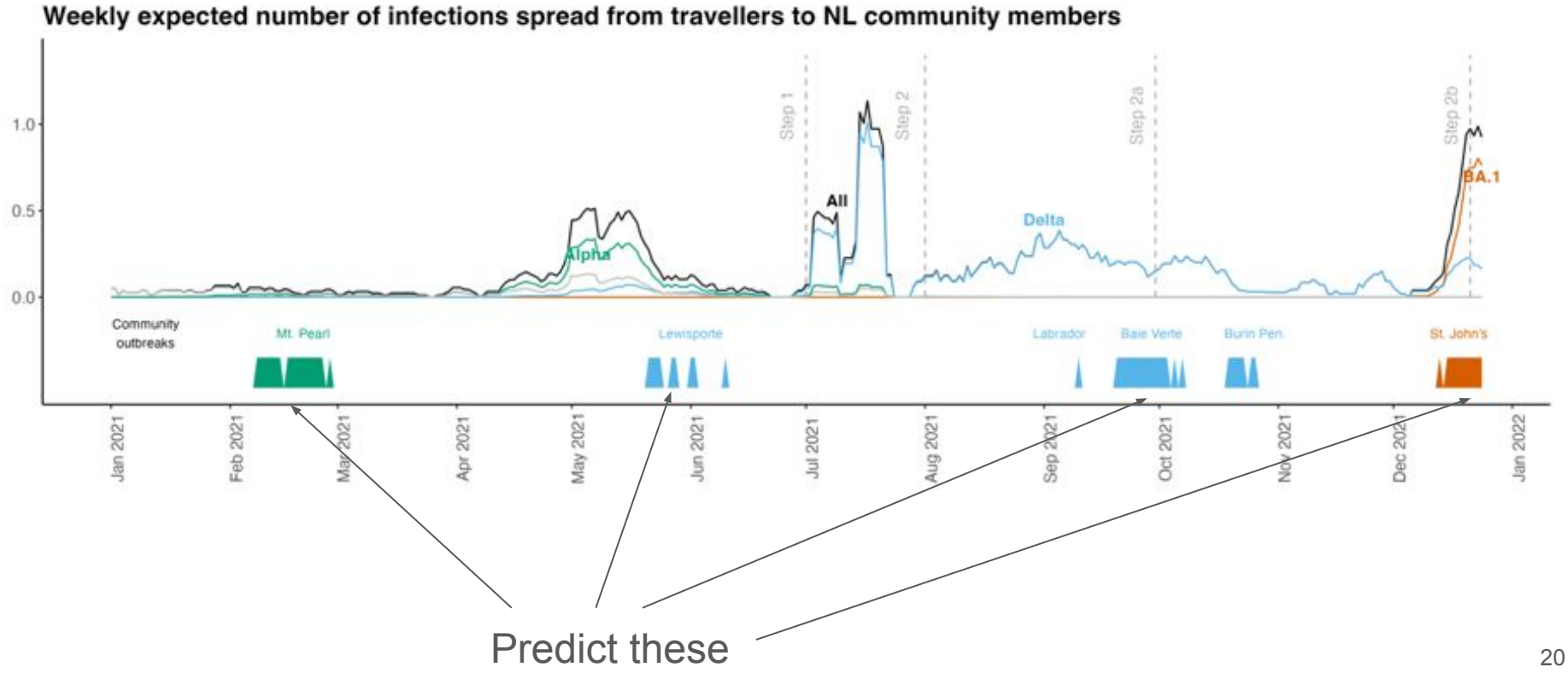
Amy



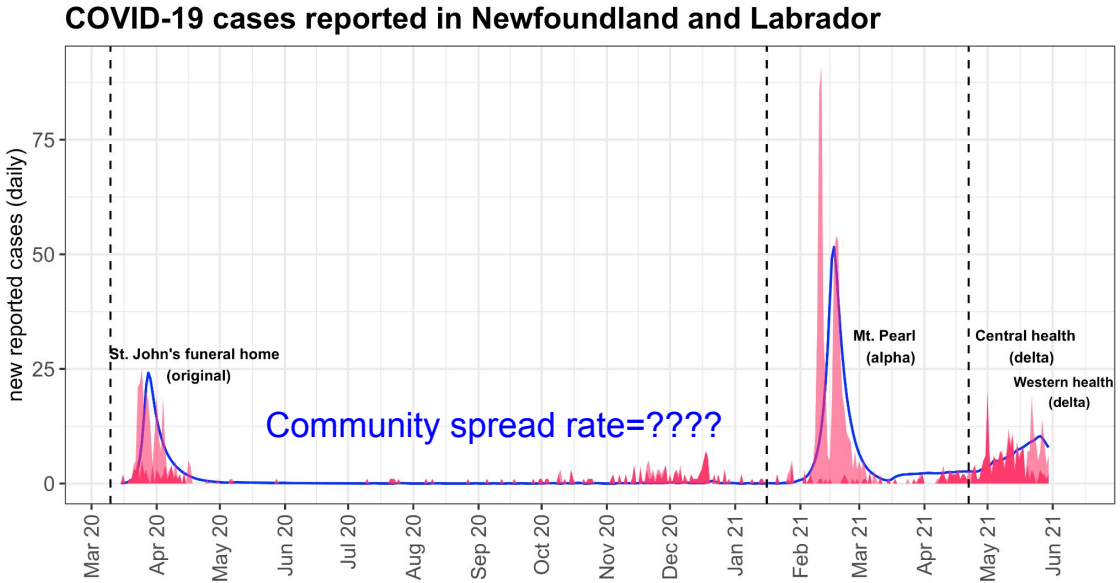
Email real time forecast is validated see Hurford et al. 2023. *Pandemic modelling for regions implementing an elimination strategy.* Journal of Theoretical Biology



4. Data and analysis needs: statistical analysis of spillover risk



4. Data and analysis needs



Methods to estimate community spread rate when there is no community spread

- contact surveys (different NPIs)
- Identifying regional factors that affect community spread

Summary

- In a region implementing elimination, decision-makers will want to know how NPIs impact cases (when there are no cases). This is hard because:
  - community spread parameter difficult to estimate
  - predicting no cases is unremarkable; predicting some cases may result in no relaxing of NPIs

- Decision variables are: spillover risk, expected number of community outbreaks, expected days with eased restrictions rather than cases

- Need to thoughtfully link importation and community spread models

Summary

- The spillover model is the necessary link between data (travel-related cases) and the community (vaccination levels, NPIs)

- We need models that can recommend elimination in some circumstances and supporting guidelines (i.e., criteria for re-opening, travel bubbles, etc)
  - To support decision-makers
  - For health equity to support vulnerable groups

Some figures & ideas by
Maria Martignoni
Zahra Mohammadi

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